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# Foundation Investigation and Design Report

*Bradford Bypass / Simcoe County Road 4 (Yonge Street) Underpass and High Fill Embankment Widening Hwy 400 - Hwy 404 Link (The Bradford Bypass)*
*Bradford, Ontario  G.W.P 2008-21-00*

Submitted to:

**AECOM**

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# PART A

## FOUNDATION INVESTIGATION REPORT
## BRADFORD BYPASS / SIMCOE COUNTY ROAD 4 (YONGE STREET) UNDERPASS AND HIGH FILL EMBANKMENT WIDENING
## 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 design of the proposed Bradford Bypass / County Road 4 Underpass bridge structure as part of the Bradford Bypass (Hwy 400 to Hwy 404 highway link) project and high fill embankment widening of the existing County Road 4, in the Town of Bradford, Ontario.

This report presents the results of the foundation investigation for the proposed new bridge (Site No. 30X-0866/B0) to carry County Road 4 over the future Bradford Bypass and for the high fill embankment widening of County Road 4 (Yonge St) between Line 8 and Line 9, as shown on the Key Plan on Drawing 1.

The purpose of this investigation is to establish the subsurface soil and shallow groundwater conditions at the proposed bridge and high fill embankment widening location, by borehole drilling and laboratory testing of selected soil samples. The results of the foundation investigation for the replacement of the culvert located at Station 10+144 on County Road 4 for the project are presented in a separate foundation investigation report.

# 2.0 SITE DESCRIPTION

County Road 4 at the location of the proposed bridge structure and embankment widening presently conveys one to two lanes of northbound and southbound traffic, with two lanes present near the intersection at Line 8.

The land use in the vicinity of the proposed bridge structure consists of a residential subdivision to the southwest and primarily agricultural surrounding on the east side. There are some houses to the northwest and northeast of the proposed bridge site and grassy field directly to the west.

The natural terrain generally slopes down from northwest to southeast, with a few natural watercourses flowing into the west side ditch and crossing under the existing embankment at one culvert location at Station 10+144 within the proposed high fill embankment footprint. The surface water flows into the east side ditch and eventually into a watercourse east of the site that eventually drains into the West Holland River. There were low-lying wet areas with cattails in the drainage ditches on the west and east side of the roadway embankment near the culvert locations.

County Road 4 at the proposed interchange generally slopes down from north to south toward 8$^{th}$ Line. The embankment side-slopes are vegetated and did not appear to exhibit signs of distress or instability during our investigation. Photographs taken of the existing site during a site visit in 2021 are provided below.

**Photograph 1 - West Embankment of County Road 4, facing north**

**Photograph 2 - East Embankment of County Road 4, facing south**

## 2.1 Proposed High Fill Embankment Widening and Bridge

According to the design-build ready contract drawings (Contract No. 2021-2124), County Road 4 will ultimately be widened on both the east and west sides, with the majority of the embankment widening to the east side. High fill embankment widening is anticipated within the following limits:

- Station 9+900 to 9+957 County Road 4 – up to 18 m widening and 8 m high to the east, up to 1.5 m widening and 2.5 m high to the west (north of proposed bridge);
- Station 10+039 to 10+200 County Road 4 – up to 17 m widening and 8 m high to the east, up to 1.5 m widening and 7 m high to the west (south of proposed bridge).

The proposed bridge structure is shown to be a two-span integral abutment bridge. Construction staging, including lane shifts and a proposed detour to the west of the existing County Road 4, is proposed to maintain flow of traffic on County Road 4.

# 3.0 INVESTIGATION PROCEDURES

The field work for this site was carried out between June 24 and October 14, 2021, during which time a total of twenty-two boreholes (designated as CR4-01 to CR4-13, HF-01 to HF-05, and CV1-01 to CV1-04) were advanced along County Road 4 and near the toes of the existing west and east side of the road embankment, at the locations shown on Drawing 1.

The investigation was carried out using a track-mounted Diedrich D-50 and D-90 drill rig, supplied and operated by Walker Drilling of Utopia, Ontario and a truck-mounted CME 55 drill rig, supplied and operated by Geo-Environmental Drilling of Halton Hills, Ontario. Traffic control for this field investigation was provided by PGC Traffic of Stouffville, Ontario. The boreholes were advanced through the overburden using 210 mm outside diameter hollow-stem augers and mud rotary techniques using casing. Mud rotary was used to counterbalance groundwater pressures and reduce sample disturbance from "blowing" sands or heaving clays. Soil samples were generally obtained at 0.75, 1.5 m, and 3.0 m intervals of depth, using a 50 mm outside (35 mm inside) diameter split-spoon sampler driven by an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedure[1]. 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. In-situ field vane tests using an MTO 'N'-sized vane were carried out in general accordance with ASTM D2573.

Standpipe piezometers were installed in Boreholes HF-01, CR4-03, CR4-07, CR4-11, CV1-01, CV1-04, and HF-05 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. All 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. The piezometers installed on the roadway were protected using a flush mount casing capped with cold-patch asphalt and seated within quick-set concrete. Piezometers located away from the roadway were protected using steel monument casings, 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, Atterberg limits, grain size distribution, and organic content) 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 Callon Dietz or obtained from offsets to staked locations in the field. 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) |
|---|---|---|---|---|
| CR4-01 | 4,887,968.8 (44.131693) | 299,230.6 (-79.5696) | 262.8 | 11.3 |

[1] American Society for Testing and Materials (ASTM) D1586-11 – Standard Test Method for Standard Penetration Tests and Split-Barrel Sampling of Soils.

| Borehole No. | MTM NAD83 Northing (Latitude, °) | MTM NAD83 Easting (Longitude, °) | Ground Surface Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|
| CR4-02 | 4,887,977.2 (44.13177) | 299,274.4 (-79.569053) | 259.72 | 9.8 |
| CR4-03 | 4,887,945.5 (44.131484) | 299,231.1 (-79.569594) | 261.18 | 49.4 |
| CR4-04 | 4,887,956.2 (44.13158) | 299,267.1 (-79.569143) | 262.8 | 18.9 |
| CR4-05 | 4,887,958.5 (44.131601) | 299,280.3 (-79.568978) | 258.01 | 49.4 |
| CR4-06 | 4,887,904.5 (44.131114) | 299,244.0 (-79.569432) | 258.2 | 49.4 |
| CR4-07 | 4,887,917.5 (44.131232) | 299,275.4 (-79.569039) | 261.29 | 18.9 |
| CR4-08 | 4,887,916.9 (44.131227) | 299,308.7 (-79.568623) | 253.27 | 49.4 |
| CR4-09 | 4,887,864.9 (44.130758) | 299,248.9 (-79.569369) | 256.46 | 49.4 |
| CR4-10 | 4,887,870.4 (44.130808) | 299,282.2 (-79.568956) | 259.94 | 18.9 |
| CR4-11 | 4,887,880.1 (44.130896) | 299,300.2 (-79.56873) | 253.34 | 50.9 |
| CR4-12 | 4,887,846.8 (44.130596) | 299,255.6 (-79.569281) | 255.23 | 11.3 |
| CR4-13 | 4,887,854.7 (44.130667) | 299,305.7 (-79.56866) | 252.75 | 9.8 |
| 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 |
| HF-01 | 4,887,995.4 (44.131934) | 299,260.2 (-79.56923) | 264.2 | 15.9 |

| Borehole No. | MTM NAD83 Northing (Latitude, °) | MTM NAD83 Easting (Longitude, °) | Ground Surface Elevation (m) | Borehole Depth (m) |
|---|---|---|---|---|
| HF-02 | 4,887,822.6 (44.130378) | 299,278.9 (-79.568995) | 258.3 | 15.9 |
| HF-03 | 4,887,823.7 (44.130388) | 299,292.2 (-79.568829) | 258.4 | 18.7 |
| HF-04 | 4,887,737.7 (44.129614) | 299,293.4 (-79.568812) | 255.52 | 15.9 |
| HF-05 | 4,887,717.7 (44.129434) | 299,314.3 (-79.568551) | 254.7 | 15.7 |

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2], 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.

The Peterborough Drumlin field region generally consists of calcareous till soils and is generally sandier (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 inferred from drilling

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

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 and cross sections along the proposed bridge and embankment widening as shown on Drawings 1 to 4 are simplifications 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 along County Road 4 consist of asphalt underlain by a predominantly non-cohesive fill with cohesive fill zones. A thin layer of non-cohesive / cohesive fill or possible re-worked soil (from previous agricultural / farming activities) was also generally encountered at the ground surface in boreholes located near / beyond the embankment toes. The fill is typically underlain by a silty clay to clayey silt deposit (upper cohesive deposit) in some areas and a sandy silt deposit in others. The upper cohesive and sandy silt layers are underlain by a silty sand deposit (generally near the north and west limits of the widening) and a clayey silt till deposit. The silty sand and portions of the cohesive till deposit are underlain by a silt deposit. The silt deposit and cohesive till deposit are further underlain by an extensive clayey silt-silt to silty clay deposit (lower cohesive deposit). The lower cohesive deposit was underlain by a very dense silt layer and hard clayey silt-silt till deposit near the termination depth of the deepest borehole (CR4-11) advanced at the site.

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

### 4.2.1 Asphalt

An approximately 100 mm and 200 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes HF-01 to HF-5, CR4-04, CR4-07, CR4-10, CV1-02, and CV1-03 which were advanced along County Road 4.

### 4.2.2 FILL

Fill was encountered below the asphalt of the existing County Road 4 embankment and at ground surface near the toes of the embankment in all boreholes except CR4-01, CR4-06, CR4-09, CR4-12, and CV1-01. The fill encountered in boreholes advanced through the middle of the road embankment was generally thicker (2.8 m to 5.4 m thick) compared to the thickness of fill encountered near the toes of the existing embankment (0.7 m to 1.4 m thick). The fill generally ranges between a granular fill (sandy silt to silty sand to sand and gravel) and a cohesive fill (clayey silt-silt to clayey sand) as described in the following sections. Interlayers of silt and clayey silt were encountered in select samples. Trace organics were also encountered in select samples of the fill, generally near the interface with the native soil. Construction debris consisting asphalt pieces was also encountered near the fill / native soil interface in Borehole CV1-03.

#### *4.2.2.1 Sandy SILT (ML) to SILTY SAND (SM) to SAND (SP) and gravel - FILL*

The SPT “N” values measured within the non-cohesive fill layers generally range from 4 blows to 60 blows per 0.3 m of penetration, indicating a loose to very dense state of compactness. Auger refusal was encountered in this layer at a depth of 0.3 m (Elevation 263.9 m) in Borehole HF-01. Grain size distribution testing was carried out on fifteen selected samples of the non-cohesive fill layer and the results are presented on Figures B1A and B1B in Appendix B. Atterberg limits testing on six selected samples of the layer measured liquid limits ranging from about 13% to 21%, plastic limits from about 12% to 18%, and corresponding plasticity indices from about 1% to 4%. Atterberg limits test results are presented on Figure B2 in Appendix B and indicate the fines portion of the samples tested is slightly plastic. One of the Atterberg limits test results returned a non-plastic result. The measured moisture content of the samples tested generally ranges from 3% to 19% with the higher moisture contents likely attributed to the presence of trace organics.

#### 4.2.2.2 CLAYEY SILT-SILT (CL-ML) to CLAYEY SAND (SC) - FILL

The SPT "N" values measured within cohesive fill layers generally range from 3 blows to 31 blows per 0.3 m of penetration, suggesting a very soft to hard consistency.

Grain size distribution testing was carried out on four selected samples of the clayey silt-silt to clayey sand fill layers, and the results are presented on Figure B3 in Appendix B. Atterberg limits testing on three selected samples of the deposit measured liquid limits ranging from about 15% to 17%, plastic limits that range from about 10% to 12%, and corresponding plasticity indices ranging from about 4% to 5%. Atterberg limits test results are presented on Figure B4 in Appendix B and indicate the cohesive fill is of low plasticity. The measured moisture content of the samples tested generally ranges from 8% to 18%.

