



Foundation Investigation and Design Report

Retaining Wall East of Midland Avenue Overpass, Highway 401 Westbound Core and Collector Lanes, Neilson Road to Warden Avenue, City of Toronto, Ontario, Ministry of Transportation, Ontario, G.W.P. No. 2162-11-00

Submitted to:

WSP

610 Chartwell Road, Suite 300
Oakville, ON Canada
L6J 4A5

Submitted by:

Golder Associates Ltd.

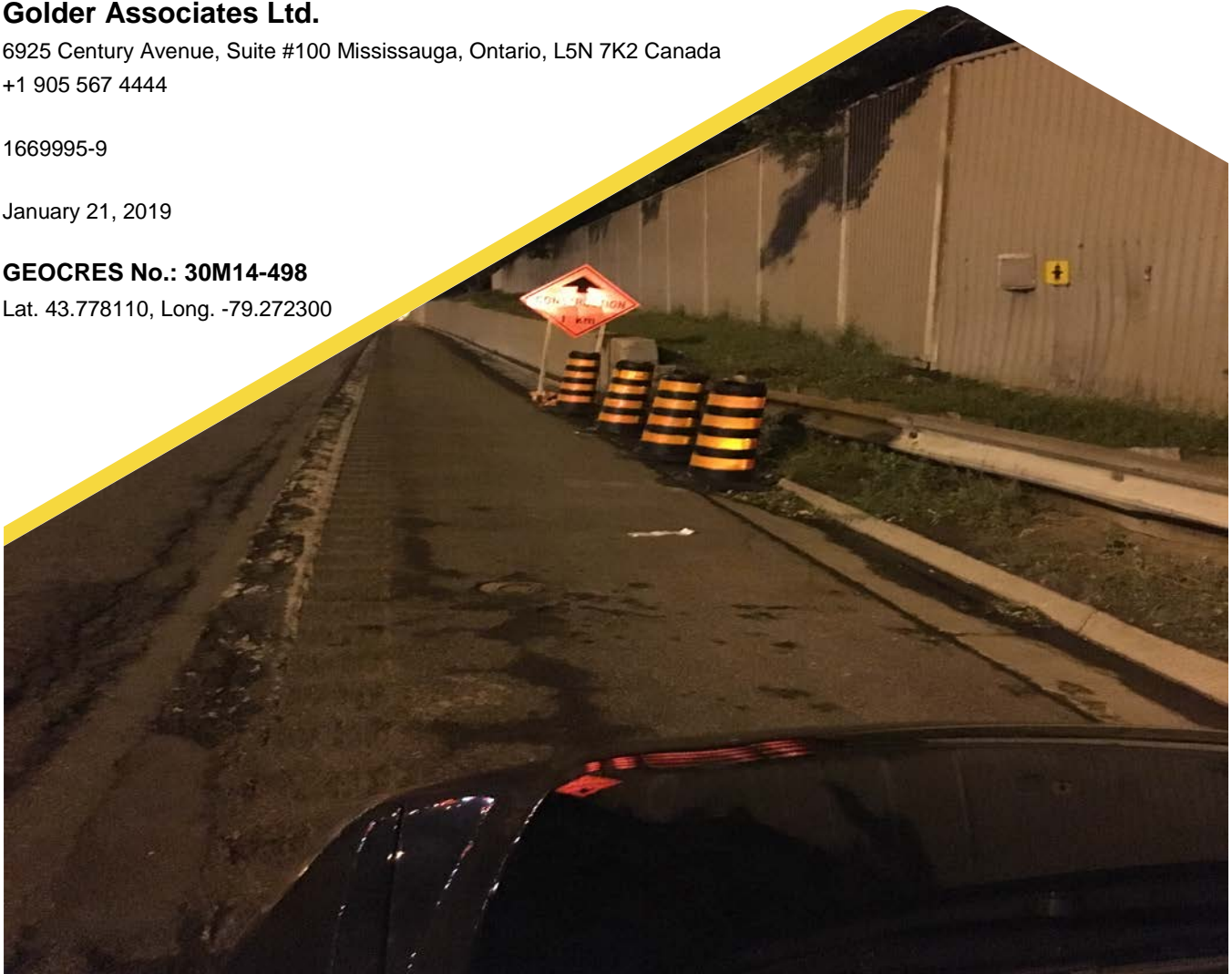
6925 Century Avenue, Suite #100 Mississauga, Ontario, L5N 7K2 Canada
+1 905 567 4444

1669995-9

January 21, 2019

GEOCRES No.: 30M14-498

Lat. 43.778110, Long. -79.272300



Distribution List

1 Hard Copy, 1 E-Copy - MTO Central Region

1 Hard Copy, 1 E-Copy - MTO Foundations Section

1 E-Copy - WSP

1 E-Copy - Golder Associates Ltd.

Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
3.0 INVESTIGATION PROCEDURES	2
3.1 1966 Investigation	2
3.2 2018 Investigation	3
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS.....	4
4.1 Regional Geology.....	4
4.2 Subsurface Conditions	4
4.2.1 Asphalt	5
4.2.2 Fill.....	5
4.2.3 Sandy Silt to Sand	6
4.2.4 Sandy Clayey Silt to Clayey Silt-to-Silt with Sand	6
4.2.5 Lower Clayey Silt	7
4.3 Groundwater Conditions	7
4.4 Analytical Testing Results	8
5.0 CLOSURE	9

PART B – FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS	10
6.1 General.....	10
6.2 General Foundation Design Context.....	11
6.2.1 Consequence and Site Understanding Classification.....	11
6.2.2 Correlation of Automatic and Manual Hammer for SPT “N” Values	11
6.2.3 Seismic Design	11
6.2.3.1 Seismic Site Classification	11
6.2.3.2 Spectral Response Values and Seismic Performance Category	12
6.3 Foundations Options for Retaining Wall	12

6.4	Concrete Retaining Wall on a Shallow Foundation.....	15
6.4.1	Founding Elevations	15
6.4.2	Geotechnical Resistances	16
6.4.3	Resistance to Lateral Loads	16
6.5	Soldier Pile and Concrete Panel Wall	17
6.5.1	Passive Resistance for Soldier Pile Sockets	17
6.5.2	Permanent Soil Anchors	17
6.6	Global Stability for Retaining Wall Options	18
6.6.1	Concrete Cantilever Retaining Wall on Shallow Foundations	19
6.6.2	Soldier Pile and Concrete Panel Wall	19
6.7	Lateral Earth Pressures for Design of Retaining Walls.....	19
6.7.1	Static Lateral Earth Pressures for Design.....	20
6.7.2	Seismic Lateral Earth Pressures for Design	21
6.8	Corrosion Assessment and Protection.....	22
6.9	Construction Considerations	22
6.9.1	Excavations	22
6.9.2	Temporary Excavation Support and Vibration Monitoring	22
6.9.3	Groundwater and Surface Water Control	23
6.9.4	Obstructions	23
6.9.5	Subgrade Protection	24
7.0	CLOSURE	24

REFERENCES

TABLES

Table 1	Comparison of Retaining Wall and Foundation Alternatives
---------	--

DRAWINGS

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

FIGURES

Figure 1	Static Global Stability Analysis – Concrete Cantilever Retaining Wall
Figure 2	Static Global Stability Analysis – Soldier Pile and Concrete Panel Wall

APPENDICES

APPENDIX A - Borehole Records from 1966 Investigation (GEOCREC No. 30M14-74)

APPENDIX B - Borehole Records from 2018 Investigation

Lists of Symbols and Abbreviations

Record of Borehole MA-03, RW-01, RW-02 and NBP1-03

APPENDIX C - Geotechnical Laboratory Test Results

Figure C-1	Grain Size Distribution – Clayey Silt with Sand (Fill)
Figure C-2	Plasticity Chart – Clayey Silt with Sand (Fill)
Figure C-3	Grain Size Distribution – Silt and Sand
Figure C-4	Plasticity Chart – Silt and Sand
Figure C-5	Grain Size Distribution – Sandy Clayey Silt to Clayey Silt to Silt with Sand
Figure C-6	Plasticity Chart – Sandy Clayey Silt to Clayey Silt to Silt with Sand

APPENDIX D - Analytical Laboratory Test Results

APPENDIX E - Non-Standard Special Provisions

Working Slab

Protection Systems – Item No.

Vibration Monitoring

Earth Excavation for Structures (Obstructions)

PART A

FOUNDATION INVESTIGATION REPORT
RETAINING WALL EAST OF MIDLAND AVENUE OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON
ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
MTO G.W.P. 2162-11-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the rehabilitation and operational improvements of the Highway 401 westbound (WB) core and collector lanes, from Neilson Road to Warden Avenue in the City of Toronto, Ontario (GWP 2162-11-00).

This report addresses the foundation investigation carried out for the proposed retaining wall east of Midland Avenue associated with the northward widening of Highway 401. This report was developed based on information from the 2018 (current) investigation, supplemented with information from a 1966 (previous) foundation investigation completed by others at the structure site, reported as follows:

- **MTO GEOCRETS No. 30M14-74:** Report titled “Foundation Investigation Report for the Proposed Extension of Hwy. #401 and Midland Ave. Crossing, Metropolitan Toronto, District #6, W.J. 66-F-87 - W.P. 260-61”, by DHO, Foundation Section, Materials and Testing Division, dated January 4, 1967;

The results of the 1966 investigation are also summarized in the following report:

- **MTO GEOCRETS No. 30M14-340:** “Preliminary Foundation Investigation and Design Report, Retaining Walls, Highway 401 Rehabilitation from Warden Avenue to Brock Road, Toronto, Ontario, W.O. 07-20012,” by Golder Associates Ltd., dated April 2012.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated November 21, 2016, which forms part of the Consultant Agreement (No. 2016-E-0009) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated July 10, 2017.

2.0 SITE DESCRIPTION

The existing retaining wall is located on the north side of Highway 401 WB, extending from Midland Avenue to McDairmid Woods Park in the City of Toronto, Ontario as shown on the Key Plan on Drawing 1. The existing retaining wall is approximately 400 m long, with the top of the retaining wall ranging between Elevation 172.6 m at the westerly most point (Midland Avenue overpass) to Elevation 173.6 m at the easterly most point. The Highway 401 roadway grade increases from about Elevations 172.5 m to 175.5 m, from west to east along the retaining wall alignment. Industrial parks are located along the south of the highway and in the southwest quadrant of the intersection, while a residential area extends along the northern side of Highway 401 and is located behind the existing retaining wall.

The existing retaining wall consists of a concrete cantilever wall on a continuous strip footing. The footings are stepped up from west to east, with the retained soil mass consisting of both a fill and a cut section as summarized below.

Section	Approximate Station	Approximate Length of Wall	Approximate Height of Wall	Approximate Footing Founding Elevation (m)
Fill	23+773 to 23+910	137 m	8.3 m to 1.1 m	164.5 to 172.2
Cut	23+910 to 24+187	277 m	1.1 m to 3.7 m to 2 m	172.1 to 173.4

3.0 INVESTIGATION PROCEDURES

3.1 1966 Investigation

A total of 15 boreholes were advanced as part of a 1966 investigation (GEOCRE No. 30M14-74) along the retaining wall extending easterly from Midland Avenue. The previous investigation boreholes used in this report have been renumbered to show the MTO GEOCRE reference number followed by the original borehole designation. For example, the boreholes from MTO GEOCRE Report No. 30M14-74 have been renumbered as 74-X, where X is the original borehole number.

The locations of the boreholes are summarized below and shown on Drawing 1. These borehole locations have been developed based on plotting the station and offset as shown on the 1966 borehole records and drawings, adjusted based on the site features shown on the drawings and converted to MTM NAD83 (Zone 10) coordinates. The borehole records from the 1966 investigation, including the summary results of the groundwater conditions and results of the geotechnical laboratory testing are presented in Appendix A and a summary of the borehole locations, ground surface elevation referenced to Geodetic datum and drilled depths are presented below. The summarized stratigraphy along the retaining wall alignment is shown on the stratigraphic profile on Drawing 1.

Borehole No.	MTM NAD 83 (Zone 10)		Borehole Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
74-1	4,848,650.4	322,931.3	166.1	36.6
74-2	4,848,645.5	322,914.7	165.6	11.1
74-14	4,848,659.2	322,962.8	167.5	9.6
74-15	4,848,667.7	322,991.8	169.9	6.6
74-16	4,848,679.9	323,027.0	173.0	9.6
74-17	4,848,688.6	323,055.0	175.1	6.6
74-18	4,848,697.4	323,087.6	175.3	6.6
74-19	4,848,708.0	323,118.0	177.2	9.6
74-20	4,848,717.0	323,146.8	178.8	6.6
74-21	4,848,725.5	323,178.4	178.6	6.6
74-22	4,848,731.4	323,207.3	178.1	9.6
74-23	4,848,738.7	323,239.2	177.7	6.6
74-24	4,848,744.3	323,263.5	177.4	6.6
74-25	4,848,750.0	323,290.5	176.7	9.6
74-26	4,848,753.3	323,316.8	174.3	6.6

The Standard Penetration Test (SPT) “N”-values presented on the borehole records of the 1966 investigation were obtained using a manual hammer.

3.2 2018 Investigation

The current foundation investigation repeated below was carried out between March 25 and May 31, 2018, during which time four boreholes (designated as Boreholes MA-03, RW-01, RW-02 and NBP1-03) were advanced along the proposed retaining wall alignment at the locations shown on Drawing 1.

The borehole investigation was carried out using CME-55 and CME-75 truck-mounted drill rigs supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. Borehole MA-03 was advanced through the overburden using 178 mm outside diameter hollow stem augers to a depth of 4.9 m below existing ground surface; Borehole RW-01 was advanced through the overburden using 216 mm outside diameter hollow stem augers to a depth of 7.9 m below existing ground surface; and Boreholes RW-02 and NBP1-03 were advanced through the overburden using 165 mm outside diameter hollow stem augers to depths of 8.4 m and 8.2 m below existing ground surface, respectively.

Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)¹.

The groundwater conditions in the open boreholes was observed during and immediately following the drilling operations. A standpipe piezometer was installed in Boreholes MA-03 and RW-01 to permit monitoring of the water level. The installed piezometers consist of a 50 mm diameter PVC pipe, with a 1.5 m slotted screen within a filter sand pack, with the piezometer sealed within the borehole near the bottom of the borehole. The annulus between the piezometer pipe and the borehole wall above the filter sand pack was backfilled to near the pavement surface with bentonite pellets and a 152 mm diameter 0.3 m long protective pipe/cap was placed around / over the piezometer pipe at the pavement surface and the pavement was reinstated around the protective pipe using cold patch asphalt.

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the borehole in the field, directed the sampling and in situ testing operations, logged the borehole and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual review. Geotechnical laboratory index and classification testing, consisting of natural moisture contents, Atterberg limits and grain size distributions, was conducted on selected samples in accordance with MTO and / or ASTM Standards as applicable. One sample from each of Boreholes RW-01, RW-02, and NBP1-03 obtained using appropriate sampling protocols, was submitted to a specialist accredited analytical laboratory under chain of custody procedures for testing of conductivity / resistivity, pH and chemical analysis of sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel.

The borehole locations were laid out in the field by Golder personnel relative to existing road features and pre-selected coordinates using a hand-held global positioning system (GPS) unit with an accuracy of 1 m in the horizontal and vertical directions. The borehole locations were then measured relative to existing site features and the ground surface (pavement) elevation at the borehole locations was established from the digital terrain model for the project. The location given on the borehole records and shown on Drawing 1 is positioned relative to

¹ ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including both MTM NAD 83 and geographic coordinates, ground surface elevation and drilled depth are summarized below.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude °)	Easting (m) (Longitude °)		
MA-03	4,848,662.6 (43.777710)	322,955.3 (-79.274464)	167.4	4.9
RW-01	4,848,7741.1 (43.778708)	323,333.3 (-79.269855)	175.0	7.9
RW-02	4,848,707.5 (43.778110)	323,129.3 (-79.272300)	174.4	8.4
NBP1-03	4,848,790.4 (43.778851)	323,378.1 (-79.269207)	174.8	8.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 401 is located within the physiographic region known as the South Slope, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)².

The South Slope region is comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by flowing streams towards Lake Ontario. The surface topography slopes gradually and uniformly southwards towards Lake Ontario. The overburden within the majority of the South Slope area is underlain by shale bedrock of the Queenston and Georgian Bay Formations which contain limestone interlayers.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the borehole advanced during the 2018 investigation, including piezometer installation details and water level readings in the piezometers, and the results of the geotechnical laboratory tests carried out on selected soil samples are presented on the borehole records provided in Appendix B. The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. The SPT “N”-values from the 1966 investigation are based on use of a manual hammer, while those in the 2018 investigation are based on use of an automatic hammer and the values are reported with no adjustment in this report, although it is recognized that SPT “N”-values obtained using a manual hammer are frequently higher than those obtained using an automatic hammer. Plot of the results of the geotechnical laboratory testing from the current investigation are presented in Appendix C. The results of the analytical testing are provided in Appendix D.

² Chapman, L.J. and Putnam, D.F., 1984, *The Physiography of Southern Ontario*, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile on Drawing 1 for the two investigations are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations, however, the factual data presented in the borehole records governs any interpretation of the site conditions. It is important to note that the current ground surface along the proposed retaining wall alignment is significantly higher than the previous ground surface at the time of the 1966 borehole investigation as a result of subsequent highway and retaining wall construction.

In general, the subsurface conditions encountered in the various boreholes advanced at the site consist of the Highway 401 pavement and pavement structures, embankment fill underlain by a deposit that grades from sandy silt to silt and sand to silty sand to sand. A sandy clayey silt to clayey silt with sand deposit and interlayers of clayey silt-to-silt with sand are present within and between the non-cohesive deposit. A lower clayey silt deposit is present beneath the sandy silt to sand deposit in one borehole. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

4.2.1 Asphalt

An approximately 152 mm to 203 mm thick layer of asphalt pavement was encountered immediately below ground surface in Boreholes RW-01, RW-02 and NBP1-03, which were advanced on the Highway 401 roadway; and an approximately 50 mm thick layer of asphalt pavement was encountered immediately below ground surface in Borehole MA-03, which was advanced in the walkway north of Highway 401 east of Midland Avenue.

4.2.2 Fill

An approximately 0.4 m to 0.5 m thick layer of gravelly sand fill was encountered underlying the asphalt pavement in Boreholes RW-01, RW-02 and NBP1-03, which were advanced on the Highway 401 roadway. The gravelly sand fill is underlain by an approximately 0.8 m thick layer of sandy silt fill in Borehole RW-01, an approximately 3.5 m thick layer of clayey silt with sand in Borehole RW-02 and an approximately 0.8 m thick layer of sandy clayey silt in Boreholes RW-02 and NBP1-03, respectively. The fill extends to between Elevations 173.5 m and 170.3 m in Boreholes RW-01, RW-02 and NBP1-03. An approximately 0.7 m thick layer of silty sand fill was encountered underlying the asphalt pavement in Borehole MA-03, advanced in the walkway north of Highway 401 east of Midland Avenue. The fill extends to about Elevation 166.6 m in Borehole MA-03.

