



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
FIRST STREET UNDERPASS  
BRIDGE REHABILITATION  
HIGHWAY 406  
ST. CATHARINES, ONTARIO  
G.W.P. 2257-13-00; SITE NO. 18-236  
  
GEOCRES NO. 30M3-291**

**Report**

to

**MMM Group Limited**

Date: January 6, 2017  
File: 11336



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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the proposed rehabilitation of the existing underpass bridge located on Highway 406 at First Street, in St. Catharines, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the underpass 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 MMM Group Limited (MMM) to carry out this foundation investigation under the MTO Assignment Number 2014-E0030.

**2. SITE DESCRIPTION**

The underpass is located at the First Street and Highway 406 crossing in St. Catharines, Ontario.

First Street crosses over Highway 406 on a two-span concrete structure of approximately 55 m in length. The approach fill adjacent to the south and north abutments of the structure is approximately 6.0 m in height.

The terrain adjacent to the structure is generally flat. Residential dwellings are located on the north side of the site. The lands to the southeast are vacant and the lands to the southwest are occupied by a commercial building.

Selected photographs of the immediate surroundings are presented in Appendix E.



The site is situated within the physiographic region known as the Haldimand Clay Plain, which is characterized by glacio-lacustrine deposits laid down in glacial Lake Warren during the Wisconsinian Age. These deposits consist of silts and clays and are generally underlain by a glacial till, which in turn overlies dolomitic limestone bedrock.

### **3. INVESTIGATION PROCEDURES**

The site investigation and field testing for this project were carried out on August 8 and 9, 2016 and consisted of drilling and sampling four boreholes (numbered FSU 16-01 and FSU 16-04) at the site. The boreholes were located on First Street near the existing approaches and abutments. All the boreholes were terminated at 9.8 m depth (Elevations 93.7 to 94.6).

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by MMM. The approximate locations of boreholes drilled at the First Street Underpass are shown on a Borehole Locations and Soil Strata drawing included in Appendix C. The coordinates and elevations of these boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendix A.

A track-mounted CME 75 drill rig was used to drill and sample the boreholes. Hollow stem augers were used to advance the boreholes until the target depth was reached. In general, soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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. Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendices A and C.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A standpipe piezometer was installed in a selected borehole (FSU 16-04). The piezometer consisted of a 25 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen enclosed in filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. Upon completion of the drilling operations, the boreholes without piezometers were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372. The details of standpipe piezometer installation and borehole completion are summarized in Table 3.1.



**Table 3.1 – Borehole Completion Details**

| Foundation Element | Borehole No. | Borehole Depth / Base Elevation (m) | Piezometer Tip Elevation (m) | Completion Details   |
|--------------------|--------------|-------------------------------------|------------------------------|--|
| North Abutment     | FSU 16-01    | 9.8/94.1                            | None installed               | Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, concrete to 0.1 m then asphalt patch to surface.                            |
| North Approach     | FSU 16-02    | 9.8/93.7                            | None installed               | Borehole backfilled with bentonite holeplug and auger cuttings to 0.2 m, then concrete and asphalt to surface.                                       |
| South Abutment     | FSU 16-03    | 9.8/94.6                            | None installed               | Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, concrete to 0.1 m then asphalt patch to surface.                            |
| South Approach     | FSU 16-04    | 9.8/94.5                            | 9.0/95.3                     | Borehole backfilled with sand filter from 9.8 m to 5.5 m, bentonite holeplug from 5.5 m to 0.3 m, sand from 0.3 m to 0.15, then concrete to surface. |

#### 4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance to MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and are presented on the figures included in Appendix B.

#### 5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A soil profile of the First Street Underpass site is presented on the “Borehole Locations and Soil Strata” drawing in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations. More detailed descriptions of the individual strata are presented below.



In general, the subsurface conditions encountered in the boreholes drilled at the First Street Underpass consist of asphalt over granular fill overlying silty clay embankment fill. An extensive deposit of native silty clay till was contacted below the fill in all the boreholes. Groundwater levels are generally in the order of 7.3 m below original ground surface. More detailed descriptions of the individual stratum are presented below.

## **5.1 Asphalt and Concrete**

The four boreholes were advanced from the top of the road embankment and encountered between 75 mm and 200 mm of asphalt surficially.

Below the asphalt a 400-mm thick layer of concrete was contacted in Boreholes FSU 16-01 and FSU 16-03, drilled through the north and south approach slabs, respectively.

## **5.2 Gravelly Sand Fill**

Granular fill was encountered below the asphalt and concrete in all the boreholes. The granular fill consisted of a brown to grey gravelly sand, some silt and clay. The thickness of the fill was 5.6 m and 1.7 m in Boreholes FSU16-01 and FSU 16-03. In Boreholes FSU16-02 and FSU 16-04, drilled at the approaches, the fill varied from 0.3 m to 1.2 m in thickness.

The depth to the base of the gravelly sand fill ranged from 0.5 m to 2.2 m (Elevations 102.1 to 103.8 m) in Boreholes FSU 16-02 to FSU 16-04. Locally, in Borehole FSU 16-01, the granular fill extended to 6.1 m (Elevation 97.8 m).

In Boreholes FSU 16-02 to 16-04, SPT 'N' values recorded in the granular fill ranged from 8 to 30 blows for 0.3 m penetration indicating loose to compact conditions. In Borehole FSU 16-01, SPT 'N' values ranged from 36 to 51 blows per 0.3 m of penetration, indicating a dense to very dense state. Moisture contents of the granular fill ranged from 4% to 16%.

The results of a grain size analyses conducted on a gravelly sand fill sample are presented on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B1 of Appendix B. The laboratory test results are summarized in the following table.

| <b>Soil Particle</b> | <b>Percentage (%)</b> |
|----------------------|-----------------------|
| Gravel               | 31                    |
| Sand                 | 52                    |
| Silt & Clay          | 17                    |



### 5.3 Silty Clay Fill

Grey silty clay fill containing trace to some sand and trace gravel, was contacted in Boreholes FSU 16-03 and FSU 16-04 underlying the granular fill at the west abutment area. The thickness of the silty clay fill was 3.9 m and 0.2 m in Boreholes FSU 16-03 and FSU 16-04, respectively.

