



**THURBER** ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT  
GULLWING CREEK BRIDGE REPLACEMENT  
HENDERSON LOOP ROAD, SITE No. 41S-24  
NEAR DRYDEN, ONTARIO  
W.O. No. 2016-11032, AGREEMENT # 6015-E-0023**

**GEOCRES Number: 52F-49**

**Report**

to

**MINISTRY OF TRANSPORTATION  
Northwest Region**

Date: April 7, 2017  
File: 14504

## **TABLE OF CONTENTS**

|     |  |   |
|-----|--|---|
| 1.  | INTRODUCTION .....                         | 1 |
| 2.  | SITE DESCRIPTION .....                     | 2 |
| 3.  | INVESTIGATION PROCEDURES .....             | 2 |
| 4.  | LABORATORY TESTING .....                   | 4 |
| 5.  | DESCRIPTION OF SUBSURFACE CONDITIONS ..... | 4 |
| 5.1 | Embankment Fill.....                       | 5 |
| 5.2 | Silty Clay .....                           | 5 |
| 5.3 | Groundwater Conditions .....               | 6 |
| 6.  | CORROSIVITY AND SULPHATE TEST RESULTS..... | 7 |
| 7.  | MISCELLANEOUS .....                        | 8 |

## **APPENDICES**

|            |  |
|------------|--|
| Appendix A | Record of Borehole Sheets  |
| Appendix B | Geotechnical and Analytical Laboratory Test Results  |
| Appendix C | Selected Site Photographs  |
| Appendix D | Borehole Locations and Soil Strata Drawing   |
| Appendix E | Record of Borehole Sheets and Borehole Location and Soil Strata Drawing, Geocres No 52F-18 |

**FOUNDATION INVESTIGATION REPORT  
GULLWING CREEK BRIDGE REPLACEMENT  
HENDERSON LOOP ROAD, SITE No. 41S-24  
NEAR DRYDEN, ONTARIO  
W.O. No. 2016-11032, AGREEMENT # 6015-E-0023**

**GEOCRES Number: 52F-49**

## **1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Gullwing Creek Bridge on Henderson Loop Road in the Township of Britton, near Dryden, Ontario.

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

Thurber was retained by the Ministry of Transportation (MTO), Northwest Region to carry out this foundation investigation under the Agreement Number 6015-E-0023, Assignment #1, W.O. 2016-11032.

The existing MTO Foundation Investigation Report titled "Gullwing Creek Structure (Henderson Loop Road), Township of Britton, District of Kenora, Lot 6, Con. II and III, W.O. 77-67009, Site 41S-24, District 20, Kenora", dated April 5, 1978, Geocres No. 52F-18 prepared for the then-proposed replacement of the original five span timber structure was reviewed. The foundation investigation documented in the report consisted of drilling one borehole to 16.2 m (53 ft) depth.

It should be noted that the elevations of the ground surface and the structure shown in the Geocres Report No. 52F-18 and on the drawing of the 1977 proposed replacement bridge differ significantly from the ground surface elevations presented on the Survey Plan of November 2016. It is probable that the archive documents utilized a local benchmark. However, no description of the location of the local benchmark was indicated in the available archive information. The Borehole Location Plan and Record of Borehole sheet of the Geocres Report No. 52F-18 are included in Appendix E for information.

## **2. SITE DESCRIPTION**

The Gullwing Creek Bridge site is located on Henderson Loop Road, approximately 0.85 km west of Highway 665, in the Township of Britton, near Dryden, Ontario. The key plan showing the general location of the bridge site is presented on the Borehole Location and Soil Strata Drawing enclosed in Appendix D.

Henderson Loop Road runs in the general east-west direction with the bridge perpendicular to the centreline of the road. Gullwing Creek flows from north to south at the structure location. At this location, the Gullwing Creek is a relatively low energy stream with well developed meandering morphology. Adjacent to the site is forested land. Sporadic farmhouses and farmlands (mostly pastures) are present in the vicinity of the site.

As indicated in the Terms of Reference, the existing bridge is a three span (2.9 m, 33.6 m and 3.2 m lengths) structure with a total length of deck of 39.7 m. The existing bridge was built in 1979 and appears to be supported on timber piles, as indicated on the archive drawing titled, "Gullwing Bailey Bridge, Henderson Loop Road", dated 1979. Each bridge abutment is shown to be supported on ten (10) No. 14 timber piles.

A Biennial Inspection Report dated November 20, 2014 indicated that the structure was generally in good to fair condition. The signs of surface decay and weathering of the structural timber, some impact damage to the sidewalks and barriers, and loss of steel coating were noted in the inspection report.

The general area of the site is located within the physiographic region known as the Severn Upland of the Canadian Shield, and is characterized by rounded knobs and ridges of the Pre-Cambrian bedrock and depressions occupied by lakes and swamps. The relief is typically less than 50 m in this region. Locally, the site lies in a shallow valley surrounded by rolling terrain with soils characterized by Lake Agassiz glaciolacustrine deposits of silts and clays.

Photographs of the bridge and surrounding area are presented in Appendix C.

## **3. INVESTIGATION PROCEDURES**

The field investigation and testing program for this project was carried out on September 14 and 15, 2016, and consisted of drilling and sampling two (2) boreholes, designated as Borehole 16-01 and 16-02. The boreholes were located on each side of the bridge, on the shoulders of Henderson Loop Road and in proximity to the existing bridge abutments. The boreholes were

drilled to a depth of 31.1 m from the ground surface, and then Dynamic Cone Penetration Testing (DCPT) was conducted below the drilled portions of both boreholes. In Borehole 16-01, a refusal to further cone penetration was encountered at 46.3 m depth. In Borehole 16-02, the DCPT was terminated at 50.3 m depth without reaching practical refusal to cone penetration. Utility clearances were obtained prior to the start of drilling. The ground surface elevations at the borehole locations were derived from the Survey Plan dated November 2016 provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 16 was used to determine the locations of the boreholes. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing enclosed in Appendix D.

A rubber track mounted CME 750 drill rig was used to advance the boreholes using hollow stem augers. Samples of the soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures as per ASTM D1586. Undrained shear strength was measured in the very soft to firm silty clay using the field vane in N size. The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and upon completion of drilling. A standpipe piezometer consisting of 25 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen was installed in Borehole 16-01. The boreholes and standpipe piezometer were decommissioned following final water level reading in general accordance with Ontario Regulation 903. Completion details of the borehole are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

| <b>Borehole Number</b>   | <b>Borehole Depth / Base Elevation (m)</b> | <b>Completion Details</b>  |
|--------------------------|--|--|
| 16-01<br>(West Abutment) | 31.1 / 322.8                               | Piezometer installed. Tip of piezometer screen at 24.4 m depth. Sand from base of borehole to 20.7 m depth and bentonite holeplug and cuttings to surface. |
| 16-02<br>(East Abutment) | 31.1 / 322.8                               | Borehole backfilled with bentonite holeplug and cuttings to surface.   |

The existing MTO report (Geocres No 52F-18) documented one borehole drilled at this site in 1978, designated as Borehole 1. Borehole 1 was advanced near the east abutment to a depth of

approximately 16.2 m with soil sampling, and then a DCPT was conducted to a depth of 30.5 m. A DCPT was also conducted near the borehole within the sampled depth. The approximate location of Borehole 1 is shown on the Borehole Locations and Soil Strata Drawing included in Appendix E.

#### **4. LABORATORY TESTING**

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were subjected to grain size distribution analyses (MTO LS702) and Atterberg Limits testing according to MTO LS703, where appropriate. The results of the laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the below ground portion of the structure, a sample of the existing native soil, and a sample of the surface water from the creek upstream of the existing bridge were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

#### **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and should be used for interpretation of the site conditions. It should be recognized that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes consisted of embankment fill underlain by an extensive deposit of silty clay extending to the depths investigated in the boreholes. Descriptions of the individual strata are presented below.

## 5.1 Embankment Fill

Granular embankment fill was encountered in both boreholes extending from the ground surface. The fill composition ranged from sand and gravel with trace silt to gravelly sand with some silt and some clay. The fill was 1.4 m to 2.3 m thick with the underside encountered at Elev. 352.5 and Elev. 351.6 in Boreholes 16-01 and 16-02, respectively. The relative density of the fill was compact with the recorded SPT-N values between 12 and 23 blows per 0.3 m of penetration.

The measured moisture content of the fill generally ranged from 5% to 9%. The results of grain size analyses conducted on two samples of the fill are presented on the record of Borehole sheets included in Appendix A, and on Figure B1 in Appendix B.

The results are summarized in the following table:

| Soil Particle | Percentage (%)  |               |
|---------------|-----------------|---------------|
|               | Sand and Gravel | Gravelly Sand |
| Gravel        | 50              | 21            |
| Sand          | 46              | 56            |
| Silt and Clay | 4               | -             |
| Silt          | -               | 12            |
| Clay          | -               | 11            |

The fill encountered in the borehole drilled in 1978 on the east side of the bridge consisted of 0.6 m of sand and gravel underlain by approximately 1.2 m of “mixture of sand and black organics”, as noted on the Record of Borehole sheet in Appendix E.

## 5.2 Silty Clay

A deposit of silty clay with trace sand was encountered below the fill in all boreholes. Trace of rootlets were noted in the silty clay samples collected immediately below the fill material. The silty clay was sampled to a depth of 31.1 m (Elev. 322.8). In Boreholes 16-01 and 16-02, the upper 4.2 m and 3.2 m of the silty clay was brown to grey in colour and appeared to be typically firm to stiff with the SPT-N values ranging from 2 to 15 blows per 0.3 m of penetration. This zone appears to form a weathered crust to the underlying very soft to firm silty clay deposit. The base of the weathered crust was estimated to be at 5.6 m and 5.5 m depth (Elev. 348.3 and Elev. 348.4) in Boreholes 16-01 and 16-02, respectively.

Underlying the weathered crust was a grey, very soft to firm silty clay, with trace of sand. Occasional seams of silt and clayey silt were noted at depth in the deposit. Field vane shear tests measured undrained shear strength ranging from 5 kPa to 79 kPa, typically 5 kPa to 40 kPa and increasing with depth. Vane tests measured that the sensitivity of the silty clay ranged from 1 to 6 indicating that the silty clay has low to medium sensitivity.

