



December 21, 2015

## FOUNDATION INVESTIGATION AND DESIGN REPORT

### TIFFIN STREET OVERPASS REPLACEMENT STRUCTURE SITE NO. 30-176/1 & 2 BARRIE, ONTARIO G.W.P. 2159-11-00

**Submitted to:**

Morrison Hershfield  
125 Commerce Valley Drive West, Suite 300  
Markham, Ontario  
L3T 7W4



**GEOCRES No. 31D-630**

**Report Number:** 1532543-1

**Distribution:**

- 1 Copy - Morrison Hershfield
- 3 Copies - MTO Central Region
- 1 Copy - MTO Foundations Section
- 1 Copy - Golder Associates Ltd.

REPORT





## Table of Contents

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

<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION.....</b>	<b>1</b>
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>1</b>
3.1 Previous Investigation by Others .....	1
3.2 Current Investigation.....	2
<b>4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS .....</b>	<b>3</b>
4.1 Regional Geology .....	3
4.2 Subsurface Conditions.....	3
4.2.1 Fill .....	3
4.2.2 Sand to Silt.....	4
4.2.3 Clayey Silt .....	4
4.3 Groundwater Conditions .....	5
<b>5.0 CLOSURE.....</b>	<b>6</b>

### **PART B – FOUNDATION DESIGN REPORT**

<b>6.0 DISCUSSION AND ENGINEERING RECOMMENDATION .....</b>	<b>7</b>
6.1 General.....	7
6.2 Foundation Options .....	7
6.2.1 Strip or Spread Footings .....	8
6.2.1.1 Frost Protection .....	8
6.2.1.2 Founding Elevations .....	8
6.2.1.3 Geotechnical Resistance .....	9
6.2.1.4 Resistance to Lateral Loads .....	10
6.3 Lateral Earth Pressures for Design.....	10
6.3.1 Seismic Considerations.....	11
6.3.1.1 Site Coefficient.....	11
6.3.1.2 Seismic Analysis Coefficient.....	11
6.4 Retained Soil System (RSS) Walls.....	12



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

6.5	Approach Embankments .....	12
6.5.1	Subgrade Preparation and Embankment Construction .....	12
6.5.2	Approach Embankment Settlement.....	12
6.5.3	Approach Embankment Stability .....	14
6.6	Design and Construction Considerations.....	15
6.6.1	Open-Cut Excavations .....	15
6.6.2	Temporary Protection Systems .....	15
6.6.3	Groundwater Control for Foundation Excavations .....	15
6.6.4	Subgrade Protection .....	15
<b>7.0</b>	<b>CLOSURE.....</b>	<b>16</b>

### REFERENCES

### DRAWINGS

Drawing 1	Highway 400 NBL – Tiffin Street Overpass, Borehole Locations and Soil Strata
Drawing 2	Highway 400 SBL – Tiffin Street Overpass, Borehole Locations and Soil Strata
Drawing 3	Highway 400 NBL and SBL – Tiffin Street Overpasses, Soil Strata

### FIGURES

Figure 1	Static Slope Stability Analysis – Widened/Raised Highway 400 SBL Embankment – Station 29+700
----------	--

### APPENDIX A Borehole Records

Lists of Abbreviations and Symbols  
Records of Boreholes 15-1 to 15-5, F1 to F4, and HF4

### APPENDIX B Geotechnical Laboratory Test Results

Figure B1	Grain Size Distribution – Silty Sand to Sand Fill
Figure B2	Grain Size Distribution – Silty Sand to Sand
Figure B3	Grain Size Distribution – Silt to Sandy Silt
Figure B4	Grain Size Distribution – Clayey Silt
Figure B5	Plasticity Chart – Clayey Silt to Silty Clay

### APPENDIX C Non-Standard Special Provisions



# **PART A**

**FOUNDATION INVESTIGATION REPORT  
HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT  
BARRIE, ONTARIO  
G.W.P. 2159-11-00**



### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services to support the detail design for the proposed replacement of the Highway 400-Tiffin Street overpasses in the City of Barrie. This report addresses the foundation investigation carried out for the proposed construction of the following structures:

- New overpass structure that will permit the Highway 400 Northbound Lanes (NBL) to cross over the widened Tiffin Street corridor.
- Replacement of the existing overpass structure for the Highway 400 Southbound Lanes (SBL) to cross over the widened Tiffin Street corridor.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed replacement structures, approach embankments and wing walls, by means of a limited borehole investigation and geotechnical laboratory testing on selected samples.

Golder has completed the foundation engineering services in accordance with Proposal No. GEOTETOB22161AA, dated March 13, 2015, originally provided to MH by Coffey Geotechnics Inc. (Coffey).

### 2.0 SITE DESCRIPTION

The existing overpass structure carrying Highway 400 over Tiffin Street is located between the Dunlop Street and Essa Road interchanges, in Barrie, Ontario, at the location shown on the Key Plan on Drawing 1.

This portion of Highway 400, including the existing Tiffin Street overpass, was built between 1950 and 1955. The existing structure consists of a 15.5 m long, single-span, concrete rigid frame structure supported on spread footings. The overpass carries six lanes of Highway 400 traffic. The existing overpass structure is approximately 30 m wide and currently lies at a 22.5 degree skew to the Highway 400 centreline.

At the site, Tiffin Street is two lanes wide where it passes beneath Highway 400; the highway is constructed on fill / raised embankments. The existing Highway 400 / Tiffin overpass structure surface level is at about Elevation 240.5 m; the new Highway 400 grade at the north and south abutments is proposed to be at about Elevation 243.5 m, requiring a grade raise of approximately 3 m.

### 3.0 INVESTIGATION PROCEDURES

#### 3.1 Previous Investigation by Others

Coffey completed a preliminary foundation investigation for the Highway 400 / Tiffin Street overpass structures involving the advancement of a total of four boreholes (F1, F2, F3 and F4) in October 2014; the records for these boreholes are provided in Appendix A. The locations of these boreholes are shown on Drawings 1 and 2.

Boreholes F1 and F2 were advanced as part of the SBL overpass structure investigation; Boreholes F3 and F4 were advanced as part of the new NBL overpass structure investigation.



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

The results of the MTO investigation are presented in Coffey's Preliminary Foundation Investigation and Design Report (GEOCRES No. 31D-587), dated February 2015.

### 3.2 Current Investigation

The field work for the subsurface investigation for the Highway 400 / Tiffin Street overpass structures was carried out between June 25 and July 13, 2015, during which time a total of six boreholes were advanced using a track-mounted drill rig, supplied and operated by specialist drilling subcontractors. The locations of the six boreholes advanced at the NBL and SBL structures are shown on Drawings 1 and 2.

The boreholes were advanced to depths ranging from 10.1 m to 19.8 m below existing ground surface using hollow stem auger drilling methods. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure. Each of the boreholes was terminated at the depths provided in the Coffey proposal, in order to avoid penetrating into a trichloroethylene (TCE) plume that is present in the vicinity of the site.

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations, and monitoring wells were installed in three boreholes (Boreholes 15-2, 15-4 and HF4) to permit monitoring of the groundwater levels at these locations. The monitoring wells consist of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within the borehole. The monitoring well installation details and water level readings are indicated on the borehole records contained in Appendix A. All remaining boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's staff who observed the drilling, sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water contents, Atterberg limits and grain size distributions were carried out on selected soil samples.

The borehole locations and ground surface elevations were obtained from the digital terrain model provided by MH. The borehole locations, including MTM NAD83 and UTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized below and are shown on Drawings 1 and 2.

Borehole No.	NAD83 MTM Zone 10 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
15-1	4914534.5	288258.2	240.5	19.8
15-2	4914565.9	288247.2	239.8	19.8
15-3	4914544.2	288286.9	240.7	19.8
15-4	4914580.1	288286.1	233.6	14.0
15-5	4914575.3	288233.7	239.5	13.7
HF4	4914537.7	288309.6	236.5	10.1



## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

This section of Highway 400 lies within the Simcoe Lowlands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, Third Edition, 1984). The soil deposits are typically interlayered, non-cohesive sand and silt layers, with occasional cohesive clayey silt to silty clay layers.

### **4.2 Subsurface Conditions**

The detailed soil and groundwater conditions encountered in the boreholes, and the results of in situ and geotechnical laboratory testing, are summarized on the borehole records in Appendix A. The results of the laboratory tested samples from Golder's current borehole investigation are shown on Figures B1 to B5 in Appendix B. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile and cross sections on Drawings 1, 2, and 3 are inferred from non-continuous sampling and, therefore, represent the transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole location.

In summary, the subsoils encountered in the boreholes consist of fill overlying interlayered native strata comprised of silt, sand, and clayey silt. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **4.2.1 Fill**

An approximately 100 mm to 400 mm thick layer of asphalt was encountered immediately below the ground surface in Boreholes 15-1 to 15-3, 15-5, F1, F2 and F4.

Each of the boreholes encountered fill materials of variable composition and thickness. As boreholes were advanced from the Highway 400 embankment grade, as well as at the Tiffin Street level, the elevations of the surface of the fill materials are variable. The elevations of the surface and base of the fill and the thickness of the fill materials as encountered in the boreholes are summarized below.

<b>Borehole No.</b>	<b>Fill Surface Depth</b>	<b>Fill Surface Elevation</b>	<b>Fill Thickness</b>	<b>Base of Fill Elevation</b>
15-1	0.3 m	240.2 m	6.9 m	233.3 m
15-2	0.1 m	239.7 m	8.6 m	231.1 m
15-3	0.3 m	240.4 m	9.9 m	230.5 m
15-4	0.0 m	233.6 m	2.2 m	231.4 m
15-5	0.4 m	239.1 m	9.8 m	229.2 m
HF-4	0.0 m	236.5 m	3.9 m	232.6 m
F1	0.2 m	240.6 m	7.0 m	233.4 m
F2	0.4 m	239.1 m	5.0 m	234.1 m
F3	0.0 m	234.1 m	1.4 m	232.7 m
F4	0.2 m	239.7 m	7.0 m	232.7 m





## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

The fill materials vary in composition from gravelly sand containing some silt and trace clay, to silty sand containing trace to some gravel. Clayey silt to silty clay layers were observed in Boreholes 15-3 and 15-5 from the current investigation, as well as in Borehole F1. Organics were found between 5.6 m and 7.2 m depth in Boreholes 15-1 and 15-2, as well as in Borehole F3. The results of grain size distribution tests completed on two selected samples of the fill from the current investigation are shown on Figure B1.

The measured Standard Penetration Test (SPT) “N”-values within the non-cohesive fill materials range from 3 blows to 74 blows per 0.3 m of penetration, indicating that the fill materials are very loose to very dense, but typically compact. The measured SPT “N”-value within the clayey silt to silty clay fill layers in Boreholes 15-5 and F1 range from 8 blows to 14 blows per 0.3 m of penetration, suggestive of a stiff consistency.

### 4.2.2 Sand to Silt

A deposit of sand to silt was encountered below the fill in Boreholes 15-1 to 15-4, HF4, and F1 to F4, and below an upper clayey silt layer in Borehole 15-5. The deposit varies in composition from sand containing some silt, to silty sand, to sandy silt, to silt containing trace to some sand, with variable amounts of gravel and trace clay. The results of grain size distribution tests carried out on three selected samples of the sand to silty sand portions of the deposit from the current investigation are shown on Figure B2, and the results of grain size distribution tests carried out on seven selected samples of the silt to sandy silt portions of the deposit are shown on Figure B3 in Appendix B.

The elevations of the surface and base of the sand to silt deposit and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Sand to Silt Surface Depth	Sand to Silt Surface Elevation	Sand to Silt Thickness	Sand to Silt Base Elevation
15-1	7.2 m	233.3 m	11.5 m	221.8 m
15-2	8.7 m	231.1 m	7.7 m	223.4 m
15-3	10.2 m	230.5 m	8.8 m	221.7 m
15-4	2.2 m	231.4 m	9.5 m	221.9 m
15-5	11.7 m	227.7 m	>2.0 m	Below 225.7 m
HF4	3.9 m	232.6 m	>6.2 m	Below 226.4 m
F1	7.2 m	233.4 m	>8.6 m	Below 224.8 m
F2	5.4 m	234.1 m	>10.4 m	Below 223.7 m
F3	1.4 m	232.7 m	>8.3 m	Below 224.4 m
F4	7.2 m	232.7 m	>8.6 m	Below 224.1 m

The measured SPT “N”-values in the sand to silt deposit range from 7 blows to 42 blows per 0.3 m of penetration, indicating this deposit is loose to dense material, but typically compact to dense.

### 4.2.3 Clayey Silt

An upper layer of clayey silt was encountered underlying the fill in Borehole 15-5, and a lower layer of clayey silt to silty clay was encountered below the sand to silt deposit in Boreholes 15-1 to 15-4. Boreholes 15-1 to 15-4





## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

were terminated in the lower clayey silt deposit. The elevation of the surface and base of the deposit and the thickness of the stratum as encountered in the boreholes are summarized below.

Borehole No.	Clayey Silt to Silty Clay Surface Depth	Clayey Silt to Silty Clay Surface Elevation	Clayey Silt to Silty Clay Thickness	Clayey Silt to Silty Clay Base Elevation
15-1	18.7 m (Lower)	221.8 m	>1.1 m	Below 220.7 m
15-2	16.3 m (Lower)	223.4 m	>3.5 m	Below 219.9 m
15-3	19.1 m (Lower)	221.7 m	>0.8 m	Below 220.9 m
15-4	11.7 m (Lower)	221.9 m	>2.4 m	Below 219.5 m
15-5	10.2 m (Upper)	229.2 m	1.5 m	227.7 m

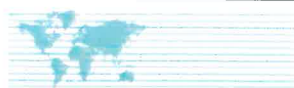
The measured SPT "N"-values within the clayey silt to silty clay deposit range from 9 blows to 37 blows per 0.3 meters of penetration, suggesting a stiff to hard consistency.

The results of a grain size distribution test completed on one selected samples of the clayey silt to silty clay deposit is shown on Figure B4 in Appendix B. Atterberg limits testing was carried out on one selected sample of the deposit and measured a plastic limit of 15 per cent, a liquid limit of 19 per cent and a plasticity index of 4 per cent. This result, which is plotted on the plasticity chart on Figure B5 in Appendix B, confirms that the tested sample of the deposit consists of clayey silt of low plasticity.

