



**THURBER** ENGINEERING LTD.

**PRELIMINARY  
FOUNDATION INVESTIGATION REPORT  
HIGHWAY 17 TWINNING, RENFREW AREA  
LITTLE HALLIDAY CREEK TRIBUTARY CULVERTS  
STA.17+570 EBL AND WBL, HORTON TOWNSHIP  
SITE NO. 29X-0404/C0  
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F-227

Report to:

**Ministry of Transportation Ontario**

Latitude: 45.505544°  
Longitude: -76.675363°

July 2022  
Thurber File No.: 24726



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## **APPENDICES**

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**PART 1. FACTUAL INFORMATION**

## **1 INTRODUCTION**

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area.

This report addresses the unnamed Little Halliday Creek tributary crossing of Highway 17, located near Station 17+570 in Horton Township just west of Renfrew, Ontario. The existing Highway 17 alignment at this site will become the future Highway 17 westbound lanes and new eastbound lanes will be constructed to the southwest of the existing alignment. Rehabilitation or replacement of the culvert currently present under the existing Highway 17 lanes is proposed, while a new culvert will be required under the proposed eastbound lanes.

This section of the report presents the factual findings obtained from foundation investigations completed for the new and existing culvert structures at Station 17+570. Thurber carried out the investigation under Ministry of Transportation of Ontario (MTO) Assignment No. 4018-E-0009.

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

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.

## **2 SITE DESCRIPTION**

### **2.1 General**

The site is located on Highway 17 approximately one kilometre northwest of the existing intersection with Bruce Street. At the site, Highway 17 runs roughly north-south and the tributary



creek, east-west. However, the travelled lanes of Highway 17 will be described herein as eastbound and westbound to maintain continuity with convention of the overall highway.

The land adjacent to the site is generally flat-lying and consists of agricultural fields. Residential homes are located along Garden of Eden Road which runs roughly parallel to the existing highway, approximately 250 m west of the site. The terrain is relatively flat with a slight downward slope towards the tributary creek. Occasional trees and shrubs are present along the existing highway right-of-way and the tributary creek.

The existing Highway 17 in the vicinity of the site is an undivided highway with two travelled lanes and a westbound passing lane, gravel shoulders, and a posted speed limit of 90 km/hr. The AADT for this existing section of Highway 17 near the site had a reported AADT of 12,300 in 2016.

The existing culvert present beneath Highway 17 is a 1.8 m diameter, 33.7 m long corrugated steel pipe (CSP) culvert and has about 2.6 m of cover. The culvert facilitates the flow of the tributary creek under the highway embankment from east to west where it meets Little Halliday Creek. The existing culvert has an invert elevation of approximately 146.3 m. It is noted that the tributary runs in a small, incised valley which was noted to be approximately 1.0 m wide. The depth of water in the creek was approximately 0.2 m on April 27, 2021.

The embankment sides are sloped at approximately 2.5H:1V and did not show any visible signs of distress at the time of the investigation.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix D for reference.

## **2.2 Site Geology**

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.

Ontario Geological Survey Map 2460 for Precambrian Geology for the Cobden Area suggests the bedrock comprises calcitic carbonate metasedimentary bedrock including calcitic and siliceous marble.

## **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation was carried out between April 27, 2021 and May 14, 2021, as part of an overall field-testing program to address several project structures. The field investigation consisted of advancing four boreholes identified as Boreholes CV-1, CV-2, CV-3, and CV-28. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.



The locations and elevations of the boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1 below. The site is located within MTM Zone 9.

**Table 3-1: Borehole Summary**

| <b>Borehole No.</b> | <b>Drilled Location</b>   | <b>Northing (Latitude)</b> | <b>Easting (Longitude)</b> | <b>Ground Surface Elevation (m)</b> | <b>Termination Depth (m)</b> |
|---------------------|---|----------------------------|----------------------------|-------------------------------------|------------------------------|
| CV-1                | Proposed Eastbound Lanes Culvert Outlet   | 5 040 609.4<br>(45.505270) | 291 050.3<br>(-76.675956)  | 146.8                               | 11.9                         |
| CV-2                | Proposed Eastbound Lanes Embankment   | 5 040 622.6<br>(45.505389) | 291 062.8<br>(-76.675796)  | 146.8                               | 11.9                         |
| CV-3                | Proposed Westbound Lanes Culvert Outlet /<br>Proposed Eastbound Lanes Culvert Inlet | 5 040 631.1<br>(45.505466) | 291 074.8<br>(-76.675642)  | 146.9                               | 11.9                         |
| CV-28               | Proposed Westbound Lanes Culvert Inlet<br>(Existing Hwy 17)                         | 5 040 650.8<br>(45.505644) | 291 113.9<br>(-76.675142)  | 147.0                               | 5.8                          |

A track-mounted CME 45 drill rig equipped with hollow stem augers was used to put down the boreholes at the site.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was completed in cohesive soils with an MTO 'N' sized vane.

Monitoring wells, 50 mm in diameter, were installed in Boreholes CV-1 and CV-28. The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B. The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended). The monitoring wells will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

In addition, four pavement boreholes were advanced through the existing highway embankment nearby at Station 17+600 to depths ranging from 1.5 m to 2.1 m. The boreholes were drilled with a solid stem auger and representative samples acquired from the augers. In situ vane shear tests were carried out in cohesive deposits.



The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's geotechnical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

#### **4 LABORATORY TESTING**

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to testing for grain size distribution and, where, appropriate, Atterberg Limits in accordance with MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on a sample of the soil.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

#### **5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Cohesive soils are described per current MTO protocols.

In general, the site stratigraphy consists of embankment fill over native deposits of silty clay to clayey silt, weathered to a crust in the upper several metres. Topsoil was encountered at the ground surface at all off-road borehole locations. All boreholes were terminated in the silty clay to clayey silt deposit.

##### **5.1 Embankment Material**

An asphalt layer ranging in thickness from 220 mm to 360 mm was encountered at ground surface in three of the four pavement boreholes drilled at 17+600. Granular fill was observed in all four boreholes and extended to depths ranging from 0.9 m to 1.5 m below ground surface. The granular fill ranged from silty gravel with sand to poorly graded sand.

The moisture content of the two samples tested was 5% and 6%. The results of grain size analyses conducted on two samples of the embankment fill are summarized below.

### Summary of Grain Size Distribution Testing – Embankment Fill

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 5 to 44        |
| Sand          | 43 to 91       |
| Silt and Clay | 4 to 13        |

## 5.2 Topsoil

A layer of topsoil was encountered at the ground surface in all boreholes. It is noted that the boreholes were put down adjacent to farmland and the extent of the topsoil may reflect the depth of the tilled layer. The topsoil was observed to range in thickness from 300 mm, in the boreholes put down west of the existing Highway 17 alignment, to 610 mm, in Borehole CV-28 put down east of the existing Highway 17 alignment. One complete sample of topsoil obtained in Borehole CV-28 had a natural moisture content of 52%.

## 5.3 Weathered Silty Clay (CI) Crust

A deposit of silty clay weathered to a grey-brown crust was identified below the topsoil in Boreholes CV-1, CV-2, and CV-3 and three of the pavement boreholes. The thickness of this layer ranged from 1.2 m to 2.0 m with base depths ranging from 1.5 m to 2.3 m (base elevations ranging from 144.5 m to 145.4 m).

SPT N-values ranged from 2 to 3 blows per 0.3 m of penetration, indicating a stiff consistency.

The moisture content of the samples tested ranges from 32% to 59%. The results of grain size analyses conducted on three samples of the weathered silty clay crust are summarized below and two from the foundations boreholes are illustrated on Figure C1 in Appendix C.

### Summary of Grain Size Distribution Testing – Weathered Silty Clay Crust

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 0              |
| Sand          | 0 – 9          |
| Silt          | 24 – 48        |
| Clay          | 44 – 67        |

The results of Atterberg Limits testing carried out on three samples of this material are summarized below and two from the foundations boreholes are illustrated on Figure C4 in Appendix C. The laboratory results indicate that the material is a silty clay of intermediate plasticity (CI).



#### Summary of Atterberg Limit Testing – Weathered Silty Clay Crust

| Parameter        | Value   |
|------------------|---------|
| Liquid Limit     | 43 – 50 |
| Plastic Limit    | 18 – 21 |
| Plasticity Index | 25 – 29 |

#### 5.4 Silty Clay (CI) to Clayey Silt (CL)

Unweathered silty clay to clayey silt was encountered below the weathered crust in Boreholes CV-1, CV-2, and CV-3, and below the topsoil in Borehole CV-28. All boreholes were terminated in this deposit at base depths ranging from 5.8 m to 11.9 m (base elevations ranging from 134.9 m to 141.2 m). Sand partings were noted throughout this layer in Boreholes CV-1, CV-2, and CV-3.

SPTs conducted in this unit gave N-values ranging from weight of hammer to 3 blows per 0.3 m of penetration. In-situ shear vane tests indicated undrained shear strengths decreasing with increasing depth, ranging from greater than 100 to 41 kPa indicating a very stiff to firm consistency. Sensitivity values ranged from 4 to 18 but were generally between about 5 and 10.

