



October 2012

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

Derry Road Overpass Highway 401 Widening from East of Credit River to Trafalgar Road, Regional Municipalities of Peel and Halton W.O. 07-20021

Submitted to:
URS Canada Inc.
75 Commerce Valley Drive East
Markham, Ontario
L3T 7N9



GEOCRES No. 30M12-346

Report Number: 10-1111-0040-5

Distribution:

3 Copies - MTO - Central Region
1 Copy - MTO – Foundations Section
2 Copies - URS Canada Inc.
2 Copies - Golder Associates Ltd.

REPORT





Table of Contents

PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	1
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	2
4.1 Regional Geology	2
4.2 Subsurface Conditions.....	3
4.2.1 Topsoil	3
4.2.2 Fill	3
4.2.3 Clayey Silt Till	4
4.2.4 Sand and Silt Till	4
4.2.5 Shale Bedrock.....	5
4.3 Groundwater Conditions	5
5.0 CLOSURE.....	6

PART B – PRELIMINARY FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	7
6.1 General.....	7
6.2 Foundation Options	7
6.3 Shallow Foundations	9
6.3.1 Founding Elevations.....	9
6.3.2 Geotechnical Resistance/Reaction	10
6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations.....	10
6.4.1 Founding Elevations.....	10
6.4.2 Axial Geotechnical Resistance/Reaction.....	11
6.5 Approach Embankments	12
6.5.1 Subgrade Preparation and Embankment Construction.....	12
6.5.2 Approach Embankment Stability	12
6.5.3 Approach Embankment Settlement.....	13



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

6.6	Construction Considerations.....	14
6.6.1	Excavation and Temporary Roadway Protection	14
6.6.2	Groundwater Control.....	14
6.6.3	Subgrade Protection	15
6.6.4	Obstructions.....	15
6.6.5	Vibration Monitoring During Pile Installation.....	15
6.7	Recommendations for Further Work in Detail Design.....	15
7.0	CLOSURE.....	16

REFERENCES

TABLES

Table 1	Comparison of Foundation Options
---------	----------------------------------

DRAWINGS

Drawing 1	Derry Road Overpass – Borehole Locations and Soil Strata
-----------	--

FIGURES

Figure 1	Static Global Stability – Derry Road Approach Embankments
----------	---

APPENDIX A Borehole Records

Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Records of Boreholes 11-501 and 11-502

APPENDIX B Laboratory Test Results

Figure B1	Grain Size Distribution Test Result – Silty Sand and Gravel Fill
Figure B2	Grain Size Distribution Test Results – Clayey Silt to Silty Clay Fill
Figure B3	Plasticity Chart – Clayey Silt to Silty Clay Fill
Figure B4	Grain Size Distribution Test Result – Clayey Silt Till
Figure B5	Plasticity Chart – Clayey Silt Till
Figure B6	Grain Size Distribution Test Results – Sand and Silt Till
Figure B7	Unconfined Compression Test
Table B1	Unconfined Compression Test
Table B2	Point Load Test on Rock Samples

APPENDIX C Borehole Records from 1990 Investigation by Geocon (GEOCRES No. 30M12-220)



**PRELIMINARY FOUNDATION REPORT - DERRY ROAD
OVERPASS WIDENING**

PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
DERRY ROAD OVERPASS
HIGHWAY 401 WIDENING FROM EAST OF CREDIT RIVER TO TRAFALGAR
ROAD, REGIONAL MUNICIPALITIES OF PEEL AND HALTON
W.O. 07-20021**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the future widening of Highway 401 from east of the Credit River in the Regional Municipality of Peel to Trafalgar Road (approximately 9.7 km) in the Regional Municipality of Halton, Ontario.

This report addresses the results of the subsurface investigation carried out for the proposed widening of the existing Derry Road overpass structures.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2008-E-0015 dated February 2010, and in Section 5.8 of the *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

The Derry Road overpass structures are located at the intersection of Highway 401 and Derry Road, approximately 7 km east of Trafalgar Road and 2 km west of Credit River in the City of Mississauga, Ontario. The westbound structure is 34 m long by 34 m wide and the eastbound structure is 31 m long by 34 m wide. Each overpass is a two-span structure with the existing abutments and piers supported on spread footings.

In general, the terrain in this area is relatively flat, with the natural ground surface in the immediate vicinity of the structure at about Elevation 178 m to 179.

The local road (Derry Road) has been constructed near the original ground surface, with its grade below Highway 401 at approximately Elevation 181 m. Highway 401 has been constructed on embankment fill that is up to approximately 7 m to 9 m in height, with the pavement grade at about Elevation 188 m at the structure site. The Highway 401 embankment side slopes are oriented at approximately 2 horizontal to 1 vertical (2H:1V).

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out in September 2011, during which time two boreholes (Boreholes 11-501 and 11-502) were advanced using a track-mounted CME-75 drill rig, supplied and operated by Geo-Environmental Drilling Inc. of Milton, Ontario. The borehole locations are shown on Drawing 1. Borehole 11-501 was advanced in the southeast quadrant from the Derry Road grade, and Borehole 11-502 was advanced in the northwest quadrant from the Derry Road grade, both adjacent to Highway 401 embankment toes.

Boreholes 11-501 and 11-502 were drilled using 108 mm inner diameter hollow stem augers through the overburden to the bedrock at depths of 6.2 m and 11.2 m, respectively. Soil samples were obtained at 0.75 m to 3 m intervals of depth in the boreholes, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure. Samples of the bedrock were obtained using an 'NQ' size rock core barrel.



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and a standpipe piezometer was installed in Borehole 11-502 to permit monitoring of the groundwater level. The piezometer consists of a 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within the borehole. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled to the ground surface with bentonite pellets. The piezometer installation details and water level readings are indicated on the borehole record contained in Appendix A. The remaining borehole (Borehole 11-501) was backfilled with bentonite pellets upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's staff who located the boreholes in the field, contacted public utility companies to locate the existing underground services and cleared the borehole locations, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits testing and grain size distribution analyses were carried out on selected soil samples. Strength testing, such as uniaxial compression and point load index, was carried out on rock core specimens. The geotechnical laboratory testing was completed according to applicable MTO LS standards.

The location of as drilled boreholes and ground surface elevations were measured in the field by Callon Dietz. The borehole locations (referenced to the MTM NAD83 co-ordinate system) and ground surface elevations (referenced to geodetic datum) are summarized in the following table and are shown on Drawing 1.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
11-501	4,829,202.0	284,186.6	181.1	9.6
11-502	4,829,297.4	284,175.7	181.7	15.0

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 401 is located in the Peel Plain close to the border of the South Slope physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984).

The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till, which is mapped in this area as the Halton Till, typically consists of clayey silt to silty clay, with occasional sand to silt zones. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt



and clay. The overburden within the majority of the Peel Plain area is underlain by shale bedrock of the Georgian Bay Formation which contains limestone interlayers.

The South Slope region slopes gradually downward towards Lake Ontario. The overburden immediately below ground surface within the South Slope generally consists of clayey silt till and silty clay till and at depth consists of alternating deposits of dense lacustrine sands and silts and overconsolidated lacustrine clays and clay tills overlying the bedrock.

4.2 Subsurface Conditions

As part of the current subsurface investigation, two boreholes were advanced in the vicinity of the Derry Road overpass. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B7 and Tables B1 and B2 contained in Appendix B. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of embankment fill overlying a deposit of clayey silt till to sand and silt till. The till deposits encountered in both boreholes are underlain by shale bedrock of the Queenston Formation.

4.2.1 Topsoil

Approximately 100 mm of topsoil was encountered immediately below the ground surface in Borehole 11-502, which is located beside Derry Road in the northwest quadrant of the structure, near the toe of the Highway 401 embankment.

4.2.2 Fill

Approximately 2.2 m of fill associated with the existing Highway 401 embankment was encountered in Borehole 10-501, extending to approximately Elevation 178.9 m. This fill consists of the following:

- An upper layer, about 0.7 m thick, of silty sand and gravel. This fill has a very dense relative density based on one measured SPT "N" value of 55 blows per 0.3 m of penetration. The result of a grain size distribution test completed on one selected sample of this fill is shown on Figure B1 in Appendix B. Laboratory testing of a selected sample of the silty sand and gravel fill material measured a natural water content of approximately 5 per cent.
- A lower layer, about 1.5 m thick, of clayey silt containing trace to some sand and trace gravel. The measured SPT "N" values within this fill range from 15 blows to 19 blows per 0.3 m penetration,



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

suggesting a stiff to very stiff consistency. Laboratory testing of a selected sample of the clayey silt fill material indicates a natural water content of about 13 per cent.

Approximately 2.9 m of fill was encountered immediately below the topsoil layer in Borehole 11-502, which was advanced near the north toe of the Highway 401 embankment immediately west of Derry Road. This fill extends to about Elevation 178.7 m. This fill varies in composition from clayey silt with sand containing some gravel, to silty clay containing some sand; minor amounts of organic matter (rootlets) were observed in the upper portion of the fill. This fill has a stiff to very stiff relative consistency based on measured SPT “N” values of 12 blows to 20 blows per 0.3 m of penetration. The results of grain size distribution tests completed on two selected sample of this fill are shown on Figure B2 in Appendix B. Atterberg limits testing conducted on two selected samples of the cohesive fill measured plastic limits of 18 per cent and 20 per cent, liquid limits of 32 per cent and 47 per cent, and plasticity indices of 14 per cent as plotted on the plasticity chart on Figure B3 in Appendix B. These test results confirm that the upper portion of the cohesive fill consists of clayey silt of low plasticity, while the lower portion of the cohesive fill consists of silty clay of medium plasticity. The natural water content measured on selected cohesive fill samples ranges from 7 percent to 24 percent.

4.2.3 Clayey Silt Till

A 0.8 m to 2.6 m thick deposit of clayey silt till was encountered immediately below the fill in both boreholes, with its base at Elevation 176.1 m to 178.1 m.

The till is comprised predominantly of clayey silt with sand, containing trace to some gravel. The result of a grain size distribution test conducted on one selected sample of the clayey silt till deposit is shown on Figure B4 in Appendix B. Atterberg limits testing was completed on one selected sample of the clayey silt till and measured a plastic limit of 17 per cent, a liquid limit of 27 per cent, and a plasticity index of 10 per cent as plotted on the plasticity chart on Figure B5 in Appendix B. These test results confirm that the clayey silt till deposit is comprised of clayey silt of low plasticity. The natural water content measured on selected clayey silt till samples ranges from about 10 per cent to 14 per cent.

The measured SPT “N” values within the clayey silt till deposit range from 15 blows to 33 blows per 0.3 m penetration, indicating that the clayey silt till has a very stiff to hard consistency.

4.2.4 Sand and Silt Till

A 1.4 m to 4.6 m thick deposit of sand and silt till containing some gravel was encountered below the clayey silt till in both boreholes, with its base at Elevation 171.5 m to 176.7 m. Cobbles and/or boulders are anticipated to be encountered within the till deposit based on evidence of hard drilling such as bouncing of the split-spoon sampler in Borehole 11-501 at depths of 3.4 m and 4.2 m and in Borehole 11-502 at a depth of 9.4 m.

The results of two grain size distribution tests completed on selected samples of the sand and silt till are shown on Figure B8 in Appendix B. The natural water content measured on selected samples of the sand and silt till ranges from approximately 7 per cent to 10 per cent.

The measured SPT “N” values within the sand and silt till range from 61 blows to greater than 100 blows per 0.3 m of penetration, suggesting a very dense relative density.



4.2.5 Shale Bedrock

Bedrock was encountered and core samples were recovered from both boreholes. The depth of the surface of the bedrock varies from 4.4 m (Elevation 176.7 m) at the southeast quadrant of the site to 10.2 m (Elevation 171.5 m) at the northwest quadrant of the site, as shown on the borehole records and on Drawing 1. The borehole records from 1990 investigation carried out by Geocon (as attached to the text of this report in Appendix C) also indicate that the elevation of the bedrock at this site varies from about Elevation 179.4 m to 171.8 m, generally declining toward the north side of the highway.

Based on the cored bedrock samples, the bedrock generally consists of red shale of the Queenston Formation. The upper 1.0 m to 1.8 m portion of the bedrock is described as highly weathered based on being able to penetrate this portion of the bedrock by augering and split-spoon sampling. The lower portion of the bedrock samples are described as slightly to moderately weathered, laminated, reddish brown to grey, and weak to medium strong. The Rock Quality Designation (RQD) measured on the core samples is typically between about 0 percent and 58 percent, indicating a rock mass of very poor to fair quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are typically between 78 percent and 100 percent and between 47 percent and 76 percent, respectively.

