

Design-Build Ready

Foundation Investigation and Design Report

*Simcoe County Road 4 (Yonge Street) Culvert Replacement
Highway 400 - Highway 404 Link (The Bradford Bypass), Bradford, Ontario
MTO G.W.P. 2008-21-00*

Submitted to:

AECOM

300 Water Street
Whitby, Ontario L1N 9J2

Submitted by:

Golder Associates Ltd.

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

19136074 Rev. 0

January 18, 2022

GEOCRES NO.: 31D-787

Latitude 44.129859°
Longitude -79.568791°



Distribution List

1 eCopy - Ministry of Transportation, Ontario (Central Region)

1 eCopy - Ministry of Transportation, Ontario (Foundations)

1 eCopy - AECOM

1 eCopy - Golder Associates Ltd.

Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
3.0 INVESTIGATION PROCEDURES	2
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS.....	3
4.1 Regional Geology.....	3
4.2 Subsurface Conditions	4
4.2.1 Asphalt	4
4.2.2 SILTY SAND (SM) to Gravelly SAND (SP) – FILL	4
4.2.3 CLAYEY SILT (CL) – FILL	5
4.2.4 Sandy SILTY CLAY (CI) to CLAYEY SILT-SILT (CL-ML) – Upper Cohesive Deposit	5
4.2.5 SILT (ML)	6
4.2.6 CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) – TILL	6
4.2.7 CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) – Lower Cohesive Deposit	7
4.3 Groundwater Conditions	7
4.4 Analytical Testing	7
5.0 CLOSURE	9

PART B – FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS	10
6.1 General.....	10
6.2 Consequence and Site Understanding Classification	11
6.3 Seismic Design.....	11
6.3.1 Seismic Site Classification	11
6.3.2 Spectral Response Values and Seismic Performance Category	11
6.3.3 Potential for Liquefaction	12
6.4 Foundation Options – Culvert Replacement	13

6.5	Founding Elevations and Sub-excavation Requirements	13
6.5.1	Box Culvert.....	13
6.5.2	Open Footing Culvert.....	14
6.6	Geotechnical Resistances.....	15
6.6.1	Box Culvert.....	15
6.6.2	Open Footing Culvert.....	16
6.7	Resistance to Lateral Loads / Sliding Resistance	17
6.8	Culvert Bedding and Backfill and Erosion Protection.....	17
6.8.1	Bedding, Cover and Backfill.....	17
6.8.2	Erosion Protection.....	18
6.9	Global Stability	18
6.9.1	Method of Analysis and Parameter Selection	18
6.9.2	Results of Analyses	19
6.10	Settlement	19
6.10.1	Method of Analysis and Parameter Selection	20
6.10.2	Results of Analysis.....	20
6.11	Lateral Earth Pressures for Design of Culvert Walls.....	21
6.12	Construction Considerations	22
6.12.1	Temporary Excavations	22
6.12.2	Temporary Protection Systems.....	22
6.12.3	Control of Groundwater and Surface Water	23
6.12.4	Embankment Widening Construction.....	24
6.12.5	Temporary Detour / Existing Culvert.....	24
6.12.6	Analytical Testing of Construction Materials	25
6.12.7	Piezometer / Well Decommissioning	25
7.0	CLOSURE	26

REFERENCES

TABLES

Table 1 Comparison of Foundation Alternatives for Culvert Replacement

DRAWINGS

Drawing 1 Borehole Locations and Soil Strata

FIGURES

Figure 1 Global Stability at County Road 4 Culvert Replacement East Side – Short-term (Undrained)
 Figure 2 Global Stability at County Road 4 Culvert Replacement East Side – Long-Term (Drained)
 Figure 3 Global Stability at County Road 4 Culvert Replacement West Side – Short-term (Undrained)
 Figure 4 Global Stability at County Road 4 Culvert Replacement West Side – Long-Term (Drained)
 Figure 5 Global Stability at County Road 4 Culvert Replacement – Temporary Condition (Staged Construction with TPS)

APPENDICES

APPENDIX A – Borehole Records

Abbreviations and Terms Used on Records of Boreholes and Test Pits

Lists of Symbols

Record of Boreholes CV1-01 to CV1-04

APPENDIX B – Geotechnical Laboratory Test Results

Figure B1 Grain Size Distribution – Sandy SILT (ML) to SILTY SAND (SM) (FILL)
 Figure B2 Plasticity Chart – SILTY SAND Layer - CLAYEY SILT (CL) (FILL)
 Figure B3 Grain Size Distribution – Sandy SILTY CLAY (CI) to CLAYEY SILT (CL) (Upper Cohesive)
 Figure B4 Plasticity Chart – Sandy SILTY CLAY (CI) to CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Upper Cohesive)
 Figure B5 Grain Size Distribution – CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)
 Figure B6 Plasticity Chart – CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)
 Figure B7 Grain Size Distribution – CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Lower Cohesive)
 Figure B8 Plasticity Chart – CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Lower Cohesive)

APPENDIX C – Analytical Test Results

Certificate of Analysis Report #C1U4508 – Borehole CV1-01

Certificate of Analysis Report #C1O9516 – Borehole CV1-04

APPENDIX D – Non-Standard Special Provisions

Special Provision FOUN0001 – Working Slab
 Special Provision FOUN0003 – Dewatering Structure Excavation
 Special Provision Soil Conditions / Obstructions
 Special Provision Piezometer / Well Decommissioning

PART A

FOUNDATION INVESTIGATION REPORT
SIMCOE COUNTY ROAD 4 (YONGE STREET) CULVERT REPLACEMENT
HIGHWAY 400 – HIGHWAY 404 LINK (THE BRADFORD BYPASS)
BRADFORD, ONTARIO
MTO G.W.P. 2008-21-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services to support the “design-build ready” design of the proposed County Road 4 Interchange Bridge over the future Bradford Bypass (Highway 400 to Highway 404 highway link) and widening of County Road 4, in the Town of Bradford-West Gwillimbury, Ontario.

This report presents the results of the foundation investigation for the proposed culvert replacement at about Station 10+144 on Simcoe County Road 4 (Yonge Street), as shown on Drawing 1.

The purpose of this investigation is to assess the subsurface soil and shallow groundwater conditions at the proposed culvert replacement, by borehole drilling and laboratory testing of selected soil samples. The results of the foundation investigation for the bridge structure, high fill embankment widening and associated earthworks for the project are presented in a separate Foundation Investigation Report.

2.0 SITE DESCRIPTION

An existing non-structural culvert is located at about Station 10+144 along County Road 4, approximately 150 m south of the proposed bridge structure that will carry County Road 4 over the future Bradford Bypass. The culvert allows stormwater to drain from the existing west ditch of County Road 4 to the east ditch where it flows into a natural watercourse east of the site and eventually flows into West Holland River. According to the design-build ready contract drawings (Contract No. 2021-2124), County Road 4 will be widened on both sides, and the existing culvert (designated CL-8 in the contract drawings) will be replaced with a new culvert at about Station 10+156, about 12 m south of the existing culvert. The proposed new culvert location was shifted south to reduce the potential for conflicts with the future Bradford Bypass / County Road 4 Interchange ramps.

The existing County Road 4 embankment near the existing culvert is approximately 5 m in height. The side slopes of the embankment are generally constructed at an inclination of 2 horizontal to 1 vertical (2H:1V) at the culvert approaches, and are sloped at about 2.5H:1V in the immediate vicinity of the existing culvert/headwall. .

The existing culvert is about 35.8 m long and consists of a 1200 mm span x 1200 mm rise concrete box with open bottom, with invert at about Elevation 251.2 m and Elevation 250.3 on the west and east ends, respectively. There is a headwall at the inlet consisting of gabion baskets, and flowing water was observed at the inlet and within the culvert (see Photographs 1 and 2 below). The outlet of the culvert was covered by dense vegetation and cattails at the time of the geotechnical/foundation investigation.



Photograph 1: Culvert inlet on west side of County Road 4 (August 2021, photograph courtesy of AECOM)



Photograph 2: Looking inside culvert (August 2021, photograph courtesy of AECOM)

Based on field observation and as shown in the photographs above, at the time of the investigation the existing culvert displayed no obvious signs of excessive settlement or cracking and the embankment side-slopes / headwall appear to be performing well with no signs of excessive erosion or instability.

The new permanent culvert is proposed to be installed approximately 12 m south of the existing culvert with a concept design concrete box dimension of 1800 mm span x 1200 mm rise and a length of about 74.9 m. The new permanent culvert invert is estimated to be at approximately Elevation 251.6 m and Elevation 250.2 m on the west and east ends, respectively. The proposed culvert replacement site is presently located in a low-lying area along the existing ditch near the embankment toes that is vegetated and covered by cattails (suggesting a generally wet environment), similar to the existing culvert site.

3.0 INVESTIGATION PROCEDURES

The field work for this site was carried out between June 25 and October 14, 2021, during which time four boreholes (designated as CV1-01, CV1-02, CV1-03 and CV1-04) were advanced near the existing culvert, at the locations shown on Drawing 1. Boreholes CV1-01 to CV1-04 were advanced to depths ranging from 9.8 m to 17.0 m below ground surface. Traffic control was necessary for advancement of Boreholes CV1-02 and CV1-03 on the roadway, and temporary traffic control was required for unloading/loading drilling equipment at Boreholes CV1-01 and CV1-04.

The investigation was carried out using track-mounted Diedrich D-50 and D-90 drill rigs, supplied and operated by Walker Drilling of Utopia, Ontario. The boreholes were advanced through the overburden using 210 mm outside diameter hollow-stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

A standpipe piezometer was installed in Boreholes CV1-01 and CV1-04 to allow for monitoring of the groundwater level. The installed piezometers consist of a 50 mm diameter PVC pipe with a slotted screen sealed within a selected

depth in the borehole. The borehole annulus surrounding the piezometer screen was backfilled with sand and the remainder of the borehole was then backfilled with bentonite to or near the ground surface. Details of the piezometer installation and water level readings are presented on the borehole records in Appendix A. The boreholes were backfilled with bentonite upon completion in general accordance with Ontario Regulation 903 Wells (as amended), and the ground surface was restored to as near original condition as practicable, using cold-patch asphalt and quick-set concrete at the road surface, as applicable.

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga laboratory where the samples underwent further visual examination. The soil laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, Atterberg limits and grain size distribution) was carried out on selected soil samples.

The as-drilled borehole locations provided on Drawing 1 and on the borehole records in Appendix A were surveyed by Golder using a hand-held Trimble Geo 7x GPS unit. The locations are positioned relative to MTM NAD 83 northing and easting (Zone 10) coordinates and the ground surface elevations are referenced to CSRS CGVD28 (HT2_0) datum. The borehole locations, including geographic coordinates, ground surface elevations, and borehole depths are summarized below.

Borehole No.	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
CV1-01	4,887,764.9 (44.129859)	299,268.2 (-79.569128)	252.2	11.3
CV1-02	4,887,762.6 (44.129838)	299,289.6 (-79.568861)	256.3	17.0
CV1-03	4,887,772.3 (44.129926)	299,303.4 (-79.568688)	256.5	17.0
CV1-04	4,887,770.4 (44.129909)	299,328.7 (-79.568372)	250.5	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)¹, the general site lies near the border of two physiographic regions of Southern Ontario known as the Peterborough Drumlin Field and the Schomberg Clay Plains.

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

The Peterborough Drumlin Field region generally consists of calcareous till soils and is generally more sandy (rather than stony) within Simcoe County. Many drumlins in this area are known to have shallow coverings of silt and fine sand which is probably wind-blown material. Deposits of clay typically lie between the drumlins in this area.

The Schomberg Clay Plain region consists of deep deposits of stratified clay and silt. In some areas, clay and silt varves (greater than 100 mm thick) are present with the clay layers typically containing up to 50% clay and 40% silt; however, the behaviour is described to be more like that of silt than clay. The Simcoe silty clay and silt loams are described to be poorly drained.

The overall topography of the area indicates the County Road 4 site lies near the bottom of an elongated hill that rises to the north and northwest, suggesting the site is located on / near a drumlin. The subsurface conditions encountered during the current investigation are generally consistent with the regional geology described above.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions as encountered in the boreholes are presented on the borehole records in Appendix A. *Abbreviations and Terms Used on Records of Boreholes and Test Pits* and *List of Symbols* sheets are provided in Appendix A to assist in the interpretation of the borehole records. The geotechnical laboratory test results are presented on the borehole records in Appendix A and on the figures in Appendix B. The analytical laboratory test results are presented in Appendix C.

The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. The boundaries between deposits on the borehole records have been interpreted from drilling observations and non-continuous sampling and, therefore, these boundaries represent transitions between soil types rather than exact planes of geological change. The interpreted stratigraphic profile near the proposed culvert replacement as shown on Drawing 1 is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions encountered in the boreholes advanced from County Road 4 consist of asphalt underlain by embankment fill consisting of gravelly sand to silty sand and clayey silt. Sandy silt fill was also encountered at the ground surface beyond the toe of the embankment on the east side, although this may be re-worked soil associated with previous agricultural / farming activities. At ground surface on the west side of the embankment and below the fill soils, a cohesive deposit of silty clay to clayey silt-silt was encountered (upper cohesive deposit), which is underlain by a glacial till deposit consisting of clayey silt to clayey silt-silt, in turn underlain by a cohesive deposit of clayey silt to clayey silt-silt (lower cohesive deposit). The groundwater level was measured to be near the existing ground surface where piezometers/wells were installed at the west and east toes of the existing embankment.

A more detailed description of the major soil layers and shallow groundwater conditions encountered within the boreholes is provided below.

4.2.1 Asphalt

Asphalt was encountered at the ground surface of County Road 4 in Boreholes CV1-02 and CV1-03. The thickness of the asphalt was measured to be about 200 mm at the borehole locations.

4.2.2 SILTY SAND (SM) to Gravelly SAND (SP) – FILL

Below the asphalt, embankment fill consisting predominantly of silty sand of slight plasticity to gravelly silty sand to gravelly sand was encountered in Boreholes CV1-02 and CV1-03. The top of the layer was encountered at Elevation

256.1 m and 256.3 m and the layer was 4.3 m and 1.2 m thick in Boreholes CV1-02 and CV1-03 respectively. Interlayers of sandy silt, clayey silt and clayey sand were encountered within the fill in both boreholes. A 0.7 m thick surficial layer of sandy silt, trace clay, trace organics was encountered at ground surface in Borehole CV1-04 (east of the embankment) and this has been interpreted as a fill material, which may be re-worked soil associated with previous agricultural / farming activities at this location; this sandy silt layer extends to Elevation 249.8 m.

The SPT “N” values measured within the silty sand to gravelly sand fill generally range from 14 blows to 60 blows per 0.3 m of penetration, indicating a compact to very dense state of compactness. The SPT “N”-value measured within the sandy silt fill beyond the toe of the embankment was 6 blows per 0.3 m of penetration, indicating a loose state of compactness.

Grain size distribution testing was carried out on selected samples of the sandy silt to silty sand embankment fill, and the results are presented on Figure B1 in Appendix B. The water content measured on samples of the non-cohesive fill ranges from about 6% to 19%.

4.2.3 CLAYEY SILT (CL) – FILL

A 3.1 m thick layer of cohesive fill consisting of clayey silt, trace sand to sandy was encountered beneath the gravelly sand to sand embankment fill deposit in CV1-03. The top of the cohesive fill was encountered at Elevation 255.0 m. An interlayer of silty sand, some gravel was encountered within the cohesive fill from a depth of 3.8 m to 4.1 m (between Elevation 252.7 m and 252.4 m). Trace organics, rootlets and asphalt pieces were observed in samples of the cohesive fill obtained from Borehole CV1-03.

The SPT “N” values measured within clayey silt fill range from 11 to 31 blows per 0.3 m of penetration, indicating a stiff to hard consistency.

Grain size distribution testing was carried out on a selected sample of the silty sand interlayer within the clayey silt fill in Borehole CV1-03 and the results are presented on Figure B1 in Appendix B. Atterberg limit testing was carried out on a sample of the silty sand interlayer and the results presented on Figure B2 in Appendix B. The Atterberg limits tests measured a liquid limit of 16%, plastic limit of 12%, and corresponding plasticity index of 4%, indicating the fines portion of the silty sand interlayer has slight plasticity and borders on being classified as a clayey sand. The water content measured on two samples of the cohesive fill are 8% and 12%.

4.2.4 Sandy SILTY CLAY (CI) to CLAYEY SILT-SILT (CL-ML) – Upper Cohesive Deposit

A cohesive deposit consisting of sandy silty clay, clayey silt and clayey silt-silt was encountered beneath the fill in Boreholes CV1-02 to CV1-04 and at ground surface in CV1-01. The top of the cohesive layer (designated upper cohesive deposit) was encountered at elevations ranging from 249.8 m to 252.0 m and this upper deposit ranges in thickness from 0.8 m to 3.0 m. Trace to some organics including pockets of rootlets / vegetation were encountered in the upper portion of the deposit in CV1-01 and trace organics were typically encountered in the upper portion of the deposit in Boreholes CV1-02 and CV1-04. A Shelby tube was taken from approximately 1.4 m to 1.7 m depth in Borehole CV1-01; however, upon extraction in the laboratory of the sampled material exhibited significant sand content and organic interlayers / pockets, with no representative samples suitable for consolidation testing.

The SPT “N” values measured within the clayey deposit ranged from 0 blows (i.e., weight of hammer) to 41 blows per 0.3 m of penetration, but generally ranged from 3 to 28 blows. In-situ field vane tests carried out within the clayey deposit in Borehole CV1-02 and CV1-03 measured undrained shear strengths ranging from about 50 kPa to 58 kPa with sensitivity values between about 1.9 and 2.5. In consideration of the SPT “N” values as well as the

field vane test results, this deposit is considered to have a very soft to hard consistency, but generally a firm to very stiff consistency. The low SPT “N” value of 0 (i.e., weight of hammer) was recorded in the surface sample of CV1-01 and can be attributed to the presence of organics near the culvert inlet and surface water drainage path.

Grain size distribution testing was carried out on three selected samples of the upper cohesive deposit, and the results are presented on Figure B3 in Appendix B. Atterberg limits testing on five selected samples of the deposit measured liquid limits ranging from about 23% to 49%, plastic limits ranging from 15% to 22%, and plasticity indices ranging from about 4% to 27%. The Atterberg limits test results are presented on Figure B4 in Appendix B and indicate the upper cohesive deposit varies from silty clay of intermediate plasticity to a clayey silt-silt of low plasticity. The measured moisture content of the samples tested generally range from 18% to 35%. A higher water content of 76% was measured on the surficial sample from Borehole CV1-01 that contained significantly more organics than the other samples. A laboratory organic content of 2.4% was measured on one sample of the clayey silt-silt upper cohesive deposit recovered from Borehole CV1-02.

4.2.5 SILT (ML)

A 1.2 m thick layer of silt was encountered underlying the upper cohesive deposit in Borehole CV1-02. The top of the silt deposit was encountered at about Elevation 250.6 m.

An SPT “N” value of 10 blows for 0.3 m of penetration was measured within the silt layer, indicating a compact state of compactness.

The water content measured on a sample of the silt was about 26%.

4.2.6 CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) – TILL

A glacial till deposit was encountered beneath the upper cohesive and silt deposits in all boreholes (CR1-01 to CR1-04). The till predominantly consists of clayey silt to clayey silt-silt with varying amounts of gravel and sand. The till is often classified as sandy at many of the sampled locations, and an interlayer of sandy silt till of slight plasticity was encountered from a depth of 4.6 m to 5.2 m (between Elevation 245.9 m and Elevation 245.3 m) in Borehole CV1-04. Auger grinding was noted during drilling in Borehole CV1-01 suggesting the presence of cobbles and/or a boulder. Although the presence of cobbles or boulders was not encountered or inferred in the other boreholes, given that the deposit is glacially derived, cobbles/boulders should be expected to be present within the till deposit.