The depth to the base of the cohesive fill was 6.1 m and 0.7 m (Elevations 98.3 and 103.6 m) in Boreholes FSU 16-03 and FSU 16-04, respectively.

SPT 'N' values obtained in the silty clay fill ranged from 2 to 22 blows for 0.3 m penetration, indicating a soft to very stiff consistency. Moisture contents of the silty clay fill ranged from 19% to 22%.

The results of grain size analyses conducted on a silty clay fill sample are presented on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B2 of Appendix B. The laboratory test results are summarized in the following table.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 0              |
| Sand          | 15             |
| Silt          | 41             |
| Clay          | 44             |

### 5.4 Silty Clay Till

A deposit of brown to grey silty clay till containing trace to some sand and trace gravel was encountered below the fill in all the boreholes. The silty clay till was contacted at 6.1 m depth (Elevations 97.8 and 98.3 m) in Boreholes FSU 16-01 and FSU 16-03, drilled near the abutments, and at 1.4 m and 0.7 m depth (Elevations 102.1 and 103.6 m), in Boreholes FSU 16-02 and FSU 16-04 drilled at the approaches.

All the boreholes were terminated within the silty clay till at 9.8 m depth (Elevations 93.7 to 94.6).

SPT 'N' values recorded in the silty clay till varied between 8 and 25 blows for 0.3 m of penetration indicating stiff to very stiff consistency. Natural moisture contents of the silty clay till ranged from 16% to 23%.



The results of grain size analyses conducted on samples of the silty clay till are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B3 of Appendix B. The results are summarized as follows:

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel        | 0              |
| Sand          | 5 to 7         |
| Silt          | 42 to 45       |
| Clay          | 50 to 51       |

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B4 of Appendix B. The results are summarized as follows:

| Index Property   | Percentage (%) |
|------------------|----------------|
| Liquid Limit     | 43 to 46       |
| Plasticity Index | 19 to 20       |

The results of the Atterberg Limits testing indicate the deposit to be of medium plasticity with a group symbol CI.

It is noted that glacial till inherently contains cobbles and boulders.

## 5.5 Groundwater Conditions

The water levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. All boreholes were open to the depths investigated and dry upon completion of drilling. A standpipe piezometer was installed in Borehole FSU 16-04 to permit longer term monitoring.

**Table 5-1. Measured Groundwater Levels**

| Borehole Number | Date           | Groundwater Level |               | Comment       |
|-----------------|----------------|-------------------|---------------|---------------|
|                 |                | Depth (m)         | Elevation (m) |               |
| 16-01           | August 8, 2016 | Dry               | -             | Open Borehole |
| 16-02           | August 8, 2016 | Dry               | -             | Open Borehole |
| 16-03           | August 9, 2016 | Dry               | -             | Open Borehole |





| Borehole Number | Date               | Groundwater Level |               | Comment       |
|-----------------|--------------------|-------------------|---------------|---------------|
|                 |                    | Depth (m)         | Elevation (m) |               |
| 16-04           | August 9, 2016     | Dry               | -             | Open Borehole |
|                 | September 26, 2106 | 7.3               | 97.0          | Piezometer    |

The values shown in Table 5-1 are short-term readings 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 or prolonged precipitation.

## 6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. MMM provided the northing and easting coordinates and ground surface elevations.

Determination Drilling of Hamilton, Ontario, supplied and operated a track-mounted CME 75 drill rig to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Omar Ali of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. R. Palomeque Reyna, P. Eng. and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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Date: January 6, 2017

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## **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.

## EXPLANATION OF ROCK LOGGING TERMS


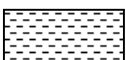

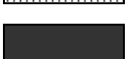

### ROCK WEATHERING CLASSIFICATION

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

### DISCONTINUITY SPACING

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

### SYMBOLS

|  |           |
|--|-----------|
|   | CLAYSTONE |
|   | SILTSTONE |
|   | SANDSTONE |
|   | COAL      |
|  | BEDROCK   |

### STRENGTH CLASSIFICATION

| <b>Rock Strength</b>  | <b>Approximate Uniaxial Compressive Strength</b> |                     | <b>Field Estimation of Hardness*</b>   |
|-----------------------|--|---------------------|--|
|                       | <b>(MPa)</b>                                     | <b>(psi)</b>        |  |
| Extremely Strong      | Greater than 250                                 | Greater than 36,000 | Specimen can only be chipped with a geological hammer                          |
| Very Strong           | 100-250  | 15,000 to 36,000    | Requires many blows of geological hammer to break                              |
| Strong                | 50-100   | 7,500 to 15,000     | Requires more than one blow of geological hammer to break                      |
| Medium Strong         | 25.0 to 50.0                                     | 3,500 to 7,500      | Breaks under single blow of geological hammer.                                 |
| Weak                  | 5.0 to 25.0                                      | 750 to 3,500        | Can be peeled by a pocket knife with difficulty                                |
| Very Weak             | 1.0 to 5.0                                       | 150 to 750          | Can be peeled by a pocket knife, crumbles under firm blows of geological pick. |
| Extremely Weak (Rock) | 0.25 to 1.0                                      | 35 to 150           | Indented by thumbnail  |

### 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 0.1m in length or larger as a % of total core run length.                |
| Uniaxial Compressive Strength (UCS) | Axial stress required to break the specimen   |
| Fracture Index:(FI)                 | Frequency of natural fractures per 0.3m of core run.  |

# 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>$W_L < 50\%$ | 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>( $W_L < 30\%$ ). |
|                      |                                 | CI           | Inorganic clays of medium plasticity, silty clays.<br>( $30\% < W_L < 50\%$ ).  |
|                      |                                 | OL           | Organic silts and organic silty-clays of low plasticity.  |
|                      | SILTS AND CLAYS<br>$W_L > 50\%$ | 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 FSU 16-01