An Unconfined Compressive Strength (UCS) test carried out on a sample of the shale bedrock obtained from Borehole 11-502 measured about 9.7 MPa, as summarised on Table B1 in Appendix B. Photographs of one bedrock core sample before and after UCS testing are shown on Figure B7 in Appendix B. Point load strength tests were performed on selected samples of the rock core. Diametral point load strength index values are shown on the Record of Drillhole Sheets and on Table B2 in Appendix B following the text of this report. The point load index (Is_{50}) results from the diametral laboratory tests carried out on three samples of the shale bedrock range from approximately 0.2 MPa to 0.6 MPa with an average value of 0.4 MPa. The point load index (Is_{50}) results from the axial laboratory tests carried out on two samples of the shale bedrock range from approximately 1.6 MPa to 2.8 MPa with an average value of 2.4 MPa. These point load test results correspond to estimated unconfined compressive strengths of approximately 5 MPa to 64 MPa, as shown on Table 2 in Appendix B.

Based on the laboratory UCS test and point load testing results as summarized in Table B1 and B2 in Appendix B, the estimated intact strength of the shale bedrock is weak to medium strong with strong limestone interbeds, excluding the upper highly weathered zones.

4.3 Groundwater Conditions

Details of the water conditions observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets following the text of this report. Both boreholes were dry and open upon completion of drilling.

One standpipe piezometer was installed in Borehole 11-502 within the lower portion of the sand and silt till deposit to monitor the groundwater level at the site. The water level measured in the piezometer is summarized in the following table:



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

Borehole Number	Ground Surface Elevation (m)	Depth to Water Level	Groundwater Elevation	Date
11-502	181.7	1.4 m	180.3 m	November 2, 2011

The groundwater level should be expected to fluctuate seasonally and should be expected to rise during wet periods of the year.

5.0 CLOSURE



This Preliminary Foundation Investigation Report was prepared by Mr. Mehdi Mostakhdemi, M.Sc., M.Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Ty Garde, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

GOLDER ASSOCIATES LTD.




m.m

Mehdi Mostakhdemi, M.Sc., M.Eng.
Geotechnical Group



L. C. COYNE

Lisa C. Coyne, P.Eng.
Senior Geotechnical Engineer, Principal



T. J. GARDE

Ty Garde, M. Eng., P.Eng.
Principal, Designated MTO Foundations Contact

MM/LCC/TJG/sm

n:\active\2010\1111\10-1111-0040 urs - highway 401 widening - halton peel\6 - reports\5 - derry road overpass\10-1111-0040-5 rpt 12oct derry road overpass.docx



**PRELIMINARY FOUNDATION REPORT - DERRY ROAD
OVERPASS WIDENING**

PART B

**PRELIMINARY FOUNDATION DESIGN REPORT
DERRY ROAD OVERPASS
HIGHWAY 401 WIDENING FROM EAST OF CREDIT RIVER TO TRAFALGAR
ROAD, REGIONAL MUNICIPALITIES OF PEEL AND HALTON
W.O. 07-20021**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides preliminary foundation design recommendations for the proposed widening and/or replacement of the existing Highway 401-Derry Road overpass structures. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the structure foundations. Further investigation and analysis will be required during detail design.

Where comments are made on construction, they are provided to highlight those aspects that could affect the future detail design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on construction aspects should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Foundation Options

Based on the planning study completed to date for the widening of Highway 401 from east of Credit River to Trafalgar Road in the City of Mississauga (within the Regional Municipality of Peel), and the Regional Municipality of Halton, it is understood that the future widening could consist of three additional lanes in both the eastbound and westbound directions on Highway 401. The existing Derry Road overpass structures will require widening or construction of separate collector structures to the north and south.

The existing structures consist of two-span overpasses, with the existing abutments and piers supported on spread footings. Based on the *General Arrangement* and *Structural* drawings for the existing structures, dated September 1994, the existing footing details are summarized below. This founding elevation is about 1m to 1.5 m below the original ground surface at the site, and about 2.5 m to 3.2 m below the present Derry Road grade.

Foundation Element	Footing Width	Founding Elevation
West abutments	3.9 m (12.8 ft.)	178.5 m
Centre Piers	3.0 m (10.0 ft.)	177.8 m
East abutments	3.9 m (12.8 ft.)	178.0 m

Based on the subsurface conditions, both shallow and deep foundation options have been considered for the north and south widening or new collector structures for the Derry Road overpass structures. A summary of the advantages and disadvantages associated with each option is provided below, and a comparison of the alternative foundation options based on advantages, disadvantages, risks and relative costs is provided in Table 1 following the text of this report.



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

- **Strip or spread footings founded on the very stiff to hard clayey silt till:** Shallow foundations (strip or spread footings) are feasible for support of the widened abutments and centre pier provided that they are founded below the fill materials on the very stiff to hard clayey silt till deposit (similar to the existing foundations). This would require excavation to a depth of approximately 2.5 m to 3.5 m relative to the present ground surface and Derry Road grade. Shallow foundations would allow for the construction of semi-integral abutments, if the existing structure can be modified to be compatible with the widening. Temporary excavation support would likely be required along both the north and south sides of Highway 401 to facilitate the removal of the existing wing walls/retaining walls adjacent to the abutments and excavation to the foundation level, and along Derry Road depending on how traffic is to be maintained/staged on the local road during construction. There is potential for up to approximately 10 mm to 15 mm of differential settlement between the existing structure and the new widened portions if shallow foundations are adopted, although the majority of this settlement will occur during or immediately following construction.
- **Footings “perched” on a compacted granular pad in the widened Highway 401 approach embankments:** Although this option would be advantageous in minimizing the depth of excavation, “perched” footings are not preferred for support of the north and south widening or replacement due to the potential settlement of the existing stiff fill layers under the widened approach embankment loading; this could be mitigated by removing the existing fill prior to constructing the widening. “Perched” footings are also not structurally compatible with the existing structure configuration, but could be appropriate if separate structures (for example, as may be possible for a core-collector system) are adopted. In this case, a longer bridge span would be required to accommodate the abutment foreslopes.
- **Driven steel H-piles:** Driven steel H-piles are feasible and suitable for support of the abutment widening, or for the abutments in a full structure replacement or new collector structures, particularly if the abutment pile caps can be perched within the approach embankments. In the case of widening, differential settlement between the existing structures (which are founded on spread footings) and the widening would be negligible. Steel H-pile foundations would also allow for the construction of integral abutments, if the existing structure can be modified to be compatible with integral abutments for the widening, or if separate collector lane structures are constructed. On the south side of Highway 401, the depth to bedrock is relatively shallow (as little as 2 m to 4 m below the Derry Road grade, at about Elevation 177 m to 179 m based on the results from the current investigation as well as borehole information from the 1990 investigation by Geocon). Therefore, deep foundations are not considered to be a practical option for support of the centre piers, or for support of a widening on the south side if the pile cap is constructed below Derry Road grade. The use of driving shoes is recommended due to the hard/very dense nature of the soils and the potential presence of cobbles and boulders in the glacially derived soils.
- **Driven steel pipe (tube) piles:** Steel tube (pipe) piles could also be considered as a deep foundation option for support of the abutments as well as associated wing walls/retaining walls at this site. This would be applicable for abutment pile caps perched within the approach embankments, or for the widening on the north side of Highway 401 with pile caps constructed below the Derry Road grade. As identified for the driven steel H-pile option, the depth to bedrock is relatively shallow on the south side of Highway 401, and deep foundations are not considered to be a practical option for support of a widening to the south side if the pile cap is constructed below Derry Road grade. It is noted that pipe piles are considered to have a



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

slightly higher risk than H-piles for “hanging up” or being deflected away from their vertical or battered orientation due to the presence of cobbles and/or boulders within the glacially-derived soils at this site.

- **Caissons:** Caissons are feasible for this site but would require the use of temporary or permanent liners given the potential risks and difficulties associated with the water-bearing sand and silt till deposit through which or in which the caissons would be constructed. Due to these risks and potential construction difficulties, caissons are not considered to be a preferred foundation system for this structure site and therefore are not discussed in detail in subsequent sections of this report. However, the relative advantages and disadvantages of caisson foundations are summarized in Table 1.

Based on the above considerations, the preferred option from a geotechnical/foundations perspective is to support the abutments and centre pier for the north and south widening or replacement on shallow foundations, due to the relatively shallow depth to bedrock on the south side of Highway 401. If a full replacement or separate collector lane structures are adopted for this structure site, the use of driven steel H-pile foundations in an integral abutment configuration is considered to be a good alternative, as it will be possible to obtain sufficient pile length with the pile caps perched within the approach embankments.

6.3 Shallow Foundations

6.3.1 Founding Elevations

For support of widened or new abutments, associated wing walls or retaining walls and the centre pier, strip or spread footings should be founded below the fill and any loose or soft to stiff surficial soils, on the very stiff to hard clayey silt till deposit. The following table provides the maximum (highest) founding elevations recommended for preliminary design of footings founded on the clayey silt till deposit. If spread footings are used for a widening, it is likely that they will be constructed to match the existing foundation elevation (approximately Elevation 177.8 to 178.5 m) and structurally connected. In the case of a full structure replacement, it may be feasible to found the footings slightly higher than the existing foundations, consistent with the elevations provided in the following table; further assessment of the impact of the existing foundations and their removal will be required at detail design, once the geometry and span of the widening and/or replacement structure is established.

Foundation Element	Borehole No.	Founding Stratum	Strip/Spread Footing Founding Elevation
South Widening or South Portion of Replacement	11-501	Very stiff to hard clayey silt till	Below 178.5 m (or lower to match existing)
North Widening or North Portion of Replacement	11-502	Very stiff to hard clayey silt till	Below 178.0 m (or lower to match existing)

Alternatively, subexcavation can be carried out to the elevations identified in the table above, then backfilled with compacted Ontario Provincial Standard Specification (OPSS) 1010 Granular A or Granular B Type II fill prior to construction of the footings at a higher elevation. In this case, the founding elevation for the new footings should



be a minimum of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration in accordance with Provincial Standards. The compacted granular pad should extend at least 1 m beyond the front and back edge of the new abutment footings, then outward and downward at 1H:1V. The granular fill should be placed in accordance with Provincial Standards.

The footing subgrade should be inspected by the Quality Verification Engineer following excavation, in accordance with OPSS 902 (*Excavating and Backfilling Structures*) to check that all existing fill, loose or soft to stiff surficial soils (if encountered), or other unsuitable material have been removed. The founding soils will be susceptible to disturbance. If the concrete for the footings cannot be poured immediately, it is recommended that a 100 mm thick concrete working slab (of 20 MPa compressive strength concrete) be placed on the prepared subgrade within four hours of its inspection and approval.

6.3.2 Geotechnical Resistance/Reaction

For preliminary design, strip or spread footings placed on the properly prepared, very stiff to hard clayey silt till (or on compacted granular fill following subexcavation of the surficial soils), at or below the design elevations given in the preceding section, should be designed based on a factored geotechnical resistance at Ultimate Limit States (ULS) of 500 kPa, and a geotechnical reaction at Serviceability Limit States (SLS, for 25 mm of settlement) of 350 kPa. These values assume a footing width of between 3 m and 4 m.

The geotechnical resistances should be reviewed if the selected footing width or founding elevation differs from those given above. In addition, these preliminary 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 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC 2006)* and its *Commentary*.

The preliminary geotechnical resistance values provided above will have to be re-evaluated and modified as necessary during detail design, based on future additional subsurface investigation at the proposed abutment and centre pier widening or replacement locations.

6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations

6.4.1 Founding Elevations

The abutments and associated wing walls/retaining walls may be supported on steel H-piles or steel pipe (tube) piles driven to found within the hard clayey silt till (having Standard Penetration Test “N” values of greater than 100 blows per 0.3 m of penetration) or the shale bedrock. The depth of the “100-blow” soils varies between the two boreholes, and further investigation will be required at the detail design stage to confirm the design founding elevations. The following pile tip elevations may be used for preliminary design purposes, assuming about 1 m to 1.5 m of penetration into the “100-blow” soil deposit or the shale bedrock:



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

Foundation Element	Borehole No.	Estimated Design Pile Tip Elevation
South Widening or South Portion of Replacement	11-501	175.5 m
North Widening or North Portion of Replacement	11-502	172.5 m

The pile caps should be constructed at a minimum depth of 1.2 m for frost protection purposes per Provincial Standards.

For the installation of steel H-piles or steel pipe piles, consideration must be given to the potential presence of cobbles and boulders within the soil deposits. In this regard, steel H-piles are preferred over steel pipe piles as pipe piles are considered to pose a higher risk of “hanging up” or being deflected away from their vertical or battered orientation during installation, due to their larger end area. The piles should be reinforced at the tip with driving shoes or flange plates to reduce the potential for damage to the piles during driving. In very dense/hard and/or bouldery soils, as may be encountered at this site, driving shoes (such as Titus Standard “H” Bearing Pile Points) are preferred over flange plates.

6.4.2 Axial Geotechnical Resistance/Reaction

For HP 310x110 piles driven to the estimated tip elevations provided in Section 6.4.1, the factored axial geotechnical resistance at ULS and the axial geotechnical reaction at SLS (for approximately 10 mm of settlement) may be taken as follows for preliminary design.