### 4.2.3 CLAYEY SILT-SILT (CL-ML) to SILTY CLAY (CI) to CLAYEY SAND (SC) - Upper Cohesive Deposit

A cohesive deposit consisting of clayey sand, silty clay and sand, and silty clay to clayey silt-silt was encountered beneath the fill soils in Boreholes CR4-03, CR4-08, CR4-11, CR4-13, HF-01, HF-04, HF-05, and CV1-02 to CV1-04, below the upper silt layer in CR4-05, and at ground surface in CR4-01, CR4-09, CV1-01. The top of the cohesive layer (designated as upper cohesive deposit) was encountered at Elevations ranging from 262.8 m to 249.8 m and ranges in thickness from 0.7 m to 6.6 m. Trace organics containing rootlets were typically encountered in the upper portion of this layer (i.e. near ground surface or near the interface with the fill soil) in Boreholes CR4-01, CR4-09, CV1-02, CV1-04, HF-04, HF-05. Pockets of organics / vegetation were encountered within the upper 1.4 m of this deposit in CV1-01, located near the inlet to the existing culvert. The deposit contained variable amounts of sand and gravel, but generally behaved in a cohesive manner.

The SPT "N" values measured within this cohesive deposit range 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 cohesive deposit in Boreholes CR4-03, CV1-02, CV1-03, and HF-04 measured undrained shear strengths ranging from about 50 kPa to >100 kPa with sensitivity values generally between about 2 and 4 In consideration of the limited field vane test results, the upper portion of this deposit is considered to have a stiff to hard consistency, but generally has a firm to very stiff consistency when considering the SPT "N"-values measured throughout the entire deposit. 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 twelve selected samples of the upper cohesive deposit, and the results are presented on Figures B5A and B5B in Appendix B. Atterberg limits testing on fourteen selected samples of the deposit measured liquid limits ranging from about 17% to 49%, plastic limits ranging from about 10% to 22%, and plasticity indices ranging from about 4% to 27%. The Atterberg limits test results are presented on Figure B6A and B6B 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 ranges from 16% to 33%. 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.

### 4.2.4 SILT (ML) to SILT (ML) and Sand

A silt to sandy silt to silt and sand deposit was encountered beneath the fill in Boreholes CR4-02, CR4-04, CR4-05, CR4-07, CR4-10, HF-02 and HF-03, below the silty sand layer in Borehole CR4-09, and below the upper cohesive deposit in CV1-02. The top of the silt to silt and sand layer was encountered at Elevations ranging from 258.5 m to 250.6 m and ranges in thickness from 0.8 m to 5 m. Trace organics / rootlets were observed in samples of this

deposit recovered from Boreholes CR4-04, CR4-07 and HF-02, near the interface with the overlying embankment fill.

The SPT “N” values measured within the silt to silt and sand deposit range from 3 blows to 31 blows per 0.3 m of penetration, indicating a very loose to dense state of compactness.

Grain size distribution testing was carried out on six selected samples of the silt to silt and sand deposit, and the results are presented on Figure B7 in Appendix B which indicate the deposit typically contains less than 10% clay. Atterberg limits testing on eight selected samples of the fines portion of the deposit measured liquid limits ranging from about 17% to 33%, plastic limits ranging from about 13% to 29%, and plasticity indices ranging from about 1% to 4%. The Atterberg limits test results are presented on Figure B8 in Appendix B and indicate the silt has slight plasticity. Two of the Atterberg limits test results returned a non-plastic result. In general, samples recovered from this deposit exhibit non-cohesive behaviour. The measured moisture content of the samples tested generally ranges from 8% to 35%. The higher moisture contents can likely be attributed to the presence of trace organics.

### 4.2.5 SILTY SAND (SM)

A non-cohesive silty sand, trace gravel to gravelly deposit was encountered beneath the upper cohesive deposit in Boreholes CR4-01, CR4-03, CR4-05, CR4-09, and HF-01, underlying the sandy silt deposit in Boreholes CR4-02 and CR4-04, and at ground surface in Boreholes CR4-06 and CR4-12. The top of the silty sand deposit was encountered at Elevations ranging from 258.6 m to 253.7 m and ranges in thickness from 1.3 m to 6.1 m. Trace organics / rootlets were observed in samples of this deposit near ground surface (Boreholes CR4-06 and CR4-12), and clayey silt pockets/interlayers were encountered in the upper zone of this deposit in Borehole CR4-03. Auger grinding was noted near the top of this deposit in Borehole CR4-01. An interlayer of clayey silt till was encountered within the deposit in Borehole CR4-06 and an interlayer of sandy silt was encountered within the deposit in Borehole CR4-09.

The SPT “N” values measured within the silty sand deposit generally range from 11 blows to 75 blows per 0.3 m of penetration, indicating a compact to very dense state of compactness. SPT “N” values of 103 per 0.3 m of penetration and 100 blows for 0.23 m of penetration were measured in this deposit in Boreholes CR4-03 and HF-01, respectively. SPT “N” values of 3, 5 and 7 blows per 0.3 m of penetration were measured in this deposit, where encountered at ground surface in CR4-12 and CR4-6. An SPT “N” value of 8 was measured in Borehole HF-1 although the “N” value may have been disturbed / influenced by “blowing sands” encountered near the sampling depth.

Grain size distribution testing was carried out on eight selected samples of the silty sand (cohesionless) deposit and the results are presented on Figure B9 in Appendix B and indicate the deposit typically contains less than 3% clay size particles. The measured moisture content of the samples tested generally ranges from 14% to 27%. The higher moisture contents can likely be attributed to trace organics in samples located near the ground surface.

### 4.2.6 SILT (ML)

A non-cohesive silt deposit was encountered underlying the silty sand to silt and sand deposits in Borehole CR4-01, CR4-3 to CR4-6, CR4-9 and HF-01, and underlying the cohesive till in Boreholes CR4-07, CR4-10, and CR4-12. The top of the silt layer was encountered at Elevations ranging from 254.1 m to 243.6 m and ranges in thickness from 7.8 m to 12.6 m where fully penetrated. Boreholes CR4-01, CR4-04, CR4-07, CR4-10, CR4-12, and HF-01 were terminated in this deposit. Layers of clayey silt-silt were encountered within the silt layer in Borehole CR4-03.

The SPT “N” values measured within the silt deposit range from 15 blows to 90 blows per 0.3 m of penetration, indicating a compact to very dense state of compactness. An SPT “N” value of 100 blows for 0.28 m of penetration was measured near the bottom of this deposit in Borehole HF-01.

Grain size distribution testing was carried out on sixteen selected samples of the silt deposit, and the results are presented on Figures B10A and B10B in Appendix B and indicate between 5% and 15% clay size particles. Atterberg limits testing on seventeen selected samples of the silt deposit measured liquid limits ranging from about 16% to 20%, plastic limits ranging from about 14% to 17%, and plasticity indices ranging from about 1% to 4%. A clayey silt-silt interlayer within the silt deposit in CR4-03 measured a liquid limit of 22, plastic limit of 16, and plasticity index of 6. The Atterberg limits test results are presented on Figures B11A and B11B in Appendix B and indicate the silt is slightly plastic. One of the Atterberg limits test results returned a non-plastic result. Generally, the deposit behaves as a cohesionless silt to silt of slight plasticity. The measured moisture content of the samples tested generally ranges from 17% to 20%.

### 4.2.7 CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

A cohesive till deposit consisting of clayey silt-silt to clayey silt to silty clay with varying amounts of sand and gravel was encountered underlying the silty sand in Boreholes CR4-06 and CR4-12, underlying the silt to silt and sand deposit in Boreholes CR4-07, CR4-10, CV1-02, HF-02 and HF-03, and underlying the upper cohesive deposit in CR4-08, CR4-11, CR4-13, CV1-01, CV1-03, CV1-04, HF-04, and HF-05. The cohesive till was described as sandy in many of the boreholes and contained interlayers of sand and gravel throughout. The top of the cohesive till layer was generally encountered at Elevations ranging from 256.2 m to 247.7 m and ranges in thickness from 1.7 m to 12.6 m where fully penetrated. Boreholes CR4-13, CV1-04, and HF-02 were terminated within the till deposit.

The SPT “N” values measured within the cohesive till deposit generally range from 8 blows per 0.3 m of penetration to about 75 blows per 0.3 m of penetration, with an average SPT “N” value of 44 blows for 0.3 m of penetration, suggesting a stiff to hard but generally hard consistency. Five SPT “N” values of greater than 100 blows for less than 0.3 m of penetration were measured in Boreholes CR4-10 (Elevation 244.5 m), CR4-11 (Elevation 249.4 m), CV1-01 (Elevation 247.3 m), CV1-02 (Elevation 245.4 m), and HF-02 (Elevation 244.4 m). The generally very stiff to hard consistency and presence of “100-blow” material (i.e. spoon refusal) and auger grinding during drilling operations within this glacially derived deposit suggests the presence of larger gravel-size particles and/or pockets of gravel or cobbles. Although coring was not required to advance boreholes beyond intervals of spoon refusal, it is possible that boulders may be present throughout this cohesive till deposit.

Grain size distribution testing was carried out on twenty-four selected samples of the cohesive till deposit, and the results are presented on Figures B12A to B12C in Appendix B. Atterberg limits testing on twenty-five selected samples of the cohesive till deposit measured liquid limits ranging from about 14% to 42%, plastic limits range from about 10% to 18%, and plasticity indices range from about 4% to 25%. The Atterberg limits test results are presented on Figures B13A to B13C in Appendix B and indicate the cohesive till deposit ranges from clayey silt-silt of low plasticity to a silty clay of intermediate plasticity. Atterberg limits test results performed on two samples of a silt seam within the cohesive till deposit returned a non-plastic result and a liquid limit of 15, plastic limit of 12, and plasticity index of 3, indicating the silt seams are slightly plastic to non-plastic. The measured moisture content of the cohesive till samples tested generally range from 7% to 24%.

### 4.2.8 CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) – Lower Cohesive Deposit

An extensive cohesive deposit consisting of clayey silt-silt to clayey silt to silty clay was encountered underlying the silt deposit in Boreholes CR4-03, CR4-05, CR4-06, and CR4-09, underlying the silty sand deposit in Borehole CR4-02, and underlying the cohesive till deposit in Boreholes CR4-08, CR4-11, CV1-01 to CV1-03, and HF-03 to HF-05. The deposit generally transitions from a clayey silt-silt to clayey silt to silty clay with depth and the boreholes identified above were all terminated within the lower cohesive deposit. The top of the cohesive layer was encountered at Elevations ranging from 252.1 m to 237.0 m and was measured to range from about 29.7 m thick (where fully penetrated in the deepest borehole CR4-11) to greater than 36.1 m thick in Borehole CR4-08 which was terminated in the cohesive deposit.

The SPT “N” values measured within the lower cohesive deposit range from 21 blows to 101 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency. SPT “N” values of 60 and 64 blows for 0.13 m of penetration, and greater than 100 blows for less than 0.3 m of penetration were measured in this deposit in Boreholes CV1-02, CV1-03, CR4-03, HF-03 and HF-05. The measured SPT “N” values generally range between 40 and 80 blows per 0.3 m of penetration in this deposit suggesting a hard consistency.

Grain size distribution testing was carried out on twenty-one selected samples of the cohesive deposit, and the results are presented on Figures B14A to B14C in Appendix B. Atterberg limits testing on twenty-two selected samples of the cohesive deposit measured liquid limits ranging from about 19% to 41%, plastic limits ranging from about 15% to 19%, and plasticity indices range from about 4% to 22%. The Atterberg limits test results are presented on Figures B15A to B15C in Appendix B and indicate the cohesive deposit generally varies between a clayey silt-silt of low plasticity to a silty clay of intermediate plasticity. Generally, the deposit is of low plasticity, transitioning to a clayey silt of low plasticity to silty clay of intermediate plasticity. The measured moisture content of the samples tested generally ranges from 15% to 31%.

### 4.2.9 SILT (ML) - Lower

An approximately 3.1 m thick layer of silt, some sand was encountered at a depth of 46.0 m below ground surface (Elevation 207.3 m) in Borehole CR4-11, below the extensive lower cohesive deposit.

The SPT “N” value measured within the silt deposit was 143 blows per 0.3 m of penetration, indicating a very dense relative density.

Grain size distribution testing was carried out on a selected sample of the silt and the results are presented on Figure B10B in Appendix B. Atterberg limits testing on a selected sample of the deposit measured a liquid limit of about 21%, plastic limit of about 19%, and corresponding plasticity index of about 2%. The Atterberg limits test results are presented on Figure B11B in Appendix B and indicate the silt deposit is slightly plastic. The measured moisture content of the sample tested was about 19%.

### 4.2.10 CLAYEY SILT-SILT (CL-ML) – Lower TILL Deposit

A lower glacial till deposit consisting of clayey silt-silt, some sand, trace gravel was encountered below the lower silt deposit at a depth of 49.1 m below ground surface (Elevation 204.3 m) in Borehole CR4-11. Borehole CR4-11 was terminated in this deposit after penetrating about 1.8 m into the lower till deposit.