### 4.3 Groundwater Conditions

The observed water levels in the open boreholes following completion of drilling, and the water levels measured the three piezometers installed at this site, are summarized in the following table. The table also provides the groundwater elevations in Borehole F3, which was installed by Coffey Geotechnics Inc. as part of the preliminary investigation at this site.

Bridge Structure	Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement	Notes
SBL	South Abutment	15-1	240.5	226.8	June 29, 2015	Open Borehole
	North Abutment	15-2	239.8	230.7 230.1	June 25, 2015 November 8, 2015	Open Borehole Monitoring Well
	North Approach	15-5	239.5	236.0	June 29, 2015	Open Borehole
NBL	South Abutment	15-3	240.7	232.9	June 28, 2015	Open Borehole
		F3	234.1	229.7	November 6, 2015	Monitoring Well
	North Abutment	15-4	233.6	227.0 229.6 229.5	July 13, 2015 August 11, 2015 November 6, 2015	Open Borehole Monitoring Well Monitoring Well



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

Bridge Structure	Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement	Notes
	South Approach	HF4	236.5	228.0 231.7 231.6	July 7, 2015 August 11, 2015 November 6, 2015	Open Borehole Monitoring Well Monitoring Well

The groundwater level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and other wet periods of the year.

### 5.0 CLOSURE

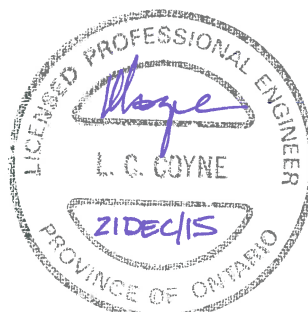
This Foundation Investigation Report was prepared by Mr. Nick La Posta, P. Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder.

#### GOLDER ASSOCIATES LTD.



Nick La Posta, P. Eng.  
Geotechnical Engineer

NL/LCC/sm



Lisa Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

\\golder.gds\gal\barrie\active\2015\3 proj\1532543 mh\_mto-hwy400&tiffin street\_barrie\report\foundations\1 - tiffin overpass\1532543 rpt01 2015-12-21 tiffin-hwy 400 foundations final.docx



# **PART B**

**FOUNDATION DESIGN REPORT  
HIGHWAY 400- TIFFIN STREET OVERPASS REPLACEMENT  
BARRIE, ONTARIO  
G.W.P. 2159-11-00**



## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATION**

### **6.1 General**

This section of the report provides foundations engineering recommendations for the detail design of the Highway 400-Tiffin Street overpass structure replacement.

The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation, supplemented with boreholes advanced during the preliminary geotechnical investigation by Coffey. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the detail design of the structure foundations and approach embankments. Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### **6.2 Foundation Options**

The existing Tiffin Street overpass structure was built between 1950 and 1955 and is a 15.5 m long, single-span concrete rigid frame structure supported on spread footings. The overpass carries six active lanes of Highway 400 traffic above Tiffin Street. The existing overpass structure is approximately 30 m wide and currently lies at a 22.5 degree skew to the Highway 400 centreline. It is understood that the existing Tiffin Street overpass structure will be replaced with twin three-lane structures, each with a clear span of 26.1 m in order to accommodate the anticipated future expansion of Tiffin Street by the City of Barrie. The new northbound structure will be built to the east of the existing structure, which will be demolished; the southbound structure will then be replaced at its existing location.

Based on the General Arrangement (GA) drawings provided by MH on August 12, 2015, the existing Highway 400 grade at the overpass structure is at about Elevation 240.5 m, and the spread footings supporting the single-span overpass structure are founded below the Tiffin Street grade at about Elevation 233.0 m. The new Highway 400 grade at the north and south abutments is proposed to be at approximately Elevation 243.5 m, requiring a grade raise of approximately 3 m, and resulting in approach embankments that are up to approximately 10 m in height. Retaining walls will be required adjacent to the abutments to support the sides of the Highway 400 northbound and southbound embankments.

It is understood that a trichloroethylene (TCE) plume exists in the vicinity of the Highway 400 / Tiffin overpass structure. Details regarding the TCE plume, as well as potential risks and design recommendations, are detailed in three Morrison Hershfield reports:

- TCE Plume Risk Assessment Report No. 1 – Structural and Geotechnical Field Investigations, dated April 2014
- TCE Plume Risk Assessment Report No. 2 – Design Alternatives, dated September 2014
- TCE Plume Risk Assessment Report No. 3 – Construction Methods, dated January 2015



A review of these reports indicates that excavations for the foundations should not extend below the water table, indicated in the reports as 4.5 m below the existing Tiffin Street grades (Elevation 230.5 m). **Further, deep foundation systems (piles, caissons, etc.) are not considered feasible due to the potential for intercepting the TCE plume.** As such, the overpass structures must be supported on shallow foundations; the associated retaining walls may also be supported on shallow foundations, or may be constructed as retained soil system (RSS) walls.

### 6.2.1 Strip or Spread Footings

#### 6.2.1.1 Frost Protection

All footings should be founded at a minimum depth of 1.5 m below lowest surrounding grade, or provided with an equivalent thickness of insulation for frost protection, in accordance with Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*). As a guide, the MTO has adopted 25 mm (1 inch) of rigid polystyrene foam insulation as equivalent to 0.3 m reduction in soil cover.

#### 6.2.1.2 Founding Elevations

Spread footings for support of the new overpasses and associated wingwalls/concrete retaining walls should be founded below any existing fill materials, on the generally compact to dense sand to silt deposit, or on compacted granular fill following subexcavation and replacement of any loose fill materials. In general, the fill materials encountered in the boreholes in the vicinity of the new abutments extend to approximately Elevation 232.6 m or higher. However, in Borehole 15-2 near the north abutment for the SBL overpass, dense silty sand to sand fill was encountered extending to about Elevation 231.1 m; in Borehole 15-3 near the south abutment for the NBL overpass, very dense silty sand to sand fill was encountered extending to about Elevation 230.5 m; and in Borehole 15-4 near the north abutment for the NBL overpass, compact sand to silty sand fill was encountered extending to about Elevation 231.4 m.

As noted above, excavations for the footings are recommended from an environmental perspective to remain above the groundwater level at the site, to avoid requirements for dewatering that could impact the mobility of the TCE plume. The groundwater level was observed to be around approximately Elevation 230.0 m to 230.4 m in Coffey's open boreholes during the preliminary investigation in October 2014. In Golder's August 2015 investigation, the water level was measured in one monitoring well near the north abutment for the NBL overpass at Elevation 229.6 m; however, the water level was also measured in a monitoring well in Borehole HF4, at the south approach to the new northbound structure, at Elevation 231.7 m, and wet soils were observed above Elevation 230 m in other boreholes as part of the current investigation. The most recent groundwater level measurements in the monitoring wells indicate that the groundwater elevations in November 2015 ranged between Elevation 229.5 m to Elevation 229.6 m at the NBL structure, Elevation 230.1 m at the SBL structure, and Elevation 231.6 m at the south approach for the NBL structure.

It is therefore recommended that foundation excavations be maintained above approximately Elevation 232 m to avoid a requirement for dewatering to maintain a stable subgrade either for forming and pouring the concrete footings, or for placement and compaction of any granular fill materials below the new footings. Based on the above considerations, the following table summarises the recommended maximum (highest) founding elevations for strip or spread footings for support of the abutments and associated wing walls for both structures. Because of the potential for variability in the fill in the vicinity of Boreholes 15-2 and 15-3, it is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to amend OPSS 902 (Excavation



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

and Backfilling for Structures), to require inspection of the footing subgrade and removal of any softened/loosened or deleterious materials; the NSSP will limit such subexcavation to a maximum depth of 0.5 m below the subgrade level.

Structure	Foundation Element	Reference Borehole Nos.	Founding Stratum	Founding Elevation
NBL Overpass	North Abutment	15-4 F4	Compact silt to silty sand/Compact sand to silty sand fill	232.5 m
	South Abutment	15-3 F3	Compact to dense silty sand/Very dense sand to silty sand fill	232.5 m
SBL Overpass	North Abutment	15-2 F2	Compact sandy silt to silty sand	232.5 m
	South Abutment	15-1 F1	Compact sand to silty sand	232.5 m

### 6.2.1.3 Geotechnical Resistance

For 6 m wide concrete footings founded at the elevations given in Section 6.2.1.2, the factored axial geotechnical resistance at Ultimate Limit States (ULS) may be taken as 525 kPa. The geotechnical resistance at Serviceability Limit States (SLS), for 25 mm of settlement, may be taken as 300 kPa.

These design values take into account the depth of footing embedment relative to the Tiffin Street grade. The geotechnical resistances provided are dependent on the footing size, configuration and applied loads; therefore, the geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from the values given above.

The geotechnical resistances provided above are given for loadings that will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC)*, using the curves for cohesive soils and non-cohesive soil.

The base of each footing excavation should be cleaned of loose / softened material. It is recommended that the founding level for the footings be inspected by geotechnical personnel immediately prior to pouring concrete to confirm the adequacy of the foundation conditions for the above-noted geotechnical resistances. If the concrete for the footings cannot be poured immediately after excavation and inspection, it is recommended that a concrete working slab (100 mm thickness of 20 MPa compressive strength concrete) be placed on the subgrade within four hours to protect the integrity of the bearing stratum. This requirement can either be added as a note on the Contract Drawings or included as an NSSP in the Contract Documents. A sample NSSP is included for this item in Appendix C.



#### **6.2.1.4 Resistance to Lateral Loads**

Resistance to lateral forces / sliding resistance between the concrete footings and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed on a concrete working slab that is cast on top of the compact to dense granular soils, the coefficient of friction,  $\tan \delta$  or  $\phi'$ , can be taken as follows:

- Cast-in-place footing to concrete working slab:  $\tan \delta = 0.7$
- Cast-in-place concrete working slab to sand to silty sand:  $\tan \phi' = 0.58$

### **6.3 Lateral Earth Pressures for Design**

The lateral earth pressures acting on the abutment stems and any associated wing walls/ retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the walls. It should be noted that these design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free-draining granular fill in accordance with OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub drains and frost taper should be in accordance with OPSD 3101.150 (*Wall, Abutments, Backfill*) and OPSD 3121.150 (*Walls, Retaining, Backfill*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS.PROV 501. Other surcharge loadings should be accounted for in the design as required.
- For restrained structures, the granular fill may be placed in a zone with the width equal to at least 1.5 m behind the back of the walls (Figure C6.20 (a) of the *Commentary* to the *CHBDC*). For unrestrained structures, the granular fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Figure C6.20 (b) of the *Commentary* to the *CHBDC*).
- For restrained structures, the pressures are based on the existing and/or proposed Highway 400 embankment fill materials and the following parameters (unfactored) may be used assuming the use of granular earth fill such as SP 110S13 (Aggregates) Select Subgrade Material (SSM) for embankment construction:





## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

Unfactored Parameters		Earth Fill
Soil unit weight:		21 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:	At rest, $K_o$	0.47
	Active, $K_a$	0.31

- For unrestrained structures, where the pressures are based on OPSS.PROV 1010 granular fill behind the wall, the following parameters (unfactored) may be assumed:

Unfactored Parameters		Granular A	Granular B Type II
Soil unit weight:		22 kN/m <sup>3</sup>	22 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:	At rest, $K_o$	0.43	0.43
	Active, $K_a$	0.27	0.27

If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the abutment support does not allow lateral yielding (such as for a rigid frame structure), at-rest earth pressures should be assumed for geotechnical design. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the *Commentary* to the *CHBDC*.

### 6.3.1 Seismic Considerations

#### 6.3.1.1 Site Coefficient

For seismic design purposes, the Site Coefficient,  $S$ , for this site, based on experience and considering the guidelines in Section 4.4.6 of the *CHBDC* may be taken as 1.2, consistent with Soil Profile Type II.

#### 6.3.1.2 Seismic Analysis Coefficient

The potential for seismic (earthquake) loading may also need to be considered for the design of abutment stems/wing walls/retaining walls and for the assessment of liquefaction potential of foundation soils in accordance with Section 4.6 of the *CHBDC*, as significant seismic loading will result in increased lateral earth pressures acting on the abutment stem and retaining walls.

According to Table A3.1.1 of the *CHBDC*, this site is located in Seismic Zone 1. The site-specific zonal acceleration ratio for Barrie is 0.05. Based on experience, for the subsurface conditions at this site, a 20 percent amplification of the ground motion may occur (i.e. Site Coefficient,  $S=1.2$  for Soil Profile II from Table 4.4 of *CHBDC*), resulting in an increase in the peak horizontal ground acceleration (PHA) from 0.05 g to 0.06 g at the ground surface. Based on Section 4.4.4 of the *CHBDC*, this bridge structure is assigned Seismic Performance Zone 1. Given this, and in accordance with Section 4.4.5.2 of the *CHBDC* (single-span bridges), no seismic analysis is required for structures located in Seismic Performance Zone 1.



## **6.4 Retained Soil System (RSS) Walls**

Geotechnical/foundation design recommendations for retained soil system (RSS) walls adjacent to the abutments are addressed in the Foundation Investigation and Design Report for retaining walls for this project, for consistency along the full length of the walls.

## **6.5 Approach Embankments**

As noted above, a new northbound overpass structure is to be constructed to the east of the existing highway, requiring construction of a new embankment to support the northbound lanes. As per the GA drawings, the top of pavement at the proposed NBL bridge approach embankments is about Elevation 243.5 m. The existing site grades in the area of the proposed approach embankments for the structure, as measured in Borehole HF4 (south of the proposed overpass) and Borehole 15-4 (north of the proposed overpass) were elevation 236.5 m and elevation 233.6 m, respectively. As such, the construction of the north and south approach embankment areas will require raising the grades by as much as about 10 m above existing grades.

It is anticipated that as part of the reconstruction of the SBL overpass, the existing embankment grades will be raised by about 3 m to achieve the proposed pavement grade.