The moisture content of the samples tested ranged from 26 to 52%. The results of nine grain size analysis tests conducted on samples of this material are summarized below and are illustrated on Figures C2 and C3 in Appendix C.

#### Summary of Grain Size Distribution Testing – Silty Clay to Clayey Silt

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 0              |
| Sand          | 0 – 3          |
| Silt          | 44 – 60        |
| Clay          | 40 – 56        |

The results of Atterberg Limits testing carried out on five samples of this material are summarized below and are illustrated on Figure C5 in Appendix C. The laboratory results generally indicate that the material is a silty clay of intermediate plasticity (CI), with one test indicating a clayey silt of low plasticity (CL).

#### Summary of Atterberg Limit Testing – Silty Clay to Clayey Silt

| Parameter        | Value   |
|------------------|---------|
| Liquid Limit     | 25 – 47 |
| Plastic Limit    | 17 – 22 |
| Plasticity Index | 8 – 28  |

## 5.5 Groundwater

Monitoring wells with diameters of 50 mm were installed in Boreholes CV-1 and CV-28. Groundwater levels recorded in the wells are presented in Table 5-1 below:

**Table 5-1: Summary of Groundwater Levels**

| Borehole No. | Bottom of Screen Elevation (m) | Groundwater Depth (m) | Groundwater Elevation (m) | Date of Measurement |
|--------------|--------------------------------|-----------------------|---------------------------|---------------------|
| CV-1         | 142.2                          | 0.3                   | 146.5                     | August 4, 2021      |
|              |                                | 0.3                   | 146.5                     | September 22, 2021  |
|              |                                | 0.4                   | 146.4                     | October 5, 2021     |
|              |                                | 0.4                   | 146.4                     | October 22, 2021    |
|              |                                | 0.6                   | 146.2                     | January 19, 2022    |
| CV-28        | 142.4                          | 0.1                   | 146.9                     | August 4, 2021      |
|              |                                | 0.1                   | 146.9                     | September 22, 2021  |
|              |                                | 0                     | 147.0                     | October 5, 2021     |
|              |                                | 0.3                   | 146.7                     | January 19, 2022    |

The creek water elevation was noted to be approximately 146.4 m on April 27, 2021.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may be different and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

## 5.6 Analytical Testing

One sample of the native silty clay was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in Table 5-2. Copies of the test results are provided in Appendix C.

**Table 5-2: Results of Chemical Analysis**

| Borehole | Sample | Depth (m) | Chloride (µg/g) | Sulphate (µg/g) | Sulphide (%) | pH (-) | Resistivity (Ohm-cm) |
|----------|--------|-----------|-----------------|-----------------|--------------|--------|----------------------|
| CV-2     | SS2    | 0.8 – 1.4 | 192             | 30              | < 0.04       | 7.66   | 2,140                |



## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Marathon Underground of Greely, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, monitoring well installation and borehole decommissioning. The field investigation was supervised on a full-time basis by Anderson de Oliveira of Thurber. Overall supervision of the investigation program was provided by Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Matt Kennedy, P.Eng. and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Matt Kennedy, M.Sc.(Eng.), P.Eng.  
Senior Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.  
Senior Geotechnical Engineer,  
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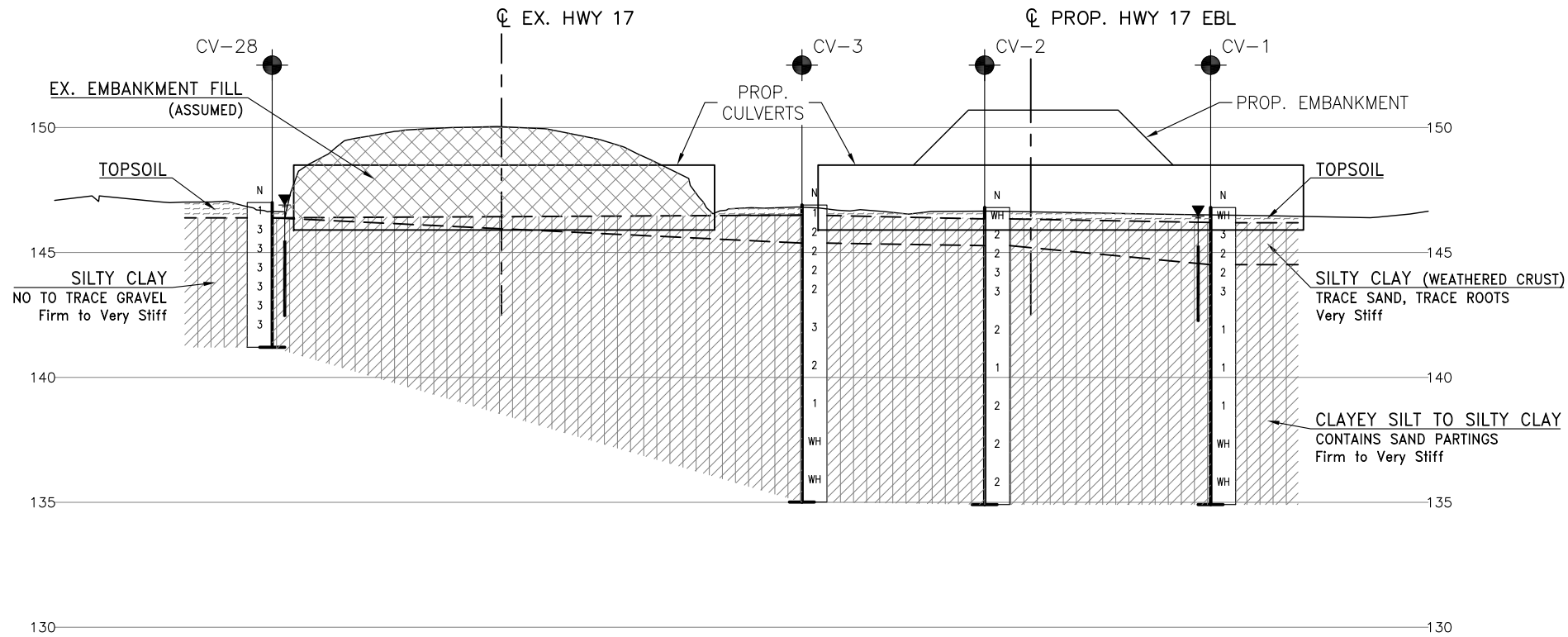
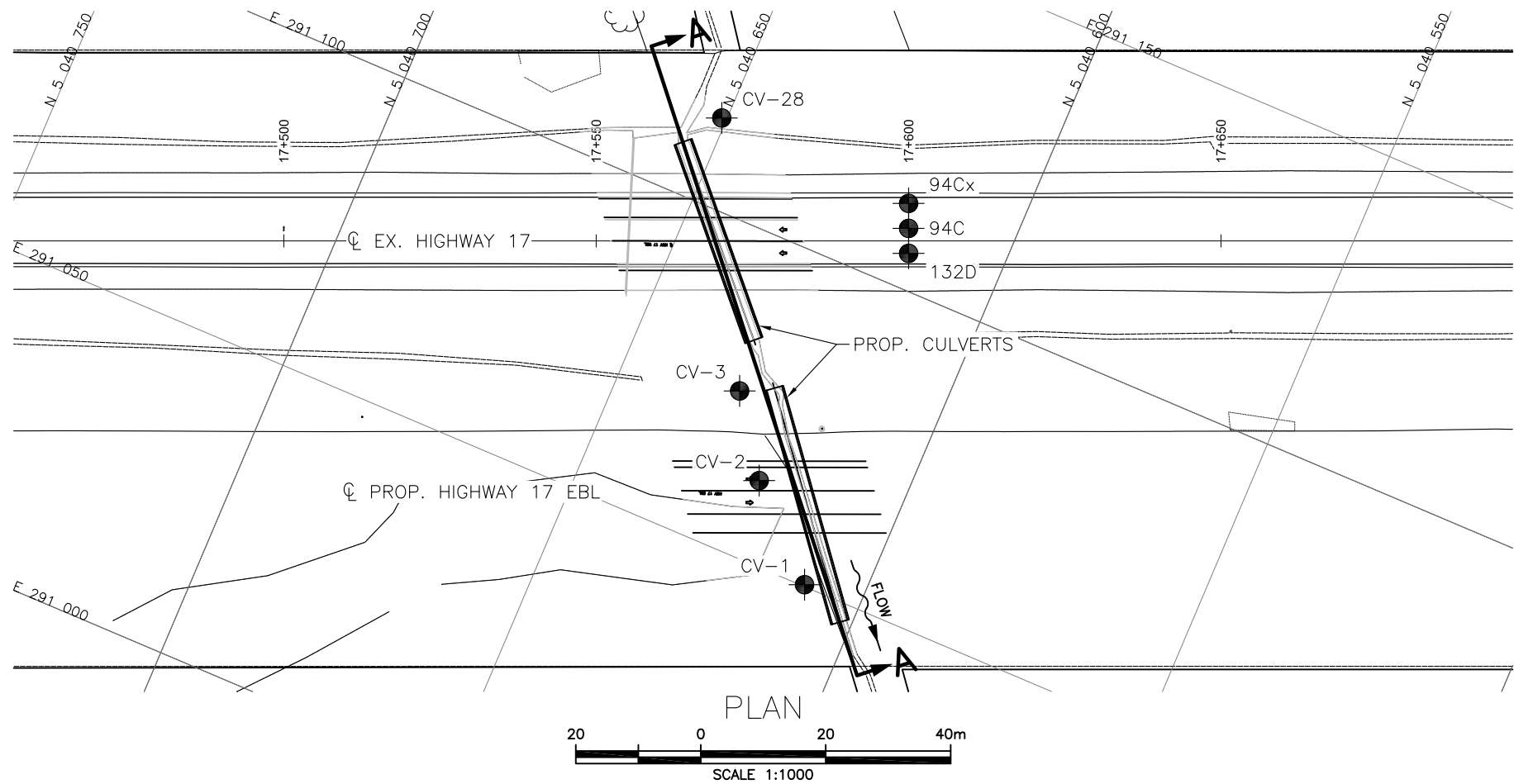


