

TECHNICAL MEMORANDUM

DATE May 2, 2019

Project No. 1669996

TO Riyaz Sheikh, P.Eng.
AECOM

FROM A. Poliacik and L. Coyne

EMAIL Apoliacik@golder.com

**FOUNDATION INVESTIGATION AND DESIGN MEMORANDUM
RETAINING WALLS AT EAST END OF DERRY ROAD NSE/W RAMP CULVERT (SITE C-C50A)
HIGHWAY 410, EGLINTON AVENUE TO MAYFIELD ROAD – CONTRACT 2
MISSISSAUGA AND BRAMPTON, ONTARIO
ASSIGNMENT NO. 2016-E-0040
GEOCRES NO. 30M12-443**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detailed design for the proposed retaining walls at the east end of the existing culvert crossing the Derry Road S-E/W Off-Ramp (Structure No. C-C50A), as part of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road in the Cities of Mississauga and Brampton, Ontario (Assignment No. 2016-E-0040).

It is understood that as part of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road, subcollector lanes will split from the left lane of the Derry Road S-E/W Off-Ramp and as such, wingwalls/retaining walls will be required at the east end of the culvert to retain the embankment of the new subcollector without extending the culvert. The walls are proposed to have a maximum height of 2.65 m.

2.0 SITE DESCRIPTION

The existing culvert site (Site No. C-C50A) is located approximately 400 m north of Derry Road along Highway 410 in the City of Brampton, Ontario. A Key Plan is provided on Drawing 1. The existing culvert is a 4.54 m wide by 2.46 m high reinforced concrete box culvert with a length of 37 m. The Derry Road Off-Ramp road grade at the site is at approximately Elevation 188 m, and the ground surface elevation at the east embankment toe is at approximately Elevation 186 m. Based on Golder's site reconnaissance at the time of the borehole investigation, no evidence of settlement or global instability of the embankment side slopes was observed at this site.

3.0 INVESTIGATION PROCEDURES

A field investigation was carried out on March 17, 2019, at which time one borehole (designated as Borehole CV-1) was advanced in the vicinity of the proposed retaining walls, at the location shown on Drawing 1. The borehole was advanced to a depth of 7.7 m below ground surface using a CME 55 track-mounted drill rig, supplied and operated by Geo-Environmental Drilling Inc. of Milton, Ontario. The borehole was advanced through the overburden using 203 mm outer diameter hollow stem augers. 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). The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in this section are uncorrected.

The groundwater conditions in the open borehole were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole CV-1 to permit monitoring of the water level at the site. The installed piezometer consists of a 50 mm diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack with the piezometer positioned near the bottom of the borehole. The borehole and annulus surrounding the piezometer pipe above the filter sand pack were backfilled to the ground surface with bentonite pellets.

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 selected soil sample from Borehole CV-1, obtained using appropriate sampling protocols, was submitted to a specialist 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.

4.0 SUBSURFACE CONDITIONS

The detailed subsurface soil and groundwater conditions encountered in Borehole CV-1 are presented on the borehole record in Appendix A. The results of the geotechnical and analytical laboratory tests are presented in Appendix B and C respectively.

The stratigraphic boundaries shown on the borehole record and on the stratigraphic profile on Drawing 1 are inferred from noncontinuous sampling, observations of drilling progress and the results of SPTs. 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 record governs any interpretation of the site conditions.

In general, the subsoils encountered in Borehole CV-1 consist of surficial topsoil underlain by a deposit of very stiff to hard clayey silt with sand, further underlain by a deposit of hard gravelly sandy clayey silt till. Additional details of the encountered stratigraphy are provided below.

4.1 Clayey Silt Till

A 2.9 m thick till deposit, consisting of clayey silt with sand, trace to some gravel, was encountered underlying approximately 130 mm of topsoil; the till extends to a depth of 3.0 m below ground surface (Elevation 182.6 m).

The measured SPT “N” values within the clayey silt till deposit range from 15 to 49 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

Atterberg limits testing was carried out on one sample of the clayey silt with sand deposit and measured a plastic limit of about 15 per cent, a liquid limit of about 25 per cent, and plasticity index of about 9 per cent. This result is plotted on Figure B-1 in Appendix B and indicates the till is a clayey silt of low plasticity. The natural water content of two samples of the clayey silt till deposit measured about 10 per cent and 11 per cent, below the plastic limit of

the material. Grain size distribution testing was carried out on one sample of the clayey silt till deposit and the results are shown on Figure B-2 in Appendix B.

4.2 Gravelly Sandy Clayey Silt Till

A gravelly sandy clayey silt till deposit was encountered underlying the clayey silt till deposit and extended to the borehole termination depth of 7.7 m below ground surface (Elevation 177.9 m). Shale fragments were encountered within this till deposit below a depth of about 7.3 m (Elevation 178.3 m). Auger grinding was observed during drilling, suggesting the presence of cobbles and/or boulders, which are commonly encountered in glacially derived materials and should be expected within this deposit.

The measured SPT “N” values within the till deposit range from 100 blows per 0.15 m of penetration to 100 blows per 0.08 m of penetration, suggesting a hard consistency.

Atterberg limits testing was carried out on one sample of this till deposit and measured a plastic limit of about 20 per cent, a liquid limit of about 30 per cent, and plasticity index of about 10 per cent. This result, which is also shown on Figure B-1 in Appendix B, indicates the till deposit is of low plasticity. The natural water content of two samples within this till deposit measured about 6 per cent, below the plastic limit of the material. Grain size distribution testing was carried out on one sample of the till deposit and the results are included on Figure B-2 in Appendix B.