### **6.5.1 Subgrade Preparation and Embankment Construction**

It is recommended that all topsoil/organic material or loose materials present within the footprint of the new northbound Highway 400 approach embankments be stripped prior to placement of new embankment fill. Detailed excavation/founding levels are provided in Golder's Foundation Investigation and Design Report for the embankment widening and retaining walls.

The approach embankment fill for the new northbound lanes and for the grade raise for the southbound lanes should be placed and compacted in accordance with OPSS.PROV 206 (Earth Excavation and Grading) and OPSS.PROV 501 (Compacting). Benching of the east side of the existing embankment should be carried out to "key in" the new fill materials for the northbound lane embankment to the existing fill materials, in accordance with OPSD 208.010 (Benching of Earth Slopes). For the SBL embankment, if and where the vertical height of the embankment exceeds 8 m, a 2 m wide, mid-height bench should be incorporated into the widened embankment side slope to mitigate erosion on the slope face.

### **6.5.2 Approach Embankment Settlement**

Settlement of the proposed Highway 400 approach embankments will occur due to the additional loading, from the new embankment construction at the NBL structure, and the 3 m grade raise at the SBL structure.

Analyses were performed using the commercially available software program "Settle3D" produced by Rocscience Inc. to estimate the settlement of the foundation soils underlying the proposed approach embankments. The maximum fill thickness modelled at the NBL approach embankment was 10 m; the maximum additional fill thickness modelled at the SBL approaches was 3 m.

The values of the parameters used in the analyses of settlement for both the NBL and SBL approach embankments as given below are based on field and laboratory test data and correlations suggested by Bowles (1984) from the soil conditions encountered in Boreholes 15-1, 15-4, 15-5, and HF4, as well as engineering judgement. An average groundwater level of Elevation 230.0 m was used in the model.



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

Approach Embankment	Soil Layer	Approx. Thickness (m)	Bulk Unit Weight (kN/m <sup>3</sup> )	Young's Modulus, E (MPa)
NBL North Embankment 15-4	Loose to very dense silty sand to sand fill	2	19	15
	Compact to dense silt to silty sand	9.5	19	25
	Very stiff to hard silty clay	2.5	19	30

Approach Embankment	Soil Layer	Approx. Thickness (m)	Bulk Unit Weight (kN/m <sup>3</sup> )	Young's Modulus, E (MPa)
NBL South Embankment HF4 15-1	Compact to dense sandy silt to sand fill	4	19	25
	Compact to dense silt to silty sand	11.5	19	20
	Stiff clayey silt	1	19	20
SBL North Embankment 15-5 15-4	Compact silty sand to sand and silt fill containing clayey silt layers	10	19	25
	Very stiff clayey silt	1.5	19	30
	Loose to dense silty sand to silt	8	19	25
	Very stiff to hard silty clay	2	19	30
SBL South Embankment 15-1	Compact to dense silty sand to gravelly sand fill	7	19	8
	Compact to dense sand to silt	11.5	19	25
	Stiff clayey silt	1	19	20

The analyses were carried out for both the north and south approach embankments and assume that all organic and loose surficial soils have been removed prior to embankment fill placement. The estimated magnitude of settlement for the approach embankment areas is provided in the table below.

Location	Estimated Elastic Settlement (mm)
NBL – North Embankment	95
NBL – South Embankment	115
SBL – North Embankment	50
SBL – South Embankment	85



The majority of the settlement is expected to occur during or shortly after construction in response to filling, based on the non-cohesive nature of the silt to sand deposits, and the generally very stiff to hard nature of the cohesive layers. However, it is recommended that the embankment for the new northbound lanes be constructed and allowed to settle (i.e. preloaded) for a minimum period of six weeks prior to final paving / approach slab construction. An Operational Constraint is provided in Appendix C to address this requirement, for inclusion in the Contract Documents.

It is recommended that a limited settlement monitoring program be carried out for the widened portions of the Highway 400 embankments that are preloaded, to monitor the magnitude and rate of settlement during the preloading period. The monitoring program should consist of the installation of a limited number of settlement plates (SPs) at the base of the fill platform in the embankment widening areas, which would be surveyed at regular intervals of time over the duration of the monitoring period. The details of the monitoring plan will be prepared in conjunction with that for the retaining walls proposed along the east side of the Highway 400 NBL widening.

### 6.5.3 Approach Embankment Stability

The Highway 400 NBL embankments in the Tiffin Street overpass area will be contained by retaining walls, and the global stability of these retaining walls is addressed in the Foundation Investigation and Design Report for the retaining walls, for consistency along the full length of the retaining walls on this project.

In regard to the Highway 400 SBL embankments, as noted above the highway grades will be raised by about 3 m; as such, the placement of additional fill on top of the existing embankment fill will be required. Limit equilibrium slope stability analyses were performed for the widened/raised SBL embankment at approximately Station 29+700. The analyses were completed using the commercially available software program "Slide", produced by Rocscience Inc., employing the Morgenstern-Price method of analysis to check that a minimum Factor of Safety of 1.3 is achieved for global stability of the proposed approach embankment height and geometry under static conditions. This minimum Factor of Safety is considered appropriate for the embankments at this site considering the design requirements and the available field and laboratory testing data.

Effective stress parameters were employed in the analyses assuming drained conditions. The soil parameters were estimated from empirical correlations using the results of in situ Standard Penetration Tests (SPT), visual classification and the results of laboratory testing; the simplified soil stratigraphy and associated unit weights and effective friction angles are summarized on Figure 1, following the text of this report. Granular earth fill embankments sloped at 2H:1V have been assumed. A groundwater elevation of 230.5 m has been incorporated into the analysis.

The results of the stability analyses shown on Figure 1 indicate that a Factor of Safety greater than 1.3 is achieved for a 2H:1V slope configuration along the west side of the widened, raised SBL embankment. The analysis assumes that all topsoil, soft or otherwise deleterious fill materials or any soils containing organics have been removed from the proposed new embankment footprint and the new embankment fill is properly placed and compacted.



## **6.6 Design and Construction Considerations**

### **6.6.1 Open-Cut Excavations**

The foundation excavations will extend through existing fill materials and into the sand and silt deposits. Where space permits, open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects. The existing fill materials, as well as the generally compact non-cohesive soils, are classified as Type 3 soil. Temporary excavations (i.e. those which are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V).

### **6.6.2 Temporary Protection Systems**

Given the proximity of the new NBL structure to the existing Highway 400 embankment, excavations into the embankment will be needed to permit the construction of the new structure. Therefore, temporary protection will be required on Highway 400 to facilitate construction of the new abutments. Temporary protection systems may also be required along the front or back edge of the new footings. These temporary excavation support systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). The lateral movement of temporary shoring systems on Highway 400 should meet Performance Level 2 as specified in OPSS 539, provided that any utilities that may be present adjacent to the temporary shoring systems, as well as the existing adjacent abutments, can tolerate this level of deformation.

As discussed in Section 6.2 and in Section 6.6.3 below, the footing founding levels have been selected to avoid the requirement for dewatering, in order to avoid impacts on the TCE plume in the vicinity of the site. The vertical elements of temporary protection systems, such as soldier piles or steel sheetpiles, may penetrate below the groundwater table within the sand/silt deposit. However, any vertical elements must be designed and constructed such that they do not penetrate through the underlying clayey silt/silty clay deposit at the following elevations/locations:

- Elevation 223.5 m in the vicinity of the north abutments; and
- Elevation 222 m in the vicinity of the south abutments.

Additionally, should an interlocking sheetpile wall be adopted by the Contractor for use as a temporary protection system, removal of the sheetpiles is required following construction completion.

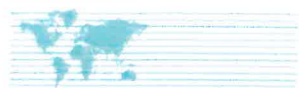
An Operational Constraint is provided in Appendix C to address these requirements, for inclusion in the Contract Documents.

### **6.6.3 Groundwater Control for Foundation Excavations**

As discussed in Section 6.2, a TCE plume exists in the vicinity of the Highway 400 / Tiffin Street Overpass structure. Further to the risk assessment completed by MH, the foundation recommendations have been developed to maintain the foundation excavations sufficiently above the anticipated groundwater level at the site, to avoid the requirement for dewatering, which could disturb the TCE plume in the vicinity of this site.

### **6.6.4 Subgrade Protection**

The sand to silt deposits that will form the subgrade for the support of shallow foundations will be susceptible to loosening and degradation on exposure to water and construction traffic. As it is proposed that spread/strip



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

footings be adopted for the foundation elements, it is recommended that a working slab of concrete be placed on the footing subgrade to form a working mat, and to protect the subgrade from degradation. This subgrade protection can be illustrated on the General Arrangement and Foundation Layout drawings, and a Non-Standard Special Provision can be included in the Contract Documents. A sample Non-Standard Special Provision to address subgrade protection is provided in Appendix C.

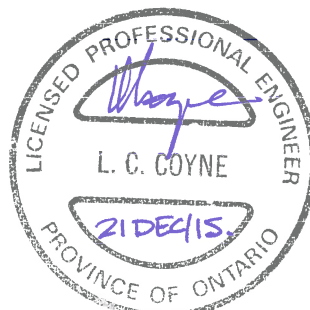
### 7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Nick La Posta, P. Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder.

#### GOLDER ASSOCIATES LTD.



Nick La Posta, P. Eng.  
Geotechnical Engineer



Lisa Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

NL/LCC/sm

\\golder.gds\gal\barrie\active\2015\3 proj\1532543 mh\_mto-hwy400&tiffin street\_barrie\report\foundations\1 - tiffin overpass\1532543 rpt01 2015-12-21 tiffin-hwy 400 foundations final.docx



## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

### REFERENCES

- Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition. McGraw Hill Book Company, New York.
- Canadian Geotechnical Society, 1992. *Canadian Foundation Engineering Manual*, 3<sup>rd</sup> Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.
- Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.
- Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

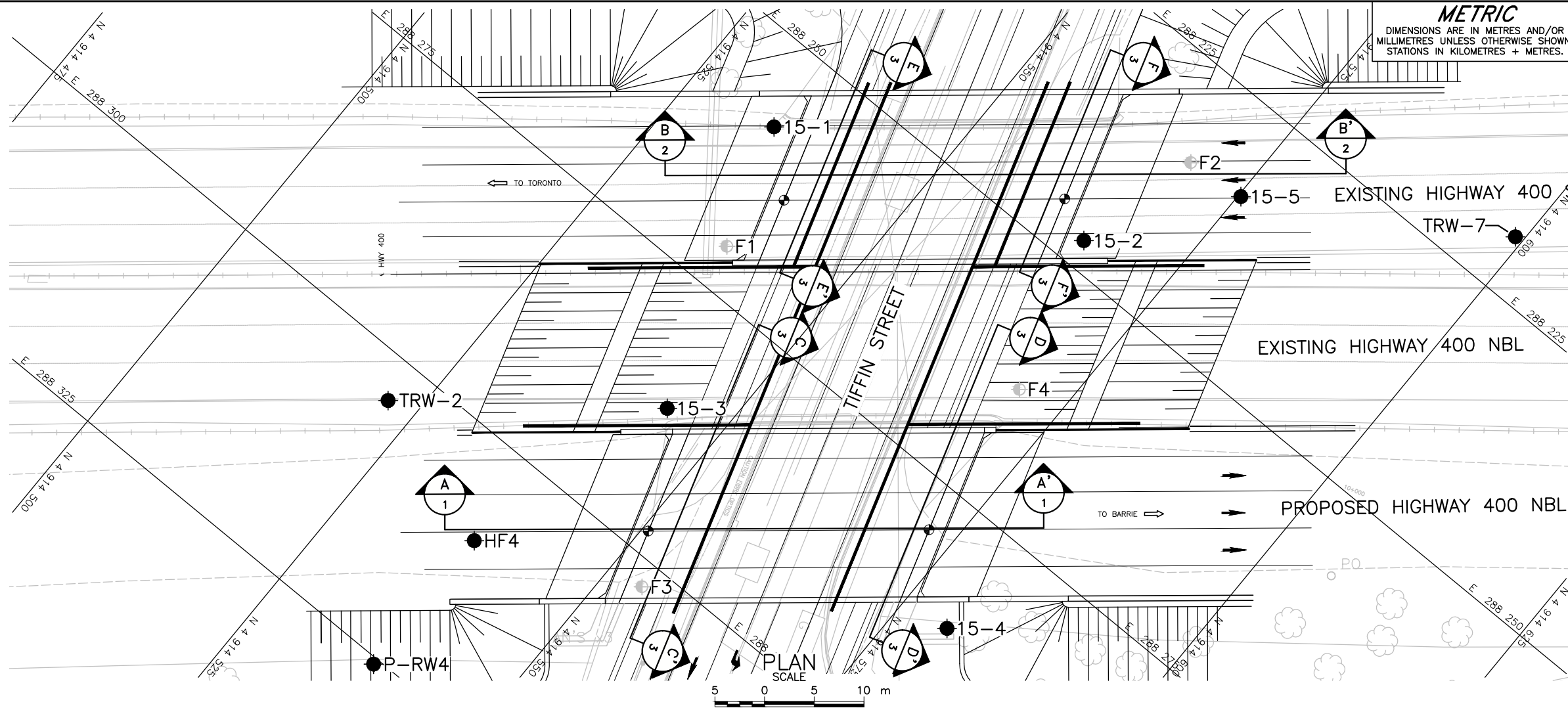
### Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Earth Excavation and Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 902	Construction Specification for Excavating and Backfilling for Structures
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

### Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3101.150	Walls, Abutments, Backfill
OPSD 3121.150	Walls, Retaining Backfill



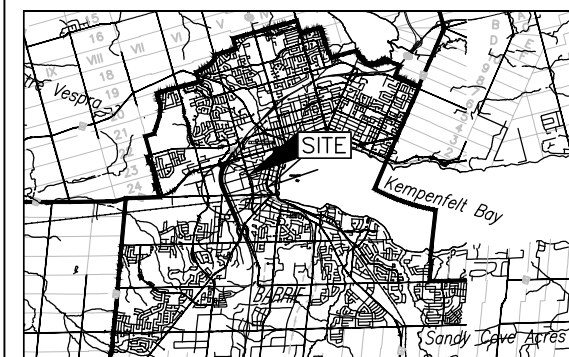


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2159-11-00

HIGHWAY 400 NBL  
TIFFIN STREET OVERPASS  
BOREHOLE LOCATIONS AND SOIL  
STRATA

SHEET



KEY PLAN

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31D-587)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- WL in Monitoring Well, measured on AUG 11, 2015
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