The top of the glacial till was encountered at elevations ranging from 247.7 m to 249.9 m and it ranged from 5.8 m to 9.5 m thick. An interlayer of sandy silt till of slight plasticity was encountered between depths of 4.6 m to 5.2 m (between Elevation 245.9 m and Elevation 245.3 m) in Borehole CV1-04. Borehole CV1-04 was terminated in this deposit at a depth of about 9.8 m (Elevation 240.7 m).

The SPT “N” values measured within the cohesive till range from 9 to 131 blows per 0.3 m of penetration, indicating a stiff to hard consistency. The lower SPT “N” values of 9 to 15 blows per 0.3 m of penetration were encountered at the top of the till in three of the boreholes, below which the SPT “N” values are higher.

Grain size distribution testing carried out on seven samples within the cohesive till deposit is presented on Figure B5 in Appendix B. Atterberg limits testing carried out on seven samples of the deposit yielded liquid limits ranging from about 15% to 35%, plastic limits ranging from 10% to 18%, and plasticity indices ranging from about 3% to 18%. The Atterberg limits test results are presented on Figure B6 in Appendix B and indicate the till deposit is generally classified as clayey silt to clayey silt-silt of low plasticity. The measured moisture content of samples tested ranges from about 7% to 24%.

4.2.7 CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) – Lower Cohesive Deposit

Below the glacial till, a deposit of clayey silt to clayey silt-silt (designated lower cohesive deposit) was encountered in Boreholes CV1-01 to CV1-03 where it was penetrated 0.7 m to 1.6 m prior to borehole termination. The top of the lower cohesive deposit was encountered at 10.2 m to 16.3 m below ground surface (between Elevation 242.0 m to Elevation 240.0 m) and the boreholes terminated within the deposit at a depth of about 11.3 m to 17.0 m below ground surface (between Elevation 240.9 m and 239.2 m).

The SPT “N” values measured within the lower cohesive deposit range from 69 blows for 0.3 m of penetration to greater than 100 blows for 0.3 m of penetration, suggesting a hard consistency.

Grain size distribution testing was carried out on three selected samples of the lower cohesive deposit and the results are presented on Figure B7 in Appendix B. Atterberg limit testing was carried out on three selected samples of the deposit as presented on Figure B8 in Appendix B. The measured liquid limits range from 19% to 24%, plastic limits range from 15% to 17%, and corresponding plasticity index ranges from 4% to 8%, indicating a clayey silt to clayey silt-silt of low plasticity.

4.3 Groundwater Conditions

A standpipe piezometer was installed in Boreholes CV1-01 and CV1-04 for monitoring of the groundwater level. The details of the piezometer installation are shown on the borehole records. The screened interval for both piezometers is within the sandy clayey silt-silt glacial till deposit. A summary of the piezometer installations including ground surface elevation, depth to groundwater and corresponding groundwater elevation measured after installation is provided below.

Borehole No. / Piezometer	Ground Surface Elevation (m)	Groundwater Depth ¹ (m)	Groundwater Elevation (m)	Date	Screened Deposit
CV1-01	252.2	0.6	251.6	November 25, 2021	Sandy Clayey Silt to Sandy Clayey Silt-Silt Till
		0.1	252.1	December 9, 2021	
CV1-04	250.5	0.2	250.3	November 25, 2021	
		1.3	249.2	December 9, 2021	

¹ Groundwater depth measured below ground surface near toe of embankment.

It should be noted that the groundwater level is subject to seasonal fluctuations following precipitation/snow melt events and should be expected to be higher during wet periods of the year. Perched groundwater within the non-cohesive fill soils (above cohesive fill or native soils) should also be expected, especially in the Spring and after periods of significant precipitation.

4.4 Analytical Testing

Two soil samples were collected and submitted to Bureau Veritas Laboratories for analysis of parameters used to assess corrosion potential to potential construction materials (i.e., concrete and steel). A summary of the analytical testing results is presented below and more details are provided in the Certificates of Analysis in Appendix C.

Borehole No.	Sample No.	Sample Depth (Elevation) (m)	Soil Type	Parameters				
				Soluble Chloride (µg/g)	Soluble Sulphate (µg/g)	pH	Conductivity (µmho/cm)	Resistivity (ohm-cm)
CV1-01	1	0.0 – 0.61 (252.2 - 251.6)	Clayey Silt	24	<20	7.03	334	3000
CV1-04	2	0.76 – 1.37 (249.7 – 249.1)	Sandy Silty Clay	91	<20	7.75	344	2900

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Bryan Lui, E.I.T., a geotechnical engineer-in-training with Golder. Mr. Kevin J. Bentley, P.Eng., Associate and MTO Foundations Designated Contact for Golder, reviewed this report. Ms. Lisa Coyne, P.Eng., Principal and MTO Foundations Designated Contact for Golder, conducted an independent quality control review of this report.

Golder Associates Ltd.



Bryan Lui, E.I.T.
Geotechnical Engineer-In-Training



Kevin J. Bentley, P.Eng.
MTO Foundations Designated Contact



Lisa Coyne, P.Eng.
MTO Foundations Designated Contact

BL/KJB/LCC/ml

Golder and the G logo are trademarks of Golder Associates Corporation

[https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/county road 4/03 - cr4 cv fidr/final fidr/19136074 - cr4 cv fidr - final.docx](https://golderassociates.sharepoint.com/sites/120387/project%20files/6%20deliverables/foundations/county%20road%204/03%20-%20cr4%20cv%20fidr/final%20fidr/19136074%20-%20cr4%20cv%20fidr%20-%20final.docx)

PART B

**SIMCOE COUNTY ROAD 4 (YONGE STREET) CULVERT REPLACEMENT
HIGHWAY 400 – HIGHWAY 404 LINK (THE BRADFORD BYPASS)
BRADFORD, ONTARIO
MTO G.W.P. 2008-21-00**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides a discussion and foundation engineering design recommendations for the replacement of the County Road 4 (Yonge Street) culvert located at about Station 10+144. The culvert replacement is required to accommodate widening of County Road 4 and the future construction of the interchange associated with the Highway 400 and Highway 404 link (The Bradford Bypass) in Town of Bradford, Ontario. The recommendations provided herein are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface exploration. The discussion and recommendations presented are intended to provide the designers with information to assess feasible foundation alternatives and carry out the design of the culvert replacement.

The Foundation Design Report (Part B of this report) including the discussion and recommendations are intended for the use of the MTO and their designers for the design-build ready concept design and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor or design-build proponents. Contractors undertaking the work must make their own interpretation based on the factual data presented in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects that could affect the concept design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect detail design, equipment selection, proposed construction methods, scheduling and the like.

6.1 General

An existing non-structural culvert is located at about Station 10+144 along County Road 4, approximately 150 m south of the proposed bridge structure that will carry County Road 4 over the future Bradford Bypass. The culvert allows stormwater to drain from the existing west ditch of County Road 4 to the east ditch where it flows into a natural watercourse east of the site and eventually flows into West Holland River.

According to the design-build ready contract drawings (Contract No. 2021-2124), County Road 4 will be widened on both sides, and the existing culvert (designated CL-8 in the design-build ready contract drawings) will be replaced with a new culvert at about Station 10+156, about 12 m south of the existing culvert. The proposed new culvert location was shifted south to reduce the potential for conflicts with the future Bradford Bypass / County Road 4 Interchange ramps. Based on the concept design drawings, the new County Road 4 will be raised by about 0.7 m at the culvert site. The new culvert construction will likely be staged to allow for half-and-half construction, with the west half being constructed first followed by the east half. A temporary protection system will be required along the existing County Road 4 roadway to accommodate the staged construction of the culvert and allow for traffic to continue along County Road 4. In addition, the west portion of the new culvert may be partially buried below the temporary detour embankment until later stages of the construction and will need to be protected accordingly. Temporary culvert extensions to the existing culvert will be required during the staged construction and is discussed in Section 6.12.5 of this report.

The existing culvert consists of a 1,200 mm span x 1,200 mm rise concrete box with open bottom and is about 35.8 m long. There is a headwall at the inlet consisting of gabion baskets and flowing water, was observed within the culvert. The replacement culvert is proposed to be an 1,800 mm span x 1,200 mm rise concrete box that is about 74.9 m long.

The following summarizes the details regarding the existing and proposed culvert:

Culvert Location	Structure Dimensions ¹	Approximate Height of Embankment ² (m)	Culvert Invert Elevation ¹ (m)	
			Upstream	Downstream
Station 10+144 (Existing Culvert)	1200 mm wide x 1200 mm high concrete box (35.8 m long)	6.2	251.2	250.3
Station 10+156 (Proposed Culvert)	1800 mm wide x 1200 mm high concrete box (74.9 m long)	6.6	251.6	250.2

Notes:

1. Culvert dimensions and invert elevations were provided by AECOM on December 7, 2021.
2. Embankment height is approximate and measured from road surface to invert level at existing and proposed new location.

6.2 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the 2019 *Canadian Highway Bridge Design Code CAN/CSA S6:19 (CHBDC, 2019)* and its Commentary, the culvert and any associated headwall foundations may be classified as geotechnical systems designed for application along a transportation corridor with large traffic volumes and with potential impacts on other transportation corridors, resulting in a “typical consequence level” associated with exceeding limit states design. In addition, given the project-specific foundation investigation carried out at this site (as presented in the Foundation Investigation Report (Part A of this report)), the level of confidence for design is considered to be a “typical degree of site and prediction model understanding” in accordance with Section 6.5 of *CHBDC (2019)*. Accordingly, the appropriate corresponding ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2 of the *CHBDC (2019)* have been used for the concept design and will apply for detail design unless the future design-builder undertakes additional investigation and high complexity testing.

6.3 Seismic Design

6.3.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation and in situ testing. Based on the energy-corrected average penetration resistance, \bar{N}_{60} below the founding level, the site may be classified as Site Class D in accordance with Table 4.1 of the *CHBDC (2019)*, in the absence of any geophysical testing.

The *CHBDC (2019)* states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 5th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2015.

6.3.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.1 of the 2019 *CHBDC*, the peak ground acceleration (*PGA*), peak ground velocity (*PGV*) and 5% damped spectral response acceleration ($S_a(T)$) values for Site Class C were obtained for the culvert site using the NBCC website (earthquakescanada.nrcan.gc.ca) and are summarized below.

Seismic Hazard Values for Site Class C	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475-year return period)
PGA (g)	0.030	0.046	0.074
PGV (m/s)	0.020	0.042	0.067
$S_a(0.2)$ (g)	0.052	0.078	0.122
$S_a(0.5)$ (g)	0.037	0.054	0.081
$S_a(1.0)$ (g)	0.021	0.032	0.048
$S_a(2.0)$ (g)	0.010	0.016	0.025
$S_a(5.0)$ (g)	0.002	0.004	0.006
$S_a(10.0)$ (g)	0.001	0.002	0.003

The values given above are for the reference ground condition Site Class C and must be modified to the site-specific seismic site classification given in Section 6.3.1 (Site Class D) to obtain design spectral values. As indicated in Section 4.4.3.3 of the CHBDC, the value of reference PGA , PGA_{ref} , for use with Tables 4.2 to 4.9 shall be taken as 80% of the PGA for Site Class C, where $S_a(0.2)/PGA$ is less than 2.0. Based on this requirement, a PGA_{ref} value of 0.059 was used for the 2,475-year return period. The corresponding site-specific Site Class D seismic hazard values, the peak ground acceleration (PGA), peak ground velocity (PGV) and design spectral response acceleration ($S(T)$), are presented below.

Seismic Hazard Values for Site Class D	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475-year return period)
PGA (g)	0.039	0.059	0.095
PGV (m/s)	0.029	0.062	0.098
$S_a(0.2)$ (g)	0.064	0.097	0.151
$S_a(0.5)$ (g)	0.054	0.079	0.119
$S_a(1.0)$ (g)	0.033	0.050	0.074
$S_a(2.0)$ (g)	0.016	0.025	0.039
$S_a(5.0)$ (g)	0.003	0.006	0.009
$S_a(10.0)$ (g)	0.001	0.003	0.004

6.3.3 Potential for Liquefaction

Liquefaction is a phenomenon whereby seismically-induced shaking generates shear stresses within the soil under undrained conditions. These stresses tend to densify the soil which may lead potentially large surface deformations,

and under undrained conditions generate excess pore water pressures that can lead to sudden temporary losses in strength. Where existing static shear stresses are present, the loss of strength can lead to significant lateral movements (analogous to slope failure) often referred to as “lateral spreading” or under certain conditions even catastrophic failure of slopes often referred to as “flow slides”. Lateral spreading and flow slide often accompany liquefaction along rivers and other shorelines.

The soil beneath the anticipated founding elevation of the culvert and associated embankment widening generally consists of stiff to hard cohesive deposits. Based on the low site-specific PGA and the stiffness of the cohesive deposits, the soils at this site are considered to have a low potential for liquefaction during a design seismic event and, therefore, liquefaction is not considered further in the design of the culvert and new embankment widening.

6.4 Foundation Options – Culvert Replacement

A closed bottom concrete box culvert or “open footing” culvert with shallow foundations are both considered feasible for the culvert replacement. Both pre-cast concrete elements (box culvert segments) and cast-in-place concrete elements are feasible from a foundation perspective. Alternative materials and shapes may be considered for the culvert provided the durability, drainage, and environmental requirements are met as per the design criteria. From a foundation perspective, a pre-cast concrete box culvert (closed bottom) is the preferred replacement structure for the site over a cast-in-place open footing culvert based on the following:

- Pre-cast concrete box (closed bottom) culvert construction minimizes the depth of excavation and groundwater control requirements as compared with open footing culverts.
- Pre-cast concrete culvert segments can usually be installed more expeditiously than cast-in-place open footing culverts, resulting in shorter durations for dewatering, surface water pumping and traffic staging and less risk of disturbance to founding soils.
- Pre-cast concrete box culvert segments are more tolerant of total and differential settlement, although this is not considered a significant concern at this culvert site.

Table 1, following the text of this report, identifies and presents an assessment of the advantages, disadvantages, relative costs and risks/consequences of box culverts and open footing culvert options for this site.

Although box culverts may not satisfy fisheries requirements in some applications, it is understood that the design team has adopted a box culvert design for this site; however, recommendations for both the box culvert option and open footing option are provided in the following sections of this report.

6.5 Founding Elevations and Sub-excavation Requirements

6.5.1 Box Culvert

Box culverts should be founded below any existing fill / soft soils or any soils containing more than trace organics. It is not considered necessary to found closed bottom box culverts below frost depth, which at this site is estimated to be 1.5 m as interpolated from Ontario Provincial Standard Drawing (OPSD) 3090.101 (Frost Penetration Depths for Southern Ontario). Pre-cast box structure sections are considered to be tolerant to small magnitudes of movement related to freeze-thaw cycles, should these occur.

The following summarizes the recommended founding levels and sub-excavation requirements for a new box culvert, based on the inverts of the proposed culvert noted in Section 6.1, an assumed closed bottom concrete thickness of 200 mm, and bedding thickness of 300 mm (see Section 6.8).

Culvert Station	Location along Culvert	Approximate Underside of Culvert ¹ , Elevation (m)	Bedding Thickness (m) / Proposed Founding Elevation (m)	Sub-Excavation Required? (soil to be removed)	Sub-excavation Depth (m) / Elevation (m)	Founding / Subgrade Soil ²
Station 10+156	Inlet	251.4	0.3 / 251.1	Yes (very soft to soft clayey silt containing organics)	0.4 / 250.7	Engineered fill above stiff to hard sandy clayey silt
	Midpoint	250.8	0.3 / 250.5	No	-	Compact silt or firm to stiff clayey silt-silt
	Outlet	250.0	0.3 / 249.7	Yes (soft sandy silt clay)	0.7 / 249.0	Engineered fill above stiff to hard clayey silt to clayey silt-silt till

Notes:

1. Underside of culvert is 200 mm below design invert to account for estimated thickness of concrete for closed bottom section.
2. Subgrade soil anticipated at base of subexcavation from closest borehole(s). If no subexcavation is required, subgrade soil will be founding soil; otherwise, engineered fill will be founding soil

The box culvert subgrade should be inspected by geotechnical personnel to ensure that all existing topsoil, fill, soft soils, soils containing more than trace amounts of organics or any unsuitable soils have been removed. Following inspection, any sub-excavated areas should be backfilled with granular material (i.e., engineered fill) meeting OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II, placed and compacted in accordance with OPSS.PROV 501 (Compacting).

The upper cohesive and silty native subgrade will be susceptible to loosening/softening and degradation on exposure to water and construction traffic. As discussed further in Section 6.8, if the sub-excavation and engineered fill placement or bedding for the culvert is not placed within four hours after preparing the subgrade, it is recommended that a concrete working slab having a minimum thickness of 100 mm and a minimum 28-day compressive strength of 20 MPa be placed to protect the integrity of the subgrade. A Non- Standard Special Provision (NSSP) to address this item is included in Appendix D, for inclusion in the design-build ready documentation as applicable.

Pre-cast box culverts comprised of articulated sections are preferred to accommodate differential settlement which may occur due to frost action or due to settlement of the foundation soils resulting from the placement of new embankment fill associated with the widening and grade raise along County Road 4 (see Section 6.10).

6.5.2 Open Footing Culvert

Strip (shallow) foundations for an open footing culvert replacement should be founded at a minimum depth of 1.5 m below the lowest surrounding grade to provide adequate protection against frost penetration, as per OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario). In addition, the footings should extend

below any existing fill, soft soils, or soils containing more than trace organics. The following summarizes the recommended design founding levels and sub-excavation requirements for a new open footing culvert supported on strip foundations, based on the concept design inverts.

Culvert Station	Location along Culvert	Approximate Invert Elevation (m)	Proposed Strip Footing Founding Elevation ¹ (m)	Sub-Excavation Required? (soil to be removed)	Sub-excavation Depth (m) / Elevation (m)	Subgrade Soil / Founding Soil ¹
Station 10+156	Inlet	251.6	250.1	No	-	Stiff to hard Sandy Clayey Silt
	Midpoint	251.0	249.5	No	-	Stiff to Hard Clayey Silt to Clayey Silt-Silt (Till)
	Outlet	250.2	248.7	No	-	Stiff to Very Stiff Clayey Silt to Clayey Silt-Silt (Till)

Notes:

- For the cast-in-place open footing culvert, the depth of the footing below the invert is equal to the depth of frost penetration of 1.5 m.

The footing subgrade should be inspected following excavation, in general accordance with OPSS.PROV 902 (Excavating and Backfilling Structures) to check that all existing fill, softened/loosened soils, soils containing excessive organics or other unsuitable material have been removed. Where sub-excavation is required to remove unsuitable materials, the sub-excavated area should be backfilled with granular material meeting OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting).

The footing subgrade will be susceptible to loosening/softening and degradation on exposure to water and construction traffic. As discussed further in Section 6.8, if the excavation and placement of concrete for the open footings does not occur within four hours after preparing the subgrade, a concrete working slab should be placed to protect the integrity of the subgrade. An example NSSP for the working slab is included in Appendix D and should be included in the design-build ready documentation as applicable.

6.6 Geotechnical Resistances

6.6.1 Box Culvert

The proposed box culvert and bedding founded on the native soils and/or engineered fill at or below the design elevations given in Section 6.5.1 may be designed based on the factored ultimate geotechnical resistances and factored serviceability geotechnical resistances (for 25 mm of settlement) given below.

Culvert	Founding Stratum	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance ¹ (for 25 mm settlement)
1,800 mm span x 1,200 mm rise closed box	<ul style="list-style-type: none"> Engineered fill (Granular 'A' or 'B' Type II) Stiff to hard clayey silt to clayey-silt till Compact silt / firm to hard clayey silt-silt Very stiff to hard clayey silt 	225 kPa	>225 kPa

Notes:

1. Refer to Section 6.9 for discussion on settlement of culverts under new embankment widening loading.
2. The factored serviceability geotechnical resistance (for 25 mm of settlement) is greater than the factored ultimate geotechnical resistance, and therefore the factored ultimate geotechnical resistance will govern design

The geotechnical resistances and settlement are dependent on the box culvert span, configuration and applied loads, including the loads imparted by the existing and new embankment widening construction; the geotechnical resistances/reactions, therefore, must be reviewed if the culvert span/footing size or founding elevation differs significantly from that given above. The geotechnical resistances provided above are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC (2019).