Foundation Element	Borehole No.	End-Bearing Stratum	Factored Geotechnical Resistance at ULS	Geotechnical Reaction at SLS
South Widening – East and West Abutments	11-501	Shale bedrock	1,600 kN	1,400 kN
North Widening – East and West Abutments	11-502	Very dense sand and silt till	1,300 kN	1,100 kN

Similar axial resistances may be used in the design of closed-end, concrete-filled, 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 9.5 mm (3/8 in.).

Pile installation should be in accordance with Provincial Standards. The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile and length of pile; the criteria must therefore be established at the time of construction after the piling equipment is known. The pile capacity should then be verified in the field by the use of the Hiley formula (MTO Standard Structural Drawing SS-103-11) during the final stages of driving to achieve the appropriate ultimate capacity.

The preliminary geotechnical resistances provided above will have to be re-evaluated and modified as necessary during detail design in consideration of the additional subsurface investigation that will be carried out at the widened foundation elements.



6.5 Approach Embankments

6.5.1 Subgrade Preparation and Embankment Construction

It is recommended that all topsoil/organic material or existing surficial fill materials be stripped from the footprint of the proposed widened approach embankments. The depth and extent of stripping should be assessed during detail design when additional subsurface information will be available for the widened approach embankment areas.

The embankment fill for the Highway 401 widening should be placed and compacted in accordance with MTO's Special Provisions. Benching of the existing Highway 401 embankment side slopes should be carried out to "key in" the new fill materials for the widening, in accordance with OPSD 208.010 (*Benching of Earth Slopes*).

Additional fill for construction of the embankment widening could consist of clean earth fill or granular fill. From a geotechnical/foundations perspective, both earth and granular fill will provide good compatibility with the existing Highway 401 embankment fill materials – both those fill materials remaining in-place in the existing embankment side slope, and any existing embankment fill that is re-used for the widening after being cut from the benches.

In accordance with MTO's standard practice, a minimum 2 m wide bench should be provided where the embankment side slopes are equal to or greater than 8 m in height, such that the uninterrupted slope height does not exceed 8 m. To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments.

6.5.2 Approach Embankment Stability

Slope stability analyses have been performed for the proposed Highway 401 embankment widening using the commercially available program SLIDE, produced by Rocscience Inc., to check that a minimum factor of safety of 1.3 is achieved for the proposed embankment heights and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed northward and southward embankment widenings on this project, considering the design requirements and the available field and laboratory testing data.

The stability analyses were completed for an approximately 7 m to 9 m high embankment widening based on the subsurface conditions as encountered in Boreholes 11-501 and 11-502. The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Soil Conditions	Bulk Unit Weight (kN/m³)	Effective Friction Angle	Undrained Shear Strength (kPa)
Embankment fill	21	32-35°	-
Very stiff to hard clayey silt till	21	32°	-
Dense to very dense sand and silt till	21	34°	-



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

The analysis results indicate that an approximately 7 m to 9 m high embankment widening with side slopes oriented no steeper than 2H:1V will have a factor of safety of greater than 1.3 against global instability, assuming appropriate subgrade preparation and proper placement and compaction of the embankment fill materials. An example static global stability result is provided on Figure 1. This preliminary assessment of the stability of the approach embankments should be reviewed and confirmed based on the subsoil conditions encountered within the proposed approach embankment footprints during detail design.

6.5.3 Approach Embankment Settlement

Based on the study completed to date, the existing 7 m to 9 m high Highway 401 embankment will require widening by approximately 20 m on both the north and south sides in this area.

Settlement analyses for the anticipated soil conditions below the widened approach embankments were carried out using both hand calculations and the commercially available computer program *Settle-3D* from Rocscience, using estimated elastic deformation moduli as given in the table below, based on correlations with the SPT “N” values and engineering judgement from experience with similar soils in this region of Ontario (Bowles, 1984; Kulhawy and Mayne, 1990; Peck et al., 1974).

Soil Conditions	Bulk Unit Weight (kN/m ³)	Elastic Modulus (MPa)
Embankment fill	21	-
Very stiff to hard clayey silt till	21	75 MPa
Dense to very dense sand and silt till	21	75 MPa

Based on this preliminary assessment, the settlement of the foundation soils under the widened 7 m to 9 m high approach embankments is estimated to be approximately 25 mm. This settlement is expected to occur relatively quickly during and immediately following construction of the widened approach embankments based on the nature of the soils at the site. This estimated magnitude of settlement should be reassessed based on the soil and groundwater conditions under the new approach embankments as determined during the detail design, with particular emphasis on the thickness and properties of any surficial soil deposits within the embankment widening footprint.

The above preliminary estimates do not include compression of the fill itself, which would occur during and after the construction of the embankment depending on the type of materials used. The magnitude of fill compression may range from 0.5 to 1 per cent of the height of the embankment, assuming approximately 98 per cent compaction of the embankment fill is achieved, relative to the material's standard Proctor maximum dry density. In the case where granular fill is used for embankment construction, settlement of the fill itself is expected to occur essentially during embankment construction, whereas non-granular earth fill materials are expected to exhibit some additional settlement over time.



6.6 Construction Considerations

The following subsections identify future construction considerations that should be considered at this stage as they may impact the planning and preliminary design. Where applicable, Non-Standard Special Provisions (NSSP) should be developed during detail design for incorporation in the Contract Documents.

6.6.1 Excavation and Temporary Roadway Protection

The foundation excavations for spread footings would extend to a depth of about 2.5 m to 3.5 m below the original ground surface and local road grade, through the existing very dense silty sand and gravel, stiff to very stiff clayey silt to silty clay fill, and into the very stiff to hard clayey silt till deposit. The excavations for pile caps could be maintained higher within the native soils or embankment fill, but would still require excavation through the existing fill.

Where space permits, open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities. The existing fill would be classified as Type 3 soil, according to the OHSA. Temporary excavations (i.e. those that are open for a relatively short time period) should be made with side slopes no steeper than 1H:1V.

At this preliminary stage, it is anticipated that temporary roadway protection would likely be required along the north and south sides of Highway 401 to facilitate the removal of the existing wing walls/retaining walls adjacent to the abutments and excavation to foundation level for the abutment widening, as well as along Derry Road depending on how traffic is to be maintained/staged on the local road during construction. The temporary excavation support system should be designed and constructed in accordance with OPSS 539 (*Construction Specification for Temporary Protection Systems*). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that the existing adjacent Highway 401 structures, as well as any adjacent utilities, can tolerate this magnitude of deformation.

It is considered that either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable for the temporary excavation support at this site, based on the subsurface soil and groundwater conditions. An interlocking sheetpile system would contribute to both ground and, where applicable, groundwater control. For a soldier pile and lagging system, it would be necessary to control seepage or include measures to mitigate loss of soil particles from the surficial silty sand deposit through the lagging boards.

6.6.2 Groundwater Control

Groundwater seepage is anticipated from “perched” water within the granular fill on top of the cohesive soils. For the potential depth of excavation associated with spread footings or pile caps, the seepage volume is expected to be relatively small, such that the water inflow can be handled by pumping from filtered sumps placed at the base of the excavations. Based on these small seepage volumes, it is expected that a Permit to Take Water (PTTW) would not be required for the groundwater control system at this site.



6.6.3 Subgrade Protection

The clayey silt till soils that will be exposed at the foundation subgrade level 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, which can be developed during the detail design stage.

6.6.4 Obstructions

The soils at this site are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of deep foundations or protection systems. The frequency of occurrence of cobbles and boulders should be identified during future investigations as part of the detail design. If conditions warrant, an NSSP should be included in the Contract Documents developed during the detail design stage to identify to the contractor the possible presence of cobbles and/or boulders within the overburden soils.

6.6.5 Vibration Monitoring During Pile Installation

A maximum peak particle velocity (PPV) of 100 mm/s is generally considered applicable for bridge structures in good condition. Based on vibration monitoring experience, it is considered unlikely that vibrations induced by conventional construction activities (such as pile driving) will reach this threshold level. Although vibration monitoring for the existing overpass structure is not expected to be required during construction at this site, there are several office and hotel buildings in the vicinity of the site. Monitoring of vibrations during construction should be considered by the general contractor to defend against potential damage claims by the owners of the nearby structures. If warranted, an NSSP should be included in the Contract Documents during the detail design stage to develop a vibration monitoring plan which would include appropriate review and alert levels for vibrations.

6.7 Recommendations for Further Work in Detail Design

Additional boreholes will be required within each of the foundation widening areas and the approach embankment widening areas during the future detail design stage of investigation, to further assess and/or confirm the subsurface conditions and the preliminary recommendations provided in this report, as follows:

- Abutments and Center Pier:
 - Assessment of the properties of the upper clayey silt till to confirm the founding elevation for spread footings within each widened foundation element.
 - Assessment of the depth and properties of the “100 blow soil” and/or bedrock to confirm pile tip elevations, if deep foundations are selected as the preferred option.



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

- Observation of the presence and frequency of cobbles and/or boulders within the soil deposits, to assess the need for an NSSP to warn the contractor of the presence of such obstructions as they may affect excavations and the installation of driven steel H-pile foundations.
- Assessment of the need for NSSP for vibration monitoring nearby commercial buildings during construction.
- Approach embankments and adjacent high fill embankments:
 - Assessment of the depth and extent of stripping of topsoil/organics and fill materials within the footprint of the widened approach embankments.
 - Further assessment of the thickness and consolidation/elastic compression properties of the soils within the footprint of the widened approach embankments, to confirm the settlement estimates.

7.0 CLOSURE



This Preliminary Foundation Design Report was prepared by Mr. Mehdi Mostakhdemi, M.Sc., M.Eng., and reviewed by Ms. Lisa Coyne, P.Eng., a geotechnical engineer and Principal with Golder. Mr. Ty Garde, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

GOLDER ASSOCIATES LTD.



m.m

Mehdi Mostakhdemi, M.Sc., M.Eng.
Geotechnical Group



Lisa C. Coyne, P.Eng.
Senior Geotechnical Engineer, Principal



Ty Garde, M. Eng., P.Eng.
Designated MTO Foundations Contact



MM/LCC/TJG/sm

n:\active\2010\1111\10-1111-0040 urs - highway 401 widening - halton peel\6 - reports\5 - derry road overpass\10-1111-0040-5 rpt 12oct derry road overpass.docx



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

REFERENCES

- Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition. McGraw Hill Book Company, New York.
- Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.
- Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.
- Kulhawy, F.H. and Mayne, P.W., 1990. *Manual on Estimating Soil Properties for Foundation Design*. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.
- NAVFAC, 1986. *Design Manual DM 7.02: Soil Mechanics, Foundation and Earth Structures*. U.S. Navy. Alexandria, Virginia.
- Ontario Geological Society, 1991. *Geology of Ontario*. Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.
- Peck, R.B., Hanson, W.E., and Thornburn, T.H., 1974. *Foundation Engineering*, Second Edition, John Wiley and Sons, New York.

Ontario Provincial Standard Specifications (OPSS)

OPSS 501	Construction Specification for Compacting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 572	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS 903	Construction Specification for Deep Foundations
OPSS 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 3000.100	Foundation Piles – Steel H-Pile Driving Shoe
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

Construction Design Estimating and Documentation (CDED) Special Provisions (SP)

SP 105S21	Amendment to OPSS 501 – Construction Specification for Compacting
SP 206S03	Earth Excavation and Grading



PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

TABLE 1 – COMPARISON OF FOUNDATION ALTERNATIVES

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
Spread/strip footings on very stiff to hard clayey silt till	<ul style="list-style-type: none"> Feasible for support of widened or new abutments, associated wing walls/retaining walls, and centre pier 	<ul style="list-style-type: none"> Existing structure supported on shallow foundations, and has performed well Relatively minor groundwater seepage anticipated Allows for semi-integral abutments Lower vibration impacts on existing structures than for driven steel H-pile or steel pipe (tube) pile installation 	<ul style="list-style-type: none"> Significant excavations (to a depth of approximately 2.5 m to 3.5 m below the original ground surface and local road grade) to extend below fill; would require temporary excavation support Moderate potential for up to about 10 mm to 15 mm of differential settlement between existing overpass and widening Precludes use of integral abutments; potentially greater maintenance required at abutments Lower geotechnical resistances as compared with deep foundations 	<ul style="list-style-type: none"> Conventional excavation and construction techniques 	<ul style="list-style-type: none"> Less expensive than deep foundations although bridge maintenance costs may be higher due to non-integral abutment configuration Estimated cost is about \$600/m³ for a concrete unit for construction of shallow foundations, excluding deeper excavation and temporary protection system
Spread/strip footings perched on compacted granular pad in approach embankment fill	<ul style="list-style-type: none"> Feasible but not recommended for support of widened abutments as this would not be compatible with existing structure 	<ul style="list-style-type: none"> Abutment pile caps could be maintained higher than footings founded on till deposit, significantly reducing subexcavation depth and associated temporary protection system requirements 	<ul style="list-style-type: none"> Not compatible with existing “closed” structure configuration; longer span with abutment foreslopes would be required Potential for greater differential settlement than for spread footings supported directly on the very stiff to hard till deposit 	<ul style="list-style-type: none"> Conventional excavation and construction techniques 	<ul style="list-style-type: none"> This option not recommended