1 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 739.0 E 323 000.5 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.08 - 2016.08.08 CHECKED BY RPR

| 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>(%) |    |    |   |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|--|----|----|----|---|---|---|---|---|----|----|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa<br>○ UNCONFINED      + FIELD VANE<br>● QUICK TRIAXIAL      × LAB VANE |    |    |    | WATER CONTENT (%)<br>w <sub>p</sub> w      w <sub>L</sub>     |   |   |   | GR  | SA | SI | CL  |
| 103.9         | GROUND SURFACE   |            |         |      |            |                            |                 | 20   | 40 | 60 | 80 | 100   |   |   |   |   |    |    |   |
| 0.0           | ASPAHLT: (75mm)  |            |         |      |            |                            |                 | 20   | 40 | 60 | 80 | 100   |   |   |   |   |    |    |   |
| 0.1           | CONCRETE: (400mm)  |            |         |      |            |                            |                 | 20   | 40 | 60 | 80 | 100   |   |   |   |   |    |    |   |
| 103.4         |  |            |         |      |            |                            |                 | 20   | 40 | 60 | 80 | 100   |   |   |   |   |    |    |   |
| 0.5           | Gravelly <b>SAND</b> , some silt and clay<br>Very Dense to Dense<br>Brown<br>Moist<br>(FILL) |            | 1       | SS   | 51         |                            | 103             |  |    |    |    |   | ○ |   |   |   |    |    |   |
|               |  |            | 2       | SS   | 36         |                            | 102             |  |    |    |    |   | ○ |   |   |   |    |    |   |
|               |  |            | 3       | SS   | 34         |                            | 101             |  |    |    |    |   | ○ |   |   |   |    | 31 | 52  |
|               |  |            | 4       | SS   | 30         |                            | 100             |  |    |    |    |   | ○ |   |   |   |    |    | 17  |
|               |  |            |         |      |            |                            |                 |  |    |    |    |   |   |   |   |   |    |    | (SI+CL)   |
|               | Grey   |            | 5       | SS   | 38         |                            | 99              |  |    |    |    |   | ○ |   |   |   |    |    |   |
|               |  |            |         |      |            |                            | 98              |  |    |    |    |   |   |   |   |   |    |    | Footings of the<br>bridge at about<br>5.2m. Borehole<br>moved 5.5m<br>north of the<br>expansion joint |
| 97.8          |  |            | 6       | SS   | 23         |                            | 97              |  |    |    |    |   | ○ | — | —   |   |    | 0  | 6   |
|               | Silty <b>CLAY</b> , trace sand<br>Very Stiff to Stiff<br>Brown<br>Moist<br>(TILL)            |            | 7       | SS   | 20         |                            | 96              |  |    |    |    |   | ○ |   |   |   |    | 43 | 51  |
|               |  |            | 8       | SS   | 15         |                            | 95              |  |    |    |    |   | ○ |   |   |   |    |    |   |
| 94.1          |  |            |         |      |            |                            |                 |  |    |    |    |   |   |   |   |   |    |    |   |
| 9.8           | END OF BOREHOLE AT 9.8m.   |            |         |      |            |                            |                 |  |    |    |    |   |   |   |   |   |    |    |   |

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No FSU 16-01

2 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 739.0 E 323 000.5 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.08 - 2016.08.08 CHECKED BY RPR

| SOIL PROFILE |   |            | SAMPLES |      |            | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT |  |  |  |  | PLASTIC LIMIT<br>W <sub>p</sub> | NATURAL MOISTURE CONTENT<br>W | LIQUID LIMIT<br>W <sub>L</sub> | UNIT WEIGHT<br>γ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|--------------|---|------------|---------|------|------------|-------------------------|-----------------|--|--|--|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| ELEV DEPTH   | DESCRIPTION   | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                         |                 | SHEAR STRENGTH kPa                       |  |  |  |  |                                 |                               |                                |                  |                                       |
|              | Continued From Previous Page  |            |         |      |            |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |
|              | BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.5m, THEN CONCRETE AND ASPHALT TO SURFACE. |            |         |      |            |                         |                 |  |  |  |  |  |                                 |                               |                                |                  |                                       |



# RECORD OF BOREHOLE No FSU 16-02

1 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 749.0 E 323 000.2 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.08 - 2016.08.08 CHECKED BY RPR

| SOIL PROFILE  |  |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |  |  | UNIT<br>WEIGHT<br><br><b>γ</b><br><br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|---|---|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |  |  |   |   |
| 103.5         | GROUND SURFACE   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |   |   |
| 0.0           | ASPHALT: (200mm)   |            |         |      |            |                            |                 | 20 40 60 80 100                             |  |  |  |   |   |
| 0.2           | Gravelly <b>SAND</b> , some silt and clay<br>Compact<br>Brown to Grey<br>Moist<br>(FILL)       |            | 1       | SS   | 17         |                            | 103             |   |  |  |  |   |   |
|               |  |            | 2       | SS   | 11         |                            |                 |   |  |  |  |   |   |
| 102.1         |  |            |         |      |            |                            | 102             |   |  |  |  |   |   |
| 1.4           | Silty <b>CLAY</b> , trace sand, trace gravel<br>Stiff to Very Stiff<br>Grey<br>Moist<br>(TILL) |            | 3       | SS   | 9          |                            |                 |   |  |  |  |   |   |
|               |  |            | 4       | SS   | 12         |                            | 101             |   |  |  |  |   |   |
|               |  |            | 5       | SS   | 11         |                            | 100             |   |  |  |  |   |   |
|               |  |            |         |      |            |                            | 99              |   |  |  |  |   |   |
|               |  |            | 6       | SS   | 20         |                            | 98              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            | 97              |   |  |  |  |   |   |
|               |  |            | 7       | SS   | 23         |                            | 96              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            | 95              |   |  |  |  |   |   |
|               |  |            | 8       | SS   | 19         |                            | 94              |   |  |  |  |   |   |
|               |  |            |         |      |            |                            |                 |   |  |  |  |   |   |
|               |  |            | 9       | SS   | 8          |                            |                 |   |  |  |  |   |   |
| 93.7          | Stiff  |            |         |      |            |                            |                 |   |  |  |  |   |   |
| 9.8           | END OF BOREHOLE AT 9.8m.   |            |         |      |            |                            |                 |   |  |  |  |   |   |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No FSU 16-02

2 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 749.0 E 323 000.2 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.08 - 2016.08.08 CHECKED BY RPR

| 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  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               | BOREHOLE DRY UPON<br>COMPLETION OF DRILLING.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>AUGER CUTTINGS TO 0.2m, THEN<br>CONCRETE AND ASPHALT TO<br>SURFACE. |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |


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# RECORD OF BOREHOLE No FSU 16-03