Differential settlement should be expected based on the varying composition and quality of the founding stratum along the culvert alignment and variable loading conditions due to the embankment widening (see Section 6.10 for further details).

6.6.2 Open Footing Culvert

Strip footings placed on the properly prepared subgrade at or below the founding elevations recommended in Section 6.5.2, should be designed based on the factored ultimate geotechnical resistance values and the factored serviceability geotechnical resistance values (for 25 mm of settlement) given below. These recommendations are based on an assumed footing width of about 0.5 m.

Culvert	Founding Stratum	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance (for 25 mm settlement)
1.8 m wide, 74.9 m long open footing culvert with footing width of approx. 0.5 m	<ul style="list-style-type: none"> Stiff to hard sandy clayey silt Stiff to hard clayey silt to clayey silt-silt till 	300 kPa	>300 kPa

Notes:

1. Refer to Section 6.9 for discussion on settlement of culverts under new embankment widening loading.
2. The factored serviceability geotechnical resistance (for 25 mm of settlement) is greater than the factored ultimate geotechnical resistance, and therefore the factored ultimate geotechnical resistance will govern design

The geotechnical resistances and settlement are dependent on the footing size, configuration and applied loads, including the loads imparted by the existing and widened embankment construction; the geotechnical resistances/reactions, therefore, must be reviewed if the footing size or founding elevation differs significantly from that given above. The geotechnical resistances provided above are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the CHBDC (2019).

Differential settlement should be expected based on the varying composition and quality of the founding stratum along the culvert alignment and variable loading conditions due to the embankment widening (see Section 6.10 for further details).

6.7 Resistance to Lateral Loads / Sliding Resistance

Resistance to sliding between the bottom of the culvert / footing and the granular engineered fill or native soils can be calculated in accordance with Section 6.10.4 of the CHBDC (2019), applying the appropriate consequence and degree of site understanding factors, as noted in Section 6.2. The unfactored interface strength parameters between the various interface materials are summarized below may be utilized to assess the critical condition for sliding resistance.

Material Interface	Unfactored Interface Strength Parameters
Pre-cast concrete box culvert on Granular 'A' or Granular 'B' Type II	$\delta' = 24^\circ$
Pre-cast concrete box culvert on compact silt or firm to stiff clayey silt-silt	$\delta' = 21^\circ$, $S_u = 50$ kPa
Cast-in-place concrete footings on Granular 'A' or Granular 'B' Type II	$f' = 35^\circ$

6.8 Culvert Bedding and Backfill and Erosion Protection

6.8.1 Bedding, Cover and Backfill

For the new box culvert, the bedding/levelling course and backfill requirements should be in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut) and OPSD 803.010 (Backfill and Cover for Concrete Culverts).

The new box culvert should be provided with at least 300 mm of OPSS.PROV 1010 (Aggregates), Granular 'A' material for bedding purposes, or alternatively a 100 mm thick concrete working slab. Granular "A" bedding is preferred from a foundations perspective; however a concrete working slab may be considered to protect the foundation soils if there will be a delay in placement of the concrete segments and/or during wetter periods of the year. The 75 mm thick levelling course may consist of OPSS.PROV 1010 (Aggregates) Granular 'A' or OPSS.PROV 1002 (Aggregates - Concrete) Fine Aggregate. Granular bedding is not required for footings for open footing culverts; such footings can be placed directly on properly prepared subgrade, as described in Section 6.5.2.

Backfill to culvert walls and cover should consist of granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates), Granular 'A' or Granular 'B' Type I or II. The backfill and cover should be placed and compacted in accordance with OPSS.PROV 501 (Compacting). The new culvert should be designed for the full overburden and hydrostatic pressures, and live load, assuming that the embankment fill has a unit weight of 22 kN/m³ for

OPSS.PROV 1010 (Aggregates) Granular 'A', 21 kN/m³ for Granular 'B' Type I or II and 19 kN/m³ for earth fill above the cover comprised of Select Subgrade Material (SSM) or earth borrow.

Excavated fill material from the existing embankment may be used to backfill above the culvert cover material within the new widened highway embankment provided the fill is suitable for re-use. Excavated fill material should meet the specifications for suitable earth borrow material as per OPSS.PROV 212 (Earth Borrow) and in accordance with OPSS.PROV 206 (Grading) and placed and compacted in accordance with OPSS.PROV 501 (Compacting). The existing fill material from above the groundwater level is expected to near its optimum moisture content for compacting. Fill material from below the groundwater level will likely require drying in order to reach optimum moisture content, prior to placement and compaction.

Backfill placement for the reconstruction and widening of the roadway embankment placed along and over the culvert should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and the new fill along the cut faces.

6.8.2 Erosion Protection

To control surface water from flowing either beneath the culvert replacement (potentially causing undermining and scouring) or around the culvert replacement (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), it is recommended that a concrete cut-off wall be provided at the upstream end of the culvert, or alternatively a clay seal could be provided at the upstream end of the culvert.

Provision should also be made for scour and erosion protection at the culvert inlet and outlet, including in front of any wing walls/retaining walls (if required) adjacent to the watercourse. The requirements for and detail design of erosion protection measures for the culvert inlets and outlets should be confirmed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSD 810.010 (*Rip-Rap Layout for Sewer and Culvert Outlets*).

To reduce erosion of the new embankment side slopes due to surface water runoff, placement of topsoil and seeding cover should be carried out as soon as practicable after construction of the embankments. In the short-term, if placement of cover material cannot be carried out soon after the construction of the embankments, erosion control blankets or equivalent should be installed to reduce erosion of the embankment slopes and control sedimentation into the watercourse located east of the site. The erosion protection should be in accordance with OPSS.PROV 803 (*Vegetative Cover*) and OPSS.PROV 804 (*Temporary Erosion Control*).

6.9 Global Stability

The following sections outline the method and soil parameters used to evaluate static global stability of the proposed embankment widening at the culvert replacement site, followed by the results of the stability assessment. It is noted that the stability analyses assume that all topsoil and surficial deposits of fill, soft soils or soils containing organics (more than trace amounts) or other deleterious materials are removed within the footprint of the proposed widening and beyond the toe of the existing embankment. It is assumed that the existing County Road 4 embankment side slopes will be stripped of all topsoil and the exposed surface stepped prior to placing new engineered fill for the widened embankment as discussed in Section 6.12.4.

6.9.1 Method of Analysis and Parameter Selection

Two-dimensional limit equilibrium slope stability analyses were performed using the commercially available program Slide2 (Version 9.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving

forces tending to cause failure, and is equal to the inverse of the product of the consequence factor, Ψ , and the geotechnical resistance factor, ϕ_{gu} . (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$).

For this stability assessment, minimum Factors of Safety of 1.3 and 1.5 have been used for the design of the widened embankment heights and geometries at the culvert location for the short-term (undrained) and long-term (drained) conditions, as per Table 6.2 of the CHBDC (2019).

The stability analysis was carried out near Station 10+144, just south of the existing culvert location. The new embankment side-slopes were modelled at 2H:1V and the groundwater level was modelled consistent with the water level measured in the piezometers. The idealized cross section used in the analyses is shown on Figures 1 to 4. A conceptual stability analysis to model the feasibility of staged construction with a temporary protection system was also carried out at Station 10+144 as shown on Figure 5. It is noted that the assessment of temporary conditions is conceptual only for general assessment of the feasibility of the staging, and does not take account of any temporary protection system that will be designed by the Contractor's engineer.

For the non-cohesive deposits at this site, the effective stress parameters employed in the analyses were estimated from empirical correlations based on the results of in situ Standard Penetration Tests (SPT). The correlations proposed by Peck et al (1974) and U.S. Navy (1986) were also employed, and the results were adjusted by engineering judgment based on precedent experience in similar soil conditions.

For cohesive deposits, total and effective stress parameters were employed in the analyses to model both short-term, (undrained) and long-term (drained) conditions. The total stress parameters (i.e., average mobilized undrained shear strength – s_u) for the cohesive soils were assessed based on the results of in situ Standard Penetration Tests (SPT), vane tests, and estimated from correlations with laboratory index test results (i.e., water content, liquid limit, etc.), where appropriate. Effective stress parameters were selected similar to the method outlined above for the granular deposits.

A summary of the engineering parameters employed in the stability analyses are shown on Figures 1 to 5.

6.9.2 Results of Analyses

The results of selected stability analyses are presented on Figures 1 to 5. Figures 1 and 3 show the short-term (undrained) model and Figures 2 and 4 show the long-term (drained) model for the east and west sides of the embankment. Figure 5 shows the critical short-term (undrained) model of the temporary half-and-half condition for the staged construction. Figures 1 and 2 show a Factor of Safety of 2.1 was calculated, in both undrained and drained condition, against global instability at the east side. Figures 3 and 4 show a Factor of Safety of 2.2 and 1.6 was calculated (for the undrained and drained condition) against global instability on the west side. Figure 5 shows a Factor of Safety of 1.3 is calculated for the conceptual condition using a temporary protection system during staged construction. The design-build contractor will need to verify that temporary conditions are stable during future detail design.

In summary, the stability analyses adjacent to the proposed culvert replacement indicate the target minimum Factors of Safety of 1.3 and 1.5 (for short-term and long-term conditions) against deep-seated global failure are achieved for 2H:1V side-slopes. If and where flatter side slopes are adopted, equivalent or higher Factors of Safety would be anticipated.

6.10 Settlement

Settlement analyses were carried out to assess impacts to the new culvert based on the proposed embankment grade raise and widening. According to the conceptual design, the existing embankment is to be widened by about

8 on the east side and up to 1 m on the west side, with a grade raise of about 0.7 m above the existing County Road 4 ground surface at the new culvert location. The proposed widened embankment side-slopes are assumed to consist of Granular 'A' or 'B' Type II soils and were modelled to be sloped at 2H:1V at the culvert location. Alternate material types may have different unit weights, and the resulting settlement will also be impacted by the final side slope geometry.

6.10.1 Method of Analysis and Parameter Selection

Settlement analyses were carried out using the commercially available program Settle3 (Version 5.0), developed by Rocscience Inc. and assume that all topsoil and surficial layers of fill, soft soils or soils containing organics (more than trace amounts) or other deleterious materials are removed within the footprint of the proposed widening and beyond the toe of the existing embankment. It is assumed that the existing County Road 4 embankment side slopes will be stripped of topsoil and deleterious materials.

An idealized cross section near the culvert location was modelled based on the borehole information and representative engineering soil parameters estimated from empirical correlations based on the results of in situ Standard Penetration Tests (SPT) and vane testing and correlated with the drained modulus parameters provided in the CHBDC (2019). The final values were adjusted by engineering judgment based on precedent experience in similar soil conditions. A drained modulus (E') value of 10 – 20 MPa was used for the native clayey silt (upper cohesive) deposit and a drained modulus value of 100 MPa was used for the underlying predominantly hard glacial till and lower cohesive deposit. A groundwater level consistent with the water level measured in the piezometers was used for the analyses. The idealized section modelled is similar to the section shown in Figure 1 for the stability analyses.

6.10.2 Results of Analysis

The results of the settlement analyses carried out near the culvert replacement section indicate total settlements ranging from less than 10 mm (above the existing County Road 4 road surface) to about 20 mm to 25 mm near the crest of the proposed widened embankment on the east side. Given that only a thin sliver of fill widening is proposed on the west side near the culvert inlet, settlements are expected to be negligible (less than 5 mm) provided the surficial clayey silt deposit containing organics is removed from within the embankment widening footprint near the culvert inlet.

Given the general firm to hard consistency of the clayey foundation soils and presence of stiff to hard glacial till at relatively shallow depth, the majority of settlement is anticipated to occur during construction and within a few months following construction of the full embankment height.

Considering the new embankment fill will be placed over the existing embankment fill, some settlement of the existing fill can also be anticipated. Although estimating actual settlement of the existing variable fill soils is difficult to predict, based on the boreholes, the existing fill is predominantly granular and competent (compact to very dense) with pockets of clayey silt fill, while the existing cohesive fill has a stiff to hard consistency and is classified as sandy in many of the grain size distributions; thus, settlement of the existing fill is also anticipated occur during construction or within about 3 months of construction of the widened embankment to full height.

As a result, preloading of the culvert foundation soils is not considered necessary provided adequate stripping (and subexcavation for box culvert option) is carried out and provided the detail design of the culvert can tolerate settlements up to 25 mm.

It is recommended that the east embankment widening be allowed to preload for a minimum of 3 months as any post-construction settlements will be reflected at the ground / road surface. If the asphalt binder course is laid

shortly following the embankment fill placement, any settlement (including differential settlement at road surface leading up to and away from the culvert location) may be reflected by subsidence of the surface of the binder asphalt and should be compensated for by placing an additional thickness of binder asphalt or by padding. If possible, the surface course asphalt should not be placed over the binder course asphalt until for at least 3 months or preferably until after the Winter season if this is possible in the schedule. Where scheduling / staging requires surface course be placed over the binder course asphalt before this time period, differential settlements would be reflected by subsidence and possible cracking of the finished pavement surface in these areas which, depending on the extend and magnitude, may require local repairs. The new culvert must also be protected or designed to accommodate the temporary loading and potential settlements from the detour embankment on the west side of the site. Based on the concept design, the detour embankment will be less than 4 m thick above the new culvert and this, along with any stripping requirements, will need to be considered in the detail design.

6.11 Lateral Earth Pressures for Design of Culvert Walls

The lateral earth pressures acting on the culvert walls or any associated headwalls or retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the walls, and the drainage conditions behind the walls. Seismic (earthquake) loading may also be considered in the design as applicable.

The following recommendations are made concerning the design of the box culvert walls. These design recommendations and parameters assume level (horizontal at the surface) backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope:

- Free-draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular 'A', Granular 'B' Type I, or Granular 'B' Type II should be used as backfill behind the culvert walls. Compaction should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Other aspects of the granular backfill requirements with respect to frost taper should be in accordance with OPSD 803.010 (*Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC (2019) Section 6.12.3 and Figure 6.8. Other surcharge loadings should be accounted for in the design, as required.
- Granular fill should be placed in a zone with the width equal to at least 1.5 m (estimated frost penetration depth) behind the back of the wall, in accordance with Figure C6.31(a) of the *Commentary to the CHBDC* (2019). The pressures are based on the proposed embankment replacement and widening backfill material and the following parameters (unfactored) may be used:

Fill Type	Soil Unit Weight (kNm ³)	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22	0.43	0.27
Granular 'B' Type I/II	21/22	0.43	0.27

Fill Type	Soil Unit Weight (kNm ³)	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Existing Fill / Select Subgrade Material / Earth Borrow	20	0.50	0.33

6.12 Construction Considerations

6.12.1 Temporary Excavations

Temporary excavations for the culvert replacement in open cut will be up to about 6 m below existing road surface for the box culvert option and will extend through the existing fills, and into the underlying clayey silt to clayey silt-silt and silty clay. If an open footing culvert is selected, temporary excavations will be up to about 7.5 m below the existing road surface through the above-noted materials and may penetrate into the native silts and clayey silt-silt till soils. Groundwater was generally encountered up to about 1.3 m above the anticipated excavation depth for the box culvert option and up to about 2 m above the anticipated excavation depth of open footings. The highest groundwater levels were encountered on the west side of the site and generally decrease towards the east side.

All excavations must be carried out in accordance with Ontario Regulation 213 (*Ontario Occupational Health and Safety Act for Construction Projects*), as amended.

At the west side of the culvert, the surficial very soft to soft saturated cohesive soils containing organics are classified as Type 4 soil. The existing fills are classified as Type 3 soils. The firm to stiff clayey silt-silt soils and compact silt soils are classified as Type 3 soils. The stiff to hard clayey silt till to clayey silt-silt till soils is classified as a Type 2 soil above the water table and Type 3 soil below the water table. At the east side of the culvert, the non-cohesive loose fill and soft to firm silty clay soils are classified as Type 3 soil above the water table and Type 4 soil below the water table.

Temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes of 1 horizontal to 1 vertical (1H:1V) or flatter for Type 2 and 3 soils and side slopes of 3 horizontal to 1 vertical (3H:1V) or flatter for Type 4 soils.

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation.

6.12.2 Temporary Protection Systems

The use of temporary protection systems is required to facilitate the installation of the new culvert based on the conceptual construction staging in order to maintain traffic along County Road 4. Temporary protection systems may also be required for temporary extensions and decommissioning of the existing culvert.

The temporary protection systems must be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*) and Special Provision 105S09. The lateral movement of temporary shoring systems at this site must meet Performance Level 2 as specified in OPSS.PROV 539, provided that any adjacent utilities (if present) can tolerate this magnitude of deformation.

Both driven sheet pile and soldier pile and lagging walls are considered feasible as temporary protection systems at the culvert site for the depth of excavation associated with the culvert replacement. The temporary protection

system and socket depth will need to be designed by the Contractor to resist global and local instability during the temporary condition. Where required, additional lateral support may be provided by anchors or rakers. In the case of driven sheet piles, it is anticipated that sheet piles may be challenging to drive deep into the glacial till and/or may become damaged if attempted to drive / vibrate through potential cobbles/boulders that may be present. If deeper penetration of vertical elements is required, soldier piles could be drilled to and/or into the glacial till. A sample NSSP has been provided in Appendix D to address the presence of granular deposits and obstructions (i.e., cobbles/boulders) for installation of any temporary protection systems through the embankment fill and within the till deposit, for inclusion into the Design-Build Ready specifications.

The selection and design of the protection system will be the responsibility of the Contractor. However, the following geotechnical parameters are applicable for conceptual design of temporary protection systems based on the boreholes advanced near the sites:

Stratigraphic Unit	γ (kN/m ³)	ϕ' (°)	s_u^3 (kPa)	K_a^1	K_o^1	$K_p^{1,2}$
New fill (Compacted SSM or Earth)	20	33	--	0.29	0.45	3.39
New fill (Granular 'A' or 'B' Type I or II)	21-22	35-36	-	0.27	0.43	3.69
Existing compact to very dense gravelly sand to silty sand (fill)	20	31	--	0.32	0.49	3.10
Existing Stiff to very stiff clayey silt (fill)	20	29	50	0.35	0.52	2.88
Compact silt	20	31	-	0.32	0.49	3.10
Soft to hard clayey silt to clayey silt-silt	20-21	29	50	0.35	0.52	2.88
Stiff to hard clayey silt to clayey silt-silt (till)	22	32	100	0.31	0.47	3.20

1. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected behind or in front of the temporary protection systems, the coefficients should be corrected accordingly, as per the CFEM (2006) or other appropriate reference.
2. The total passive resistance below the base of the excavation (i.e. adjacent to the temporary protection system) may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the CHBDC (2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.
3. For cohesive deposits, an assessment for both the drained (ϕ') and undrained (s_u) cases should be made to establish the more conservative earth pressure condition for design.

6.12.3 Control of Groundwater and Surface Water

The groundwater level measured in the piezometers installed at the site ranges from about Elevation 252.1 m to Elevation 249.2 m, which is about 0.6 m to 1.3 m below the ground surface adjacent to the embankment and up to about 4.4 m to 7.3 m below the top of the existing highway embankment. The water level is approximately 0.2 m to 1.4 m above the proposed base of the excavations (including proposed sub-excavation) for the box culvert option and about 0.5 m to 2 m above the proposed founding level of the open footings. The higher water levels were encountered on the west side of the site (near the inlet) and where the natural drainage path is obstructed by the highway embankment fill.

Although seepage from the predominantly cohesive native soils is expected to be minor, unwatering/dewatering of groundwater perched within the non-cohesive embankment fill and of water-bearing non-cohesive soils below the groundwater level where encountered at subgrade level, as well as surface water control, will be required for excavation and construction of the culvert. The perched groundwater in non-cohesive soils should be lowered as near as practicable to the underlying less permeable cohesive soils; this will likely be achieved via dewatering from sumps and pumps for perched groundwater, although a system of sumps or shallow wells may be necessary where

silt/sand materials are present at and below the subgrade level. In this case, the groundwater level should be lowered to at least 0.5 m below the base of the excavation prior to carrying out subgrade inspection, placement and compaction of engineered fill, bedding or placement of working slab, and placement of the culvert segments and backfill.