The SPT “N” value measured within the till deposit was 106 blows per 0.3 m of penetration, suggesting a hard consistency.

Grain size distribution testing was carried out on a selected sample of the lower till deposit, and the results are presented on Figure B12C in Appendix B. Atterberg limits testing on the selected sample of the deposit measured a liquid limit of about 21%, plastic limit of about 14%, and corresponding plasticity index of about 7%. The Atterberg limits test results are presented on Figure B13C in Appendix B and indicate the till deposit is a clayey silt-silt of low plasticity. The measured moisture content of the sample tested was about 13%.

## 4.3 Groundwater Conditions

Standpipe piezometers were installed in Boreholes CR4-03, CR4-07, CR4-11, HF-1, HF-05, CV1-01 and CV1-04 for monitoring of the groundwater level. The details of the piezometer installation are shown on the borehole records. 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) | Depth to Groundwater (m) | Groundwater Elevation (m) | Date | Screened Deposit | Closest Foundation Element |
|---|---|---|---|---|---|---|
| HF-01 | 264.2 | 4.9 | 259.3 | December 9, 2021 | Silty Clay and Silty Sand | High Fill Widening |
| CR4-03 | 261.2 | 1.6 | 259.6 | September 24, 2021 | Silty Sand and Clayey Silt-Silt to Silt | North Abutment |
| | | 1.0 | 260.2 | December 9, 2021 | | |
| CR4-07 | 261.3 | 6.1[1] | 255.2[1] | July 15, 2021 | Clayey Silt Till and Silt | Centre Pier |
| | | no reading[2] | no reading[2] | December 9, 2021 | | |
| CR4-11 | 253.3 | 1.2[1] | 252.1[1] | August 30, 2021 | Clayey Silt-Silt and Sand Till | South Abutment |
| | | 0.0 | 253.3 | November 25, 2021 | | |
| | | -(0.2) | 253.5 | December 9, 2021 | | |
| CV1-01 | 252.2 | 0.6 | 251.6 | November 25, 2021 | Sandy Clayey Silt to Sandy Clayey Silt-Silt Till | Culvert Replacement |
| | | 0.1 | 252.1 | December 9, 2021 | | |
| CV1-04 | 250.5 | 0.2 | 250.3 | November 25, 2021 | Sandy Clayey Silt to Sandy Clayey Silt-Silt Till | Culvert Replacement and High Fill Widening |
| | | 1.3 | 249.2 | December 9, 2021 | | |

| Borehole No. / Piezometer | Ground Surface Elevation (m) | Depth to Groundwater (m) | Groundwater Elevation (m) | Date | Screened Deposit | Closest Foundation Element |
|---|---|---|---|---|---|---|
| HF-05 | 254.7 | 3.9 | 250.8 | December 9, 2021 | Clayey Silt to Sandy Clayey Silt-Silt Till | High Fill Widening |

Notes:

1. Water level measured during or upon completion of drilling activities.
2. Attempted to measure water level but unable to remove plug to access open pipe due to frozen material/bentonite surrounding the plug.

As indicated above, a piezometer reading was attempted in CR4-07 located on County Road 4; however, site personnel were unable to dislodge the frozen material (soil and bentonite seal) that appears to have swelled and frozen around the plug (see Photograph *3* below).

Photograph 3 – Frozen soil/bentonite surrounding an covering plug in piezometer at Borehole CR4-07

It should be noted that the groundwater level is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year / snow melt. Perched groundwater within the non-cohesive fill soils (above cohesive fill or native cohesive soils) should be expected, especially in the Spring or after periods of significant precipitation. Given that the existing County Road 4 embankment acts as a barrier to the natural sloping ground / drainage path from northwest to southeast, surface water flow within the ditches (especially along the west ditch) may also influence surrounding groundwater conditions.

## 4.4 Analytical Testing

Five soil samples were collected and submitted to Bureau Veritas Laboratories for analysis of parameters used to assess corrosion potential on general construction materials (i.e. steel and concrete). A summary of the analytical

testing results is presented below and more details are provided in the Certificates of Analysis provided 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) |
| CR4-03 | 4 | 2.29 – 2.89 (257.1 – 256.5) | Clayey Silt | <20 | <20 | 7.69 | 165 | 6100 |
| CR4-06 | 4 | 3.81 – 4.42 (254.3 – 253.6) | Clayey Silt | <20 | 45 | 7.96 | 182 | 5500 |
| CR4-09 | 4 | 7.62 – 8.23 (249.3 – 248.7) | Silty Sand | <20 | <20 | 7.94 | 72 | 14,000 |
| 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 |

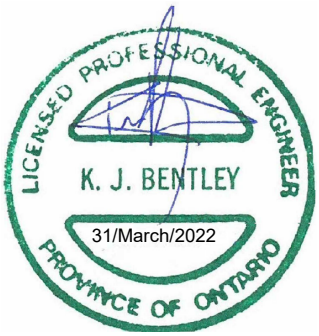
## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Alysha Kobylinski, P.Eng., a geotechnical engineer with Golder. Mr. Kevin J. Bentley, P.Eng., and MTO Foundations Designated Contact for Golder, conducted an independent quality control review of this report.

# Signature Page

**Golder Associates Ltd.**


Alysha Kobylinski, P.Eng.
*Geotechnical Engineer*

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*Associate, MTO Foundations Designated Contact*

ACK/KJB/ml



https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/county road 4/02 - cr4 fidr/03 - final fidr/19136074_3000 - cr4 fidr - 2022'03'31.docx

# PART B

## FOUNDATION DESIGN REPORT
## BRADFORD BYPASS / SIMCOE COUNTY ROAD 4 (YONGE STREET) UNDERPASS AND HIGH FILL EMBANKMENT WIDENING
## 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 design recommendations for the proposed Bradford Bypass / County Road 4 Underpass Bridge (Site No. 30X-0866/B0) to accommodate the future construction of the interchange associated with the Highway 400 to Highway 404 link (The Bradford Bypass) in the Town of Bradford, Ontario. In addition, foundation design recommendations are provided for the proposed County Road 4 (Yonge St.) high fill embankment widening. 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 sufficient information to assess the feasible foundation alternatives and carry out the design of the bridge foundations and high fill embankment widening.

The Foundation Design Report (Part B of this report) including the discussion and recommendations are intended for the use of 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 (and supplement as necessary) as such interpretation may affect detail design, equipment selection, proposed construction methods, scheduling and the like.

## 6.1 General

Based on the design-build ready contract drawings (Contract No. 2021-2124), County Road 4 will be widened and a new Bradford Bypass / County Road 4 Underpass Bridge will be constructed along County Road 4, between 8$^{th}$ Line and 9$^{th}$ Line. Based on the concept design drawings, the new 2-span bridge is about 82 m long (between about Station 9+957 and 10+039) and will consist of integral abutments with a single central pier. The new bridge will accommodate 2 lanes of northbound traffic, 2 lanes of southbound traffic, plus the speed change lanes along County Road 4 associated with the future ramps associated with the interchange. The proposed County 4 grade at the proposed north and south abutments will be at approximately Elevations 262.8 m and 260.4 m, respectively, generally at or within 0.5 m of the existing County Road 4 grade at those locations. The proposed grade of the future Bradford Bypass is at approximately 253 m for the travelled lanes at the proposed bridge location, although the interim grade below the bridge structure is shown to be up to about Elevation 258 m on the concept drawings, which is about the same elevation of the existing natural ground surface on the west side of the bridge location. The interim grade below the bridge generally follows the natural ground surface adjacent to the bridge / existing embankment which slopes down from about Elevation 258 m at the existing west ditch to about Elevation 254 m at the east ditch at the middle of the proposed bridge location. When the future Bradford Bypass grade is constructed, removal of up to about 5 m of soil will be required below and on the west side of the bridge. The proposed County Road 4 bridge has a structural classification of “Other” as it carries a municipal roadway over an MTO-owned highway. The proposed new County Road 4 profile will consist of up to a 4.5 m cut north of the proposed bridge and up to a 0.8 m fill south of the bridge, relative to the existing County Road 4 profile. The proposed County Road 4 widening will be predominantly on the east side (up to about 17 m and 18 m of embankment widening near the bridge south and north abutments respectively) that will result in new widened embankment heights up to about 8 m near the bridge abutments. The widened high fill embankments (greater than about 4.5 m high on the east side)

extend to about Station 9+900 north of the bridge and to about Station 10+200 south of the bridge. There is limited to no widening on the west side of the existing embankment.

Referring to the concept drawing staging plan, widening of County Road 4 on the east side is scheduled to be one of the first stages of work, followed by construction of a detour west of the existing County Road 4 alignment and proposed new bridge location. A temporary protection system is likely required along the existing County Road 4 roadway (north of the proposed bridge location) to accommodate the detour and proposed lowering of County Road 4 in future stages. In addition, replacement of the existing culvert (at Station 10+144) south of the bridge is required but is discussed in a separate foundation investigation and design report. After traffic is diverted to the west detour, full construction of the new bridge and associated foundations (including an up to 13 m deep cut for the proposed shallow foundation option at the centre pier) is proposed to be carried out, after which traffic can be diverted back onto the new widened County Road 4 and new bridge structure.

## 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 bridge 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, $\Psi$, and geotechnical resistance factors, $\phi_{gu}$ and $\phi_{gs}$, from Tables 6.1 and 6.2 of the *CHBDC* (2019) have been used for the concept design. The design-builder may undertake additional investigation and high complexity testing to modify the geotechnical resistance factors as appropriate. In addition, reference is made to the MTO Material Engineering and Research Office (MERO) Memorandum #2020-01 (dated March 23, 2020) for future settlement and stability analyses during detail design, as applicable.

## 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, $\overline{N}_{60}$ 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 bridge 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 |

In accordance with the CHBDC, the proposed bridge structure has been given an importance category as defined in Section 4.4.2 of “other” bridge. The site specific hazard values above, $S_a(0.2)$ = 0.15 and $S_a(1.0)$ = 0.074,

satisfy the criteria for structure periods less than, equal, or greater than 0.5 seconds, and in consideration of its importance category, indicate that the bridge structure falls in Seismic Performance Category 1 in accordance with Table 4.10 of the CHBDC. Based on this Seismic Performance Category, it is understood that no seismic analysis is required.

### 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 proposed bridge foundations / pile caps and associated embankment widening generally consists of compact to very dense silt to silty sand and stiff to hard cohesive deposits. Based on the low site-specific PGA and the compactness / consistency of the non-cohesive / cohesive deposits, the soils at this site are considered to have a low potential for liquefaction during a design seismic event and liquefaction is not considered further in the foundation design for this structure.

## 6.4 Foundation Types

Based on the proposed structure configuration shown on the concept design drawings and the subsurface conditions encountered at this site, both shallow and deep foundation options have been considered for support of the new abutments and centre pier. A summary of the advantages and disadvantages associated with each option is provided below and a comparison of the alternative foundation options based on advantages, disadvantages, risks, and relative costs is provided in Table 1 following the text of this report.

For the proposed integral abutments, long driven steel H-piles founded in the hard cohesive deposit are considered the most suitable from a foundations perspective and are shown on the concept design drawings. If alternative abutment design options are being considered, the foundations could also consist of drilled shafts (caissons). Shallow foundations are not considered practical for the abutments given that they would need to be founded below the existing embankment fill / groundwater level which would impact the concept staging and detour designs which are also limited by adjacent property restrictions. Shallow foundations at the abutments are not discussed further in this report.

For the centre pier foundation, shallow footings founded below the embankment fill and within the dense to very dense silt / hard clayey silt till deposits are considered suitable and the most practical option for support (from a foundations and constructability perspective) and are shown on the concept design drawings. Alternatively, caissons (with a permanent liner) could also be considered for the pier foundation and could be continuous with the columns to reduce excavation and dewatering efforts. For this reason, caissons at the pier are considered the preferred foundation option if they can be designed and constructed with appropriate quality assurance to accommodate the future Bradford Bypass grade and subsequent removal of soil surrounding the columns. Driven steel piles are not considered practical at the pier location unless an innovative design and construction procedure is developed by the design-build contractor.