The measured Standard Penetration Test (SPT) “N”-value within the silty sand and sandy silt fill is 19 blows per 0.3 m of penetration, indicating a compact level of compactness. The SPT “N”-values measured within the cohesive (clayey silt) fill range between 10 blows and 36 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

A grain size distribution test was carried out on one sample of the cohesive fill layer encountered during the 2018 investigation, and the result is shown on Figure C-1 in Appendix C. Atterberg limits testing was carried out on one selected sample of the cohesive fill layer encountered during the 2018 investigation and measured a liquid limit of 17 per cent, a plastic limit of 10 per cent, and a corresponding plasticity index of 7 per cent. The result, which is plotted on a plasticity chart on Figure C-2 in Appendix C, indicate that the fill layer consists of a clayey silt of low plasticity. The natural water content measured selected samples of the cohesive fill range between about 8 and 11 per cent. The natural water content measured on one selected sample of the non-cohesive fill is about 10 per cent.

4.2.3 Sandy Silt to Sand

A sandy silt to sand deposit, comprised of various interlayers ranging in composition from sandy silt to silt and sand to silty sand to sand was encountered in most boreholes, of both the 1966 and 2018 investigations, as described in more detail below.

A silt and sand deposit was encountered underlying the fill layer in Borehole MA-03 at a depth of 0.8 m, corresponding to Elevation 166.6 m. The borehole terminated within this deposit, penetrating it for a thickness of 4.1 m. A 0.5 m thick sand deposit was encountered underlying the clayey silt with sand deposit (described below in Section 4.2.4) in Borehole RW-02 at a depth of 7.8 m, corresponding to Elevation 166.6 m. A silt and sand deposit was encountered underlying the clayey silt to silt with sand deposit in Borehole NBP1-3 at a depth of 7.2 m, corresponding to Elevation 167.6 m; and the borehole was terminated within this deposit, penetrating it for a thickness of 1.0 m. A silty sand to sandy silt deposit containing clayey silt interlayers was encountered immediately below the original ground surface in Boreholes 74-1, 74-2, 74-14 to 74-17, and 74-19 to 74-26 from the 1966 investigation. All boreholes, except Borehole 74-1, terminated within this deposit, penetrating it for a thickness between 6.5 m and 11.2 m. The thickness of the deposit in Borehole 74-1 is 22.6 m, with the bottom of the deposit encountered at Elevation 143.5 m.

The SPT “N”-values measured within the various layers of the sandy silt to sand deposit range vary from 25 blows to 156 blows per 0.3 m of penetration, up to 100 blows for 0.04 m of penetration, with the “N”-values increasing with depth, indicating a compact to very dense level of compactness. One “N”-value of 6 blows per 0.3 m of penetration was measured within the sand layer underlying the clayey silt with sand deposit in Borehole RW-02 indicating a loose level of compactness in this layer.

Grain size distribution tests were carried out on three samples of the silt and sand deposit encountered during the 2018 investigation, and the results are shown on Figure C-3 in Appendix C. Grain size distribution test was carried out on eight selected samples of the silty sand to sandy silt deposit recovered during the 1966 investigation and the results are presented on the borehole records included in Appendix A. Atterberg limits testing was carried out on three selected samples of the silt and sand deposit encountered during the 2018 investigation and two tests measured liquid limits of 13 per cent and 14 per cent, plastic limits of 11 per cent and 13 per cent, and plasticity indices of 1 per cent. The results, which are plotted on a plasticity chart on Figure C-4 in Appendix C, indicate that the deposit contains silt of slight plasticity. One sample was non-plastic.

Atterberg limits testing was carried out on selected samples of the clayey silt interlayers from the 1966 investigation and measured plastic limits ranging from about 10 per cent to 18 per cent, liquid limits ranging from about 15 per cent to 29 per cent, and plasticity indices ranging from about 3 per cent to 11 per cent. These test results confirm that the interlayers consist of clayey silt of low plasticity. Two Atterberg limit tests carried out on selected samples of the silty sand to sandy silt deposit were non-plastic, and overall indicate that the deposit is predominantly non-cohesive.

The natural water content measured selected samples of the sandy silt to silty sand range between about 3 per cent and 23 per cent. The high/variable water contents can be attributed to the presence of clayey silt layers within the predominantly non-cohesive deposit.

4.2.4 Sandy Clayey Silt to Clayey Silt-to-Silt with Sand

A sandy clayey silt to clayey silt-to-silt with sand deposit was encountered underlying the fill in Boreholes RW-01, RW-02 and NBP1-03 at depths ranging from 1.5 m to 4.1 m, corresponding to between Elevations 173.5 m and

170.3 m. Boreholes RW-01 terminated within this deposit, penetrating it for a thickness of 6.4 m. The deposit is 3.7 m thick and 5.7 m thick in Boreholes RW-02 and NBP1-03, respectively. A lower 0.1 m thick layer of sandy clayey silt was encountered underlying the sand deposit in Borehole RW-02 at a depth of 8.3 m, corresponding Elevation 166.1 m. The borehole terminated within this layer on refusal to further split spoon advancement. A silt to clayey silt deposit was encountered immediately beneath ground surface in Borehole 74-18 of the 1966 investigation; and the borehole was terminated within this deposit, penetrating it for a thickness of 6.6 m.

The SPT “N”-values measured within the cohesive deposit / layers range from 20 blows to 185 blows per 0.3 m of penetration with “N”-values up to 100 blows for 0.08 m of penetration, with the values increasing with depth, suggesting a very stiff to hard consistency.

Grain size distribution tests were carried out on four samples of the cohesive deposit encountered during the 2018 investigation, and the results are shown on Figure C-5 in Appendix C. Atterberg limits testing was carried out on four selected samples of the cohesive deposit encountered during the 2018 investigation and measured liquid limits of 16 per cent, plastic limits ranging between 9 per cent and 12 per cent, and plasticity indices ranging between 5 per cent and 7 per cent. The results, which are plotted on a plasticity chart on Figure C-6 in Appendix C, indicate that the deposit consists of clayey silt of low plasticity. Atterberg limits test was carried out on two selected samples of the cohesive deposit encountered during the 1966 investigation and measured liquid limits of about 18 per cent and 19 per cent, plastic limits of about 11 per cent and 12 per cent, and plasticity indices of about 7 per cent indicating that this material is classified as a clayey silt of low plasticity. The natural water content measured selected samples of the cohesive deposit range between about 4 per cent and 9 per cent.

4.2.5 Lower Clayey Silt

A clayey silt deposit was encountered below the silty sand to sandy silt in Borehole 74-1 from the 1966 investigation at a depth of 22.6 m below the original ground surface, corresponding to Elevation 143.5 m. The borehole terminated within this deposit, penetrating it for a thickness of 14.0 m.

The measured SPT “N” values within the clayey silt deposit range from 91 to 106 blows per 0.3 m of penetration, suggesting a hard consistency.

Atterberg limits testing was carried out on one sample of the clayey silt deposit and measured a plastic limit of about 17 per cent, a liquid limit of about 25 per cent, and a corresponding plasticity index of about 8 per cent, confirming that the deposit consists of a clayey silt of low plasticity. The natural water content measured on three samples of the clayey silt is about 18 per cent.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations during the 2018 and 1966 investigations, and in the piezometers installed in Boreholes MA-03 and RW-01, as summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date	Comments
MA-03	167.4	Dry	-	May 31, 2018	Piezometer (on completion)
		3.7	163.7	July 30, 2018	Piezometer
RW-01	175.0	Dry	-	Mar. 28, 2018	Piezometer (on completion)
		4.5	170.5	July 30, 2018	Piezometer
RW-02	174.4	6.3	168.1	Apr. 9, 2018	Open Borehole
NBP1-3	174.8	Dry	-	Mar. 25, 2018	Open Borehole
74-1	166.1	1.8	164.3	Oct. 5, 1966	Open Borehole
74-2	165.6	2.5	163.1	Oct. 6, 1966	Open Borehole
74-22	178.1	6.7	171.4	Nov. 9, 1966	Open Borehole
74-23	177.7	4.7	173.0	Nov. 9, 1966	Open Borehole
74-24	177.4	4.5	172.9	Nov. 14, 1966	Open Borehole
74-25	176.7	4.6	172.1	Nov. 14, 1966	Open Borehole

As these water levels were measured immediately after completion of drilling, they may not represent the stabilized groundwater level at the site, nor the current level in the case of the 1966 data. Based on the observed water conditions, together with soil colour transitions from brown to grey, the groundwater level is estimated to range between approximately Elevations 164 m and 173 m. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.4 Analytical Testing Results

Three soil samples were submitted to an accredited analytical laboratory for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. Detailed analytical test results are included in Appendix D and the test results are summarized below.

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (umho/cm)	Chlorides (ug/g)	Soluble Sulphates (ug/g)
RW-01 / 3	8.07	1,300	743	370	<20*
RW-02 / 9	8.28	6,300	160	<20*	68
NBP1-03 / 6	8.0	1,600	627	320	<20*

* Reportable Detection Limit

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Jorge M.A. Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant of Golder, conducted an independent technical and quality control review of the report.

Golder Associates Ltd.



Nikol Kochmanová, Ph.D., P.Eng., PMP
Geotechnical Engineer



Jorge M.A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

NK/JMAC/rb

Golder and the G logo are trademarks of Golder Associates Corporation

<https://golderassociates.sharepoint.com/sites/16003g/6.deliverables/9.rw/3.final/1669995fidr092019jan21hwy401wb.rw.docx>

PART B

FOUNDATION DESIGN REPORT
RETAINING WALL EAST OF MIDLAND AVENUE OVERPASS
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES, NEILSON
ROAD TO WARDEN AVENUE, CITY OF TORONTO, ONTARIO
MTO G.W.P. 2162-11-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed retaining wall extending easterly of Midland Avenue associated with the northward widening of Highway 401 as part of the rehabilitation and operational improvements of the Highway 401 westbound core and collector lanes, from Neilson Road to Warden Avenue in the City of Toronto, Ontario. These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the 2018 subsurface investigation at this site, supplemented with data from the 1966 investigation. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible foundation alternatives and carry out the design of the proposed retaining wall. The foundation investigation report, discussions and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and their designers, and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Foundation Investigation Report (Part A) of this report. Where comments are made on construction, they are provided to highlight those aspects that 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 must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

The existing retaining wall was constructed in 1969 together with the construction of the Midland Avenue overpass. The following design drawings are available for the Midland Avenue Overpass:

- Contract No. 69-09, W.P. No. 252-61-7, Drawings D-6151-1 to D-6151-7: "Retaining Wall No. 3", prepared by Department of Highways Ontario, Bridge Division, dated April 1967.

The existing retaining wall is a concrete cantilever type structure on a continuous strip footing. The footing is stepped up from west to east, with the retained soil mass consisting of both a fill and a cut section as summarized below.

Section	Approximate Station	Approximate Length of Wall	Approximate Height of Wall	Approximate Footing Founding Elevation (m)
Fill	23+773 to 23+910	137 m	8.3 m to 1.1 m	163.7 to 172.0
Cut	23+910 to 24+187	277 m	1.1 m to 3.7 m to 2 m	172.0 to 173.4

The existing retaining wall extends along the north side of Highway 401, and is located in close proximity to private properties and an up to 2.6 m widening of Highway 401 is proposed along the retaining wall alignment. Based on the design drawings provided by WSP, dated August 2018, and discussions with WSP, given the limited width of available right of way along the proposed Highway 401 widening, it is proposed to leave the existing retaining wall in place and construct a new retaining wall immediately to the north of it. The existing retaining wall will be retrofitted with soil anchors tied back under the highway as a means to extend its' lateral retaining capacity service life as it will not be accessible for future repairs/strengthening. The new retaining structure is proposed to be a cantilever wall on a continuous strip footing that is tied to the existing strip footing, i.e., the new retaining wall strip footing will be founded at the same elevation as the existing retaining wall strip footing and the footing will be connected to the

new footing by dowels. The space between the existing wall and new retaining wall is to be filled with either granular backfill, unsinkable fill (U-fill), or a combination of both materials. Once the new wall is constructed the existing retaining wall is to be cut off at a depth sufficiently below the highway grade and adequate soil cover is to be provided over the remaining below-grade portion of the existing wall to avoid a “hard-point” at the road surface. It is recommended that a drainage system be incorporated within the backfill between the existing wall and new retaining wall. The drainage system showed be consistent with OPD 3190.100 (*Wells, Retaining and Abutment, Wall Drain*) including provision of a positive outlet for drainage.

6.2 General Foundation Design Context

6.2.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* CAN/CSA S6-14 (*CHBDC* (2014)) and its *Commentary*, the retaining wall and its foundation system may be classified as a geotechnical system designed for application along a transportation corridor having large traffic volumes and as having potential impacts on other transportation corridors, resulting in a “typical consequence level” associated with exceeding limit states design.

Based on the level of foundation investigation completed as part of the 1966 and 2018 investigations in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design for the proposed retaining wall has been assessed as “typical degree of site and prediction model understanding”.

The corresponding consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2, respectively, of the *CHBDC* (2014) have been used for the assessment of the geotechnical resistances of the new foundations.

6.2.2 Correlation of Automatic and Manual Hammer for SPT “N” Values

The results of the 2018 investigation generally demonstrate lower Standard Penetration Test (SPT) “N”-values than encountered in the boreholes from the 1966 investigation (GEOCREC No. 30M14-74). The differences are considered largely due to the use of an automated hammer with higher efficiency in the 2018 investigation as compared to a manually operated hammer (i.e., rope cathead) that was used in the 1966 investigation. The 2018 SPT “N”-values correlate reasonably well with the 1966 data when corrected to a 60% efficiency of hammer energy transfer, as suggested in CFEM (2006). The foundation options and recommendations presented below are based on the normalized “N₆₀”-values, where applicable.

6.2.3 Seismic Design

6.2.3.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation and laboratory testing. The SPT “N”-values measured in the soil layers and the interpreted shear wave velocity of soils up to 30 m below founding level were used to define the seismic site classification in accordance with Table 4.1 of the *CHBDC* (2014). Based on this methodology, it is considered that a Site Class C would be applicable for the design of the retaining wall extending along the north side of Highway 401 east of Midland Avenue.

6.2.3.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.4 of the *CHBDC* (2014) and as obtained from NRC (2017) website, the peak ground acceleration (PGA), peak ground velocity (PGV) and design spectral acceleration (Sa) values for Site Class C are presented below.

Seismic Hazard Values	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475 return period)
PGA (g)	0.040	0.071	0.134
PGV (m/s)	0.031	0.052	0.090
Sa (0.2) (g)	0.068	0.115	0.209
Sa (0.5) (g)	0.043	0.067	0.112
Sa (1.0) (g)	0.024	0.036	0.059
Sa (2.0) (g)	0.011	0.018	0.028
Sa (5.0) (g)	0.0024	0.0041	0.0069
Sa (10.0) (g)	0.0011	0.0017	0.0029

6.3 Foundations Options for Retaining Wall

This section of the report presents a comparison of alternative retaining wall / foundation types based on advantages and disadvantages of wall types and provides geotechnical recommendations for the feasible types of walls and foundation alternatives for this site.

It should be noted that the selection of the type of wall and foundation alternative will depend on many factors beyond geotechnical / foundation considerations. From a geotechnical/foundations perspective the type of retaining wall considered suitable for the replacement of the existing retaining wall given the soil conditions as encountered in the various boreholes drilled at the retaining wall site include the following:

- **Concrete Retaining Wall on Shallow Foundations:** A concrete cantilever retaining wall supported on shallow foundations (concrete strip footing) is geotechnically feasible for the new retaining wall. Removal of the existing retaining wall would require excavation to the base of the existing foundation(s), which would also allow for construction of new shallow foundations for the replacement structure. However, removal of the existing retaining wall would require a large excavation zone, extending into one or more of the Highway 401 WB core lanes, and temporary protection systems would be required parallel to Highway 401 for the removal and construction of the new retaining wall. Additionally, widening of the highway platform would require benching of the new fill material into the existing fill material, further extending the excavation zone. Alternatively, given the narrow widths of the proposed widening, and the private property right-of-way constraints along the north side of Highway 401, consideration given to leaving the existing wall in place and constructing a new wall in front of it is appropriate. A concrete cantilever retaining wall supported on shallow foundations is typically less tolerable to post construction settlements than other more flexible wall systems;

therefore, as it is proposed that the new foundations be tied to the existing foundations, some level of differential settlement (say 25 mm) should be accounted for in the structural design of the new wall.

- **Fill Section:** For the section of the retaining wall backfill and assuming that the existing retaining wall remains in place, the existing wall would act as a temporary protection system along Highway 401 such that and the new retaining wall could be founded at about the existing footing elevations, provided competent material is present at this level, so as not to undermine the existing foundations. A temporary excavation easement to allow construction of the new wall may be required depending on the proximity of private property to the alignment of the new wall.
- **Cut Section:** For the section of wall that will be constructed to retain existing soil at greater elevation than the Highway 401 grade, a temporary protection systems would be required both along Highway 401, which could be provided by the existing retaining wall if left in place, and along the slope or cut bank to the north of the new wall. A temporary cut slope at 2H:1V may be excavated to allow for the construction of the new retaining wall foundations and wall stem, followed by backfilling against the wall, in which case a temporary excavation easement may be required depending on the proximity of private property.
- **Concrete Retaining Wall on Deep Foundations:** A concrete cantilever retaining wall supported on deep foundations (steel H piles or drilled shafts) is geotechnically feasible but is not considered practical from a constructability perspective nor warranted from a foundations perspective. Pre-augering would be required for pile foundations due to the presence of “100-blow” material at shallow depths. Temporary or permanent liners may be required to construct the deep foundations (i.e., drilled shafts) based on the soil conditions encountered during the investigation. As with a concrete cantilever retaining wall supported on shallow foundations, if the existing retaining wall is removed, temporary protection systems will be required along the highway limits for the removal and construction of the new retaining wall and benching of the existing fill to key-in the new fill material into the existing fill would be required. Removal of the existing retaining wall will require excavation to the base of the existing foundation(s), but the excavation would also then allow for construction of the pile caps for the new retaining wall. If the existing retaining wall foundations are left in place, the pile cap for the new retaining wall could be tied to the existing shallow foundations. As excavations to the same depths as for shallow foundations would be required for the construction of the new pile caps, and given the presence of competent material at shallow depths, deep foundations are not a practical alternative at this site and are not discussed further.
- **Soldier Pile and Concrete Panel Wall:** A soldier pile and concrete panel system is geotechnically feasible for the new retaining wall in the cut section but may not be practical as competent material is present at shallow depths. This type of wall is advantageous in “top-down” construction applications as part of a cut widening, as is the case for the cut section of the retaining wall, rather than for an embankment widening as is the case for the fill section of the retaining wall. The existing retaining wall could be left in place, with the new wall constructed in front, thereby decreasing the excavation zone and the need for temporary excavation support along the retaining wall. If the exiting retaining wall is removed, the soldier pile and concrete panel system could act as a temporary protection system along the new retaining wall alignment, and temporary protection systems would also be required parallel to Highway 401 to facilitate the removal of the existing retaining wall. Additionally, if the existing retaining wall is removed, the new fill material would have to be benched into the existing fill requiring cutting into the highway platform.
- **Fill Section:** A soldier pile and concrete panel system is not considered practical from a constructability perspective and not warranted from a foundations perspective for the fill section of the retaining wall as

competent material is present at shallow depths. It is considered that construction of a soldier pile and concrete panel wall would be more time-consuming than the construction of a concrete cantilever wall due to the various steps involved (i.e., augering holes; placing and concreting soldier piles; placing backfill in lifts and installing concrete panels; and installing and pre-stressing tie-backs, including testing of selected tie-backs). Lateral restraint in the form of soil anchors could be required at some locations. In fill sections of the wall alignment, lateral restraints (anchors) would have to extend under the existing and widened highway platform. The soldier pile wall could be constructed as a traditional “soldier pile and wood lagging” wall, then enhanced with pre-cast or cast in place concrete panels on the exposed face for aesthetic considerations.