Dr. P.K. Chatterji, P.Eng.  
MTO Review Principal,  
Senior Geotechnical Engineer



## **Appendix A.**

### **Borehole Location Plan and Stratigraphic Drawings**



SECTION ALONG A-A



H 1:500

V 1:250

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

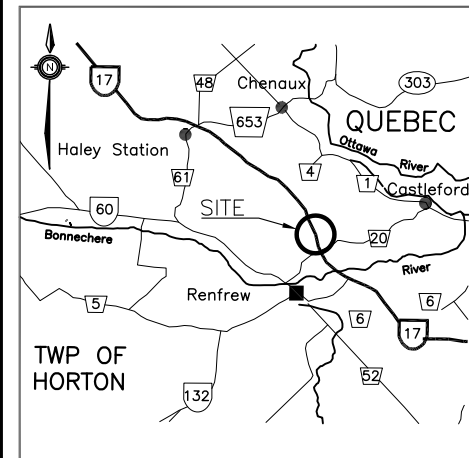


CONT No  
WP No

HIGHWAY 17 TWINNING  
CULVERT STA. 17+570

BOREHOLE LOCATIONS AND SOIL STRATA

Ontario



KEYPLAN

LEGEND

|      |                                       |
|------|---------------------------------------|
| ●    | Borehole                              |
| 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   |
|-------|-----------|-------------|-----------|
| CV-1  | 146.8     | 5 040 609.4 | 291 050.3 |
| CV-2  | 146.8     | 5 040 622.6 | 291 062.8 |
| CV-28 | 147.0     | 5 040 650.8 | 291 113.9 |
| CV-3  | 146.9     | 5 040 631.1 | 291 074.8 |
| 132D  | 149.7     | 5 040 614.8 | 291 105.6 |
| 94C   | 149.7     | 5 040 616.4 | 291 109.3 |
| 94Cx  | 149.7     | 5 040 617.9 | 291 113.0 |

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Structural elements, surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F-227

| REVISIONS | DATE   | BY   | DESCRIPTION |
|-----------|--------|------|-------------|
| DESIGN    | MJK    | CHK  | PKC         |
| DRAWN     | MFA    | CHK  | MJK         |
| CODE      | LOAD   | DATE | JUL 2022    |
| SITE      | STRUCT | DWG  | 1           |



## **Appendix B.**

### **Record of Borehole Sheets**



## SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

### TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

|         |  |
|---------|--|
| Topsoil | mixture of soil and humus capable of supporting vegetative growth                              |
| Peat    | mixture of fragments of decayed organic matter   |
| Till    | unstratified glacial deposit which may include particles ranging in sizes from clay to boulder |
| Fill    | material below the surface identified as placed by humans (excluding buried services)          |

### TERMINOLOGY DESCRIBING SOIL STRUCTURE:

|            |   |
|------------|---|
| Desiccated | having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc. |
| Fissured   | having cracks, and hence a blocky structure   |
| Varved     | composed of alternating layers of silt and clay   |
| Stratified | composed of alternating successions of different soil types, e.g. silt and sand             |
| Layer      | > 75 mm in thickness  |
| Seam       | 2 mm to 75 mm in thickness  |
| Parting    | < 2 mm in thickness   |

### RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

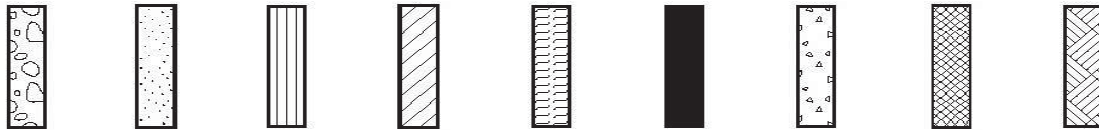
### DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



### STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders  
Cobbles  
Gravel      Sand      Silt      Clay      Organics      Asphalt      Concrete      Fill      Bedrock

### TEXTURING CLASSIFICATION OF SOILS

| Classification | Particle Size       |
|----------------|---------------------|
| Boulders       | Greater than 200 mm |
| Cobbles        | 75 – 200 mm         |
| Gravel         | 4.75 – 75 mm        |
| Sand           | 0.075 – 4.75 mm     |
| Silt           | 0.002 – 0.075 mm    |
| Clay           | Less than 0.002 mm  |

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

### SAMPLE TYPES

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

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

| Descriptive Term | SPT “N” Value   |
|------------------|-----------------|
| Very Loose       | Less than 4     |
| Loose            | 4 – 10          |
| Compact          | 10 – 30         |
| Dense            | 30 – 50         |
| Very Dense       | Greater than 50 |



### MODIFIED UNIFIED SOIL CLASSIFICATION

| Major Divisions      |  | Group Symbol | Typical Description  |
|----------------------|--|--------------|--|
| COARSE GRAINED SOIL  | GRAVEL AND GRAVELLY SOILS                  | GW           | Well-graded gravels or gravel-sand mixtures, little or no fines.   |
|                      |  | GP           | Poorly-graded gravels or gravel-sand mixtures, little or no fines.   |
|                      |  | GM           | Silty gravels, gravel-sand-silt mixtures.  |
|                      |  | GC           | Clayey gravels, gravel-sand-clay mixtures.   |
|                      | SAND AND SANDY SOILS                       | SW           | Well-graded sands or gravelly sands, little or no fines.   |
|                      |  | SP           | Poorly-graded sands or gravelly sands, little or no fines.   |
|                      |  | SM           | Silty sands, sand-silt mixtures.   |
|                      |  | SC           | Clayey sands, sand-clay mixtures.  |
| FINE GRAINED SOILS   | SILT AND CLAY SOILS<br>$W_L < 35\%$        | ML           | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
|                      |  | CL           | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.               |
|                      |  | OL           | Organic silts and organic silty-clays of low plasticity.   |
|                      | SILT AND CLAY SOILS<br>$35\% < W_L < 50\%$ | MI           | Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.                             |
|                      |  | CI           | Inorganic clays of medium plasticity, silty clays.   |
|                      |  | OI           | Organic silty clays of medium plasticity.  |
|                      | SILT AND CLAY SOILS<br>$W_L > 50\%$        | MH           | Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.                             |
|                      |  | CH           | Inorganic clays of high plasticity, fat clays.   |
|                      |  | OH           | Organic clays of high plasticity, organic silts.   |
| HIGHLY ORGANIC SOILS |  | Pt           | Peat and other organic soils.  |

Note -  $W_L$  = Liquid Limit



## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

|                           |  |
|---------------------------|--|
| Fresh (FR)                | No visible signs of weathering.  |
| Fresh Jointed (FJ)        | Weathering limited to surface of major discontinuities.  |
| Slightly Weathered (SW)   | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials. |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable.                             |
| Highly Weathered (HW)     | Weathering extends throughout the rock mass and the rock is partly friable.                                    |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.       |

### TERMS

|  |  |
|--|--|
| Total Core Recovery: (TCR)             | Core recovered as a percentage of total core run length.   |
| Solid Core Recovery: (SCR)             | Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. |
| Rock Quality Designation: (RQD)        | Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length           |
| Unconfined Compressive Strength: (UCS) | Axial stress required to break the specimen.   |
| Fracture Index: (FI)                   | Frequency of natural fractures per 0.3 m of core run.  |

### DISCONTINUITY SPACING

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

### STRENGTH CLASSIFICATION

| Rock Strength    | Approximate Uniaxial Compressive Strength (MPa) |
|------------------|---|
| Extremely Strong | Greater than 250                                |
| Very Strong      | 100 – 250                                       |
| Strong           | 50 – 100  |
| Medium Strong    | 25 – 50   |
| Weak             | 5 – 25  |
| Very Weak        | 1 – 5   |
| Extremely Weak   | 0.25 – 1  |