1 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 678.8 E 322 997.8 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.09 - 2016.08.09 CHECKED BY RPR

| 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 | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%) |                   |  |
|---------------|--|--|---------|------|------------|----------------------------|-----------------|---|----|----|----|------------------------------------|-------------------------------------|-----------------------------------|-------------------------|---|-------------------|--|
| ELEV<br>DEPTH | DESCRIPTION  | STRAT PLOT   | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |    |    |    |                                    |                                     |                                   |                         |   | WATER CONTENT (%) |  |
| 104.4         | GROUND SURFACE   |  |         |      |            |                            |                 | 20  | 40 | 60 | 80 | 100                                |                                     |                                   |                         |   | GR SA SI CL       |  |
| 0.0           | ASPHALT: (100mm)   |  |         |      |            |                            |                 |   | 20 | 40 | 60 | 80                                 | 100                                 |                                   |                         |   |                   |  |
| 0.1           | CONCRETE: (400mm)  |  |         |      |            |                            |                 |   | 20 | 40 | 60 | 80                                 | 100                                 |                                   |                         |   |                   |  |
| 103.9         |  |  |         |      |            |                            | 104             |   |    |    |    |                                    |                                     |                                   |                         |   | 0 15 41 44        |  |
| 0.5           | Gravelly SAND<br>Compact<br>Grey<br>Moist<br>(FILL)              | 1  | SS      | 16   |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  | 2  | SS      | 30   |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
| 102.2         |  |  |         |      |            |                            | 103             |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
| 2.2           | Silty CLAY, some sand<br>Soft<br>Grey<br>Moist<br>(FILL)         | 3  | SS      | 2    |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  | 4  | SS      | 2    |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            | 102             |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            | 101             |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            | 100             |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               | Trace asphalt pieces<br>Very Stiff                               | 5  | SS      | 22   |            |                            | 99              |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
| 98.3          |  |  |         |      |            |                            | 98              |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
| 6.1           | Silty CLAY, trace sand<br>Very Stiff<br>Brown<br>Moist<br>(TILL) | 6  | SS      | 25   |            |                            | 97              |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            | 96              |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            | 95              |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |
|               |  |  |         |      |            |                            |                 |   |    |    |    |                                    |                                     |                                   |                         |   |                   |  |

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No FSU 16-03

2 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 678.8 E 322 997.8 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.09 - 2016.08.09 CHECKED BY RPR

| 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  |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               | BOREHOLE DRY UPON<br>COMPLETION OF DRILLING.<br>BOREHOLE BACKFILLED WITH<br>BENTONITE HOLEPLUG AND<br>AUGER CUTTINGS TO 0.5m, THEN<br>CONCRETE AND ASPHALT TO<br>SURFACE. |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |

# RECORD OF BOREHOLE No FSU 16-04

1 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 668.8 E 322 998.1 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.09 - 2016.08.09 CHECKED BY RPR

| SOIL PROFILE  |                                      |            | SAMPLES |      |            | GROUND WATER<br>CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION<br>RESISTANCE PLOT |  |                                    |                                     | UNIT<br>WEIGHT<br>$\gamma$<br>kN/m <sup>3</sup> | REMARKS<br>&<br>GRAIN SIZE<br>DISTRIBUTION<br>(%)<br>GR SA SI CL |           |
|---------------|--------------------------------------|------------|---------|------|------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|---|--|-----------|
| ELEV<br>DEPTH | DESCRIPTION                          | STRAT PLOT | NUMBER  | TYPE | "N" VALUES |                            |                 | SHEAR STRENGTH kPa                          |  |                                    |                                     |   |  |           |
| 104.3         | GROUND SURFACE                       |            |         |      |            |                            |                 | 20 40 60 80 100                             |  | PLASTIC<br>LIMIT<br>W <sub>P</sub> | NATURAL<br>MOISTURE<br>CONTENT<br>W | LIQUID<br>LIMIT<br>W <sub>L</sub>               |  |           |
| 0.0           | ASPHALT: (150mm)                     |            |         |      |            |                            |                 | 20 40 60 80 100                             |  | WATER CONTENT (%)                  |                                     |   |  |           |
| 0.2           | Gravelly SAND                        |            | 1       | SS   | 8          |                            | 104             |   |  |                                    |                                     |   |  |           |
| 103.8         | Loose                                |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
| 0.5           | Brown                                |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
| 103.6         | Moist                                |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
| 0.7           | (FILL)                               |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Silty CLAY, trace sand, trace gravel |            | 2       | SS   | 9          |                            | 103             |   |  |                                    |                                     |   |  |           |
|               | Firm                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Grey                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Moist                                |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | (FILL)                               |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Silty CLAY, trace sand, trace gravel |            | 3       | SS   | 14         |                            | 102             |   |  |                                    |                                     |   |  |           |
|               | Stiff to Very Stiff                  |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Grey                                 |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | Moist                                |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               | (TILL)                               |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            | 4       | SS   | 14         |                            | 102             |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            | 5       | SS   | 15         |                            | 101             |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            | 6       | SS   | 20         |                            | 100             |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            | 99              |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            | 7       | SS   | 25         |                            | 98              |   |  |                                    |                                     |   |  | 0 5 45 50 |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            | 97              |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            | 8       | SS   | 16         |                            | 96              |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |
|               |                                      |            |         |      |            |                            | 95              |   |  |                                    |                                     |   |  |           |
| 94.5          |                                      |            | 9       | SS   | 12         |                            |                 |   |  |                                    |                                     |   |  |           |
| 9.8           | END OF BOREHOLE AT 9.8m.             |            |         |      |            |                            |                 |   |  |                                    |                                     |   |  |           |

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No FSU 16-04

2 OF 2

METRIC

GWP# 2257-13-00 LOCATION First Street Underpass N 4 779 668.8 E 322 998.1 ORIGINATED BY OA  
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.09 - 2016.08.09 CHECKED BY RPR

| 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   |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |
|               | BOREHOLE DRY UPON<br>COMPLETION OF DRILLING.<br>Piezometer installation consists of<br>25mm diameter Schedule 40 PVC pipe<br>with a 1.52m slotted screen.<br><br>WATER LEVEL READINGS<br>DATE DEPTH(m) ELEV.(m)<br>2016.09.26 7.3 97.0 |            |         |      |            |                            |                 |   |  |  |  |  |                                    |                                     |                                   |  |  |