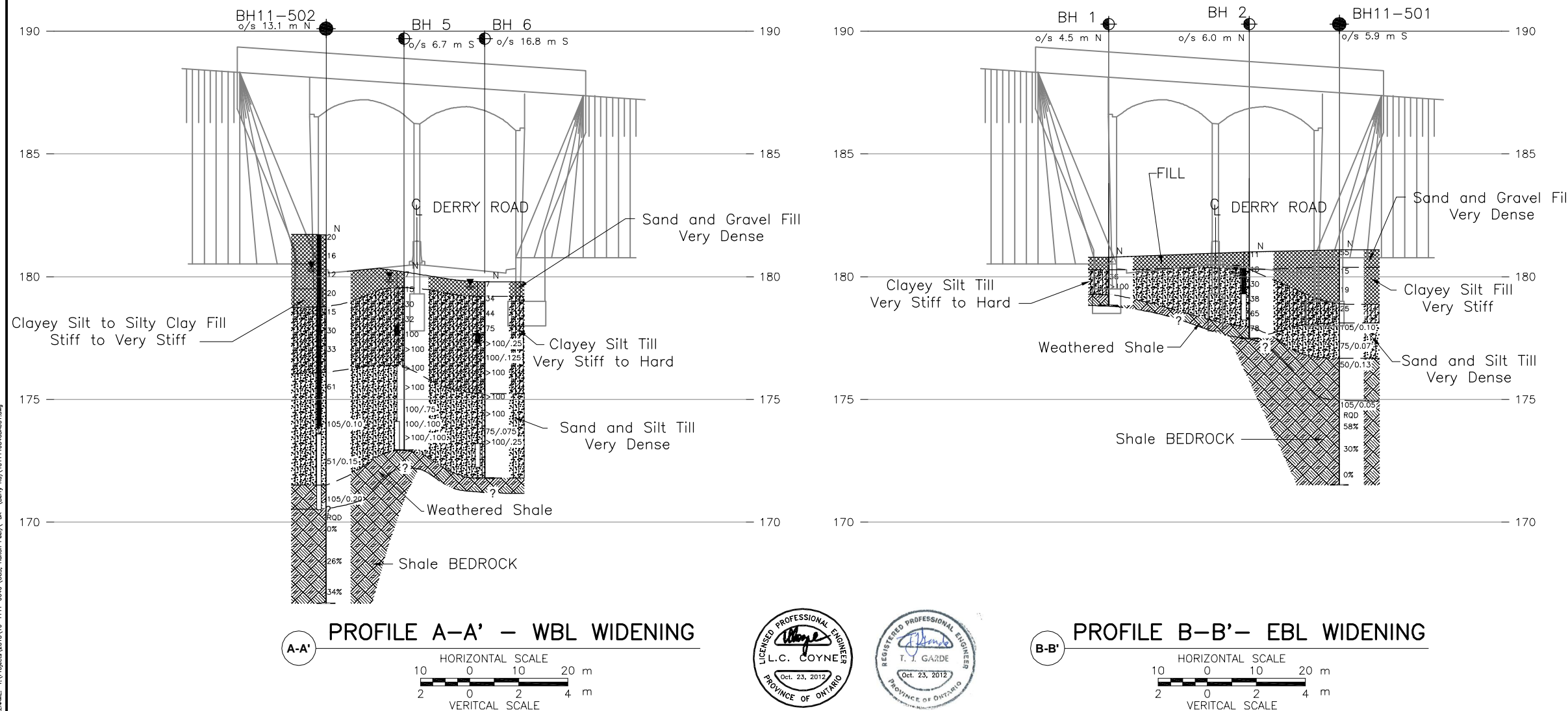
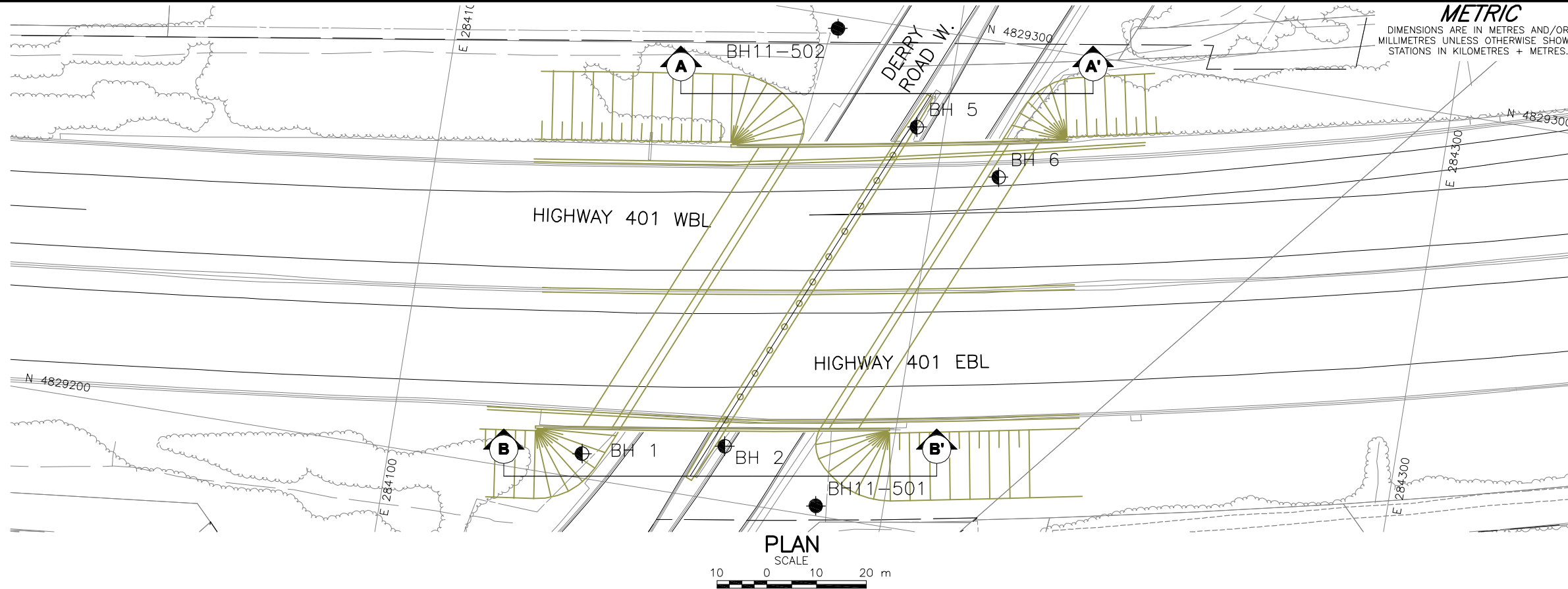
PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
Steel H-piles driven to found in very dense till or shale bedrock	<ul style="list-style-type: none">• Feasible for support of widened or new abutments and associated wing walls/retaining walls• Not considered feasible for widening at centre pier due to shallow depth to bedrock	<ul style="list-style-type: none">• If separate collector structures (eg., core-collector system) or structurally disconnected, abutment pile caps could be maintained higher than footings founded on till deposit, reducing depth of excavation and temporary excavation support requirements adjacent to Highway 401 and Derry Road• Limited groundwater control required• Allows for integral abutment construction if existing structure can be modified to accommodate, or if replacement is adopted• Would minimize differential settlement between existing overpass and widened portions of structure	<ul style="list-style-type: none">• Minor potential for encountering obstructions (cobbles and/or boulders) during pile driving; this could result in piles “hanging up” and lower geotechnical resistances• Potential for noise and/or vibration impacts on nearby commercial buildings	<ul style="list-style-type: none">• Conventional construction methods for H-pile foundations	<ul style="list-style-type: none">• Lower relative cost compared with caisson option• Estimated unit cost is approximately \$250/linear metre for pile installation and \$600/m³ for pile cap construction

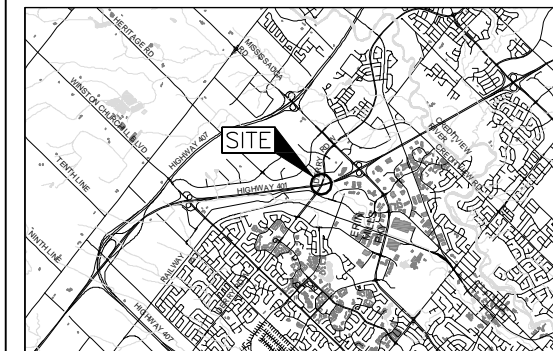


PRELIMINARY FOUNDATION REPORT - DERRY ROAD OVERPASS WIDENING

Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
Steel pipe (tube) piles, driven to found in very dense till or shale bedrock	<ul style="list-style-type: none"> • Feasible for support of widened or new abutments and associated wing walls/ retaining walls • Not considered feasible for widening at centre pier due to shallow depth to bedrock 	<ul style="list-style-type: none"> • If separate structure (eg., core-collector) or structurally disconnected, abutment pile caps could be maintained higher than footings founded on till, reducing depth of excavation and temporary protection system requirements adjacent to Highway 401 and Derry Road • Limited groundwater control • Allows for semi-integral abutment configuration if existing structure can be modified, or if replacement is adopted • Would minimize differential settlement between foundation elements 	<ul style="list-style-type: none"> • Slightly greater risk than for steel H-pile foundations if obstructions (cobbles and/or boulders) are encountered during driving; this could result in piles “hanging up” and lower geotechnical resistances • Potential for noise and/or vibration impacts on nearby commercial buildings 	<ul style="list-style-type: none"> • Conventional construction methods 	<ul style="list-style-type: none"> • Costs for steel pipe (tube) piles slightly higher than for steel H-piles
Caissons founded in very dense till or shale bedrock	<ul style="list-style-type: none"> • Feasible but not recommended for support of abutments and wing walls/ retaining walls and piers 	<ul style="list-style-type: none"> • Abutment pile caps could be maintained higher than footings founded on till deposit, reducing depth of excavation and temporary excavation support requirements adjacent to Highway 401 and Derry Road • Higher capacity than for steel H-piles, so reduced number of deep foundation elements compared to steel H-piles 	<ul style="list-style-type: none"> • Risk of ground disturbance in water-bearing sand and silt till deposit, including risk of base disturbance if caissons founded in this deposit; it is recommended that caissons if adopted extend through the till deposit to bear directly on shale bedrock • Temporary or permanent liners would be required; likely not possible to inspect caisson base • Precludes use of integral abutments 	<ul style="list-style-type: none"> • Minor to moderate risk of loosening water-bearing sand and silt till if caissons founded in this material; it is recommended that caissons be advanced through the cohesionless till to bear directly on the bedrock 	<ul style="list-style-type: none"> • Higher cost compared with shallow foundations or steel H-piles

CONT No.
WO No. 07-20021DERRY ROAD WEST OVERPASS
HIGHWAY 401 WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN

SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation - Geocon 1990
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer
- WL upon completion of drilling
- ? Inferred Transition from Weathered Shale to Shale Bedrock

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH 1	180.8	4829204.9	284138.6
BH 2	181.0	4829210.9	284166.6
BH 5	180.2	4829280.4	284194.5
BH 6	179.8	4829273.0	284212.3
BH11-501	181.1	4829202.0	284186.6
BH11-502	181.7	4829297.4	284175.7

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 preliminary design configuration as shown elsewhere in the Preliminary Design Report.