# RECORD OF BOREHOLE No CV-1

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.50527°, Long: -76.675956°  
Culvert 17+570 MTM Zone 9: N 5 040 609.4 E 291 050.3 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.05.13 - 2021.05.14 CHECKED BY FG

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  | PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT |  | UNIT<br>WEIGHT<br><br>γ | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--|---|--|-------------------------|---|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  | W <sub>p</sub> W                      W <sub>L</sub>    |  |                         |   |
| 146.8         | Ground Surface  |            |         |      |            |                            |                 | 20   40   60   80   100                     |  |   |  |                         |   |
| 0.0           | TOP SOIL (300 mm)   |            |         |      |            |                            |                 | ○ UNCONFINED      + FIELD VANE              |  |   |  |                         |   |
| 146.5         |   |            | 1       | SS   | WH         |                            |                 | ● QUICK TRIAXIAL    × LAB VANE              |  |   |  |                         |   |
| 0.3           | <b>SILTY CLAY</b><br>Trace roots<br>Grey-brown with yellow mottles<br>Very stiff<br>Homogeneous structure<br><b>[WEATHERED CRUST]</b> |            | 2       | SS   | 3          |                            | 146             |   |  |   |  |                         | 0   0   48   52                                   |
|               |   |            | 3       | SS   | 2          |                            | 145             |   |  |   |  |                         |   |
|               |   |            | 4       | SS   | 2          |                            | 144             |   |  |   |  |                         |   |
|               |   |            | 5       | SS   | 3          |                            | 143             |   |  |   |  |                         | 0   3   55   42                                   |
|               |   |            | 6       | SS   | 1          |                            | 142             |   |  |   |  |                         |   |
|               |   |            | 7       | SS   | 1          |                            | 141             |   |  |   |  |                         |   |
|               |   |            | 8       | SS   | 1          |                            | 140             |   |  |   |  |                         |   |
|               |   |            | 9       | SS   | WH         |                            | 139             |   |  |   |  |                         | 0   0   48   52                                   |
|               |   |            |         |      |            |                            | 138             |   |  |   |  |                         |   |
|               |   |            |         |      |            |                            | 137             |   |  |   |  |                         |   |

Continued Next Page

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

# RECORD OF BOREHOLE No CV-1

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.50527°, Long: -76.675956°  
Culvert 17+570 MTM Zone 9: N 5 040 609.4 E 291 050.3 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.05.13 - 2021.05.14 CHECKED BY FG

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT                                    |  |  | PLASTIC<br>LIMIT<br><br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br><br>W | LIQUID<br>LIMIT<br><br>W <sub>L</sub> | 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<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |  |  |   |                                       |   |  |
|               | Continued From Previous Page   |            |         |      |            |                            |                 | 20 40 60 80 100  |  |  |  |   |                                       |   |  |
| 134.9         | <b>CLAYEY SILT to SILTY CLAY</b><br>Contains sand partings<br>Grey-brown to grey<br>Firm to very stiff<br>Homogeneous structure  |            |         |      |            |                            |                 |  |  |  |  |   |                                       |   |  |
|               |  |            | 10      | SS   | WH         |                            | 136             |  |  |  |  |   |                                       |   |  |
|               |  |            |         |      |            |                            |                 |  |  |  |  |   |                                       |   |  |
|               |  |            |         |      |            |                            |                 | 10.0<br>+  |  |  |  |   |                                       |   |  |
|               |  |            |         |      |            |                            | 135             |  |  |  |  |   |                                       |   |  |
| 11.9          | End of Borehole<br>Monitoring well installation consists of<br>50-mm diameter Schedule 40 PVC<br>pipe with a 3-m slotted screen<br>DATE    DEPTH (m)    ELEV. (m)<br>2021.08.04    0.3       146.5<br>2021.09.22    0.3       146.5<br>2021.10.05    0.4       146.4<br>2021.10.22    0.4       146.4<br>2022.01.19    0.6       146.4 |            |         |      |            |                            |                 |  |  |  |  |   |                                       |   |  |

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

# RECORD OF BOREHOLE No CV-2

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.505389°, Long: -76.675796°  
Culvert 17+570 MTM Zone 9: N 5 040 622.6 E 291 062.8 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.05.13 - 2021.05.13 CHECKED BY FG

| 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 | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|-----------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20 40 60 80 100                             | 20 40 60 80 100 |                                    |                                     |                                   |                     |   |
| 146.8         | Ground Surface   |            |         |      |            |                            |                 |   |                 |                                    |                                     |                                   |                     |   |
| 0.0           | TOP SOIL (300 mm)  |            |         |      |            |                            |                 |   |                 |                                    |                                     |                                   |                     |   |
| 146.5         |  |            | 1       | SS   | WH         |                            |                 |   |                 |                                    |                                     |                                   |                     |   |
| 0.3           | <b>SILTY CLAY</b><br>Trace sand<br>Trace roots<br>Grey-brown with yellow mottles<br>Very stiff<br>Homogeneous structure<br>[WEATHERED CRUST] |            | 2       | SS   | 2          |                            | 146             |   |                 |                                    |                                     |                                   |                     |   |
| 145.3         |  |            | 3       | SS   | 2          |                            | 145             |   |                 |                                    |                                     |                                   |                     | 0 0 52 48   |
| 1.5           | <b>SILTY CLAY</b><br>Contains sand partings<br>Grey-brown to grey<br>Firm to very stiff<br>Homogeneous structure                             |            | 4       | SS   | 3          |                            | 144             |   |                 |                                    |                                     |                                   |                     |   |
|               |  |            | 5       | SS   | 3          |                            | 143             |   |                 |                                    |                                     |                                   |                     |   |
|               |  |            | 6       | SS   | 2          |                            | 142             |   |                 |                                    |                                     |                                   |                     | 0 0 51 49   |
|               |  |            | 7       | SS   | 1          |                            | 141             |   |                 |                                    |                                     |                                   |                     |   |
|               |  |            | 8       | SS   | 2          |                            | 140             |   |                 |                                    |                                     |                                   |                     |   |
|               |  |            | 9       | SS   | 2          |                            | 139             |   |                 |                                    |                                     |                                   |                     |   |
|               |  |            |         |      |            |                            | 138             |   |                 |                                    |                                     |                                   |                     | 0 1 58 41   |
|               |  |            |         |      |            |                            | 137             |   |                 |                                    |                                     |                                   |                     |   |

Continued Next Page

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

# RECORD OF BOREHOLE No CV-2

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.505389°, Long: -76.675796°  
Culvert 17+570 MTM Zone 9: N 5 040 622.6 E 291 062.8 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.05.13 - 2021.05.13 CHECKED BY FG

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | PLASTIC<br>LIMIT<br>w <sub>p</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>w | LIQUID<br>LIMIT<br>w <sub>L</sub> | UNIT<br>WEIGHT<br><br>γ<br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br><br>GR SA SI CL |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|------------------------------------|-------------------------------------|-----------------------------------|--|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | 20 40 60 80 100                             | SHEAR STRENGTH kPa<br>○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |  |                                    |                                     |                                   |  |  |
|               | Continued From Previous Page   |            |         |      |            |                            |                 |   |  |  |  |                                    |                                     |                                   |  |  |
| 134.9         | <b>SILTY CLAY</b><br>Contains sand partings<br>Grey-brown to grey<br>Firm to very stiff<br>Homogeneous structure |            | 10      | SS   | 2          |                            | 136             |   |  |  |  |                                    |                                     |                                   |  |  |
| 11.9          | End of Borehole  |            |         |      |            |                            | 135             |   |  |  |  |                                    |                                     |                                   |  |  |

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

# RECORD OF BOREHOLE No CV-3

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.505466°, Long: -76.675642°  
Culvert 17+570 MTM Zone 9: N 5 040 631.1 E 291 074.8 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.05.12 - 2021.05.13 CHECKED BY FG

| 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 | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                   |            |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|---|--------------|------------------------------------|-------------------------------------|-----------------------------------|---------------------|---|-------------------|------------|
| ELEV<br>DEPTH | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |              |                                    |                                     |                                   |                     |   | WATER CONTENT (%) |            |
|               |   |            |         |      |            |                            |                 | ○ UNCONFINED                                | + FIELD VANE |                                    |                                     |                                   |                     |   | ● QUICK TRIAXIAL  | × LAB VANE |
| 146.9         | Ground Surface  |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
| 0.0           | TOP SOIL (300 mm)   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
| 146.6         |   |            | 1       | SS   | 1          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
| 0.3           | SILTY CLAY<br>Trace sand<br>Trace roots<br>Grey with yellow mottles<br>Very stiff<br>Homogeneous structure<br>[WEATHERED CRUST] |            | 2       | SS   | 2          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
| 145.4         |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
| 1.5           | CLAYEY SILT to SILTY CLAY<br>Contains sand partings<br>Grey<br>Firm to very stiff<br>Homogeneous structure                      |            | 3       | SS   | 2          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 4       | SS   | 2          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 5       | SS   | 2          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 6       | SS   | 3          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 7       | SS   | 2          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 8       | SS   | 1          |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            | 9       | SS   | WH         |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |
|               |   |            |         |      |            |                            |                 |   |              |                                    |                                     |                                   |                     |   |                   |            |