4.3 Groundwater Conditions

Borehole CV-1 was observed to be dry upon completion of drilling and upon installation of the piezometer. On April 8, 2019, approximately one month following piezometer installation, the water level within the piezometer was measured to be 0.1 m above the ground surface (Elevation 185.7 m).

The groundwater level at the site 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

One soil sample was submitted for analysis of parameters used to assess the potential corrosivity of the soil to steel and concrete. Detailed analytical test results are included in Appendix C and the test results are summarized below.

Borehole No. / Sample No.	Soil Description	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Chlorides (µg/g)	Soluble Sulphates (µg/g)
CV-1 / 3	Clayey silt till	7.88	1,700	591	35 (0.004%)	480 (0.05%)

5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

The following sections provide detail foundation design recommendations for the proposed wingwalls/retaining walls at the east end of the culvert. These recommendations are based on interpretation of the factual data obtained from the foundation investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and carry out the design of the culvert retaining walls.

5.1 General Foundation Design Context

5.1.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the 2014 *Canadian Highway Bridge Design Code* CAN/CSA S6-14 (2014 CHBDC) and its *Commentary*, the culvert and its foundation system (including retaining walls) may be classified as having large traffic volumes and their performance 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 in comparison to the degree of site understanding in Section 6.5 of 2014 CHBDC, the level of confidence for design for the culvert retaining walls 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 of the CHBDC (2014) have been used for design, as indicated in the sections below.

5.1.2 Seismic Design

5.1.2.1 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 up to 30 m below founding level were used to define the seismic site classification in accordance with Table 4.1 of the 2014 CHBDC. Based on this methodology, it is considered that a Site Class C would be applicable for the design of the culvert retaining walls.

5.1.2.2 Spectral Response Values and Seismic Performance Category

The 2014 CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The GSC has developed a new set of seismic hazard maps (referred to as the 5th generation seismic hazard maps) that were made available for public use in December 2015, through the Natural Resources Canada (2018) website.

In accordance with Section 7.5.5.1 of the 2014 CHBDC, buried structures should be designed to resist inertial forces associated with a seismic event having a 2% exceedance in 50 years (i.e., a 2,475 year return period), where the horizontal ground acceleration ratio A_H is equal to the peak ground acceleration, PGA, as specified in Section 4.4.3 of 2014 CHBDC. Therefore, based on Section 4.4.3 of the 2014 CHBDC and the location of the culvert (Latitude 43.6539 and Longitude -79.6811), the reference Site Class C PGA value, which corresponds to the site-specific PGA value, based on the 5th generation seismic hazard maps published by the GSC is as follows.

Seismic Hazard Values (Site Class C)	2% Exceedance in 50 years (2,475 years return period)
PGA (g)	0.082

5.2 Foundation/Retaining Wall Options

As per discussions with AECOM, it is understood that the retaining walls could consist of cast-in-place concrete cantilever walls or precast retaining walls; precast retaining walls have the advantage of faster construction as compared with cast-in-place concrete. Retained soil system walls, while feasible from a foundation perspective

based on the competent soils at the site, require special approval of MTO's RSS Committee for use adjacent to watercourses, and hence are not addressed further in this memorandum. Permanent soldier pile and panel system walls are also feasible; however, the relatively shallow depth to "100-blow" till and the presence of cobbles/boulders in the till would make soldier pile installation difficult, and hence this wall type is not preferred and is not treated further in this foundation design memorandum. Therefore, from a geotechnical/foundations perspective, concrete cantilever retaining walls on strip footings are preferred at this site.

5.3 Strip Footing Foundations

5.3.1 Founding Elevation and Factored Geotechnical Resistances

It is understood that strip footings for concrete cast-in-place or pre-cast retaining walls will be founded at approximately Elevation 183.8 m (approximately 1.5 m below the ground surface in front of the wall, and below the foundation frost penetration depth per OPSD 3090.101). The founding soils at this depth/elevation are anticipated to consist of very stiff to hard clayey silt with sand and are considered suitable for support of the strip footings.

Strip footings founded at Elevation 183.8 m, with a width of 2.5 m, may be designed based on the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance (for 25 mm of settlement) given below.

Footing Width (m)	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance (kPa)
2.5	350	>350

5.3.2 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the base of the concrete footings and the subgrade should be calculated in accordance with Section 6.10.5 of the 2014 CHBDC. For cast-in-place concrete (either the footing itself, or a concrete working slab) or pre-cast concrete footings, the factored coefficient of friction, $\tan \phi'$ or $\tan \delta$, can be taken as follows:

- Cast-in-place footing or working slab to clayey silt till: $\tan \phi' = 0.62$
- Pre-cast footing on clayey silt till: $\tan \delta = 0.44$

5.4 Global Stability

Slope stability analyses for both drained and undrained conditions have been performed for the proposed retaining walls 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 (FoS) of numerous potential failure surfaces was computed in order to establish the minimum 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 1.5 is adopted for the design of retaining walls under static conditions at the end of construction as per the 2014 CHBDC. 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 stability analyses assume a groundwater level at Elevation 185.6 m, a maximum wall height of 2.7 m, and a minimum footing width of 2.5. Based on this information, the proposed concrete retaining walls or precast retaining walls will have a FoS greater than 1.5 against global instability for both drained and undrained conditions and are

therefore satisfactory. Results of the analyses are provided on Figures 1 and 2. The structural designer must ensure that the wall satisfies sliding and overturning conditions.

If the wall geometry changes, for example to include a shorter wall section with a slope at the wall toe, or a slope above the top of the wall, the footing dimension may need to be increased to achieve the minimum required FoS. Golder will re-analyze the final wall/slope configuration if significant sloping ground conditions are incorporated into the design.