## 6.5 Driven Steel Piles

Both abutments may be supported on driven piles (steel H-piles or tube piles) founded in the hard extensive lower cohesive deposit, especially if integral abutments are being considered. The centre pier may also be supported on driven piles (steel H-piles or tube piles) founded in the hard extensive lower cohesive deposit, although is not considered practical given the future excavation for the Bradford Bypass at the pier location will result in pile caps being up to 13 m below existing County Road 4 elevation, in addition to logistical challenges of driving piles, cutting off at pile cap level, and backfilling up to the interim grade just below the bridge deck. Consideration must be given to the presence of cobbles and boulders that may be present within the glacially derived till deposit across the site and potential obstructions within the existing variable embankment fill. The presence of gravel pockets or cobble sized fragments (or possible boulders) was inferred by grinding of the augers / casing or "100-blow" SPT values encountered in several boreholes within the till deposit, and within the silty sand deposit at the north approach to the proposed bridge.

In this regard, steel H-piles are preferred over steel tube piles given that H-piles are more commonly used for integral abutment design and that steel tubes are considered to pose a higher risk of "hanging up" or being deflected from their vertical or battered orientation during installations, due to their larger end area. It is recommended that the steel H-piles be reinforced at the tip with driving shoes (e.g. Titus H bearing pile point or APF Hard Bite) to reduce the potential for damage to the piles during driving into the very stiff to hard deposits. The requirement for driving shoes should be included in the Contract Drawings and the driving shoes should be designed to be flush with the sides / perimeter surface of the pile so as not to create an over cut (creating a void behind shoe) that will reduce shaft friction as the piles are driven. Preaugering may be considered to reduce the risk of piles "hanging up" on potential pockets of gravel or cobbles (or possible boulders) and if considered, the design geotechnical resistances provided herein must be reviewed and revised as necessary during detail design. An NSSP has been provided in Appendix D to address the presence of obstructions within the till deposit and silty sand deposit, for inclusion into the Contract Documents.

Corrugated steel pipes (CSPs) backfilled with loose sand are recommended to be installed as part of the integral abutment design consistent with the Ministry of Transportation, Structural Office Report SO-96-01 titled "Integral Abutment Bridges".

The foundation design recommendations for the driven piles are provided in the following sections.

### 6.5.1 Founding Elevations

Steel H-piles should be driven into the very stiff to hard cohesive deposit, the surface of which varies across the site. Based on the extensive cohesive deposit with 'N'-values generally less than 100-blows, it is anticipated that the piles will need to extend to depths of at least 30 m at each abutment. At select locations where till will need to be penetrated (centre pier and south abutment), pre-augering through the till is likely required for integral abutment design where piles must be installed in a single row with limited tolerance. The following ranges in pile tip elevations may be used for design.

| Foundation Element | Founding Stratum | Elevation at Underside of Pile Cap (m) | Estimated Pile Tip Elevation (m) | Estimated Pile Length[2] (m) |
|---|---|---|---|---|
| North Abutment | Hard Clayey Silt to Silty Clay | 258.0[1] | 228 | 30 |
| | | | 223 | 35 |
| | | | 218 | 40 |
| Centre Pier | Hard Clayey Silt to Silty Clay | 248.5 | 218.5 | 30 |
| | | | 213.5 | 35 |
| | | | 208.5 | 40 |
| South Abutment | Hard Clayey Silt to Silty Clay | 255.0[1] | 225 | 30 |
| | | | 220 | 35 |
| | | | 215 | 40 |

**Notes:**
1. As per AECOM's concept design drawings dated November 2021.
2. Includes length of pile in 3 m long CSP surround at underside of pile cap at abutments.

The depths indicated above should be considered minimum depths for the corresponding long-term axial geotechnical resistances provided in the next section and high-strain dynamic testing must be performed on select piles to confirm geotechnical axial resistances.

Lower design pile elevations (i.e. longer piles) should be considered if short-term axial geotechnical resistances (upon end of initial driving or beginning of re-tap within a two week period) equal to the values provided in the next section are desired.

### 6.5.2 Axial Geotechnical Resistance

The factored ultimate and serviceability geotechnical resistances that may be used for the design of steel H-piles (HP 310x110 or HP 360x132) are presented below.

| Foundation Element | Pile Tip Elevation (m) | Founding Stratum | Factored Ultimate Geotechnical Resistance (kN)[2] | | Factored Serviceability Geotechnical Resistance (for 25 mm of settlement)[1,2] (kN) | |
|---|---|---|---|---|---|---|
| | | | HP310 x 110 | HP360 x 132 | HP310 x 110 | HP360 x 132 |
| North Abutment | 228.0 | Hard Clayey Silt to Silty Clay | 1,000 | 1,150 | 1,000 | 1,150 |

| Foundation Element | Pile Tip Elevation (m) | Founding Stratum | Factored Ultimate Geotechnical Resistance (kN)[2] | | Factored Serviceability Geotechnical Resistance (for 25 mm of settlement)[1,2] (kN) | |
|---|---|---|---|---|---|---|
| | | | HP310 x 110 | HP360 x 132 | HP310 x 110 | HP360 x 132 |
| | 223.0 | Hard Clayey Silt to Silty Clay | 1,150 | 1,325 | 1,150 | 1,325 |
| | 218.0 | Hard Clayey Silt to Silty Clay | 1,300 | 1,500 | 1,300 | 1,500 |
| Centre Pier | 218.5 | Hard Clayey Silt to Silty Clay | 800 | 1,000 | 800 | 1,000 |
| | 213.5 | Hard Clayey Silt to Silty Clay | 900 | 1,150 | 900 | 1,150 |
| | 208.5 | Hard Clayey Silt to Silty Clay | 1,100 | 1,350 | 1,100 | 1,350 |
| South Abutment | 225.0 | Hard Clayey Silt to Silty Clay | 1,000 | 1,150 | 1,000 | 1,150 |
| | 220.0 | Hard Clayey Silt to Silty Clay | 1,150 | 1,325 | 1,150 | 1,325 |
| | 215.0 | Hard Clayey Silt to Silty Clay | 1,300 | 1,500 | 1,300 | 1,500 |

**Notes:**

1. The factored serviceability geotechnical resistance for 25 mm of settlement will be greater than the factored ultimate geotechnical resistance and, as such, the SLS condition does not apply.
2. Geotechnical resistance assumes sufficient time (estimated to be minimum 2 weeks) for piles to “set-up” and realize strength gain as pore pressures dissipate after initial driving.

The estimated factored ultimate geotechnical resistances provided above are calculated on both shaft and tip resistances, but predominantly shaft and assume piles have had sufficient time to "set-up" and allow pore pressures to dissipate after initial driving in order to achieve the design geotechnical resistances. It is noted that some “relaxation” may also occur in the dense to very dense silts. All pile installation/driving should be carried out in accordance with OPSS.PROV 903 (*Deep Foundations*) as amended by Special Provision 109F57. Section 903.07.02.07.03 of SP109F57 should specify the appropriate ultimate resistance using high-strain dynamic testing (also referred to as Pile Driving Analyzer (PDA) testing) and appropriate factors in the CHBDC. In addition, the SP109F57 fill-in should be modified to reference OPSS.PROV 903 Section 903.07.02.07.06 (Retapping) and revise the contract language such that retapping of piles be performed no sooner than 2 weeks (not 24 hrs) after initial driving due to the presence of the clayey silt and silt soils that are anticipated to take sufficient time for pore water pressures to dissipate and design geotechnical resistances stated above realized.

If time to allow piles to “set-up” and achieve strength gain cannot be accommodated in the construction schedule, the design pile geotechnical resistances provided in the table above should be reduced by at least 200 kN if being tested at end of initial drive or beginning or retap within a 2 week wait period. A minimum of two piles per foundation element should be tested using high-strain dynamic testing to confirm the design resistance has been achieved at the design tip elevation.

In order to reduce the risk of piles not achieving the design geotechnical resistance at the design tip elevation, the design-builder can consider a combination of the following options:

- Lower axial geotechnical resistances for design;
- High-strain dynamic testing (PDA) on all piles at end-of-initial drive (EOID) and at a specified number of piles on beginning-of-restrike (BOR) or retap;
- Advanced static pile load test as per ASTM D-1143, and
- Evaluation of strength gain with time to ascertain that geotechnical resistance will ultimately be achieved (as indicated above with initial 2 week wait period).

The selected design and testing method(s) must consider logistical challenges and potential schedule impacts as part of the detailed design and planned construction.

The subsequent pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile and length of pile; the criteria must therefore be established at the time of construction after the piling equipment is known to ensure that the piles are not overdriven, to avoid possible damage to the piles, and to calibrate with the results of the high-strain dynamic testing. Alternatively, high-strain dynamic testing could be performed on all piles.

### 6.5.3 Downdrag Loads on Piles

As per the concept construction staging drawings, County Road 4 is to be widened on the east side at the proposed bridge abutments during the first stage of construction and any immediate or consolidation settlements are anticipated to occur within 2 months of fill placement (estimated to be up to about 17 m and 18 m wide and 8 m thick on the east side of the south and north abutment locations). As a result, provided driven piles on the east side are installed at least 2 months after the full embankment widening is placed at / near the abutments, downdrag loads are not considered to be a concern. The design-build contractor must assess downdrag loads if the detail design and construction staging is different from the concept design staging procedure.

### 6.5.4 Resistance to Lateral Loads

The design of piles subjected to lateral loads should take into account such factors as the relative rigidity of the pile to the surrounding soil, the fixity condition at the head of the pile (i.e., at the pile cap level), the structural capacity of the pile to withstand bending moments, the soil resistance that can be mobilized, the tolerable lateral deflections at the head of the pile and group effects. The concept design drawing indicates an integral abutment design and battered piles (in the direction of County Road 4) are not anticipated. For a longer, more flexible pile, the maximum yield moment of the pile may be reached prior to mobilization of the lateral geotechnical resistance. For design purposes, both the structural and geotechnical resistances should be evaluated to establish the governing case.

The resistance to lateral loading in front of a single pile may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, $k_h$ (kPa/m), is based on the equations below. However, the response of a pile to lateral loads is highly non-linear and methods that assume linear behavior (such as subgrade reaction

theory) are generally appropriate where the maximum pile deflections are less than about 1% of the pile or drilled shaft diameter, where the loading is static (no cycling) and where the pile material is linear (CFEM, 2006). If one or more of these conditions are not satisfied, lateral pile analysis for detail design should be carried out using non-linear methods such as p-y curves.

For non-cohesive soils:

$$k_h = \frac{n_h z}{B}$$

where: $n_h$ = coefficient related to soil density (kPa/m)
$z$ = depth below pile cap or bottom of CSP for integral abutments (m), and,
$B$ = width of pile (m)

For cohesive soils:

$$k_h = \frac{67 s_u}{B}$$

where: $s_u$ = undrained shear strength of the soil (kPa), and,
$B$ = width of pile (m)

The values of $n_h$ (Terzaghi, 1955 and Reese, 1975) and $s_u$ to be incorporated into the calculations of the coefficient of horizontal subgrade reaction ($k_h$) within the fill and native overburden, to be used for the structural analysis of the piles at this site, are summarized below. The range in values reflect the variability in the explored subsurface conditions, the soil properties, the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that $k_h$ is a function of deflection). In developing these recommendations, the design groundwater level has been taken at approximately Elevation 260 m to 254 m at the north and south abutments, respectively.

| Soil Unit | Location Relative to Groundwater | $n_h$ (kPa/m) | $s_u$ (kPa) |
|---|---|---|---|
| Loose to very dense Sandy Silt to Silty Sand to Sand and Gravel - Fill | Above Groundwater | 4,000 - 6,500 | -- |
| | Below Groundwater | 3,000 - 5,500 | |
| Very soft to hard Clayey Silt-Silt to Clayey Sand - Fill | Below Groundwater | -- | 50 - 100 |
| Firm to very stiff Clayey Silt-Silt to Silty Clay to Clayey Sand (Upper Cohesive) | Below Groundwater | -- | 50 - 100 |
| Very loose to dense Silt to Silt and Sand | Below Groundwater | 9,500 | -- |
| Compact to very dense Silt to Silty Sand | Below Groundwater | 16,800 | -- |
| Very stiff to hard Clayey Silt-Silt to Silty Clay Till | Below Groundwater | -- | 150 |
| Hard Clayey Silt-Silt to Clayey Silt to Silty Clay | Below Groundwater | -- | 200 |

Both the structural and geotechnical lateral resistances of the piles should be evaluated to establish the governing case at ULS. At SLS, the horizontal reaction of the piles will be controlled by deflections and the horizontal resistance of the piles should be calculated based on the coefficient of horizontal subgrade reaction ($k_h$) of the soil as discussed above. The SLS reaction should be taken as that corresponding to tolerable design deflection of the integral abutment system. For non-integral systems, the SLS reaction is typically the value taken at a horizontal deflection of 10 mm at the underside of the abutment wall / pile cap (*CHBDC* (2019) *Commentary* Section 6.11.2.2).