Continued Next Page

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

## METRIC

[illegible]

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



# RECORD OF BOREHOLE No CV-28

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.505644°, Long: -76.675142°  
Culvert 17+570 MTM Zone 9: N 5 040 650.8 E 291 113.9 ORIGINATED BY AO  
HWY 17 BOREHOLE TYPE CME45 Trackmount, HSA COMPILED BY AO  
DATUM Geodetic DATE 2021.04.27 - 2021.04.27 CHECKED BY FG

| SOIL PROFILE  |   |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT              |  | PLASTIC LIMIT |  | NATURAL<br>MOISTURE<br>CONTENT |  | LIQUID LIMIT |           | UNIT<br>WEIGHT<br><br>$\gamma$<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                                       |  | W P           |  | W                              |  | W L          |           |   |  |
| 147.0         | Ground Surface  |            |         |      |            |                            |                 | 20 40 60 80 100  |  |               |  |                                |  |              |           |   |  |
| 0.0           | TOP SOIL (610 mm)   |            | 1       | SS   | 1          |                            |                 | ○ UNCONFINED + FIELD VANE<br>● QUICK TRIAXIAL × LAB VANE |  |               |  |                                |  |              |           |   |  |
| 146.4         | <b>SILTY CLAY</b><br>No to trace gravel<br>Grey<br>Firm to very stiff<br>Homogeneous structure  |            |         |      |            |                            | 146             |  |  |               |  |                                |  |              |           | 0 0 49 51   |  |
| 0.6           |   |            | 2       | SS   | 3          |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            | 3       | SS   | 3          |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            | 4       | SS   | 3          |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            | 5       | SS   | 3          |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   | 6          | SS      | 3    |            |                            | 143             |  |  |               |  |                                |  |              | 0 0 44 56 |   |  |
|               |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
|               |   | 7          | SS      | 3    |            |                            | 142             |  |  |               |  |                                |  |              |           |   |  |
| 141.2         |   |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |
| 5.8           | End of Borehole<br>Monitoring well installation consists of<br>50-mm diameter Schedule 40 PVC<br>pipe with a 3-m slotted screen<br>DATE DEPTH (m) ELEV. (m)<br>2021.08.04 0.1 146.9<br>2021.09.22 0.1 146.9<br>2021.10.05 0.0 147.0<br>2022.01.19 0.3 146.7 |            |         |      |            |                            |                 |  |  |               |  |                                |  |              |           |   |  |

DOUBLE LINE 24726 CULVERT 17+570 GINT.GPJ 2012TEMPLATE(MTO).GDT 22-6-29



# **TWINNING OF HIGHWAY 17 - PART 1B FROM 1 KM WEST OF MILLER / ANDERSON RD TO 3KM WEST OF BRUCE ST COUNTY OF RENFREW**

| <b>94Cx Station 17+600</b>    | <b>6m LT CL</b>                                 | <b>D 0</b> |
|-------------------------------|---|------------|
| 0- 220 Asph                   |   |            |
| 220- 1 Br Sa and Gr Tr Si     | Moist   |            |
| 1- 1.8 Br Si(y) Cl Tr Sa      | Moist   | *          |
|                               | w @ 1.4m = 32%                                  |            |
|                               | Percent Passing 4.75 mm = 100%                  |            |
|                               | 75 µm = 91%                                     |            |
|                               | 5 µm = 67%                                      |            |
|                               | Frost Susceptibility = LSFH                     |            |
|                               | W <sub>L</sub> = 50%                            |            |
|                               | W <sub>P</sub> = 21%                            |            |
|                               | P <sub>I</sub> = 28%                            |            |
|                               | MTC Soil Classification = CI                    |            |
|                               | Existing WB Lane 2. Partially Paved OSH Asphalt |            |
|                               | Thickness = 75mm. Firm @ 2.1 m                  |            |
|                               | PH  |            |
| <b>94C Station 17+600</b>     | <b>2m LT CL</b>                                 | <b>D 0</b> |
| 0- 360 Asph                   |   |            |
| 360- 1 Br Sa and Gr Tr Si     | Moist   |            |
| 1- 1.3 Br Sa W Gr Tr Si       | Moist   |            |
| 1.3- 1.8 Br Si(y) Cl          | Moist   |            |
|                               | Existing WB Lane. Firm @ 2.0 m                  |            |
|                               | PH  |            |
| <b>132D Station 17+600</b>    | <b>2m RT CL</b>                                 | <b>D 0</b> |
| 0- 350 Asph                   |   |            |
| 350- 700 Br Sa and Gr Some Si | Moist   | *          |
|                               | w @ 0.5m = 6%                                   |            |
|                               | Percent Passing 4.75 mm = 56%                   |            |
|                               | 75 µm = 13%                                     |            |
| 700- 1.5 Br Sa Tr Si Tr Gr    | Moist   | *          |
|                               | w @ 1.1m = 5%                                   |            |
|                               | Percent Passing 4.75 mm = 95%                   |            |
|                               | 75 µm = 4%                                      |            |
|                               | Existing EB Lane                                |            |
|                               | PH  |            |

| <b>93Cx Station 17+800</b>        | <b>2m LT CL</b>  | <b>D 0</b>   |
|-----------------------------------|------------------|--------------|
| 0- 320 Asph                       |                  |              |
| 320- 770 Br Sa and Gr Tr Si       | Moist            |              |
| 770- 2 Br Si(y) Cl                | Moist            |              |
|                                   | Existing WB Lane |              |
|                                   | PH               |              |
| <b>92B Station 18+000</b>         | <b>8m LT CL</b>  | <b>D-0.2</b> |
| 0- 350 Br Sa and Gr Tr Si         | Moist            |              |
| 350- 1.5 Br Sa W Gr Tr Si Occ Cob | Moist            |              |
|                                   | Existing WB OSH  |              |
|                                   | PH               |              |

| <b>92Cx Station 18+000</b>  | <b>2m LT CL</b>    | <b>D 0</b> |
|-----------------------------|--------------------|------------|
| 0- 275 Asph                 |                    |            |
| 275- 750 Br Sa and Gr Tr Si | Moist              |            |
| 750- 1.5 Br Sa W Gr Tr Si   | Moist              |            |
|                             | Existing WB Lane 1 |            |
|                             | PH                 |            |

| <b>92C Station 18+000</b>         | <b>1.5m LT CL</b>                               | <b>D 0</b> |
|-----------------------------------|---|------------|
| 0- 225 Asph                       |   |            |
| 225- 650 Br Sa and Gr Tr Si       | Moist   |            |
| 650- 1.5 Br Sa W Gr Tr Si Occ Cob | Moist   |            |
|                                   | Existing WB Lane 2. Partially Paved OSH Asphalt |            |
|                                   | Thickness = 55mm                                |            |
|                                   | PH  |            |

| <b>134D Station 18+000</b>  | <b>2m RT CL</b>                               | <b>D 0</b> |
|-----------------------------|---|------------|
| 0- 350 Asph                 |   |            |
| 350- 600 Br Sa and Gr Tr Si | Moist   |            |
| 600- 1.5 Br Sa Tr Si        | Moist   |            |
|                             | Existing EB Lane. Partially Paved OSH Asphalt |            |
|                             | Thickness = 90mm                              |            |
|                             | PH  |            |

| <b>136D Station 18+300</b>  | <b>2m RT CL</b>                               | <b>D 0</b> |
|-----------------------------|---|------------|
| 0- 340 Asph                 |   |            |
| 340- 600 Br Sa and Gr Tr Si | Moist   |            |
| 600- 1.5 Br Sa Tr Si        | Moist   |            |
|                             | Existing EB Lane. Partially Paved OSH Asphalt |            |
|                             | Thickness = 80mm                              |            |
|                             | PH  |            |

| <b>99B Station 18+400</b>            | <b>11m LT CL</b>              | <b>D-0.2</b> |
|--------------------------------------|-------------------------------|--------------|
| 0- 400 Br Sa and Gr Tr Si            | Moist                         |              |
| 400- 1.6 Br Sa Some Gr Tr Si Occ Cob | Moist                         |              |
| 1.6- Gry Sa(y) Si                    | Moist                         |              |
|                                      | Existing WB OSH. Firm @ 1.7 m |              |
|                                      | PH                            |              |

| <b>90Cx Station 18+400</b>  | <b>2m LT CL</b>  | <b>D 0</b> |
|-----------------------------|------------------|------------|
| 0- 330 Asph                 |                  |            |
| 330- 850 Br Sa and Gr Tr Si | Moist            | *          |
| 850- 1.5 Br Sa W Gr Tr Si   | Moist            | *          |
|                             | Existing WB Lane |            |
|                             | PH               |            |

| <b>90C Station 18+400</b>         | <b>1.5m LT CL</b>  | <b>D 0</b> |
|-----------------------------------|--------------------|------------|
| 0- 300 Asph                       |                    |            |
| 300- 500 Br Sa and Gr Tr Si       | Moist              |            |
| 500- 1.5 Br Sa W Gr Tr Si Occ Cob | Moist              |            |
|                                   | Existing WB Lane 2 |            |
|                                   | PH                 |            |