- **Cut Section:** For the cut section, a soldier pile and concrete panel system is considered both feasible and practical, as the wall could serve as a temporary protection system and permanent retaining wall, reducing the excavation requirements north of Highway 401, while the existing wall could remain in place acting as a protection system to the existing highway platform. If the existing retaining wall is to be left in place, a soldier pile and concrete panel system could be constructed to the north of the existing wall, thereby reducing the excavation requirements.
- **Reinforced Soil System (RSS) Wall:** An RSS wall is geotechnically feasible for the replacement of the existing retaining wall but is not considered practical from a constructability perspective. For both the fill and cut sections, the existing retaining wall would have to be removed in order to provide sufficient space to for the required reinforcing strip lengths due to the height of the retaining wall, namely closest to Midland Avenue. This would require that the excavations be extended to the base of the existing foundations, which would increase the excavation zone and temporary protections would be required. If the existing retaining wall is left in place, an RSS wall would not be feasible unless the new retaining wall alignment is moved further to the north to account for the required reinforcing strips. As with the concrete retaining wall option, the extent of temporary excavation required to construct the RSS wall on native soils may require a temporary excavation support system, or, depending on the available area, a temporary construction easement. Based on excavation requirements and the impracticality of constructing an RSS wall, this option is not discussed further.
- **Fill Section:** For an RSS wall to be constructed within the fill section, the existing retaining wall and potentially a portion of the existing highway platform, would have to be removed to accommodate the required reinforcing strips. Temporary protection systems would be required parallel to Highway 401 to facilitate in the removal of the existing retaining wall and construction of the RSS wall, followed by removal of the protection system and benching of the existing fill (roadway platform) to key-in the new fill material with the existing fill material. Alternatively, the existing retaining wall could be left in place and the RSS wall could be constructed further to the north to allow for required reinforcing strip length but this construction may require acquisition of property to the north given the height of the retaining wall is up to 8 m; or possibly the reinforcing strips could also be tied to the existing retaining wall to achieve the required lateral resistance.
- **Cut Section:** An RSS wall is not considered practical from a constructability perspective in a cut section as removal of the existing retaining wall would be required, and necessitating excavation into both the Highway 401 WB core lanes and into the slope on the north side of the existing retaining wall, which would then be backfilled with the reinforcing soil mass.
- **Conventional Earth Embankment or Reinforced Earth Slope:** A conventional earth slope constructed at an inclination of 2 Horizontal to 1 Vertical (2H:1V) or a reinforced earth slope constructed with slopes steeper

than 2H:1V (for example, 1.5H:1V or 1H:1V) is geotechnically feasible but not considered technically practical for either a fill section or cut section due to property right-of-way restrictions and are not discussed further.

A comparison of the various retaining wall options based on advantages, disadvantages and relative cost is presented in Table 1. Based on a comparison of the advantages/disadvantages between the various wall types and foundation alternatives and given the subsurface conditions as encountered at the boreholes, the preferred retaining wall alternative from a foundations perspective is a concrete cantilever retaining wall founded on shallow foundations for the fill section and soldier pile and concrete panel system for the cut section, although a concrete cantilever retaining wall is also considered feasible / appropriate for the cut section. The following sections of this report present the results of the assessment/analyses of settlement and global stability for the retaining wall, comparison of the wall/foundation alternatives and provide geotechnical recommendations for the preferred option.

6.4 Concrete Retaining Wall on a Shallow Foundation

6.4.1 Founding Elevations

A concrete cantilever retaining wall founded on a strip footing is feasible for both the fill and the cut sections of the retaining wall extending between Sta. 23+773 to Sta. 23+910 and Sta 23+910 to Sta. 24+187, respectively. If the existing retaining wall is removed, the new foundations can be founded at the same elevation as the existing footings. If the existing retaining wall is to remain in place and is to be adapted for use as a retention system, the new foundations should be founded at the same founding elevation as the existing footings so as not to undermine the existing foundations. Based on the design drawings provided by WSP, the existing retaining wall is to remain in place and re-purposed to provide for lateral support and the new foundations are to be tied / dowelled to the existing foundations.

The strip footing for the concrete retaining wall at this site should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration as interpreted from OPSD 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*). For support of the concrete retaining wall, the strip footing should be founded below any existing fill and softened, disturbed or loose/firm soils, on the native compact to very dense sandy silt to sand / stiff to hard sandy clayey silt to clayey silt-to-silt with sand deposits at founding elevations of the existing retaining wall strip footing(s) as shown on the original contract drawings and summarized below.

Section	Approximate Station	Approximate Footing Founding Elevation (m)
Fill	23+773 to 23+910	163.7 to 172.0 (stepped)
Cut	23+910 to 24+187	172.0 to 173.4 (stepped)

The footing subgrade should be inspected by a Foundation Engineer following excavation, in accordance with OPSS 902 (*Excavating and Backfilling Structures*) to check that all existing fill and loose/firm soils and soils containing organics have been removed. Any softened/disturbed or otherwise deleterious areas should be further subexcavated and backfilled with OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II soils, that is placed and compacted in accordance with the requirements of OPSS.PROV 501 (*Compaction*).

The native soils at this site will be susceptible to disturbance on exposure to construction activities and/or ponded water. If the concrete for the retaining wall footing cannot be poured within 4 hours after excavation and inspection, it is recommended that a 100 mm thick concrete working slab be placed on the subgrade after its inspection and

approval, to protect the integrity of the subgrade. A Non-Standard Special Provision (NSSP) to address this item is included in Appendix E, and this should be included in the Contract Documents if this wall/foundation type is adopted.

6.4.2 Geotechnical Resistances

A strip footing constructed on the properly prepared subgrade comprised of native materials and at the elevations noted above, should be designed based on the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance (for 25 mm of settlement) as follows:

Option	Footing Width (m)**	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm of Settlement)
New Retaining Wall	3	650	Does not govern*
	4	750	Does not govern*
	5	825	750
Widened Existing Foundations (Existing + Widened)	3 (1 + 2)	650	Does not govern*
	4 (2 + 2)	750	Does not govern*
	5 (3 + 2)	825	750
	6.5 (4.5 + 2)	950	575

* The factored serviceability geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored ultimate geotechnical resistance and does not govern.

** Geotechnical resistance for 3.5 m and 4.5 m wide footings may be interpolated between those given for 3.0 m, 4.0 m and 5.0 m wide footings.

The geotechnical resistances and settlement are dependent on the footing size, configuration and applied load, the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differ from those given above. In addition, these geotechnical resistances are provided for loads applied perpendicular to the surface of the footings; where applicable, inclination of the load should be taken into account in accordance with Section 6.10.4 of the *CHBDC* (2014) and its *Commentary*.

6.4.3 Resistance to Lateral Loads

Resistance to lateral forces / sliding resistance between the new concrete footing and the subgrade should be calculated in accordance with Section 6.10.5 of the *CHBDC* (2014). For a cast-in-place concrete footing constructed on the compact to very dense sandy silt to sand / stiff to hard sandy clayey silt to clayey silt-to-silt with sand deposits, the coefficient of friction, $\tan \phi'$, can be taken as 0.5 and on a Granular A pad can be taken as 0.6,

as interpreted from *NAVFAC* (1986). This represents an unfactored value; in accordance with the *CHBDC*, the appropriate consequence factor and degree of site understanding factor from Table 6.1 and 6.2 in the *CHBDC* (2014) are to be applied in calculating the horizontal resistance.

6.5 Soldier Pile and Concrete Panel Wall

A soldier pile and concrete panel wall system may be advantageous for the cut section of the retaining wall, since it would minimize temporary excavation into the slope to the north of the retaining wall compared to the other wall types (i.e., for construction of footings for a concrete cantilever wall). This type of wall could also be used for the fill section of the retaining wall, but it is not considered practical from a constructability perspective.

This wall system would consist of soldier piles socketted to sufficient depth to provide the necessary passive resistance for the maximum retained soil height. Caisson construction, including installation of the embedded H-piles, should be carried out consistent with OPSS.PROV 903 (*Deep Foundations*). The upper 1.2 m of soil in front of the soldier piles should be ignored in the calculation of the passive resistance, to account for frost effects. It is recommended that the soldier piles extend to a depth of at least the height of the wall plus the top 1.2 m, or deeper as necessary to satisfy limiting equilibrium requirements. Additional lateral support to the soldier pile and concrete panel wall system could be provided in the form of permanent soil anchors installed at strategic locations along the retaining wall positioned in a manner as to not interfere with any adjacent utilities / services or structure supporting systems if present in the area.

The concrete lagging panels should be installed such that the unsupported height of the existing foreslope fill does not exceed 1.2 m at any time, and the space behind the lagging should be immediately packed with granular material, which will also aid in providing for seepage drainage from behind the wall. If sufficient thickness of free-draining granular soil can not be provided behind the concrete panels to achieve adequate drainage, consideration should be given to using a drainage sheet/mat. The drainage medium behind the wall should be connected to a drain discharging to a positive drainage system. An insulation layer could also be provided immediately behind the wall to provide protection from frost penetration, if required.

6.5.1 Passive Resistance for Soldier Pile Sockets

The ultimate passive lateral pressure in front of the soldier piles may be assessed using Brom's (1964) equation using the design parameters / values as follows:

- K_p the coefficient of passive earth pressure, which may be taken as 3.0 in the existing fill soils and 3.3 in the native soil deposits at this site. This K_p value must be reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.16 of *CHBDC*;
- γ' the effective unit weight of the soil in front of the soldier pile socket, which may be taken as 10 kN/m³ below the groundwater level.

As noted above, the upper 1.2 m of soil in front of the soldier piles should be ignored in the calculation of the passive resistance, to account for disturbance during installation, and for frost effects as interpreted from OPSPD 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*).

6.5.2 Permanent Soil Anchors

If required, additional lateral support to the wall system, existing or new, could be provided in the form of permanent soil anchors. If required, a soil anchor support system can be designed to accommodate the loads applied from lateral earth pressures and surcharge pressures from area, line or point loads and take into account any sloping

ground behind the retaining wall system. For design, the soil anchors may be sized based on the following unfactored bond stresses acting between the grout and native soil:

Soil Deposit	Estimated Ultimate Load Transfer (kN/m)*
Compact sandy silt to sand	100
Dense to very dense sandy silt to sand	130
Stiff to very stiff sandy clayey silt to clayey silt-to-silt with sand	30
Hard sandy clayey silt to clayey silt-to-silt with sand	60

* The estimated ultimate load transfer is based on an assumed nominal anchor diameter between 150 mm and 200 mm, and is given as the load per metre of grouted length.

In accordance with the *CHBDC* (2014), an appropriate consequence factor and degree of site understanding factor are to be applied to the unfactored bond stress values given above for ULS conditions. The SLS value for 25 mm of displacement will not govern; for design purposes an SLS value equal to the ULS value should be used.

The sustained working load should not be greater than 60 per cent of the ultimate tensile strength of the anchor tendons or bars. Soil tie-back anchors should have their fixed length (bond zone) formed within the native compact to very dense sandy silt to sand / stiff to hard sandy clayey silt to clayey silt-to-silt with sand deposits, and should be installed at a downwards angle of 20 degrees or steeper. The first row of anchors should be installed not less than 1.5 m below the top of the wall face. A minimum of 4.5 m of overburden is required above the center of the fixed length (bond zone) to provide the necessary overburden pressure: to develop anchor capacity in gravity-grouted anchors; to prevent grout leakage during installation of pressure grouted anchors; and to prevent heaving of the ground surface for higher grout pressure operations (FHWA, 1999). The fixed length (bond zone) of the anchors should be at least 3 m (and may be up to 8 m) and should be maintained behind a line drawn upward at 45 degrees from the toe of the proposed wall. The horizontal spacing between anchors will be dependent of the spacing of the soldier piles but should be greater than four times the diameter of the anchor diameter (grouted section) or 1.2 m. The permanent soil anchors should be provided with suitable corrosion protection.

Lateral earth pressures for design are discussed in Section 6.7. Anchor installation, grouting and testing should be carried out in accordance with OPSS 942 (*Pre-Stressed Soil and Rock Anchors*) and SP109S58.

6.6 Global Stability for Retaining Wall Options

The static global stability of various retaining wall types was assessed using the commercially available program SLIDE 2018, produced by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the factor of safety of numerous potential failure surfaces was computed to establish the minimum Factor of Safety (FoS). The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum factored FoS of 1.54 is adopted for the design (height and geometry) of retaining walls and retained soil under static conditions at the end of construction as per the *CHBDC* (2014). This FoS is considered adequate for the retaining walls at this site considering the design requirements and the field data available. In general, circular slip surfaces were analysed in the design.

The soil parameters used in the short-term (undrained) analyses (Φ for non-cohesive materials and S_u for cohesive soil) and long-term (effective stress) analyses (Φ' for non-cohesive and cohesive soil), as given below, were

estimated from empirical correlations using the results of in situ Standard Penetration Tests (SPTs) (Bowles, 1984) and geotechnical classification testing.

Soil Deposit	Bulk Unit Weight (kN/m ³)	Effective Friction Angle (Φ)	Undrained Shear Strength (S _u , kPa)
New Granular 'A' or Granular 'B' Type II	22	35°	-
New Earth Fill or SSM	20	30°	-
Existing granular fill	19	32°	-
Existing cohesive fill	20	30°	50
Stiff to hard clayey silt	20	32°	200
Compact to dense sandy silt to sand	20	32°	-
Very dense sandy silt to sand	20	34°	-

6.6.1 Concrete Cantilever Retaining Wall on Shallow Foundations

The results of the static global stability analyses indicate a minimum factor of safety greater than 1.54 is achieved for an up to 8.3 m high (exposed face) concrete retaining wall at this site for both short-term and long-term conditions. An example of the static global stability results is provided on Figure 1.

6.6.2 Soldier Pile and Concrete Panel Wall

The results of the static global stability analyses indicate a minimum factor of safety greater than 1.54 is achieved for an up to 8.3 m high (exposed face) soldier pile and concrete panel retaining wall at this site for both the short-term and long-term conditions provided the soldier pile embedment length is consistent with the minimum length recommended in Section 6.5 (i.e., H_{wall} +1.2 m). An example of the static global stability results is provided on Figure 2.

6.7 Lateral Earth Pressures for Design of Retaining Walls

The lateral earth pressures acting on the retaining wall 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 loads transferred to the wall from the existing abutment piles, construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the wall. Seismic (earthquake) loading must also be taken into account in the design. The following recommendations are made concerning the design of the retaining walls:

- Free-draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II, should be used as backfill behind the walls or wall facing. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill or reinforced soil mass as may be specified by the proprietary wall designer. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Other aspects of the granular backfill requirements with respect to subdrains and frost taper should be in accordance with OPSS 3121.150 (*Walls, Retaining, Backfill, Minimum Granular Requirement*), and OPSS 3190.100 (*Walls, Retaining and Abutment, Wall Drain*).

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall, in accordance with *CHBDC* (2014) Section 6.12.3 and Figure 6.6. Hand operated compaction equipment should be used to compact the backfill soils immediately behind the wall as per OPSS.PROV 501 (*Compacting*). Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall, per Figure C6.20(a) of the *Commentary* to the *CHBDC* (2014). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line flatter than 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of the footing, per Figure C6.20(b) of the *Commentary* to the *CHBDC* (2014).
- Where space is restricted and the walls are constructed in a top-down fashion, with a thin or absent zone of granular backfill behind the wall (i.e., soldier pile and concrete panel), it is recommended that drainage measures (e.g., pre-fabricated sheets) be incorporated on the back of the wall, before or concurrent with the panel installation, to promote drainage and minimize the risk of frost action during freezing temperatures. The wall system and facing should also incorporate subdrains connected to a positive drainage system or weep holes at intervals through the wall face.

6.7.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. The coefficients of static lateral earth pressure must be adjusted to take account of the slope above the wall.

- For an unrestrained wall, the pressures are based on the granular fill in the backfill zone, and the following parameters (unfactored) may be used:

Fill Type	Unit Weight of Material	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_0	Active, K_a
Granular 'A'	22 kN/m ³	0.43	0.27
Granular 'B' Type II	21 kN/m ³	0.43	0.27

- For a soldier pile and concrete panel wall, or for a restrained wall, the pressures are based on the existing slope material, or foreslope fill if present, and the following parameters (unfactored) may be used assuming the presence of earth fill:

Fill Type	Unit Weight of Material	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_0	Active, K_a
Earth Fill	20 kN/m ³	0.50	0.33

- If the retaining wall structure allows for lateral yielding, active earth pressures should be used in the 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 C6.12.1 and Table C6.6 of the *Commentary* to the *CHBDC* (2014).

- If the retaining wall structure does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.

6.7.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must also be taken into account in the design of retaining wall in accordance with Section 4.6.5 of the *CHBDC* (2014). In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the retaining wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the earthquake induced dynamic earth pressure.
- In accordance with Sections 4.6.5 and C.4.6.5 of the *CHBDC* (2014) and its *Commentary*, for structures that allow lateral yielding, the horizontal seismic coefficient, k_h , used in the calculation of the seismic active pressure coefficient, is taken as 0.5 times the site-specific PGA. For structures that do not allow lateral yielding, k_h is taken as equal to the site-specific PGA. For both cases the value of the vertical seismic coefficient k_v is taken as zero.
- The following seismic active pressure coefficients (K_{AE}) may be used in design; these coefficients reflect the maximum K_{AE} obtained for each of the earthquake design periods and backfill conditions. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is level. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

Wall Type	Design Earthquake	Site PGA	Seismic Active Pressure Coefficients, K_{AE}		
			Granular A	Granular B Type II	Earth Fill/SSM
Yielding Wall (unrestrained)	475-Yr	0.040g	0.26	0.26	0.31
	975-Yr	0.071g	0.27	0.27	0.32
	2,475 Yr	0.134g	0.28	0.28	0.34
Non-Yielding Wall (restrained)	475-Yr	0.040g	0.27	0.27	0.33
	975-Yr	0.071g	0.29	0.29	0.35
	2,475 Yr	0.134g	0.33	0.33	0.39

- The K_{AE} value for a yielding wall is applicable provided that the wall can move up to $250k_h$ (measured in mm), where k_h is the site-specific PGA as given above. This corresponds to displacements of 10 mm, 18 mm and 34 mm for the 475-year, 975-year and 2,475-year design earthquakes at this site.
- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its

toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined per Section C4.6.5 of the *Commentary to CHBDC* (2014).