Group action for lateral loading should also be evaluated by reducing the coefficient of horizontal subgrade reaction either in the direction of loading or perpendicular to the direction of loading by relevant group pile efficiency factors as outlined in Section C6.11.3.4 of the *Commentary to the CHBDC* (2019).

## 6.6 Centre Pier – Spread/Strip Footing

The centre pier may be supported on strip or spread footings founded on the dense to very dense silt and/or hard clayey silt till as shown on the concept design drawings. It is noted that excavations up to about 13 m deep (i.e. from existing Country Road 4 surface to founding level of spread footing below future Bradford Bypass grade) will be required for construction of the spread/strip footings. As previously mentioned, the concept design drawings indicate that after construction of the spread/strip footings and pier columns/walls, the excavated area is to be reinstated to an interim grade below the bridge which will generally follow the native ground surface and slope downward from west to east.

At the pier location, the measured groundwater level is about 6.7 m above the approximate founding level (El. 248.5 m) of the proposed shallow foundation and associated excavation. As a result, the groundwater level will need to be temporarily lowered about 7 m at the centre pier location to allow for excavation and construction of the foundation in the dry. Advanced dewatering of the non-cohesive fills, silty sand to sandy silt, and silt will be required to maintain stable temporary slopes during excavation (See Section 6.11), allow placement of concrete, and suitable placement and compaction of backfill soils. Given the fine-grained nature of the cohesionless soils, well points and/or eductor systems are anticipated to be required. Consideration could be given to using temporary protection systems, possibly as a groundwater cut-off, to reduce dewatering and excavation efforts; however, the top of the underlying cohesive clayey deposit is over 22 m deep below the existing County Road 4 surface. For this reason, a combined excavation with temporary protection system (acting as a cut-off) may be the preferred option to construct the shallow foundations.

A detailed discussion on temporary excavation and dewatering requirements at the pier location is provided in Section 6.14.1 and 6.14.4, and foundation design recommendations for the shallow footings are provided in the following sections.

### 6.6.1 Founding Elevations

The following founding elevation shown on the concept drawings may be considered for design provided it is at least 1.5 m below the future grade of the Bradford Bypass (i.e. below frost depth at this location).

| Foundation Element | Founding Stratum | Highest Proposed Founding Elevation (m) |
|---|---|---|
| Centre Pier | Dense silt; Hard clayey silt till | 248.5 |

Consideration must be given to the potential for differential settlement across the footprint of the centre pier foundation given that founding soils consist of dense to very dense silt at the west half and hard clayey silt till at the east half, and considering the west half is currently loaded by the existing County Road 4 embankment which will eventually be excavated and regraded as part of the Bradford Bypass. Further discussion on estimated settlements at the pier location due to staging operations is provided in Section 6.12.

### 6.6.2 Geotechnical Resistance

A strip or spread footing constructed on the properly prepared subgrade founded at or below the design elevation given above can be designed for the factored ultimate geotechnical resistance and factored serviceability geotechnical resistance (for 25 mm of settlement) given below.

| Foundation Element | Founding Stratum | Estimated Footing Width | Factored Ultimate Geotechnical Resistance (kPa) | Factored Serviceability Geotechnical Resistance (kPa) (for 25 mm of settlement) |
|---|---|---|---|---|
| Centre Pier | Dense silt or hard clayey silt till | 2 - 5 m | 375 | 325 |

The factored ultimate and serviceability geotechnical resistances are dependent on the footing width and founding elevation and as such, the geotechnical resistances should be reviewed if the footing width varies from that specified above or if the founding elevations differ from that given in the previous section. The serviceability resistance does not take into account any settlements from adjacent embankment loading as discussed in Section 6.12. The factored ultimate geotechnical resistances provided are based on a load applied concentrically to the centreline/centroid of the footing, as shown on Figure 6.4 of the *CHBDC (2019)*. Where a load is applied eccentrically from the centreline/centroid of the footing, the pressure distribution at ULS and SLS and the eccentricity limit of the footing should be taken into consideration in accordance with Section 6.10.5 of the *CHDBC* (2019) and its Commentary. Once the structural design is substantially complete, the structural engineer should verify with the foundations engineer whether the factored ultimate and serviceability geotechnical resistances provided above require revision based on any load inclination.

The footing subgrade should be inspected by qualified geotechnical personnel following excavation, in general accordance with OPSS 902 (*Excavating and Backfilling - Structures*) to check that the foundation subgrade is consistent with the geotechnical exploration and that all loosened, disturbed or other unsuitable materials have been removed.

The dense silt and hard clayey silt till subgrade can be susceptible to disturbance and degradation on exposure to water and construction traffic and therefore, it is recommended that a concrete working slab be placed over the subgrade to protect the integrity of the foundation soils. A Special Provision should be included in the Contract Documents for a working slab, a copy of which is provided in Appendix D (FOUN0001).

### 6.6.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral loads / sliding resistance between the new concrete footing and the subgrade should be calculated in accordance with Section 6.10.4 of *CHBDC* (2019), applying the appropriate consequence and degree of site understanding factors, as noted in Section 6.2. For a cast-in-place concrete footing or concrete working slab constructed directly on the dense silt or hard clayey silt till, or for a concrete footing on a concrete working slab, the sliding resistance may be calculated based on the following unfactored interface strength parameters.

| Interface Materials | Unfactored Interface Strength Parameters |
|---|---|
| Cast-in-place concrete footing or working slab on dense silt or hard clayey silt till | $\delta'$=24°, $S_u$ = 150 kPa |
| Cast-in-place concrete footing on concrete working slab | $\delta'$=35° |

## 6.7 Alternative Option at Abutments and Pier - Drilled Shafts (Caissons)

Although not included in the concept design, drilled shafts(caissons) are considered to be feasible foundation alternatives at the abutments and pier location. Caissons are typically not considered practical for integral abutment design although conventional abutment design may be considered if the design criteria / contract documents allow. Caissons may also be considered for the centre pier and may be preferred if circular pier columns are considered to allow for continuous construction of caisson foundation to pier column. Consideration must be made for the future Bradford Bypass grade and any portion of the pier column that will be exposed above the future Bradford Bypass ground surface must meet the applicable design standards (e.g. aesthetics, structural requirements, etc.).

For preliminary design at the pier location, a 20 m long, 1.2 m diameter drilled shaft (caisson) founded within the hard clayey silt to silty clay deposit (base of caisson at about Elevation 228 m) is estimated to have a factored ultimate geotechnical resistance value of about 2,250 kN. Larger diameter or longer caissons may be considered as necessary if higher geotechnical resistances are required. For preliminary design, a factored shaft resistance of 30 kPa may be assumed for the cast-in-place concrete / soil interface, however this value will need to be checked and confirmed by the design-builder when installation method and detail design is confirmed. Downdrag assessment and lateral resistance of caissons should be designed similar to the methods provided for piles in Section 6.5.3 and 6.5.4.

If caisson foundations are adopted for support of any of the foundation elements, a temporary or permanent liner would be required to support the soils during construction, to reduce disturbance and loss of ground in the water-bearing cohesionless soils and cohesive soils containing silt and sand interlayers. Specialized construction techniques would be required during advancement of the caisson to maintain a sufficient head of water and/or drilling fluid within the liner to prevent basal heave and disturbance of water-bearing cohesionless layers/interlayers. Concrete will need to be placed using tremie techniques and verification of the base may not be feasible, thus, a design based solely on shaft friction is considered applicable.

Caisson installation must be in accordance with OPSS.PROV 903 (Deep Foundations). If caissons are being considered, an NSSP has been provided in Appendix D for inclusion into the Contract Documents. The NSSP will address the requirements for supply and installation of drilled shafts (caissons) including the use of temporary or permanent liners/casings and slurry, the placement of concrete by tremie methods, cleaning and inspection of the shafts and base of the drilled shafts as applicable, and quality control testing.

## 6.8 Frost Protection

The spread / strip footing(s) and pile / caisson caps should be founded at a minimum depth of 1.5 m below the lowest surrounding final grade, including any distance measured perpendicular to the sloping ground surface to

provide adequate protection against frost penetration (as interpreted from OPSD 3090.101 – *Foundation Frost Penetration Depths for Southern Ontario)*.

## 6.9 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment walls and any associated wingwalls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. The following recommendations are made concerning the design of the abutment walls and wingwalls:

- Free-draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular A or Granular B Type II should be used as backfill behind the walls. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Other aspects of the granular backfill requirements with respect to subdrains and frost taper should be in general accordance with OPSD 3101.150 (*Walls, Abutment, Backfill, Minimum Granular Requirement*), OPSD 3121.150 (*Walls, Retaining, Backfill, Minimum Granular Requirement*), and 3190.100 (*Walls, Retaining and Abutment, Wall Drain*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with *CHBDC* (2019) Section 6.12.3 and Figure 6.8. Care must be taken during the compaction operation not to overstress the wall, with limitations required on heavy construction equipment and requirements for the use of hand-operated compaction equipment per OPSS.PROV 501 *(Compacting).* Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.5 m behind the back of the wall in accordance with Figure C6.31(a) of the *Commentary to the CHBDC* (2019). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at flatter than 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of the footing or pile cap in accordance with Figure C6.31(b) of the *Commentary to the CHBDC* (2019).

### 6.9.1 Static At-Rest and Active Lateral Earth Pressures

The following guidelines and recommendations are provided regarding the lateral earth pressures for static loading conditions. These design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

The following parameters (unfactored) may be used assuming the use of Granular fill as backfill behind the abutments:

| Fill Type | Unit Weight of Material (kN/m$^3$) | Coefficients of Static Lateral Earth Pressure | |
|---|---|---|---|
| | | At-Rest, $K_o$ | Active, $K_a$ |
| Granular A or Granular B Type II | 21 | 0.41 | 0.26 |

If the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.12 of the *Commentary to the CHBDC* (2019).

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

## 6.10 Embankment Widening / Approach Embankments

### 6.10.1 Subgrade Preparation and Embankment Construction

As previously discussed, the proposed County Road 4 widening will be predominantly on the east side (up to about 17 m and 18 m of embankment widening near the south and bridge abutments) that will result in new widened embankment heights up to about 8 m near the bridge abutments. The widened high fill embankments (greater than about 4.5 m high on the east side) extend to about Station 9+900 north of the bridge and to about Station 10+200 south of the bridge. There is limited to no widening on the west side of the existing embankment.

Prior to placing any engineered fill for the high fill embankment widening, the plan limits should be cleared of existing vegetation and stripped of all surficial and near-surface layers of asphalt (on County Road 4 surface), topsoil, organic soils, and any loosened / softened fill layers (possible re-worked soil from farming activities) or fill containing deleterious materials as per OPSS.PROV 206 (Grading). Based on the geotechnical exploration, the thickness of organic deposits (including topsoil) and loosened / softened fill generally ranges between 0.7 m to 0.9 m beyond the toes of the existing embankment. Any temporary access roads or detour embankments / roads are the responsibility of the design-build contractor and appropriate subgrade preparation should be considered in collaboration with the design life and anticipated maintenance of the temporary roadway.

After approval of the subgrade, construction of the embankment widening should consist of engineered fill consisting of suitable earth fill. Suitable earth fill may consist of imported OPSS.PROV1010 Select Subgrade Material (SSM) or Granular ‘A’ or ‘B’ soils, or earth fill meeting the requirements of OPSS.PROV 212 (*Borrow).* Consideration can be given to re-using the existing embankment fill that will be cut / excavated in some areas of County Road 4 provided the fill is free of excessive organics and deleterious materials, near its optimum moisture content, is approved by the contractors geotechnical engineer and can placed and compacted in accordance with OPSS.PROV 501 (Compacting). In addition, benching of the existing County Road 4 embankment side-slopes should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes) to effectively ‘key-in’ the new fill with the existing fill to reduce the potential for creating a localized weak plane that could cause instability during or after construction.

Embankment side-slopes constructed of Granular ‘A’, ‘B’, or SSM may sloped at 2 horizontal to 1 vertical (2H:1V) or flatter. If suitable borrow or on-site earth fill is being considered, the design-builder must confirm that a minimum friction angle of 36 degrees is appropriate for the selected material to be consistent with the stability analyses performed at this stage confirming 2H:1V slopes are acceptable. Alternatively, the design-builder can perform additional slope stability analyses using a lower friction angle that is appropriate for the selected borrow or earth fill to check if 2H:1V slopes meet the target factor of safety or if side-slopes need to be flattened in the high fill areas. The embankment side slopes should also include a minimum 2 m wide bench at mid-height for all fill heights greater than 8 m (measured from top of roadway to embankment toe where it meets the native ground surface) as indicated

in OPSD 202.010 (Slope Flattening). All embankment construction should be carried out in accordance with OPSS.PROV 206 (Grading).