The DCPT carried out below that depth indicated the SPT N values gradually increased to 100 blows per 0.150 m of penetration at 46.3 m depth in Borehole 16-01, and the SPT N values reached approximately 60 blows per 0.15 m penetration at 50.3 m depth in Borehole 16-02.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and are illustrated in Figures B2 to B3 of Appendix B. The results of the grain size distribution tests are summarized below.

| Particle Size | Percentage (%) |
|---------------|----------------|
| Gravel        | 0              |
| Sand          | 0 to 8         |
| Silt          | 32 to 81       |
| Clay          | 19 to 68       |

The results of Atterberg Limits testing conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and are illustrated on the Plasticity Charts (Figures B4 and B5) in Appendix B. Liquid limits ranged from 21% to 53% and the plasticity indices ranged from 8% to 34%, indicating plasticity of the deposit ranging from low to high. Moisture contents of the silty clay varied from 22% to 80%.

### 5.3 Groundwater Conditions

Water levels were monitored in the open boreholes during drilling operations. Wash boring was used to advance boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater conditions. A standpipe piezometer was installed in Borehole 16-01 after completion of drilling. The water level measured in the piezometer and in open boreholes are presented in Table 5.1.



**Table 5.1 – Water Level Measurements**

| Borehole | Date               | Water Level |           | Comment          |
|----------|--------------------|-------------|-----------|------------------|
|          |                    | Depth (m)   | Elev. (m) |                  |
| 16-01    | September 15, 2016 | 6.1         | 347.8     | In piezometer    |
| 16-02    | September 15, 2016 | 4.5         | 349.4     | In open borehole |

The water level in Gullwing Creek was shown on the Survey Plan at Elev. 349.34 m in October 2016.

The recorded levels are short-term readings and seasonal fluctuations of the groundwater and river level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## 6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty clay crust from Borehole 16-01, and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

**Table 6.1 – Analytical Test Results**

| Parameter               | Units (Soil) | Units (Water) | Test Results                               |                      |
|-------------------------|--------------|---------------|--|----------------------|
|                         |              |               | BH 16-01, SS#3, 2.3 m – 2.9 m (Silty Clay) | Gullwing Creek Water |
| Sulphide                | %            | mg/L          | <0.02                                      | 0.026                |
| Chloride                | µg/g         | mg/L          | 37   | 0.95                 |
| Sulphate                | µg/g         | mg/L          | 18   | 1.8                  |
| pH                      | No unit      | No unit       | 6.37-6.84                                  | 7.96                 |
| Electrical Conductivity | µS/cm        | µS/cm         | 145  | 109                  |
| Resistivity             | Ohms.cm      | Ohms.cm       | 6900                                       | 917                  |
| Redox Potential         | mV           | mV            | 270  | 218                  |
| Corrosivity Index       | -            | -             | 1  | 14                   |

## 7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic feature and comparing with the Survey Plan provided by MTO.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Troy MacKinnon of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was conducted by SGS Canada Inc.

Interpretation of the field data and preparation of this report was carried out by Ms. Anna Piascik, P.Eng and Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Anna Piascik, P.Eng.  
Senior Geotechnical Engineer



Mark Farrant, P.Eng.  
Geotechnical Engineer



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



## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

| CLASSIFICATION | PARTICLE SIZE      | VISUAL IDENTIFICATION                               |
|----------------|--------------------|---|
| Boulders       | Greater than 200mm | same  |
| Cobbles        | 75 to 200mm        | same  |
| Gravel         | 4.75 to 75mm       | 5 to 75mm   |
| Sand           | 0.075 to 4.75mm    | Not visible particles to 5mm                        |
| Silt           | 0.002 to 0.075mm   | Non-plastic particles, not visible to the naked eye |
| Clay           | Less than 0.002mm  | Plastic particles, not visible to the naked eye     |

### 2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

| TERMINOLOGY                     | PROPORTION    |
|---------------------------------|---------------|
| Trace or Occasional             | Less than 10% |
| Some                            | 10 to 20%     |
| Adjective (e.g. silty or sandy) | 20 to 35%     |
| And (e.g. sand and gravel)      | 35 to 50%     |

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| DESCRIPTIVE TERM | UNDRAINED SHEAR STRENGTH (kPa) | APPROXIMATE SPT <sup>(1)</sup> 'N' VALUE |
|------------------|--------------------------------|--|
| Very Soft        | 12 or less                     | Less than 2                              |
| Soft             | 12 to 25                       | 2 to 4                                   |
| Firm             | 25 to 50                       | 4 to 8                                   |
| Stiff            | 50 to 100                      | 8 to 15                                  |
| Very Stiff       | 100 to 200                     | 15 to 30                                 |
| Hard             | Greater than 200               | Greater than 30                          |

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

| DESCRIPTIVE TERM | SPT "N" VALUE   |
|------------------|-----------------|
| Very Loose       | Less than 4     |
| Loose            | 4 to 10         |
| Compact          | 10 to 30        |
| Dense            | 30 to 50        |
| Very Dense       | Greater than 50 |

### 5. LEGEND FOR RECORDS OF BOREHOLES

|   |   |  |                        |
|---|---|--|------------------------|
| SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE | SS Split Spoon Sample                     | WS Wash Sample                         | AS Auger (Grab) Sample |
|   | TW Thin Wall Shelby Tube Sample           | TP Thin Wall Piston Sample             |                        |
|   | PH Sampler Advanced by Hydraulic Pressure | PM Sampler Advanced by Manual Pressure |                        |
|   | WH Sampler Advanced by Self Static Weight | RC Rock Core                           | SC Soil Core           |

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

# UNIFIED SOILS CLASSIFICATION

| MAJOR DIVISIONS      |   | GROUP SYMBOL | TYPICAL DESCRIPTION   |
|----------------------|---|--------------|---|
| COARSE GRAINED SOILS | GRAVEL AND GRAVELLY SOILS               | GW           | Well-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |   | GP           | Poorly-graded gravels or gravel-sand mixtures, little or no fines.  |
|                      |   | GM           | Silty gravels, gravel-sand-silt mixtures.   |
|                      |   | GC           | Clayey gravels, gravel-sand-clay mixtures.  |
|                      | SAND AND SANDY SOILS                    | SW           | Well-graded sands or gravelly sands, little or no fines.  |
|                      |   | SP           | Poorly-graded sands or gravelly sands, little or no fines.  |
|                      |   | SM           | Silty sands, sand-silt mixtures.  |
|                      |   | SC           | Clayey sands, sand-clay mixtures.   |
| FINE GRAINED SOILS   | SILTS AND CLAYS<br>W <sub>L</sub> < 50% | ML           | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.           |
|                      |   | CL           | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.<br>(W <sub>L</sub> < 30%). |
|                      |   | CI           | Inorganic clays of medium plasticity, silty clays.<br>(30% < W <sub>L</sub> < 50%).   |
|                      |   | OL           | Organic silts and organic silty-clays of low plasticity.  |
|                      | SILTS AND CLAYS<br>W <sub>L</sub> > 50% | MH           | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.  |
|                      |   | CH           | Inorganic clays of high plasticity, fat clays.  |
|                      |   | OH           | Organic clays of medium to high plasticity, organic silts.  |
| HIGHLY ORGANIC SOILS |   | Pt           | Peat and other highly organic soils.  |
| CLAY SHALE           |   |              |   |
| SANDSTONE            |   |              |   |
| SILTSTONE            |   |              |   |
| CLAYSTONE            |   |              |   |
| COAL                 |   |              |   |

# RECORD OF BOREHOLE No 16-01

1 OF 5

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 009.3 E 314 811.3 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.14 - 2016.09.14 CHECKED BY AMP

| 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>γ<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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |                                    |                                     |                                   |  |  |
| 353.9<br>0.0  | GROUND SURFACE   |            |         |      |            |                            |                 |  |  |                                    |                                     |                                   |  |  |
|               | <b>SAND</b> and <b>GRAVEL</b> , trace silt<br>Compact<br>Brown<br>Moist<br>(FILL)                            |            | 1       | SS   | 23         |                            | 353             |  |  | ○                                  |                                     |                                   |  | 50 46 4<br>(SI+CL)   |
| 352.5<br>1.4  | Silty <b>CLAY</b> , trace sand<br>Firm to Stiff<br>Brown to Grey<br>Moist to Wet<br>(Weathered Crust)        |            | 2       | SS   | 15         |                            | 352             |  |  | ○                                  |                                     |                                   |  |  |
|               |  |            | 3       | SS   | 10         |                            | 351             |  |  |                                    | ○                                   |                                   |  |  |
|               |  |            | 4       | SS   | 7          |                            | 350             |  |  |                                    |                                     |                                   |  | 0 8 63 29  |
|               |  |            | 5       | SS   | 5          |                            | 349             |  |  |                                    | ○                                   |                                   |  |  |
| 348.3<br>5.6  | Silty <b>CLAY</b> , trace sand, occasional<br>clayey silt and silt seams<br>Very Soft to Soft<br>Grey<br>Wet |            | 6       | SS   | 0          |                            | 348             |  |  |                                    | ○                                   |                                   |  |  |
|               |  |            | 7       | SS   | 0          |                            | 346             |  |  |                                    |                                     |                                   |  | 0 0 32 68  |
|               |  |            | 8       | SS   | 0          |                            | 345             |  |  |                                    | ○                                   |                                   |  |  |
|               |  |            |         |      |            |                            | 344             |  |  |                                    |                                     |                                   |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-01