6.8 Corrosion Assessment and Protection

The results of analytical testing on a soil sample from each of Boreholes RW-01, RW02 and NBP1-03, advanced near the alignment of the proposed retaining wall are summarized in Section 4.4 and the analytical laboratory test report is included in Appendix D. The analytical test results were compared to CSA A23.1 Table 3 (*"Additional requirements for concrete subjected to sulphate attack"*) for potential sulphate attack on concrete. The sulphate concentration measured in the tested samples (<0.002% and 0.007%) is below the exposure class of S-3 (Moderate). Therefore, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

The analytical test results of the soil samples were also compared to the MTO Gravity Pipe Design Guidelines (2014) for the potential attack on buried steel and the pH is not considered detrimental to the steel durability. The resistivity measured in the tested soil samples (i.e., 1,300 ohm-cm, 1,600 ohm-cm and 6,300 ohm-cm) indicate "very low corrosiveness" to "severe corrosiveness" potential. Based on the results of the samples tested, and given that the structure will be exposed to de-icing salt, consideration should be given by the designer to designing for a "C" type exposure class as defined by CSA A23.1 Table 1.

It is ultimately up to the structural designer to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 "Durability Requirements" are followed.

6.9 Construction Considerations

6.9.1 Excavations

The foundation excavation for the retaining wall strip footing, for both the fill section and cut section, will extend through the fill materials of varying consistency and level of compactness into the native compact to very dense sandy silt to sand / stiff to hard sandy clayey silt to clayey silt-to-silt with sand deposits. Open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) and Regulation 213 for Construction Activities. The existing fill materials are classified as Type 3 soil and the native soils are classified as Type 2 soil, according to the OHSA. Temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes no steeper than 1H:1V through the Type 3 soils and to within 1.2 m of the bottom of the excavation in Type 2 soils only.

6.9.2 Temporary Excavation Support and Vibration Monitoring

Temporary excavation support is likely required to facilitate the removal of the existing retaining wall strip footing foundation and / or for the construction of the new retaining wall foundations in order to maintain traffic on Highway 401 and to reduce the extent of excavation required for the project. The temporary excavation support systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539, provided that the existing structure, as well as any adjacent utilities, can tolerate this magnitude of deformation.

We understand that it is proposed to leave the existing retaining wall in place during construction of the new retaining wall, and then cut off the existing wall at an appropriate level below the roadway grade. In this case, the existing retaining wall could serve as the temporary roadway protection system. If the existing wall is fully removed, or a new temporary protection system is required, it is considered that either a driven, interlocking sheetpile system or

a soldier pile and timber lagging system would be suitable to provide temporary excavation support at this site, based on the inferred subsurface soil conditions and groundwater conditions. An interlocking sheetpile system would contribute to both ground and, where applicable, groundwater control should seepage from non-cohesive zones or interlayers/lenses within the cohesive deposits to occur. For a soldier pile and lagging system, it would be necessary to control seepage and also to include measures to mitigate loss of soil particles through the lagging boards in the event that water-bearing non-cohesive soils are encountered.

If a soldier pile and lagging system is used along the cut section of the proposed retaining wall, the system could be left in place as a permanent structure with proper drainage constructed in behind the wall and a facing panel installed where the wall is exposed, this minimizing extent of the excavation otherwise required for a specific temporary protection system.

Existing residential properties are located along the south side of the existing retaining wall in close proximity to the alignment of the proposed retaining wall. The use of vibratory equipment for protection system installation should be minimized where possible, and vibration monitoring of residences within a zone of influence of 200 m should be considered. Vibration levels less than a maximum peak particle velocity (PPV) of 50 mm/s are generally considered applicable for buildings in good condition. An NSSP for vibration monitoring all aspects of the construction is included in Appendix E.

Consideration could be given to either partial or full removal of the protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the protection system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the underpass sites, or to the road structure above. An NSSP is included in Appendix E which addresses the removal or cut-off of the protection system.

The selection and design of the protection system is the responsibility of the contractor.

6.9.3 Groundwater and Surface Water Control

The groundwater level at the site was encountered between Elevations 164 m and 173 m, that is at depths of 3.7 m and 4.5 m below ground surface as measured in two piezometers, and at depth between about 1.8 m and 6.7 m below ground surface in open boreholes, generally at about 4.5 m below ground surface. Excavations for construction of the retaining wall foundations will likely extend to or to below the water level; however, it is expected that water inflow from granular zones of fill or present within the native material can be handled by pumping from well filtered sumps located outside the foundation footprint.

Surface water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation therefore and all surface water should be directed away from the excavations.

6.9.4 Obstructions

While cobbles and/or boulders were not encountered in the boreholes advanced during the previous and current investigations along the proposed retaining wall alignment, they are inferred present due to the difficulty to augering and grinding of the augers at varying depths in the boreholes drilled for the nearby Midland Avenue Overpass site. The cobbles and/or boulders may affect the installation of soldier piles, as well as temporary protection systems. It is recommended that driving shoes be used on all steel H-piles to facilitate driving into the overburden soils. In addition, it is recommended that a Notice to Contractor be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soils and an example is presented in Appendix E.

6.9.5 Subgrade Protection

The native soils that will be exposed at the foundation subgrade level will be susceptible to disturbance from construction traffic, groundwater infiltration and/or ponded water. To limit this degradation, it is recommended that the footing be constructed within four hours after preparation, inspection and approval of the footing subgrade or a concrete working slab be placed on the subgrade within this time period. This requirement can be addressed with a note on the General Arrangement drawing and/or with an NSSP. An NSSP is included in Appendix E.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Jorge M.A. Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant of Golder, conducted an independent technical and quality control review of the report.

Golder Associates Ltd.



Nikol Kochmanová, Ph.D., P.Eng., PMP
Geotechnical Engineer



Jorge M.A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

NK/JMAC/rb

Golder and the G logo are trademarks of Golder Associates Corporation

https://golderassociates.sharepoint.com/sites/16003g/6_deliverables/9_rw/3_final/1669995_fidr09_2019jan21_hwy_401wb_rw.docx

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 (CFEM)*, 3rd Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.

Canadian Geotechnical Society. 2006. *Canadian Foundation Engineering Manual (CFEM)*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Canadian Standards Association (CSA). 2014. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-14*. CSA Special Publication.

Chapman, L.J. and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

CSA Group. 2014. A23.1-14/A23.2-14 - Concrete materials and methods of concrete construction / Test methods and standard practices for concrete.

National Resources Canada, 2017. *Earthquake Hazard*. http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php. Accessed on November 6, 2018.

Unified Facilities Criteria, U.S. Navy. 1986. *NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures*. Alexandria, Virginia.

U.S. Department of Transportation, Federal Highway Administration. *Geotechnical Engineering Circulation No. 4, Ground Anchors and Anchored Systems*. June 1999.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
------------	---

Commercial Software:

Slide (Version 2018) by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 3000.100	Foundation, Piles, Steel H-Pile Driving Shoe
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSD 3121.150	Walls, Retaining, Backfill Minimum Granular Requirement
OPSD 3190.100	Walls, Retaining and Abutment Wall Drain

Ontario Provincial Standard Specification:

OPSS.PROV 501	Construction Specifications for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures

OPSS.PROV 903 Construction Specification for Deep Foundations

OPSS 942 Construction Specification for Prestressed Soil and Rock Anchors

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Special Provisions

SP109558 Amendment to OPSS942

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects (as amended)

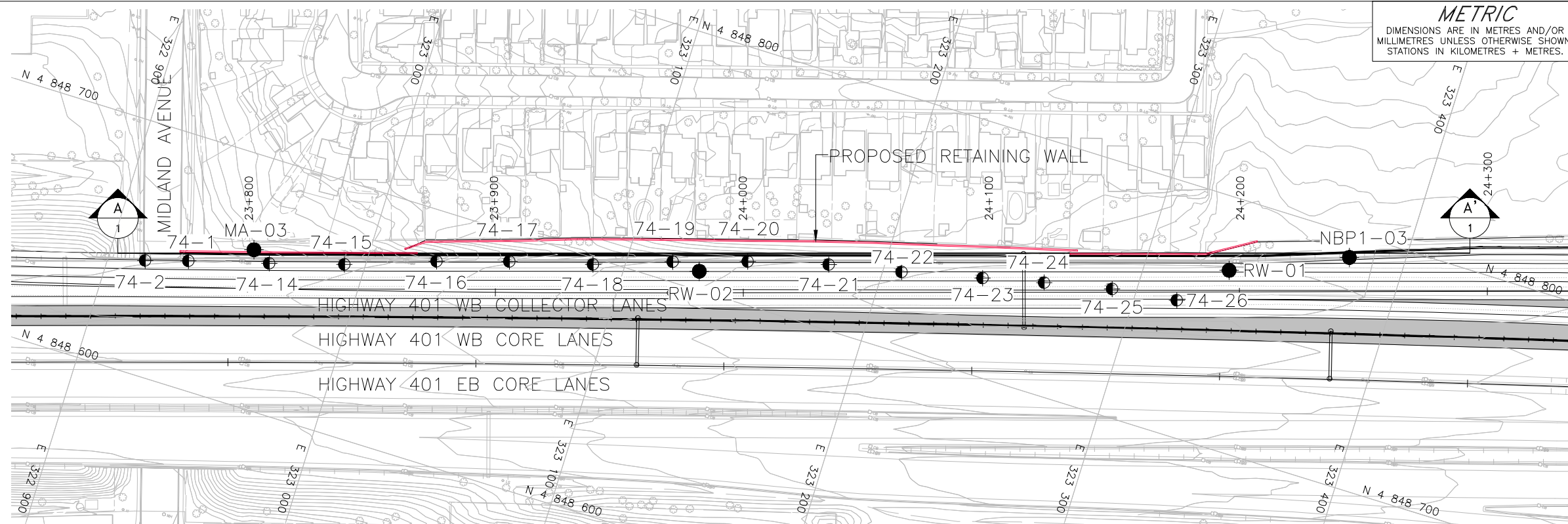
Ministry of Transportation, Ontario

Gravity Pipe Design Guideline. Drainage and Hydrology Design and Contract Standards Office, 2014.

TABLE 1 – COMPARISON OF RETAINING WALL AND FOUNDATION ALTERNATIVES

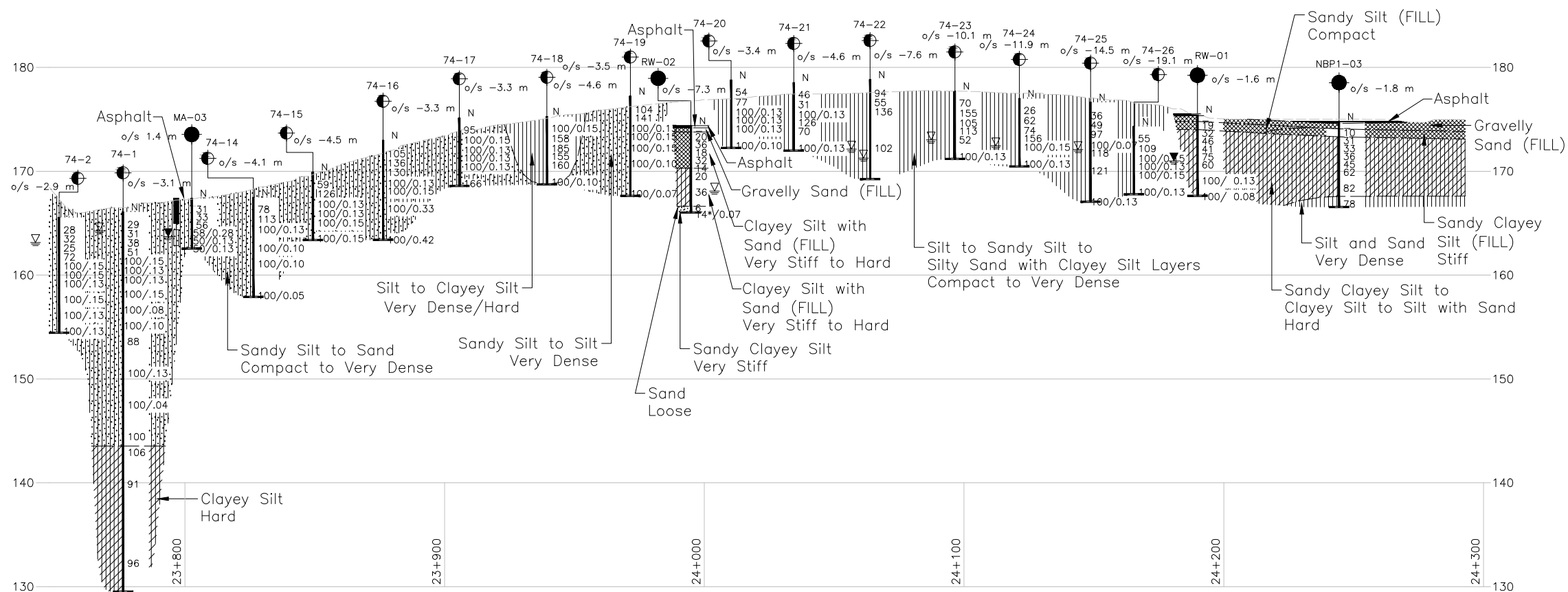
Foundation Option	Feasibility		Advantages	Disadvantages	Relative Costs	Risks/Consequences
	Fill Section (Sta. 23+773 to Sta. 23+910)	Cut Section (Sta. 23+910 to Sta. 24+187)				
Concrete Cantilever Wall on Shallow Foundations	Feasible and preferred alternative as the new footings can be founded at the founding elevations of the existing retaining wall footings whether the existing wall/ footings are removed or the new footings can be tied to the existing foundations if the existing retaining wall is left in place.	Feasible and preferred alternative as the new footings can be founded at the same elevation as the existing footings and connected to the existing footings if necessary.	<ul style="list-style-type: none">• Conventional excavation and construction techniques.• Suitable founding stratum below depth of frost penetration.• If the existing retaining wall is removed, the new footings can be founded at the same elevation, i.e., no additional excavation would be required.	<ul style="list-style-type: none">• Less tolerable to post construction settlements.• Temporary excavation support will be required.• A temporary construction easement may be required for the cut section.• Footings must be founded below depth of frost penetration.	<ul style="list-style-type: none">• Higher cost relative to RSS wall	<ul style="list-style-type: none">• More susceptible for visible distortion if differential settlement occurs.
Concrete Retaining Wall on Deep Foundations	Feasible but not practical from a construction perspective and not warranted from a foundations perspective due to competent founding subgrade material present at shallow depths.		<ul style="list-style-type: none">• Higher geotechnical axial resistances available from deep foundations.• Potentially less settlement of wall element.	<ul style="list-style-type: none">• Temporary/permanent liners may be required to allow for construction of caissons• If refusal (100-blow) stratum or obstructions are encountered at shallow depths, can get piles to hang-up, requiring pre-drilling• Would still require excavations to frost depth, same as shallow foundations.	<ul style="list-style-type: none">• Higher cost relative to RSS wall or shallow foundations.	<ul style="list-style-type: none">• Least demanding on right-of-way space if tie-backs not required.
Soldier Pile and Concrete Panel Wall	Feasible but not practical from a construction perspective as this is a widening.	Feasible and preferred alternative if the existing retaining wall is left in place as temporary protection systems; and additional excavations into the back slope would not be required.	<ul style="list-style-type: none">• Most advantageous in “top-down” construction applications, such as the cut section.• Minimizes excavation and requirement for temporary excavation support.• May be constructed as a traditional soldier pile and wood lagging wall, then enhanced with concrete facing (panels)	<ul style="list-style-type: none">• Easement for soil anchors may be required at the cut section, depending on distance from wall to property limits• Likely more time-consuming to install than other wall types due to steps involved (pre-augering for socket holes, placing soldier piles and concrete, installing concrete panels, installing, pre-stressing and testing tie-backs if such a lateral resistance system is required).	<ul style="list-style-type: none">• Comparable costs to concrete retaining wall, but higher than RSS wall.•	<ul style="list-style-type: none">• Need adequate right-of-way for tie back anchors, if such are required.• Least demanding on right-of-way space if tie-backs not required.

Foundation Option	Feasibility		Advantages	Disadvantages	Relative Costs	Risks/Consequences
	Fill Section (Sta. 23+773 to Sta. 23+910)	Cut Section (Sta. 23+910 to Sta. 24+187)				
RSS Wall	Feasible but not practical as this would require removal of the existing retaining wall and excavations into Highway 401 WB core lanes for the required reinforcing strip lengths, especially for the higher wall heights closer to Midland Avenue.	N/A	<ul style="list-style-type: none">• More tolerable to post construction settlements.• Lowest cost alternative where feasible.	<ul style="list-style-type: none">• Larger amount of excavation into Highway 401 lanes required to install reinforcing strips; temporary protection systems required.	<ul style="list-style-type: none">• Lower cost than concrete retaining wall or walls supported on deep foundations.	<ul style="list-style-type: none">• Can better accommodate some degree of differential settlement
Reinforced Earth Slope Embankment	Not feasible due to space restrictions.	N/A	<ul style="list-style-type: none">• Relative ease of construction but proprietary design / product required.• Vegetated surfaces could be used to improve aesthetics.	<ul style="list-style-type: none">• Proprietary product / design.• Special treatment of reinforced earth slope surfaces required to allow vegetation to grow and minimize erosion.• Would require a larger footprint to accommodate slope from new highway crest to toe of slope.	<ul style="list-style-type: none">• Lower cost than RSS wall.	<ul style="list-style-type: none">• Requires wider right-of-way footprint potentially encroaching onto private property.• Can accommodate some degree of differential settlement but susceptible to surface erosion



PLAN

SCALE



REFERENCE

Base plan provided in digital format by WSP, drawings files no. H17M-01449-00_XA01.dwg, No.H17M-01449-00_XB01.dwg and H17M-01449-00_XY01.dwg, received October 26, 2017.
Design Layout provided in digital format by WSP, drawing file no. H17M-01449-00_XN01.dwg, received November 28, 2017.
Noise Barrier walls plan provided in digital format by WSP, drawings files New Noise Barrier Locations Sept 12, 2018.dwg, received September 12, 2018.
Existing ground provided in digital format by WSP, drawing file no. Contours Sept. 12, 2019.dwg, received September 12, 2018.