The design parameters used for stability and settlement analysis of the proposed embankment widening of County Road 4, including the immediate approach embankments to the new bridge (i.e., from approximately Station 9+935 to 9+955 and Station 10+040 to 10+060, respectively) is discussed in the following section.

### 6.10.2 Design Parameter Selection

The foundation engineering parameters for the soil types encountered in the foundation boreholes advanced at this site and the proposed new embankment widening soils are summarized below. For stability and settlement analysis, the groundwater level behind the abutment stem walls was assumed to be at Elevation 260 m and 254 m at the north and south abutments, respectively.

| Stratigraphic Unit | $\gamma$ (kN/m$^3$) | $\varphi'$ (°) | $S_u$ (kPa) | $E'$ (MPa) |
|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | 21 | 35 - 36 | -- | -- |
| Loose to Very Dense Sandy Silt to Silty Sand to Sand and Gravel Fill | 20 | 31 - 34 | -- | -- |
| Very soft to Hard Clayey Silt-Silt to Clayey Sand Fill | 20 | 28-29 | 50 – 100 | -- |
| Firm to Very Stiff Clayey Silt-Silt to Silty Clay to Clayey Sand (Upper Cohesive) | 20-21 | 29 - 30 | 50 – 100 | 20 - 50 |
| Very Loose to Dense Silt to Silt and Sand | 20 | 31-32 | -- | -- |
| Compact to Very Dense Silty Sand | 20 | 34 | -- | 5 - 25 |
| Compact to Very Dense Silt | 20 | 34 | -- | 20 - 25 |
| Stiff to Hard Clayey Silt-Silt to Clayey Silt to Silty Clay Till | 21-22 | 32-35 | 100-150 | 50 - 100 |
| Hard Clayey Silt-Silt to Clayey Silt to Silty Clay (Lower Cohesive) | 21 | 32 | 150 -200 | 150 |
| Very Dense Silt (Lower) | 21 | 35 | -- | 150 |
| Hard Clayey Silt-Silt Till (Lower Till) | 21 | 35 | 200 | 150 |

Notes:

$\gamma$ = bulk unit weight
$\varphi'$ = angle of internal friction
$S_u$ = undrained shear strength
E' = drained modulus

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.

## 6.11 Global Stability

The following sections outline the method and geometries used to evaluate static global stability of the proposed embankment widening of County Road 4 (including at the approach embankments to the proposed bridge) followed by the results of the stability assessment. It is noted that the stability analyses assume that all organics (topsoil) and surficial deposits of softened/loosened soil or other deleterious materials have been removed within the footprint of the proposed widening and the existing County Road 4 embankment side slopes will be stepped prior to placing new engineered fill for the widened embankment as discussed in Section 6.10.1.

### 6.11.1 Method of Analysis

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, $\Psi$, and the geotechnical resistance factor, $\phi_{gu}$. (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$).

For this stability assessment, minimum target Factors of Safety of 1.3 and 1.5 have been used for the design of the widened embankment heights and geometries at the proposed bridge abutments / high fill areas for the short-term (undrained) and long-term (drained) conditions, and to assess the feasibility of the proposed temporary open cut excavation for the construction of the centre pier, as per Table 6.2 of the CHBDC (2019).

The stability analysis was carried out at the following locations / stations with new embankment side-slopes modelled at 2H:1V and the groundwater level modelled consistent with the water level measured in the closest piezometers.

| Location | County Road 4 Stationing |
|---|---|
| North Approach – Permanent Widening Configuration | 9+935 – 9+955 |
| South Approach – Permanent Widening Configuration | 10+040 – 10+060 |
| High Fill near Culvert – Permanent Widening Configuration | 10+040 |
| Centre Pier – Temporary Excavation Configuration | 9+960 to 10+040 (along bridge centreline) |

The idealized cross section for the permanent embankment widening used in the analyses is shown on Figures 1 to 12. A conceptual cross section of a temporary cut slope for construction of the pier foundation is shown on Figures 13 and 14 assuming a 1H:1V and 2H:1V slope angle respectively. It is noted that the short-term stability assessment for the temporary cut slope condition is conceptual to assess the feasibility of the concept design staging and detail design of the temporary cut slope and confirmation of adequate stability (for undrained and drained conditions) must be assessed by and is the responsibility of the Contractor's designer.

A summary of the engineering parameters employed in the stability analyses are shown on Figures 1 to 14 and are as per design parameters provided in subsection 6.10.2.

### 6.11.2 Results of Analyses

The stability analyses for the select sections along the widened County Road 4 embankment indicate the approach embankments / abutments will have a global Factor of Safety of greater than 1.3 for the short-term (temporary) condition, and the approach embankments / abutments will have a global Factor of Safety greater than 1.5 for the long-term (permanent) condition, where embankment side slopes are 2H:1V or flatter. The stability analyses for the temporary excavation to construct the centre pier indicate side slopes of 1H:1V do not provide an adequate factor of safety (i.e. Factor of Safety less than 1.3) and side slopes of about 2H:1V or flatter are required to satisfy the minimum factor of safety for the short-term (temporary) condition. The results of the stability analyses are summarized below and are shown on Figures 1 to 14 following the text of this report.

| Foundation Element | Static Global Stability | Slope Face | Factor of Safety |
|---|---|---|---|
| North Abutment and Embankment Widening (2H:1V side slopes) (Station 9+950) | Short-term (undrained) | East | > 1.3 (Figure 1) |
| | Long-term (drained) | | > 1.5 (Figure 2) |
| | Short-term (undrained) | West | > 1.3 (Figure 3) |
| | Long-term (drained) | | > 1.5 (Figure 4) |
| South Abutment and Embankment Widening (2H:1V side slopes) (Station 10+040) | Short-term (undrained) | East | > 1.3 (Figure 5) |
| | Long-term (drained) | | > 1.5 (Figure 6) |
| | Short-term (undrained) | West | > 1.3 (Figure 7) |
| | Long-term (drained) | | > 1.5 (Figure 8) |
| High Fill Embankment Widening near Culvert (2H:1V side slopes) (Station 10+040) | Short-term (undrained) | East | > 1.3 (Figure 9) |
| | Long-term (drained) | | > 1.5 (Figure 10) |
| | Short-term (undrained) | West | > 1.3 (Figure 11) |
| | Long-term (drained) | | > 1.5 (Figure 12) |
| Temporary Excavation for Bridge Pier (1H:1V side slopes) | Short-term (undrained) | North-South | < 1.3 (Figure 13) |

| Foundation Element | Static Global Stability | Slope Face | Factor of Safety |
|---|---|---|---|
| Temporary Excavation for Bridge Pier (2H:1V side slopes) | Short-term (undrained) | North-South | > 1.3 (Figure 14) |

In summary, the stability analyses for the permanent embankment widening 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.

The Contractor is responsible for detail design and ensuring stability of all temporary cut slopes on the project. Based on our conceptual assessment, temporary excavation (up to about 13 m deep) for the pier foundation will require slopes flatter than 1H:1V and may approach 2H:1V to achieve an adequate factor of safety assuming advanced groundwater lowering is performed prior to excavation. Alternatively, a temporary protection system could be considered.

## 6.12 Settlement

To estimate the magnitude of expected settlement of the foundation soils due to the loading of the permanent high fill embankment widening, analyses were carried using the commercially available program Settle3 (Version 5.0), developed by Rocscience Inc. A three-dimensional model was generated to assess the estimated settlements and identify the critical locations where settlement may impact the design and construction. The settlement analyses assume that all topsoil and any surficial deposits containing organic material, loosened/softened zones, or other deleterious materials have been removed and new granular fill (Granular ‘A’ and ‘B’ soils) placed and compacted as discussed in Section 6.10.1. The stress distribution calculations used in the settlement analyses were based on Westergaard's (1938) solution and the applied loading of the embankment fill widening assumed a unit weight of 21 kN/m$^3$.

The foundation settlements consist predominantly of the following:

- Immediate settlement mainly of the granular soils (short-term); and,
- Primary time-dependent consolidation of the cohesive deposits (long-term)

The thickness of the compressible foundation soils and the height of the high fill embankment vary along the extents of the high fill area. As such, the calculated settlements along the length of the high fill embankment widening similarly varied; however, the maximum settlements were identified to occur on the east side and within the north and south approach embankments leading up the bridge abutments. As minimal embankment widening is proposed on the west side of the existing embankment and minimal grade raise proposed, settlements along the existing centreline of the County Road 4 alignment and west portion of the embankment are considered negligible.

A summary of the estimated magnitude of settlement on the east side of the north and south approach embankments is presented below. The estimated settlement at the pier location from the influence of the adjacent embankment fill widening at the north and south approaches was also calculated and shown below.

| Location | Approximate County Road 4 Station | Approximate Maximum Embankment Height [1] | Settlement, $\delta$[2] | |
|---|---|---|---|---|
| North Approach Embankment | Station 9+940 to Station 9+960 | 8 m | $\delta_{Immediate}$ = | 50 mm |
| | | | $\delta_{Primary}$ = | 40 mm |
| | | | $\delta_{Total}$ = | 90 mm |
| Centre Pier (during stage 1 temporary embankment widening to shift traffic east)[3] | Station 9+990 to Station 10+010 | 8 m | $\delta_{Immediate}$ = | <10 mm |
| | | | $\delta_{Primary}$ = | <10 mm |
| | | | $\delta_{Total}$ = | <20 mm |
| South Approach Embankment | Station 10+035 to Station 10+055 | 8 m | $\delta_{Immediate}$ = | 35 mm |
| | | | $\delta_{Primary}$ = | 35 mm |
| | | | $\delta_{Total}$ = | 70 mm |

**Notes:**
1. The proposed maximum embankment heights are based on cross sections provided along County Road 4 and existing ground surface profiles provided in AECOM's Final Design Team drawings dated October 28, 2021. Embankment heights are approximate and are relative to original ground surface at the east toe of the existing County Road 4 embankment.
2. The total settlement ($\delta_{Total}$) is defined as the sum of the immediate settlement ($\delta_{immediate}$) due to elastic compression of the predominantly non-cohesive deposits as well as primary ($\delta_{Primary}$) settlements due to time-dependent consolidation of the cohesive deposits.
3. Although the existing embankment height is up to 8 m at the pier location, it is anticipated that only a partial temporary widening (up to 8 m wide) will be completed to accommodate a temporary shift in traffic to the east during the first stage of construction. As a result, settlements at the pier location are much less than at the abutments where it is assumed that the full embankment widening (up to 17 m and 18 m) will be completed at the south and north approach embankments (up to the abutments) during the first stage.

The target settlement performance criteria for design of approach embankments are outlined in MTO's "*Embankment Settlement Criteria for Design*", dated July 2, 2010. In general, new embankments approaching structural elements such as bridge abutments are to be designed such that total settlement and rate of differential settlement do not exceed 25 mm, over a 20-year period following completion of construction.

Based on the estimated magnitude of settlement at the north and south approach embankments as shown above, settlement mitigation options such as preloading (allowing the embankment widening to remain in place for a period of time before construction of bridge abutments and pier) will be required to meet the settlement performance criterion. The table below provides an estimated preload duration at each abutment to meet the settlement performance criterion.

| Location | Time for Preload to Remain in Place to reduce future consolidation settlements to less than 25 mm |
|---|---|
| North Approach Embankment | 1 - 2 months |
| South Approach Embankment | 1 - 2 months |

The permanent embankment widening configuration on the east side of County Road 4 must be constructed in the first stage of construction to allow the loading to effectively preload and induce consolidation settlement of the foundation soils before installation of the bridge foundations or final paving of County Road 4 within the high fill section. Any temporary traffic shift to the east during the preload period may experience some settlement and cracking of the interim detour pavement (if applicable) and should be monitored and maintained to ensure safe traffic conditions until the detour is completed to the west of County Road 4 and traffic diverted.

The design-build contractor must also consider the future 'unloading' scenario when grades are lowered below and adjacent to the bridge to accommodate the proposed new Bradford Bypass highway. Based on a preliminary assessment of the concept design and anticipated interim grade below the completed bridge (understood to be sloped to meet the native ground surface west and east of the bridge), future excavation ("unloading") of up to about 5 m of soil is anticipated below the west and north limits of the bridge. The "unloading" is anticipated to result in less than 15 mm of heave or "rebound" at the Bradford Bypass grade and associated foundations. The bridge structure must be designed to accommodate any future rebound associated with the permanent excavation / unloading associated with the future Bradford Bypass grade.