2 OF 5

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 009.3 E 314 811.3 ORIGINATED BY TM  
HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
DATUM Geodetic DATE 2016.09.14 - 2016.09.14 CHECKED BY AMP

| 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>γ<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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |  |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page  |            |         |      |            |                            |                 |  |  |  |  |                                    |                                     |                                   |  |  |
|               | Silty <b>CLAY</b> , trace sand, occasional clayey silt and silt seams<br>Very Soft to Soft<br>Grey<br>Wet |            | 9       | SS   | 0          |                            | 343             |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 342             | 1.7  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 10      | SS   | 0          |                            | 341             |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 340             | 2.4  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 11      | SS   | 0          |                            | 339             |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 338             | 1.8  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 12      | SS   | 0          |                            | 337             |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 336             | 1.2  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            | 13      | SS   | 0          |                            | 335             |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 334             | 1.6  |  |  |  |                                    |                                     |                                   |  |  |
|               | clayey silt seam  |            | 14      | SS   | 0          |                            |                 |  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            |                 | 1.0  |  |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            |                 |  |  |  |  |                                    |                                     |                                   |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity



## METRIC

| SOIL PROFILE   |   |            |         |                            |                 |
|--|---|------------|---------|----------------------------|-----------------|
| ELEV<br>DEPTH  | DESCRIPTION   | STRAT PLOT | SAMPLES | GROUND WATER<br>CONDITIONS | ELEVATION SCALE |
|  |   |            | NUMBER  | TYPE                       |                 |
|  | Continued From Previous Page  |            |         |                            |                 |
| 322.8  | Silty <b>CLAY</b> , trace sand, occasional clayey silt and silt seams<br>Very Soft to Soft<br>Grey<br>Wet |            | 18      | SS                         | 0               |
| 31.1   | End of sampling and start DCPT at 31.1m   |            |         |                            |                 |
| <div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>w<sub>p</sub> w w<sub>L</sub></div> <div>WATER CONTENT (%)</div> <div>UNIT WEIGHT γ</div> <div>kN/m<sup>3</sup></div> <div>GR SA SI CL</div> |   |            |         |                            |                 |

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

## METRIC

[illegible]



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 16-02

1 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| 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><b>γ</b><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                     | ○ UNCONFINED      + FIELD VANE | ● QUICK TRIAXIAL      × LAB VANE | W <sub>P</sub> W      W <sub>L</sub> |   |  |  |   |  |  |  |  |
| 353.9         | GROUND SURFACE  |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
| 0.0           | Gravelly <b>SAND</b> , some silt, some clay<br>Compact<br>Brown<br>Moist<br>(FILL)  |   | 1       | SS   |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  | 2       | SS   | 21         |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  | 3       | SS   | 12         |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
| 351.6         |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
| 2.3           | Silty <b>CLAY</b> , trace sand, some<br>organics (rootlets) in the upper 1.0m<br>zone<br>Soft to Stiff<br>Brown to Grey<br>Moist<br>(Weathered Crust) |  | 4       | SS   | 9          |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  | 5       | SS   | 9          |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  | 6       | SS   | 2          |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |
|               |   |  |         |      |            |                            |                 |   |                                |                                  |                                      |   |  |  |   |  |  |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

2 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| 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>γ<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 (%) |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page  |            |         |      |            |                            |                 |   |                   |                                    |                                     |                                   |  |  |
|               | Silty <b>CLAY</b> , trace sand, occasional<br>clayey silt and silt seams<br>Soft to Firm<br>Grey<br>Wet |            |         |      |            |                            |                 |   |                   |                                    |                                     |                                   |  |  |
|               |   |            | 10      | SS   | 0          |                            | 343             | 2.7<br>+                                    |                   |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 342             | 1.9<br>+                                    |                   |                                    |                                     |                                   |  |  |
|               |   |            | 11      | SS   | 0          |                            | 341             |   |                   |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 340             | 2.2<br>+                                    |                   |                                    |                                     |                                   |  |  |
|               |   |            | 12      | SS   | 0          |                            | 339             |   |                   |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 338             | 1.7<br>+                                    |                   |                                    |                                     |                                   |  |  |
|               |   |            | 13      | SS   | 0          |                            | 337             |   |                   |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 336             | 2.1<br>+                                    |                   |                                    |                                     |                                   |  |  |
|               |   |            | 14      | SS   | 0          |                            | 335             |   |                   |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 334             |   |                   |                                    |                                     |                                   |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

3 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |                                 | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT |  |  | UNIT 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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE | W <sub>p</sub> W W <sub>L</sub> | WATER CONTENT (%)                                   |  |  |  |  |
|               | Continued From Previous Page<br>Silty <b>CLAY</b> , trace sand, occasional<br>clayey silt and silt seams<br>Soft to Firm<br>Grey<br>Wet |            |         |      |            |                            |                 |  |                                 |   |  |  |  |  |
|               |   |            | 16      | SS   | 0          |                            | 333             |  |                                 |   |  |  |  | 0 0 71 29  |
|               |   |            |         |      |            |                            | 332             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 331             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 330             |  |                                 |   |  |  |  |  |
|               |   |            | 17      | SS   | 0          |                            | 329             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 328             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 327             |  |                                 |   |  |  |  |  |
|               |   |            | 18      | SS   | 0          |                            | 326             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 325             |  |                                 |   |  |  |  |  |
|               |   |            |         |      |            |                            | 324             |  |                                 |   |  |  |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

4 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| 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>γ<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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |                                    |                                     |                                   |  |  |
| 322.8         | Continued From Previous Page<br>Silty <b>CLAY</b> , trace sand, occasional<br>clayey silt and silt seams<br>Soft to Firm<br>Grey<br>Wet |            | 19      | SS   | 0          |                            | 323             |  |  |                                    |                                     |                                   |  | 0 0 81 19  |
| 31.1          | End of sampling and start DCPT at<br>31.1m  |            |         |      |            |                            | 322             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 321             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 320             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 319             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 318             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 317             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 316             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 315             |  |  |                                    |                                     |                                   |  |  |
|               |   |            |         |      |            |                            | 314             |  |  |                                    |                                     |                                   |  |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

5 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| SOIL PROFILE  |                              |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT<br>20 40 60 80 100<br>SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE<br>20 40 60 80 100 | PLASTIC LIMIT<br>NATURAL MOISTURE CONTENT<br>LIQUID LIMIT<br>W <sub>p</sub> — W — W <sub>L</sub><br>WATER CONTENT (%)<br>20 40 60 | UNIT WEIGHT<br>γ<br>kN/m <sup>3</sup> | REMARKS & GRAIN SIZE DISTRIBUTION (%)<br>GR SA SI CL |
|---------------|------------------------------|------------|---------|------|------------|----------------------------|-----------------|---|---|---------------------------------------|--|
| ELEV<br>DEPTH | DESCRIPTION                  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 |   |   |                                       |  |
|               | Continued From Previous Page |            |         |      |            |                            |                 |   |   |                                       |  |
| 313           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 312           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 311           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 310           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 309           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 308           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 307           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 306           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 305           |                              |            |         |      |            |                            |                 |   |   |                                       |  |
| 304           |                              |            |         |      |            |                            |                 |   |   |                                       |  |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-02

6 OF 6

METRIC

W.P. 2016-11032 LOCATION Gullwing Creek Bridge N 5 531 004.9 E 314 858.0 ORIGINATED BY TM  
 HWY Henderson Loop Rd. BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN  
 DATUM Geodetic DATE 2016.09.15 - 2016.09.15 CHECKED BY AMP

| 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>γ<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                          |  |  |  |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 303.6         |   |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
| 50.3          | END OF BOREHOLE AT 50.3m.<br>WATER LEVEL IN OPEN BOREHOLE<br>AT 4.5m DEPTH.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>CUTTINGS TO SURFACE. |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |





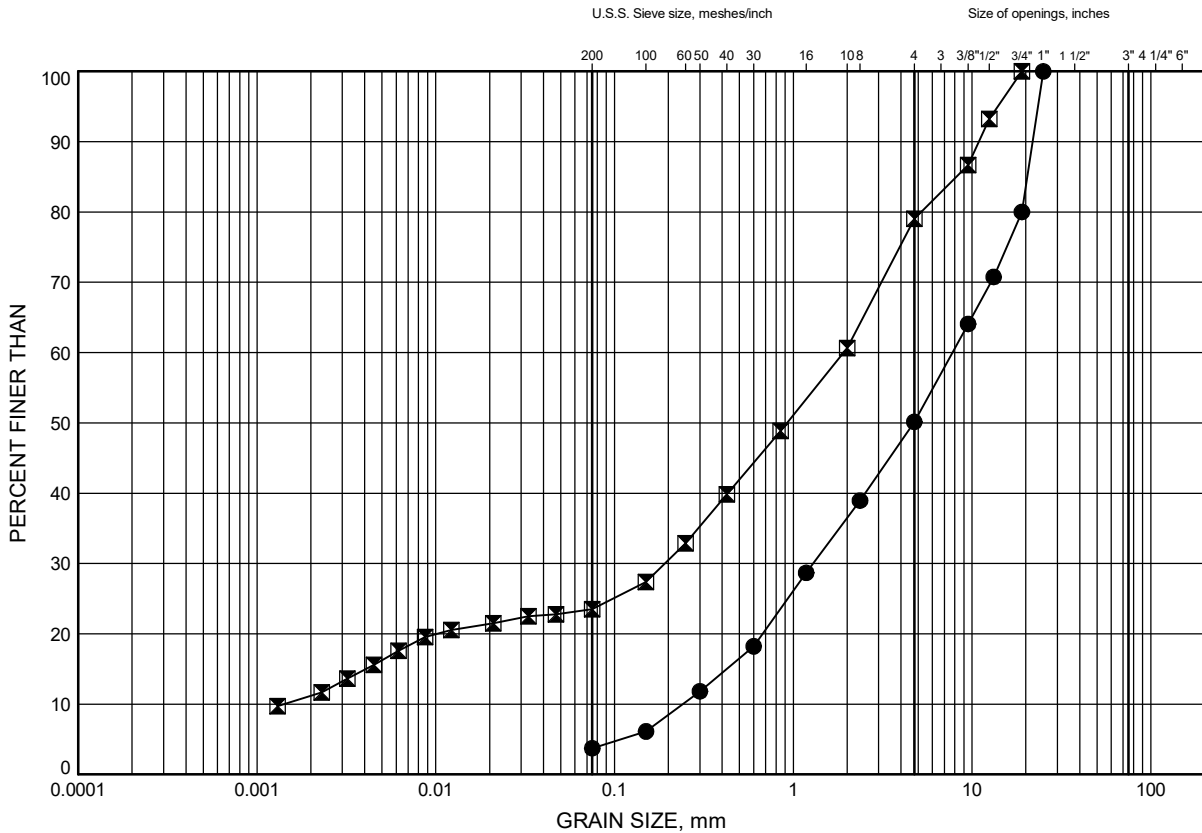
## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**