Dewatering operations should be in general accordance with OPSS.PROV 902 (*Excavation and Backfilling – Structures*), as amended by either SP FOUN0003 (*Dewatering Structure Excavation*) if open footings are selected or SP517F01 (*Dewatering System, Temporary Flow Passage System*) if a box culvert is selected. It is recommended that a design engineer be required, and that the requirement for pre-construction survey be marked as not applicable in the fill-in sections for these special provisions. An example of the FOUN0003 NSSP is included in Appendix D for reference and inclusion in the Contract Documents.

Construction water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment, Conservation and Parks (MECP). Certain takings of groundwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP's Environmental Activity and Sector Registry (EASR), requiring a "Water Taking Plan" and a "Discharge Plan" (to be developed by the Design-Builder). A Category 3 PTTW would be required for water takings in excess of 400,000 L/day. The contractor will be responsible for obtaining any required discharge approvals.

Surface water should be directed away from the excavations at all times. For this reason, it is anticipated that temporary extensions to the existing culvert and temporary culvert(s) below the detour embankment will be required and these are the responsibility of the Design-Builder.

6.12.4 Embankment Widening Construction

Construction of the embankment widening near the culvert replacement should consist of engineered fill consisting of OPSS.PROV1010 Granular A, B Type I or II, or select subgrade material (SSM). Earth fill may be considered; however, its suitability would be dependent on the quality of the source, including its plasticity and water content. The engineered fill materials should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*) and OPSS.PROV 206 (*Grading*).

Fill placement on top of the existing (stripped) embankment side-slopes should be carried out as per OPSD 208.010 (*Benching of Earth Slopes*) to integrate the existing and new embankment fill.

6.12.5 Temporary Detour / Existing Culvert

It is noted that a temporary detour is proposed on the west side of the site to accommodate staging of the embankment widening and construction of the new bridge structure north of the culvert site. As a result, temporary extensions of the existing culvert are likely required to maintain drainage and storm water flows from the west side to the east side of the existing embankment. Design of the temporary drainage network and culvert extensions are the responsibility of the Contractor and any temporary culverts will need to be designed to accommodate the loading from any embankment fill for the proposed widened embankment and temporary detour embankment. The temporary culvert extensions will need to be removed and/or properly decommissioned (along with the existing culvert) in the later stages of construction. Decommissioning of the existing culvert may require unwatering and localized patching prior to filling the culvert with a suitable unshrinkable fill (or equivalent) to prevent future collapse of the culvert and to fill the void sufficiently to eliminate any preferred pathway for future embankment soil loss and/or groundwater flow into the culvert.

6.12.6 Analytical Testing of Construction Materials

The results of analytical tests carried out on two soil samples (clayey silt and sandy silty clay) are presented in Section 4.4 and in the Certificate of Analysis in Appendix C.

The analytical test results for sulphate were compared to CSA A23.1 Table 3 (*Additional requirements for concrete subjected to sulphate attack*) to assess the potential severity of sulphate attack on concrete during its service life. The sulphate concentrations measured on the soil samples are less than 0.1 per cent, which is below the Moderate degree of exposure (i.e., below the Class S3 exposure limits), and the degree of sulphate attack is considered “Negligible” according to Table 7.2 in MTO’s *Gravity Pipe Design Guidelines* (2014). Therefore, based on the soil samples tested, when the designer is selecting the exposure class for the concrete structure, the effects of sulphates from within the site soils in contact with any portion of the proposed structure constructed below the ground surface may not need to be considered.

The analytical test results of the soil samples for resistivity were compared to Table 3.2 of MTO’s *Gravity Pipe Design Guidelines* (2014), to assess the relative level of corrosion potential on buried steel in contact with soil. The resistivity values measured on the soil samples from Borehole CV1-01 and CV1-04 are 3,000 ohm-cm and 2,900 ohm-cm, indicating a “Moderate corrosiveness.” Given that the proposed structure will also be exposed to significant additional de-icing salt/chemicals in the future as part of the Bradford Bypass interchange, consideration should be given by the designer to designing a concrete structure for a “C” type exposure class as defined by CSA A23.1 Table 1.

The pH measured on the soil samples ranges from about 7.0 to 7.8, which is not considered to be detrimental to durability, according to the MTO *Gravity Pipe Design Guidelines* (2014).

Ultimately, it is the structural designer’s decision to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 (Durability Requirements) are satisfied.

6.12.7 Piezometer / Well Decommissioning

It is recommended that the groundwater level at the site be measured closer to the time of construction, in order for the Contractor to assess the dewatering / surface water infiltration flow diversion requirements during construction. The piezometers installed in Boreholes CV1-01 and CV1-04 should be decommissioned during construction and a Non-Standard Special Provision (NSSP) should be included in the Design-Build Ready specifications; an example NSSP for this purpose is attached in Appendix D.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Bryan Lui, E.I.T., a geotechnical engineer-in-training with Golder. Mr. Kevin J. Bentley, P.Eng., an MTO Foundations Designated Contact for Golder, reviewed this report. Ms. Lisa Coyne, P.Eng., also an MTO Foundations Designated Contact, conducted an independent quality control review of this report.

Golder Associates Ltd.



Bryan Lui, E.I.T.
Geotechnical Engineer-In-Training



Kevin J. Bentley, P.Eng.
MTO Foundations Designated Contact



Lisa Coyne, P.Eng.
MTO Foundations Designated Contact

BL/KJB/LCC/ml

Golder and the G logo are trademarks of Golder Associates Corporation

[https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/county road 4/03 - cr4 cv fidr/final fidr/19136074 - cr4 cv fidr - final.docx](https://golderassociates.sharepoint.com/sites/120387/project%20files/6%20deliverables/foundations/county%20road%204/03%20-%20cr4%20cv%20fidr/final%20fidr/19136074%20-%20cr4%20cv%20fidr%20-%20final.docx)

REFERENCES

- Canadian Geotechnical Society. 2006. *Canadian Foundation Engineering Manual (CFEM)*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code (CHBDC (2019)) and Commentary on CAN/CSA-S6-19*.
- Chapman, L.J. and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.
- Peck, R.B., Hanson, W.E., and Thornburn, T.H. 1974. *Foundation Engineering*, 2nd Edition, John Wiley and Sons, New York.
- Ministry of Transportation, Ontario. 2014. *Gravity Pipe Design Guidelines*.
- National Research Council of Canada. 2015. *National Building Code of Canada*
- Natural Resources Canada. 2015. *Geological Survey of Canada – Seismic Hazard Model for Canada*
- United Facilities Criteria, U.S. Navy, 1986. *NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures*, Alexandria, Virginia.

Commercial Software:

Slide2 (Version 9.0) by Rocscience Inc.

Settle3 (Version 5.0) by Rocscience Inc.

Ontario Occupational Health and Safety Act:

O.Reg. 213 Construction Projects (as amended)

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 212	Construction Specification for Earth Borrow
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 803	Construction Specification for Vegetative Cover
OPSS.PROV 804	Construction Specification for Temporary Erosion Control
OPSS.PROV 902	Construction Specification for Excavating and Backfilling – Structures
OPSS.PROV 1002	Material Specification for Aggregates, Concrete
OPSS.PROV 1004	Material Specification for Aggregates, Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less than or Equal to 3.0 m
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario

Special Provision

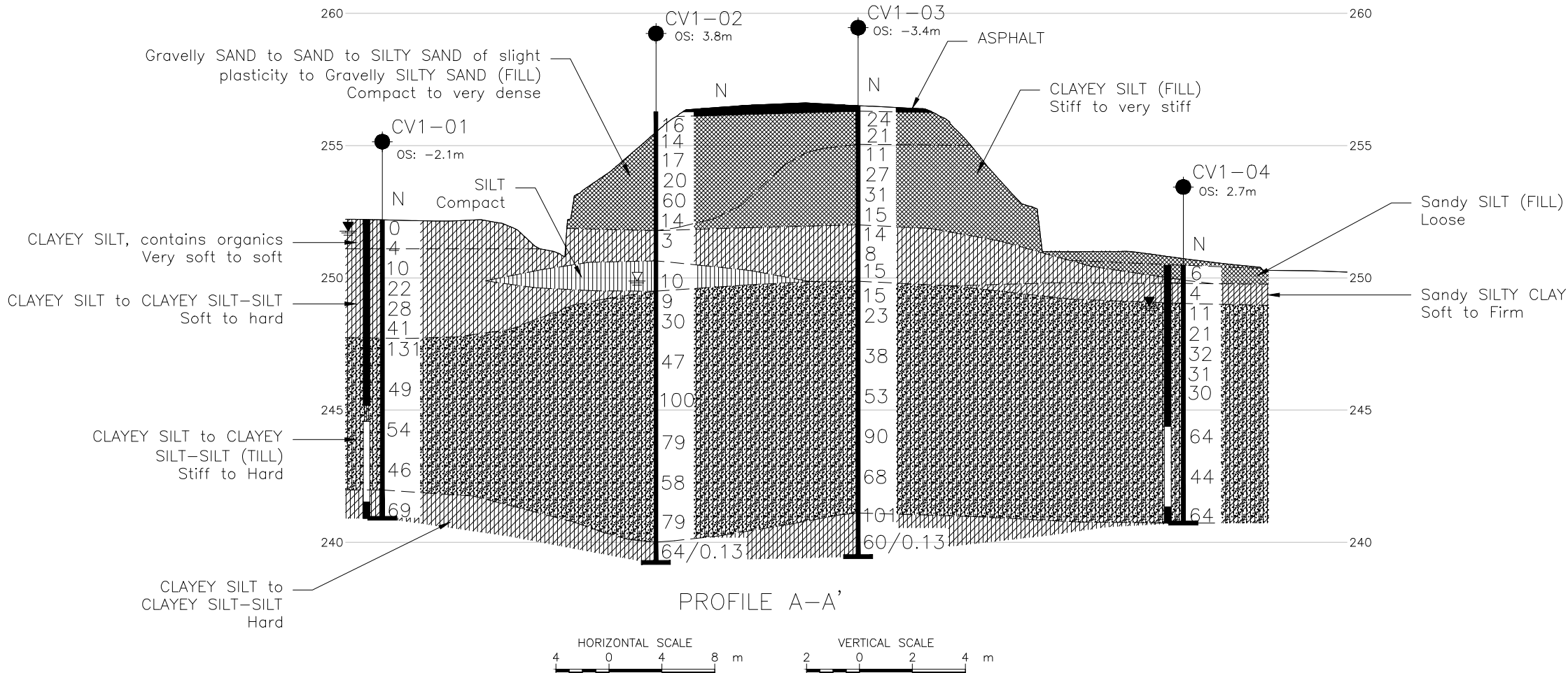
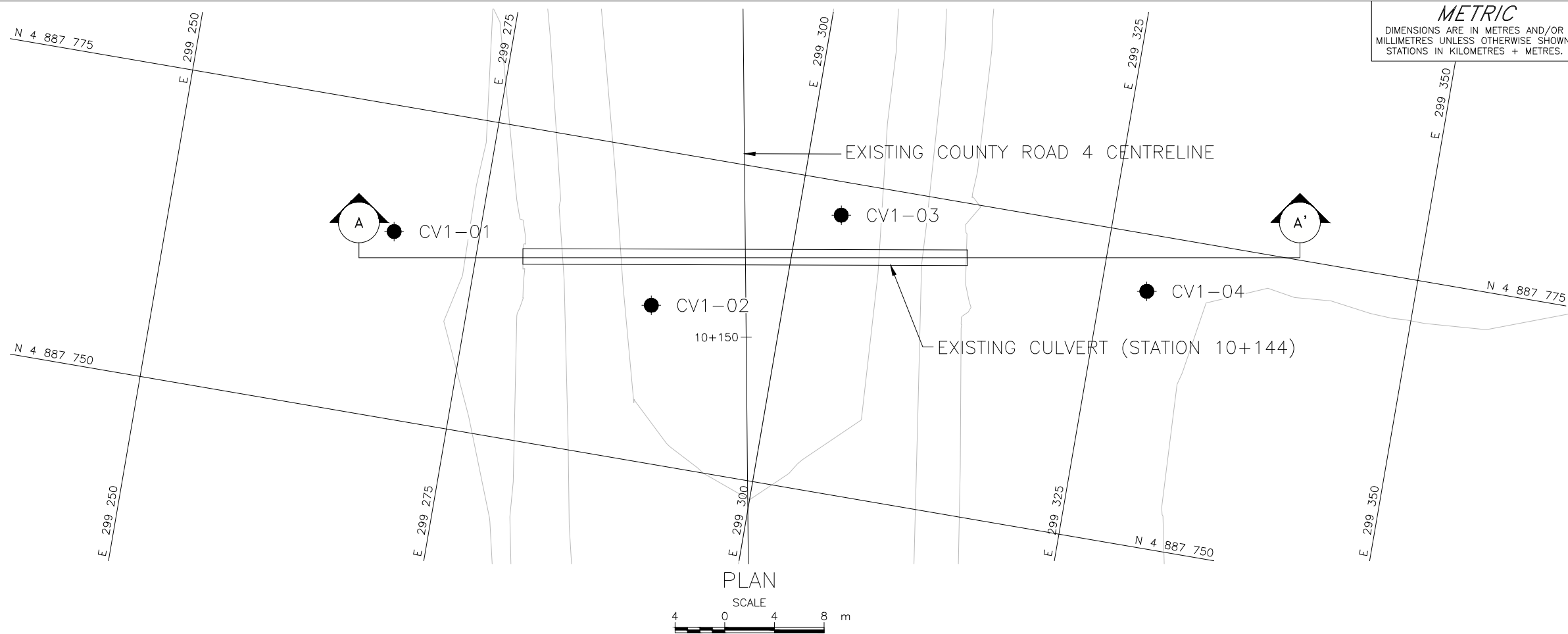
Special Provision 110S06 Amendment to OPSS.PROV 1010

Ontario Water Resources Act

O.Reg. 903 Wells (as amended)

Table 1: Comparison of Foundation Alternatives for Culvert Replacement

Options	Advantages	Disadvantages	Relative Costs	Risks / Consequences
Box Culvert Replacement	<ul style="list-style-type: none"> Minimizes depth of excavation, temporary excavation support system and dewatering requirements compared to open footing option. Pre-cast box sections expected to allow faster construction than cast-in-place open footings, with shorter duration for dewatering and surface water pumping / diversion. Can better accommodate differential settlement anticipated by placement of new embankment fill and construction staging. 	<ul style="list-style-type: none"> Subexcavation and replacement with engineered fill (up to 0.7 m) anticipated to be required Larger and deeper box may be required if special substrate is needed along invert to satisfy fisheries requirements, although not anticipated. 	<ul style="list-style-type: none"> Less overall cost relative to open footing culvert replacement due to shorter period of open excavation, shallower temporary support system and less effort for dewatering systems. 	<ul style="list-style-type: none"> May not satisfy specific fisheries requirements related to natural channel substrate, if applicable. Potential inflated costs or schedule delays for precast units related to pandemic.
Open Footing Culvert Replacement	<ul style="list-style-type: none"> Would satisfy fisheries requirements related to natural channel substrate, if applicable. May be feasible to build culvert replacement on pre-cast footing sections and three-sided precast culvert segments (segmented box), to accelerate construction schedule and reduce time for dewatering and surface water pumping, although cast-in-place footings are preferred. 	<ul style="list-style-type: none"> Excavation depths are greater than for box culvert option to found footings at/below frost depth, resulting in increased effort for temporary excavation support and dewatering requirements. Cast-in-place footings require longer duration for construction, including dewatering and surface water pumping, as compared with pre-cast culvert segments or footing elements. 	<ul style="list-style-type: none"> Greater overall cost relative to box culvert replacement due to deeper excavations which will result in additional time and effort related to temporary support systems and dewatering system operation. 	<ul style="list-style-type: none"> Longer construction time and deeper excavations (below groundwater) introduce greater risk to disturbance to open footing subgrade. Excavations and support systems will have to penetrate deeper into hard till possibly containing cobbles/boulders Groundwater levels will have to be lowered to greater depths. Less accommodating to differential settlement, although estimate of settlement is considered to be within tolerable limits.



CONT No. 2021-2124
WP No. 2008-21-00

BRADFORD BYPASS
SIMCOE COUNTY ROAD 4 CULVERT REPLACEMENT
BOREHOLE LOCATION PLAN AND
SOIL STRATA

SHEET



LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
CV1-01	252.2	4887764.9	299268.2
CV1-02	256.3	4887762.6	299289.6
CV1-03	256.5	4887772.3	299303.4
CV1-04	250.5	4887770.4	299328.7



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 final design configuration as shown elsewhere in the Contracts Documents.

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

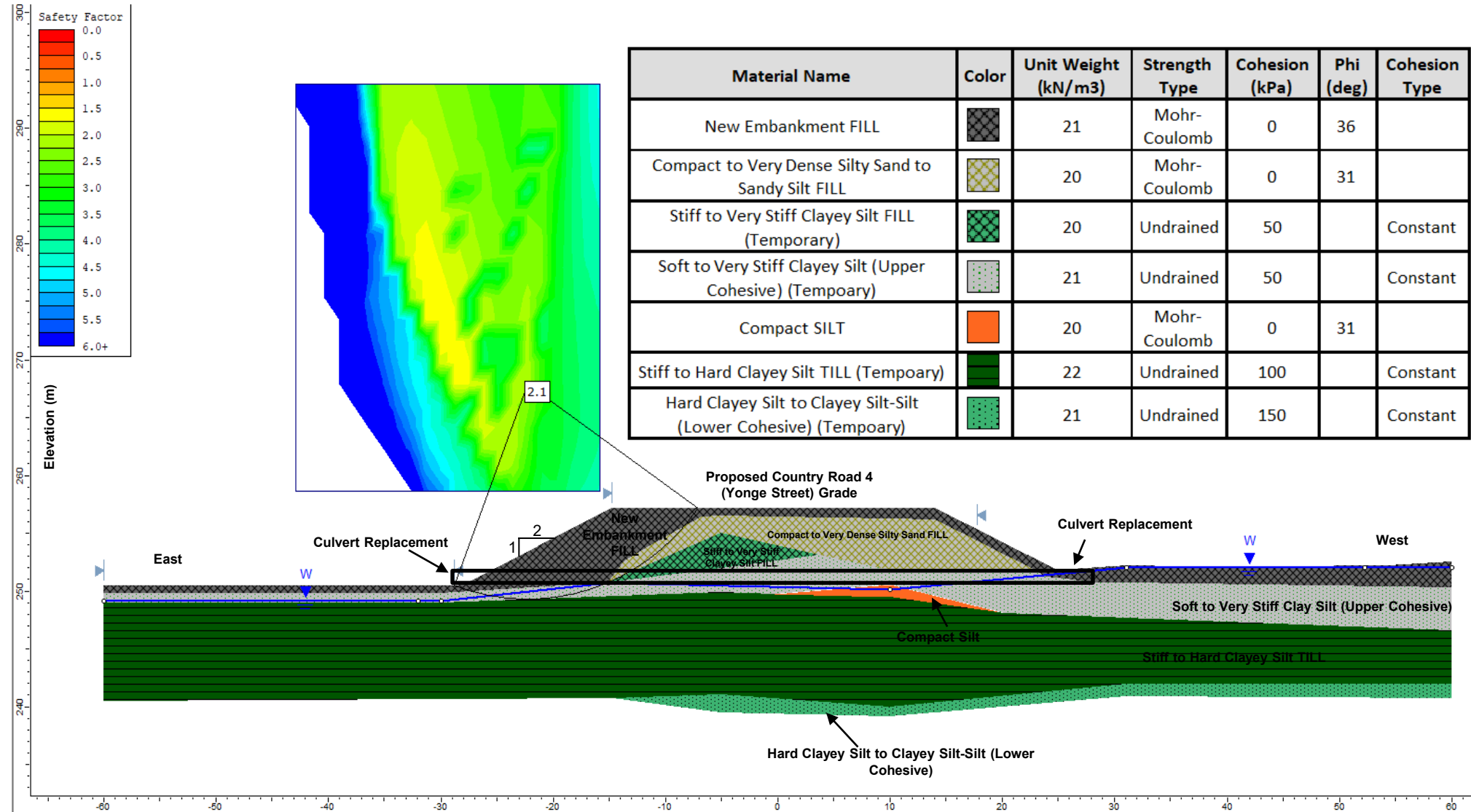
REFERENCE

Base plans provided in digital format by Aecom, drawing file no. 20-23507 Bradford Bypass.dwg, received November 3, 2021.
General arrangement provided in digital format by Aecom, file no. 01_County RD. UP OVER BBP_ga.dwg, received June 6, 2021.