5.5 Settlement

Settlement of the subgrade soils beneath the retaining walls and backfill can be expected as a result of the loading from the new fills on the native soil deposits. Settlement of new granular fill that is properly placed and compacted should be expected to occur during construction.

To estimate the magnitude of the expected settlements of the native soil deposits, the immediate compression of the native deposits was modelled by estimating an elastic modulus of deformation based on the SPT 'N' values and using empirical correlations. The total post-construction settlement is estimated to be less than 20 mm, and to occur during and relatively quickly following completion of construction, which meets MTO's settlement performance criteria for embankment widening and for structures.

5.6 Lateral Earth Pressures for Design

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

The following recommendations are made concerning the design of the retaining walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (Materials Specification for *Aggregates*) Granular 'A' or Granular 'B' Type II, should be used as backfill behind the walls. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with the 2014 CHBDC Section 6.12.3 and Figure 6.6. Hand-operated compaction equipment should be used to compact the backfill soils immediately behind the walls as per OPSS.PROV 501. 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 on Figure C6.20(a) of the Commentary to the 2014 CHBDC. For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1 horizontal to less than 1 vertical (1H:<1V) extending up and back from the rear face of the footing or pile cap on Figure C6.20(b) of the Commentary to the 2014 CHBDC.

5.6.1 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. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated.

- For a restrained wall, the pressures are based on the fill behind the granular backfill zone, and the following parameters (unfactored) may be used assuming the use of earth fill for the westward widening of the highway/ramp embankments; values are also provided for the use of Granular B:

Material	Earth Fill	Granular B Type I or II
Soil Unit Weight:	20 kN/m ³	21 kN/m ³
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	0.33 0.50	0.27 0.43

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

Material	Granular 'A'	Granular 'B' Type II
Soil Unit Weight:	22 kN/m ³	21 kN/m ³
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	0.27 0.43	0.27 0.43

- If the wall 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.
- If the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. 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 2014 CHBDC.

5.6.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must also be taken into account in the design of abutment / wingwalls / retaining walls in accordance with Section 4.6.5 of the 2014 CHBDC. 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 abutment stem and/or retaining walls. The walls 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 2014 CHBDC and its Commentary, for structures which 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
Yielding Wall	475-Yr	0.038	0.26	0.26	0.31
	975-Yr	0.066	0.26	0.26	0.32
	2,475 Yr	0.077	0.29	0.29	0.35
Non-Yielding Wall	475-Yr	0.038	0.27	0.27	0.32
	975-Yr	0.066	0.28	0.28	0.34
	2,475 Yr	0.12	0.29	0.29	0.35

- The K_{AE} value for a yielding wall is applicable provided that the wall can move up to $250k_h$ mm, where k_h is the site-specific PGA as given in the table above.
- 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 2014 CHBDC.

5.7 Corrosion Assessment and Protection

The results of an analytical test on one soil sample are summarized in Section 4.4 and presented in Appendix C. The potential for sulphate attack and corrosion are discussed in the following sub-sections. However, 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 when designing concrete elements.

5.7.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-14 Table 3 ("*Additional requirements for concrete subjected to sulphate attack*") for potential sulphate attack on concrete. The sulphate concentration measured in the tested sample is below the exposure class of S-3 (Moderate). Therefore, based on the one soil sample tested, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

5.7.2 Potential for Corrosion

The test results indicate a pH of 7.88 and a resistivity of 1,700 ohm-cm. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to concrete durability as it is less than a pH of 8.0. The resistivity is less than 2,000 ohm-cm, which indicates that the soil corrosiveness is severe ($R < 2,000$ ohm-cm), as per Table 3.2 of the Gravity Pipe Design Guidelines (MTO, 2014). The retaining walls will be located adjacent to the road shoulder and be exposed to de-icing salt. Therefore, concrete should be designed for a "C" type exposure class as defined by CSA A23.1 Table 1.

5.8 Construction Considerations

5.8.1 Surface Water and Groundwater Control

Control of the surface water will be necessary for the construction of the retaining walls to allow excavation and foundation construction to be carried out in dry conditions. Groundwater seepage through the predominantly cohesive soils is expected to be minor and will likely be able to be handled by pumping from properly filtered sumps within the excavation. Although not encountered in Borehole CV-1, non-cohesive embankment fill is anticipated to be present above the native soils in proximity to the roadway, and some perched water should be anticipated within the non-cohesive fill.

Depending on the creek or drainage flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe or diverted by pumping from behind a temporary cofferdam. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the till subgrade soils; further discussion on this aspect is provided in Section 5.6.3.

SP 517F01 should be included in the Contract Documents to address temporary flow passage requirements for the culvert site. It is not necessary to specify a requirement for dewatering, pre-construction surveys or design engineer requirements in this SP; AECOM should complete the applicable fill-in for the temporary flow passage requirements.

5.8.2 Excavation and Temporary Protection Systems/Cofferdams

Temporary excavations for the culvert extension will be made through existing embankment fill, and into the very stiff to hard clayey silt till. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing embankment fill would be classified as Type 3 soil, while the very stiff to hard clayey silt till deposit would be classified as a Type 2 soils, according to the OHSA. Where space permits, temporary open-cut excavations through these materials should be made with side slopes formed no steeper than 1H:1V, assuming proper groundwater and surface water control is in place.