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

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

REFERENCE

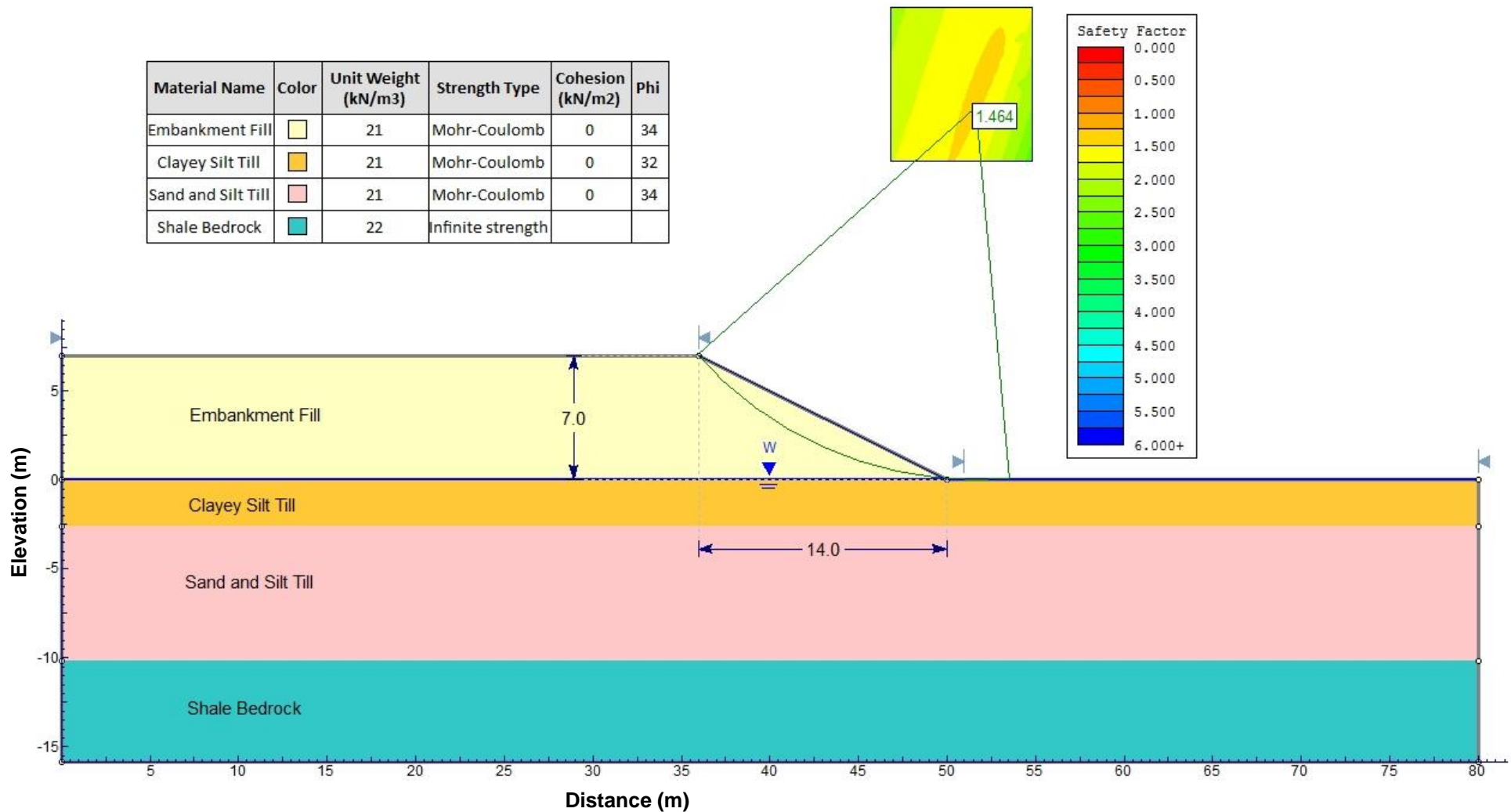
Base plans provided in digital format by URS, drawing file nos. ACAD-X-base1_to_Trafalgar.dwg, ACAD-Aerials_MTO_ROW_Property Boundaries.dwg and Derry_Road_Overpass_GA.dwg, received August 17, 2011, August 29, 2011 and August 16, 2011

NO.	DATE	BY	REVISION
1	10/23/2012	JFC	1
Geocres No. 30M12-346			
HWY. 401		PROJECT NO. 10-1111-0040	
SUBM'D. MM		DATE: 10/23/2012	
DRAWN: JFC		SITE:	
CHKD. MM		APPD. LCC	
DIST.		DWG. 1	



Static Global Stability – Derry Road Approach Embankments

Figure 1





APPENDIX A

Borehole Records



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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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) Cohesionless Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test 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

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



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

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

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
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	

PROJECT <u>10-1111-0040</u>		RECORD OF BOREHOLE No 11-501		SHEET 1 OF 2		METRIC	
G.W.P. <u>07-20021</u>		LOCATION <u>N 4829202.0 ; E 284186.6</u>		ORIGINATED BY <u>AM</u>			
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>Track-Mounted CME55, 108 mm I.D. Hollow Stem Augers</u>		COMPILED BY <u>MM</u>			
DATUM <u>NAD83</u>		DATE <u>September 12, 2011</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _P	W	W _L		
								20	40	60	80	100					
181.1	GROUND SURFACE																
0.0	Silty sand and gravel (FILL) Very dense Brown Moist		1	SS	55												38 47 11 4
180.4																	
0.7	Clayey silt, trace to some sand, trace gravel (FILL) Very stiff Brown Moist		2	SS	15												
			3	SS	19												
178.9																	
2.2	CLAYEY SILT with sand, trace gravel (TILL) Very stiff Reddish brown Moist		4	SS	25												
178.1																	
3.0	SAND and SILT, some clay, some gravel, containing cobbles or boulders (TILL) Very dense Reddish brown Moist		5	SS	105/0.10												15 36 43 6
			6	SS	75/0.07												
176.7	Split spoon bouncing at a depth of 3.4 m and 4.2 m																
4.4	SHALE (BEDROCK) Highly weathered Red Moist		7	SS	50/0.13												
175.0																	
6.2	Shale with limestone interbeds (BEDROCK)		8	SS	106/0.06												
	Bedrock cored from depths of 6.2 m to 9.6 m		1	RC	REC 98%												RQD = 58%
	For bedrock coring details, refer to Record of Drillhole 11-501																
			2	RC	REC 93%												RQD = 30%
			3	RC	REC 78%												RQD = 0%
171.5																	
9.6	END OF BOREHOLE																
	NOTE: 1. Borehole dry on completion of overburden drilling operations.																

GTA-MTO 001 1011110040.GPJ GAL-MISS.GDT 7/9/12 DD

PROJECT: 10-1111-0040

RECORD OF DRILLHOLE: 11-501

SHEET 2 OF 2

LOCATION: N 4829202.0 ; E 284186.6

DRILLING DATE: September 12, 2011

DATUM: NAD83

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track-Mounted CME 55

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN																NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
				DEPTH (m)			JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate				BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage				PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular				PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough				MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA								HYDRAULIC CONDUCTIVITY K, cm/sec		Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jn	10 °	10 °	10 °																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
		Continued from Record of Borehole BH11-501		174.94																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

DEPTH SCALE

1 : 50



LOGGED: AM

CHECKED: LCC

GTA-RCK 018 1011110040.GPJ GAL-MISS.GDT 7/9/12 DD

PROJECT 10-1111-0040		RECORD OF BOREHOLE No 11-502		SHEET 1 OF 3		METRIC	
G.W.P. 07-20021		LOCATION N 4829297.4 ; E 284175.7		ORIGINATED BY AM			
DIST Central HWY 401		BOREHOLE TYPE Track-Mounted CME55, 108 mm I.D. Hollow Stem Augers		COMPILED BY MM			
DATUM NAD83		DATE September 13, 2011		CHECKED BY LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m³	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	W _p	W	W _L			
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
181.7	GROUND SURFACE													GR SA SI CL	
181.7	TOPSOIL		1	SS	20					○	-----			16 32 33 19	
180.3	Clayey silt with sand, some gravel, containing rootlets (FILL) Very stiff Brown Moist		2	SS	16										
180.3	Silty clay, some sand, trace gravel (FILL) Stiff to very stiff Brown Moist		3	SS	12						○-----○	47		0 15 41 44	
178.7			4	SS	20										
178.7	CLAYEY SILT with sand, trace gravel (TILL) Very stiff to hard Brown Moist		5	SS	15					○	-----			12 26 44 18	
176.1			6	SS	30										
176.1			7	SS	33					○					
176.1	SAND and SILT, trace clay, some gravel, containing cobbles and boulders (TILL) Very dense Reddish brown Moist to wet		8	SS	61										
176.1			9	SS	105/0.10					○				15 37 40 8	
176.1			10	SS	51/0.15										
171.5	SHALE (BEDROCK) Highly weathered Red Moist		11	SS	105/0.20					○					
170.5	Shale (BEDROCK)		1	RC	REC 100%									RQD = 0%	
170.5	Bedrock cored from depths of 11.2 m to 15.0 m		2	RC	REC 93%									RQD = 26%	
170.5	For bedrock coring details, refer to Record of Drillhole 11-502		3	RC	REC 91%									RQD = 34%	
166.7															

Continued Next Page

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

GTA-MTO 001 1011110040.GPJ GAL-MISS.GDT 7/9/12 DD

PROJECT <u>10-1111-0040</u>		RECORD OF BOREHOLE No 11-502		SHEET 2 OF 3		METRIC	
G.W.P. <u>07-20021</u>		LOCATION <u>N 4829297.4 ; E 284175.7</u>		ORIGINATED BY <u>AM</u>			
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>Track-Mounted CME55, 108 mm I.D. Hollow Stem Augers</u>		COMPILED BY <u>MM</u>			
DATUM <u>NAD83</u>		DATE <u>September 13, 2011</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)								
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100		10	20	30					
15.0	END OF BOREHOLE NOTES: 1. Borehole dry on completion of overburden drilling operations. 2. Monitoring well was dry and open upon completion of drilling. 3. Water level in monitoring well measured as follows: Date Depth (m) Elev. (m) 11/02/11 1.4 180.3																				

GTA-MTO 001 1011110040.GPJ GAL-MISS.GDT 7/9/12 DD

PROJECT: 10-1111-0040

RECORD OF DRILLHOLE: 11-502

SHEET 3 OF 3

LOCATION: N 4829297.4 ; E 284175.7

DRILLING DATE: September 13, 2011

DATUM: NAD83

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track-Mounted CME 55

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
				DEPTH (m)	FLUSH									RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
														TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja				Jn																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
		Continued from Record of Borehole BH11-502		170.52																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				</

DEPTH SCALE

1 : 50



LOGGED: AM

CHECKED: LCC

GTA-RCK 018 1011110040.GPJ GAL-MISS.GDT 7/9/12 DD



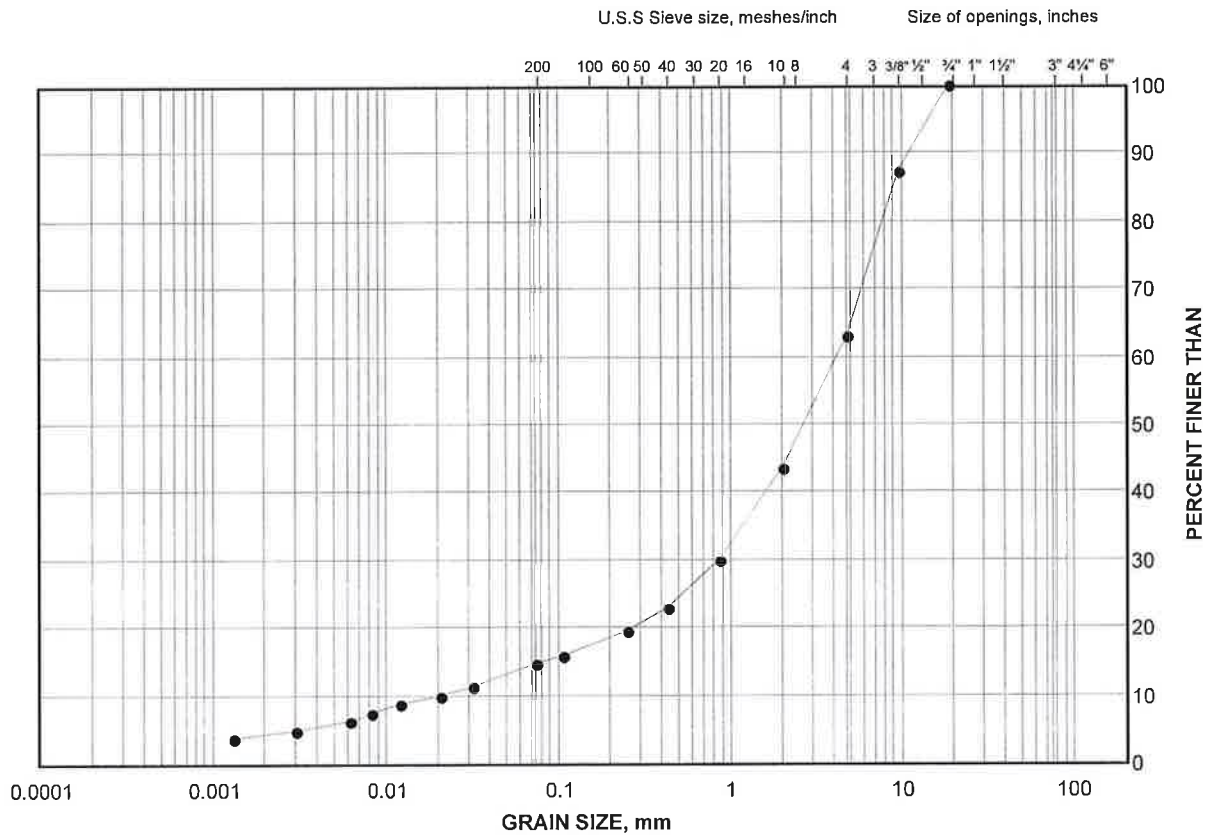
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silty Sand and Gravel Fill