RETAINING WALL PROFILE



NOTES

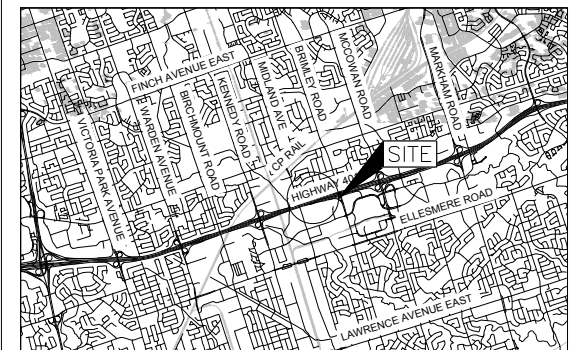
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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



CONT No. GWP No. 2162-11-00

RETAINING WALL
HIGHWAY 401 WESTBOUND CORE AND COLLECTORS
BOREHOLE LOCATIONS AND SOIL STRATA



KEY PLAN

SCALE



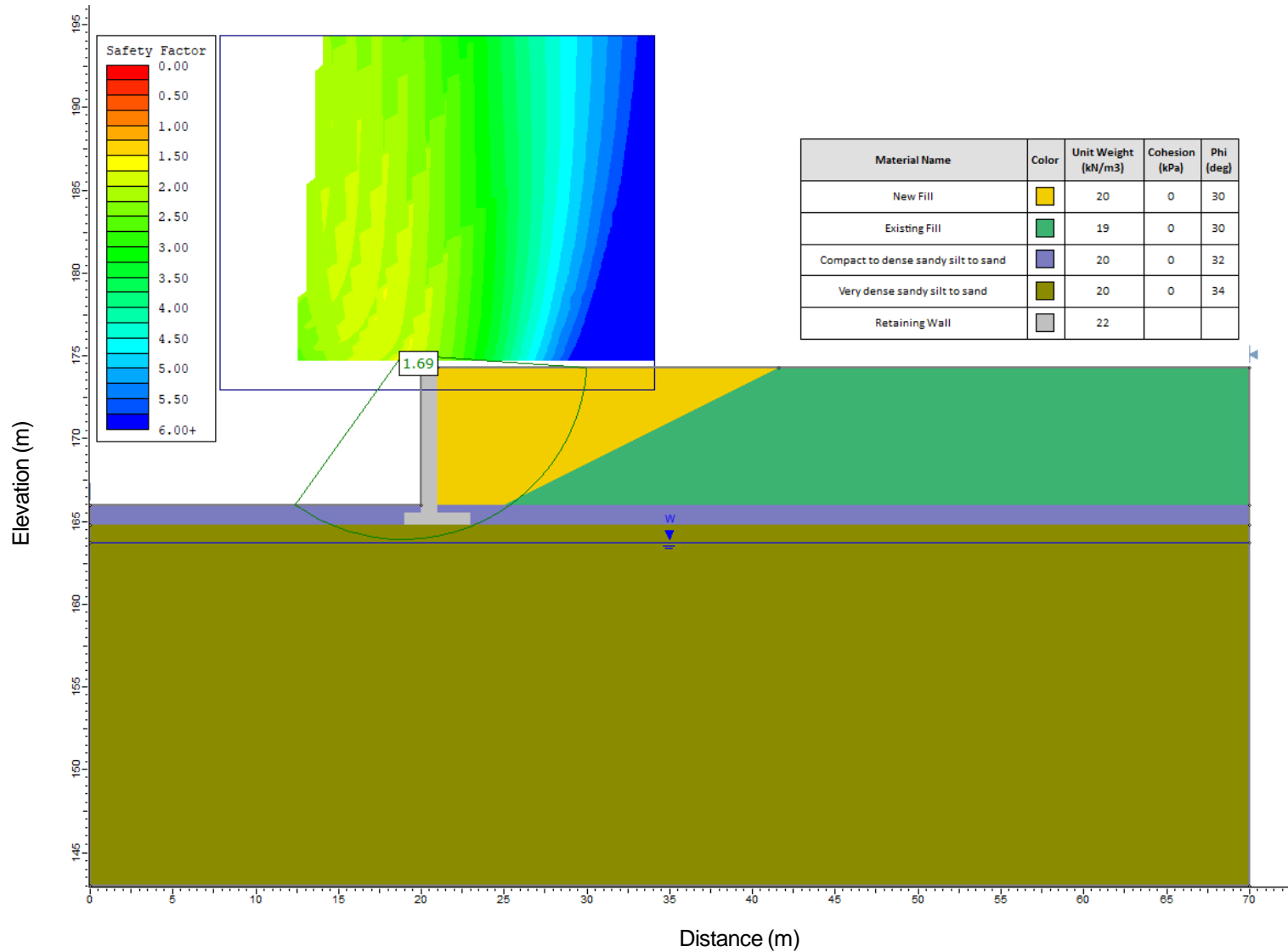
LEGEND

- Borehole - Current Investigation
- Borehole - 1966 Investigation (GEOCRE No. 30M14-74)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on June 30, 2018
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
74-1	166.1	4848650.4	322931.3
74-2	165.6	4848645.5	322914.7
74-14	167.5	4848659.2	322962.8
74-15	169.9	4848667.7	322991.8
74-16	173.0	4848680.0	323027.0
74-17	175.1	4848688.6	323055.0
74-18	175.3	4848697.4	323087.6
74-19	177.2	4848708.0	323118.0
74-20	178.8	4848717.0	323146.8
74-21	178.6	4848725.5	323178.4
74-22	178.1	4848731.4	323207.4
74-23	177.7	4848738.7	323239.2
74-24	177.4	4848744.3	323263.5
74-25	176.7	4848750.0	323290.5
74-26	174.3	4848753.3	323316.8
MA-03	167.4	4848662.6	322955.2
NBP1-03	174.8	4848790.4	323378.1
RW-01	175.0	4848771.1	323333.3
RW-02	174.4	4848707.5	323129.3

NO.	DATE	BY	REVISION
1	01/22/2019	DD	1
Geocres No. 30M14-498			
HWY. 401	PROJECT NO. 1669995	DIST.	
SUBM'D. NK	CHKD. NK	DATE: 01/22/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. JMAC	DWG. 1



CLIENT
Ministry of Transportation Ontario (MTO)

CONSULTANT

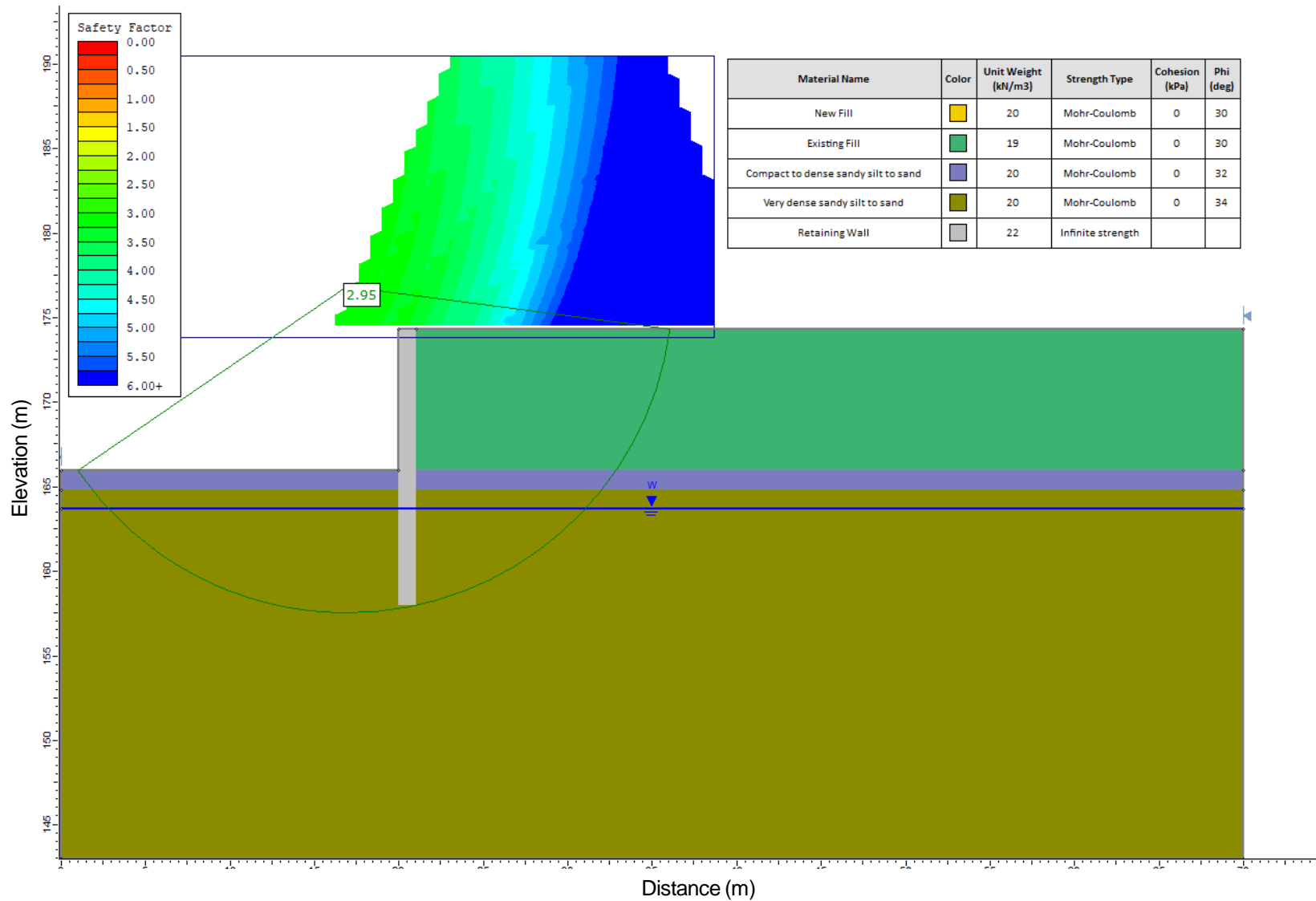


YYYY-MM-DD 2019-01-21
PREPARED NK
DESIGN NK
REVIEW JMAC
APPROVED JMAC

PROJECT
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES
NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO
G.W.P. NO. 2162-11-00

TITLE
RETAINING WALL EAST OF MIDLAND AVENUE OVERPASS
STATIC GLOBAL STABILITY ANALYSIS
CONCRETE CANTILEVER RETAINING WALL

PROJECT No.
1669995



CLIENT
Ministry of Transportation Ontario (MTO)

CONSULTANT



YYYY-MM-DD	2019-01-21
PREPARED	NK
DESIGN	NK
REVIEW	JMAC
APPROVED	JMAC

PROJECT
HIGHWAY 401 WESTBOUND CORE AND COLLECTOR LANES
NEILSON ROAD TO WARDEN AVENUE, CITY OF TORONTO
G.W.P. NO. 2162-11-00

TITLE
RETAINING WALL EAST OF MIDLAND AVENUE OVERPASS
STATIC GLOBAL STABILITY ANALYSIS
SOLDIER PILE AND CONCRETE PANEL WALL

PROJECT No.
1669995

APPENDIX A

**Borehole Records from 1966
Investigation (GEOCRES No.
30M14-74)**

OFFICE REPORT ON SOIL EXPLORATION

BH 74-2

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB 66-F-87 LOCATION Sta. 370 + 52: 134' Lt. of E ORIGINATED BY A.K.B.
W.P. 260-61 BORING DATE Oct. 6, 1966 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE Washboring, BX Casing CHECKED BY SR

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	wp	w	wL		
165.6	543.2	GROUND LEVEL														
	0.0															
		Brown & Grey	1	SS	28	540										
		Sandy	2	SS	32											
			3	SS	25											
		Silt with occasional layer of clayey silt	4	SS	72	530										
			5	SS	100/6"											
			6	SS	100/6"											
		Very Dense	7	SS	100/5"	520										
			8	SS	100/6"											
			9	SS	100/5"	510										
154.4	506.7		10	SS	100/5"											
11.1	36.5	End of Borehole														

▼ W.L.
= El. 535.2'
163.1m
Gr. 5%
Sa. 50%
Si. 42%
Cl. 3%

Gr. 1%
Sa. 30%
Si. 59%
Cl. 10%

OFFICE REPORT ON SOIL EXPLORATION

BH 74-14

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 14

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 372 + 15, 132' Lt. of C

ORIGINATED BY A.K.B.

W.P. 260-61

BORING DATE November 4, 1966

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT %			
(W) 167.5	519.5	GROUND LEVEL										
	0.0	Brown & Grey Sandy Silt with traces of Clay. Very Dense.										
			1	SS	78							
			2	SS	113							
			3	SS	100/5"	540						
			4	SS	100/4"	530						
			5	SS	100/4"	520						
157.9 9.6	518.0 31.5	End of Borehole	6	SS	100/2"							

BH 74-15

BH 74-15

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 15

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 373 + 13; 130' Lt. of ϕ

ORIGINATED BY AKB

W.P. 260-61

BORING DATE November 7, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Washboring BX Casing

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WP — W — WL							
							SHEAR STRENGTH P.S.F.					WATER CONTENT %							
557.5	GROUND LEVEL											10	20	30					
0.0	Brown & Grey Sandy silt with traces of clay Very Dense		1	SS	59	550													
			2	SS	126														
			3	SS	100/5"														
			4	SS	100/5"														
			5	SS	100/6"	540													
536.0			6	SS	100/6"														
21.5	End of Borehole																		

Gr. 2%
Sa. 39%
Si. 50%
Cl. 9%

OFFICE REPORT ON SOIL EXPLORATION

BH 74-16

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 16

FOUNDATION SECTION

JOB 66-F-87 LOCATION Sta. 374 + 33; 137' Lt. of C ORIGINATED BY AKB
 W.P. 260-61 BORING DATE November 7, 1966 COMPILED BY AKB
 DATUM Geodetic BOREHOLE TYPE Continuous Flight Auger Hole CHECKED BY AKB

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WP	W	WL		
(W) 172.0	567.6	GROUND LEVEL														
	0.0															
			1	SS	105											
			2	SS	136	560										
			3	SS	130											
			4	SS	100/5"											
			5	SS	100/6"	550										
			6	SS	100/4"											
						540										
163.4	536.1		7	SS	100/5"											
9.6	31.5	End of Borehole														

Gr. 3%
Sa. 52%
Si. & Cl. 45%

Gr. 5%
Sa. 40%
Si. 41%
Cl. 14%

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 17

FOUNDATION SECTION

LOCATION Sta. 375 + 28; 137' Lt. of C

ORIGINATED BY A.K.B.

W.P. 260-61

BCRING DATE November 8, 1966

COMPILED BY A.K.B.

DATUM _____ Geodetic

BOREHOLE TYPE Washboring, BX Casing

CHECKED BY

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

BH 74-19

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 19

FOUNDATION SECTION

JOB 66-F-87 LOCATION Sta. 377 + 43.5'; 142' Lt. of C ORIGINATED BY AKB
W.P. 260-61 BORING DATE November 7, 1966 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Continuous Flight Auger Hole CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — % PLASTIC LIMIT — % WATER CONTENT — %			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	W _p	W	W _L		
177.2	581.5	GROUND LEVEL														
0.0						580										
	Brown & Grey		1	SS	104							o				
	Sandy Silt to Silt.		2	SS	141							o	N.P.			
			3	SS	100/5"	570						o				
	Very Dense		4	SS	100/6"								o			
			5	SS	100/6"							o	—			
			6	SS	100/4"	560						o				
167.6	550.0															
96	31.5	End of Borehole	7	SS	100/3"							o				

BH 74-20

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 20

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 378 + 42; 146.5' Lt. of C

ORIGINATED BY AKB

W.P. 260-61

BORING DATE November 8, 1966

COMPILED BY AKB

DATUM: Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY ✓

[illegible]

BH 74-21

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 21

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 379 + 46: 147' E. of

ORIGINATED BY AKB

W. P. 260-61

BORING DATE November 8, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

BH 74-22

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 22

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 380 + 42; 141' Lt. of E

ORIGINATED BY AKB

W.P. 260-61

BORING DATE November 9, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY

SOIL PROFILE

SAMPLES

DYNAMIC PENETRATION RESISTANCE

BLOWS / FOOT
20 40 60 80 100

SHEAR STRENGTH P.S.F.

LIQUID LIMIT — WL

PLASTIC LIMIT — WP

WATER CONTENT — W

WP — W — WL

WATER CONTENT %

10 20 30

BULK DENSITY
P.C.F.

REMARKS

ELEV.
DEPTH

DESCRIPTION

STRAT. PLOT

NUMBER

TYPE

BLOWS / FOOT

ELEV. SCALE

(M)

178.1

584.4

GROUND LEVEL

Brown & Grey

Sandy Silt to
Clayey Silt

Very Dense & Hard

1 SS 94

2 SS 55

3 SS 136

4 SS 121

5 SS 64

6 SS 102

580

570

560

7 SS 100/6"

168.5

552.9

9.6

31.5

End of Borehole

Sa. 35%
Si. 64%
Cl. 1%

W.L.
El. 562.4
171.4m

OFFICE REPORT ON SOIL EXPLORATION

BH 74-23

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 23

FOUNDATION SECTION

JOB 66-F-87 LOCATION Sta. 381 + 49: 141.5' Lt. OF # ORIGINATED BY AKB
W.P. 260-61 BORING DATE November 9, 1966 COMPILED BY AKB
DATUM Geodetic BOREHOLE TYPE Continuous Flight Auger Hole CHECKED BY AKB

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WP	WL		
171.7	583.1	GROUND LEVEL										
	0.0	Brown & Grey Sandy silt to clayey silt. Very dense & hard										
			1	SS	70	580						
			2	SS	155							
			3	SS	105							
			4	SS	113	570						
			5	SS	52							
171.2	561.6		6	SS	100/5"							
6.6	21.5	End of Borehole										

W.L.
El. 567.6
173.0m

OFFICE REPORT ON SOIL EXPLORATION

BH 74-24

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 24

FOUNDATION SECTION

JOB 66-F-87

LOCATION Sta. 362 / 29.5; 141' Lt. of E

ORIGINATED BY AKB

W.P. 260-61

BORING DATE November 14, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY

SOIL PROFILE

SAMPLES

DYNAMIC PENETRATION RESISTANCE

BLOWS / FOOT

20 40 60 80 100

SHEAR STRENGTH P.S.F.

LIQUID LIMIT — WL

PLASTIC LIMIT — WP

WATER CONTENT — W

WP — W — WL

WATER CONTENT %

10 20 30

BULK DENSITY

P.C.F.

REMARKS

(W)

ELEV. DEPTH

DESCRIPTION

STRAT. PLT

NUMBER

TYPE

BLOWS / FOOT

ELEV. SCALE

177.4

582.1

GROUND LEVEL

0.0

Brown & Grey
Sandy silt with
traces of clay

Very dense.

1

SS

26

2

SS

62

3

SS

74

4

SS

156

5

SS

100

6"

6

SS

100

5"

580

570

170.9

560.6

6.6

21.5

End of Borehole

W.L.

E1.567.1

Sa. 46% R2.9m

Si. 54%

OFFICE REPORT ON SOIL EXPLORATION

BH 74-25

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 25

FOUNDATION SECTION

JOB 66-E-87

LOCATION Sta. 383 + 19; 140' Lt. of E

ORIGINATED BY AKB

W.P. 260-61

BORING DATE November 14, 1966

COMPILED BY AKB

DATUM Geodetic

BOREHOLE TYPE Continuous Flight Auger Hole

CHECKED BY _____

SOIL PROFILE

SAMPLES

DYNAMIC PENETRATION RESISTANCE

BLOWS / FOOT

20 40 60 80 100

SHEAR STRENGTH P.S.F.

LIQUID LIMIT WL

PLASTIC LIMIT WP

WATER CONTENT W

WP WL

WATER CONTENT %
10 20 30

BULK DENSITY
P.C.F.