NO.	DATE	BY	REVISION
Geocres No. 31D-787			
HWY. BRADFORD BYPASS	PROJECT NO. 19136074	DIST. .	
SUBM'D. BL	CHKD. BL	DATE: 1/18/2022	SITE: .
DRAWN: DD	CHKD. KJB	APPD. LCC	DWG. 1

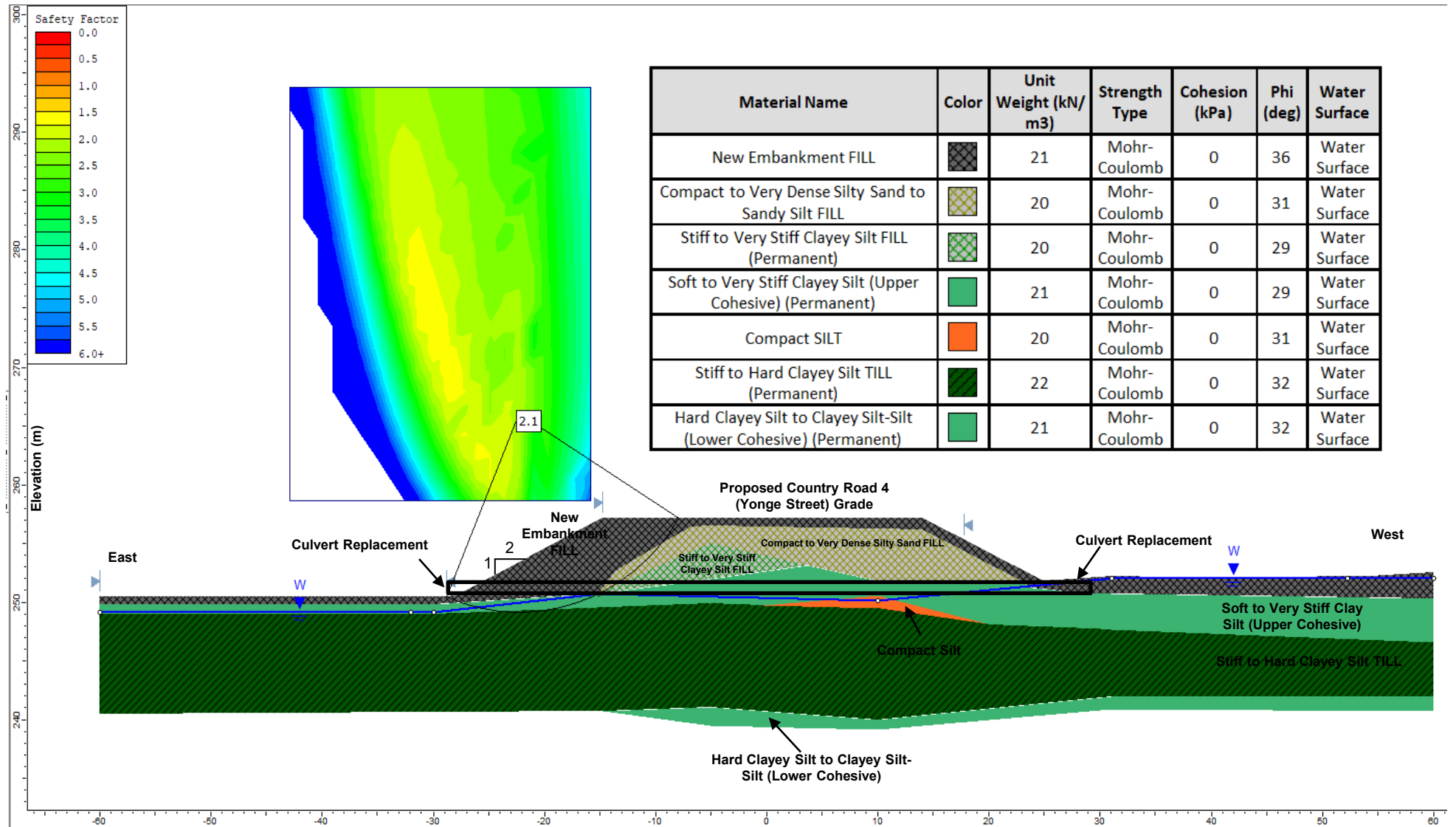
Global Stability at County Road 4 Culvert Replacement East Side Short-Term (Undrained) Condition

Figure 1



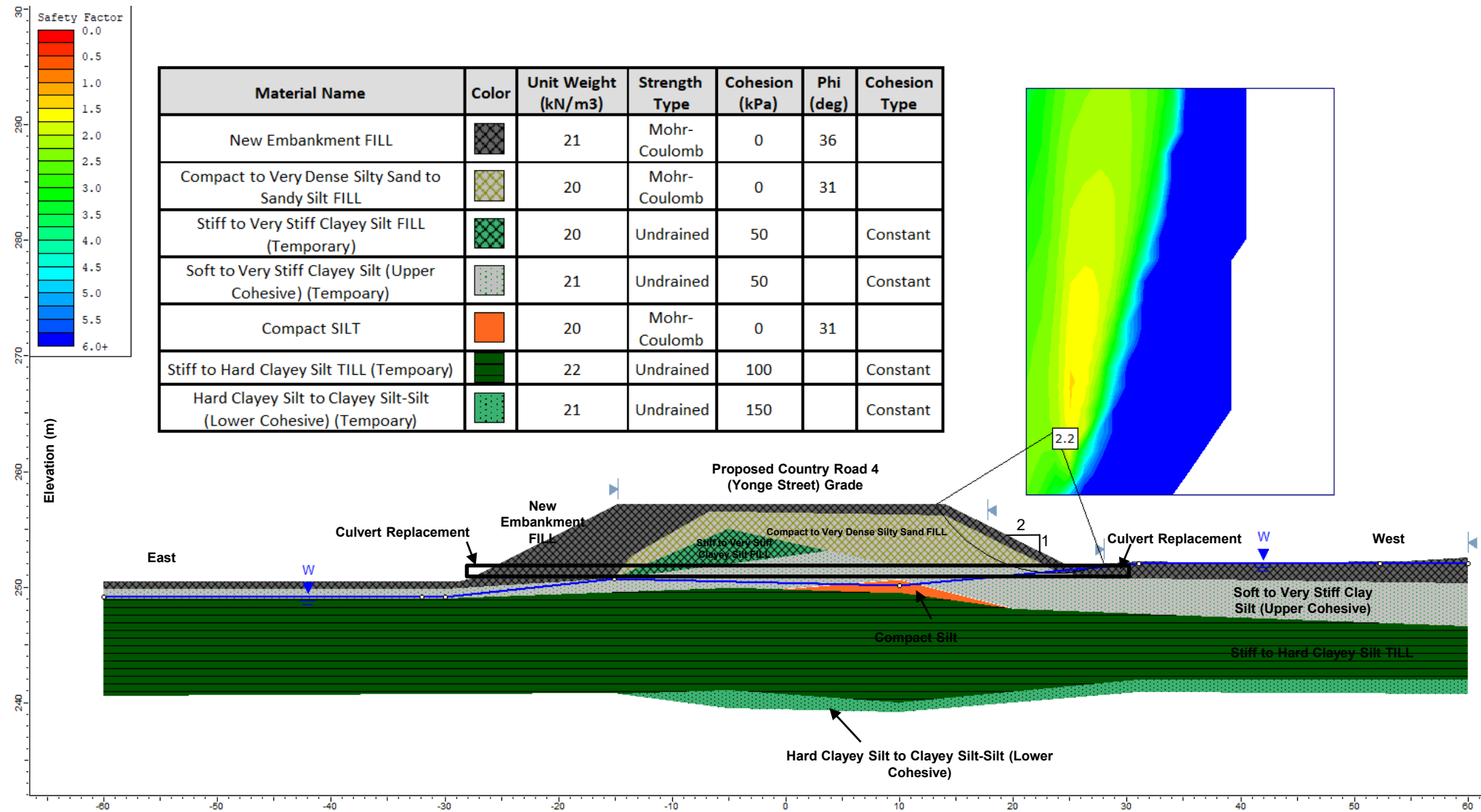
Global Stability at County Road 4 Culvert Replacement East Side Long-Term (Drained) Condition

Figure 2



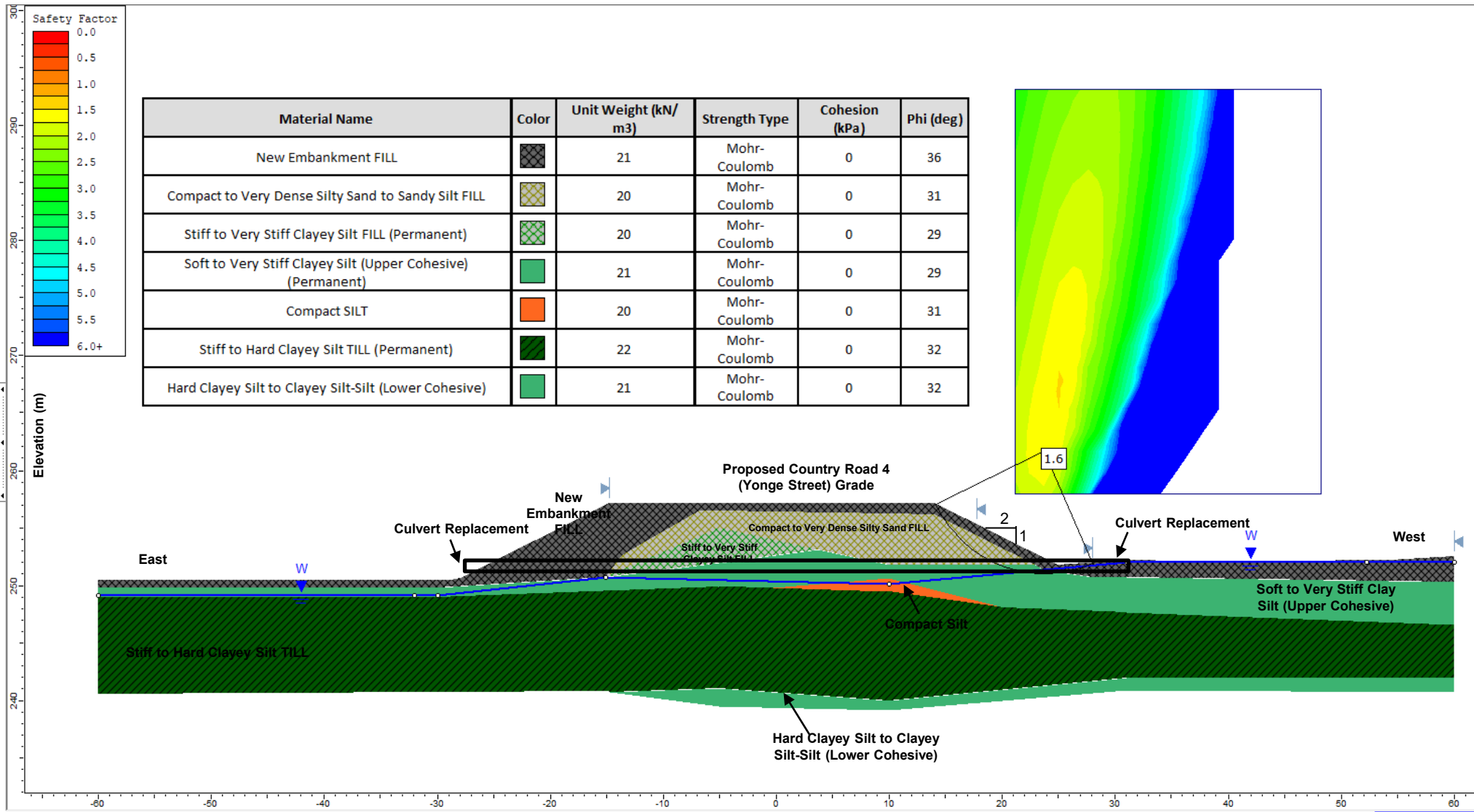
Global Stability at County Road 4 Culvert Replacement West Side Short-Term (Undrained) Condition

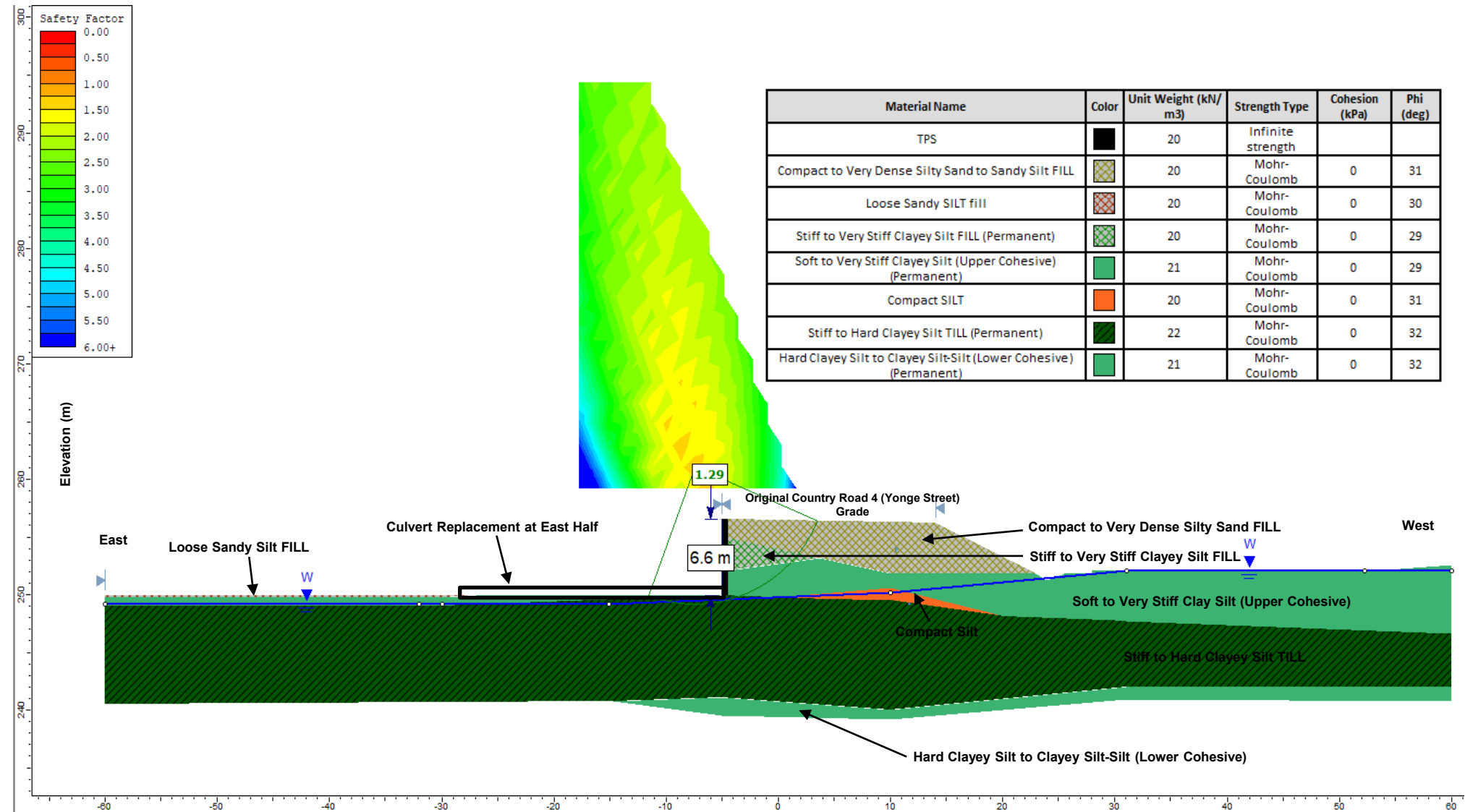
Figure 3



Global Stability at County Road 4 Culvert Replacement West Side Long-Term (Drained) Condition

Figure 4





APPENDIX A

Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse	19 to 75	0.75 to 3
	Fine	4.75 to 19	(4) to 0.75
SAND	Coarse	2.00 to 4.75	(10) to (4)
	Medium	0.425 to 2.00	(40) to (10)
	Fine	0.075 to 0.425	(200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (<i>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , trace fines)

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An 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 (*u*) and sleeve friction (*f_s*) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL, w _p	plastic limit
LL, 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
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
Y	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

COARSE-GRAINED SOILS

Compactness¹

Term	SPT 'N' (blows/0.3m) ²
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

- Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
- SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N' ^{1,2} (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)

σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_L or LL	liquid limit
w_P or PL	plastic limit
I_P or PI	plasticity index $= (w_L - w_P)$
NP	non-plastic
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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	modified 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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
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 or 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 $\gamma = \rho \cdot g$ (i.e., mass density multiplied by
acceleration due to gravity)

Notes: 1
2

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

PROJECT 19136074

RECORD OF BOREHOLE No. CV1-01

Sheet 1 of 2

METRIC

G.W.P. 2008-21-00

LOCATION N 4887764.9; E 299268.2 NAD83 / MTM zone 10 (LAT. 44.129859; LONG. -79.569128)

ORIGINATED BY DP

DIST Central HWY Bradford Bypass -
County Road 4

BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger

COMPILED BY ACK/BL

DATUM CGVD28 Surface Elevation:252.19 m

DATE Oct 14, 2021 -



CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined					PL W _p	NMC W	LL W _L							

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

PROJECT	19136074		RECORD OF BOREHOLE		No. CV1-01	Sheet 2 of 2	METRIC	
G.W.P.	2008-21-00		LOCATION	N 4887764.9; E 299268.2 NAD83 / MTM zone 10 (LAT. 44.129859; LONG. -79.569128)			ORIGINATED BY	DP
DIST	Central	HWY	Bradford Bypass - County Road 4	BOREHOLE TYPE	210 mm O.D. Hollow Stem Auger		COMPILED BY	ACK/BL
DATUM	CGVD28 Surface Elevation:252.19 m		DATE	Oct 14, 2021 -		CHECKED BY	KJB	

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined					PL W _p	NMC W	LL W _L	NP Nonplastic 20 40 60 80						
242.0 10.2	CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL) Hard Grey Moist CLAYEY SILT-SILT (CL-ML), trace sand Hard Grey Moist						242															
			11	SS	69													0	2	79	19	
240.9 11.28	End of Borehole Note: 1. Water level in piezometer measured at a depth of 0.6 m (Elev. 251.6 m) on November 25, 2021. 2. Water level in piezometer measured at a depth of 0.1 m (Elev. 252.1 m) on December 9, 2021.						241															
							240															
							239															
							238															
							237															
							236															
							235															
							234															
							233															

⁺3, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

PROJECT 19136074

RECORD OF BOREHOLE No. CV1-02

Sheet 1 of 2

METRIC

G.W.P. 2008-21-00

LOCATION

N 4887762.6; E 299289.6 NAD83 / MTM zone 10 (LAT. 44.129838; LONG. -79.568861)