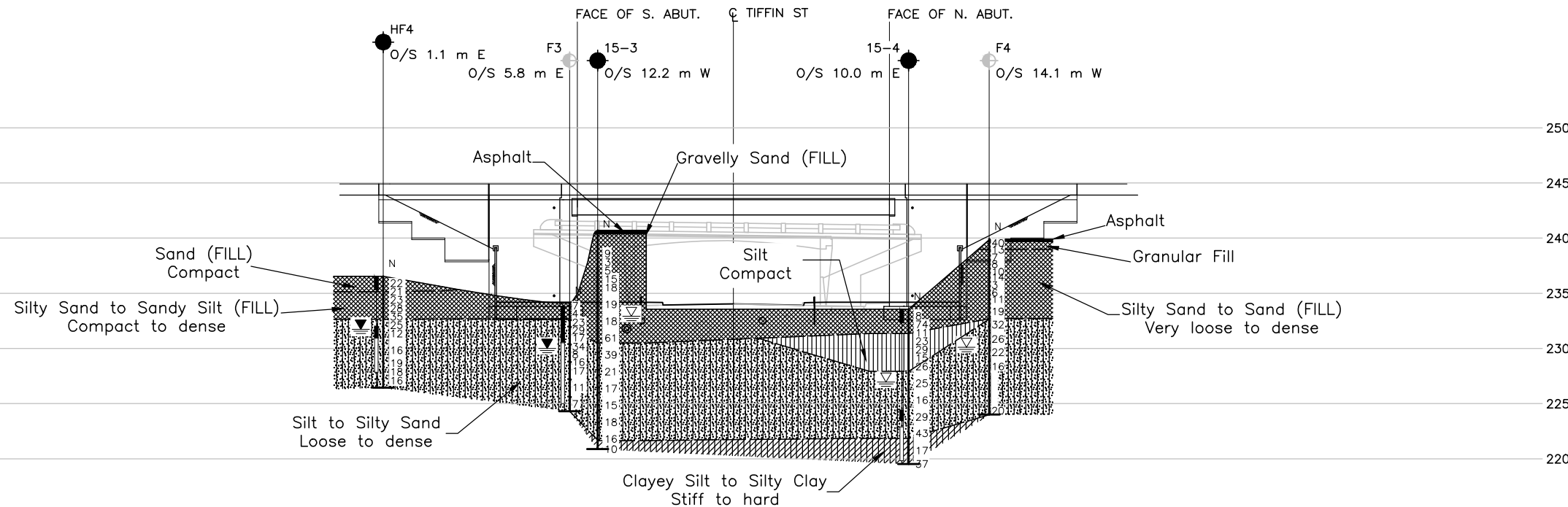
No.	ELEVATION	NORTHING	EASTING
15-1	240.5	4914534.5	288258.2
15-2	239.8	4914565.9	288247.2
15-3	240.7	4914544.2	288286.9
15-4	233.6	4914580.1	288286.1
15-5	239.5	4914575.3	288233.7
F1	240.8	4914538.5	288270.5
F2	239.5	4914569.2	288234.3
F3	234.1	4914553.7	288302.4
F4	239.9	4914570.4	288262.9
HF4	236.5	4914537.7	288309.6

NOTES

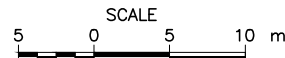
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.



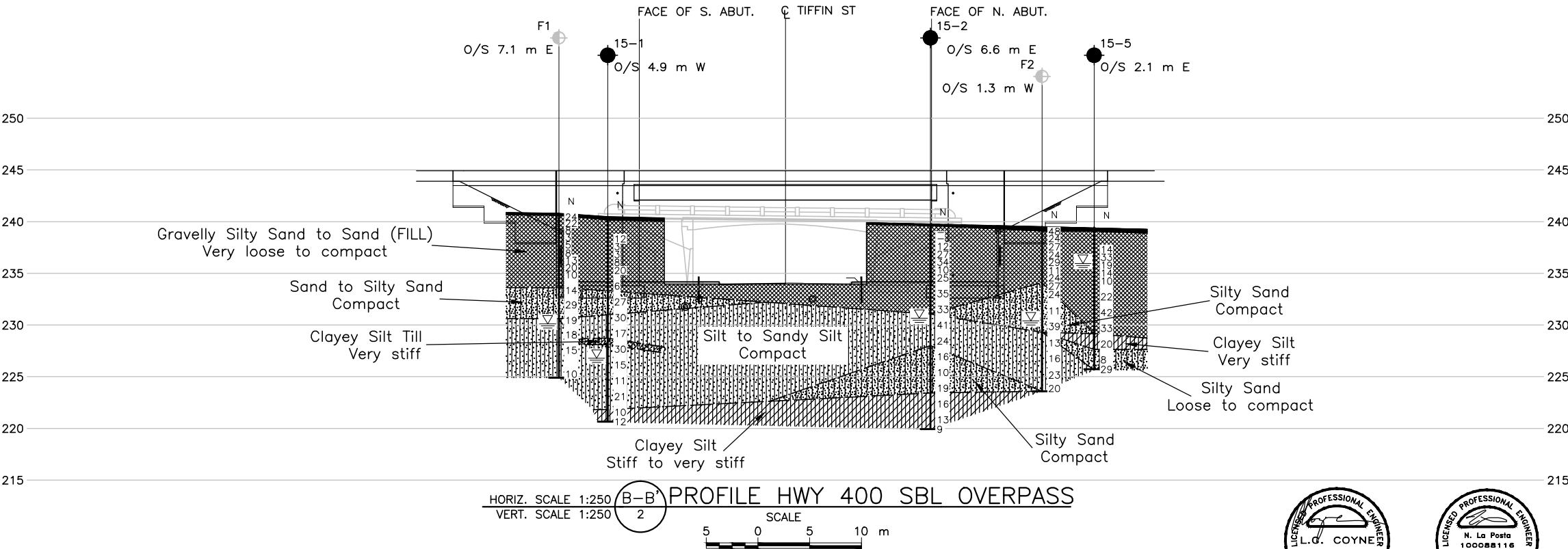
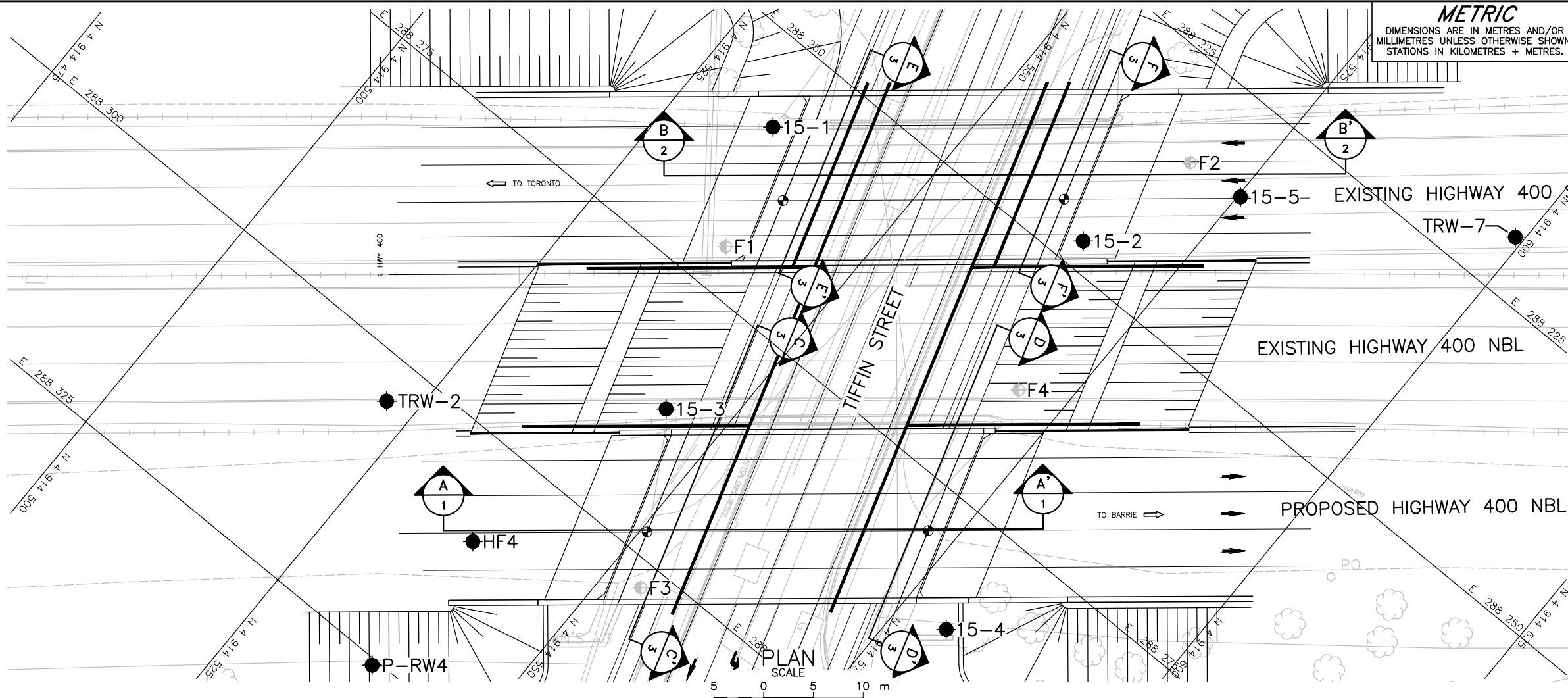
HORIZ. SCALE 1:250  
VERT. SCALE 1:250  
A-A' 1  
PROFILE HWY 400 NBL OVERPASS



REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file nos. x1124220\_Base.dwg, received Aug. 08, 2015.

NO.	DATE	BY	REVISION
Geocres No. 31D-630			
HWY. 400	PROJECT NO. 1532543		DIST. CENTRAL
SUBM'D. NLP	CHKD. NLP	DATE: 12/22/2015	SITE: 30-176/1+2
DRAWN: JJJ	CHKD. NLP	APPD. LCC	DWG. 1



CONT No.  
GWP No. 2159-11-00

HIGHWAY 400 SBL  
TIFFIN STREET OVERPASS  
BOREHOLE LOCATIONS AND SOIL  
STRATA

SHEET

KEY PLAN

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31D-587)
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- WL in piezometer, measured on AUG 11, 2015
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
15-1	240.5	4914534.5	288258.2
15-2	239.8	4914565.9	288247.2
15-3	240.7	4914544.2	288286.9
15-4	233.6	4914580.1	288286.1
15-5	239.5	4914575.3	288233.7
F1	240.8	4914538.5	288270.5
F2	239.5	4914569.2	288234.3
F3	234.1	4914553.7	288302.4
F4	239.9	4914570.4	288262.9
HF4	236.5	4914537.7	288309.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file nos. x1124220\_Base.dwg, received Aug. 08, 2015.

NO.	DATE	BY	REVISION
Geocres No. 31D-630			
HWY. 400	PROJECT NO. 1532543		DIST. CENTRAL
SUBM'D. NLP	CHKD. NLP	DATE: 12/22/2015	SITE: 30-176/1+2
DRAWN: JLL	CHKD. NLP	APPD. LCC	DWG. 2

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

CONT No.,  
GWP No.2159-11-00

HIGHWAY 400 NBL AND SBL  
TIFFIN STREET OVERPASSES

SHEET

SOIL STRATA



LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31D-587)
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ≡ WL in piezometer, measured on AUG 11, 2015
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
15-1	240.5	4914534.5	288258.2
15-2	239.8	4914565.9	288247.2
15-3	240.7	4914544.2	288286.9
15-4	233.6	4914580.1	288286.1
15-5	239.5	4914575.3	288233.7
F1	240.8	4914538.5	288270.5
F2	239.5	4914569.2	288234.3
F3	234.1	4914553.7	288302.4
F4	239.9	4914570.4	288262.9
HF4	236.5	4914537.7	288309.6