REMARKS

(W)

176.7

0.0

167.1

9.6

ELEV. DEPTH

DESCRIPTION

STRAT. PLOT

NUMBER

TYPE

BLOWS / FOOT

ELEV. SCALE

GROUND LEVEL

Brown

Sandy silt with occ.
layers of clayey silt

Dense to very dense
and hard

1 SS 36

2 SS 49

3 SS 97

4 SS 100/3"

5 SS 118

6 SS 121

7 SS 100/5"

570

560

550

WL
WL 564.6
172.1m

End of Borehole

BH 74-26

[illegible]

APPENDIX B

**Borehole Records from 2018
Investigation**

LIST OF SYMBOLS

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

I. GENERAL

π	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

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	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
γ'	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

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

(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_{α}	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
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (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 cm² 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

Compactness	N
Condition	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 ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
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)
γ	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 <u>1669995</u>		RECORD OF BOREHOLE No MA-03		SHEET 1 OF 1		METRIC	
G.W.P. <u>2219-14-00</u>		LOCATION <u>N 4848662.6 ;E 322955.2</u>		ORIGINATED BY <u>DS</u>			
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>CME 55 Truck-Mounted Drill Rig, 178 mm O.D. Hollow Stem Augers</u>		COMPILED BY <u>SE</u>			
DATUM <u>Geodetic</u>		DATE <u>May 31, 2018</u>		CHECKED BY <u>NK/LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								20	40	60	80	100	20	40	60		80	100		
167.4	GROUND SURFACE																			
0.0	Silty sand, trace gravel (FILL) Brown Moist																			
166.6																				
0.8	SILT and SAND, trace to some clay, trace gravel Dense to very dense Brown to grey below 3.0 m Moist		1	SS	31															
			2	SS	33															
			3	SS	56															
			4	SS	58/0.28															
			5	SS	50/0.13															
			6	SS	50/0.13															
162.5	END OF BOREHOLE																			
4.9	NOTES: 1. Piezometer dry on completion of installation. 2. Water level measured in piezometer as follow: Date Depth (m) Elev. (m) Jul 30/18 3.7 163.7																			



GTA-MTO 001 S:\CLIENTS\MTO\HWY 401\02 DATA\GINT\HWY 401.GPJ GAL-GTA.GDT 01/21/19

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

PROJECT 1669995		RECORD OF BOREHOLE No RW-02		SHEET 1 OF 1		METRIC	
G.W.P. 2219-14-00		LOCATION N 4848707.5 ; E 323129.3		ORIGINATED BY JS			
DIST Central HWY 401		BOREHOLE TYPE CME 75 Truck-Mounted Drill Rig, 165 mm O.D. Hollow Stem Augers		COMPILED BY KAW			
DATUM Geodetic		DATE April 9, 2018		CHECKED BY NK/LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m³	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			W _p	W	W _L
174.4	GROUND SURFACE																
0.0	ASPHALT (203 mm)																
173.8 0.6	Gravelly sand, trace to some silt (FILL) Brown Moist		1	AS	-												
	2		SS	20													
	3		SS	36								○					
	4		SS	18								○					
	5		SS	32								○	—				4 37 43 16
170.3 4.1	CLAYEY SILT with SAND, trace to some gravel Stiff to hard Grey Moist to wet		6	SS	14							○					
			7	SS	20												
			8	SS	36							○	—			5 39 41 15	
166.6 7.8	SAND, trace to some silt, trace to some clay Loose Grey Wet		9A														
			9B	SS	6												
166.1 8.4	SANDY CLAYEY SILT, trace gravel Very stiff Grey Moist END OF BOREHOLE - Refusal to Split Spoon NOTES: 1. Water level measured in open borehole at a depth of approximately 6.3 m (Elev. 168.1 m) below ground surface upon completion of drilling.		10A	SS	14*/0.07												
			10B														

NOTES:

1. Water level measured in open borehole at a depth of approximately 6.3 m (Elev. 168.1 m) below ground surface upon completion of drilling.

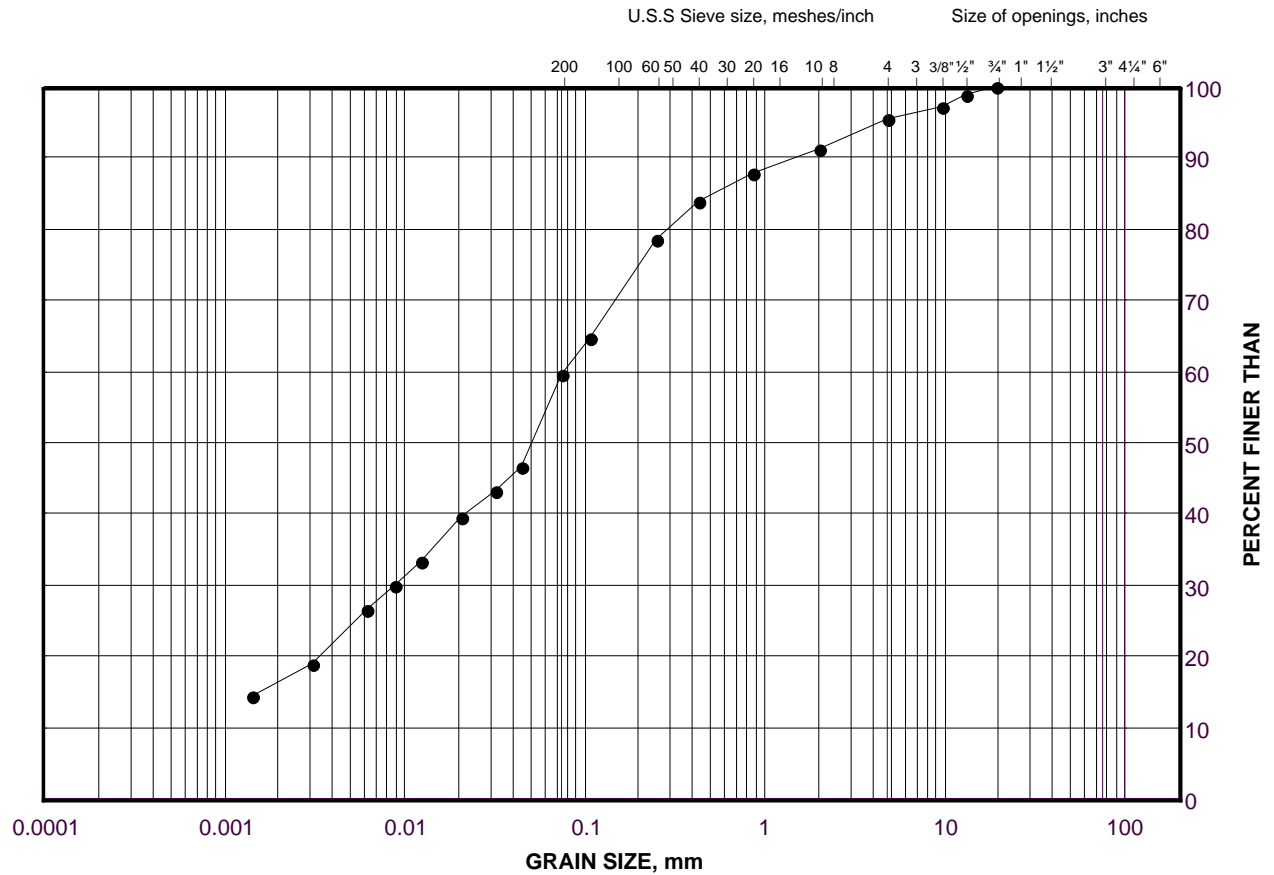
APPENDIX C

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE C-1



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

LEGEND

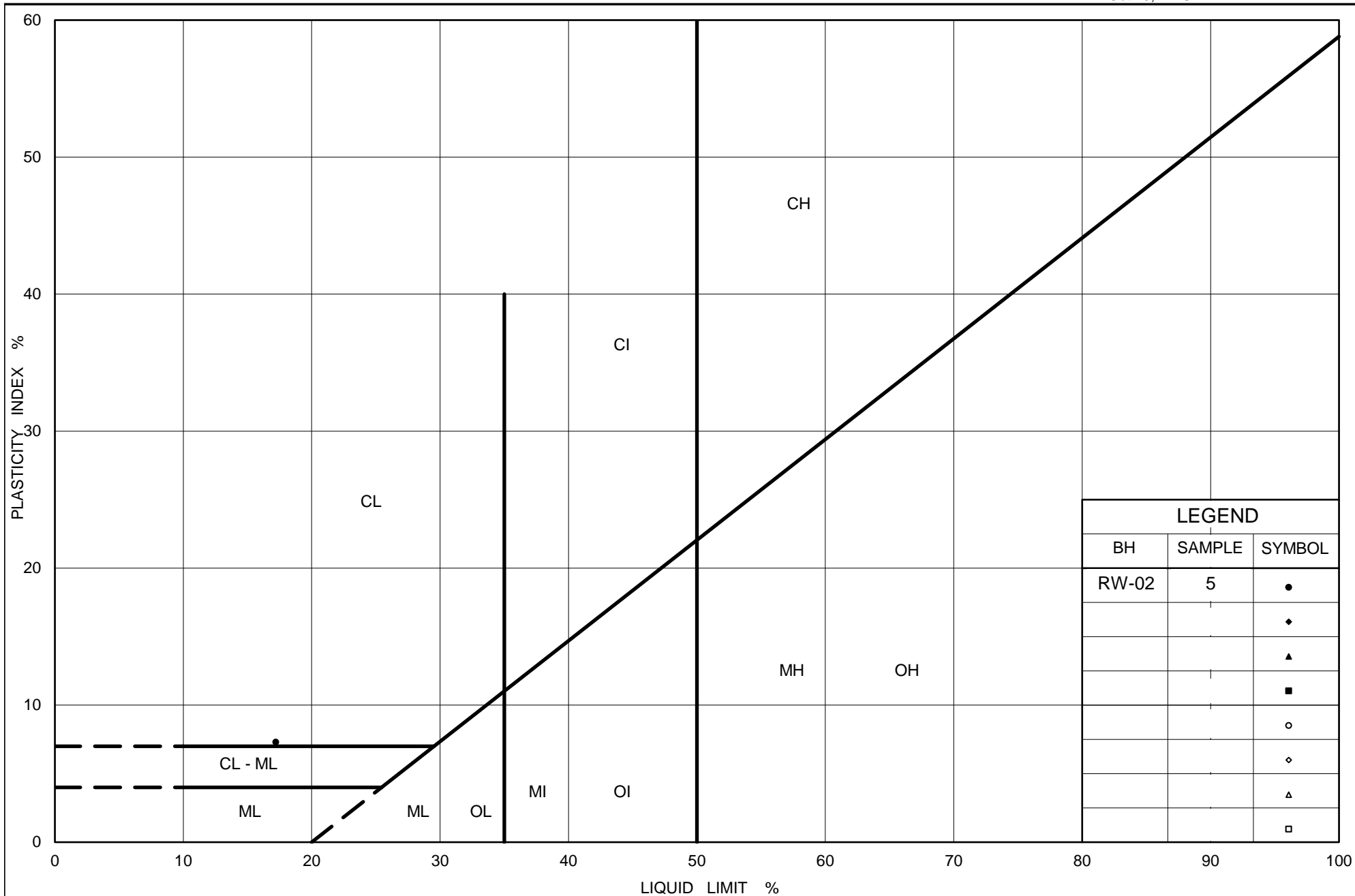
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	RW-02	5	171.1

Project Number: 1669995

Checked By: NK

Golder Associates

Date: 06-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt with Sand (Fill)

Figure No. C-2

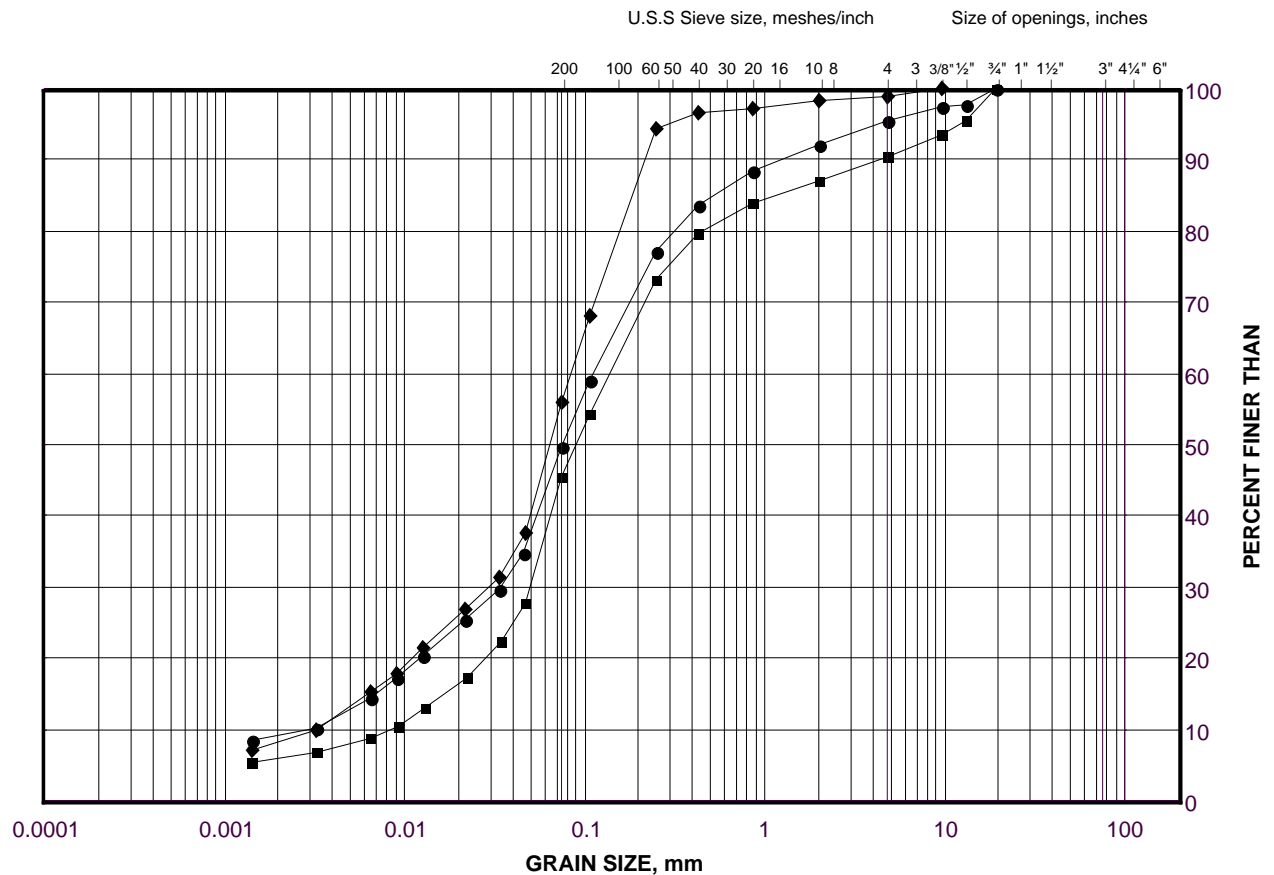
Project No. 1669995 (1006)

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE C-3



LEGEND

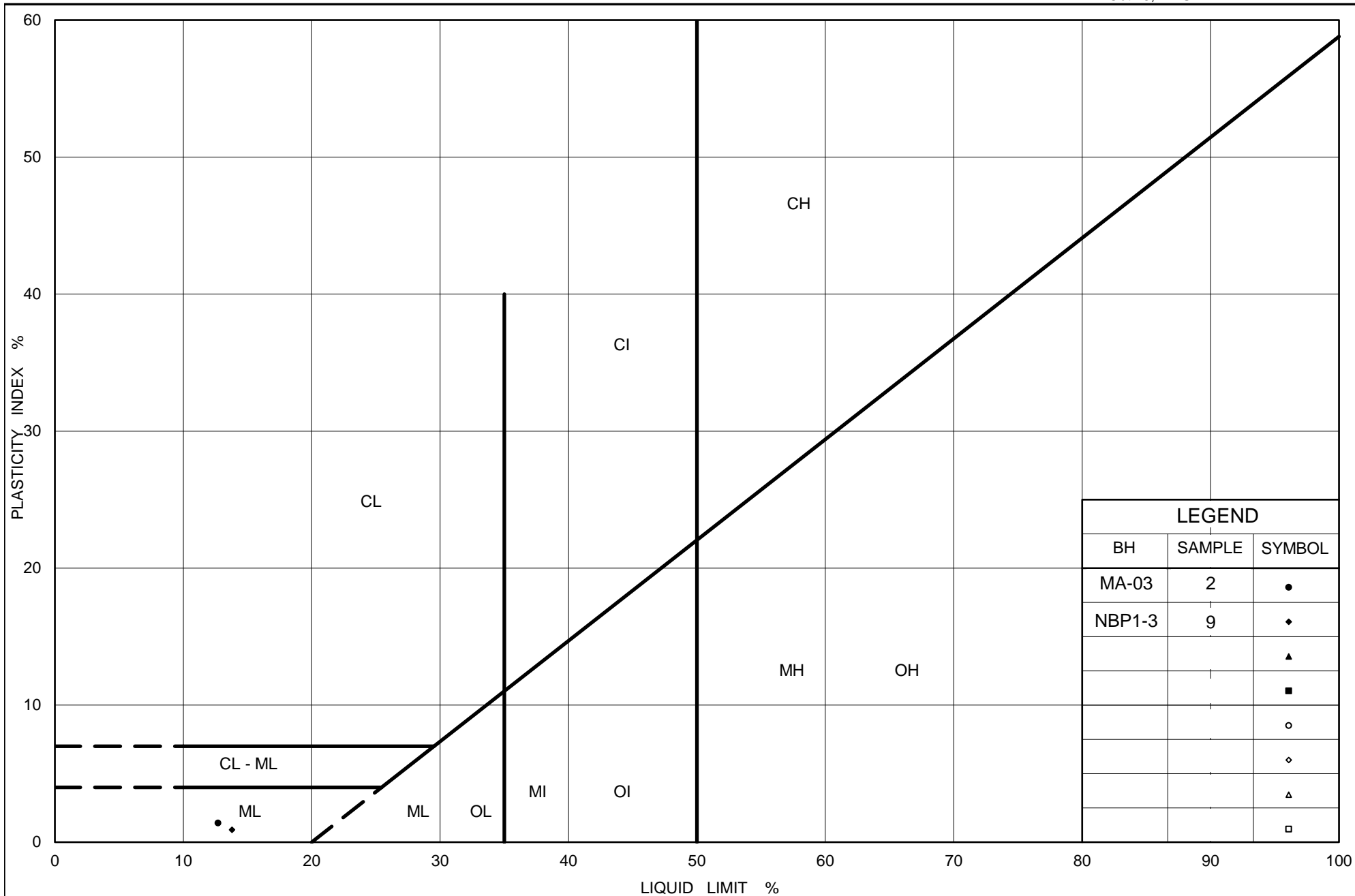
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	MA-03	2	165.6
■	MA-03	6	162.7
◆	NBP1-3	9	166.9