ORIGINATED BY

MM

DIST Central HWY Bradford Bypass -
County Road 4

BOREHOLE TYPE

210 mm O.D. Hollow Stem Auger

COMPILED BY

ACK/BL

DATUM CGVD28 Surface Elevation:256.28 m

DATE

Jul 05, 2021 - Jul 06, 2021

CHECKED BY

KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined					PL W _p	NMC W	LL W _L							
0.0	ASPHALT (200 mm)																					
256.1	SILTY SAND (SM) of slight plasticity, some gravel to gravelly SILTY SAND (SM) (FILL) Compact to very dense Brown Moist - 0.8 to 1.0 m: pocket of clayey silt (CL) (between Elev. 255.5 m and Elev. 255.3 m) - 2.5 to 2.9 m: layer of sandy silt (ML) (between Elev. 253.8 m and Elev. 253.4 m) - 3.0 to 3.2 m: layer of sandy silt (ML) (between Elev. 253.2 m and Elev. 253.1 m)		1	SS	16																	
0.2			2a																			
			2b		SS	14																
			3		SS	17																
			4a																			
			4b		SS	20																
			5a																			
			5b		SS	60																
			6		SS	14																
4.5																						
251.8	CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel, trace organics, trace rootlets Soft to firm Brown Moist		7	SS	3																	
250.6	SILT (ML), trace sand Compact Grey Wet																					
5.6			8	SS	10																	
249.5	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL) Stiff to hard Brown to grey Moist - 9.1 m: becoming grey (Elev. 247.2 m)		9	SS	9																	
6.8			10	SS	30																	
			11	SS	47																	

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³⁰% STRAIN AT FAILURE

PROJECT	19136074		RECORD OF BOREHOLE		No. CV1-02	Sheet 2 of 2	METRIC	
G.W.P.	2008-21-00		LOCATION	N 4887762.6; E 299289.6 NAD83 / MTM zone 10 (LAT. 44.129838; LONG. -79.568861)			ORIGINATED BY	MM
DIST	Central	HWY	Bradford Bypass - County Road 4	BOREHOLE TYPE	210 mm O.D. Hollow Stem Auger		COMPILED BY	ACK/BL
DATUM	CGVD28 Surface Elevation:256.28 m		DATE	Jul 05, 2021 - Jul 06, 2021			CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE <div><div>0</div><div>10</div><div>20</div><div>30</div><div>40</div><div>50</div><div>60</div><div>70</div><div>80</div><div>90</div><div>100</div></div> <div><div>Field Vane</div><div>Remoulded</div><div>Pocket Pen</div><div>Quick Triaxial</div><div>Unconfined</div></div>	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT γ kN/m³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L							
							20	40	60	80	100	NP Nonplastic 20 40 60 80										
	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL) Stiff to hard Brown to grey Moist		12	SS	100		246															
							245															
			13	SS	79		244					OH					8	33	46	13		
							243															
			14	SS	58		242															
							241															
			15	SS	79		240															
240.0 16.3	CLAYEY SILT (CL) Hard Grey Moist		16	SS	64/130mm		240															
239.2 17.04	End of Borehole Note: 1) Water encountered at a depth of 6.1 m (Elev. 250.2 m) during drilling.						239															
							238															
							237															

+³, x³ : Numbers refer to Sensitivity o³⁰% STRAIN AT FAILURE

PROJECT 19136074

RECORD OF BOREHOLE No. CV1-03

Sheet 1 of 2

METRIC

G.W.P. 2008-21-00

LOCATION

N 4887772.3; E 299303.4 NAD83 / MTM zone 10 (LAT. 44.129926; LONG. -79.568688)

ORIGINATED BY

MM

DIST Central HWY Bradford Bypass -
County Road 4

BOREHOLE TYPE

210 mm O.D. Hollow Stem Auger

COMPILED BY

ACK/BL






DATUM CGVD28 Surface Elevation:256.50 m

DATE

Jun 25, 2021 - Jun 28, 2021

CHECKED BY

KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE <div><div>○●●●●×</div></div>	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) <div>Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined</div>					PL W _p	NMC W	LL W _L							
0.0	ASPHALT (200 mm)						20	40	60	80	100	NP Nonplastic	20	40	60	80						
256.3 0.2	Gravelly SAND (SP) to SAND (SP), some gravel (FILL) Compact Brown Moist		1	SS	24								○									
	- 1.1 to 1.4 m: layer of clayey sand (SC) (between Elev. 255.4 m and Elev. 255.1 m)		2a																			
255.0			2b	SS	21																	
1.4	CLAYEY SILT (CL), trace sand to sandy, some to trace gravel (FILL) Stiff to very stiff Brown to dark brown Moist		3a																			
	- 2.1 to 2.3 m: containing trace organics and dark brown (between Elev. 254.4 m and Elev. 254.2 m)		3b	SS	11																	
			4a										○									
			4b	SS	27																	
			5	SS	31																	
252.0	- 3.8 to 4.1 m: layer of silty sand (SM), some gravel (between Elev. 252.7 m and Elev. 252.4 m) - 4.1 to 4.4 m: cotaining rootlets and asphalt pieces (between Elev. 252.4 m and Elev. 252.1 m)		6a	SS	15									○								
			6b																			
4.5	CLAYEY SILT-SILT (CL-ML), some sand, trace gravel Firm to stiff Brown Moist		7	SS	14																	
			8	SS	8									○								
	- 6.1 to 6.7 m: no sample recovery		9	SS	15																	
249.7 6.8	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace to some gravel (TILL) Very stiff to hard Grey Moist			10	SS	15		⊕	×					⊕								
		11		SS	23																	
		12		SS	38																	

Continued on Next Page

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

PROJECT 19136074

RECORD OF BOREHOLE No. CV1-03

Sheet 2 of 2

METRIC

G.W.P. 2008-21-00

LOCATION

N 4887772.3; E 299303.4 NAD83 / MTM zone 10 (LAT. 44.129926; LONG. -79.568688)

ORIGINATED BY

MM

DIST Central HWY Bradford Bypass -
County Road 4

BOREHOLE TYPE

210 mm O.D. Hollow Stem Auger

COMPILED BY

ACK/BL

DATUM CGVD28 Surface Elevation:256.50 m

DATE

Jun 25, 2021 - Jun 28, 2021

CHECKED BY

KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE <div><div>○●●</div></div>
--------------	--	--	---------	--	--	---------------------------	--

+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

PROJECT 19136074

RECORD OF BOREHOLE No. CV1-04

Sheet 1 of 1

METRIC

G.W.P. 2008-21-00

LOCATION

N 4887770.4; E 299328.7 NAD83 / MTM zone 10 (LAT. 44.129909; LONG. -79.568372)

ORIGINATED BY

DP

DIST Central HWY Bradford Bypass -
County Road 4

BOREHOLE TYPE

210 mm O.D. Hollow Stem Auger

COMPILED BY

ACK/BL




DATUM CGVD28 Surface Elevation:250.48 m

DATE

Aug 26, 2021 - Aug 27, 2021

CHECKED BY

KJB

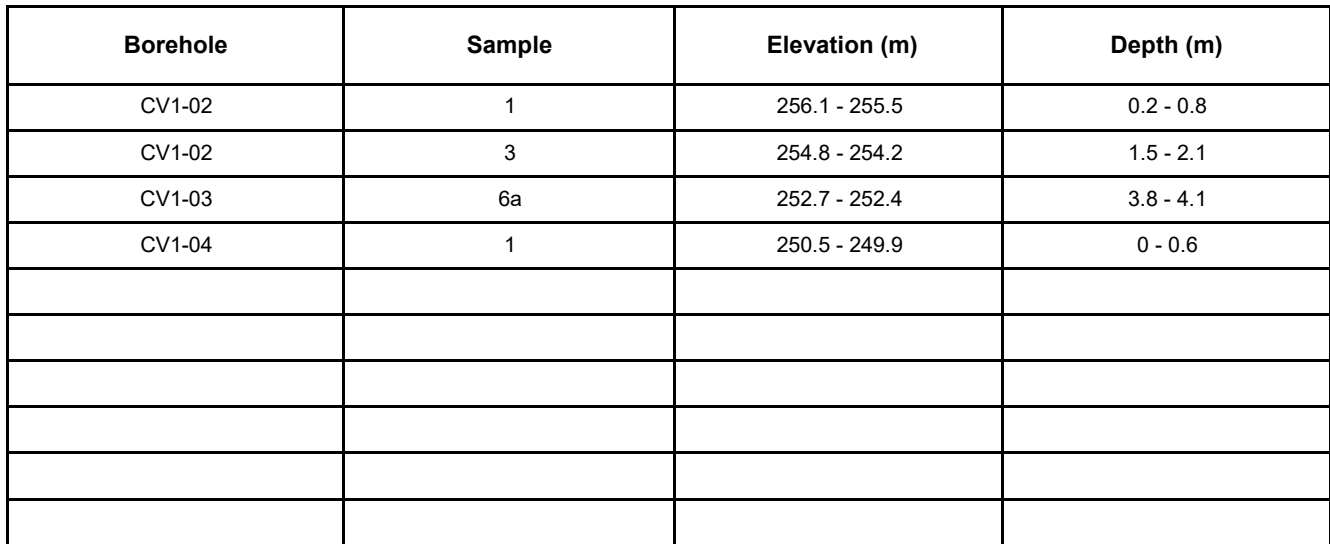
SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)				UNIT WEIGHT γ kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined					PL W _p	NMC W	LL W _L							
0.0	Sandy SILT (ML), trace clay, trace organics (FILL) Brown Moist Loose		1	SS	6		250											0	32	65	3	
249.8																						
0.7	Sandy SILTY CLAY (CI), trace organics Brown Moist Soft to firm		2	SS	4													0	17	37	46	
249.0							249															
1.4	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), some sand to sandy, trace gravel (TILL) Brown to grey Moist Stiff to hard		3	SS	11																	
			4	SS	21		248											8	18	39	35	
			5	SS	32		247															
	- 3.8 m: becoming grey (Elev. 246.7m)		6	SS	31																	
			7	SS	30		246															
	- 4.6 to 5.2 m: layer of sandy silt (ML) of slight plasticity TILL (between Elevation 245.9 m and Elevation 245.3 m)		8	SS	64													5	34	47	14	
			9	SS	44		243															
			10	SS	64		241															
240.7	End of Borehole																					
9.75	Note:																					

1. Water level in piezometer measured at a depth of 0.2 m
(Elev. 250.3 m) on November 25, 2021.2. Water level in piezometer measured at a depth of 1.3 m
(Elev. 249.2 m) on December 9, 2021.+³, x³: Numbers refer to Sensitivity o³% STRAIN AT FAILURE

APPENDIX B

Geotechnical Laboratory Test Results

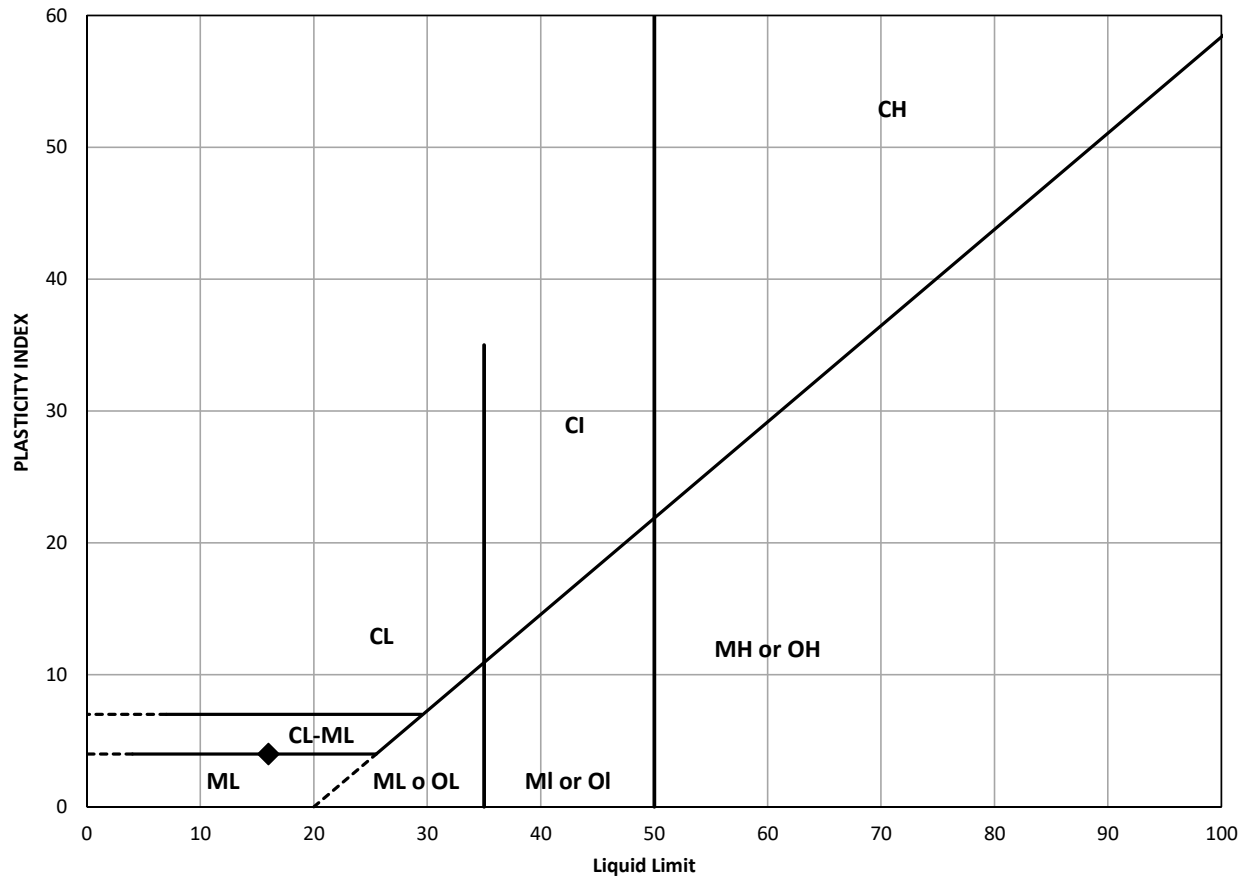
PATH: [https://goldeassociates.sharepoint.com/sites/120387/Project Files/6 Deliverables/Foundations/County Road 403 - CR4 CV FIDR/Appendix B - Lab Figures/excel working file](https://goldeassociates.sharepoint.com/sites/120387/Project%20Files/6%20Deliverables/Foundations/County%20Road%20403-%20CR4%20CV%20FIDR/Appendix%20B-%20Lab%20Figures/excel%20working%20file) | FILE NAME: B1 - Gran Size Chart_Rev 2.xlsm




B1



PLASTICITY CHART

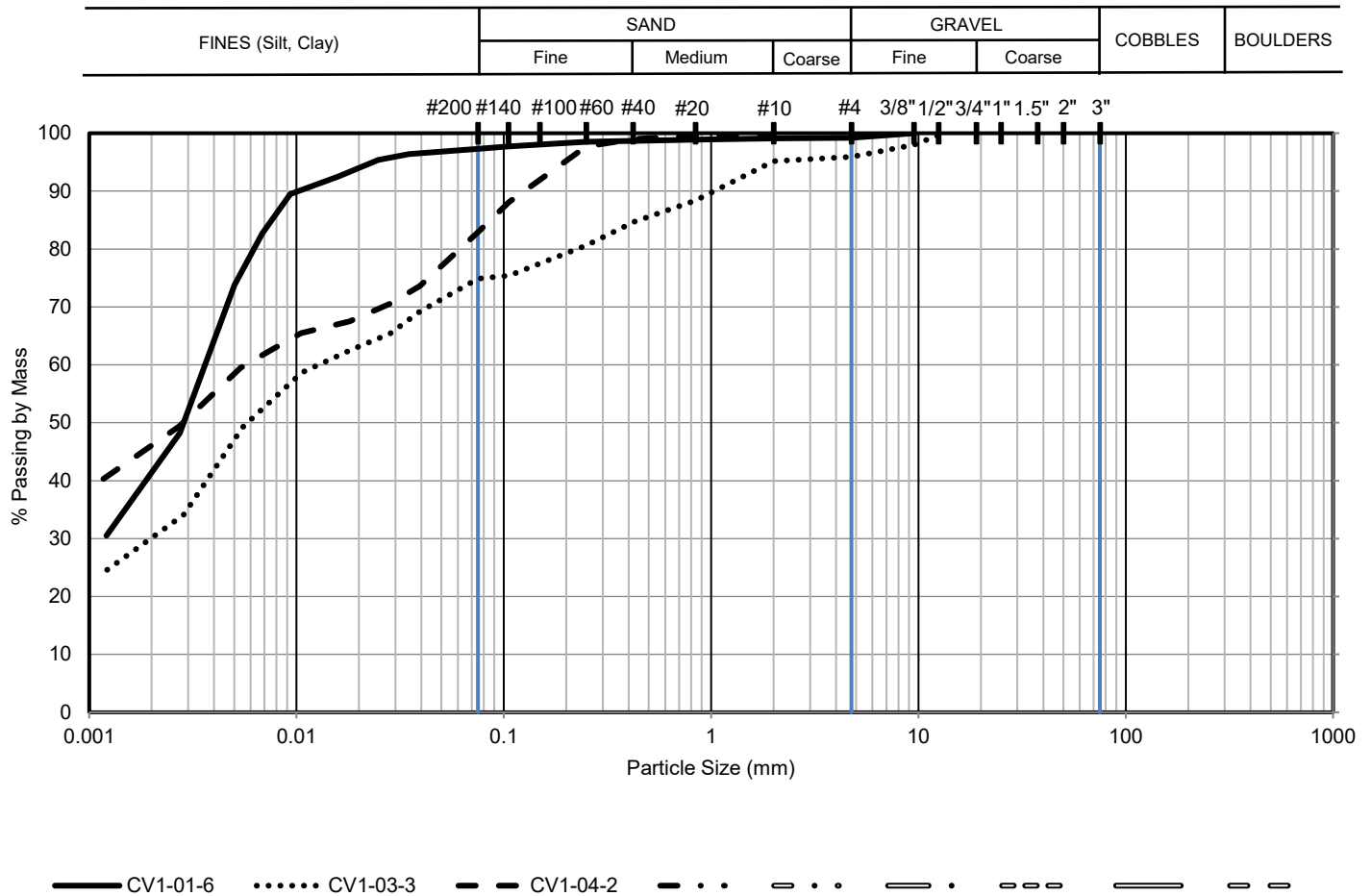


	Borehole	Sample / Specimen Number	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Notes		
◆	CV1-03	6a	3.8 - 4.1	16	12	4	Silty Sand Layer		


CLIENT		PROJECT			
AECOM / MTO		Bradford Bypass - County Road 4			
CONSULTANT	YYYY-MM-DD	2021-12-11	TITLE		
	DESIGNED	-	SILTY SAND LAYER - CLAYEY SILT (CL) (FILL)		
	PREPARED	BL			
	REVIEWED	KJB			
	APPROVED	KJB			
	PROJECT NO.	CONTROL	REV.	FIGURE	
	19136074	0	2	B2	

PATH: https://golderasociates.sharepoint.com/sites/120387/Project Files/6 Deliverables/Foundations/County Road 4/03 - CR4 CV FIDR/Appendix B - Lab Figures/excel working file | FILE NAME: Atterberg Output MTO_Rev 2.xlsm