## **Appendix C.**

### **Laboratory Testing**

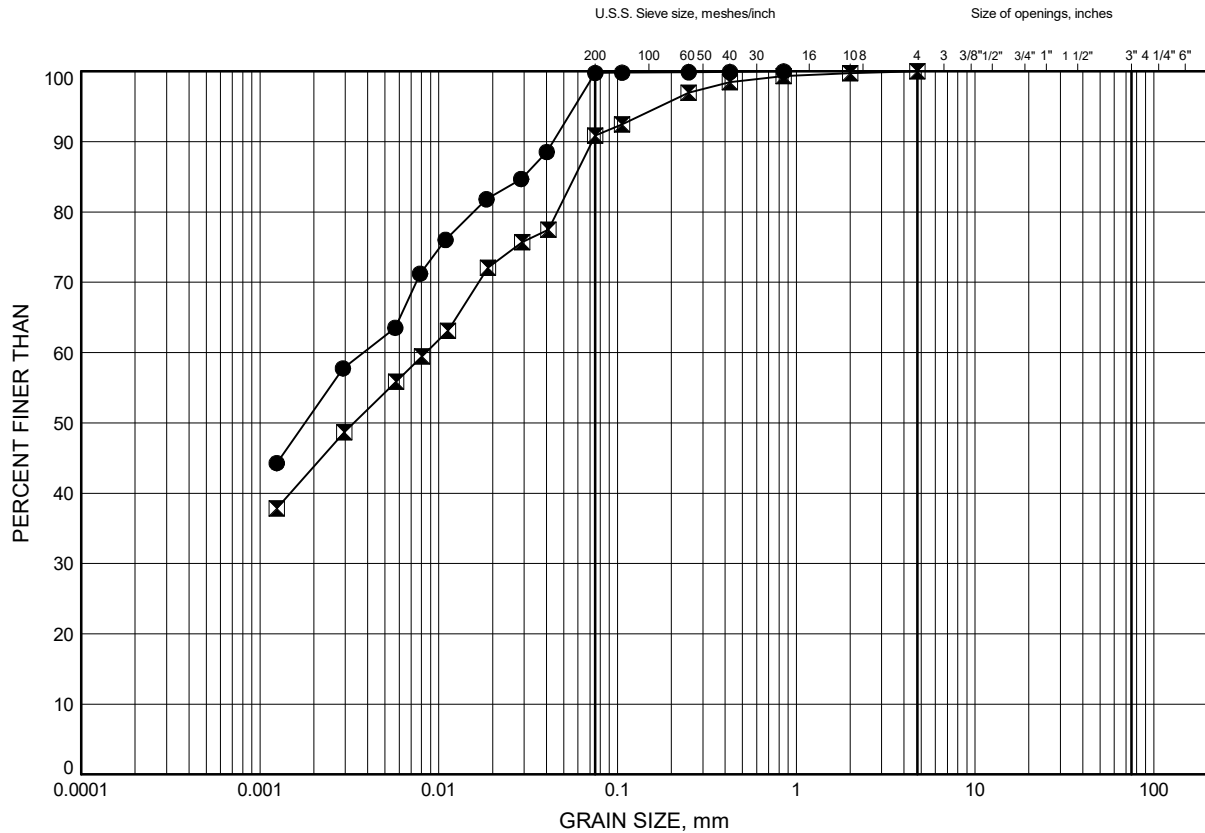


**Appendix C.1**  
**Particle Size Analysis Figures**  
**Atterberg Limit Test Results**

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C1

## Weathered Silty Clay (Cl) Crust



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CV-1     | 1.1       | 145.7     |
| ⊠      | CV-3     | 1.1       | 145.8     |

Date August 2021  
WP# 4068-09-00

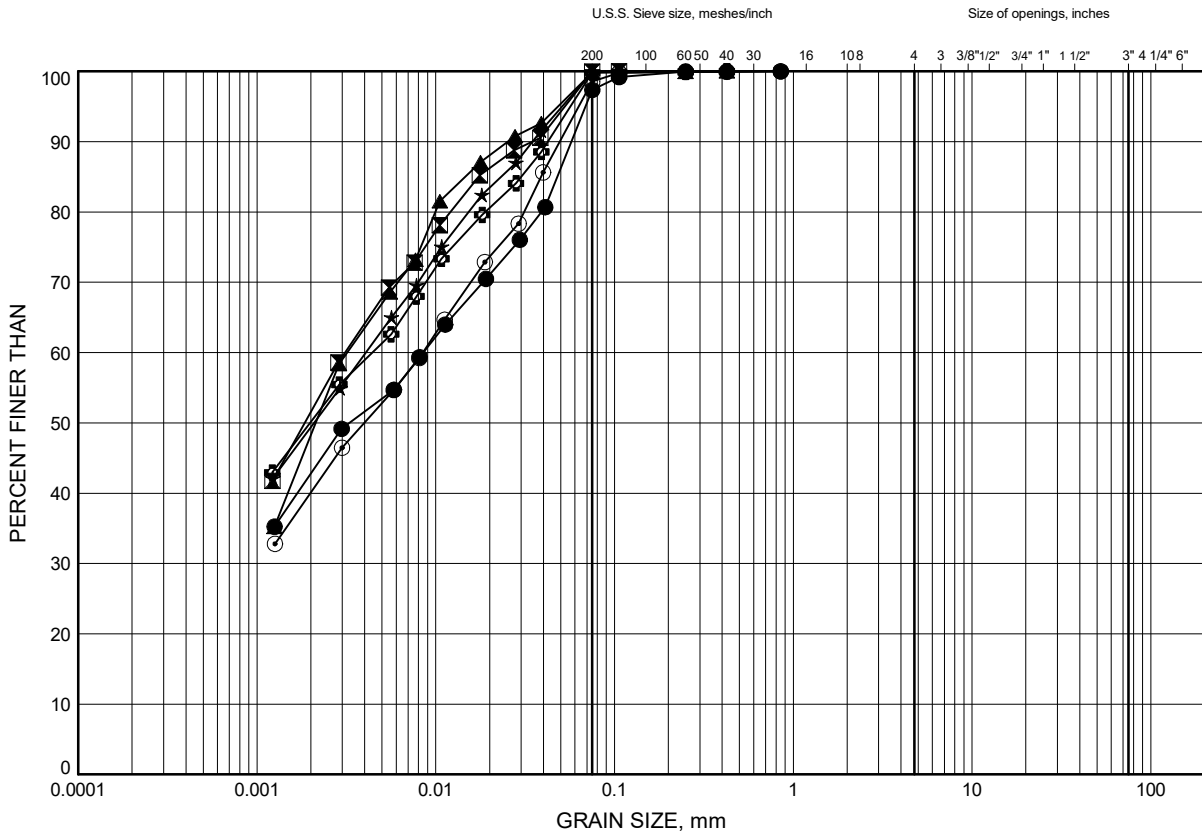


Prep'd MJK  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C2

## Clayey Silt (CL) to Silty Clay (CI)



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

### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CV-1     | 3.4       | 143.4     |
| ⊠      | CV-1     | 7.9       | 138.9     |
| ▲      | CV-2     | 1.8       | 145.0     |
| ★      | CV-2     | 4.9       | 141.9     |
| ⊙      | CV-2     | 9.4       | 137.4     |
| ⊕      | CV-3     | 2.6       | 144.3     |