## 6.13 Analytical Testing of Construction Materials

The results of analytical tests carried out on five soil samples are presented in Section 4.4 and details are provided on 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 range between <0.002% to 0.0045%, which is below the Moderate degree of exposure (i.e., below the class S3 exposure limits) and may be considered negligible according to Table 7.2 of MTO's Gravity Pipe Design Guidelines (2014). Therefore, based on the soil samples tested, when the designer is selecting the exposure class for concrete structures, the effects of sulphates from within the site soils in contact with the spread footing or pile caps and any portion of the proposed structure constructed below the ground surface may not need to be considered.

The pH measured on the soil samples ranges between about 7 to 8. According to the MTO Gravity Pipe Design Guidelines (2014), a pH less than 5.5 is considered strongly acidic while a pH greater than 8.5 is considered strongly alkaline; both of which are indicative of an increased potential for corrosion.

The resistivity measured in the five samples ranges between 2900 ohm-cm to 14,000 ohm-cm, which indicates that the potential soil corrosiveness on buried steel and concrete is very low (10,000 > R > 6,000) to moderate (4,500 > R > 2,000) as per Table 3.2 of the MTO Gravity Pipe Design Guideline (2014). Given that the proposed structure will be exposed to de-icing salt/chemicals, consideration should be given by the designer to designing the concrete structure for a "C" type exposure class as defined by CSA A23.1 Table 1.

These recommendations are provided as guidance only; the design-build structural designer should take the results of the laboratory testing into consideration for selecting appropriate materials and corrosion susceptibility for design service of the structure foundations. Ultimately, it is the 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.

## 6.14 Construction Considerations

### 6.14.1 Temporary Open-Cut Excavations

For construction of the proposed bridge abutments and pier, it is anticipated that temporary excavations will extend through the asphalt, topsoil, cohesive and non-cohesive embankment fill, as well as saturated native deposits of loose to compact silty sand to sandy silt, soft to stiff clayey silt, firm to hard clayey silt till, and compact to dense silt. Temporary excavations at the north abutment, centre pier, and south abutment are anticipated to be up about 5 m, 13 m, and 5 m deep, respectively, below the top of the existing County Road 4 embankment.

All temporary excavations must be carried out in accordance with Ontario Regulation 213 of the Ontario Occupational Health and Safety Act for Construction Projects (OHSA), as amended. As per OHSA, the fill layers may be classified as Type 3 soils, and as such, temporary excavations within the fill should be made with side slopes of one horizontal to one vertical (1H:1V) or flatter. Where excavation is to be carried out below the groundwater level in saturated non-cohesive fills, soft clayey silt sols, and the native silty sand to sandy silt and silt soils, the soils should be classified as Type 4, which requires side slopes of three horizontal to one vertical (3H:1V) or flatter unless the deposits are dewatered in which case they can be classified as Type 3. The native firm to stiff clayey silt and firm to hard clayey silt till may be classified as Type 3 soils.

### 6.14.2 Temporary Protection Systems

Temporary protection systems are expected to be required along County Road 4 to facilitate the conceptual construction staging of the detour west of County Road 4 and lower the County Road 4 grade north of the proposed bridge locations, and allow for construction of the new bridge and embankment widening with reduced impact to traffic. Depending on the selected foundation option and stability of the temporary open cuts (to be designed by the design-build contractor), temporary protection systems may also be required to facilitate the localized excavation and construction of the abutments and specifically the pier foundation.

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

Both driven sheet pile and solider pile and lagging walls are considered feasible as temporary protection systems along County Road 4, north and west of the bridge site. 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 and taking into account adjacent surcharge loads (e.g. traffic). Where required, additional lateral support may be provided by anchors. In the case of driven sheet piles, it is anticipated that sheet piles may be challenging to drive deep into the glacial till or silty sand (containing potential pockets of gravel and/or cobbles) and/or may become damaged if attempted to drive / vibrate through potential cobbles/boulders or obstructions that may be present. It is noted that the embankment fill is variable and an obstruction was encountered within the fill in Borehole HF-01. If deeper penetration of vertical elements is required, soldier piles could be drilled to and/or into the deposits. A sample NSSP has been provided in Appendix D to address the presence of granular deposits and obstructions (i.e., gravel and cobbles or boulders) for installation of any temporary protection systems through the embankment fill and within the till and silty sand deposit, for inclusion into the Design-Build Ready specifications.

The selection and design of the protection system will be the responsibility of the Contractor. The geotechnical parameters provided in Section 6.10.2 may used for conceptual design of temporary protection systems based on the stratigraphy of the closest boreholes to the proposed temporary protection system installation.

### 6.14.3 Obstructions

Cobbles and/or boulders may be encountered within the glacial till deposits and silty sand deposit, which may affect the installation of deep foundations, shallow foundations, and temporary protection systems. It is recommended that pile tip reinforcement, such as flange reinforcement or driving shoes per OPSD 3000.100, be used on all steel H-piles to minimize damage during pile driving at the site. If drilled shaft foundations are selected, the construction equipment should be capable of advancing the temporary or permanent casings through such obstructions. Similarly, preaugering should be considered for driven piles and soldier piles for the bridge foundations and any temporary protections systems. Removal of cobbles/boulders and subsequent backfilling (as required) to provide a competent foundation subgrade should be anticipated at the spread / strip footings for the pier.

An NSSP has been provided in Appendix D to address the presence of obstructions within the till deposit and silty sand deposit, for inclusion into the Contract Documents.

### 6.14.4 Groundwater and Surface Water Control

The groundwater level measured in the piezometers installed at the north abutment (CR4-03), centre pier (CR4-07) and south abutment (CR4-11) were at about Elevation 260.2 m, 255.2 m, and 253.5 m (ranging from about 1.0 m below to about 0.2 m above the existing ground surface adjacent to the embankment and up to about 2.6 m to 6.4 m below the top of the existing highway embankment). Referring to the concept design drawings, the bottom of the pile cap at the north and south abutment is at about 257.5 m and 254.5 m respectively, and the bottom of the centre pier footing is at about Elevation 248.5 m.

The measured water level is about 2.7 m above the base of pile cap (and 5.7 m above the bottom of the integral abutment CSP liner) at the north abutment and about 1 m below the base of pile cap (and 2 m above the bottom of the integral abutment CSP liner) at the south abutment. At the pier location, the measured water level is about 6.7 m above the approximate founding level of the proposed shallow foundation and associated excavation. Water levels were generally higher on the west side (as opposed to the east side) of the existing embankment where the natural drainage path is obstructed by the existing highway embankment fill.

As a result, the groundwater level will need to be temporarily lowered about 3 m to 6 m at the north abutment, 0 m to 2 m at the south abutment, and about 7 m at the centre pier location to allow for excavation and construction of the foundation elements (and associated CSP liners) in the dry.

Details regarding the assessment of the potential dewatering needs for the proposed bridge structure foundations are found under separate cover in AECOM's *Hydrogeological Investigation Report – Bradford Bypass – County Road 4, draft report* dated January 2022.

Advanced dewatering of the non-cohesive fills, silty sand to sandy silt, and silt will be required to maintain stable temporary slopes and avoid basal instability (heave or boiling)during and after excavation, allow placement of concrete, and suitable placement and compaction of backfill soils. Given the fine-grained nature of the cohesionless soils, well points and/or eductor systems are anticipated to be required, especially at the pier location where the integrity of the founding subgrade must be maintained. The groundwater level will need to be lowered to at least 0.5 m below the base of the founding soils and prior to carrying out the excavation to as not to disturb the founding soils (avoid instability or basal heave or boiling), subgrade inspection, placement and compaction of engineered fill or backfill, placement of working slab, and placement of any concrete in the dry. The dewatering target elevations and estimated hydraulic conductivities and dewatering estimates for the proposed construction are presented in Table 6 and 7, respectively, of AECOM's *Hydrogeological Investigation Report – Bradford Bypass – County Road 4.*

Dewatering operations should be in general accordance with OPSS.PROV 902 (*Excavation and Backfilling – Structures*), as amended by SP FOUN0003 (*Dewatering Structure Excavation*). It is recommended that a design engineer be required, and that the requirement for a pre-construction survey be checked during detail design, especially if temporary protections systems or other temporary works may be impacted by dewatering. 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 must be directed away from the excavations at all times. In particular, surface water drainage west of the site must be properly diverted / controlled such that the integrity of the pier footing subgrade is maintained. For this reason, it is anticipated that temporary extensions to the existing culvert and temporary culvert(s) south of the bridge site and below the detour embankment will be required and these are the responsibility of the Design-Builder.

To reduce erosion of the permanent embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection must be in accordance with OPSS.PROV 804 (*Seed and Cover*).

### 6.14.5 Piezometer / Well Decommissioning

A standpipe piezometer was installed in select boreholes to permit monitoring of the groundwater level at the site. Ontario Regulation (O.Reg.) 903 amended by O.Reg. 128/03 of the Ontario Water Resources Act requires that monitoring wells are properly abandoned/decommissioned by qualified personnel. It is recommended that the decommissioning of the standpipe piezometers be carried out as part of the construction activities at the site so that water level measurements can be taken during detail design and immediately prior to and during construction to assist in dewatering / surface water infiltration and flow diversion / discharge plan requirements. The standpipe piezometers installed in Boreholes CR4-03, CR4-07, CR4-11, HF-01, HF-05, CV1-01 and CV1-04 must be decommissioned by the design-builder and an example NSSP to be included in the contract documents is included in Appendix D.

### 6.14.6 Vibration Monitoring

Although the site is in a relatively rural area with the closest residences located more than 185 m from the bridge site, for due diligence purposes, vibration monitoring and condition surveys are recommended prior to and during construction (specifically for installation of deep foundations and temporary protection systems) to confirm that construction techniques and associated vibration levels experienced at nearby structures and utilities are maintained below tolerable levels, and to mitigate potential claims from property or utility owners.

As a general guide, the following maximum peak particle velocity (PPV) values should not be exceeded during construction:

- Existing structures (culverts) and utilities: 50 mm/s;
- Conventional commercial/industrial buildings: 50 mm/s; and,

- Residential homes and wells: 25 mm/s.

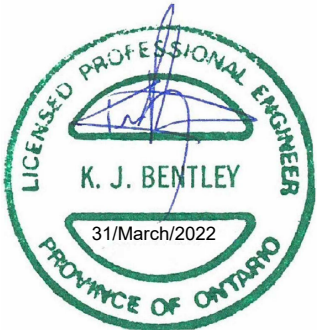
It is considered good practice to conduct vibration monitoring and pre- and post-construction condition surveys at existing structures or sensitive utilities within an approximately 100 m radius of any installation of deep foundations and/or temporary protection systems.

# 7.0 CLOSURE

This Foundation Design Report was prepared by Alysha Kobylinski, P.Eng., a geotechnical engineer with Golder. Mr. Kevin J. Bentley, P.Eng., and MTO Foundations Designated Contact for Golder, conducted an independent quality control review of this report.

# Signature Page

**Golder Associates Ltd.**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*Geotechnical Engineer*

Kevin Bentley, P.Eng.
*Associate, MTO Foundations Designated Contact*

ACK/KJB/ml

# REFERENCES

AECOM. 2022. *Hydrogeological Investigation Report – Bradford Bypass – County Road 4 (Draft dated January).*

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-S6-14.

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.

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Ministry of Transportation, Ontario. 2004. *Gravity Pipe Design Guidelines*.

Terzaghi, K., 1955. Evaluation of Coefficients of Subgrade Reaction. *Geotechnique*, Vol. 5, No. 4, pp. 297-326. Discussion in Vol. 6, No. 2, pp. 94-98.

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

Westergaard, H.M., 1938. A problem of elasticity suggested by a problem in soil mechanics: A soft material reinforced by numerous strong horizontal sheets. In *Contributions to the Mechanics of Solids*, Stephen Timoshenko 60th Anniversary Volume, MacMillan, New York, pp. 260-277.

**Commercial Software:**

Settle3 (Version 9.0) by Rocscience Inc.

Slide2 (Version 9.0) by Rocscience Inc.