NOTES

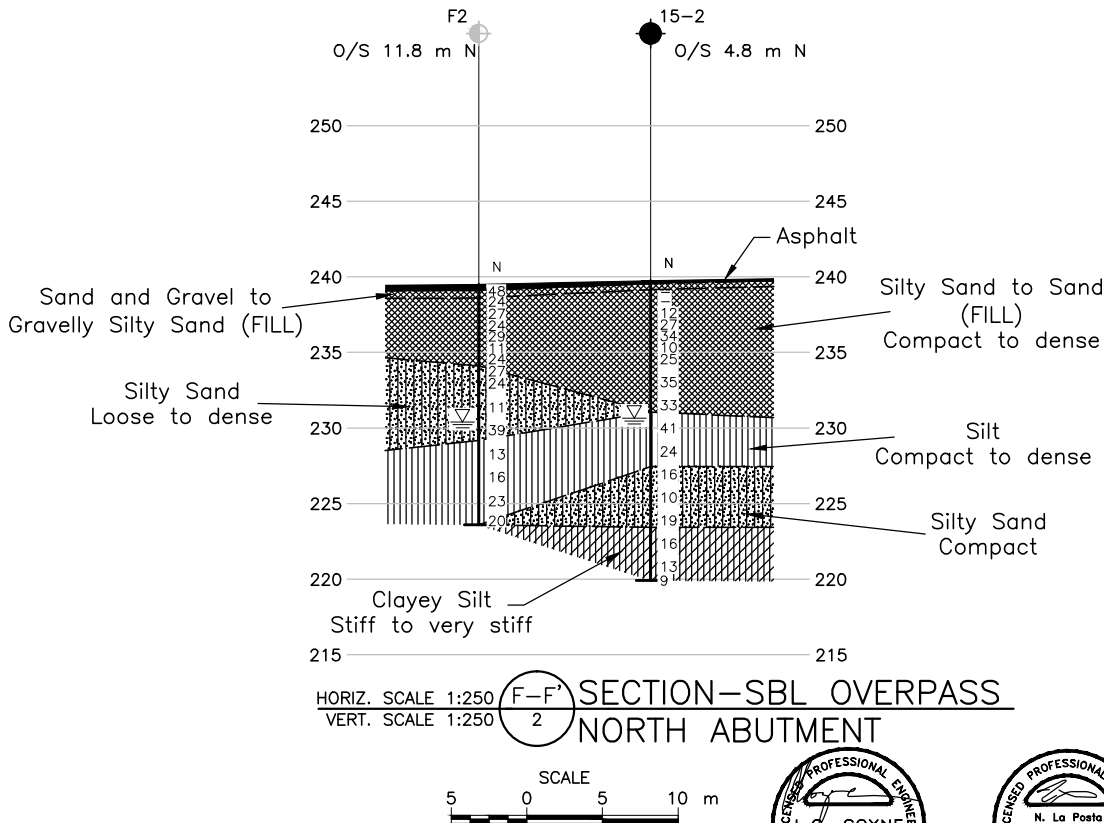
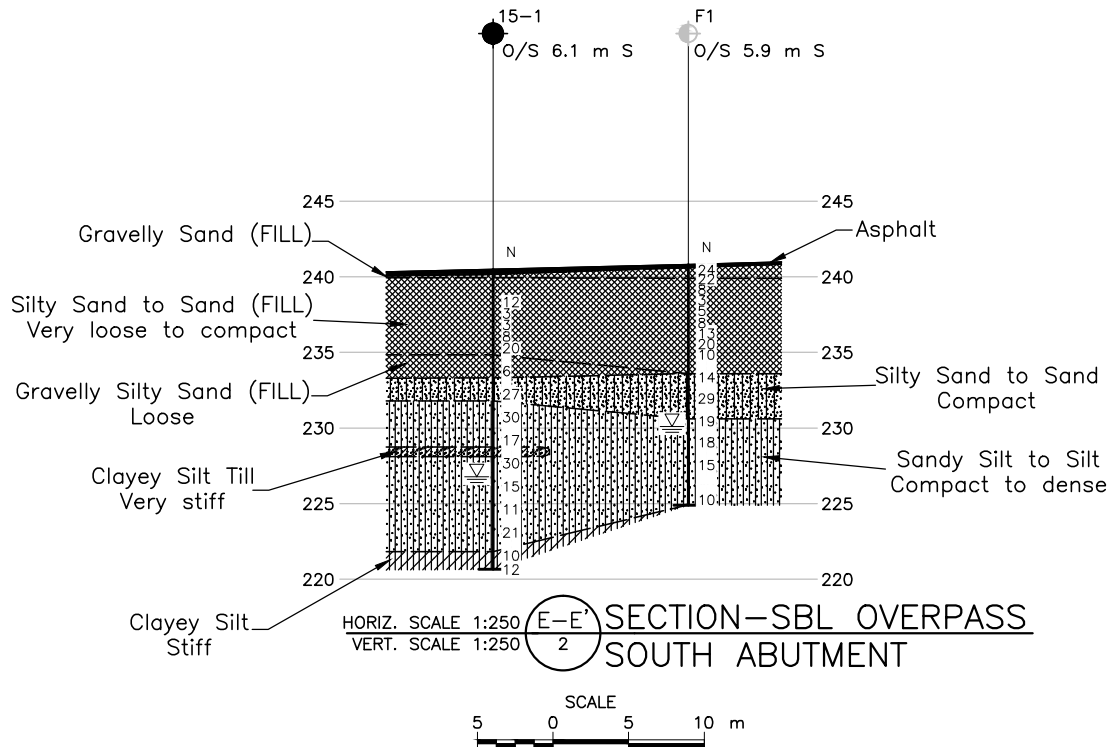
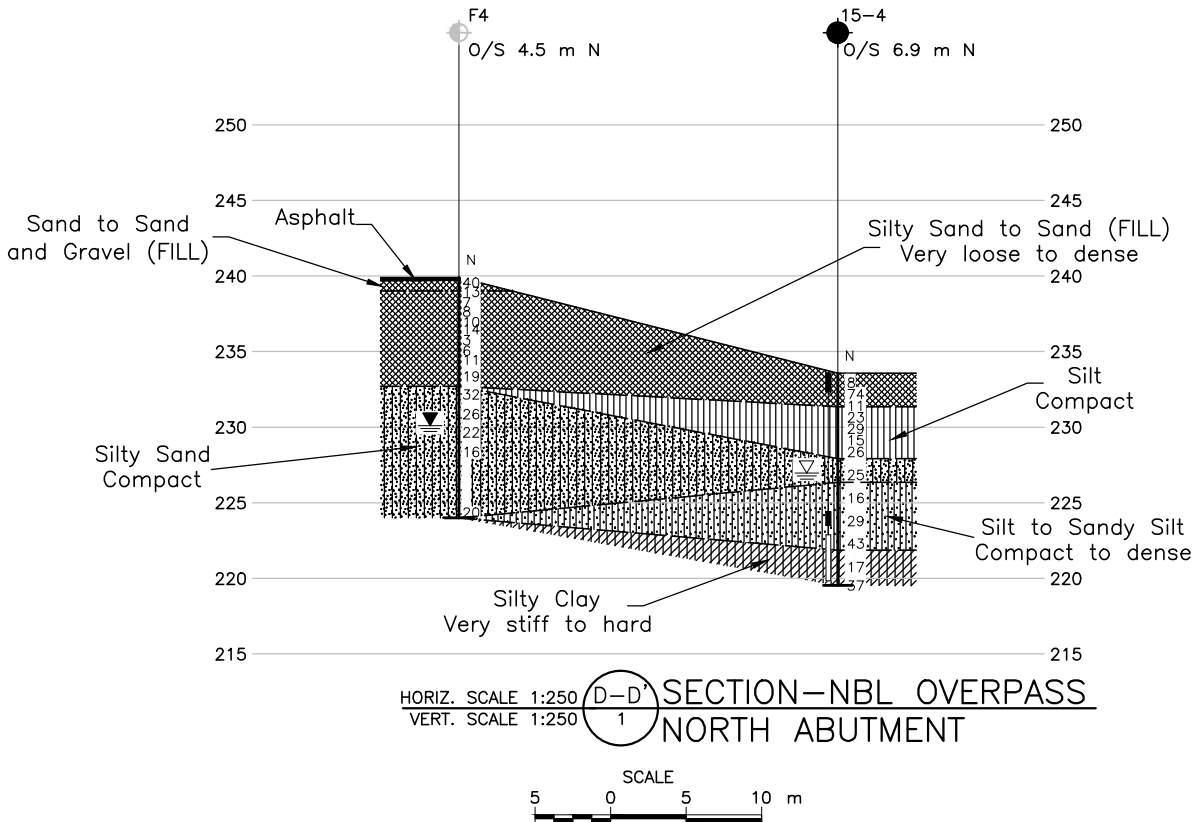
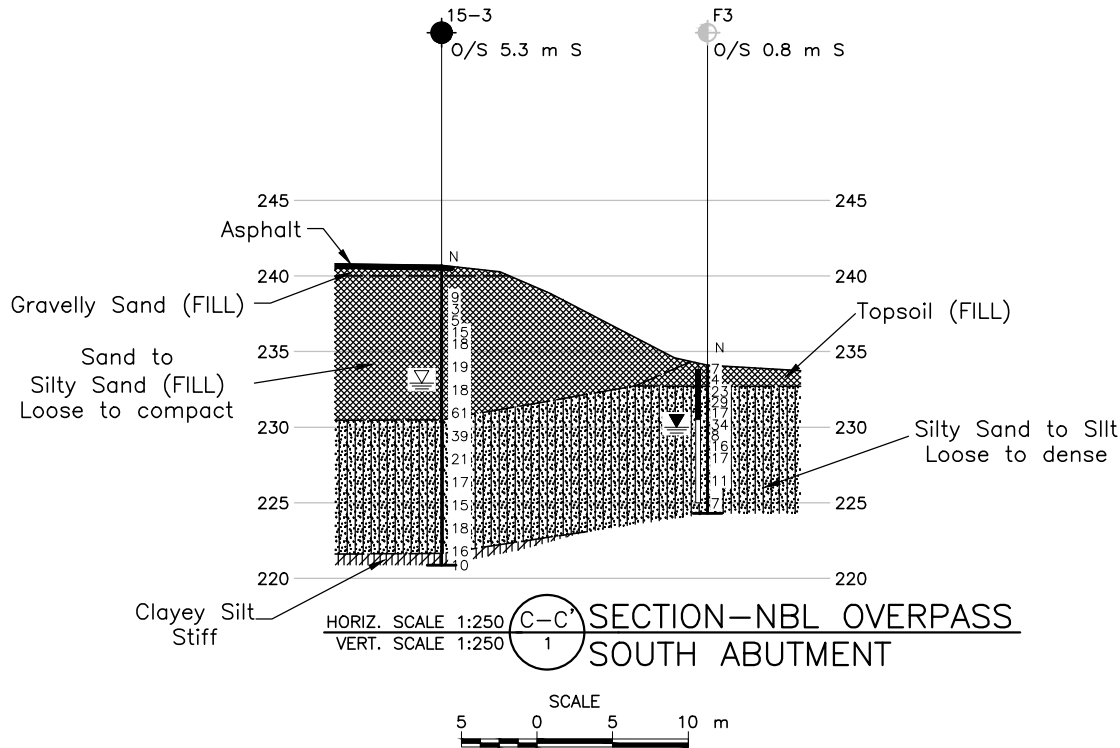
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file nos. x1124220\_Base.dwg, received Aug. 08, 2015.



NO.	DATE	BY	REVISION
Geocres No. 31D-630			
HWY. 400		PROJECT NO. 1532543	DIST. CENTRAL
SUBM'D. NLP	CHKD. NLP	DATE: 12/22/2015	SITE:30-176/1+2
DRAWN: JJL/TB	CHKD. NLP	APPD. LCC	DWG. 3

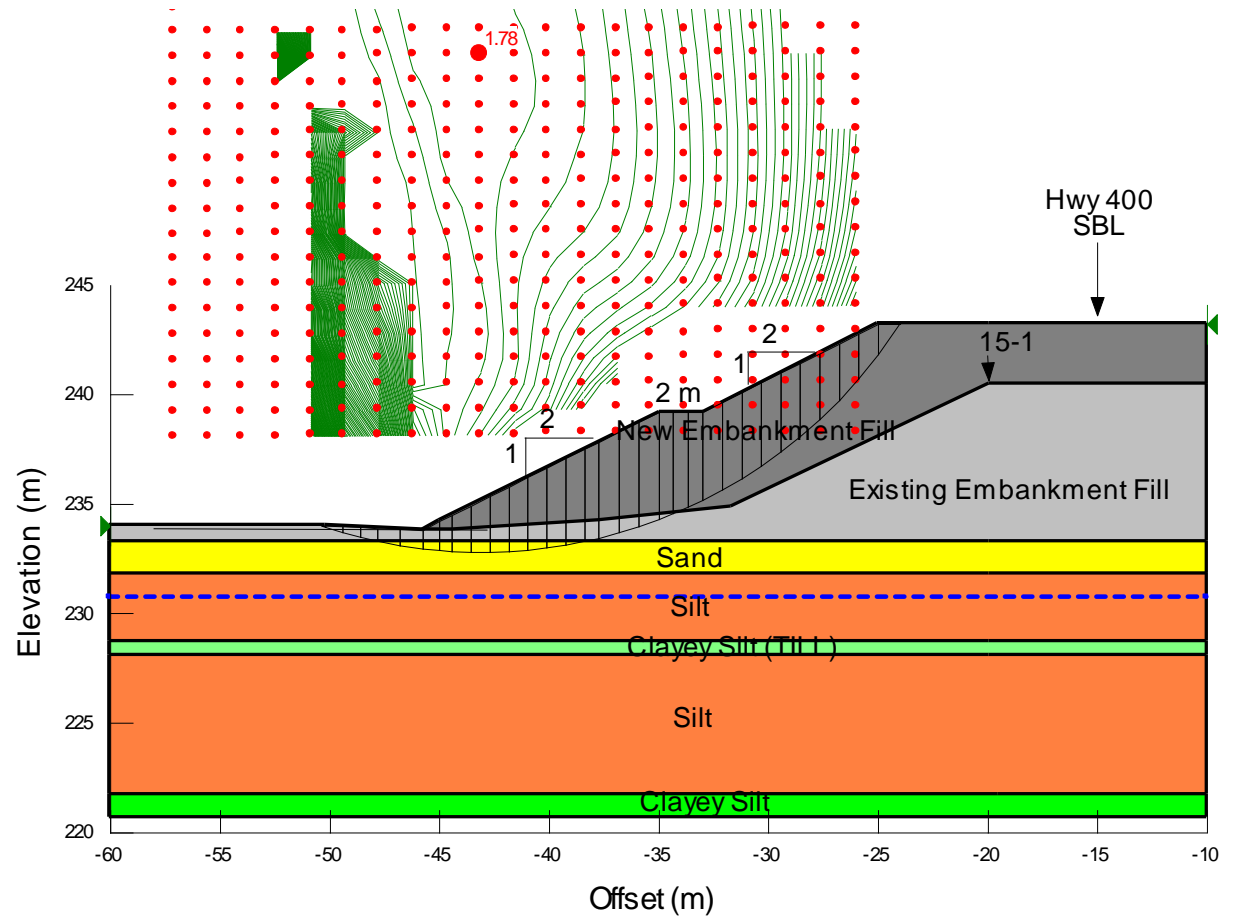




# Static Slope Stability Analysis Widened/Raised Highway 400 SBL Embankment – Station 29+700

Figure 1

Material Name	Unit Weight (kN/m <sup>3</sup> )	Friction Angle (°)
New Granular Fill	21	35
Existing Embankment Fill	21	30
Sand (Compact)	21	30
Silt (Compact)	20	30
Clayey Silt Till	21	32
Silt (Compact to Dense)	20	32
Clayey Silt (Stiff)	19	30





# **APPENDIX A**

## **Borehole Records**



## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_C$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