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	11-501	1	180.8

Project Number: 10-1111-0040-5

Checked By: MM

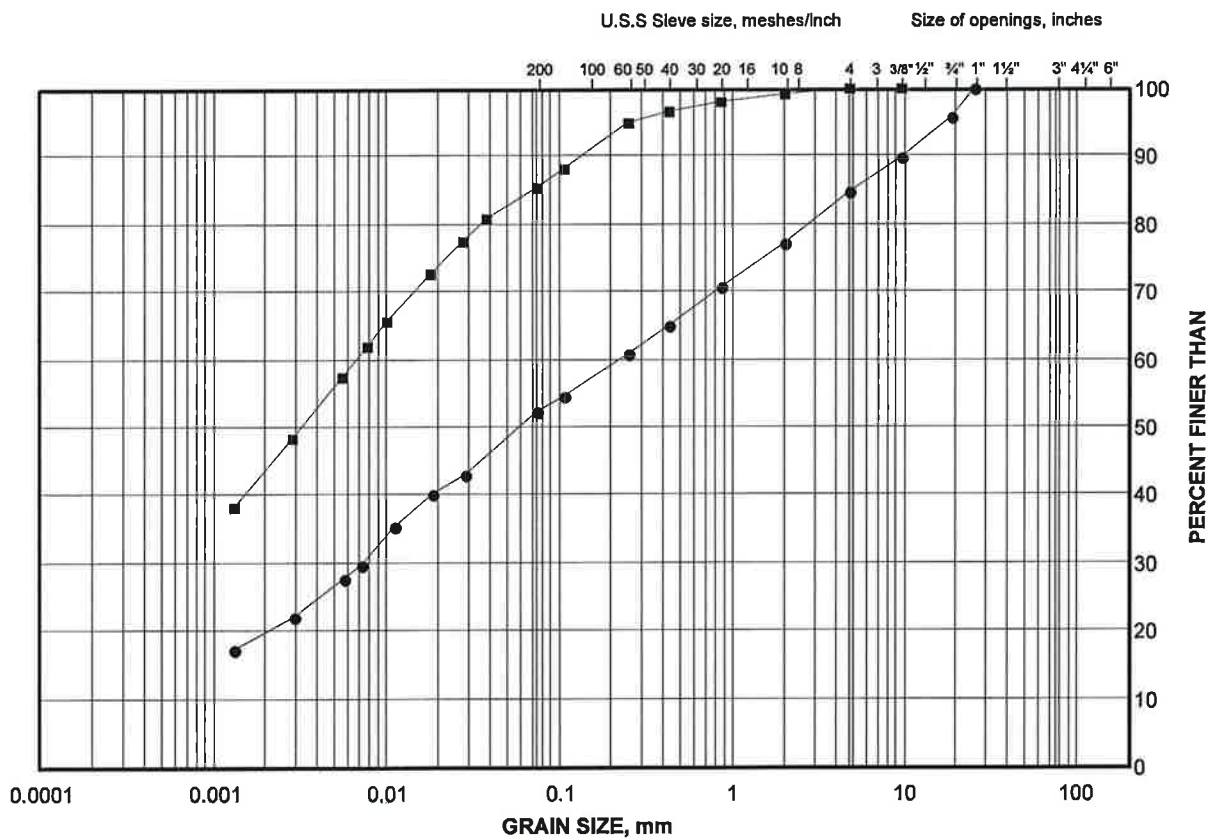
Golder Associates

Date: 21-Feb-12

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay Fill

FIGURE B2



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

LEGEND

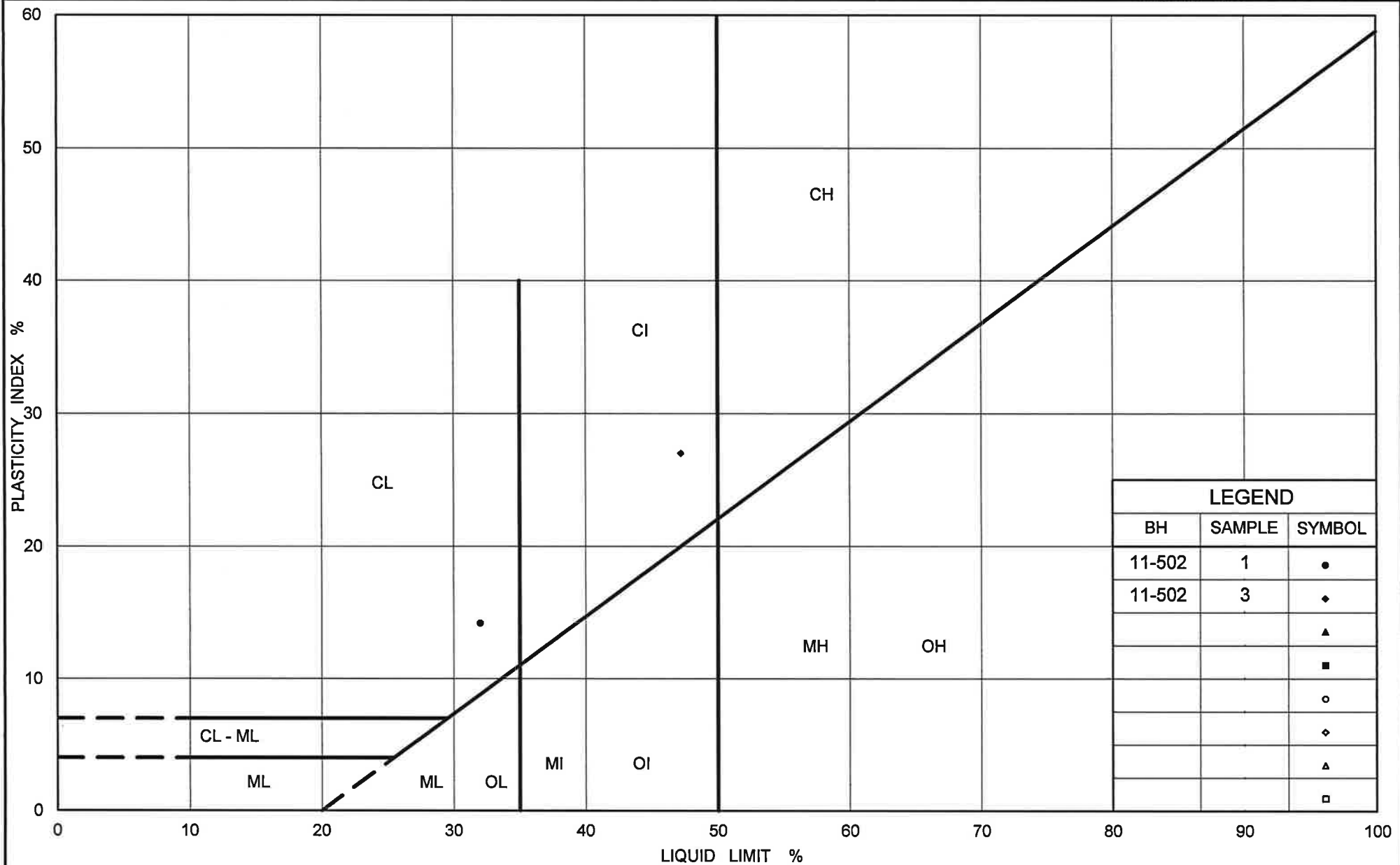
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	11-502	1	181.4
■	11-502	3	179.9

Project Number: 10-1111-0040-5

Checked By: MM

Golder Associates

Date: 21-Feb-12



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt to Silty Clay Fill

Figure No. B3

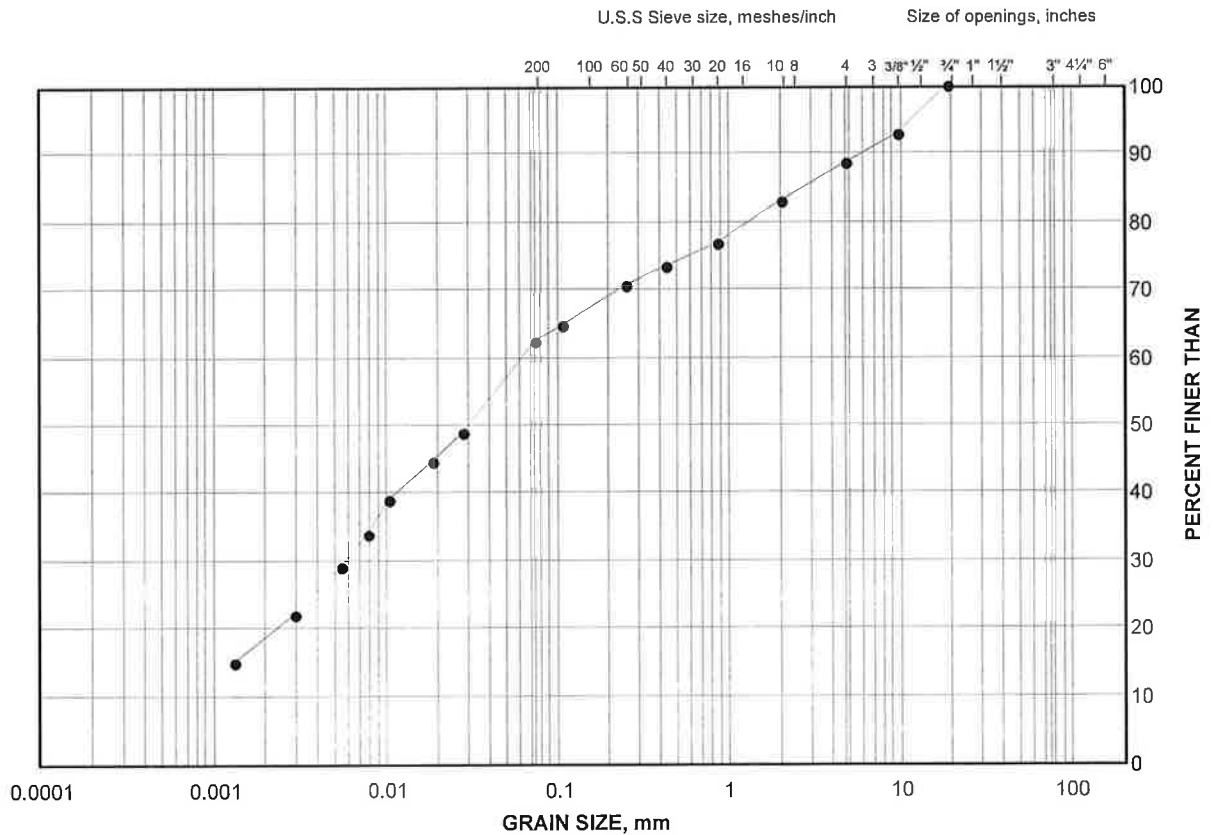
Project No. 10-1111-0040-5

Checked By: MM

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B4



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

LEGEND

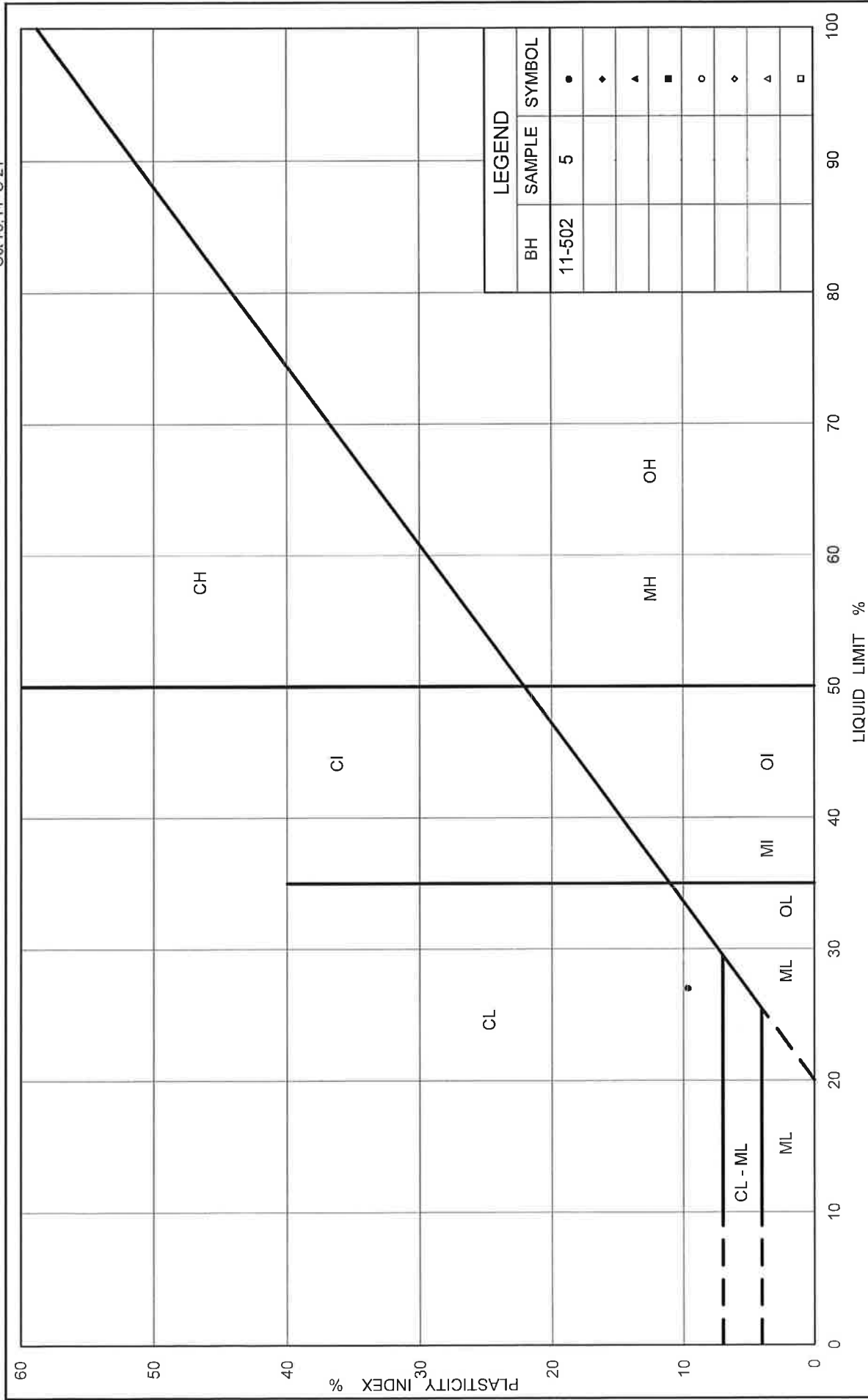
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	11-502	5	178.4