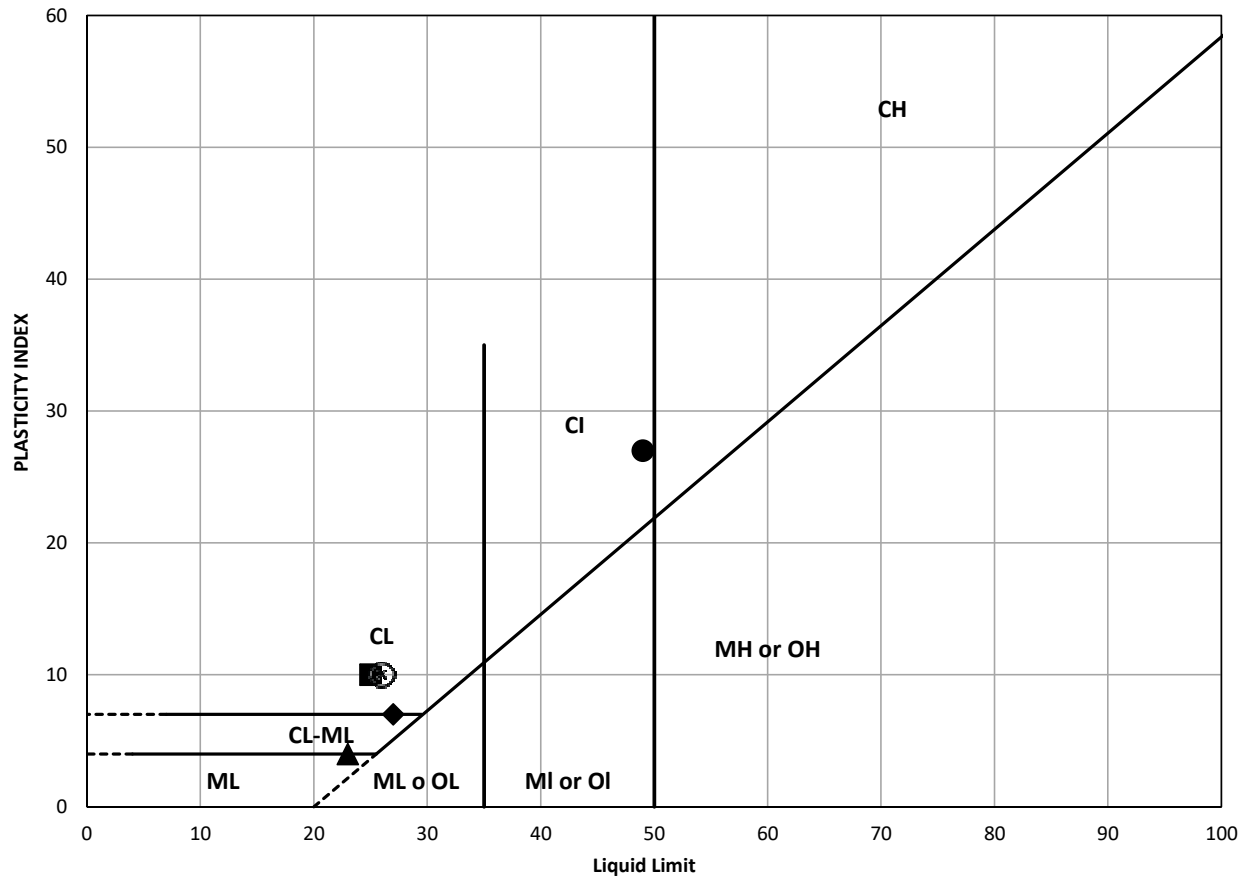
GRAIN SIZE DISTRIBUTION



Borehole	Sample Number	Elevation (m)	Depth (m)
CV1-01	3	250.7 - 250.1	1.5 - 2.1
CV1-01	6	248.4 - 247.8	3.8 - 4.4
CV1-04	2	249.7 - 249.1	0.8 - 1.4

CLIENT		PROJECT	
AECOM / MTO		Bradford Bypass - County Road 4	
CONSULTANT	YYYY-MM-DD	2021-12-11	
	DESIGNED	-	
	PREPARED	BL	
	REVIEWED	KJB	
	APPROVED	KJB	
 GOLDER MEMBER OF WSP		TITLE	
		Sandy SILTY CLAY (CI) to CLAYEY SILT (CL) (Upper Cohesive)	
PROJECT NO.		CONTROL	REV.
19136074		0	2
		FIGURE	
		B3	

PLASTICITY CHART



	Borehole	Sample / Specimen Number	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index				
⊗	CV1-01	3	1.5-2.1	26	16	10				
■	CV1-01	6	3.8 - 4.4	25	15	10				
◆	CV1-02	7	4.6 - 5.2	27	20	7				
▲	CV1-03	8	5.3 - 5.8	23	19	4				
●	CV1-04	2	0.8 - 1.4	49	22	27				

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass - County Road 4

CONSULTANT



YYYY-MM-DD	2021-12-11
DESIGNED	-
PREPARED	BL
REVIEWED	KJB
APPROVED	KJB

TITLE

Sandy SILTY CLAY (CI) to CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Upper Cohesive)

19136074

CONTROL

0

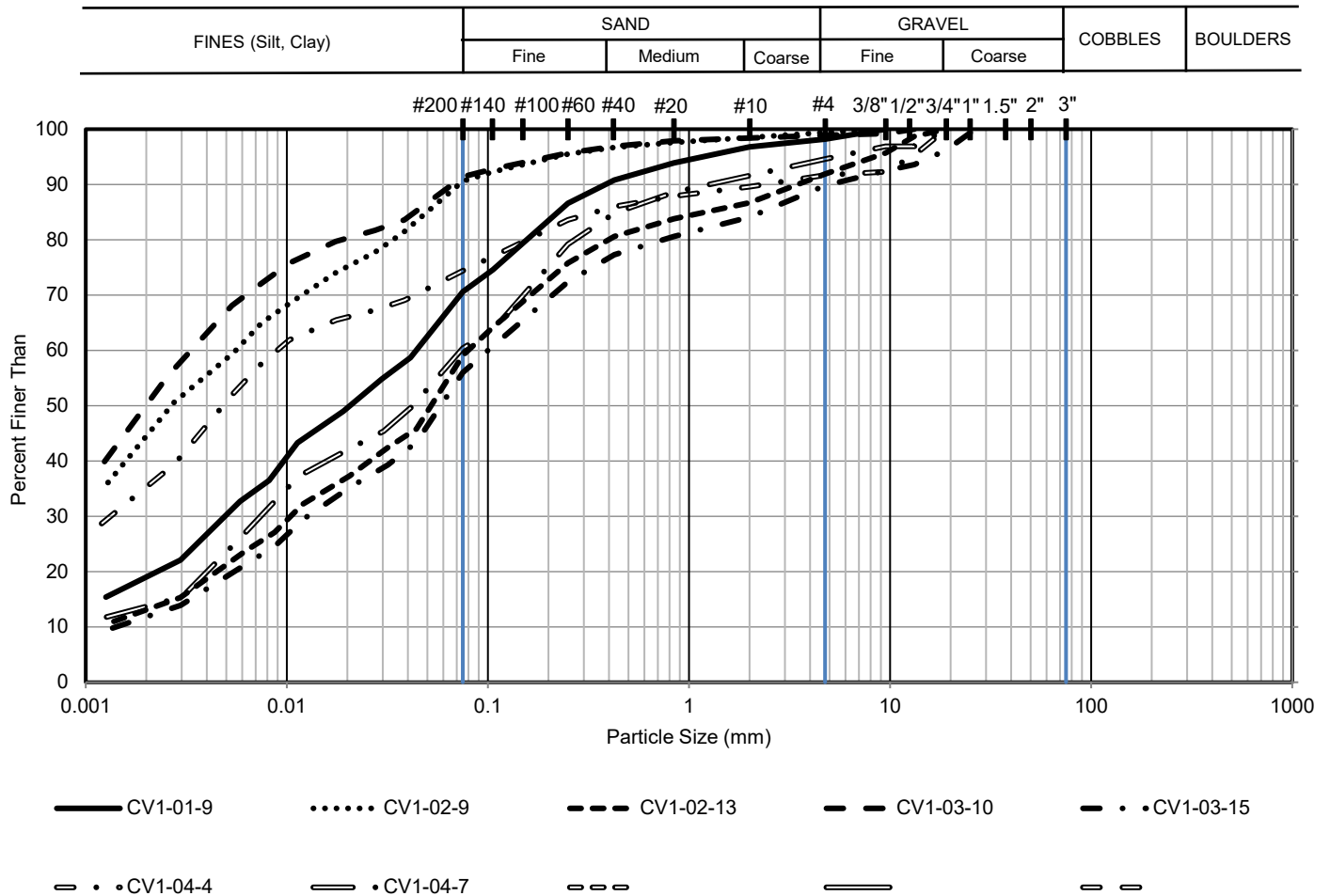
REV.

2

FIGURE

B4

GRAIN SIZE DISTRIBUTION



Borehole	Sample Number	Elevation (m)	Depth (m)
CV1-01	9	244.6 - 244.0	7.6 - 8.2
CV1-02	9	249.4 - 248.8	6.9 - 7.5
CV1-02	13	244.1 - 243.5	12.2 - 12.8
CV1-03	10	249.6 - 249.0	6.9 - 7.5
CV1-03	15	242.8 - 242.2	13.7 - 14.3
CV1-04	4	248.2 - 247.6	2.3 - 2.9
CV1-04	7	245.9 - 245.3	4.6 - 5.2

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2021-12-11

DESIGNED -

PREPARED BL

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass

TITLE

CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)

PROJECT NO.

19136074

CONTROL

0

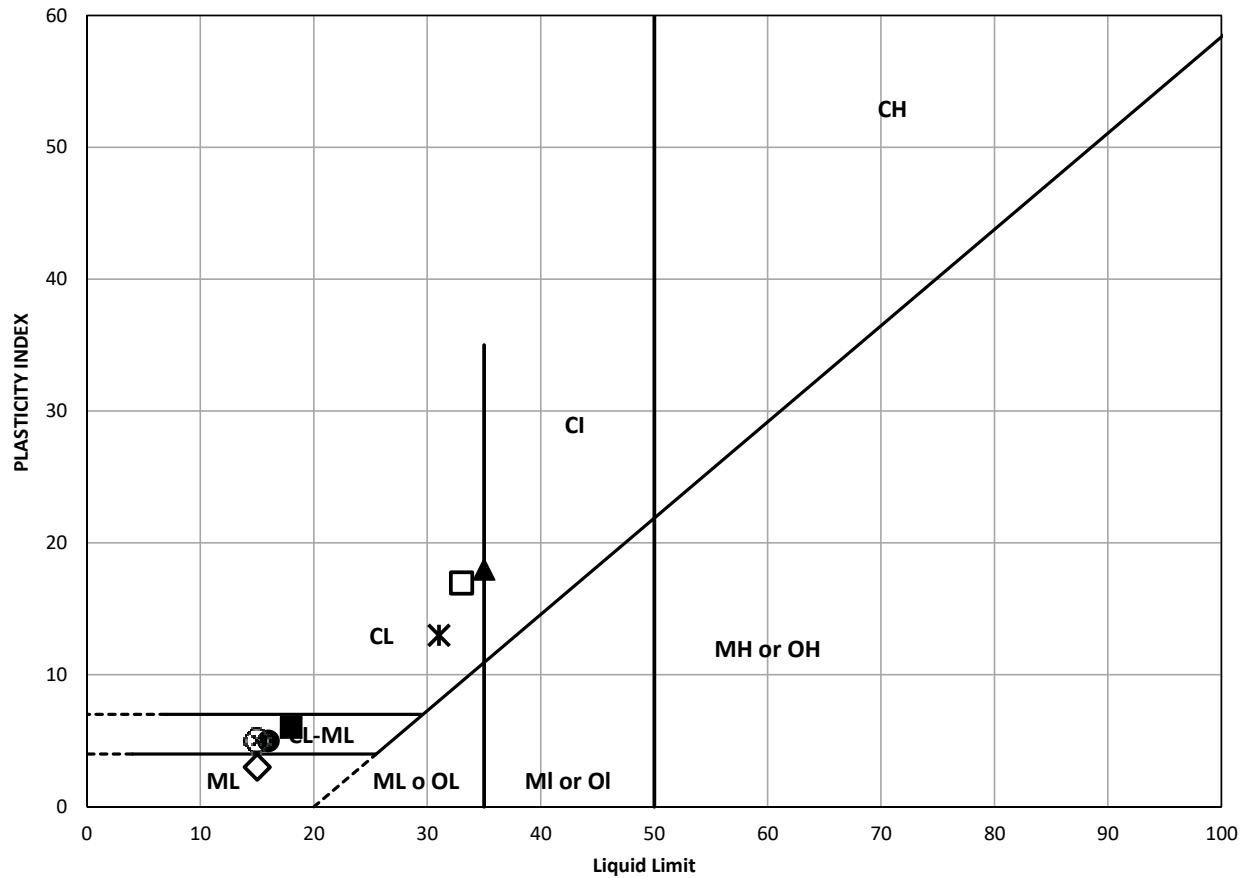
REV.

2

FIGURE

B5

PLASTICITY CHART

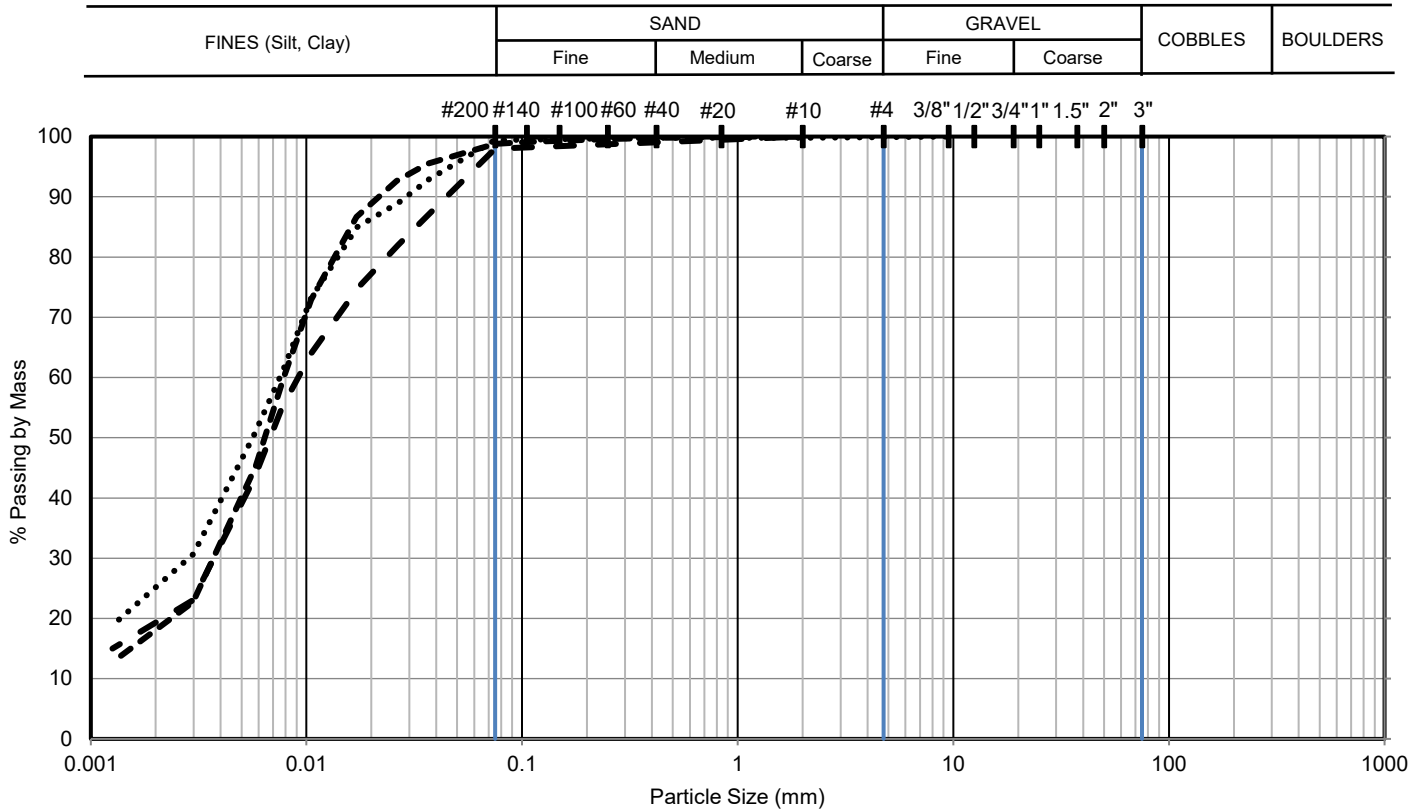


	Borehole	Sample / Specimen Number	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Notes		
■	CV1-01	9	7.6 - 8.2	18	12	6			
▲	CV1-02	9	6.9 - 7.5	35	17	18			
●	CV1-02	13	12.2 - 12.8	16	11	5			
*	CV1-03	10	6.9 - 7.5	31	18	13			
⊗	CV1-03	15	13.7 - 14.3	15	10	5			
□	CV1-04	4	2.3 - 2.9	33	16	17			
◇	CV1-04	7	4.6 - 5.2	15	12	3	Sandy Silt Layer		

CLIENT				PROJECT			
AECOM / MTO				Bradford Bypass - County Road 4			
CONSULTANT		YYYY-MM-DD		TITLE			
		2021-12-11		CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)			
		DESIGNED -					
		PREPARED BL					
		REVIEWED KJB					
		APPROVED KJB		PROJECT NO.	CONTROL	REV.	FIGURE
				19136074	0	2	B6

PATH: https://golderrassociates.sharepoint.com/sites/120387/Project Files/6 Deliverables/Foundations/County Road 4/03 - CR4 CV FIDR/Appendix B - Lab Figures/excel working file | FILE NAME: Atterberg Output MTO_Rev 2.xlsm

GRAIN SIZE DISTRIBUTION



..... CV1-02-16 - - - CV1-03-17 - - - CV1-01-11 - . . - . . - . . - . . - . . - . . - . .

Borehole	Sample Number	Elevation (m)	Depth (m)
CV1-01	11	241.5 - 240.9	10.7 - 11.3
CV1-02	16	239.5 - 239.2	16.8 - 17.0
CV1-03	17	239.7 - 239.5	16.8 - 17.0

CLIENT

AECOM / MTO

PROJECT

Bradford Bypass - County Road 4

CONSULTANT



YYYY-MM-DD 2021-12-11

DESIGNED -

PREPARED BL

REVIEWED KJB

APPROVED KJB

TITLE

CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Lower Cohesive)

PROJECT NO.

19136074

CONTROL

0

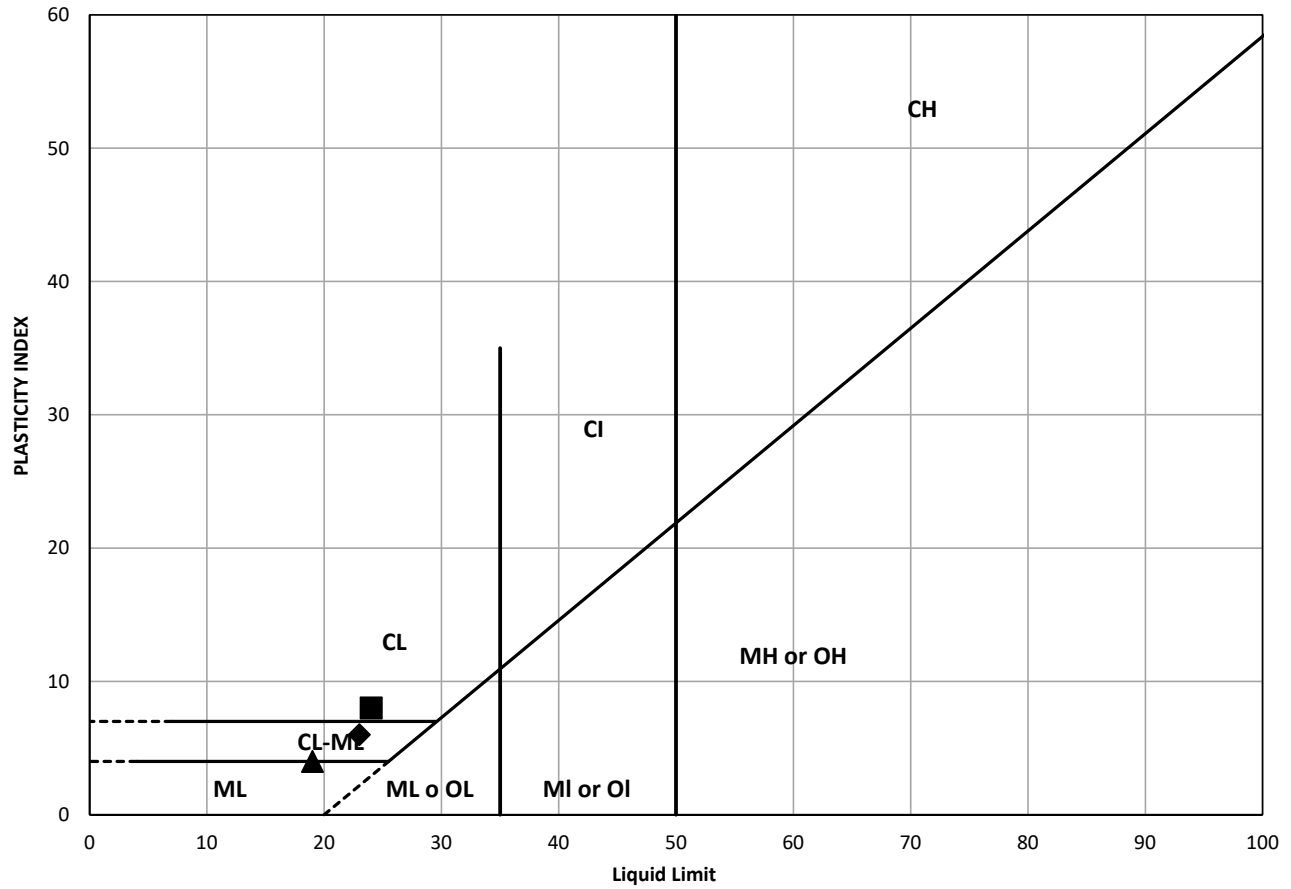
REV.