# Gullwing Creek Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1

## Sand and Gravel to Gravelly Sand Fill



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16-01    | 1.07      | 352.87    |
| ⊠      | 16-02    | 1.07      | 352.85    |

Date April 2017  
W.P. 2016-11032

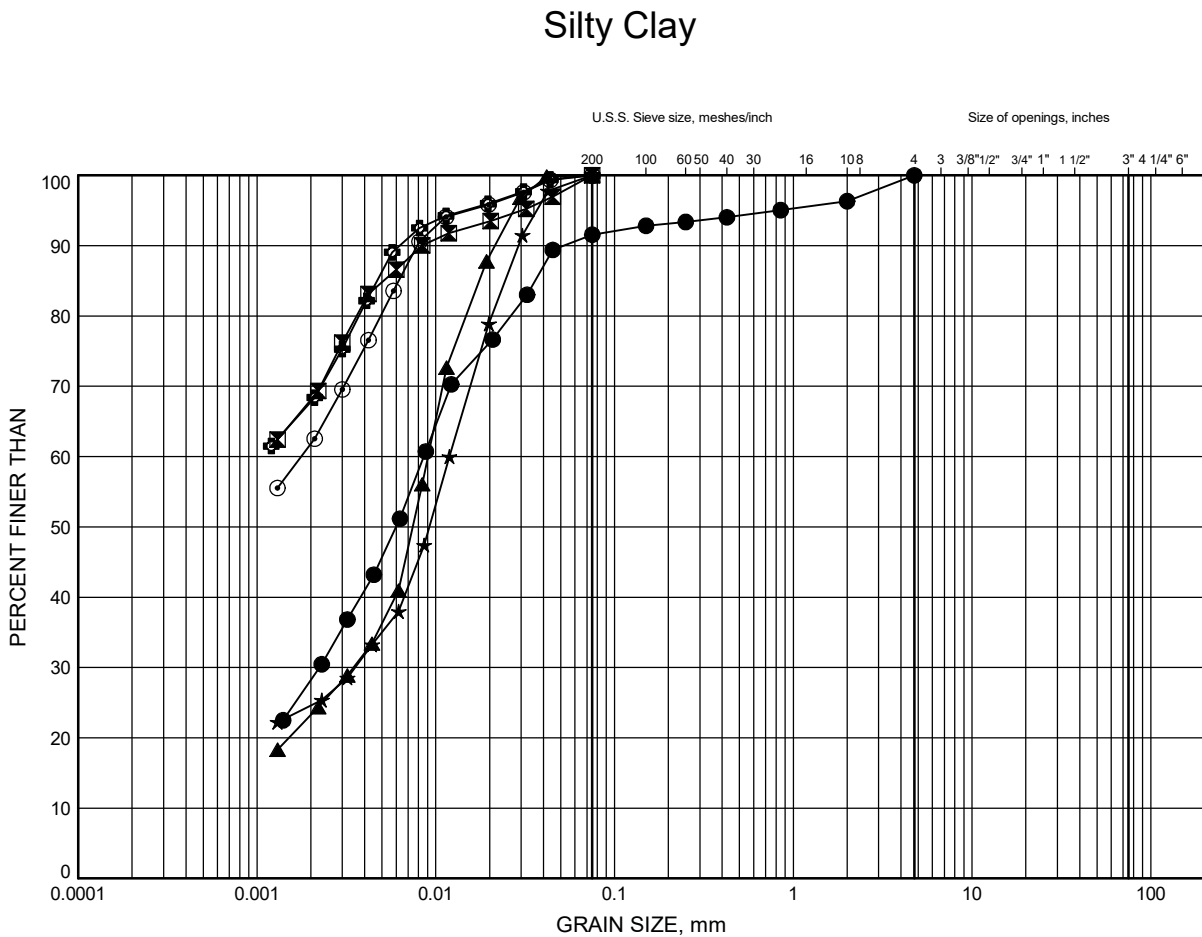


Prep'd MFA  
Chkd. AMP

# Gullwing Creek Bridge

## GRAIN SIZE DISTRIBUTION

FIGURE B2



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16-01    | 3.35      | 350.59    |
| ⊠      | 16-01    | 7.92      | 346.02    |
| ▲      | 16-01    | 18.59     | 335.35    |
| ★      | 16-01    | 27.74     | 326.20    |
| ⊙      | 16-02    | 3.35      | 350.56    |
| ⊕      | 16-02    | 7.92      | 345.99    |

Date April 2017  
W.P. 2016-11032

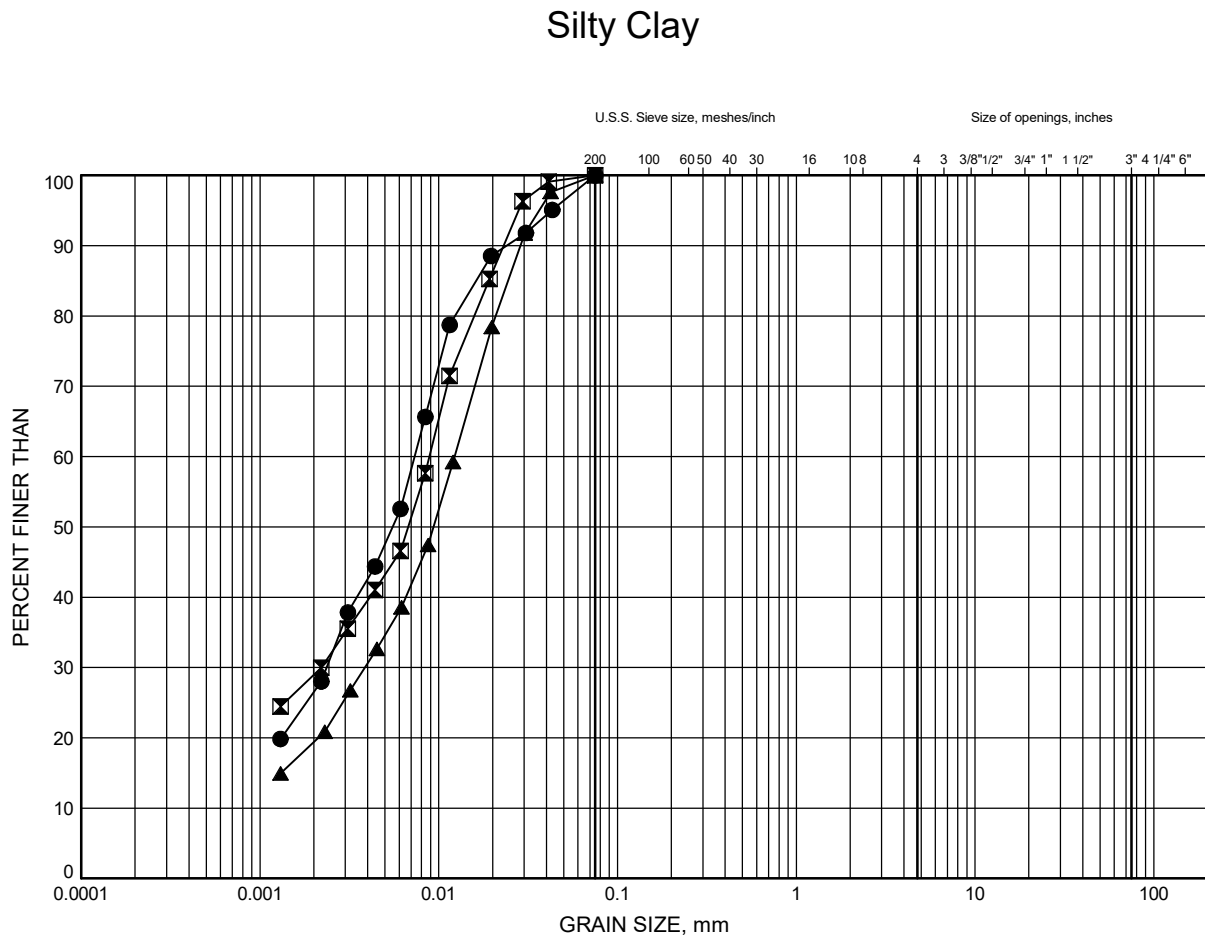


Prep'd MFA  
Chkd. AMP

# Gullwing Creek Bridge

## GRAIN SIZE DISTRIBUTION

FIGURE B3



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16-02    | 14.02     | 339.89    |
| ⊠      | 16-02    | 21.64     | 332.27    |
| ▲      | 16-02    | 30.78     | 323.13    |