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

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

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

Notes: 1  
2

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



## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

#### Dynamic Cone Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils Consistency

	$C_u, S_u$	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

### V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



PROJECT			1532543			<b>RECORD OF BOREHOLE No 15-1</b>						1 OF 2 <b>METRIC</b>									
G.W.P.			2159-11-00			LOCATION			N 4914534.5; E 288258.2						ORIGINATED BY D.M						
DIST			Central HWY 400			BOREHOLE TYPE			200 mm Diameter Hollow Stem Augers						COMPILED BY NLP						
DATUM			GEODETIC			DATE			June 29, 2015						CHECKED BY LCC						
SOIL PROFILE							SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT									
ELEV DEPTH	DESCRIPTION					STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub>		UNIT WEIGHT <b>γ</b> kN/m³		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
240.5	GROUND SURFACE											20 40 60 80 100		10 20 30							
0.0	ASPHALT											20 40 60 80 100		10 20 30							
240.2																					
0.5	Gravelly sand, trace silt, crushed (FILL) Grey Moist										240										
	Sand, trace to some gravel, some silt, containing organics and rootlets (FILL)										239										
238.6	Compact to very loose Brown Moist						1A	SS	12												
1.9							1B														
	Silty sand to sand, trace to some silt, trace clay, trace to some gravel (FILL)										238										
	Loose to compact Light brown to brown Moist						2	SS	3										8 79 10 3		
											237										
							3	SS	3												
											236										
	- 12.7 mm clayey silt pocket observed at 4.3 m																				
	- Refusal inferred to be on cobble at 4.4 m										235										
	- Trace rounded to angular gravel, below 4.6 m										234										
234.8																					
5.6	Gravelly silty sand, containing organics (FILL) Loose Dark brown Moist						6	SS	6												
233.3																					
7.2	SAND, some silt Compact Brown Moist										233										
							7	SS	27												
231.8											232										
8.7	Sandy SILT to SILT, trace sand, trace clay Compact to dense Brown Wet										231										
							8	SS	30												
											230										
											229										
228.7																					
11.7	CLAYEY SILT, trace sand, trace gravel (TILL) Very stiff Brown Moist										228										
228.1							10A														
12.4	SILT, trace clay, some sand Compact to dense Grey Wet						10B	SS	30												
											227										
											226										
							11	SS	15												

Continued Next Page

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

PROJECT <u>1532543</u>				RECORD OF BOREHOLE <b>No 15-1</b>				2 OF 2 <b>METRIC</b>									
G.W.P. <u>2159-11-00</u>				LOCATION <u>N 4914534.5; E 288258.2</u>				ORIGINATED BY <u>D.M</u>									
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NLP</u>									
DATUM <u>GEODETIC</u>				DATE <u>June 29, 2015</u>				CHECKED BY <u>LCC</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SILT, trace clay, some sand Compact to dense Grey Wet		12	SS	11		225										
							224										
	- 51 mm thick silty clay pocket observed at 17.3 m		13	SS	21		223										
221.8			14A	SS	10		222										
18.7	CLAYEY SILT, trace fine sand Stiff Grey - Containing pockets of wet sandy silt below 19.2 m		14B														
220.7			15	SS	12		221										
19.8	END OF BOREHOLE  NOTES:  1. Groundwater measured at a depth of 13.7 m (Elev. 226.8 m) during drilling.  2. Borehole sloughed to 11.9 m (Elev. 228.6 m) after removal of augers.																



SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

1 OF 2 **METRIC**

CHECKED BY           LCC          

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

SSUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

PROJECT 1532543			RECORD OF BOREHOLE No 15-2			2 OF 2 METRIC											
G.W.P. 2159-11-00			LOCATION N 4914565.9; E 288247.2			ORIGINATED BY AK											
DIST Central HWY 400			BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers			COMPILED BY NLP											
DATUM GEODETIC			DATE June 25, 2015			CHECKED BY LCC											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m <sup>3</sup>	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30				
223.4	SILTY SAND, trace clay Compact Grey Moist to wet		14	SS	19		224										
16.3	CLAYEY SILT, trace sand Stiff to very stiff Grey		15	SS	16		223										
							222										
			16	SS	13		221										
219.9			17	SS	9		220										
19.8	END OF BOREHOLE  NOTE:  1. Groundwater measured at a depth of 9.1 m (Elev. 230.7 m) during drilling operations.																

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

PROJECT <u>1532543</u>				<b>RECORD OF BOREHOLE No 15-3</b>				1 OF 2 <b>METRIC</b>								
G.W.P. <u>2159-11-00</u>				LOCATION <u>N 4914544.2; E 288286.9</u>				ORIGINATED BY <u>D.M</u>								
DIST <u>Central</u> HWY <u>400</u>				BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NLP</u>								
DATUM <u>GEODETIC</u>				DATE <u>June 28, 2015</u>				CHECKED BY <u>LCC</u>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
240.7	GROUND SURFACE															
0.0	ASPHALT															
240.4																
240.1	Gravelly sand, trace silt (FILL) Brown Moist															
0.6	Sand, trace to some silt, trace gravel to silty sand (FILL) Loose to compact Light brown to brown Moist															
	- Wet below a depth of 2.3 m		1	SS	9											
			2	SS	3											
			3A	SS	5											
			3B	SS	5											
	- 51 mm thick silty clay layer observed at a depth of 4.0 m		4	SS	15											
			5	SS	18											
			6	SS	19											
			7	SS	18											
			8	SS	61											
230.5																
10.2	SILT, trace to some sand, trace clay Dense Brown Moist		9	SS	39											
228.9																
11.8	SILTY SAND, trace clay Compact Brown becoming grey below a depth of 13.7 m Wet		10	SS	21											
			11	SS	17											

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

Continued Next Page

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

PROJECT <u>1532543</u>		<b>RECORD OF BOREHOLE No 15-3</b>		2 OF 2 <b>METRIC</b>	
G.W.P. <u>2159-11-00</u>		LOCATION <u>N 4914544.2; E 288286.9</u>		ORIGINATED BY <u>D.M</u>	
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>		COMPILED BY <u>NLP</u>	
DATUM <u>GEODETIC</u>		DATE <u>June 28, 2015</u>		CHECKED BY <u>LCC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					GR	SA	SI	CL
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>						
	--- CONTINUED FROM PREVIOUS PAGE ---																				
221.7	SILTY SAND, trace clay Compact Brown becoming grey below a depth of 13.7 m Wet		12	SS	15																
			13	SS	18																
			14	SS	16																
19.1	CLAYEY SILT, trace fine sand Stiff Grey																				
220.9			15	SS	10																
19.8	END OF BOREHOLE																				
	NOTES:  1. Groundwater encountered at 10.7 m (Elev. 230.0 m) during drilling.  2. Groundwater measured in augers at 7.8 m (Elev. 232.9 m) upon completion.  3. Borehole sloughed to 11.6 m (Elev. 229.1 m) upon removal of augers.																				

PROJECT 1532543			RECORD OF BOREHOLE No 15-4			1 OF 2 METRIC														
G.W.P. 2159-11-00			LOCATION N 4914580.1; E 288286.1			ORIGINATED BY AK														
DIST Central HWY 400			BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers			COMPILED BY NLP														
DATUM GEODETIC			DATE July 13, 2015			CHECKED BY LCC														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>			γ	GR	SA	SI	CL
233.6	GROUND SURFACE							20	40	60	80	100	10	20	30	kN/m <sup>3</sup>				
0.0	Sand to silty sand, trace gravel (FILL) Loose to very dense Brown Moist		1	SS	8		233													
			2	SS	74		232													
			3	SS	11		231													
231.4	SILT, trace to some sand, trace clay Compact Light brown Moist to wet		4	SS	23		230													
2.2			5	SS	29		229													
			6	SS	15		228													
			7	SS	26		227													
227.9	SILTY SAND Compact Grey Moist to wet		8A	SS	25		226													
227.0			8B				225													
6.6	SILT, trace to some sand to sandy, trace clay Compact to dense Grey Wet		9	SS	16		224													
			10	SS	29		223													
			11A	SS	43		222													
			11B				221													
221.9	SILTY CLAY, trace sand Very stiff to hard Grey		12	SS	17		220													
			13	SS	37															
219.5																				
14.0																				

Continued Next Page

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

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:



PROJECT <u>1532543</u>		<b>RECORD OF BOREHOLE No 15-4</b>				2 OF 2 <b>METRIC</b>										
G.W.P. <u>2159-11-00</u>		LOCATION <u>N 4914580.1; E 288286.1</u>				ORIGINATED BY <u>AK</u>										
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>200 mm Diameter Hollow Stem Augers</u>				COMPILED BY <u>NLP</u>										
DATUM <u>GEODETIC</u>		DATE <u>July 13, 2015</u>				CHECKED BY <u>LCC</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
	END OF BOREHOLE  NOTE:  1. Groundwater measured at a depth of 6.6 m (Elev. 227.0 m) during drilling.															

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

PROJECT 1532543		RECORD OF BOREHOLE No 15-5					1 OF 1 METRIC						
G.W.P. 2159-11-00		LOCATION N 4914575.3; E 288233.7					ORIGINATED BY D.M						
DIST Central HWY 400		BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers					COMPILED BY NLP						
DATUM GEODETIC		DATE June 29, 2015					CHECKED BY LCC						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)
239.5	GROUND SURFACE							20 40 60 80 100					
0.0 239.1	ASPHALT												
238.8 0.6	Gravelly sand, trace silt (FILL) Brown Moist Sand, some gravel, trace silt (FILL) Brown Moist						239						
237.9							238						
1.5 237.2	Clayey silt, trace to some sand, trace gravel (FILL) Stiff Brown Moist		1	SS	14								
2.2	Silty sand, trace clay, trace gravel (FILL) Compact to dense Brown to greyish brown Moist		2	SS	33		237						
			3	SS	19		236						
			4	SS	14		235						
234.4	- 25 mm sand seam at 4.2 m Compact to loose Moist - Asphalt pieces at 4.9 m		5A 5B	SS	10								
5.1	Sand and silt, trace to some clay (FILL) Compact Brown, oxidation staining Moist						234						
233.1			6A 6B	SS	22		233						
6.4	Silty sand, trace clay, containing silty clay pockets (FILL) Compact to dense Brown Moist  - Wet below 7.6 m						232						
			7	SS	42		231						
			8	SS	33		230						
229.2							229						
10.2	CLAYEY SILT, trace sand Very stiff Grey Moist		9	SS	20		228						
227.7							227						
11.7	SILTY SAND, trace clay Loose to compact Grey Wet		10	SS	8								
			11	SS	29		226						
225.7													
13.7	END OF BOREHOLE												
	NOTE:  1. Groundwater measured at 3.5 m (Elev. 236.0 m) during drilling.												

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

PROJECT		1532543		<b>RECORD OF BOREHOLE No HF4</b>		1 OF 1 <b>METRIC</b>								
G.W.P.		2159-11-00		LOCATION		N 4914537.7; E 288309.6								
DIST		Central HWY 400		BOREHOLE TYPE		200 mm Diameter Hollow Stem Augers								
DATUM		GEODETIC		DATE		July 7, 2015								
				ORIGINATED BY		AK								
				COMPILED BY		NLP								
				CHECKED BY		LCC								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
236.5	GROUND SURFACE													
0.0	Sand, trace gravel, trace silt (FILL) Compact Dark brown to brown Moist		1	SS	22									
			2	SS	21									
235.1														
1.4	Silty sand to sandy silt, trace gravel (FILL) Compact to dense Light brown to brown Moist		3	SS	23									
			4	SS	28									
			5	SS	35									
232.6														
3.9	SILT, trace sand, trace clay Compact Grey Moist to wet		6	SS	25									
			7	SS	12									
230.9														
5.6	SANDY SILT to SILTY SAND Compact Grey Moist		8	SS	16									
			9	SS	19									
			10	SS	18									
			11	SS	16									
226.4														
10.1	END OF BOREHOLE													
NOTES: 1. Groundwater encountered at 8.5 m (Elev. 228.0 m) during drilling. 2. Groundwater measured at 4.8 m (Elev. 231.7 m) on August 11, 2015.														

SUD-MTO 001 1532543.GPJ GAL-MISS.GDT 07/10/15 DATA INPUT:

GEOTETOB22181AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F1

1 OF 2

METRIC

GWP 2074-11-00 LOCATION 29+721, 2.6 m Li C/L (N 4914538.6, E286270.5) ORIGINATED BY LG  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 15/10/2014 CHECKED BY SH

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			20	40	60	80	100		
240.8	GROUND SURFACE												
240.6	220 mm ASPHALT												
239.8	PAVEMENT GRANULAR FILL: 0.2 m Sand and Gravel 0.4 m Sand, some gravel		1	SS		240							
239.6			2	SS									
239.4	FILL: Silty Sand trace to some gravel trace silty clay lenses grey to brown, compact to loose moist		3	SS		239							
239.2			4	SS		238							
239.0	very loose		5	SS									
238.8			6	SS		237							
238.6	silty clay lenses		7	SS		236							
238.4			8	SS		235							
238.2			9	SS		234							
238.0	silty clay lenses		10	SS		233							
237.8			11	SS		232							
237.6	SILTY SAND brown, compact, moist		12	SS		231							
237.4			13	SS		230							
237.2			14	SS		229							
237.0			15	SS		228							
236.8	SILT trace sand, trace clay brown, compact, moist		16	SS		227							
236.6			17	SS		226							
236.4			18	SS									
236.2			19	SS									
236.0	SANDY SILT grey, compact, wet		20	SS									
235.8			21	SS									
235.6			22	SS									
235.4			23	SS									
235.2			24	SS									
235.0			25	SS									
234.8			26	SS									
234.6			27	SS									
234.4			28	SS									
234.2			29	SS									
234.0			30	SS									
233.8			31	SS									
233.6			32	SS									
233.4			33	SS									
233.2			34	SS									
233.0			35	SS									
232.8			36	SS									
232.6			37	SS									
232.4			38	SS									
232.2			39	SS									
232.0			40	SS									
231.8			41	SS									
231.6			42	SS									
231.4			43	SS									
231.2			44	SS									
231.0			45	SS									
230.8			46	SS									
230.6			47	SS									
230.4			48	SS									
230.2			49	SS									
230.0			50	SS									
229.8			51	SS									
229.6			52	SS									
229.4			53	SS									
229.2			54	SS									
229.0			55	SS									
228.8			56	SS									
228.6			57	SS									
228.4			58	SS									
228.2			59	SS									
228.0			60	SS									
227.8			61	SS									
227.6			62	SS									
227.4			63	SS									
227.2			64	SS									
227.0			65	SS									
226.8			66	SS									
226.6			67	SS									
226.4			68	SS									
226.2			69	SS									
226.0			70	SS									
225.8			71	SS									
225.6			72	SS									