2

FIGURE

B7

PLASTICITY CHART



	Borehole	Sample / Specimen Number	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index				
▲	CV1-01	11	10.7 - 11.3	19	15	4				
■	CV1-02	16	16.8 - 17.0	24	16	8				
◆	CV1-03	17	16.8 - 17.0	23	17	6				

CLIENT				PROJECT			
AECOM / MTO				Bradford Bypass - County Road 4			
CONSULTANT		YYYY-MM-DD		2021-12-11		TITLE	
		DESIGNED		-		CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (Lower Cohesive)	
		PREPARED		BL			
		REVIEWED		KJB			
		APPROVED		KJB			
PROJECT NO.		CONTROL		REV.		FIGURE	
19136074		0		2		B8	

APPENDIX C

Analytical Test Results



Your P.O. #: 19136074
Your Project #: 19136074
Site Location: BRADFORD
Your C.O.C. #: N/A

Attention: Alysha Kobylinski

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

Report Date: 2021/10/25
Report #: R6870745
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1U4508

Received: 2021/10/19, 17:12

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2021/10/22	2021/10/22	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/10/22	2021/10/22	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2021/10/24	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2021/10/22	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2021/10/22	2021/10/22	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/10/20	2021/10/22	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/10/22	2021/10/22	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

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

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

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

(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE, Calgary, AB, T2E 6P8

(2) Offsite analysis requires that subcontracted moisture be reported.



Your P.O. #: 19136074
Your Project #: 19136074
Site Location: BRADFORD
Your C.O.C. #: N/A

Attention: Alysha Kobylnski

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

Report Date: 2021/10/25
Report #: R6870745
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1U4508
Received: 2021/10/19, 17:12

Encryption Key

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

=====

This report has been generated and distributed using a secure automated process.

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



BUREAU
VERITAS

Bureau Veritas Job #: C1U4508

Report Date: 2021/10/25

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD

Your P.O. #: 19136074

Sampler Initials: MTI

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		QZC436		
Sampling Date		2021/10/14		
COC Number		N/A		
	UNITS	CV1-01 SS #01	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	3000		7648263
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	24	20	7653603
Conductivity	umho/cm	334	2	7654176
Available (CaCl2) pH	pH	7.03		7653702
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	7653605
Sulphide	mg/kg	19.7	0.5	7655839
Physical Testing				
Moisture-Subcontracted	%	4.8	0.30	7659320
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				



BUREAU
VERITAS

Bureau Veritas Job #: C1U4508

Report Date: 2021/10/25

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD
Your P.O. #: 19136074
Sampler Initials: MTI

TEST SUMMARY

Bureau Veritas ID: QZC436
Sample ID: CV1-01 SS #01
Matrix: Soil

Collected: 2021/10/14
Shipped:
Received: 2021/10/19

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7653603	2021/10/22	2021/10/22	Avneet Kour Sudan
Conductivity	AT	7654176	2021/10/22	2021/10/22	Kien Tran
Moisture (Subcontracted)	BAL	7659320	N/A	2021/10/24	Kerstin Joyce Lague
Sulphide in Soil	SPEC	7655839	N/A	2021/10/22	Bailey Morrison
pH CaCl ₂ EXTRACT	AT	7653702	2021/10/22	2021/10/22	Taslima Aktar
Resistivity of Soil		7648263	2021/10/22	2021/10/22	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7653605	2021/10/22	2021/10/22	Avneet Kour Sudan



BUREAU
VERITAS

Bureau Veritas Job #: C1U4508

Report Date: 2021/10/25

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD

Your P.O. #: 19136074

Sampler Initials: MTI

GENERAL COMMENTS

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

Package 1	12.7°C
-----------	--------

Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C1U4508

Report Date: 2021/10/25

QUALITY ASSURANCE REPORT

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD

Your P.O. #: 19136074

Sampler Initials: MTI

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7653603	Soluble (20:1) Chloride (Cl ⁻)	2021/10/22	108	70 - 130	102	70 - 130	<20	ug/g	1.4	35
7653605	Soluble (20:1) Sulphate (SO ₄)	2021/10/22	102	70 - 130	101	70 - 130	<20	ug/g	NC	35
7653702	Available (CaCl ₂) pH	2021/10/22			100	97 - 103			0.53	N/A
7654176	Conductivity	2021/10/22			101	90 - 110	<2	umho/cm	5.2	10
7655839	Sulphide	2021/10/22	NC	75 - 125	110	75 - 125	<0.5	mg/kg		
7659320	Moisture-Subcontracted	2021/10/24					<0.30	%		

N/A = Not Applicable

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

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

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

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

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

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



BUREAU
VERITAS

Bureau Veritas Job #: C1U4508

Report Date: 2021/10/25

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD

Your P.O. #: 19136074

Sampler Initials: MTI

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Gita Pokhrel, Senior Analyst

Maria Magdalena Florescu, Ph.D., P.Chem., QP, Inorganics Manager

Ewa Pranjić, M.Sc., C.Chem, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/5

WORK ORDER

CHAIN OF CUSTODY RECORD

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name: Golder Associates Ltd.	Contact Name: Alysha Kobylinski	Company Name: same	Contact Name: _____	Quotation #: Golder rates	P.O. #/ AFER: 19136074	<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses	
Address: 6925 Century Ave., Suite 100	Phone: 647-239-0174 Fax: _____	Address: _____	Phone: _____ Fax: _____	Project #: 19136074	Site Location: Bradford	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Email: canadaaccounts@bvlabs.com; akobylinski@golder.com	Email: akobylinski@golder.com; 120387@golder.com	Email: _____		Site #: _____	Site Location Province: Ontario	Rush TAT (Surcharges will be applied) <input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days	
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY				Sampled By: _____		Date Required: _____	
Regulation 153 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table _____ FOR RSC (PLEASE CIRCLE) Y / N		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQO <input type="checkbox"/> Region _____ <input type="checkbox"/> Other (Specify) _____ REG 558 (MIN. 3 DAY TAT REQUIRED)		Analysis Requested FIELD FILTERED (CIRCLED) Metals / Hg / Cr / V BTEX / PHC / F1 PHC / F2 / F4 VOCs REG 153 METALS & INORGANICS REG 153 ICDMS METALS REG 153 METALS (Hg, Cr, V, ICDMS Metals, IWS - B) CORROSIVITY PACKAGE (+ SULPHIDE) HOLD - DO NOT ANALYZE		LABORATORY USE ONLY CUSTODY SEAL Present <input checked="" type="checkbox"/> Intact <input checked="" type="checkbox"/> COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> N COMMENTS	
Include Criteria on Certificate of Analysis: Y / N		SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS					
SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLED) Metals / Hg / Cr / V		
1 CV1-01 SS #01	2021-10-14	PM	Soil	2		2 JARS. NO REDOX POTENTIAL.	
2							
3							
4							
5							
6							
7							
8							
9							
10							
RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)		
Muhammad Talha Irshad	2021-10-19		Y. THOMPSON	21/10/19	17:12		

MSA with BV Signed May 18, 2020.
Golder standing offer rates in email from Julie Clement dated Sept 20, 2021.
Corrosivity package including chloride, conductivity, resistivity, pH, sulphate, sulphide is \$98.60/sample.

19-Oct-21 17:12

Ema Gitej

C1U4508

ENV 970

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas Laboratories' standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgement of the above.



Your Project #: 19136074
Site Location: BRADFORD, ON
Your C.O.C. #: NA

Attention: Alysha Kobylinski

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

Report Date: 2021/09/11
Report #: R6806324
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1O9516

Received: 2021/08/31, 17:09

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2021/09/03	2021/09/07	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/09/07	2021/09/07	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2021/09/05	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2021/09/03	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2021/09/03	2021/09/03	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/08/31	2021/09/07	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/09/03	2021/09/07	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

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

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

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

(1) This test was performed by Bureau Veritas Calgary via Mississauga

(2) Offsite analysis requires that subcontracted moisture be reported.



Your Project #: 19136074
Site Location: BRADFORD, ON
Your C.O.C. #: NA

Attention: Alysha Kobylnski

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

Report Date: 2021/09/11
Report #: R6806324
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1O9516
Received: 2021/08/31, 17:09

Encryption Key

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

=====

This report has been generated and distributed using a secure automated process.

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



BUREAU
VERITAS

BV Labs Job #: C109516
Report Date: 2021/09/11

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD, ON
Sampler Initials: DP

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		QNK728			QNK728		
Sampling Date		2021/08/28			2021/08/28		
COC Number		NA			NA		
	UNITS	CV1-04 SS2	RDL	QC Batch	CV1-04 SS2 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	2900		7552774			
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	91	20	7559715	84	20	7559715
Conductivity	umho/cm	344	2	7561625	351	2	7561625
Available (CaCl2) pH	pH	7.75		7559086			
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	7559718			
Sulphide	mg/kg	0.9 (1)	0.5	7572621			
Physical Testing							
Moisture-Subcontracted	%	23	0.30	7567648	26	0.30	7567648
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate (1) Sample contained greater than 10% headspace at time of extraction.							



BUREAU
VERITAS

BV Labs Job #: C109516

Report Date: 2021/09/11

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD, ON

Sampler Initials: DP

TEST SUMMARY

BV Labs ID: QNK728
Sample ID: CV1-04 SS2
Matrix: Soil

Collected: 2021/08/28
Shipped:
Received: 2021/08/31

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7559715	2021/09/03	2021/09/07	Alina Dobreanu
Conductivity	AT	7561625	2021/09/07	2021/09/07	Massarat Jan
Moisture (Subcontracted)	BAL	7567648	N/A	2021/09/05	Salini Vidhyadharan
Sulphide in Soil	SPEC	7572621	N/A	2021/09/03	Bailey Morrison
pH CaCl2 EXTRACT	AT	7559086	2021/09/03	2021/09/03	Neil Dassanayake
Resistivity of Soil		7552774	2021/09/07	2021/09/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7559718	2021/09/03	2021/09/07	Avneet Kour Sudan

BV Labs ID: QNK728 Dup
Sample ID: CV1-04 SS2
Matrix: Soil

Collected: 2021/08/28
Shipped:
Received: 2021/08/31

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7559715	2021/09/03	2021/09/07	Alina Dobreanu
Conductivity	AT	7561625	2021/09/07	2021/09/07	Massarat Jan
Moisture (Subcontracted)	BAL	7567648	N/A	2021/09/05	Salini Vidhyadharan



BUREAU
VERITAS

BV Labs Job #: C109516

Report Date: 2021/09/11

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD, ON

Sampler Initials: DP

GENERAL COMMENTS

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

Package 1	5.3°C
-----------	-------

Results relate only to the items tested.



BUREAU
VERITAS

BV Labs Job #: C109516

Report Date: 2021/09/11

QUALITY ASSURANCE REPORT

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD, ON

Sampler Initials: DP

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7559086	Available (CaCl ₂) pH	2021/09/03			100	97 - 103			0.14	N/A
7559715	Soluble (20:1) Chloride (Cl ⁻)	2021/09/07	NC	70 - 130	106	70 - 130	<20	ug/g	8.3	35
7559718	Soluble (20:1) Sulphate (SO ₄)	2021/09/07	103	70 - 130	96	70 - 130	<20	ug/g	1.8	35
7561625	Conductivity	2021/09/07			99	90 - 110	<2	umho/cm	2.0	10
7567648	Moisture-Subcontracted	2021/09/05					<0.30	%	13	20
7572621	Sulphide	2021/09/03	115	75 - 125	114	75 - 125	<0.5	mg/kg		

N/A = Not Applicable

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

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

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

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

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



BUREAU
VERITAS

BV Labs Job #: C109516

Report Date: 2021/09/11

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD, ON

Sampler Initials: DP

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Brad Newman, B.Sc., C.Chem., Scientific Service Specialist

Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/5

CHAIN OF CUSTODY RECORD

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name: Golder Associates		Company Name: ← Same		Quotation #:		<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses	
Contact Name: Alysha Kobylinski		Contact Name:		P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Address: 6925 Century Ave, Suite 100		Address:		Project #: 19136074		Rush TAT (Surcharges will be applied)	
Mississauga, ON				Site Location: Bradford, ON		<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days	
Phone: 647-239-0174 Fax:		Phone: Fax:		Site #:		Date Required:	
Email: akobylinski@golder.com		Email: akobylinski@golder.com		Site Location Province: ONTARIO		Rush Confirmation #:	
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY				Sampled By: DP/AK			
Regulation 153		Other Regulations		Analysis Requested		LABORATORY USE ONLY	
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine		<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw		<div>FIELD FILTERED (CIRCLE) Metals / Hg / CrVI</div> <div>BTEX / PHC F1</div> <div>PHCs F2 - F4</div> <div>VOCs</div> <div>REG 153 METALS & INORGANICS</div> <div>REG 153 ICPMS METALS</div> <div>REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)</div> <div>CORROSIVITY PACKAGE</div> <div>HOLD - DO NOT ANALYZE</div>		CUSTODY SEAL Y / N	
<input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse		<input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw				Present Intact	
<input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other		<input type="checkbox"/> PWQO Region				COOLER TEMPERATURES	
<input type="checkbox"/> Table _____		<input type="checkbox"/> Other (Specify) _____				4/6/6	
FOR RSC (PLEASE CIRCLE) Y / N		<input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)				COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> Y / N	
Include Criteria on Certificate of Analysis: Y / N						COMMENTS	
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS						2 jars.	
SAMPLE IDENTIFICATION		DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED		
1	CV1-04 SS2	2021-08-28	PM	Soil	2		
2							
3							
4							
5							
6							
7							
8							
9							
10							
RELINQUISHED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Alysha Kobylinski		2021/08/31	4:40 PM	Jaymuthan / Rouse		2021/08/31	17:09

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Bureau Veritas Laboratories' standard Terms and Conditions. Signing of this Chain of Custody is subject to the terms available at <http://www.bvlabs.com/terms-and-conditions>

31-Aug-21 17:09

Ema Gitej



C109516

DOE ENV 005

APPENDIX D

Non-Standard Special Provisions

WORKING SLAB - Item No.

Special Provision

1.0 SCOPE

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

2.0 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 902 Excavating and Backfilling - Structures

3.0 DEFINITIONS - Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS - Not Used

5.0 MATERIALS

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

6.0 EQUIPMENT - Not Used

7.0 CONSTRUCTION

7.01 Excavation

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

7.02 Protection of Founding Soil

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

7.03 Protection of Founding Bedrock - N/A

The surface of the footing founding rock shall be exposed, cleaned and any loose or fractured parts removed so that sound rock is exposed. The working slab shall be placed on the exposed cleaned sound founding rock surface as specified in the Contract Documents.

Thickness of the mass concrete pad shall depend on the slope and irregularities in the exposed founding rock surface. A nominal thickness and a footprint plan view area has been specified on the Contract Documents

7.04 Dewatering

Dewatering shall be carried out according to OPSS 902 and any Special Provisions.

8.0 QUALITY ASSURANCE - Not Used

9.0 MEASUREMENT FOR PAYMENT - Not Used

10.0 BASIS OF PAYMENT

10.01 Working Slab - Item

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

DEWATERING STRUCTURE EXCAVATIONS - Item No.

Special Provision No. FOUN0003

Amendment to OPSS 902, November 2019

902.02 REFERENCES

Section 902.02 of OPSS 902 is amended by the addition of the following:

Ontario Provincial Standard Specifications, Construction

OPSS 517 Dewatering
OPSS 805 Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

Section 902.03 of OPSS 902 is amended by the addition of the following:

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a 2- year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

902.04.02 Submission Requirements

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

902.04.02.01 Preconstruction Survey

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of 50 metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website <https://www.ontario.ca/environment-and-energy/map-well-records> or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

902.04.02.02 Working Drawings

Working Drawings for the dewatering system shall be according to OPSS 517.

902.07 CONSTRUCTION

902.07.04 Dewatering Structure Excavation

Subsection 902.07.04 of OPSS 902 is amended by the addition of the following clauses:

902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

902.07.04.05 Removal

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTICE TO CONTRACTOR – Soil Conditions / Obstructions

Special Provision

The Contractor is advised that excavations required in this Contract will be advanced through granular fill materials (where present), various interlayers of granular and native material through/into cohesive soils which may contain lenses or layers of potentially saturated cohesionless soils. The granular soils could slough (if dry) or flow (if water-bearing) into unsupported auger holes during caisson / drilled pile installations for temporary protection systems. Appropriate construction procedures and equipment shall be implemented to eliminate ground loss during installation of temporary protection systems. The Contractor shall give due consideration to using temporary liners or tremie concreting techniques where conditions warrant.

The Contractor is also advised that the soils throughout the project area are glacially-derived and contain cobbles and boulders (cobbles are defined as rock fragments that cannot pass through a screen with 75 mm square openings, but that are less than 300 mm in maximum dimension; boulders are defined as rock fragments with their maximum dimension equal to or greater than 300 mm) which could affect the installation of foundations and/or temporary protection systems. Appropriate equipment and procedures shall be implemented for excavations, installation of the foundations and temporary protection systems to penetrate or remove obstructions (cobbles and boulders), and advance into the stiff to hard till deposit, to depths/elevations specified in the Contract.

DECOMMISSIONING OF PIEZOMETERS – Item No.

Special Provision

1.0 SCOPE

This special provision covers the requirements for the decommissioning of the piezometers located within the project limits.

Two Standpipe piezometers were installed in Borehole CV1-01 and CV1-04. The piezometers have been left in place to allow for monitoring of groundwater levels up to the time of construction. The piezometer location (relative to MTM NAD 83 Zone 10 and in latitude and longitude), piezometer diameter, borehole diameter, and piezometer depth are summarized below.

Standpipe Piezometer Identification	Approximate Location		PVC Pipe and Screen diameter / Borehole diameter	Depth (Below Ground Surface) to Tip of Screen
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
CV1-01	4,887,764.9 (44.129859)	299,268.2 (-79.569128)	50 mm / 210 mm	10.7 m
CV1-04	4,887,770.4 (44.129909)	299,328.7 (-79.568372)	50 mm / 210 mm	9.1 m

2.0 REFERENCES – Not Used

3.0 DEFINITIONS – Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS – Not Used

5.0 MATERIALS – Not Used

6.0 EQUIPMENT – Not Used

7.0 CONSTRUCTION

As part of the construction activities, the Contractor shall properly decommission the standpipe piezometers prior to the start of the construction works. The abandonment / decommissioning method for standpipe piezometers shall satisfy at least the minimum requirements of Ontario Regulation 903 Wells, as amended under the Ontario Water Resources Act.

In addition, the Contractor shall provide a written record of the decommissioning procedure to the Contract Administrator. The record shall include plugging material used, depth of plugging material and limit of the PVC standpipe/screen removal.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT – Not Used

10.0 BASIS OF PAYMENT

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



golder.com