Date April 2017  
W.P. 2016-11032

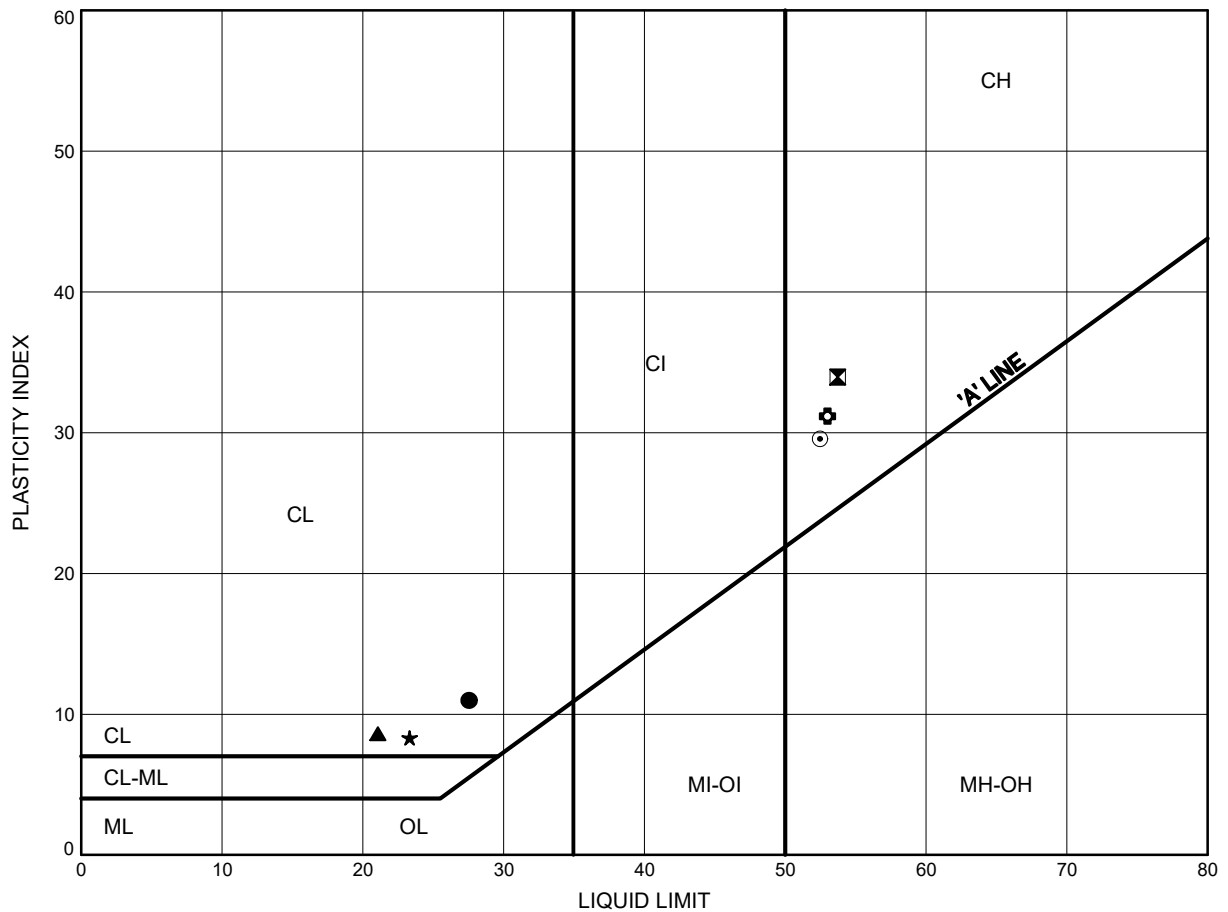


Prep'd MFA  
Chkd. AMP

Gullwing Creek Bridge  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B4

Silty CLAY



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16-01    | 3.35      | 350.59    |
| ⊠      | 16-01    | 7.92      | 346.02    |
| ▲      | 16-01    | 18.59     | 335.35    |
| ★      | 16-01    | 27.74     | 326.20    |
| ⊙      | 16-02    | 3.35      | 350.56    |
| ⊕      | 16-02    | 7.92      | 345.99    |

Date April 2017  
W.P. 2016-11032

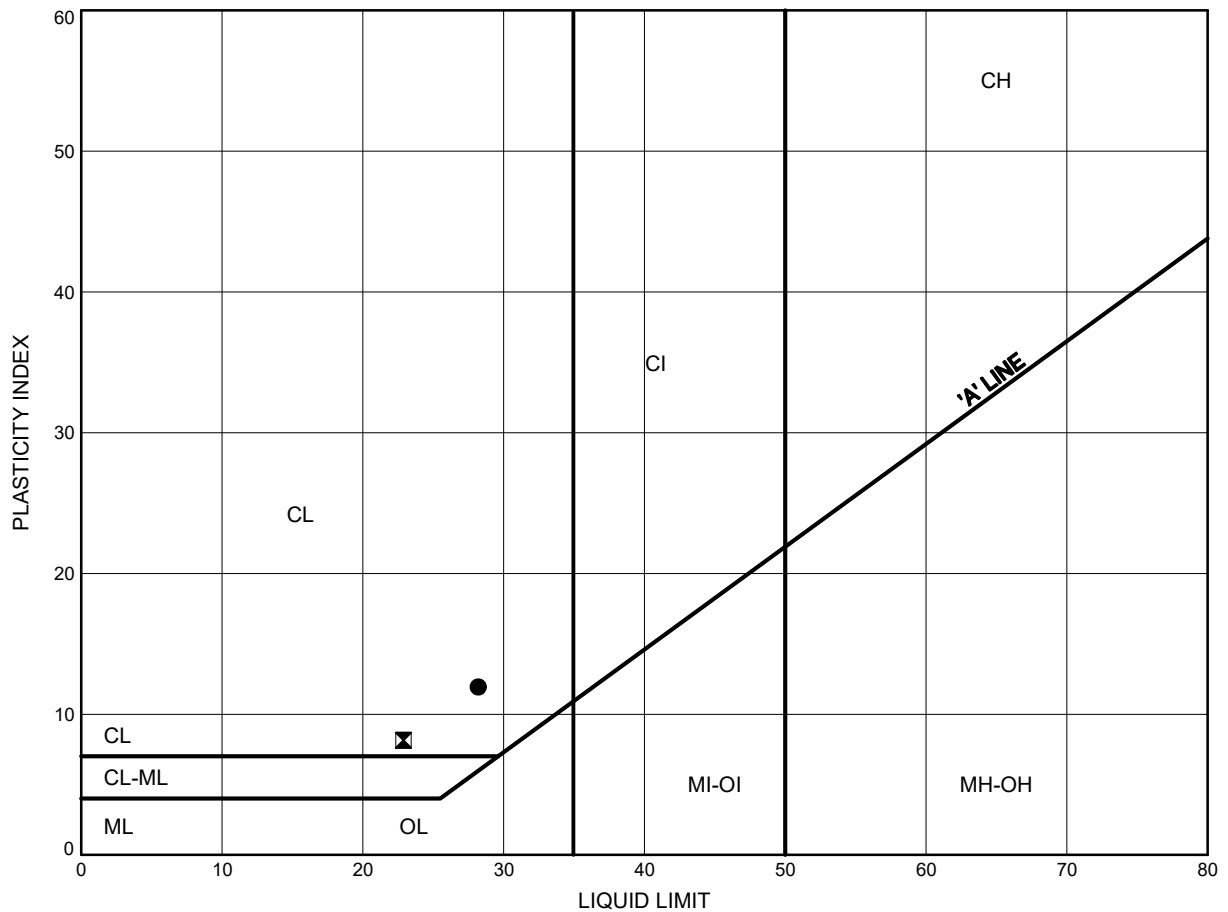


Prep'd AN  
Chkd. AMP

Gullwing Creek Bridge  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B5

Silty CLAY



**LEGEND**

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | 16-02    | 14.02     | 339.89    |
| ⊠      | 16-02    | 30.78     | 323.13    |

Date April 2017  
 W.P. 2016-11032



Prep'd AN  
 Chkd. AMP

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 14504****02-November-2016****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 228  
Fax:

**Date Rec. :** 27 October 2016  
**LR Report:** CA14590-OCT16  
**Reference:** 14504 Mark Farrant

**Copy: #1**


## CERTIFICATE OF ANALYSIS

### Final Report

| Analysis                           | 1:<br>Analysis Start<br>Date | 2:<br>Analysis Start<br>Time | 3:<br>Analysis<br>Approval Date | 4:<br>Analysis<br>Approval Time | 5:<br>BH-1, SS#3,<br>7.5'-9.5' |
|------------------------------------|------------------------------|------------------------------|---------------------------------|---------------------------------|--------------------------------|
| Sample Date & Time                 |                              |                              |                                 |                                 | 20-Oct-16                      |
| Temperature Upon Receipt [°C]      | ---                          | ---                          | ---                             | ---                             | 14.0                           |
| Corrosivity Index [none]           | 02-Nov-16                    | 16:55                        | 02-Nov-16                       | 16:55                           | 1                              |
| pH [no unit]                       | 31-Oct-16                    | 10:29                        | 01-Nov-16                       | 08:56                           | 6.37                           |
| Soil Redox Potential [mV]          | 28-Oct-16                    | 17:11                        | 31-Oct-16                       | 13:39                           | 270                            |
| Sulphide [%]                       | 31-Oct-16                    | 13:26                        | 31-Oct-16                       | 14:04                           | < 0.02                         |
| % Moisture (wet wt) [%]            | 28-Oct-16                    | 08:04                        | 31-Oct-16                       | 08:58                           | 23.9                           |
| pH [no unit]                       | 28-Oct-16                    | 07:54                        | 31-Oct-16                       | 08:49                           | 6.84                           |
| Chloride [µg/g]                    | 28-Oct-16                    | 20:20                        | 01-Nov-16                       | 11:12                           | 37                             |
| Sulphate [µg/g]                    | 28-Oct-16                    | 20:20                        | 01-Nov-16                       | 11:12                           | 18                             |
| Conductivity [uS/cm]               | 28-Oct-16                    | 07:54                        | 31-Oct-16                       | 08:49                           | 145                            |
| Resistivity (calculated) [Ohms.cm] | 02-Nov-16                    | 16:54                        | 02-Nov-16                       | 16:54                           | 6900                           |

Temperature of Samples upon receipt 14 degrees C  
Cooling agent present  
Custody Seal not present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

  
**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - KOL 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 14504**LR Report :** CA14590-OCT16

### Method Descriptions

| Parameter      | SGS Method Code           | Reference Method Code |
|----------------|---------------------------|-----------------------|
| Anions by IC   | ME-CA-[ENV]IC-LAK-AN-001  | EPA300/MA300-Ions1.3  |
| Carbon/Sulphur | ME-CA-[ENV]ARD-LAK-AN-020 | ASTM E1918            |
| Conductivity   | ME-CA-[ENV]EWL-LAK-AN-006 | SM 2510               |
| Metals Prep    | ME-CA-[ENV]ARD-LAK-AN-013 |                       |
| pH             | ME-CA-[ENV]EWL-LAK-AN-001 | SM 4500               |