Continued Next Page

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

GEOTETO22181AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F1

2 OF 2

METRIC

GWP 2074-11-00 LOCATION 29+721, 2.6 m Lt C/L (N 4914538.5, E288270.5) ORIGINATED BY LG  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 15/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  Y  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE							PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w LIQUID LIMIT w <sub>L</sub> WATER CONTENT (%)				
225.6 15.0	SANDY SILT grey, compact, wet		15	SS	10		225												
224.8 15.9																			
End of Borehole wet cave- in @10.7 m																			

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

20  
15  
10  
(%) STRAIN AT FAILURE

GEOTETO22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH F2

1 OF 2

METRIC

GWP 2074-11-00 LOCATION 10+030, 10.8 m LI C/L (N 4914566.2, E 288234.3) ORIGINATED BY JD  
DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
DATUM Geodetic DATE 23/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)					
								20 40 60 80 100		PLASTIC LIMIT W <sub>P</sub>			NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	20 40 60 80 100		10 20 30	
								○ UNCONFINED	+ FIELD VANE						○ POCKET PENETR.	× LAB VANE		
239.6	GROUND SURFACE																	
0.0	400 mm ASPHALT																	
239.1																		
0.4	PAVEMENT GRANULAR FILL: 0.3 m Sand and Gravel 0.2 m Sand, some gravel		1	SS	48		239											
238.6			2	SS	24													
0.9	FILL: Silty Sand brown to grey, dense to compact, moist																	
	trace clay		3	SS	27		238											
			4	SS	24		237											
			5	SS	29		236						8 71 15 6					
			6	SS	11		235											
			7	SS	24		234											
234.1			8	SS	27		233											
5.4	SILTY SAND trace gravel, trace clay brown to grey, compact, moist to wet		9	SS	24		232											
			10	SS	11		231						wet spoon					
			11	SS	39		230						1 70 24 5					
229.3			12	SS	13		229											
10.2	SILT some sand, trace clay, dilatant grey, compact, wet		13	SS	16		228											
			14	SS	23		227											
	sand and silt						226											
							225											
224.5																		

Continued Next Page

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

20  
15 10 5  
(%) STRAIN AT FAILURE

GEOTETOB22181AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F2

2 OF 2

METRIC

GWP 2074-11-00 LOCATION 10+030, 10.8 m Lt C/L (N 4914569.2, E 288234.3) ORIGINATED BY JD  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 23/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
224.5 15.0	SILT some sand, trace clay, dilatant grey, compact, wet													
223.7 15.9			15	SS	20		224							
15.9	End of Borehole cave-in @ 9.1 m Water level @ 9.1 m (not stabilized)* upon completion.													

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

20  
15-10-5  
10 (%) STRAIN AT FAILURE

GEOTETO22161AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F3

1 OF 1

METRIC

GWP 2074-11-00 LOCATION 28+712, 31.8 m Rt C/L (N 4914553.7, E288302.4) ORIGINATED BY LG  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N-VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		
							20 40 60 80 100	20 40 60 80 100			10 20 30				
234.1 0.0	GROUND SURFACE														
	0.1 m TOPSOIL FILL: Silty Sand to Sand and Silt trace to some gravel trace rootlets trace organics brown, loose, moist		1	SS	7		234								
232.7 1.4			2	SS	4		233								
	SILTY SAND trace gravel, trace clay brown, loose to dense, moist to wet		3	SS	23		232								
			4	SS	29		231								
			5	SS	17		230								
			6	SS	34		229								
			7	SS	8		228								
			8	SS	16		227								
			9	SS	17		226								
			10	SS	11		225								
224.4 9.8	loose		11	SS	7										
End of Borehole Water level upon completion @ 4.2 m Piezometer installed to 9.1 m. Piezometer water level records : Oct. 31, 2014 4.1 m (El. 230 m)															



GEOTETOB22161AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F4

1 OF 2

METRIC

GWP 2074-11-00 LOCATION 10+012, 11.9 m Rt C/L (N 4814570.4, E 288282.9) ORIGINATED BY LG  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● POCKET PENETR.			× LAB VANE	W <sub>P</sub>	W
239.9	GROUND SURFACE						20	40	60	80	100				
239.9	230 mm ASPHALT														
0.2	PAVEMENT GRANULAR FILL: 0.4 m Sand and Gravel 0.3 m Sand, some gravel		1	SS	40										
239.0	FILL: Silty Sand trace to some gravel brown to grey, very loose to dense, moist		2	SS	13										
0.9			3	SS	7										
			4	SS	8										
			5	SS	10										
			6	SS	14										
			7	SS	3										
			8	SS	6										
			9	SS	11										
232.7	SILTY SAND trace gravel, trace clay brown to grey, compact, moist to wet		10	SS	19										
7.2			11	SS	32										
			12	SS	26										
			13	SS	22										
			14	SS	16										

Continued Next Page

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

GEOTETOB22161AA: Hwy 400/ Tiffin Street

# RECORD OF BOREHOLE No BH F4

2 OF 2

METRIC

GWP 2074-11-00 LOCATION 10+012, 11.9 m Rt C/L (N 4814570.4, E 288262.9) ORIGINATED BY LG  
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP  
 DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
224.8 16.0	SILTY SAND trace gravel brown to grey, compact, moist to wet		15	SS	20												
224.1 15.9	End of Borehole cave-in @ 11.6 m Water level upon completion @ 9.8 m																



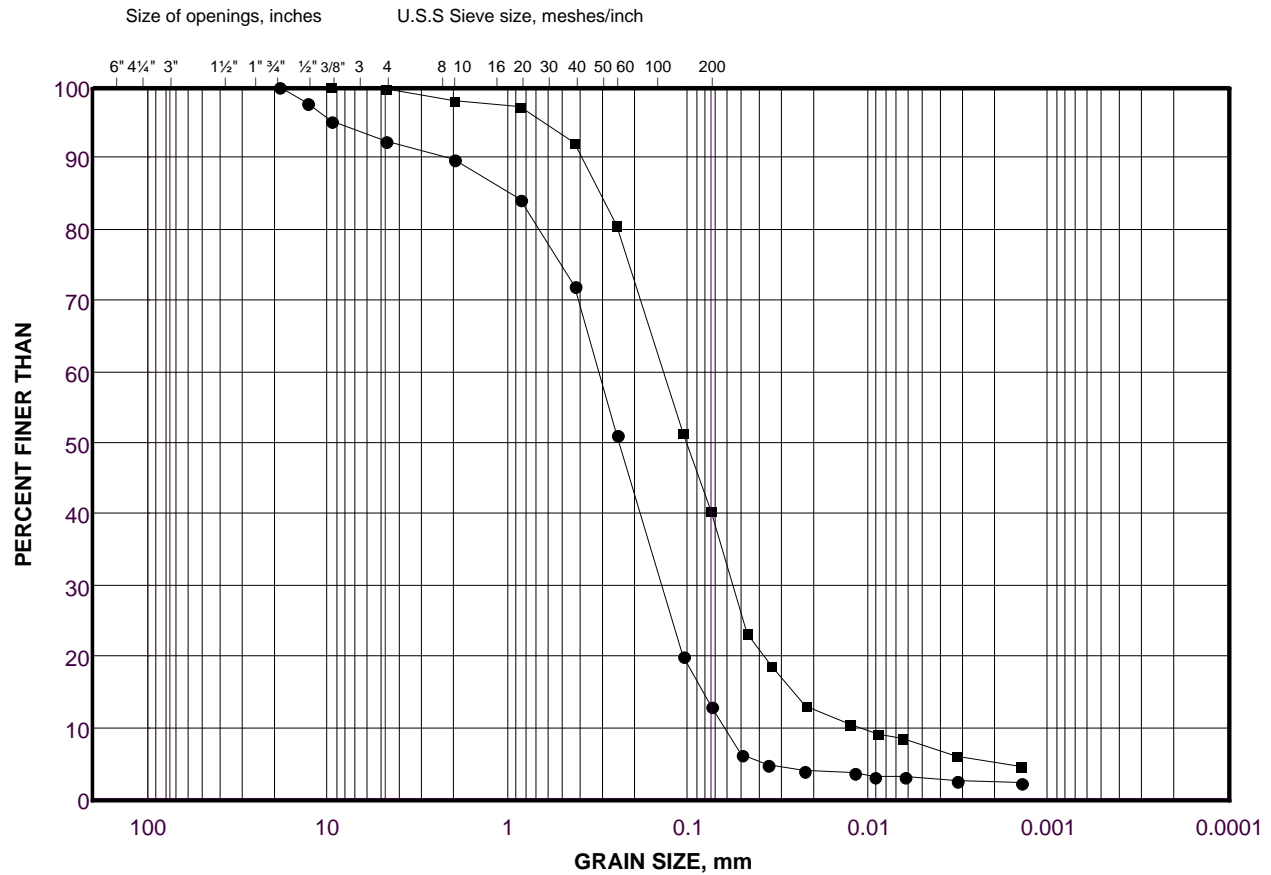
# **APPENDIX B**

## **Geotechnical Laboratory Test Results**

# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand Fill

FIGURE B1



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-1	2	238.0
■	15-1	4	236.5

Project Number: 1532543

Checked By: LCC

**Golder Associates**

Date: 04-Sep-15

## Silty Sand to Sand

The graph displays the relationship between grain size (mm) and percent finer than. The x-axis is logarithmic, ranging from 100 mm to 0.0001 mm. The y-axis is linear, ranging from 0 to 100 percent finer than. The graph includes a grid and a series of data points connected by lines, showing a typical particle size distribution curve.

Grain Size (mm)	Percent Finer (%)
100	100
50	100
25	100
12.5	100
6.3	100
3.15	100
1.6	100
0.8	100
0.425	100
0.25	100
0.15	98
0.075	95
0.0425	92
0.025	88
0.015	78
0.0075	63
0.00425	56
0.0025	44
0.0015	37
0.00075	32
0.000425	27
0.00025	22
0.00015	19
0.000075	17
0.0000425	14
0.000025	12
0.000015	10
0.0000075	8
0.00000425	6
0.0000025	5
0.0000015	4
0.00000075	3
0.000000425	2
0.00000025	1
0.00000015	1
0.000000075	1
0.0000000425	1
0.000000025	1
0.000000015	1
0.0000000075	1
0.00000000425	1
0.0000000025	1
0.0000000015	1
0.00000000075	1
0.000000000425	1
0.00000000025	1
0.00000000015	1
0.000000000075	1
0.0000000000425	1
0.000000000025	1
0.000000000015	1
0.0000000000075	1
0.00000000000425	1
0.0000000000025	1
0.0000000000015	1
0.00000000000075	1
0.000000000000425	1
0.00000000000025	1
0.00000000000015	1
0.000000000000075	1
0.0000000000000425	1
0.000000000000025	1
0.000000000000015	1
0.0000000000000075	1
0.00000000000000425	1
0.0000000000000025	1
0.0000000000000015	1
0.00000000000000075	1
0.000000000000000425	1
0.00000000000000025	1
0.00000000000000015	1
0.000000000000000075	1
0.0000000000000000425	1
0.000000000000000025	1
0.000000000000000015	1
0.0000000000000000075	1
0.00000000000000000425	1
0.0000000000000000025	1
0.0000000000000000015	1
0.00000000000000000075	1
0.000000000000000000425	1
0.00000000000000000025	1
0.00000000000000000015	1
0.000000000000000000075	1
0.0000000000000000000425	1
0.000000000000000000025	1
0.000000000000000000015	1
0.0000000000000000000075	1
0.00000000000000000000425	1
0.0000000000000000000025	1
0.0000000000000000000015	1
0.00000000000000000000075	1
0.000000000000000000000425	1
0.00000000000000000000025	1
0.00000000000000000000015	1
0.000000000000000000000075	1
0.0000000000000000000000425	1
0.000000000000000000000025	1
0.000000000000000000000015	1
0.0000000000000000000000075	1
0.00000000000000000000000425	1
0.0000000000000000000000025	1
0.0000000000000000000000015	1
0.00000000000000000000000075	1
0.000000000000000000000000425	1
0.00000000000000000000000025	1
0.00000000000000000000000015	1
0.000000000000000000000000075	1

COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

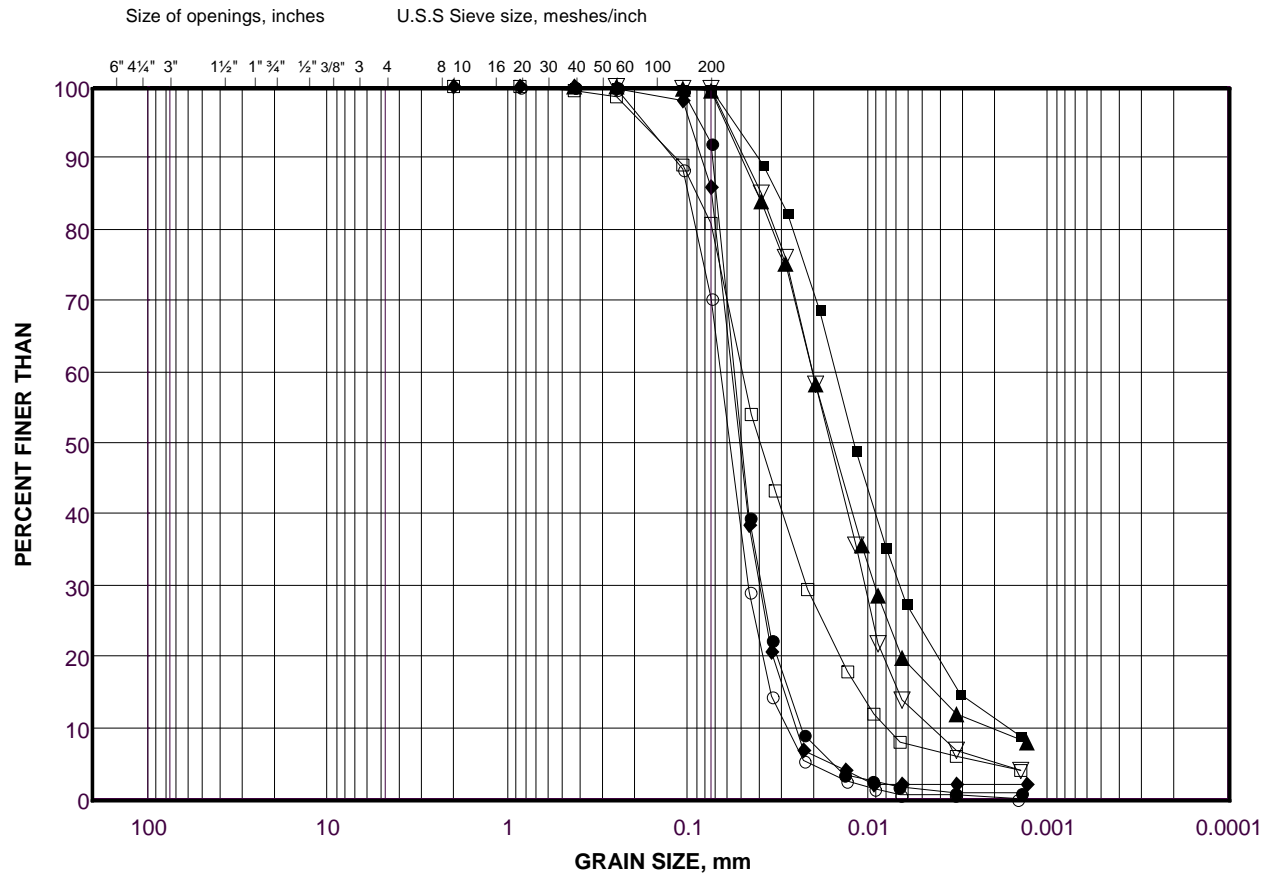
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-3	4	236.6
■	15-2	6	235.6
◆	15-1	7	232.6

Date: 04-Sep-15

# GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B3



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	15-4	10	224.2
■	15-2	11	228.8
◆	15-1	12	225.0
▲	15-4	6	229.5
▽	HF4	7	231.7
○	HF4	9	228.6
□	15-3	9	229.8

Project Number: 1532543

Checked By: LCC

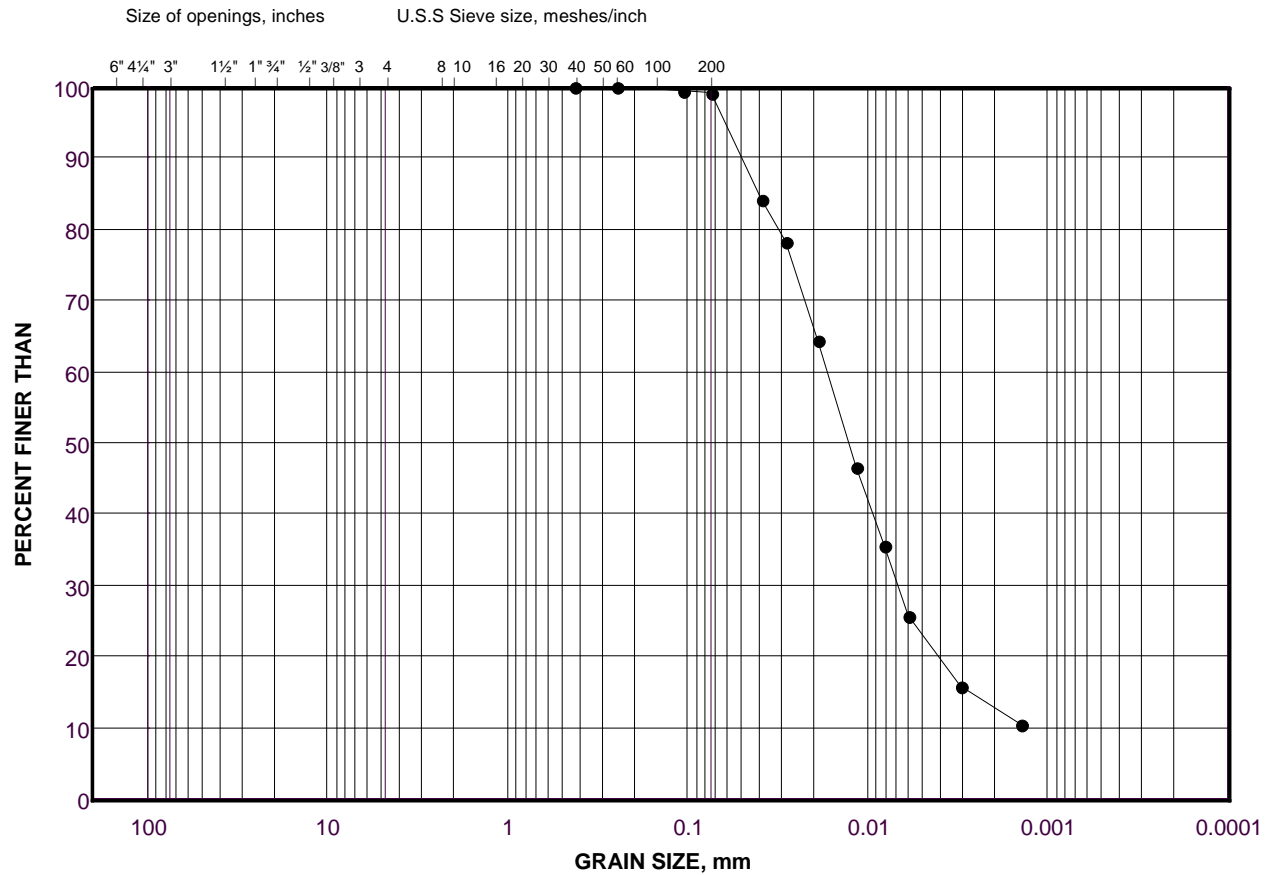
**Golder Associates**

Date: 07-Oct-15

# GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B4



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

## LEGEND

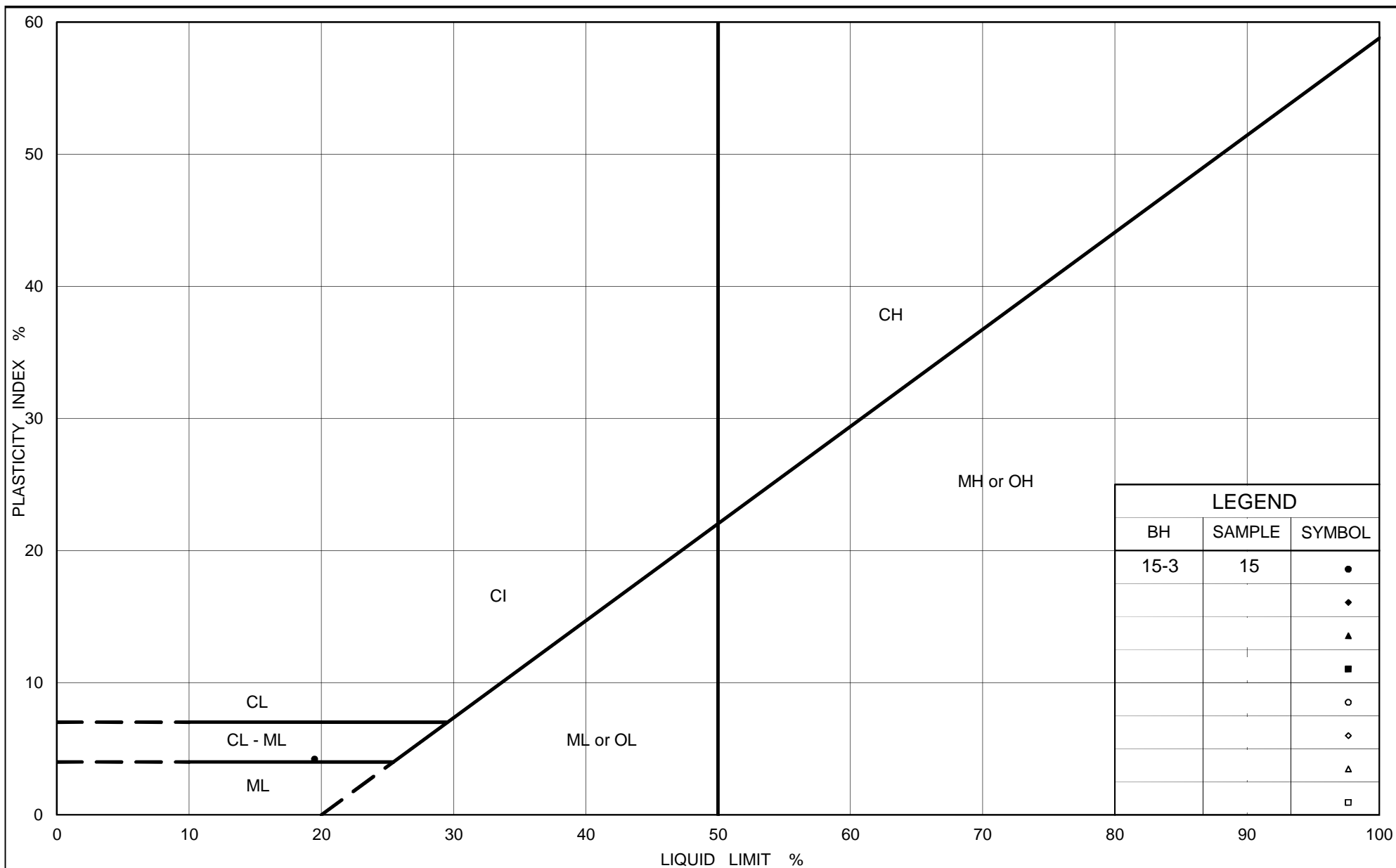
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	15-3	15	221.2

Project Number: 1532543

Checked By: \_\_\_\_\_ LCC

**Golder Associates**

Date: 07-Oct-15



## PLASTICITY CHART Clayey Silt

Figure No. B5

Project No. 1532543

Checked By: LCC





# **APPENDIX C**

## **Non-Standard Special Provisions**



**WORKING SLAB - Item No.**

Special Provision

**1.0 SCOPE**

This Special Provision covers the requirements for the supply and placement of a concrete working slab under structure foundations.

**2.0 REFERENCES**

This Special Provision refers to the following standards, specifications or publications:

**Ontario Provincial Standard Specifications, Construction**

OPSS 902      Excavating and Backfilling - Structures

**3.0 DEFINITIONS - Not Used**

**4.0 DESIGN AND SUBMISSION REQUIREMENTS - Not Used**

**5.0 MATERIALS**

Concrete for working slabs shall have a minimum 28 day strength of 20 MPa.

**6.0 EQUIPMENT - Not Used**

**7.0 CONSTRUCTION**

**7.01 Excavation**

Excavation for the working slab shall be according to OPSS 902.

**7.02 Protection of Founding Soil**

Following inspection and approval of the prepared subgrade, a working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade as specified in the Contract Documents.

**7.03 Dewatering**

Dewatering shall be carried out according to OPSS 902.

**8.0 QUALITY ASSURANCE - Not Used**

**9.0 MEASUREMENT FOR PAYMENT - Not Used**

**10.0 BASIS OF PAYMENT**



**10.01                      Working Slab - Item**

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work.



**OPERATIONAL CONSTRAINT – Preload Period – Embankment Widening Construction**

---

Special Provision

---

The Contractor shall schedule his operations to include the following preloading times for the new Highway 400 northbound lane (NBL) embankment, to allow time for settlement:

- The new Highway 400 NBL embankment shall be constructed up to the top of the granular sub-base material, and the fills shall remain in place for a minimum period of six (6) weeks before paving.

Prior to placement of the Granular A base material and paving, the Contractor shall conduct a survey to determine the elevations of the top of the Granular B sub-base material, and shall place additional Granular B material as and where required to achieve the pavement design sub-base elevation.

The Contractor shall not proceed with final granular placement and paving until approval has been given by the Contract Administrator.



**Temporary Protection Systems – Item No.**

Special Provision

**Amendment to OPSS.PROV 539**

**539.07 CONSTRUCTION**

**539.07.01 General**

Section 539.07.01 is amended by the addition of the following:

The Contractor is advised of the presence of a trichloroethylene (TCE) plume within the limits of the project. Vertical elements of the temporary protection system (eg., soldier piles or sheetpiles) may penetrate below the groundwater table into the sand/silt deposit. However, such vertical elements shall not penetrate into or through the underlying clayey silt to silty clay deposit. The surface of this deposit was encountered at the following elevations, and vertical elements in these areas shall not penetrate below this level.

Tiffin Street Overpasses:

- Elevation 223.5 m in the vicinity of the north abutments
- Elevation 222 m in the vicinity of the south abutments

Barrie-Collingwood Railway (BCR) Overhead Structure:

- Elevation 225 m in the vicinity of the north abutments
- Elevation 225 m in the vicinity of the south abutments

**539.07.02 Removals**

Section 539.07.02 is amended by the addition of the following:

Where an interlocking sheetpile wall is adopted as a temporary protection system measure on this project, removal of the sheetpile wall is required following completion of construction to minimize impacts on the TCE plume, unless otherwise approved by the Contract Administrator.



---

## FOUNDATION REPORT - HIGHWAY 400-TIFFIN STREET OVERPASS REPLACEMENT, GWP 2159-11-00

---

### Excavating and Backfilling – Structures – Item No.

---

Special Provision

---

#### **Amendment to OPSS 902**

**902.07                      CONSTRUCTION**

**902.07.05                Excavation**

**902.07.05.02           Excavation for Foundations**

Section 902.07.05.02 is amended by the addition of the following:

The footing subgrade shall be inspected by the Quality Verification Engineer (QVE) prior to placement of the concrete working slab. Where softened/loosened or deleterious materials are present at the subgrade level, they shall be subexcavated, but such subexcavation shall not extend more than 0.5 m below the subgrade level, in order to maintain the excavation above the groundwater level at the site.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

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

**Golder Associates Ltd.**  
**6925 Century Avenue, Suite #100**  
**Mississauga, Ontario, L5N 7K2**  
**Canada**  
**T: +1 (905) 567 4444**