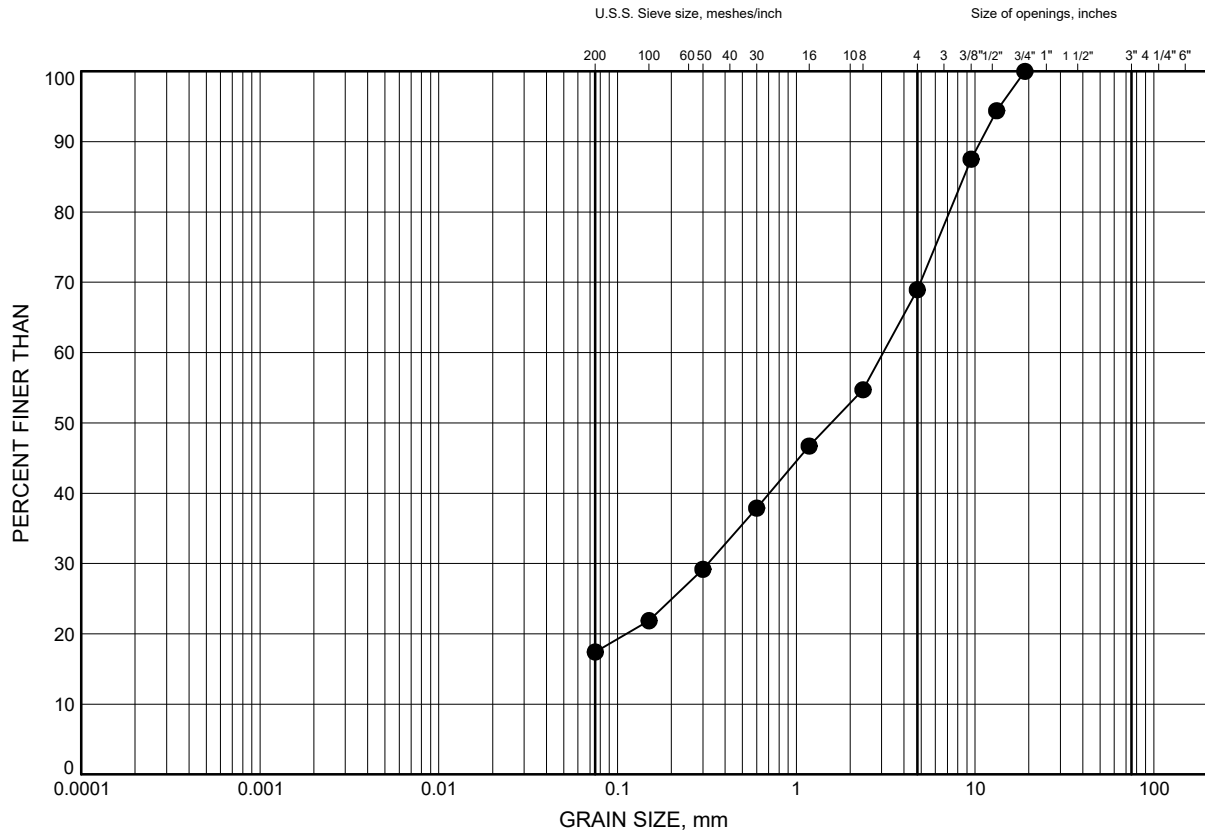
## **Appendix B**

### **Laboratory Test Results**

First Street Underpass  
GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND FILL



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

LEGEND

| SYMBOL | BOREHOLE  | DEPTH (m) | ELEV. (m) |
|--------|-----------|-----------|-----------|
| ●      | FSU 16-01 | 2.59      | 101.31    |