Date August 2021  
WP# 4068-09-00

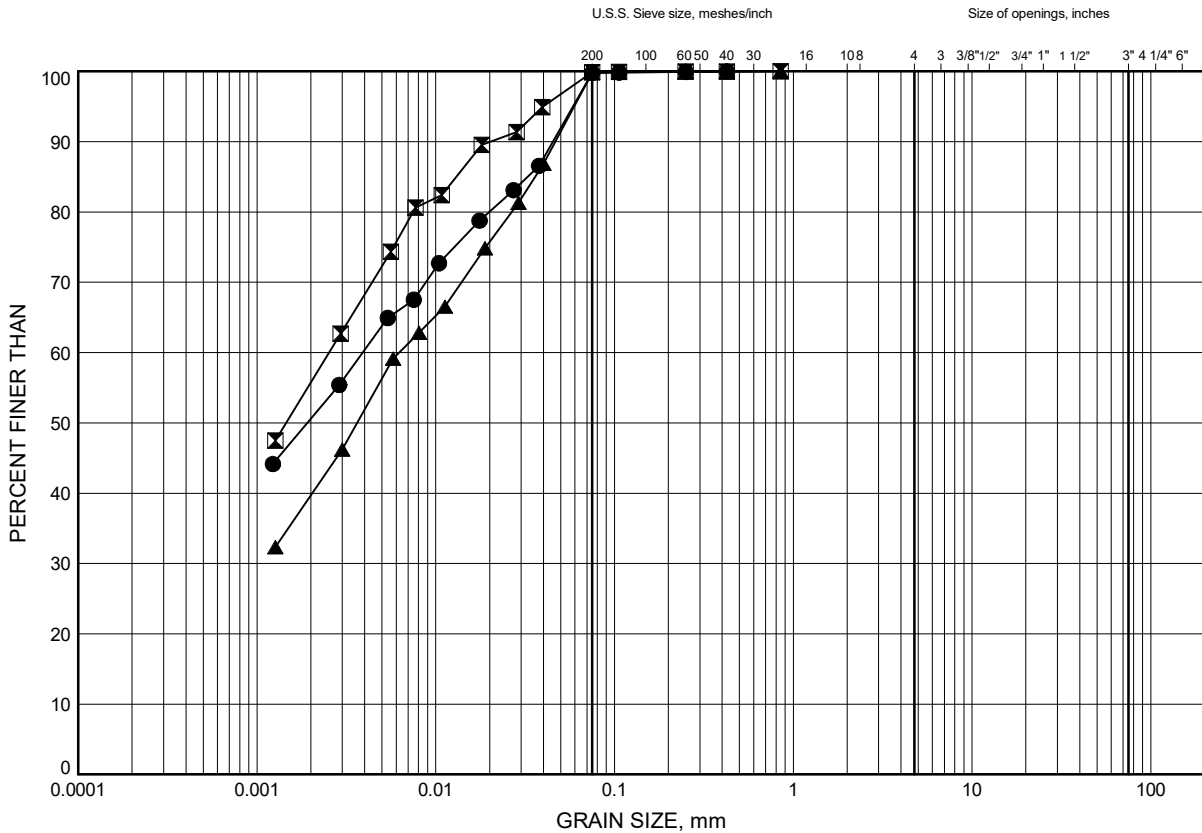


Prep'd MJK  
Chkd. FG

# Highway 17 Twinning GRAIN SIZE DISTRIBUTION

FIGURE C3

## Silty Clay (CI)



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

## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CV-28    | 1.1       | 145.9     |
| ⊠      | CV-28    | 4.1       | 142.9     |
| ▲      | CV-3     | 6.4       | 140.5     |

Date August 2021  
WP# 4068-09-00

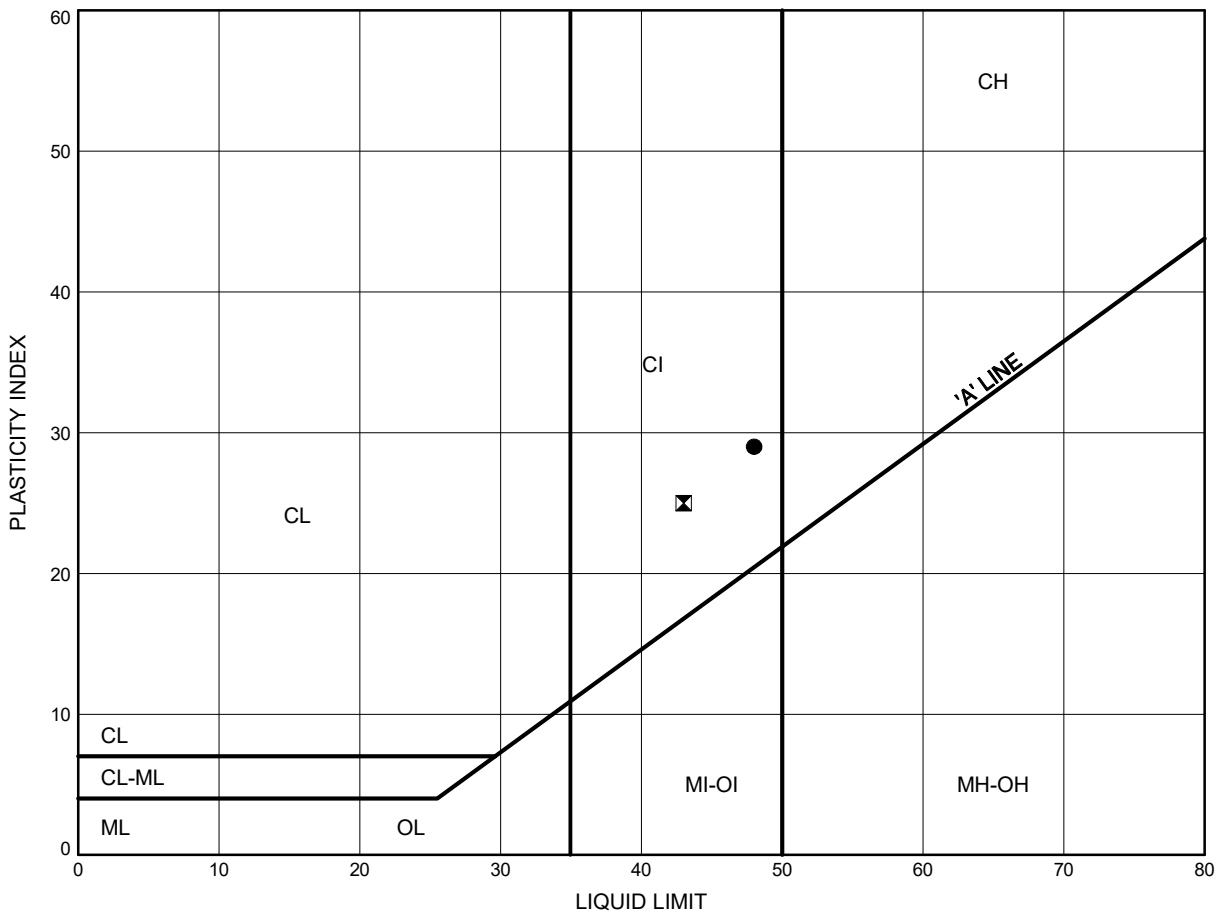


Prep'd MJK  
Chkd. FG

# Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C4

### Weathered Silty Clay (CI) Crust



### LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CV-1     | 1.1       | 145.7     |
| ⊠      | CV-3     | 1.1       | 145.8     |

Date August 2021  
 WP# 4068-09-00



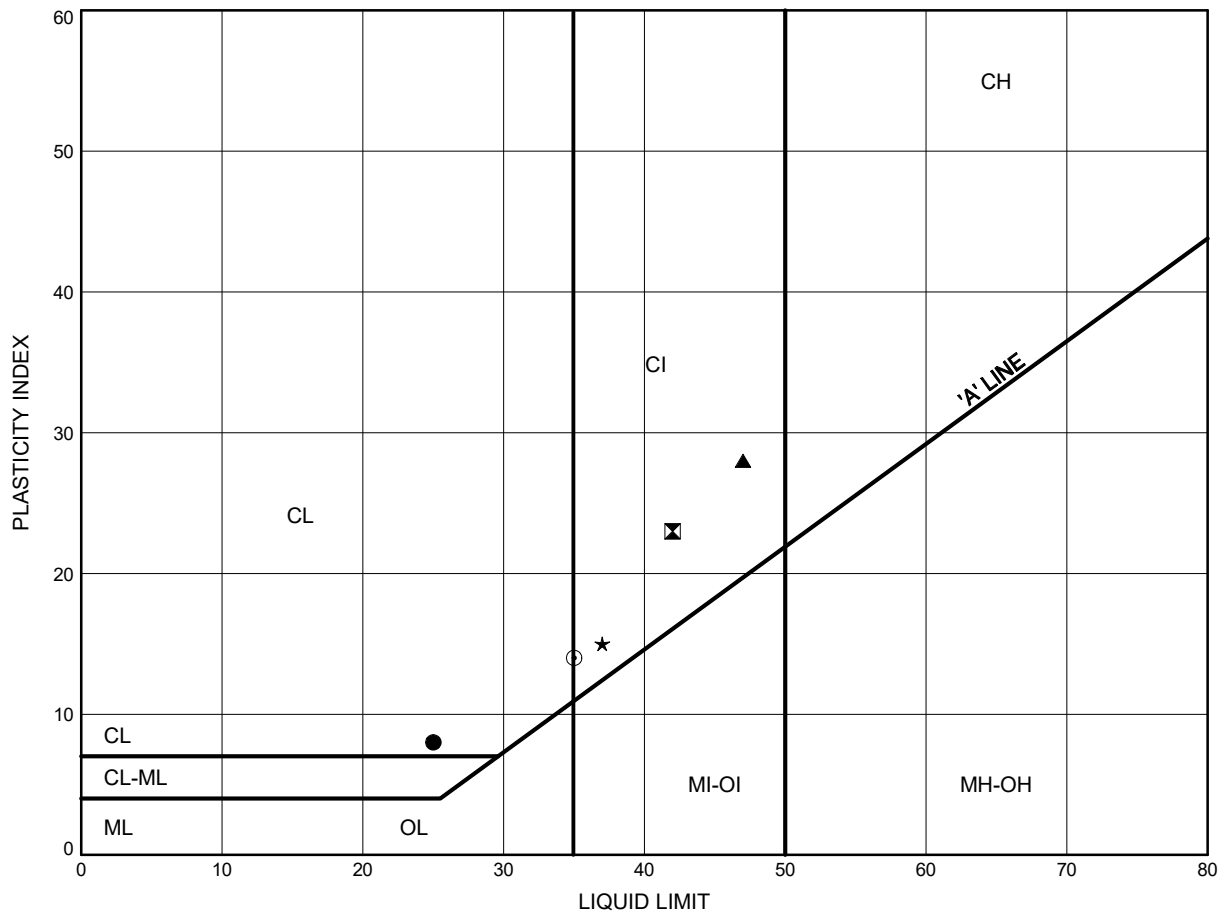
Prep'd MJK  
 Chkd. FG



# Highway 17 Twinning ATTERBERG LIMITS TEST RESULTS

FIGURE C5

Clayey Silt (CL) to Silty Clay (CI)



## LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ●      | CV-1     | 3.4       | 143.4     |
| ⊠      | CV-2     | 1.8       | 145.0     |
| ▲      | CV-28    | 1.1       | 145.9     |
| ★      | CV-28    | 4.1       | 142.9     |
| ⊙      | CV-3     | 2.6       | 144.3     |

Date August 2021  
 WP# 4068-09-00



Prep'd MJK  
 Chkd. FG



## **Appendix C.2**

### **Analytical Testing Results**

## Certificate of Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104  
Ottawa, ON K1B 4S5  
Attn: Justin Gray

Client PO: 24726  
Project: Culverts 17+570 and 17+893  
Custody: 48670

Report Date: 21-May-2021  
Order Date: 17-May-2021

**Order #: 2121164**

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

| Paracel ID | Client ID         |
|------------|-------------------|
| 2121164-01 | CV2 SS2 2'6"-4'6" |
| 2121164-02 | CV6 SS3 5'-7'     |

Approved By:



Mark Foto, M.Sc.  
Lab Supervisor

Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

**Analysis Summary Table**

| Analysis     | Method Reference/Description                     | Extraction Date | Analysis Date |
|--------------|--|-----------------|---------------|
| Anions       | EPA 300.1 - IC, water extraction                 | 21-May-21       | 21-May-21     |
| Conductivity | MOE E3138 - probe @25 °C, water ext              | 20-May-21       | 21-May-21     |
| pH, soil     | EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext. | 18-May-21       | 19-May-21     |
| Resistivity  | EPA 120.1 - probe, water extraction              | 20-May-21       | 21-May-21     |
| Solids, %    | Gravimetric, calculation                         | 18-May-21       | 19-May-21     |

Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

|  |              |                   |                 |   |   |
|--|--------------|-------------------|-----------------|---|---|
|  | Client ID:   | CV2 SS2 2'6"-4'6" | CV6 SS3 5'-7'   | - | - |
|  | Sample Date: | 13-May-21 09:00   | 14-May-21 14:00 | - | - |
|  | Sample ID:   | 2121164-01        | 2121164-02      | - | - |
|  | MDL/Units    | Soil              | Soil            | - | - |

**Physical Characteristics**

|          |              |      |      |   |   |
|----------|--------------|------|------|---|---|
| % Solids | 0.1 % by Wt. | 67.3 | 70.5 | - | - |
|----------|--------------|------|------|---|---|

**General Inorganics**

|              |               |      |      |   |   |
|--------------|---------------|------|------|---|---|
| Conductivity | 5 uS/cm       | 468  | 504  | - | - |
| pH           | 0.05 pH Units | 7.66 | 7.73 | - | - |
| Resistivity  | 0.10 Ohm.m    | 21.4 | 19.8 | - | - |

**Anions**

|          |            |     |     |   |   |
|----------|------------|-----|-----|---|---|
| Chloride | 5 ug/g dry | 192 | 168 | - | - |
| Sulphate | 5 ug/g dry | 30  | 63  | - | - |

Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

### Method Quality Control: Blank

| Analyte                   | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------------------|--------|-----------------|-------|---------------|------|------------|-----|-----------|-------|
| <b>Anions</b>             |        |                 |       |               |      |            |     |           |       |
| Chloride                  | ND     | 5               | ug/g  |               |      |            |     |           |       |
| Sulphate                  | ND     | 5               | ug/g  |               |      |            |     |           |       |
| <b>General Inorganics</b> |        |                 |       |               |      |            |     |           |       |
| Conductivity              | ND     | 5               | uS/cm |               |      |            |     |           |       |
| Resistivity               | ND     | 0.10            | Ohm.m |               |      |            |     |           |       |

Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

### Method Quality Control: Duplicate

| Analyte                         | Result | Reporting Limit | Units    | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------------------------|--------|-----------------|----------|---------------|------|------------|-----|-----------|-------|
| <b>Anions</b>                   |        |                 |          |               |      |            |     |           |       |
| Chloride                        | 53.7   | 5               | ug/g dry | 51.6          |      |            | 4.1 | 20        |       |
| Sulphate                        | 79.3   | 5               | ug/g dry | 77.9          |      |            | 1.8 | 20        |       |
| <b>General Inorganics</b>       |        |                 |          |               |      |            |     |           |       |
| Conductivity                    | 467    | 5               | uS/cm    | 468           |      |            | 0.2 | 5         |       |
| pH                              | 7.20   | 0.05            | pH Units | 7.23          |      |            | 0.4 | 2.3       |       |
| Resistivity                     | 21.4   | 0.10            | Ohm.m    | 21.4          |      |            | 0.2 | 20        |       |
| <b>Physical Characteristics</b> |        |                 |          |               |      |            |     |           |       |
| % Solids                        | 93.4   | 0.1             | % by Wt. | 94.2          |      |            | 0.9 | 25        |       |

Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

**Method Quality Control: Spike**

| Analyte       | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------|--------|-----------------|-------|---------------|------|------------|-----|-----------|-------|
| <b>Anions</b> |        |                 |       |               |      |            |     |           |       |
| Chloride      | 142    | 5               | ug/g  | 51.6          | 90.2 | 82-118     |     |           |       |
| Sulphate      | 165    | 5               | ug/g  | 77.9          | 87.0 | 80-120     |     |           |       |



Certificate of Analysis

Report Date: 21-May-2021

Client: Thurber Engineering Ltd.

Order Date: 17-May-2021

Client PO: 24726

Project Description: Culverts 17+570 and 17+893

**Qualifier Notes:**

None

**Sample Data Revisions**

None

**Work Order Revisions / Comments:**

None

**Other Report Notes:**

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

## Subcontracted Analysis

**Thurber Engineering Ltd.**

2460 Lancaster Rd, Suite 104

Ottawa, ON K1B 4S5

Attn: Justin Gray

Tel: (613) 408-6795

Fax: (613) 247-2185

Paracel Report No **2121164**

Client Project(s): **Culverts 17+570 and 17+893**

Client PO: **24726**

Reference: **Standing Offer**

CoC Number: **48670**

Order Date: 17-May-21

Report Date: 21-May-21

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

| Paracel ID | Client ID         | Analysis        |
|------------|-------------------|-----------------|
| 2121164-01 | CV2 SS2 2'6"-4'6" | Sulphide, solid |
| 2121164-02 | CV6 SS3 5'-7'     | Sulphide, solid |

**SGS Canada Inc.**

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

**Paracel Laboratories**

Attn : Dale Robertson

300-2319 St.Laurent Blvd.  
Ottawa, ON  
K1G 4K6, Canada

Phone: 613-731-9577  
Fax:613-731-9064

27-May-2021

**Date Rec. :** 19 May 2021  
**LR Report:** CA13681-MAY21  
**Reference:** Project#: 2121164

**Copy:** #1

## CERTIFICATE OF ANALYSIS

### Final Report

| Sample ID                  | Sample Date & Time | Sulphide (Na <sub>2</sub> CO <sub>3</sub> ) % |
|----------------------------|--------------------|---|
| 1: Analysis Start Date     |                    | 26-May-21                                     |
| 2: Analysis Start Time     |                    | 15:06   |
| 3: Analysis Completed Date |                    | 26-May-21                                     |
| 4: Analysis Completed Time |                    | 17:03   |
| 5: QC - Blank              |                    | < 0.04  |
| 6: QC - STD % Recovery     |                    | 111%  |
| 7: QC - DUP % RPD          |                    | ND  |
| 8: RL                      |                    | 0.02  |
| 9: CV2 SS2 2'6"-4'6"       | 13-May-21 09:00    | < 0.04  |
| 10: CV6 SS3 5'-7'          | 14-May-21 14:00    | 0.05  |

RL - SGS Reporting Limit  
ND - Not Detected

Kimberley Didsbury  
Project Specialist,  
Environment, Health & Safety



**Appendix D.**  
**Site Photographs**





**Photo 1. Existing embankment, westbound lanes, looking north at culvert inlet (2021/04/27)**



**Photo 2. Existing culvert inlet, looking northwest (2021/04/27)**





**Photo 3. Existing culvert outlet, looking west towards location of proposed eastbound lanes (2021/04/27)**



**Photo 4. Existing culvert outlet, looking west (2021/04/27)**





**Photo 5. Highway 17 looking northwest (2021/04/27)**