It is anticipated that temporary protection systems will be required parallel to the ramp/highway to allow for excavation into the existing embankment side slopes, or that temporary protection systems/cofferdams will be required parallel to the drainage channel to form a surface water cut-off and allow for construction in dry conditions. The selection and design of the protection system/cofferdam will be the responsibility of the Contractor. However, based on the presence of hard ("100-blow") soils at relatively shallow depth, as well as the presence of cobbles/boulders within the till deposit at this site, it is unlikely that driven steel sheetpiles will be practicable or feasible for protection systems/cofferdams at this site. As such, the contractor will likely need to adopt a soldier pile and lagging type of protection system if they are not able to shift traffic sufficiently to allow an open excavation through the existing embankment side slope to construct the walls. A Notice to Contractor is provided in Appendix E for inclusion in the Contract documents, warning of the presence of hard ground and obstructions at the site.

The lateral movement of the temporary protection system should meet Performance Level 2 as specified in OPSS.PROV 539 (*Construction Specification for Temporary Protection Systems*), provided that any adjacent utilities can tolerate this magnitude of deformation.

5.8.3 Subgrade Protection

If strip footings are adopted, the subgrade soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade. This requirement can be addressed with a note on the General Arrangement drawing and/or with an NSSP. An NSSP is provided in Appendix D for inclusion in the Contract documents.

If pre-cast footings are adopted for support of the walls, a concrete working slab is not required, provided that the pre-cast footings are placed within four hours after the preparation, inspection and approval of the footing subgrade.

5.8.4 Backfill

Backfill for the culvert retaining walls should be completed in accordance with OPSD 3101.150 (*Backfill and Cover for Retaining Walls*). Backfill should consist of granular fill meeting the requirements of OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II. The backfill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*).

6.0 CLOSURE

This Foundation Investigation and Design Memorandum was prepared by Mr. Eric Naylor, EIT, an engineer-in-training with Golder, and Ms. Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the memorandum.

Golder Associates Ltd.



Anastasia Poliacik, P.Eng.
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EN/AP/LCC/rb

<https://golderassociates.sharepoint.com/sites/12504g/6.deliverables/fnds/2.phase2-siteinvestigation/contract2/3.derryrdculvert/3.final/1669996mem2-32019may2hwy410derryroadculvert.docx>

DRAWINGS

Drawing 1 Borehole Locations and Soil Strata

FIGURES

Figure 1 Static Global Stability – Short Term (Undrained) Conditions
Figure 2 Static Global Stability – Long Term (Drained) Conditions

APPENDICES

APPENDIX A – Borehole Record

Lists of Symbols
Abbreviations and Terms Used on Records of Boreholes and Test Pits
Record of Borehole No. CV-1

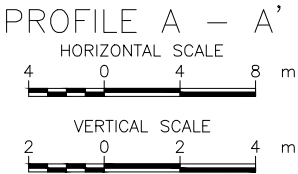
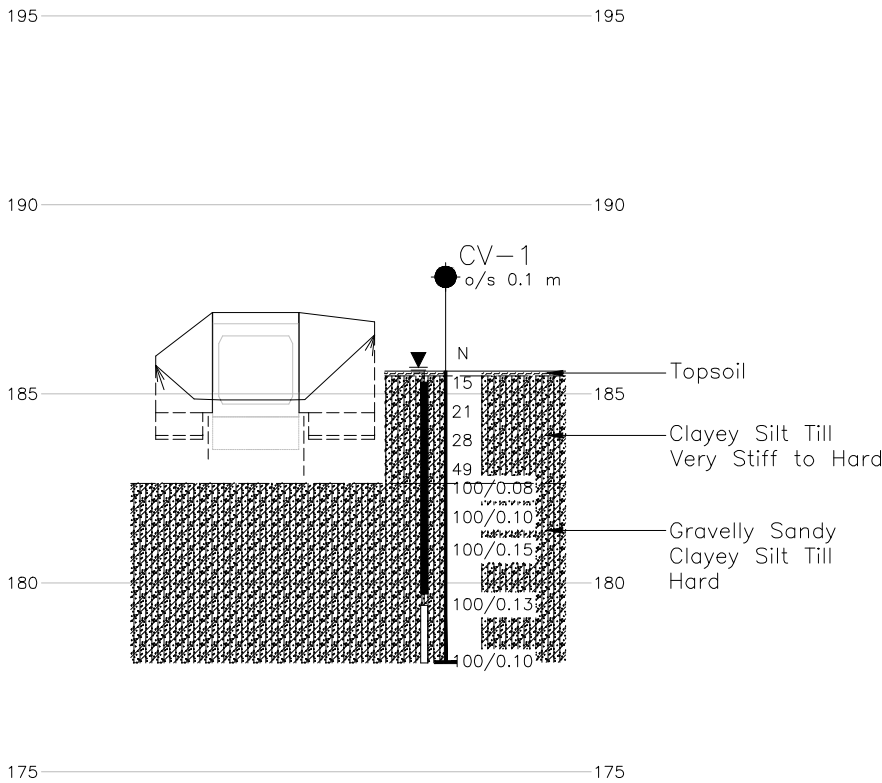
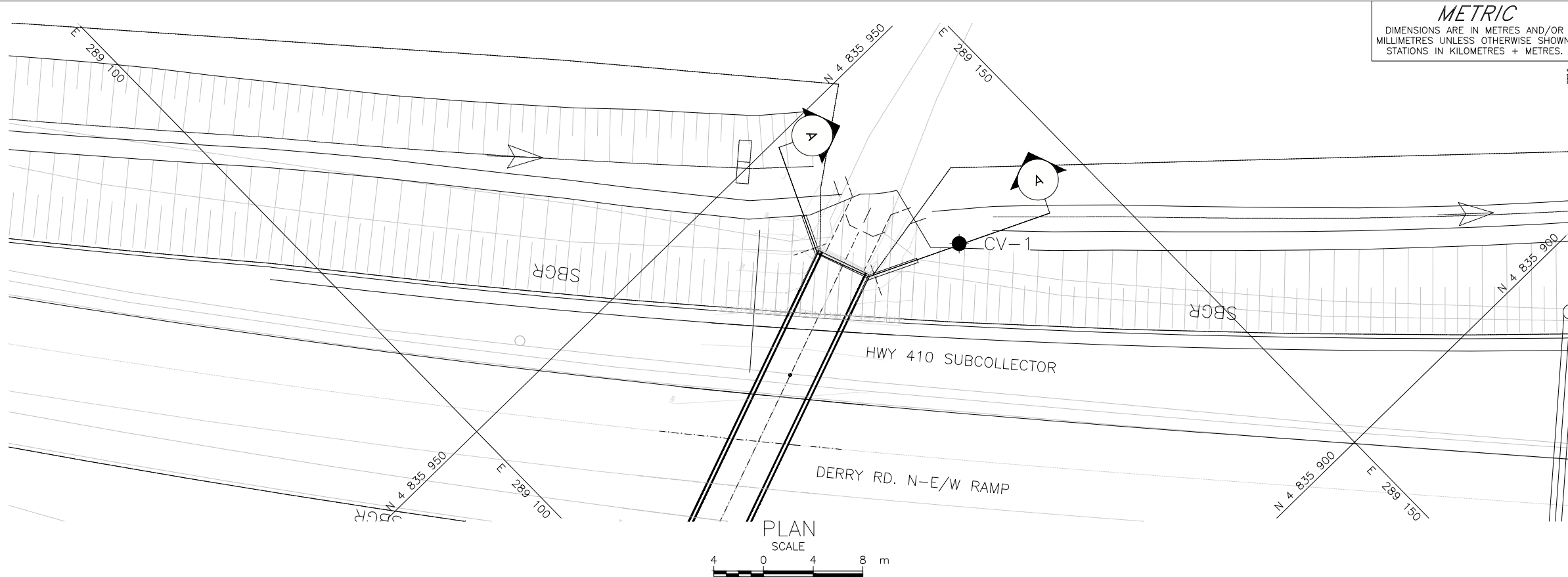
APPENDIX B – Geotechnical Laboratory Test Results