**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 14504

**LR Report :** CA14590-OCT16

## Quality Control Report

| Inorganic Analysis                        |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
|---|-----------------|---------|--------------|--|-----|---------------------|--------------------|---------------------|------|-----------------------------------|---------------------|------|
| Parameter                                 | Reporting Limit | Unit    | Method Blank |  | RPD |                     | LCS / Spike Blank  |                     |      | Matrix Spike / Reference Material |                     |      |
|   |                 |         |              |  | RPD | Acceptance Criteria | Spike Recovery (%) | Recovery Limits (%) |      | Spike Recovery (%)                | Recovery Limits (%) |      |
|   |                 |         |              |  |     | %                   |                    | Low                 | High |                                   | Low                 | High |
| Anions by IC - QCBatchID: DI00421-OCT16   |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Chloride                                  | 0.4             | µg/g    | <0.4         |  | 1   | 20                  | 104                | 80                  | 120  | 103                               | 75                  | 125  |
| Sulphate                                  | 0.4             | µg/g    | <0.4         |  | 12  | 20                  | 98                 | 80                  | 120  | 100                               | 75                  | 125  |
| Carbon/Sulphur - QCBatchID: ECS0038-OCT16 |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Sulphide                                  | 0.02            | %       | <0.02        |  | NV  | 20                  | 102                | 80                  | 120  |                                   |                     |      |
| pH - QCBatchID: ARD0091-OCT16             |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| pH  | 0.05            | no unit |              |  | 0   | 20                  | 101                | 80                  | 120  |                                   |                     |      |

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - KOL 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 14504**

17-November-2016

**Thurber Engineering Ltd.**

Attn : Mark Farrant

103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 228  
Fax:

**Date Rec. :** 19 September 2016  
**LR Report:** CA13497-SEP16  
**Reference:** 14504 Mark Farrant

**Copy:** #1

## CERTIFICATE OF ANALYSIS


### Final Report

| Analysis                           | 1:<br>Analysis<br>Start Date | 2:<br>Analysis Start<br>Time | 3:<br>Analysis<br>Approval<br>Date | 4:<br>Analysis<br>Approval<br>Time | 5:<br>MDL | 6:<br>Gullwing Creek |
|------------------------------------|------------------------------|------------------------------|------------------------------------|------------------------------------|-----------|----------------------|
| Sample Date & Time                 |                              |                              |                                    |                                    |           | 13-Sep-16 11:00      |
| Temperature Upon Receipt [°C]      | ---                          | ---                          | --                                 | --                                 | ---       | 19.0                 |
| pH [no unit]                       | 20-Sep-16                    | 07:23                        | 21-Sep-16                          | 11:11                              | 0.05      | 7.96                 |
| Conductivity [µS/cm]               | 20-Sep-16                    | 07:23                        | 21-Sep-16                          | 11:11                              | 2         | 109                  |
| Resistivity (calculated) [Ohms.cm] | 21-Sep-16                    | 10:38                        |                                    |                                    | ---       | 917                  |
| Redox Potential [mV]               | 19-Sep-16                    | 16:42                        | 20-Sep-16                          | 10:53                              | ---       | 218                  |
| Chloride [mg/L]                    | 20-Sep-16                    | 07:42                        | 21-Sep-16                          | 10:05                              | 0.04      | 0.95                 |
| Sulphate [mg/L]                    | 20-Sep-16                    | 07:42                        | 21-Sep-16                          | 10:05                              | 0.04      | 1.8                  |
| Sulphide [mg/L]                    | 20-Sep-16                    | 15:10                        | 21-Sep-16                          | 09:09                              | 0.006     | 0.026                |
| Corrosivity Index [none]           | 21-Sep-16                    | 12:25                        | 21-Sep-16                          | 12:25                              |           | 14                   |

Temperature of samples upon receipt 19 degrees C  
Cooling Agent Present  
Custody Seal Present and Intact

Sulphide bottle received broken, solution from the general bottle containing zero headspace was used to fill a new Sulphide bottle.

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

  
Deanna Edwards, B.Sc, C.Chem  
Project Specialist  
Environmental Services, Analytical

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - KOL 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 14504****LR Report : CA13497-SEP16****Method Descriptions**

| Parameter       | SGS Method Code           | Reference Method Code |
|-----------------|---------------------------|-----------------------|
| Anions by IC    | ME-CA-[ENV]IC-LAK-AN-001  | EPA300/MA300-Ions1.3  |
| Conductivity    | ME-CA-[ENV]EWL-LAK-AN-006 | SM 2510               |
| pH              | ME-CA-[ENV]EWL-LAK-AN-006 | SM 4500               |
| Redox Potential |                           | SM 2580               |
| Sulphide by SFA | ME-CA-[ENV]SFA-LAK-AN-008 | SM 4500               |



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 14504

**LR Report :** CA13497-SEP16

## Quality Control Report

| Inorganic Analysis                         |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
|--|-----------------|---------|--------------|--|-----|---------------------|--------------------|---------------------|------|-----------------------------------|---------------------|------|
| Parameter                                  | Reporting Limit | Unit    | Method Blank |  |     |                     | LCS / Spike Blank  |                     |      | Matrix Spike / Reference Material |                     |      |
|  |                 |         |              |  | RPD | Acceptance Criteria | Spike Recovery (%) | Recovery Limits (%) |      | Spike Recovery (%)                | Recovery Limits (%) |      |
|  |                 |         |              |  |     | %                   |                    | Low                 | High |                                   | Low                 | High |
| Anions by IC - QCBatchID: DIO0257-SEP16    |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Chloride                                   | 0.04            | mg/L    | <0.04        |  | 4   | 20                  | 100                | 80                  | 120  | 104                               | 75                  | 125  |
| Sulphate                                   | 0.04            | mg/L    | <0.04        |  | 7   | 20                  | 95                 | 80                  | 120  | 103                               | 75                  | 125  |
| Conductivity - QCBatchID: EWL0255-SEP16    |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Conductivity                               | 2               | µS/cm   | < 2          |  | 0   | 10                  | 99                 | 90                  | 110  | NA                                |                     |      |
| pH - QCBatchID: EWL0255-SEP16              |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| pH   | 0.05            | no unit | NA           |  | 0   |                     | 100                |                     |      | NA                                |                     |      |
| Redox Potential - QCBatchID: EWL0252-SEP16 |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Redox Potential                            | no              | mV      | NA           |  | 9   | 20                  | 100                | 80                  | 120  | NA                                |                     |      |
| Sulphide by SFA - QCBatchID: SKA0140-SEP16 |                 |         |              |  |     |                     |                    |                     |      |                                   |                     |      |
| Sulphide                                   | 0.006           | mg/L    | <0.02        |  | ND  | 20                  | 95                 | 80                  | 120  | NV                                | 75                  | 125  |