Project Number: 10-1111-0040-5

Checked By: MM

Golder Associates

Date: 21-Feb-12



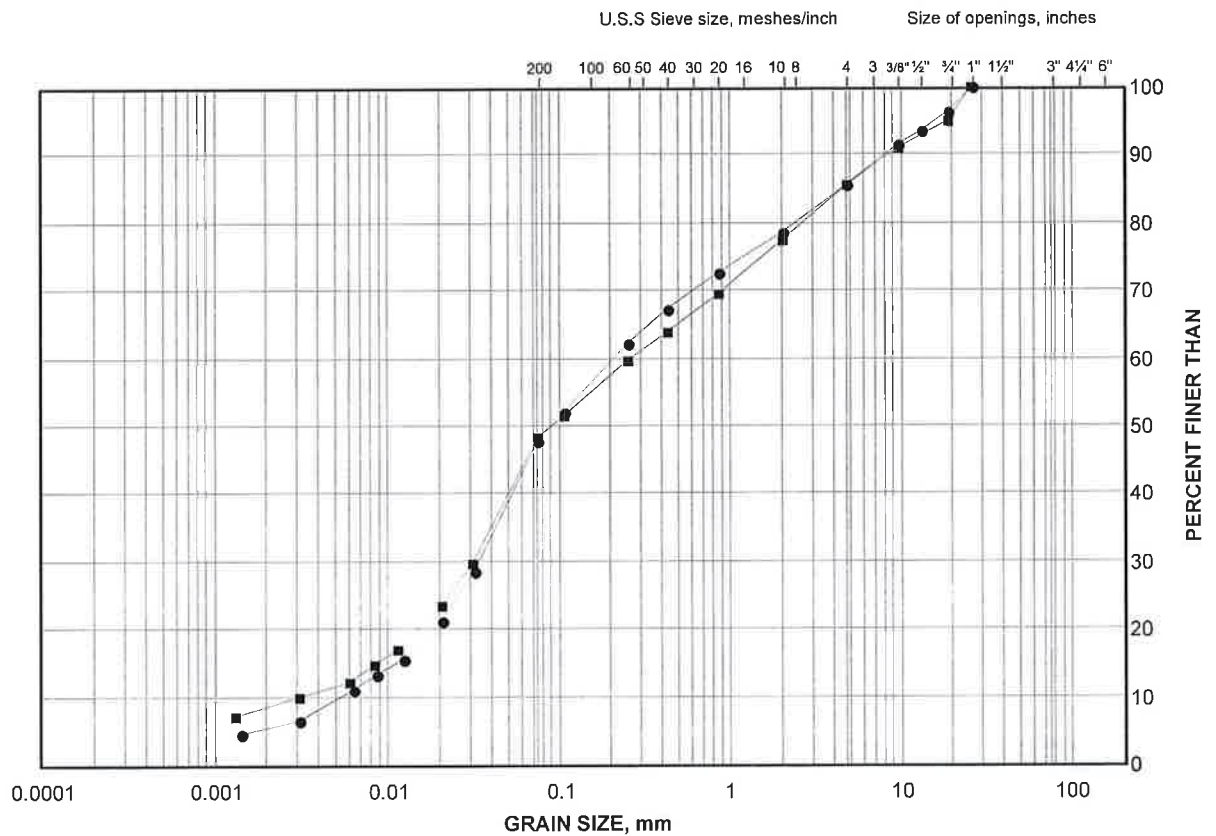
LEGEND		
BH	SAMPLE	SYMBOL
11-502	5	•
		♦
		▲
		■
		○
		◇
		△
		□

<p>Ministry of Transportation Ontario</p>	<p>PLASTICITY CHART Clayey Silt Till</p>	
	<p>Figure No. B5</p>	
	<p>Project No. 10-1111-0040-5</p>	
<p>Checked By: MM <i>pl</i></p>		

GRAIN SIZE DISTRIBUTION

Sand and Silt Till

FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	11-501	5	177.8
■	11-502	9	174.0

Project Number: 10-1111-0040-5

Checked By: MM *[Signature]*

Golder Associates

Date: 21-Feb-12

UNCONFINED COMPRESSION TEST

ASTM D7012-07

FIGURE B7



BEFORE COMPRESSION



AFTER COMPRESSION

Date 10/19/2011
Project 10-1111-0040-5

Golder Associates

Drawn Frank
Chkd. MM

TABLE B1 - UNCONFINED COMPRESSION TEST (UC)

ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	10-1111-0040-5	SAMPLE NUMBER	-
BOREHOLE NUMBER	11-502	SAMPLE DEPTH, m	12.98-13.18

TEST CONDITIONS

MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST, min	>2 <15	L/D	2.51

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.81	WATER CONTENT, (specimen) %	2.50
SAMPLE DIAMETER, cm	4.71	UNIT WEIGHT, kN/m ³	23.84
SAMPLE AREA, cm ²	17.43	DRY UNIT WT., kN/m ³	23.26
SAMPLE VOLUME, cm ³	205.77	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	500.48	VOID RATIO	0.14
DRY WEIGHT, g	488.27		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	9.7
----------------------	---	-------------------------	-----

REMARKS:	DATE:	10/19/2011
----------	-------	------------

Checked By: MM

Golder Associates

TABLE B2 - POINT LOAD TEST ON ROCK SAMPLES

PROJECT NO. 10-1111-0040-5

TITLE URS / Hwy 401 Widening / Halton Peel

DATE October, 2011

Borehole Number	Sample Depth (m)	Test Type	Core Length (mm)	Core ⁽²⁾ Diameter (mm)	Equivalent Diameter (mm)	Ram Pressure (kPa)	Load (P) (kN)	Is Axial (MPa)	Is Diametral (MPa)	Is (50mm) (MPa)	Approx. ⁽¹⁾ UCS (MPa)
11-501	8.13-8.20	A	20.38	47.11	34.96	4,140.00	3.92	3.211	-	2.733	63
11-501	6.39-6.46	A	18.36	46.98	33.14	3,860.00	3.66	3.332	-	2.769	64
11-502	12.73-12.80	A	15.08	47.08	30.07	1,950.00	1.85	2.045	-	1.627	37
11-502	12.36-12.43	D	29.23	46.91	-	560.00	0.53	-	0.241	0.234	5
11-501	7.00-7.07	D	39.40	44.48	-	1,360.00	1.29	-	0.652	0.618	13

⁽¹⁾ $Is_{50} \times C$ (actual value will have to be confirmed by UCS testing), from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.

⁽²⁾ Actual distance between point load cones at time of failure.

Checked By: MM 

Golder Associates



APPENDIX C

**Borehole Records from 1990 Investigation by Geocon
(GEOCRES No. 30M12-220)**



PROJECT Highway 401 and Derry Road East BORING 1
Bridge, Mississauga PAGE 1 OF 1
 CONTRACT NO. T11659/53772 BORING DATE May 9/90
 DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
	DISTURBED	SS - SPLIT SPOON	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY (cm/s)	
	GOOD	ST - THIN WALLED OPEN (SHELBY)	Y - WET UNIT WEIGHT (kN/m³)	DS - DIRECT SHEAR	
	105T	PS - PISTON SAMPLER	C - CONSOLIDATION	Q - TRIAXIAL QUICK	
		WS - WASH SAMPLE	P.P. - POCKET PENETROMETER (KPL)	ROD - ROCK QUALITY DESIGNATION	
		RC - ROCK CORE			
		BU - BULK			
		AS - AUGER			
		T - SPLIT TUBE			
STRATIGRAPHY		TESTS		SAMPLES	
DEPTH - m	DESCRIPTION	WATER LEVEL	UNDRAINED SHEAR STRENGTH (kPa)	OTHER TESTS	CONDITION
			Q TEST FIELD VANE LAB VANE INTACT REMOULDED WATER CONTENT - W% LIQUID LIMIT - WL% PLASTIC LIMIT - WP% DYNAMIC PENETRATION TEST - BLOWS/0.3 m		
0.00	Ground Surface				
0.53	Soft, silty clay with Sand and Gravel. Some Organics (Fill).				
1.52	Hard, greenish brown to brown silty clay Till.				
1.98	Hard, brownish red, weathered Shale.				
	End of Borehole				
	Auger Refusal				



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 2
 Bridge, Mississauga PAGE 1 OF 1
 CONTRACT NO. T11659/53772 BORING DATE May 9/90
 DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
<div style="display: flex; align-items: center;"> <div style="width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></div> DISTURBED </div> <div style="display: flex; align-items: center;"> <div style="width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></div> GOOD </div> <div style="display: flex; align-items: center;"> <div style="width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></div> LOST </div>	SS - SPLIT SPOON ST - THIN WALLED OPEN (SHELBY) PS - PISTON SAMPLER WS - WASH SAMPLE RC - ROCK CORE	BU - BULV AS - AUGER T - SPLIT TUBE	GS - GRAIN SIZE ANALYSIS Y - WET UNIT WEIGHT kN/m ³ C - CONSOLIDATION P.P. - POCKET PENETROMETER kPa	K - PERMEABILITY cm/s DS - DIRECT SHEAR Q - TRIAXIAL QUICK RD - ROCK QUALITY DESIGNATION	
STRATIGRAPHY		TESTS		SAMPLES	
DEPTH m	ELEVATION m DEPTH m	DESCRIPTION	SYMBOL	WATER LEVEL	OTHER TESTS
				Q TEST FIELD VANE INTACT REMOULDED LAB VANE INTACT REMOULDED WATER CONTENT - W% LIQUID LIMIT - WL% PLASTIC LIMIT - WP% DYNAMIC PENETRATION TEST - BLOWS/0.3 m K ₁₀₀ -R ₁₀₀ -R ₁₀₀	CONDITION TYPE NUMBER RECOVERY % STANDARD PENETRATION - N BLOWS/0.3m
0	180.83	Ground Surface			
	0.00	Compact, greyish white gravelly sand (possible Fill).			SS 1 1 11
1	180.13	Hard, greyish brown to brown silty clay Till. Some sand and gravel. Occasional oxidized layers. Shale fragments below 1.85 m.			SS 2 63 10
2	0.70				SS 3 63 30
					SS 4 60 38
3	177.78	Highly weathered, brownish red Shale.			SS 5 100 66
	3.05				SS 6 100 78
	177.32				
	3.51	End of Borehole			
4		Auger Refusal			

W.L. IN STANDPIPE @ EL. 180.00 ON MAY 29/90



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 3
Bridge, Mississauga PAGE 1 OF 2
CONTRACT NO. T11659/53772 BORING DATE May 9/90
DATUM T11659/53772 CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS		
DISTURBED	GOOD	SS - SPLIT SPOON	ST - THIN WALLED OPEN (SHELBY)	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY (cm/s)	
LOST		PS - PISTON SAMPLER	WS - WASH SAMPLE	Y - WET UNIT WEIGHT (kN/m ³)	DS - DIRECT SHEAR	
		RC - ROCK CORE	BU - BULK	C - CONSOLIDATION	Q - TRIAXIAL, QUICK	
			AS - AUGER		RQD - ROCK QUALITY DESIGNATION	
			Y - SPLIT TUBE			
STRATIGRAPHY			TESTS		SAMPLES	
DEPTH	ELEVATION	DESCRIPTION	SYMBOL	WATER LEVEL	OTHER TESTS	CONDITION
						TYPE
						NUMBER
						RECOVERY %
						STANDARD PENETRATION - N BLOWS/0.3m
0	186.60	Ground Surface				
1	0.00	Firm, greyish brown mixture of clayey silt till and weathered shale. Some roots (Fill)				SS 1 - 8
1	179.45					SS 2 75 7
1	115	Very stiff to hard, brown, silty clay till, some sand and gravel.				SS 3 54 25
2	178.77					SS 4 75 70
2	1.83	Very dense, reddish brown silt Till. Some sand and gravel. Trace clay and shale fragments.				SS 5 92 77
3						
4	177.00	Bedrock				
4	3.60	See Rock Boring Log				
5						
6						
7	173.86	End of Borehole				
7	6.74					