Figure B-1 Plasticity Chart – Clayey Silt Till to Gravelly Sandy Clayey Silt Till
Figure B-2 Grain Size Distribution – Clayey Silt Till to Gravelly Sandy Clayey Silt Till

APPENDIX C – Analytical Laboratory Test Results

APPENDIX D – Non-Standard Special Provisions and Operational Constraint

Notice to Contractor – Obstructions and Hard Soil Conditions
NSSP – Working Slab

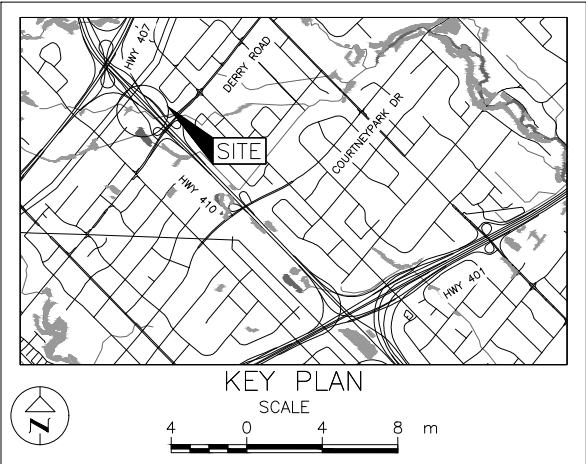


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. 2019-2014
GWP No. 2369-15-00

HIGHWAY 410
DERRY ROAD CULVERT
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on April 08, 2019
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
CV-1	185.6	4835933.7	289138.4

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.

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. X-60543038-C-CourtneyPark-NC - Addendum.dwg, received April 04, 2019 and ACAD-X-60543038-C-Base.dwg, received April, 12, 2019 and Email_01_Derry Road S-EW Ramp Culvert_GA.dwg, received April 16, 2019.



NO.	DATE	BY	REVISION
Geocres No. 30M12-443			
HWY. 410		PROJECT NO. 1669996	DIST. CENTRAL
SUBM'D. NK	CHKD. NK	DATE: 05/01/2019	SITE: C-C50A
DRAWN: DD	CHKD. AMP	APPD. LCC	DWG. 1

Global Stability Analysis

Short-Term (Undrained) Analysis

Figure 1

Material Name	Unit Weight (kN/m ³)	Cohesive Shear Strength (kPa)	Friction Angle (degrees)
New Granular Fill	21	-	33
Very Stiff to Hard Clayey Silt with Sand Till	20	150	-
Hard Gravelly Sandy Clayey Silt Till	21	200	-