Date November 2016  
GWP# 2257-13-00



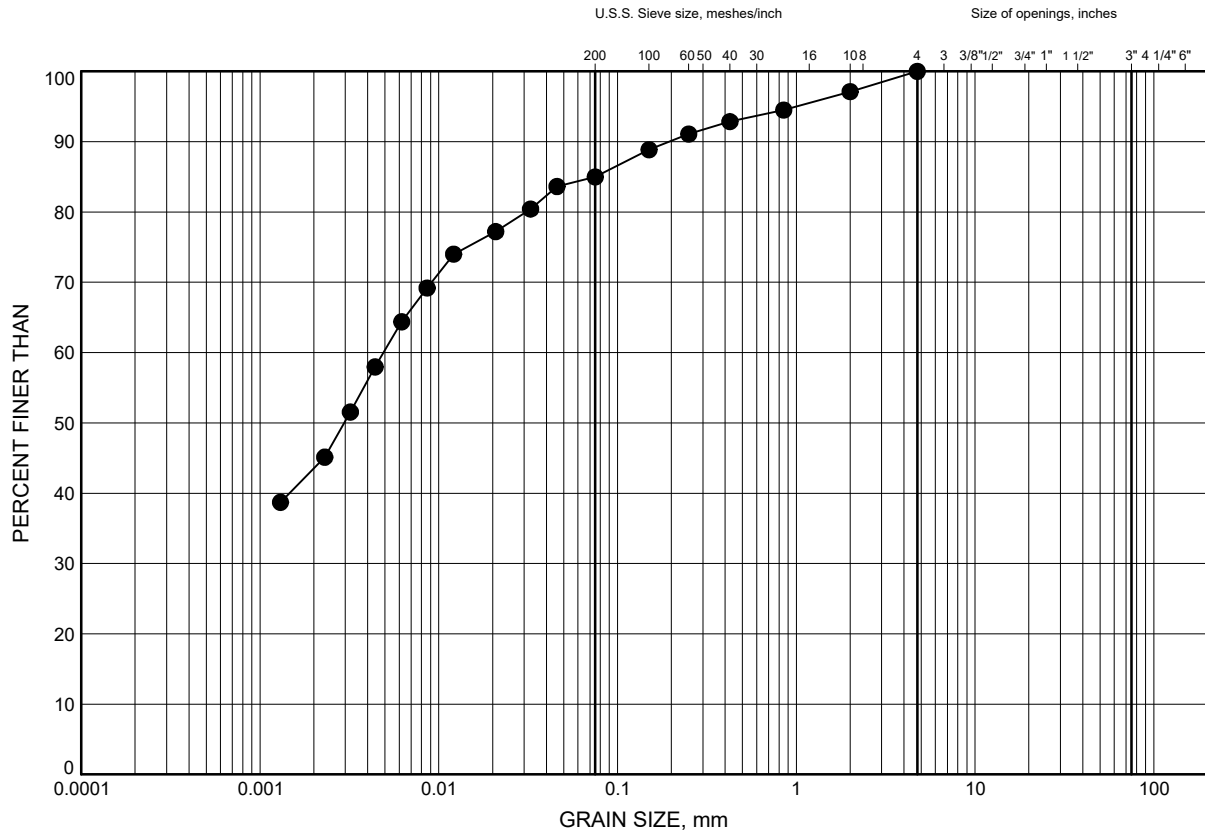
Prep'd AN  
Chkd. RPR



# First Street Underpass GRAIN SIZE DISTRIBUTION

FIGURE B2

## Silty CLAY FILL



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

### LEGEND

| SYMBOL | BOREHOLE  | DEPTH (m) | ELEV. (m) |
|--------|-----------|-----------|-----------|
| ●      | FSU 16-03 | 3.35      | 101.05    |

Date November 2016

GWP# 2257-13-00



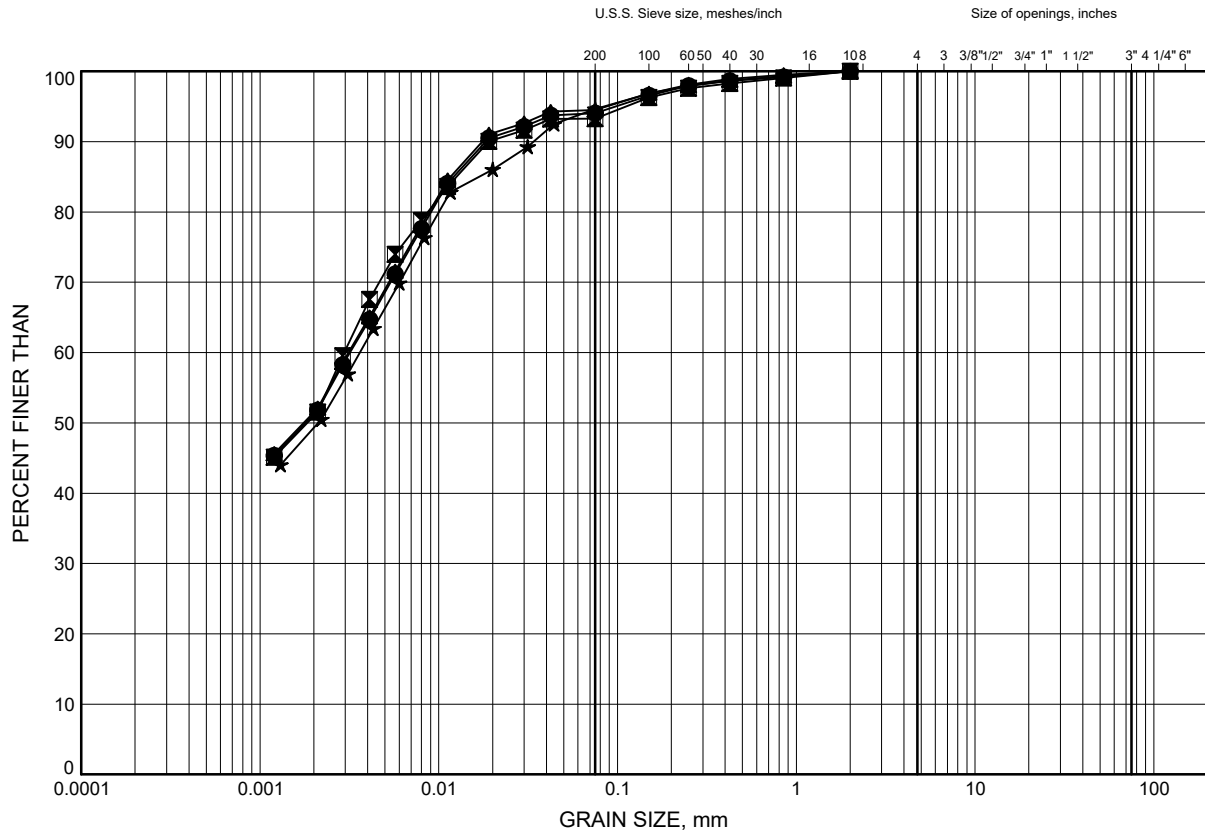
Prep'd AN

Chkd. RPR

# First Street Underpass GRAIN SIZE DISTRIBUTION

FIGURE B3

## Silty CLAY TILL



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

### LEGEND

| SYMBOL | BOREHOLE  | DEPTH (m) | ELEV. (m) |
|--------|-----------|-----------|-----------|
| ●      | FSU 16-01 | 6.40      | 97.50     |
| ⊠      | FSU 16-02 | 7.92      | 95.58     |
| ▲      | FSU 16-03 | 9.45      | 94.95     |
| ★      | FSU 16-04 | 6.40      | 97.90     |