## **Appendix C**

### **Selected Site Photographs**



Photograph 1 – Henderson Loop Road and Gullwing Creek Bridge; Looking West





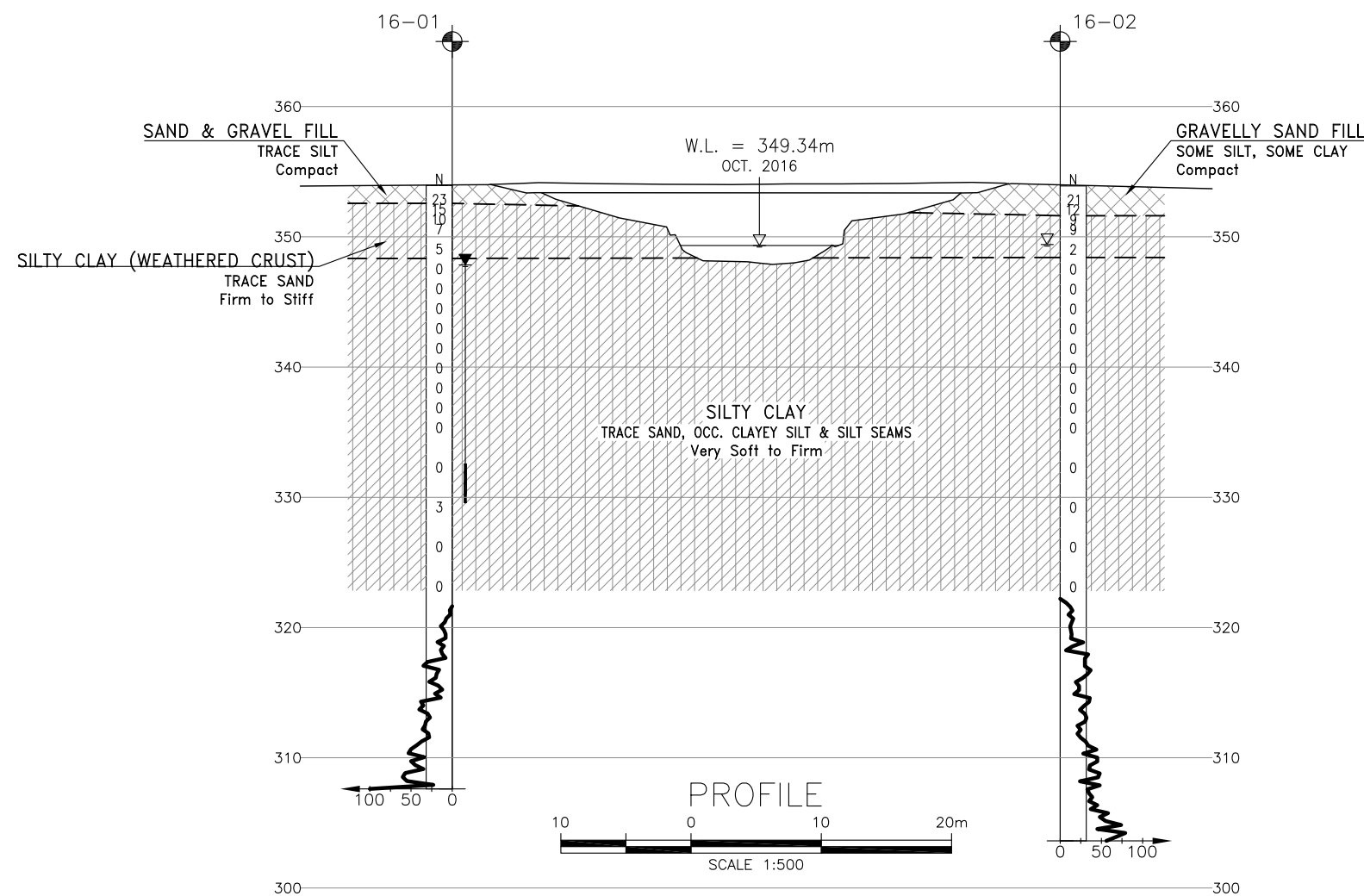
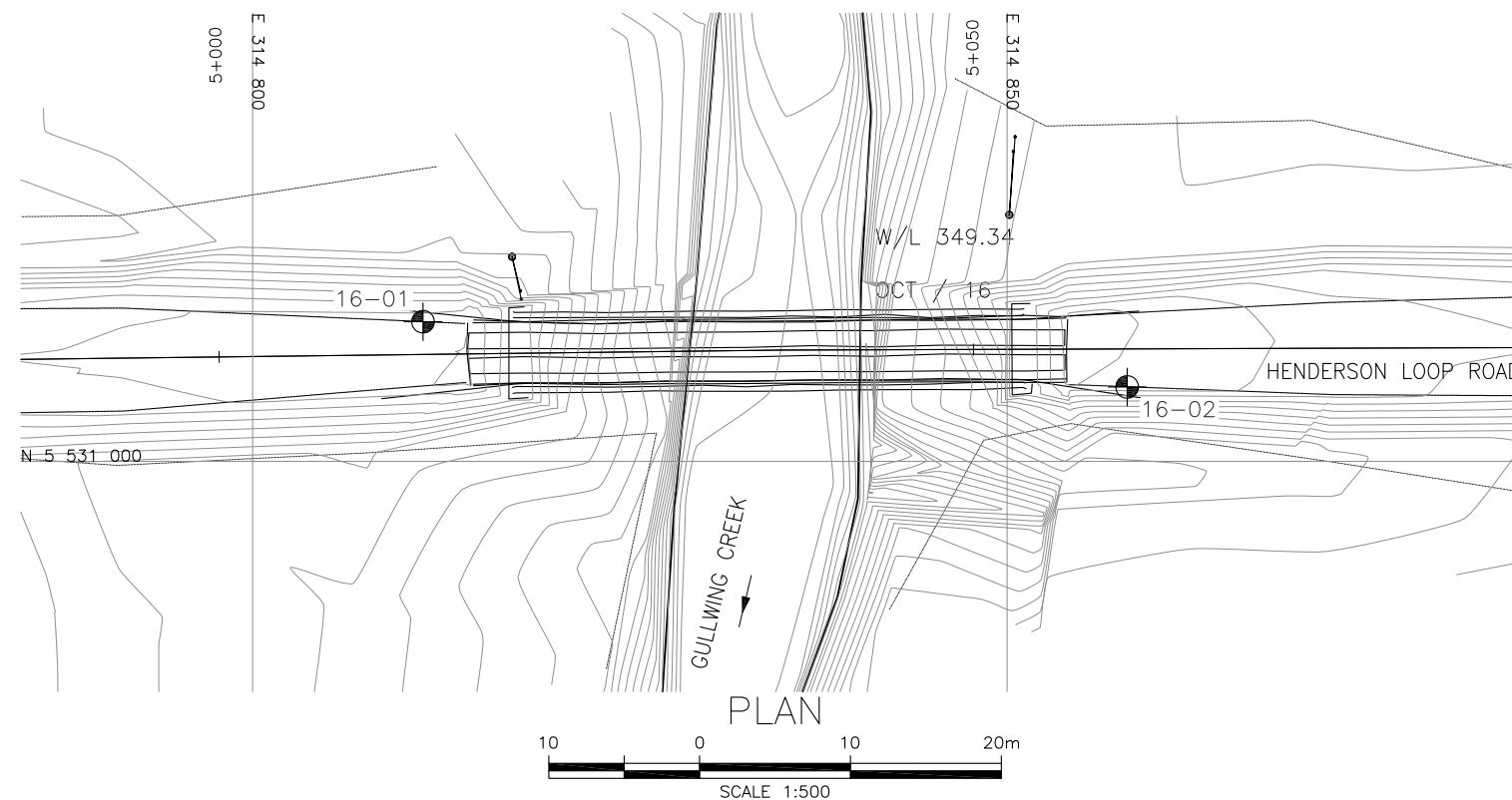
Photograph 2 – Gullwing Creek Bridge; Looking West



## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**





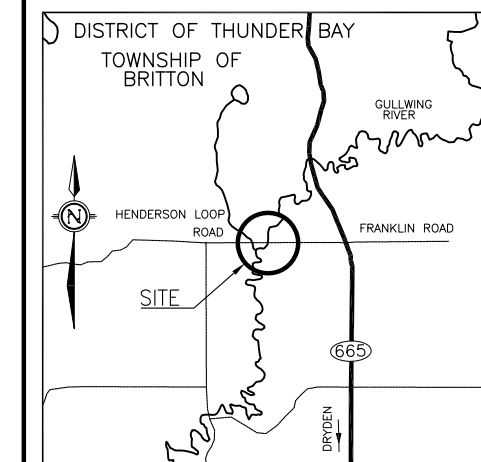
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
WP No 6113-15-00








SHEET  
7



## KEYPLAN

## LEGEND

|   |                                       |
|---|---------------------------------------|
|  | Borehole                              |
|  | Borehole and Cone                     |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure, Hydraulic                   |
|  | Water Level                           |
|  | Head Artesian Water                   |
|  | Piezometer                            |
| 90%   | Rock Quality Designation (RQD)        |
| A/R   | Auger Refusal                         |

| NO    | ELEVATION | NORTHING    | EASTING   |
|-------|-----------|-------------|-----------|
| 16-01 | 353.9     | 5 531 009.3 | 314 811.1 |
| 16-02 | 353.9     | 5 531 004.9 | 314 858.6 |

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) MTM Zone 16 co-ordinate system used to obtain Borehole Northings and Eastings.

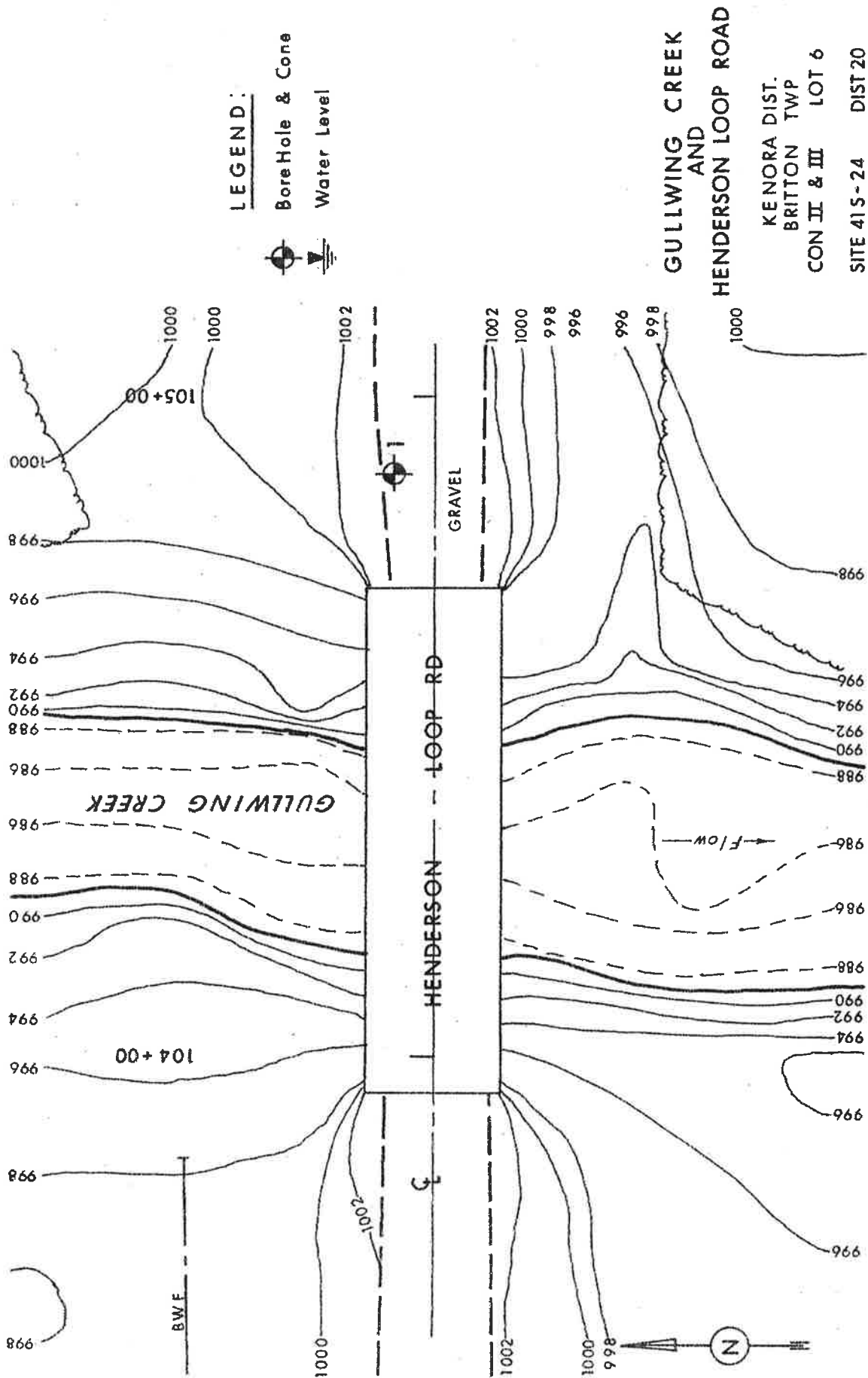
GEOCRES No. 52F-49

[illegible]



## **Appendix E**

**Record of Borehole Sheets and Borehole Location and Soil Strata Drawing  
Geocres No 52F-18**



KENORA DIST.  
BRITTON TWP  
CON II & III LOT 6  
SITE 41 S-24 DIST 20

WO 77 - 67009

Figure No 1

REF No E-5605-1; NOV 1977

## EXPLANATION OF TERMS USED IN REPORT

**'N' VALUE:** AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

**DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3):** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 LB-IMPACTS ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