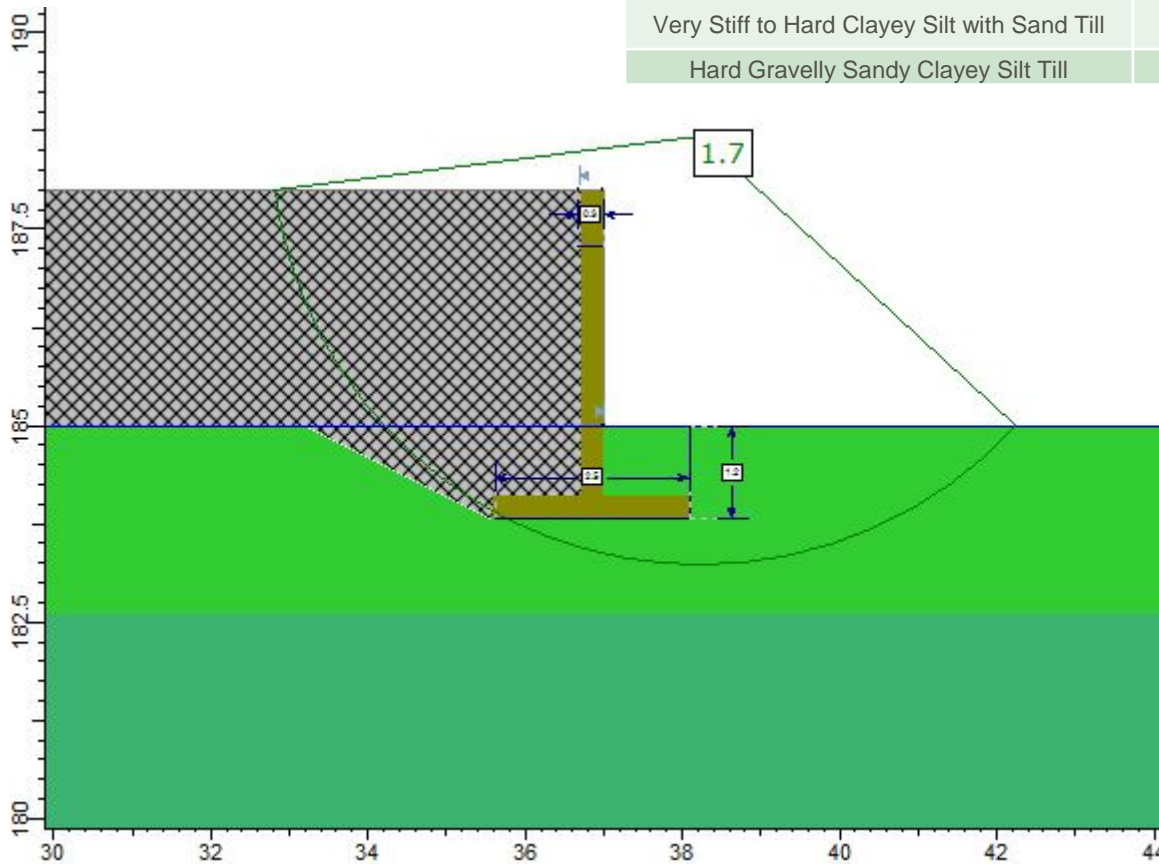


Global Stability Analysis

Long-Term (Drained) Analysis

Figure 2

Material Name	Unit Weight (kN/m ³)	Cohesive Shear Strength (kPa)	Friction Angle (degrees)
New Granular Fill	21	-	33
Very Stiff to Hard Clayey Silt with Sand Till	20	-	32
Hard Gravelly Sandy Clayey Silt Till	21	-	34



APPENDIX A

Borehole Record

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

(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

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

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

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

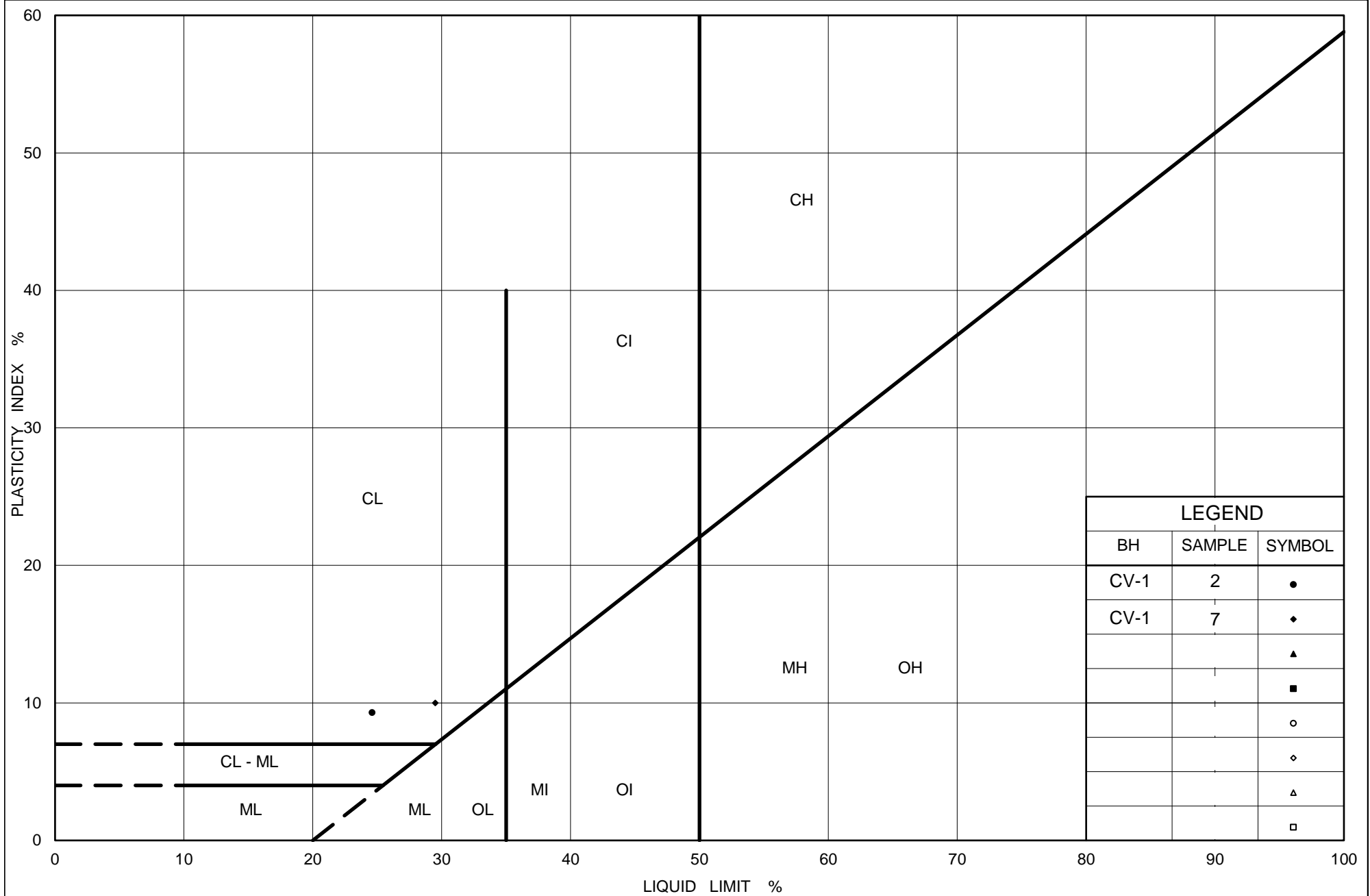
Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