Date November 2016

GWP# 2257-13-00



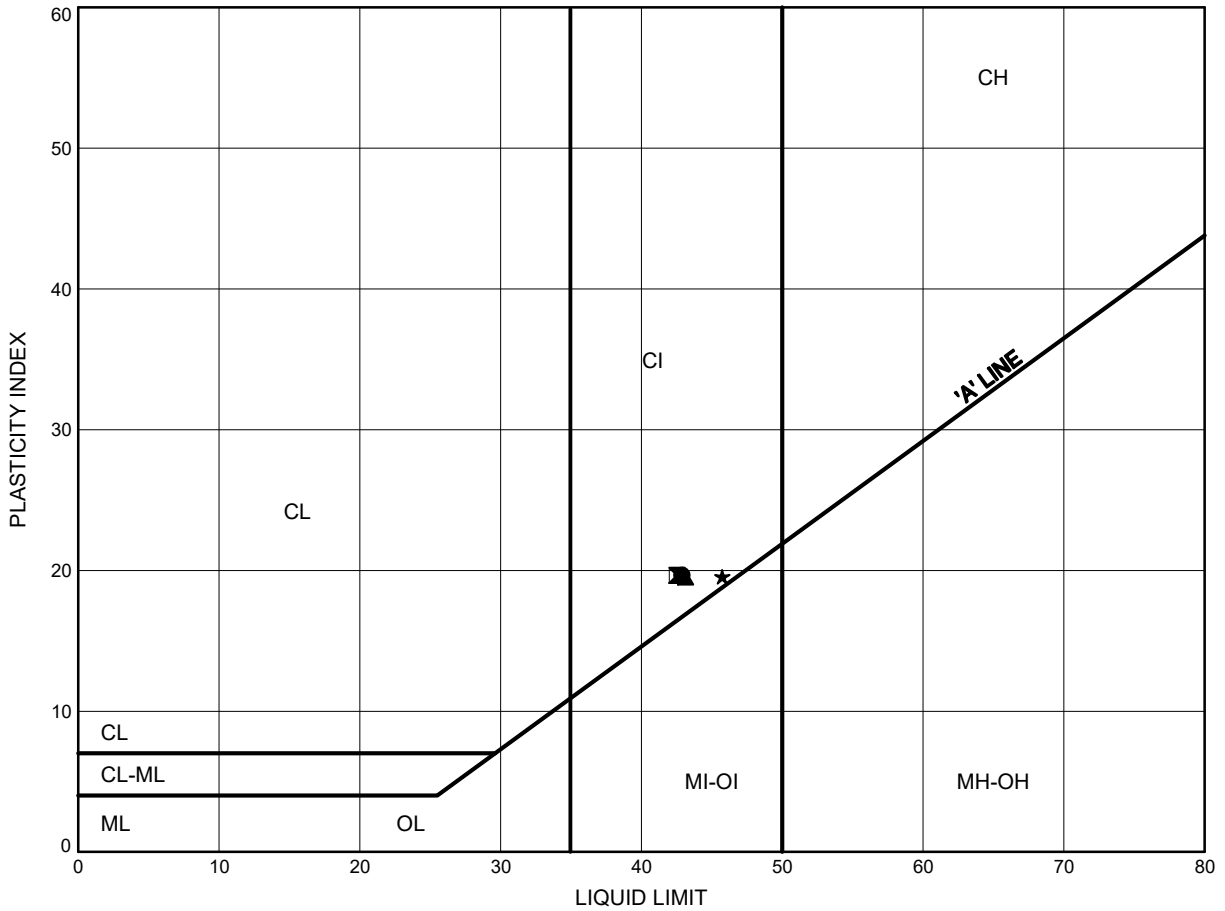
Prep'd AN

Chkd. RPR

First Street Underpass  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B4

Silty CLAY TILL



**LEGEND**

| SYMBOL | BOREHOLE  | DEPTH (m) | ELEV. (m) |
|--------|-----------|-----------|-----------|
| ●      | FSU 16-01 | 6.40      | 97.50     |
| ⊠      | FSU 16-02 | 7.92      | 95.58     |
| ▲      | FSU 16-03 | 9.45      | 94.95     |
| ★      | FSU 16-04 | 6.40      | 97.90     |