Project Number: 1669995

Checked By: NK

Golder Associates

Date: 06-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART Silt and Sand

Figure No. C-4

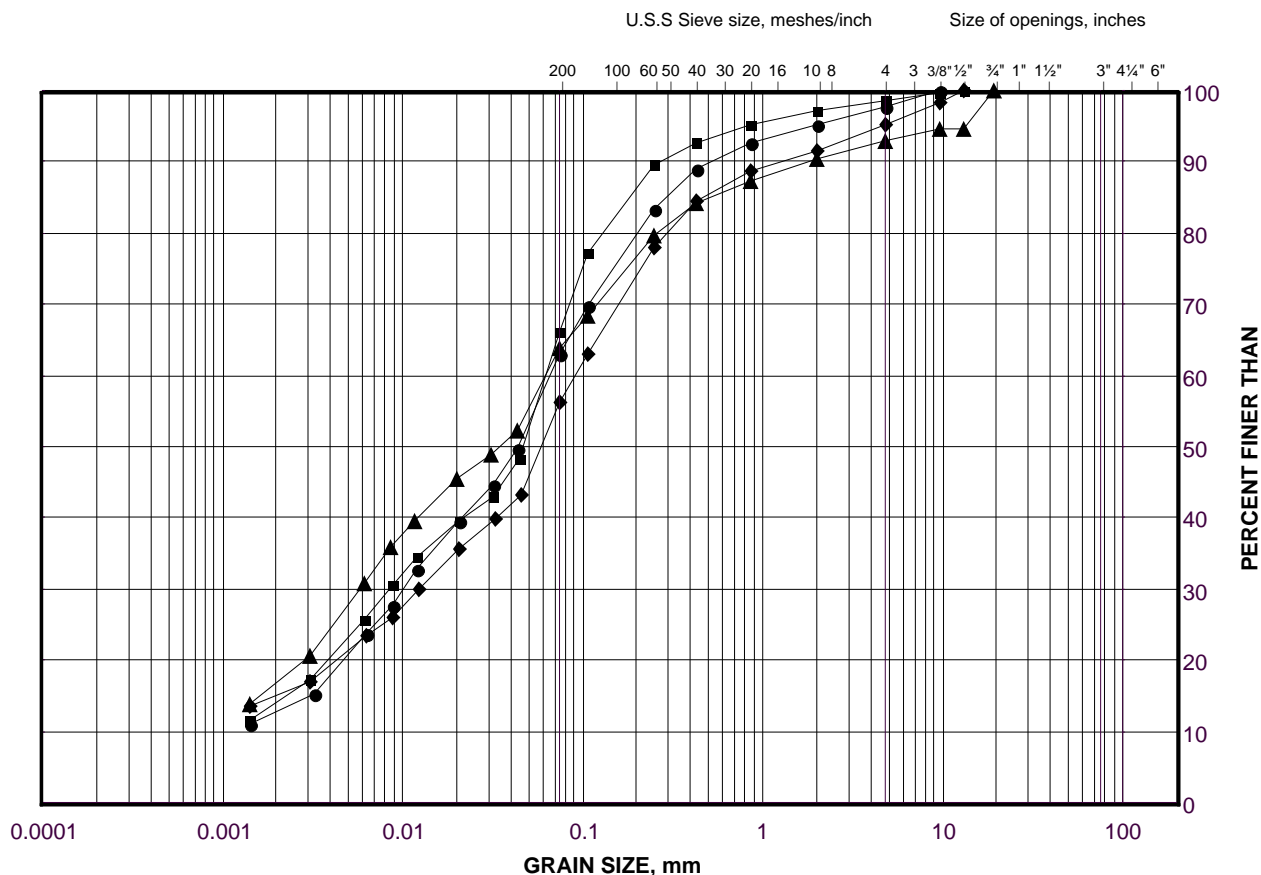
Project No. 1669995 (1006)

Checked By: NK

GRAIN SIZE DISTRIBUTION

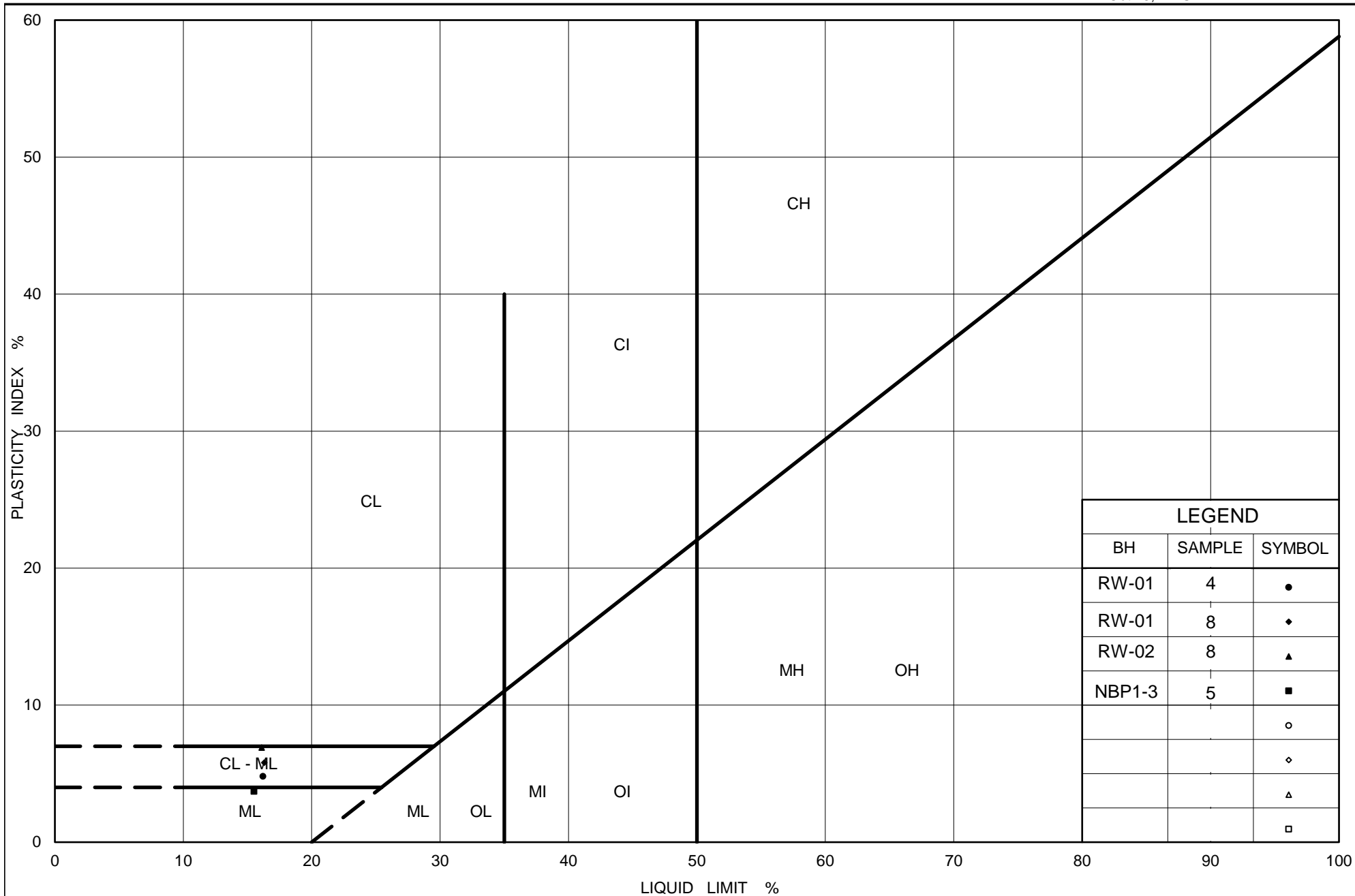
Sandy Clayey Silt to Clayey Silt to Silt with Sand

FIGURE C-5



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	RW-01	4	172.8
■	NBP1-3	5	171.4
◆	RW-02	8	168.0
▲	RW-01	8	169.2



Ministry of Transportation

Ontario

PLASTICITY CHART Sandy Clayey Silt to Clayey Silt to Silt with Sand

Figure No. C-6

Project No. 1669995 (1006)

Checked By: NK

APPENDIX D

Analytical Laboratory Test Results

Your Project #: 1669995
Site Location: 401W

Attention: Nikol Kochmanova

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Your C.O.C. #: 668025-02-01, 668025-03-01, 668025-04-01, 668025-05-01

Report Date: 2018/06/08
Report #: R5226716
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8D5245

Received: 2018/06/05, 16:46

Sample Matrix: Soil
Samples Received: 31

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	31	N/A	2018/06/08	CAM SOP-00463	EPA 325.2 m
Conductivity	20	N/A	2018/06/07	CAM SOP-00414	OMOE E3530 v1 m
Conductivity	11	N/A	2018/06/08	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl ₂ EXTRACT	20	2018/06/07	2018/06/07	CAM SOP-00413	EPA 9045 D m
pH CaCl ₂ EXTRACT	11	2018/06/08	2018/06/08	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	20	2018/06/06	2018/06/07	CAM SOP-00414	SM 23 2510 m
Resistivity of Soil	11	2018/06/06	2018/06/08	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	31	N/A	2018/06/08	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1669995
Site Location: 401W

Attention: Nikol Kochmanova

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Your C.O.C. #: 668025-02-01, 668025-03-01, 668025-04-01, 668025-05-01

Report Date: 2018/06/08
Report #: R5226716
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8D5245
Received: 2018/06/05, 16:46

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF SOIL

Maxxam ID		GWL599	GWL600	GWL601		GWL601		
Sampling Date		2018/02/14	2018/04/09	2018/02/28		2018/02/28		
COC Number		668025-02-01	668025-02-01	668025-02-01		668025-02-01		
	UNITS	BR-03 SA#14	RW-02 SA#9	MR-01 SA#10	QC Batch	MR-01 SA#10 Lab-Dup	RDL	QC Batch

Calculated Parameters

Resistivity	ohm-cm	680	6300	1400	5567331			
-------------	--------	-----	------	------	---------	--	--	--

Inorganics

Soluble (20:1) Chloride (Cl)	ug/g	730	<20	390	5569372	420	20	5569372
Conductivity	umho/cm	1480	160	718	5568916	708	2	5568916
Available (CaCl2) pH	pH	8.02	8.28	8.08	5568601			
Soluble (20:1) Sulphate (SO4)	ug/g	270	68	50	5569377	51	20	5569377

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Lab-Dup = Laboratory Initiated Duplicate

Maxxam ID		GWL602		GWL603		GWL604		GWL605		
Sampling Date		2018/04/11		2018/04/12		2018/03/19		2018/03/21		
COC Number		668025-02-01		668025-02-01		668025-02-01		668025-02-01		
	UNITS	OH-7 SA#5	QC Batch	OH-4 SA#4	RDL	MRU-01 SA#4	RDL	BRU-01 SA#6	RDL	QC Batch

Calculated Parameters

Resistivity	ohm-cm	710	5567331	1300		330		990		5567331
-------------	--------	-----	---------	------	--	-----	--	-----	--	---------

Inorganics

Soluble (20:1) Chloride (Cl)	ug/g	680	5569369	220	20	1700	60	620	20	5569369
Conductivity	umho/cm	1410	5570740	764	2	3050	2	1010	2	5570740
Available (CaCl2) pH	pH	7.99	5568601	8.01		8.07		8.07		5569005
Soluble (20:1) Sulphate (SO4)	ug/g	280	5569370	370	20	<20	20	<20	20	5569370

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF SOIL

Maxxam ID		GWL606			GWL606			GWL607	GWL608		
Sampling Date		2018/03/14			2018/03/14			2018/03/22	2018/04/05		
COC Number		668025-02-01			668025-02-01			668025-02-01	668025-02-01		
	UNITS	CN-02 SA#23B	RDL	QC Batch	CN-02 SA#23B Lab-Dup	RDL	QC Batch	KR-01 SA#9	NW1-04 SA#6	RDL	QC Batch

Calculated Parameters											
Resistivity	ohm-cm	3200		5567331				940	2000		5567331
Inorganics											
Soluble (20:1) Chloride (Cl)	ug/g	<20	20	5569369				580	230	20	5569372
Conductivity	umho/cm	312	2	5570740	314	2	5570740	1070	508	2	5568916
Available (CaCl2) pH	pH	8.12		5568601				8.01	8.26		5568601
Soluble (20:1) Sulphate (SO4)	ug/g	200	20	5569370				<20	<20	20	5569377
RDL = Reportable Detection Limit											
QC Batch = Quality Control Batch											
Lab-Dup = Laboratory Initiated Duplicate											

Maxxam ID		GWL609	GWL610	GWL611	GWL612	GWL613	GWL614		
Sampling Date		2018/02/25	2018/04/11	2018/02/26	2018/04/11	2018/04/06	2018/04/10		
COC Number		668025-03-01	668025-03-01	668025-03-01	668025-03-01	668025-03-01	668025-03-01		
	UNITS	KR-03S SA#10	NW-05 SA#7B	MA-01 SA#11	NW-04 SA#4	NW-03S SA#7	NW-08 SA#7	RDL	QC Batch

Calculated Parameters									
Resistivity	ohm-cm	2300	620	1300	1000	1600	1300		5567331
Inorganics									
Soluble (20:1) Chloride (Cl)	ug/g	210	820	280	510	340	350	20	5569372
Conductivity	umho/cm	437	1620	797	979	643	778	2	5568916
Available (CaCl2) pH	pH	8.21	8.11	8.09	8.16	8.08	8.13		5568601
Soluble (20:1) Sulphate (SO4)	ug/g	<20	24	310	<20	23	77	20	5569377
RDL = Reportable Detection Limit									
QC Batch = Quality Control Batch									

RESULTS OF ANALYSES OF SOIL

Maxxam ID		GWL615		GWL616		GWL617		GWL618		
Sampling Date		2018/04/10		2018/03/25		2018/03/28		2018/03/26		
COC Number		668025-03-01		668025-03-01		668025-03-01		668025-03-01		
	UNITS	NW-07 SA#5A	QC Batch	NBP1-3 SA#6	QC Batch	RW-01 SA#3	QC Batch	NW1-02 SA#3	RDL	QC Batch

Calculated Parameters										
Resistivity	ohm-cm	610	5567331	1600	5567331	1300	5567331	2300		5567331
Inorganics										
Soluble (20:1) Chloride (Cl)	ug/g	810	5569372	320	5569369	370	5569372	170	20	5569372
Conductivity	umho/cm	1630	5568916	627	5568916	743	5568916	429	2	5570740
Available (CaCl2) pH	pH	8.10	5568601	8.00	5568601	8.07	5568601	8.13		5568601
Soluble (20:1) Sulphate (SO4)	ug/g	<20	5569377	<20	5569370	<20	5569377	<20	20	5569377
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										

Maxxam ID		GWL618		GWL619		GWL620		GWL621		
Sampling Date		2018/03/26		2018/03/26		2018/04/09		2018/03/06		
COC Number		668025-03-01		668025-04-01		668025-04-01		668025-04-01		
	UNITS	NW1-02 SA#3 Lab-Dup	QC Batch	NW1-01 SA#4	QC Batch	NBP1-01 SA#9	QC Batch	CN-01 SA#20A	RDL	QC Batch

Calculated Parameters										
Resistivity	ohm-cm			4200	5567331	1200	5567331	2900		5567331
Inorganics										
Soluble (20:1) Chloride (Cl)	ug/g			78	5569372	460	5569369	120	20	5569372
Conductivity	umho/cm			238	5568916	835	5570740	343	2	5568916
Available (CaCl2) pH	pH	8.09	5568601	8.24	5568601	8.13	5569005	8.34		5568601
Soluble (20:1) Sulphate (SO4)	ug/g			<20	5569377	<20	5569370	92	20	5569377
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										
Lab-Dup = Laboratory Initiated Duplicate										

RESULTS OF ANALYSES OF SOIL

Maxxam ID		GWL622		GWL623		GWL624		
Sampling Date		2018/02/25		2018/04/12		2018/04/13		
COC Number		668025-04-01		668025-04-01		668025-04-01		
	UNITS	CP-01 SA#12	QC Batch	OH-5 SA#7	QC Batch	OH-9 SA#5	RDL	QC Batch

Calculated Parameters								
Resistivity	ohm-cm	1500	5567331	1000	5567331	1400		5567331
Inorganics								
Soluble (20:1) Chloride (Cl)	ug/g	340	5569369	490	5569372	330	20	5569369
Conductivity	umho/cm	649	5570740	974	5568916	733	2	5570740
Available (CaCl2) pH	pH	8.10	5569005	8.14	5568601	8.16		5569005
Soluble (20:1) Sulphate (SO4)	ug/g	<20	5569370	29	5569377	<20	20	5569370
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								

Maxxam ID		GWL624			GWL625			GWL626		
Sampling Date		2018/04/13			2018/05/29			2018/04/12		
COC Number		668025-04-01			668025-04-01			668025-04-01		
	UNITS	OH-9 SA#5	RDL	QC Batch	NB-02 SA#4	RDL	QC Batch	OH-01 SA#7	RDL	QC Batch

Calculated Parameters										
Resistivity	ohm-cm				870		5567331	300		5567331
Inorganics										
Soluble (20:1) Chloride (Cl)	ug/g	330	20	5569369	670	20	5569372	1700	60	5569369
Conductivity	umho/cm				1150	2	5568916	3300	2	5570740
Available (CaCl2) pH	pH				8.24		5569005	7.47		5569005
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5569370	62	20	5569377	250	20	5569370
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										
Lab-Dup = Laboratory Initiated Duplicate										

RESULTS OF ANALYSES OF SOIL

Maxxam ID		GWL627			GWL628			GWL629		
Sampling Date		2018/05/09			2018/05/07			2018/05/30		
COC Number		668025-04-01			668025-04-01			668025-05-01		
	UNITS	KR-02 SA#3	RDL	QC Batch	MR-02 SA#7	RDL	QC Batch	BR-01 SA#4	RDL	QC Batch
Calculated Parameters										
Resistivity	ohm-cm	470		5567331	760		5567331	400		5567331
Inorganics										
Soluble (20:1) Chloride (Cl)	ug/g	1100	40	5569369	670	20	5569372	1300	60	5569369
Conductivity	umho/cm	2140	2	5568916	1310	2	5568916	2490	2	5570740
Available (CaCl2) pH	pH	8.24		5569005	8.08		5569005	8.04		5569005
Soluble (20:1) Sulphate (SO4)	ug/g	26	20	5569370	70	20	5569377	130	20	5569370
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										

TEST SUMMARY

Maxxam ID: GWL599
Sample ID: BR-03 SA#14
Matrix: Soil

Collected: 2018/02/14
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL600
Sample ID: RW-02 SA#9
Matrix: Soil

Collected: 2018/04/09
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL601
Sample ID: MR-01 SA#10
Matrix: Soil

Collected: 2018/02/28
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL601 Dup
Sample ID: MR-01 SA#10
Matrix: Soil

Collected: 2018/02/28
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL602
Sample ID: OH-7 SA#5
Matrix: Soil

Collected: 2018/04/11
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas

TEST SUMMARY

Maxxam ID: GWL602
Sample ID: OH-7 SA#5
Matrix: Soil

Collected: 2018/04/11
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL603
Sample ID: OH-4 SA#4
Matrix: Soil

Collected: 2018/04/12
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL604
Sample ID: MRU-01 SA#4
Matrix: Soil

Collected: 2018/03/19
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL605
Sample ID: BRU-01 SA#6
Matrix: Soil