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

APPENDIX B

Geotechnical Laboratory Test Results



LEGEND		
BH	SAMPLE	SYMBOL
CV-1	2	●
CV-1	7	◆
		▲
		■
		○
		◇
		△
		□



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt Till to Gravelly Sandy Clayey Silt Till

Figure No. B-1

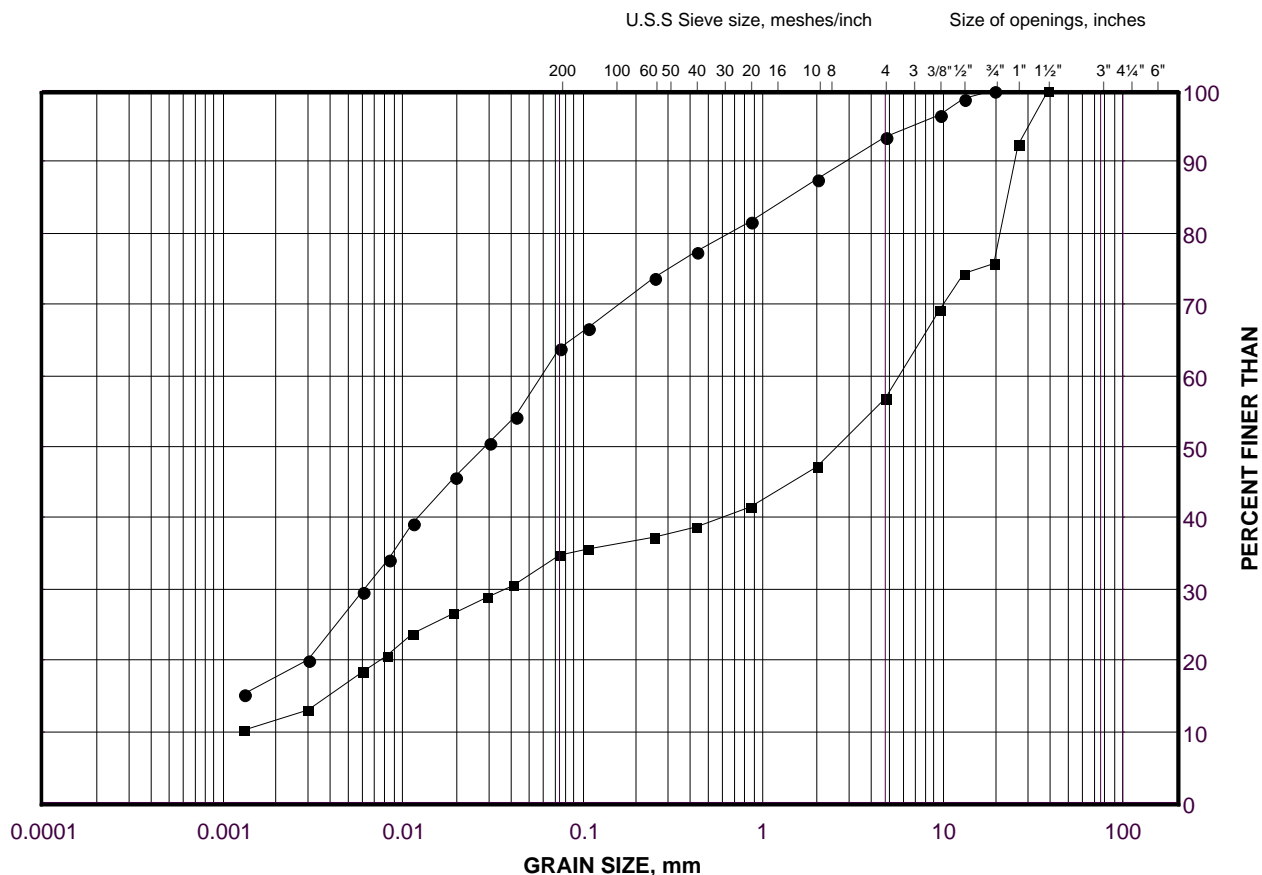
Project No. 1669996 (2100)

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt Till to Gravelly Sandy Clayey Silt Till

FIGURE B-2



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV-1	2	183.8
■	CV-1	6	180.9

Project Number: 1669996

Checked By: _____

Golder Associates

Date: 17-Apr-19

APPENDIX C

Analytical Laboratory Test Results

Your Project #: 1669996
Site Location: HIGHWAY 410
Your C.O.C. #: 711260-01-01

Attention: Nikol Kochmanova

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

Report Date: 2019/04/06
Report #: R5659885
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B984871

Received: 2019/04/02, 10:06

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	8	2019/04/04	2019/04/05	CAM SOP-00463	SM 4500-Cl E m
Conductivity	8	2019/04/05	2019/04/05	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	8	2019/04/04	2019/04/04	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	8	2019/04/02	2019/04/05	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	8	2019/04/04	2019/04/05	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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