**SOIL QUALITY:** SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

| $S_u$ (PSF) | 0 - 250   | 250 - 500 | 500 - 1000 | 1000 - 2000 | 2000 - 4000 | > 4000 |
|-------------|-----------|-----------|------------|-------------|-------------|--------|
|             | VERY SOFT | SOFT      | FIRM       | STIFF       | VERY STIFF  | HARD   |

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

| 'N' (BLOW/FT) | 0 - 5      | 5 - 10 | 10 - 30 | 30 - 50 | > 50       |
|---------------|------------|--------|---------|---------|------------|
|               | VERY LOOSE | LOOSE  | COMPACT | DENSE   | VERY DENSE |

**ROCK QUALITY:** ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

| RQD (%) | 0 - 25    | 25 - 50 | 50 - 75 | 75 - 90 | 90 - 100  |
|---------|-----------|---------|---------|---------|-----------|
|         | VERY POOR | POOR    | FAIR    | GOOD    | EXCELLENT |

**JOINTING AND BEDDING:**

| SPACING  | 2"         | 2" - 12" | 1' - 3'    | 3' - 10' | > 10'      |
|----------|------------|----------|------------|----------|------------|
| JOINTING | VERY CLOSE | CLOSE    | MOD. CLOSE | WIDE     | VERY WIDE  |
| BEDDING  | VERY THIN  | THIN     | MEDIUM     | THICK    | VERY THICK |

## ABBREVIATIONS & SYMBOLS




### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $CUU$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

### FIELD SAMPLING

S S SPLIT SPOON  
W S WASH SAMPLE  
S T SLOTTED TUBE SAMPLE  
B S BLOCK SAMPLE  
C S CHUCK SAMPLE  
T W THINWALL OPEN  
T P THINWALL PISTON  
O S OSTERBERG SAMPLE  
F S FOIL SAMPLE  
R C ROCK CORE  
P H T.W. ADVANCED HYDRAULICALLY  
P M T.W. ADVANCED MANUALLY

### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_a$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_p$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE   
 $w$  SLOPE ANGLE-BACKFACE OF WALL   
 $\beta$  ANGLE OF SLOPE   
 $N_q, N_c, N_{\gamma}$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_P$  PLASTIC LIMIT  
 $w_S$  SHRINKAGE LIMIT  
 $I_P$  PLASTICITY INDEX =  $w_L - w_P$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_P}{w_L - w_P}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_P}$   
 $A_c$  ACTIVITY =  $\frac{I_P \text{ of soil}}{I_P \text{ of } \mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

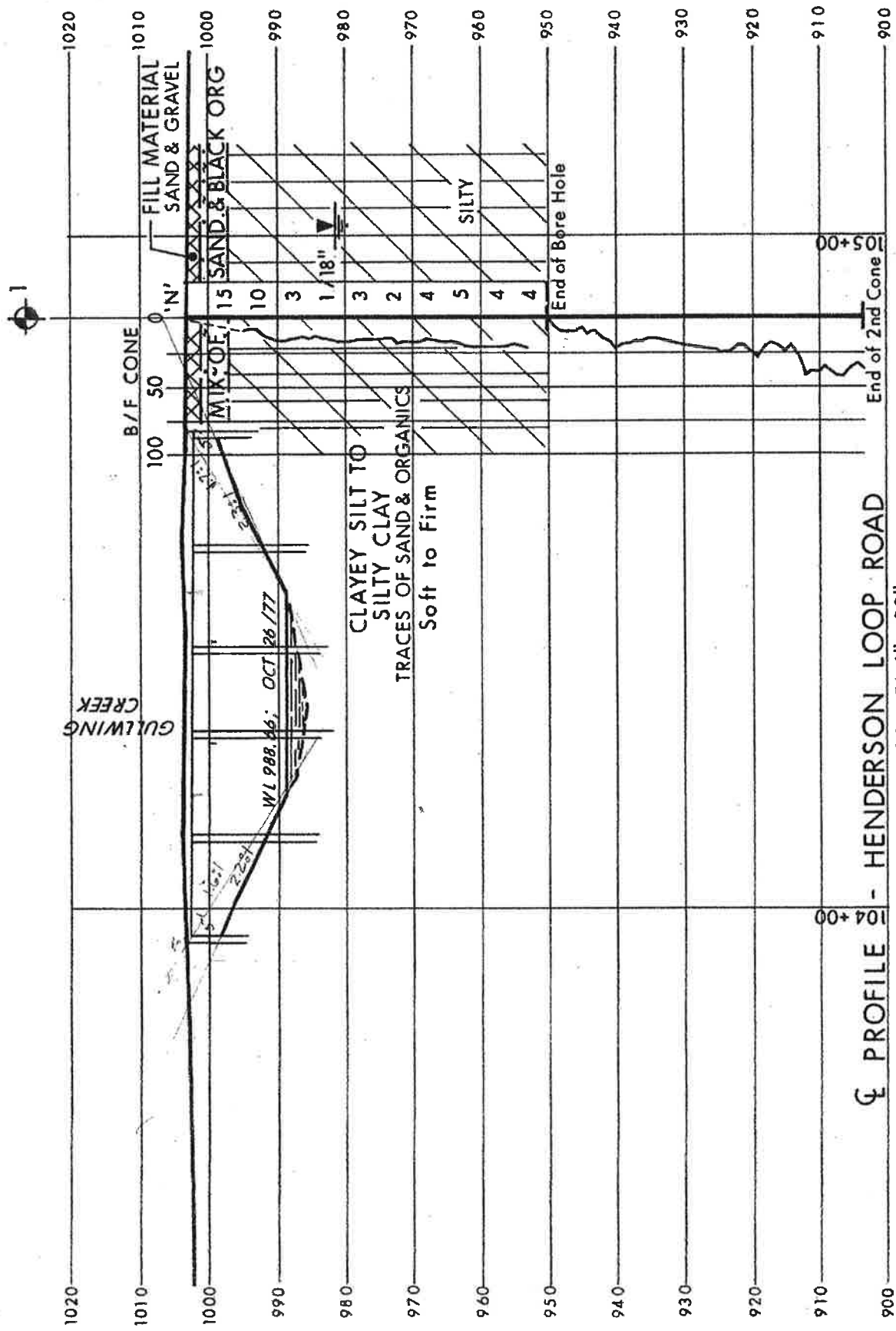
### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_n$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $\alpha_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)



SITE 41S-24 DIST 20  
WO 77-67009

Q PROFILE - HENDERSON LOOP ROAD

SCALE: 1" = 20"

Figure No 2

KENORA DIST, BRITTON TWP  
CON II & III LOT 6



# RECORD OF BOREHOLE No 1

WO 77-67009 LOCATION Sta. 104+88; o/s 6' Lt. & Henderson Loop Road ORIGINATED BY PP  
DIST 20 HWY Twp. Rd. BOREHOLE TYPE Continuous Flight Auger & Cone Tests COMPILED BY PP  
DATUM Assumed DATE February 12, 1978 CHECKED BY

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION<br>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>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |                    |                   |
|---------------|--|------------|---------|------|------------|----------------------------|--------------------|---|------------------------------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------|--|--------------------|-------------------|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | 'N' VALUES |                            |                    | 20 40 60 80 100                             |                                    |                                    |                                     |                                   |                     |  | SHEAR STRENGTH PSF | WATER CONTENT (%) |
|               |  |            |         |      |            |                            |                    | ○ UNCONFINED                                | + FIELD VANE                       |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            |         |      |            |                            |                    | ● QUICK TRIAXIAL    × LAB VANE              |                                    |                                    |                                     |                                   |                     |  |                    |                   |
| 1003.2        | Ground Level   |            |         |      |            |                            |                    | 200 400 600 800 1000                        |                                    | 15                                 | 30                                  | 45                                |                     |  |                    |                   |
| 0.0           | Sand & Gravel<br>Fill Material   |            |         |      |            |                            | 1000               |   | Frozen Zone<br>Pre-augered         |                                    |                                     |                                   | Org.<br>1.03%       |  |                    |                   |
| 2.0           | Mixture of Sand<br>997.2 & Black Organics                                    |            | 1       | SS   | 15         |                            |                    |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
| 6.0           | Clayey Silt to<br>Silty Clay.<br>Traces of Sand<br>and Organics              |            | 2       | SS   | 10         |                            | 990                |   | + S=6                              |                                    |                                     |                                   |                     | 0 0 41 59  |                    |                   |
|               | Soft to Firm   |            | 3       | SS   | 3          |                            |                    |   | + S=3                              |                                    |                                     |                                   |                     |  |                    |                   |
|               | Silty  |            | 4       | SS   | 1/18       |                            | 980                |   | + S=4                              |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            | 5       | SS   | 3          |                            |                    |   | + S=3                              |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            | 6       | SS   | 2          |                            | 972                |   | + S=6                              |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            | 7       | SS   | 4          |                            | 970                |   | + S=3                              |                                    |                                     |                                   |                     | 0 1 32 67  |                    |                   |
|               |  |            | 8       | SS   | 5          |                            | 960                |   | + S=3                              |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            | 9       | SS   | 4          |                            |                    |   | + S=3<br>End of First<br>Cone Test |                                    |                                     |                                   |                     |  |                    |                   |
| 950.2         |  |            | 10      | SS   | 4          |                            |                    |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
| 53.0          | End of Borehole  |            |         |      |            |                            | 950                |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            |         |      |            |                            | 940                |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            |         |      |            |                            | 930                |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            |         |      |            |                            | 920                |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
|               |  |            |         |      |            |                            | 910                |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
| 903.2         |  |            |         |      |            |                            |                    |   | End of Second<br>Cone Test         |                                    |                                     |                                   |                     |  |                    |                   |
| 100.0         | End of Cone Test   |            |         |      |            |                            |                    |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |
|               | Note: The Second<br>Cone Test Was<br>Advanced From The<br>Bottom of Borehole |            |         |      |            |                            |                    |   |                                    |                                    |                                     |                                   |                     |  |                    |                   |

Note: The Second  
Cone Test Was  
Advanced From The  
Bottom of Borehole