W.L. IN STANDPIPE @ EL. 178.9 ON MAY 29/90

SEE ROCK BORING LOG



ROCK BORING LOG

PROJECT Highway 401 and Derry Road East BORING 3
Bridge, Mississauga PAGE 2 OF 2
 CONTRACT NO. T11659/53772 BORING DATE May 9, 1990
 DATUM Geodetic CASING NQ

SAMPLE TYPES

RC - ROCK CORE
(NXL) - SIZE OF CORE

ABBREVIATIONS

- SCR - SOLID CONE RECOVERY
- ROD - ROCK QUALITY DESIGNATION
- DS - DIRECT SHEAR
- T - TRIAXIAL TEST
- UCS - UNCONFINED COMPRESSION STRENGTH
- S.G. - SPECIFIC GRAVITY
- γ - UNIT WEIGHT kN/m³

JOHN APACINE

SPACING	< 50mm	50 ~ 300mm	0.3m ~ 1m	1m ~ 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MODERATE	WIDE	VERY WIDE

STRATIGRAPHY

ROCK CHARACTERISTICS

[illegible]



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 4
 Bridge, Mississauga PAGE 1 OF 2
 CONTRACT NO. T11659/53772 BORING DATE May 9/90
 DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
	DISTURBED	SS - SPLIT SPOON	BU - BULK	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY - cm/s
	GOOD	ST - THIN WALLED OPEN (SHELBY)	AS - AUGER SAMPLE	Y - WET UNIT WEIGHT - kN/m ³	DS - DIRECT SHEAR
	LOST	PS - PISTON SAMPLER	T - SPLIT TUBE	C - CONSOLIDATION	O - TRIAXIAL, QUICK
		WS - WASH SAMPLE		AP - POCKET PENETROMETER	ROD - ROCK QUALITY DESIGNATION
		RC - ROCK CORE			

STRATIGRAPHY		TESTS		SAMPLES	
DEPTH - m	DESCRIPTION	WATER LEVEL	UNDRAINED SHEAR STRENGTH - kPa	OTHER TESTS	CONDITION
			O TEST * P.P. FIELD VANE INTACT REMOULDED LAB VANE INTACT REMOULDED WATER CONTENT - W% LIQUID LIMIT - W _L % PLASTIC LIMIT - W _P % DYNAMIC PENETRATION TEST - BLOWS/0.3 m X-X-X		
0.181.09	Ground Surface				
0.00	Loose, grey sandy silt and clay. Some organics and wood chips (Fill).				SS 1 67 6
0.61	Compact, brown to blackish brown silt, some sand, trace clay and organics. Cohesive below 1.2 m. (possible Fill)				SS 2 60 15
1.79.09					SS 3 68 14
2.00	Dense to very dense, reddish brown, sandy silt Till. Trace to some gravel. Trace to some Clay. 150 mm thick sand layer at 5.3 m.				SS 4 67 31
				GS	SS 5 75 42
					SS 6 100 70/50mm
	Some weathered shale fragments at bottom of layer.				SS 7 100 84
				GS	SS 8 96 100
					SS 9 100 100
					SS 10 83 >100
174.04	Bedrock				R.O. 1 0
7.05	(see Rock Boring Log and Borehole 4A).				
					2 96
171.48	End of Borehole -				
9.61					

W.L. IN STANDPIPE @ EL. 180.00M ON MAY 09/90

SEE FINAL BORING LOG



ROCK BORING LOG

PROJECT Highway 401 and Derry Road East BORING 4
Bridge, Mississauga PAGE 2 OF 2
CONTRACT NO. T11659/53772 BORING DATE May 14, 1990
DATUM Geodetic CASING NQ

SAMPLE TYPES

RC - ROCK CORE
(NXL) - SIZE OF CORE

ABBREVIATIONS

BCN	-	SOLID CORE RECOVERY
RQD	-	ROCK QUALITY DESIGNATION
DB	-	DIRECT SHEAR
T	-	TRIAXIAL TEST
UCS	-	UNCONFINED COMPRESSION STRENGTH
S.G.	-	SPECIFIC GRAVITY
γ	-	UNIT WEIGHT KN/m^3

INDEX

SPACING	< 50mm	50 - 100mm	0.1m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MODERATE	WIDE	VERY WIDE

STRATIGRAPHY

ROCK CHARACTERISTICS

[illegible]



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 4A
Bridge, Mississauga PAGE 1 OF 1
CONTRACT NO. T11659/53772 BORING DATE May 15/90
DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
DISTURBED	GOOD	SS - SPLIT SPOON	BU - BULV	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY - cm/s
LOST		ST - THIN WALLED OPEN (SHELBY)	AS - AUGER	Y - WET UNIT WEIGHT - kN/m ³	DS - DIRECT SHEAR
		PS - PISTON SAMPLER	T - SPLIT TUBE	C - CONSOLIDATION	Q - TRIAXIAL QUICK
		WS - WASH SAMPLE			RQD - ROCK QUALITY DESIGNATION
		RC - ROCK CORE			

STRATIGRAPHY		TESTS		SAMPLES					
DEPTH - m	DESCRIPTION	SYMBOL	WATER LEVEL	OTHER TESTS	CONDITION	TYPE	NUMBER	RECOVERY %	STANDARD PENETRATION - N BLOWS/0.3m
0	181.04								
0.00	Ground Surface								
1									
2									
3									
4									
5									
6	174.34								
6.10	Very dense reddish brown sandy silt Till. Some weathered, brownish red, shale.								
7	174.04								
7.00	Weathered brownish red shale with grey shale interbeds.								
7.57	End of Borehole								
8									

UNDRAINED SHEAR STRENGTH kPa

Q TEST

FIELD VANE

LAB VANE

INTACT

REMOULDED

WATER CONTENT - W%

LIQUID LIMIT - W_L%

PLASTIC LIMIT - W_P%

DYNAMIC PENETRATION TEST - BLOWS/0.3 m

SS 1 75 >100

SS 2 100 100/100mm

SS 3 50 1100/150mm



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 5
Bridge, Mississauga PAGE 1 OF 1
CONTRACT NO. T11659/53772 BORING DATE May 14/90
DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
<input checked="" type="checkbox"/> DISTURBED	<input type="checkbox"/> GOOD	SS - SPLIT SPOON	BU - BULK	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY - cm/s
<input type="checkbox"/> LOST		ST - THIN WALLED OPEN (SHELBV)	AS - AUGER SAMPLE	Y - WET UNIT WEIGHT kN/m ³	DS - DIRECT SHEAR
		PS - PISTON SAMPLER	T - SPLIT TUBE	C - CONSOLIDATION	O - TRIAXIAL QUICK
		WS - WASH SAMPLE		PP - POCKET PENETROMETER	RQD - ROCK QUALITY DESIGNATION
		RC - ROCK CORE			

STRATIGRAPHY		TESTS		SAMPLES					
DEPTH - m	DESCRIPTION	SYMBOL	TESTS	OTHER TESTS	CONDITION	TYPE	NUMBER	RECOVERY %	STANDARD PENETRATION - N BLOWS/0.3 m
			Q TEST * P.P. UNDRAINED SHEAR STRENGTH kPa FIELD VANE INTACT REMOULDED LAB VANE INTACT REMOULDED WATER CONTENT - W% LIQUID LIMIT - W _L % PLASTIC LIMIT - W _p % DYNAMIC PENETRATION TEST - BLOWS/0.3 m X-X-X-X						
0	180.15								
0	0.00								
1	179.54								
0	0.61								
1									
2									
3									
4	176.34								
3	3.81								
5									
6									
7									
8	172.89								
7	7.26								
8									

Ground Surface

Loose, grey sand and gravel, traces of clay below 0.15 m (possible Fill)

Hard, brown silty clay Till. Some sand and gravel.

Very dense, reddish brown silty sand Till. Some gravel.

Some shale fragments at bottom of layer.

End of Borehole

Auger Refusal

W.L.N. STANDPIPE
EL. 179.15 ON MAY 19/90



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 6
Bridge, Mississauga PAGE 1 OF 1
 CONTRACT NO. T11659/53772 BORING DATE May 11/90
 DATUM Geodetic CASING HSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
	DISTURBED	SS - SPLIT SPOON	BU - BULK	GS - GRAIN SIZE ANALYSIS	K - PERMEABILITY - cm/s
	GOOD	ST - THIN WALLED OPEN (SHELBY)	AS - AUGER SAMPLE	7 - WET UNIT WEIGHT - kN/m ³	DS - DIRECT SHEAR
	LOST	PS - PISTON SAMPLER	T - SPLIT TUBE	C - CONSOLIDATION	Q - TRIAXIAL, QUICK
		WS - WASH SAMPLE		P.P. - POCKET PENETROMETER	RQD - ROCK QUALITY DESIGNATION
		RC - ROCK CORE			

STRATIGRAPHY		TESTS		SAMPLES					
DEPTH - m	DESCRIPTION	SYMBOL	WATER LEVEL	OTHER TESTS	CONDITION	TYPE	NUMBER	RECOVERY %	STANDARD PENETRATION - N BLOWS/0.3m
0.00	Ground surface								
0.00	Loose, greyish brown sand and gravel. (Fill)					SS	1	75	7
0.61	Hard, greyish brown to brown silty clay Till. Some sand and gravel.					SS	2	67	34
2.45	Higher sand content below 2.45 m.					SS	3	92	44
3.0	Some boulders at 3.0 - 3.6 m.					SS	4	67	75
3.6						SS	5	58	7100/250mm
3.6						SS	6	17	100/125mm
4.57	Very dense, reddish brown silty sand Till. Some gravel.					SS	7	67	100
4.57						SS	8	100	7100
6.1	Some weathered shale fragments toward bottom of layer.					SS	9	100	7100
6.1						SS	10	0	75/75mm
8.0	End of Borehole					SS	11	83	7100/250mm
8.0	Auger Refusal								



W.C. IN STAND PIPE @ EL. 179.65 ON MAY 29/90



Geocon

BORING LOG

PROJECT Highway 401 and Derry Road East BORING 8
Bridge, Mississauga PAGE 1 OF 1
CONTRACT NO. T11659/53772 BORING DATE May 15/90
DATUM Geodetic CASING SSA

SAMPLE CONDITION		SAMPLE TYPES		ABBREVIATIONS	
 DISTURBED	 GOOD	SS - SPLIT SPOON ST - THIN WALLED OPEN (SHELBY) PS - PISTON SAMPLER WS - WASH SAMPLE RC - ROCK CORE	BU - BULK AS - AUGER SAMPLE T - SPLIT TUBE	GS - GRAIN SIZE ANALYSIS Y - WET UNIT WEIGHT - kN/m ³ C - CONSOLIDATION	K - PERMEABILITY (cm/s) DS - DIRECT SHEAR O - TRIAXIAL QUACK ROD - ROCK QUALITY DESIGNATION
STRATIGRAPHY		TESTS		SAMPLES	
DEPTH	ELEVATION DEPTH	DESCRIPTION	SYMBOL	WATER LEVEL	OTHER TESTS
			UNDRAINED SHEAR STRENGTH (kPa)		
			Q TEST		
			FIELD VANE		
			LAB VANE		
			INTACT		
			REMOULDED		
			WATER CONTENT W%		
			LIQUID LIMIT W _L %		
			PLASTIC LIMIT W _P %		
			DYNAMIC PENETRATION TEST - BLOWS/0.3 m x x x		
			OTHER TESTS		
			CONDITION		
			TYPE		
			NUMBER		
			RECOVERY		
			STANDARD PENETRATION BLOWS/0.3m		
0	181.71	Ground surface			
0.00	181.40	Topsoil			
0.31		Blackish grey sandy silt, some gravel, trace clay. (Fill). Topsoil and peat between 1.98 and 2.59 m.			
1					
2					
179.12	2.59	Blackish grey to grey sandy silt Till. Some gravel.			
3	178.66				
3.05		End of Borehole			
4					



BORING LOG

PROJECT Highway 401 and Derry Road East BORING 9
Bridge, Mississauga PAGE 1 OF 1
 CONTRACT NO. T11659/53772 BORING DATE May 15/90
 DATUM Geodetic CASING SSA

[illegible]

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

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

solutions@golder.com
www.golder.com

Golder Associates Ltd.
2390 Argentia Road
Mississauga, Ontario, L5N 5Z7
Canada
T: +1 (905) 567 4444