Collected: 2018/03/21
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL606
Sample ID: CN-02 SA#23B
Matrix: Soil

Collected: 2018/03/14
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk

TEST SUMMARY

Maxxam ID: GWL606
Sample ID: CN-02 SA#23B
Matrix: Soil

Collected: 2018/03/14
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL606 Dup
Sample ID: CN-02 SA#23B
Matrix: Soil

Collected: 2018/03/14
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar

Maxxam ID: GWL607
Sample ID: KR-01 SA#9
Matrix: Soil

Collected: 2018/03/22
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL608
Sample ID: NW1-04 SA#6
Matrix: Soil

Collected: 2018/04/05
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL609
Sample ID: KR-03S SA#10
Matrix: Soil

Collected: 2018/02/25
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

TEST SUMMARY

Maxxam ID: GWL610
Sample ID: NW-05 SA#7B
Matrix: Soil

Collected: 2018/04/11
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL611
Sample ID: MA-01 SA#11
Matrix: Soil

Collected: 2018/02/26
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL612
Sample ID: NW-04 SA#4
Matrix: Soil

Collected: 2018/04/11
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL613
Sample ID: NW-03S SA#7
Matrix: Soil

Collected: 2018/04/06
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL614
Sample ID: NW-08 SA#7
Matrix: Soil

Collected: 2018/04/10
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine

TEST SUMMARY

Maxxam ID: GWL614
Sample ID: NW-08 SA#7
Matrix: Soil

Collected: 2018/04/10
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL615
Sample ID: NW-07 SA#5A
Matrix: Soil

Collected: 2018/04/10
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL616
Sample ID: NBP1-3 SA#6
Matrix: Soil

Collected: 2018/03/25
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL617
Sample ID: RW-01 SA#3
Matrix: Soil

Collected: 2018/03/28
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL618
Sample ID: NW1-02 SA#3
Matrix: Soil

Collected: 2018/03/26
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar

TEST SUMMARY

Maxxam ID: GWL618
Sample ID: NW1-02 SA#3
Matrix: Soil

Collected: 2018/03/26
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL618 Dup
Sample ID: NW1-02 SA#3
Matrix: Soil

Collected: 2018/03/26
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas

Maxxam ID: GWL619
Sample ID: NW1-01 SA#4
Matrix: Soil

Collected: 2018/03/26
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL620
Sample ID: NBP1-01 SA#9
Matrix: Soil

Collected: 2018/04/09
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL621
Sample ID: CN-01 SA#20A
Matrix: Soil

Collected: 2018/03/06
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

TEST SUMMARY

Maxxam ID: GWL622
Sample ID: CP-01 SA#12
Matrix: Soil

Collected: 2018/02/25
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL623
Sample ID: OH-5 SA#7
Matrix: Soil

Collected: 2018/04/12
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5568601	2018/06/07	2018/06/07	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL624
Sample ID: OH-9 SA#5
Matrix: Soil

Collected: 2018/04/13
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL624 Dup
Sample ID: OH-9 SA#5
Matrix: Soil

Collected: 2018/04/13
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL625
Sample ID: NB-02 SA#4
Matrix: Soil

Collected: 2018/05/29
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk

TEST SUMMARY

Maxxam ID: GWL625
Sample ID: NB-02 SA#4
Matrix: Soil

Collected: 2018/05/29
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL626
Sample ID: OH-01 SA#7
Matrix: Soil

Collected: 2018/04/12
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL627
Sample ID: KR-02 SA#3
Matrix: Soil

Collected: 2018/05/09
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL628
Sample ID: MR-02 SA#7
Matrix: Soil

Collected: 2018/05/07
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569372	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5568916	N/A	2018/06/07	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/07	2018/06/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569377	N/A	2018/06/08	Alina Dobreanu

Maxxam ID: GWL629
Sample ID: BR-01 SA#4
Matrix: Soil

Collected: 2018/05/30
Shipped:
Received: 2018/06/05

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5569369	N/A	2018/06/08	Deonarine Ramnarine
Conductivity	AT	5570740	N/A	2018/06/08	Tahir Anwar
pH CaCl2 EXTRACT	AT	5569005	2018/06/08	2018/06/08	Gnana Thomas
Resistivity of Soil		5567331	2018/06/08	2018/06/08	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5569370	N/A	2018/06/08	Alina Dobreanu

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	20.0°C
-----------	--------

Most samples have been received and analyzed past the recommended hold time of 30 days as per client request.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1669995
Site Location: 401W
Sampler Initials: AM

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5568601	Available (CaCl ₂) pH	2018/06/07			100	97 - 103			0.50	N/A
5568916	Conductivity	2018/06/07			98	90 - 110	<2	umho/cm	1.4	10
5569005	Available (CaCl ₂) pH	2018/06/08			101	97 - 103			0.13	N/A
5569369	Soluble (20:1) Chloride (Cl)	2018/06/08	NC	70 - 130	108	70 - 130	<20	ug/g	0.23	35
5569370	Soluble (20:1) Sulphate (SO ₄)	2018/06/08	114	70 - 130	107	70 - 130	<20	ug/g	NC	35
5569372	Soluble (20:1) Chloride (Cl)	2018/06/08	NC	70 - 130	107	70 - 130	<20	ug/g	7.2	35
5569377	Soluble (20:1) Sulphate (SO ₄)	2018/06/08	NC	70 - 130	102	70 - 130	<20	ug/g	2.5	35
5570740	Conductivity	2018/06/08			98	90 - 110	<2	umho/cm	0.64	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).



VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	Nikol Kochmanova	P. O. #:			
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	1669995		668025
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	(905) 567-6100 Ext: 1459 Fax:	Project Name:	40/W	COC #:	Project Manager:
Email:	AP_CustomerService@golder.com	Email:	Nikol_Kochmanova@golder.com	Site #:			Erna Gitej
				Sampled By:		C#668025-02-01	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY						ANALYSIS REQUESTED (PLEASE BE SPECIFIC)								Turnaround Time (TAT) Required: Please provide advance notice for rush projects			
Regulation 153 (2011)			Other Regulations			Special Instructions										Regular (Standard) TAT:	
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw									(will be applied if Rush TAT is not specified): Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.				
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw									Job Specific Rush TAT (if applies to entire submission) Date Requested: _____ Time Required: _____				
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other	<input type="checkbox"/> For RSC	<input type="checkbox"/> MISA Municipality _____									Rush Confirmation Number: _____ (call lab for #)					
<input type="checkbox"/> Table _____			<input type="checkbox"/> PWOO									# of Bottles _____ Comments _____					
<input type="checkbox"/> Other _____			<input type="checkbox"/> _____														
Include Criteria on Certificate of Analysis (Y/N)? _____																	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Or VI	Corrosivity - pkg. (Cl, SO4, pH, Resistivity/EC - no Sulphide and Redox Potential)											
1	BR-03 SA#14	Feb 14/18	AM	SOIL	X												
2	RW-02 SA#9	Apr 9/18	AM	SOIL	X												
3	MR-01 SA#10	Feb 28/18	AM	SOIL	X												
4	OH-7 SA#5	Apr 11/18	AM	SOIL	X												
5	OH-4 SA#4	Apr 12/18	AM	SOIL	X												
6	MEN-01 SA#4	Mar 14/18	AM	SOIL	X												
7	BRU-d SA#6	May 21/18	AM	SOIL	X												
8	CN-02 SA#23B	Mar 14/18	AM	SOIL	X												
9	KR-01 SA#9	Mar 22/18	AM	SOIL	X												
10	NWL-04 SA#6	Apr 5/18	AM	SOIL	X												

05-Jun-18 16:46
Ema Gitej
B8D5245
GK1 ENV-1309

* RELINQUISHED BY: (Signature/Print) Alex MacMillan du... Date: (YY/MM/DD) 18/06/05 Time 10:45 RECEIVED BY: (Signature/Print) [Signature] Date: (YY/MM/DD) 18/06/05 Time 16:46 # jars used and not submitted Laboratory Use Only Time Sensitive Temperature (°C) on Recl 20.20/20 Custody Seal Present Intact Yes No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.
** IT IS THE RESPONSIBILITY OF THE RELINQUISHING PARTY TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.
*** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM
White: Maxxa Yellow: Client



Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campbell Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

CHAIN OF CUSTODY RECORD



2 of 4
Page 1/1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name: #1326 Golder Associates Ltd	Company Name: Nikol Kochmanova	Quotation #: B80683	Maxxam Job #:	Bottle Order #:			
Attention: Accounts Payable	Attention: Nikol Kochmanova	P.O. #:					
Address: 6925 Century Ave Suite 100	Address:	Project: 1669995					
Mississauga ON L5N 7K2		Project Name: 401W					
Tel: (905) 567-4444 Fax: (905) 567-6561	Tel: (905) 567-6100 Ext: 1459 Fax:	Site #:			COC #:		Project Manager:
Email: AP_CustomerService@golder.com	Email: Nikol_Kochmanova@golder.com	Sampled By:			C#668025-03-01		Ema Gitej

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY				ANALYSIS REQUESTED (PLEASE BE SPECIFIC)										Turnaround Time (TAT) Required: Please provide advance notice for rush projects			
Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table <input type="checkbox"/>				Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Municipality <input type="checkbox"/> PWQO <input type="checkbox"/> Other				Special Instructions				Field Filtered (please circle): Metals / Hg / Cr / V Corrosivity pH (CL, SO4, pH) Reactivity/EC - no Sulphide and Redox (Potential)		Regular (Standard) TAT: (will be applied if Rush TAT is not specified): Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details. Job Specific Rush TAT (if applies to entire submission) Date Required: Time Required: Rush Confirmation Number: (call lab for #)			
Include Criteria on Certificate of Analysis (Y/N)?														# of Bottles		Comments	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix													
1	KR-03 SA#10	Feb 25/18	AM	SOIL													
2	NW-05 SA#7B	Apr 11/18	AM	SOIL													
3	MA-01 SA#11	Feb 26/18	AM	SOIL													
4	NW-04 SA#4	Apr 11/18	AM	SOIL													
5	NW-03 SA#7	Apr 6/18	AM	SOIL													
6	NW-02 SA#7	Apr 10/18	AM	SOIL													
7	NW-07 SA#5A	Apr 10/18	AM	SOIL													
8	NBP1-3 SA#6	Mar 25/18	AM	SOIL													
9	RW-01 SA#3	Mar 28/18	AM	SOIL													
10	NWL02 SA#3	Mar 26/18	AM	SOIL													
* RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	# jars used and not submitted		Laboratory Use Only							
See page 1				See page one						Time Sensitive		Temperature, (°C) on Reel		Custody Seal		Yes	No
														Present			
														Intact			
* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.										SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM							
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.										White: Maxxa Yellow: Client							
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.																	

CHAIN OF CUSTODY RECORD

3 of 4
Page 11

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	Nikol Kochmanova	P.O. #:			
Address:	6925 Century Ave Suite 100	Address:		Project:	1669995		668025
	Mississauga ON L5N 7K2			Project Name:	401W	COC #:	Project Manager:
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	(905) 567-6100 Ext: 1459 Fax:	Site #:			Erna Gitej
Email:	AP_CustomerService@golder.com	Email:	Nikol_Kochmanova@golder.com	Sampled By:		C668025-04-01	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)			Other Regulations		Special Instructions
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylew	
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558.	<input type="checkbox"/> Storm Sewer Bylaw	
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other	<input type="checkbox"/> For RSC	<input type="checkbox"/> MISA	Municipality _____	
<input type="checkbox"/> Table _____			<input type="checkbox"/> PWQO		
			<input type="checkbox"/> Other _____		

Include Criteria on Certificate of Analysis (Y/N)?

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix
1		NW1-01 SA#4	Mar 26/18	AM	SOIL
2		NBP1-1 SA#9	Apr 9/18	AM	SOIL
3		CN-01 SA#20A	Mar 6/18	AM	SOIL
4		CP-01 SA#12	Feb 25/18	AM	SOIL
5		OH-5 SA#7	Apr 12/18	AM	SOIL
6		OH-1 SA#5	Apr 13/18	AM	SOIL
7		NB-02 SA#4	May 29/18	AM	SOIL
8		OH-1 SA#7	Apr 12/18	AM	SOIL
9		KR-02 SA#3	May 9/18	AM	SOIL
10		MR-02 SA#7	May 7/18	AM	SOIL

Field Filtered (please circle):

Corrosivity pkg (Cl, SO₄, pH, Resistivity/EC - no Sulphide and Redox Potential)

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

This image shows a full page of blank graph paper. The grid consists of 10 columns and 10 rows of squares. There are some minor scanning artifacts, such as small dark specks and faint smudges, scattered across the grid. A vertical crease or fold line is visible down the center of the page.

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:

(will be applied if Rush TAT is not specified):

Standard TAT = 5-7 Working days for most tests.

Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)

Date Required: _____ Time Required: _____

Rush Confirmation Number:

	(call lab for #)
--	------------------

# of Bottles	Comments
--------------	----------

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Laboratory Use Only					
See Page 1			See page one				Time Sensitive	Temperature (°C) on Receipt	Custody Seal Present	Yes	No	

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.



* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT [HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF](http://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF)

SAMPLES MUST BE KEPT COOL ($< 10^{\circ}\text{C}$) FROM TIME OF SAMPLING
UNTIL DELIVERY TO MAXXAM

White: Maxxa Yellow: Client

Page 1

INVOICE TO:			REPORT TO:			PROJECT INFORMATION:			Laboratory Use Only:					
Company Name: #1326 Golder Associates Ltd			Company Name: Nikol Kochmanova			Quotation #: B80683			Maxxam Job #:		Bottle Order #:			
Attention: Accounts Payable			Attention: Nikol Kochmanova			P.O.#:								
Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2			Address:			Project: 1669995			COC #:		Project Manager:			
Tel: (905) 567-4444 Fax: (905) 567-6561			Tel: (905) 567-6100 Ext: 1459 Fax:			Project Name:					Ema Gitej			
Email: AP_CustomerService@golder.com			Email: Nikol_Kochmanova@golder.com			Site #:			C#668025-05-01					
						Sampled By:								
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY						ANALYSIS REQUESTED (PLEASE BE SPECIFIC)						Turnaround Time (TAT) Required: Please provide advance notice for rush projects		
Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____			Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWQO <input type="checkbox"/> Other _____			Special Instructions			Regular (Standard) TAT: (will be applied if Rush TAT is not specified). Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.					
Include Criteria on Certificate of Analysis (Y/N)?						Job Specific Rush TAT (if applies to entire submission) Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #)								
Sample Barcode Label		Sample (Location) Identification		Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Conductivity µS/cm (Cl, SO4, pH, Resistivity/EC - no Suphate and Redox Potential)				# of Bottles	Comments	
1		BR-d SA#4		May 30/18	AM	SOIL	X							
2														
3														
4														
5														
6														
7														
8														
9														
10														
* RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)		Time	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	# jars used and not submitted	Laboratory Use Only				
See page 1					See page one					Time Sensitive	Temperature (°C) on Receipt	Custody Seal Present	Yes	No
												Intact		
* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.										White: Maxxa Yellow: Client				
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.										SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM				
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.														

APPENDIX E

Non-Standard Special Provisions

CONCRETE WORKING SLAB - Item No.

Non-Standard Special Provision

1.0 Scope

This Special Provision covers the requirements for the supply and placement of a concrete working slab for the base of the excavations associated with the construction of the retaining wall east of Midland Avenue Overpass for widening of the Highway 401 Westbound lanes.

2.0 References

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

Ontario Provincial Standard Specifications
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.

7.03 Protection of Subgrade

The native subgrade for the retaining wall will be susceptible to disturbance and softening/loosening from construction traffic and ponded water. Following inspection and approval of the prepared subgrade, a concrete working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade within four hours.

The concrete working slab be placed in accordance with OPSS.PROV 904.

7.04 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.

END OF SECTION

TEMPORARY PROTECTION SYSTEMS - Item No.

Special Provision

Amendment to OPSS 539, November 2014

593.07.02 Removal of Protection Systems

Subsection 539.07.02 of OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems shall be removed from the right-of-way unless it is specified in the Contract Documents that the protection system may be left in place.

Where piles are left in place, the top shall be removed to at least 1.2 m below the finished grade or ground level.

The method and sequence of removal shall be such that there shall be no damage to the new work, existing work and facility being protected.

All disturbed areas shall be restored to an equivalent or better condition than existing prior to the commencement of construction.

VIBRATION MONITORING - Item No.

Non-Standard Special Provision

Scope

This special provision describes requirements for vibration monitoring during soldier pile or sheet pile installation works for the construction of the retaining wall east of Midland Avenue for widening of the Highway 401 Westbound lanes and installation of temporary protection systems.

References

The subsurface conditions at the site are described in the following Foundation Investigation Report:

Retaining Wall East of Midland Avenue Overpass,
Highway 401 Westbound Core and Collector Lanes, Neilson Road to Warden Avenue, City of
Toronto, Ontario,
Ministry of Transportation, Ontario
G.W.P. No. 2162-11-00

Definitions

Contractor's Engineer: An Engineer with a minimum of five (5) years of experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Contractor's Engineer shall be retained by the Contractor to ensure general conformance with the contract documents and issue certificate(s) of conformance.

Submission Requirements

The Contractor/Contractor's Engineer shall submit details of the vibration monitoring plan to the Contract Administrator for review. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- Qualifications of vibration monitoring specialist.
- Details regarding proposed instrumentation.
- Proposed location of instruments.
- Proposed frequency of readings.
- Proposed methods for adjusting piling methods if readings show vibrations exceeding tolerable levels.

Monitoring

The vibration monitoring equipment shall be placed as close as possible to the works. The Contractor/Contractor's Engineer shall take readings on the existing bridge foundations and on existing residential structures located within 200 m of the works during installation of any deep foundation elements (including piles for temporary protection systems), starting with the pile furthest away for each foundation element.

The vibrations measured at the site shall not exceed 50 mm/s (peak particle velocity).

The results shall be submitted to the Contract Administrator after each pile installation, prior to continuing with the subsequent piles. As a minimum, the pile number, location, set criteria and driving/drilling log must be submitted with vibration monitoring results.

If the vibration monitoring results are acceptable, the Contractor may continue with the next pile(s) with readings taken during driving of each pile. The results of subsequent piles should be submitted to the Contract Administrator after each pile has been driven.

If the readings are not within the limits stated above, the Contractor must alter the driving procedures until the vibrations at the existing structures are within acceptable levels. The above process must be repeated for each pile.

Certificate of Conformance (CoC)

Upon completion of the work in each area of pile driving, the Contractor shall submit to the Contract Administrator a CoC sealed and signed by the Contractor's Engineer. The certificate shall state that the vibrations on the existing structure were below the limits stated above, and where the levels were exceeded, what procedures were used to reduce the vibrations to below the limits stated above.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

EARTH EXCAVATION FOR STRUCTURE (Obstructions) – Item No.

Notice To Contractor

Amendment to OPSS 902, November 2010

Excavating and Backfilling – Structures

902.07 CONSTRUCTION

Section 902.07 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the potential presence of cobbles and boulders within the fill and native soils, as encountered in the area of the Midland Avenue Overpass. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations, pile driving, caisson drilling and installation of temporary protection systems.



golder.com