Date November 2016  
 GWP# 2257-13-00

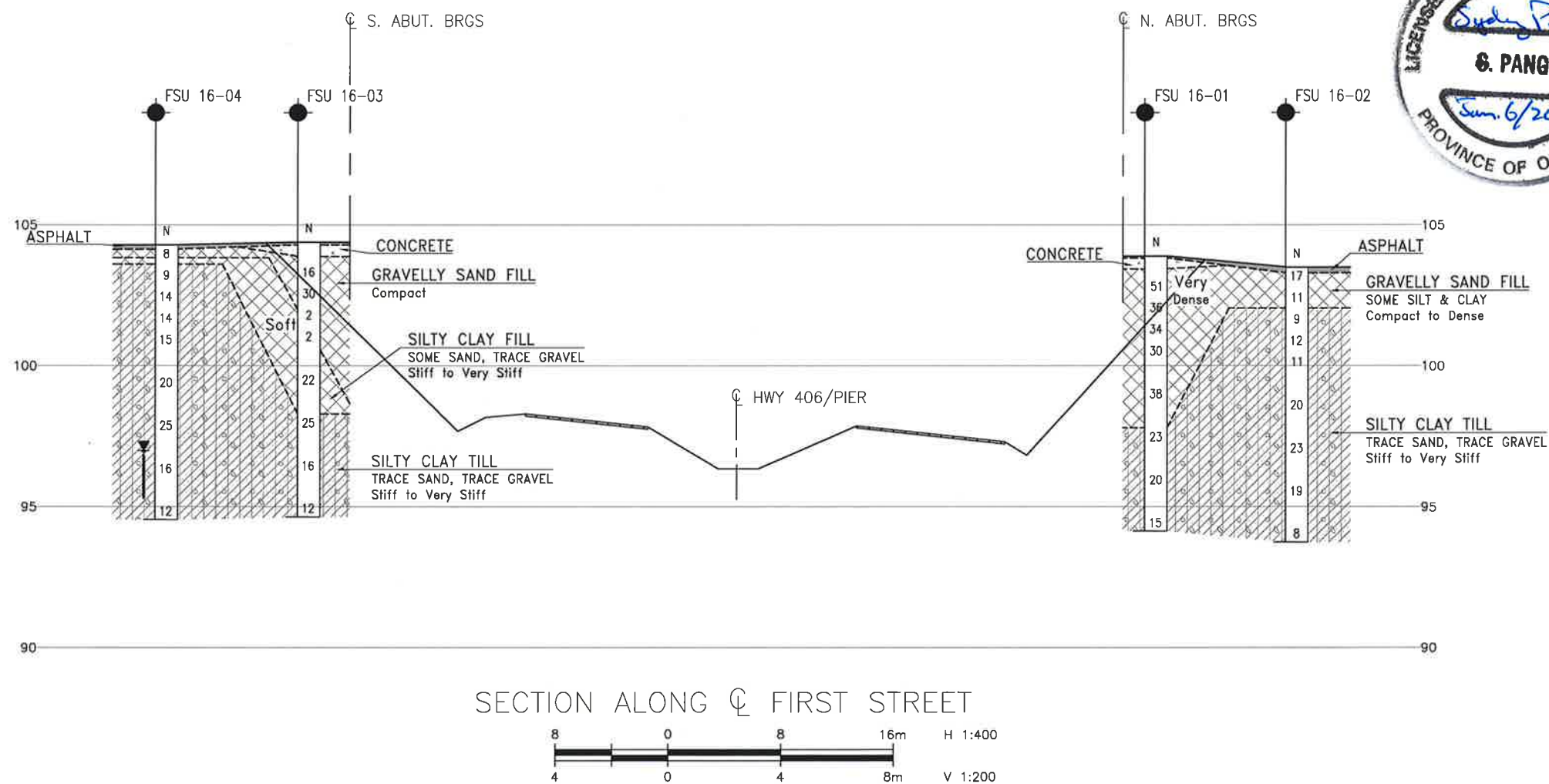
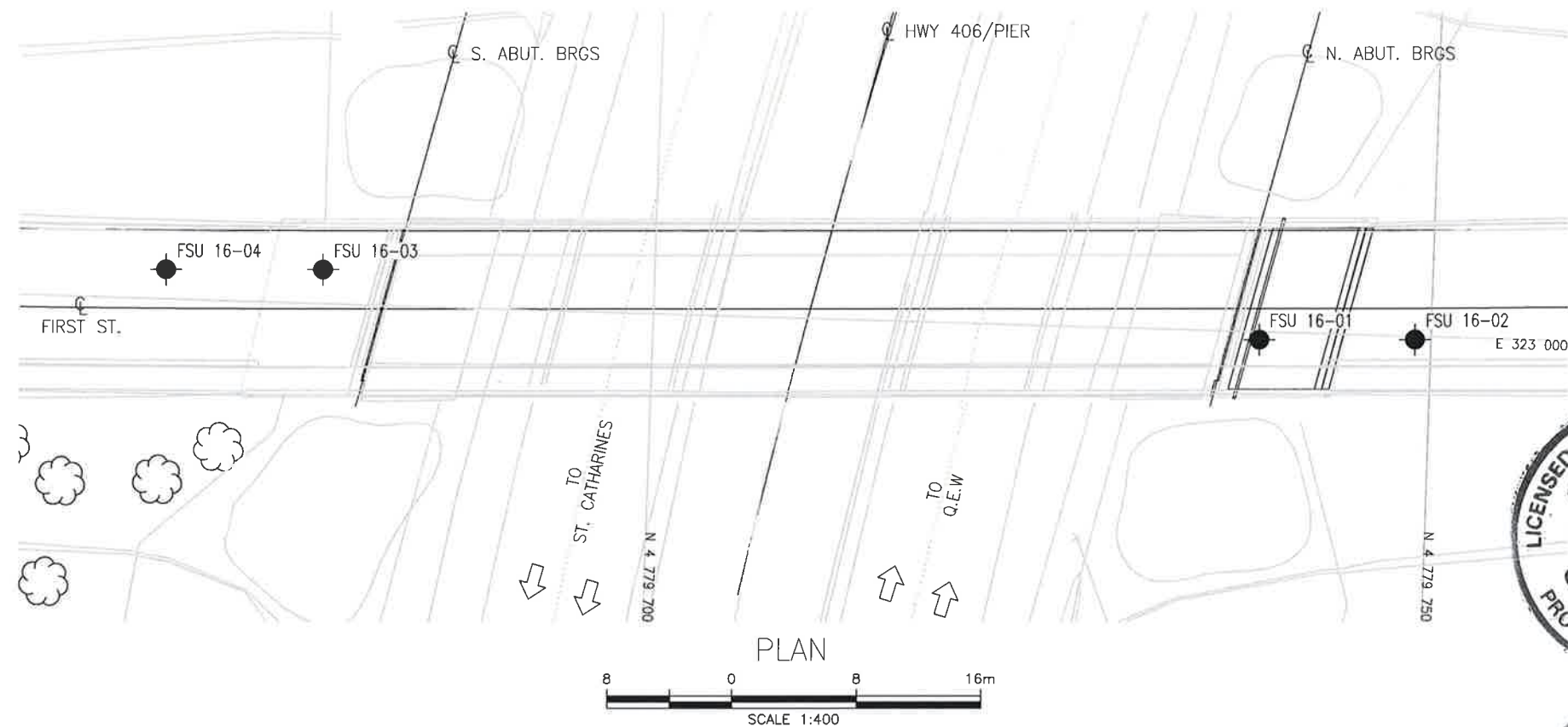


Prep'd AN  
 Chkd. RPR



## **Appendix C**

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



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

CONT No  
WP No 2257-13-00

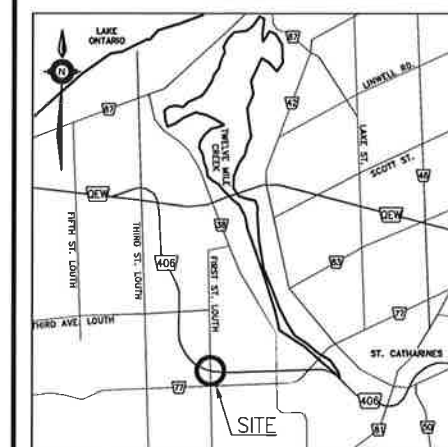
HIGHWAY 406  
FIRST STREET UNDERPASS  
BRIDGE REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA








**MMM GROUP**



**THURBER ENGINEERING LTD.**



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                         |

[illegible]

-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.

GEOCRES No. 30M3-291

| REV | DATE  |     | BY  |     | DESCRIPTION |        |      |          |
|-----|-------|-----|-----|-----|-------------|--------|------|----------|
|     | DATE  | RPR | CHK | SKP | CODE        | LOAD   | DATE | JAN 2017 |
|     | DRAWN | AN  | CHK | RPR | SITE        | STRUCT | DWG  | R2-22    |



## **Appendix D**

### **Selected Site Photographs**





**Photo 1. - East Side of First Street underpass at Highway 406**



**Photo 2.- Southeast quadrant of First Street underpass at Highway 406**



**Photo 3.- Northeast quadrant of First Street underpass at Highway 406**



**Photo 4. - Northwest quadrant of First Street underpass at Highway 406**





**Photo 5.- Southwest quadrant of First Street underpass at Highway 406**