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. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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. When sampling is not conducted by Maxxam, results relate to the supplied 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 #: 1669996
Site Location: HIGHWAY 410
Your C.O.C. #: 711260-01-01

Attention: Nikol Kochmanova

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

Report Date: 2019/04/06
Report #: R5659885
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B984871
Received: 2019/04/02, 10:06

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		JIO278		JIO279		JIO280	JIO281	JIO282		
Sampling Date		2019/03/12		2019/03/11		2019/03/10	2019/03/10	2019/03/11		
COC Number		711260-01-01		711260-01-01		711260-01-01	711260-01-01	711260-01-01		
	UNITS	OH-1 SA5	RDL	OH-2 SA2	RDL	OH-3 SA4	OH-4 SA3	OH-6 SA4	RDL	QC Batch

Calculated Parameters										
Resistivity	ohm-cm	1700		480		3900	1200	570		6050148
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	770	20	44	430	820	20	6053319
Conductivity	umho/cm	579	2	2100	2	255	869	1760	2	6055159
Available (CaCl2) pH	pH	7.87		7.84		7.85	7.85	7.44		6051675
Soluble (20:1) Sulphate (SO4)	ug/g	590	20	1100	60	51	61	440	20	6053340
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										

Maxxam ID		JIO283	JIO284	JIO285			JIO285	
Sampling Date		2019/03/17	2019/03/19	2019/03/24			2019/03/24	
COC Number		711260-01-01	711260-01-01	711260-01-01			711260-01-01	
	UNITS	CV-1 SA3	VMS-1 SA3	VMS-2 SA6	RDL	QC Batch	VMS-2 SA6 Lab-Dup	QC Batch

Calculated Parameters								
Resistivity	ohm-cm	1700	2400	4700		6050148		
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	35	100	30	20	6053319		
Conductivity	umho/cm	591	412	214	2	6055159		
Available (CaCl2) pH	pH	7.88	7.84	7.69		6051675	7.68	6051675
Soluble (20:1) Sulphate (SO4)	ug/g	480	140	50	20	6053340		
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								
Lab-Dup = Laboratory Initiated Duplicate								

Maxxam Job #: B984871
Report Date: 2019/04/06

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

TEST SUMMARY

Maxxam ID: JIO278
Sample ID: OH-1 SA5
Matrix: Soil

Collected: 2019/03/12
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO279
Sample ID: OH-2 SA2
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO280
Sample ID: OH-3 SA4
Matrix: Soil

Collected: 2019/03/10
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO281
Sample ID: OH-4 SA3
Matrix: Soil

Collected: 2019/03/10
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO282
Sample ID: OH-6 SA4
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva

TEST SUMMARY

Maxxam ID: JIO282
Sample ID: OH-6 SA4
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO283
Sample ID: CV-1 SA3
Matrix: Soil

Collected: 2019/03/17
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO284
Sample ID: VMS-1 SA3
Matrix: Soil

Collected: 2019/03/19
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO285
Sample ID: VMS-2 SA6
Matrix: Soil

Collected: 2019/03/24
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO285 Dup
Sample ID: VMS-2 SA6
Matrix: Soil

Collected: 2019/03/24
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas

GENERAL COMMENTS

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

Package 1	1.3°C
-----------	-------

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
6051675	Available (CaCl ₂) pH	2019/04/04			100	97 - 103			0.16	N/A
6053319	Soluble (20:1) Chloride (Cl ⁻)	2019/04/05	NC	70 - 130	103	70 - 130	<20	ug/g	3.0	35
6053340	Soluble (20:1) Sulphate (SO ₄)	2019/04/05	NC	70 - 130	106	70 - 130	<20	ug/g	12	35
6055159	Conductivity	2019/04/05			102	90 - 110	<2	umho/cm	2.3	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)

VALIDATION SIGNATURE PAGE

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



Anastassia Hamanov, Scientific 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.

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:	N. Kol Kochmanov	Quotation #:	B80683	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:		P.O. #:			
Address:	6925 Century Ave Suite 100	Address:		Project:	1663496		
	Mississauga ON L5N 7K2			Project Name:	Highway 410	COC #:	Project Manager:
Tel:	(905) 567-4444	Tel:		Site #:			
Fax:	(905) 567-6561	Fax:		Sampled By:	SE/IMP		
Email:	AP_CustomerService@golder.com	Email:	nikol-kochmanov@golder.com				

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

[illegible]

02-Apr-19 10:06

Ema Gitej

B984871

CA2 ENV-1089

* 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				
Eric Naylor	19/04/02	10:05	[Signature]	19/04/02	10:06		Time Sensitive	Temperature (°C) on Receipt 7/11	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 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

APPENDIX D

Non-Standard Special Provisions and Operational Constraint

NOTICE TO CONTRACTOR – OBSTRUCTIONS

The Contractor shall be alerted to the presence of cobbles, boulders and hard soil conditions within the glacial till deposit at the east end of the culvert at the Derry Road N-E/W off-ramp.

Considerations of the presence of these conditions and potential obstructions must be made in the selection of appropriate equipment and procedures for excavations and for the installation of temporary protection systems (if adopted).

Concrete Working Slab – Item No.

Non-Standard Special Provision

The subgrade for cast-in-place retaining wall foundations 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 shall have a compressive strength of at least 20 MPa and be placed in accordance with OPSS 904.

Where pre-cast footings are used for these retaining walls, a concrete working slab is not required provided that the pre-cast footings are placed within four hours after the preparation, inspection and approval of the subgrade.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall include full compensations for all labour and materials to complete the work.

END OF SECTION