**Ontario Occupational Health and Safety Act:**

Ontario Regulation 213 Construction Projects (as amended)

Ontario Regulation 903 Wells (as amended)

**Ontario Provincial Standard Specifications (OPSS):**

| | |
|---|---|
| OPSS.PROV 206 | Construction Specification for Grading |
| OPSS.PROV 212 | Construction Specification for Earth Borrow |
| OPSS.PROV 501 | Construction Specification for Compacting |
| OPSS.PROV 539 | Construction Specification for Temporary Protection Systems |
| OPSS.PROV 804 | Construction Specification for Seed and Cover |
| OPSS 902 | Construction Specification for Excavating and Backfilling - Structures |
| OPSS.PROV 903 | Construction Specification for Deep Foundations |
| OPSS.PROV 1010 | Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material |

Special Provision 109F57 Amendment to OPSS.PROV 903

**Ontario Provincial Standard Drawings (OPSD)**

| | |
|---|---|
| OPSD 202.010 | Slope Flattening |
| OPSD 208.010 | Benching of Earth Slopes |
| OPSD 3000.100 | Foundations, Piles, Steel H-Pile Driving Shoe |
| OPSD 3090.101 | Foundation, Frost Penetration Depths for Southern Ontario |
| OPSD 3101.150 | Walls, Abutments, Backfill, Minimum Granular Requirements |
| OPSD 3121.150 | Walls, Retaining, Backfill, Minimum Granular Requirements |

**Table 1: Comparison of Foundation Alternatives – Bradford Bypass / County Road 4 Bridge**

| Foundation Option | Advantages | Disadvantages | Relative Costs | Risk / Consequences |
|---|---|---|---|---|
| Steel H-piles driven into lower cohesive deposit | ■ Conventional construction methods for H-pile foundations at abutments.<br>■ Allows for integral abutment design and perched pile caps within existing / proposed embankment fill | ■ Not practical at pier location where temporary excavation and/or temporary protection system installation and removal required to accommodate large laydown area for pile driving rig and to construction pile cap up to 13 m below County Road 4 grade<br>■ Requires driving shoes due to potential presence of cobbles and boulders within the till deposits.<br>■ Noise of pile driving hammer to local residences<br>■ No competent “100-blow” end bearing soil present at shallow depth and long friction piles required<br>■ Long friction piles likely need sufficient time to “set-up” in clayey and silty soils to achieve geotechnical resistance | ■ Lower relative cost than drilled shafts (caissons)<br>■ Lower relative cost than shallow foundations considering excavation, dewatering, and backfilling requirements and altered staging / detour arrangements compared to concept design. | ■ Risk of piles getting “hung up” or being “deflected” or “twisted” due to cobbles and boulders that may be present within the till or obstructions in the fill deposits.<br>■ Long pile lengths may require thicker steel sections to achieve design resistance and to reduce damage during driving<br>■ Higher risk of misalignment with depth; piles for integral abutment must be in line.<br>■ Noise complaints and/or local noise bylaws<br>■ Schedule needs to accommodate time for pile “set-up” / relaxation to achieve higher capacities. |
| Drilled Shafts (Caissons) founded within the lower cohesive deposit | ■ Conventional construction methods for drilled shaft foundations at abutments<br>■ Innovative design / construction could allow for pier foundation and circular pier to be constructed with limited excavation to future Bradford Bypass grade.<br>■ Offers higher geotechnical resistance compared to driven steel piles at same | ■ More specialized procedure may be required at pier foundation to allow continuous transition from foundation to centre pier that will be exposed in future Bradford Bypass excavation / construction. Permanent liners may be required to be exposed after future Bradford Bypass excavation..<br>■ Likely not feasible at abutments for integral design<br>■ Temporary or permanent casings will be required, plus special measures such as | ■ Higher relative cost than driven piles at abutments.<br>■ At pier, possibly comparable to shallow foundation given reduced costs associated with dewatering / excavation if innovative design developed. However, increased | ■ Will be difficult to inspect the base of the drilled shaft due to the presence of slurry / drilling mud inside the casings.<br>■ Risk of encountering cobbles/boulders that may be present in the till or obstructions in the fill deposits.<br>■ If considered for pier foundation and actual pier construction (to avoid excavation/dewatering and |

| | | | | |
|---|---|---|---|---|
| | depth, requiring fewer foundation elements.<br>■ Dewatering efforts could be reduced at pier location compared to shallow foundation option. | use of slurry to counterbalance groundwater pressures and minimize ground disturbance and use of tremie methods for concrete placement.<br>■ Generation of soil cuttings / management of slurry during drilled shaft advancement and concrete placement.<br>■ Presence of “100-blow” soils for optimal end-bearing design not encountered and design likely based on friction component of shaft. | cost for permanent steel liners if required at pier. | interim backfilling), the quality / competency of future exposed pier will need to be confirmed. |
| Shallow Foundations founded below existing embankment fill on native soils | ■ Conventional construction can be accommodated at pier location with staged construction and detour.<br>■ Temporary protection system could be considered to reduce dewatering efforts and volume of excavation although top of cohesive deposit (El. 240 m) for groundwater cut-off located more than 22 m below County Road 4 grade. | ■ Deep excavation (up to 13 m deep below County Road 4 grade) in open cut and/or with temporary protection system for shallow foundation required to found below the future Bradford Bypass grade, and subsequent backfilling to interim grade required.<br>■ Dewatering required to allow for excavation and construction of new footing in the dry and maintain stable foundation subgrade<br>■ If temporary protection system is used, installation and full removal will be required. | ■ Lower cost compared to deep foundation options; however, additional costs for excavation (possible temporary protection system) and dewatering requirements. | ■ Dewatering in silts may require well points or eductor systems in advance of excavation<br>■ Risk of disturbance to foundation soils (especially silt) if dewatering effort is not adequate<br>■ Low risk of differential heave when future Bradford Bypass grade is excavated below bridge considering west portion will have up to about 5 m of interim backfill removed and east portion will have about 1 m of interim backfill removed. |

# Drawings

MINISTRY OF TRANSPORTATION, ONTARIO

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

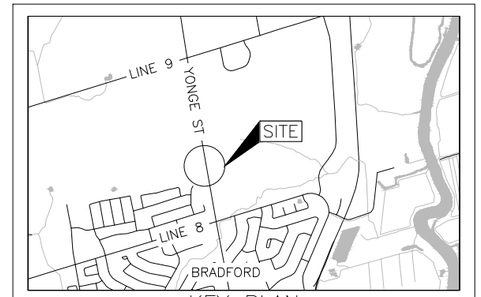
CONT No. 2021-2124
WP No. 2008-21-00

SHEET

# BRADFORD BYPASS
SIMCOE COUNTY ROAD 4 BRIDGE AND WIDENING

## BOREHOLE LOCATION PLAN

WSP GOLDER




KEY PLAN
SCALE
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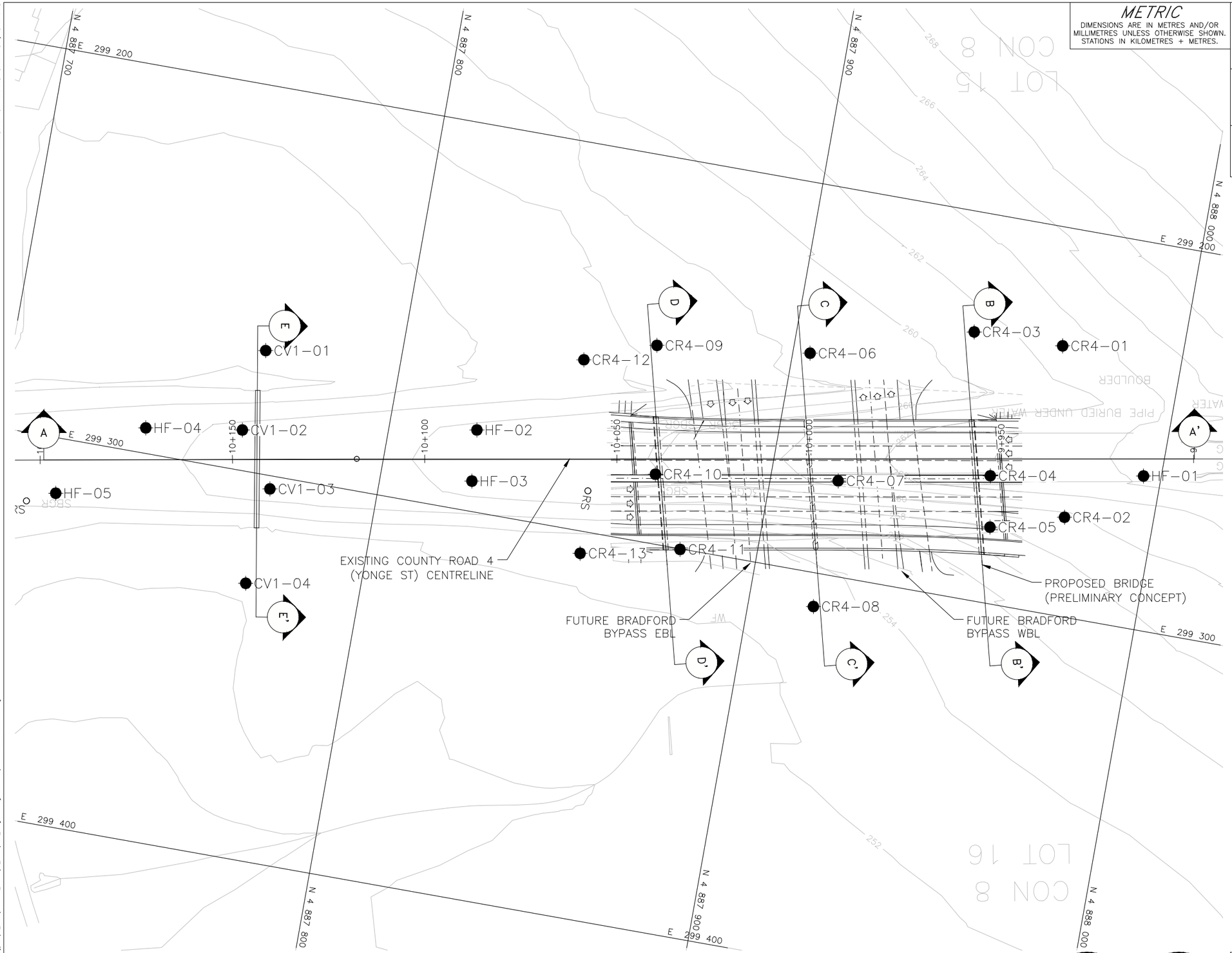



PLAN
SCALE
10 0 10 20 m

## LEGEND

● Borehole – Current Investigation

BOREHOLE CO-ORDINATES

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| CR4-01 | 262.8 | 4887968.8 | 299230.6 |
| CR4-02 | 259.7 | 4887977.1 | 299274.4 |
| CR4-03 | 261.2 | 4887945.5 | 299231.0 |
| CR4-04 | 262.8 | 4887956.2 | 299267.1 |
| CR4-05 | 258.0 | 4887958.5 | 299280.3 |
| CR4-06 | 258.2 | 4887904.5 | 299244.0 |
| CR4-07 | 261.3 | 4887917.5 | 299275.4 |
| CR4-08 | 253.3 | 4887916.9 | 299308.7 |
| CR4-09 | 256.5 | 4887864.9 | 299249.0 |
| CR4-10 | 259.9 | 4887870.4 | 299282.0 |
| CR4-11 | 253.3 | 4887880.1 | 299300.2 |
| CR4-12 | 255.2 | 4887846.8 | 299256.0 |
| CR4-13 | 252.8 | 4887854.7 | 299305.7 |
| 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 |
| HF-01 | 264.2 | 4887995.4 | 299260.2 |
| HF-02 | 258.3 | 4887822.6 | 299278.8 |
| HF-03 | 258.4 | 4887823.7 | 299292.2 |
| HF-04 | 255.5 | 4887737.7 | 299293.4 |
| HF-05 | 254.7 | 4887717.7 | 299314.3 |

## 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.

## 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.

LICENSED PROFESSIONAL ENGINEER
A. C. KOBYLINSKI
100533760
Feb. 17, 2022
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
K. J. BENTLEY
Feb. 17, 2022
PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| . | . | . | . |

Geocres No. 31D-794

| | | | |
|---|---|---|---|
| HWY. BRADFORD BYPASS | PROJECT NO. 19136074 | | DIST. CENTRAL |
| SUBM'D. ACK | CHKD. ACK | DATE: 02/17/2022 | SITE: . |
| DRAWN: DD | CHKD. KJB | APPD. KJB | DWG. 1 |

PLOT DATE: February 17, 2022
FILENAME: S:\Clients\MTO\Bradford_Bypass\99_PROJ\19136074_Aecom\45_PROD\0001_Bridge and High Fills (GDR)\19136074-0001-BG-0001.dwg

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

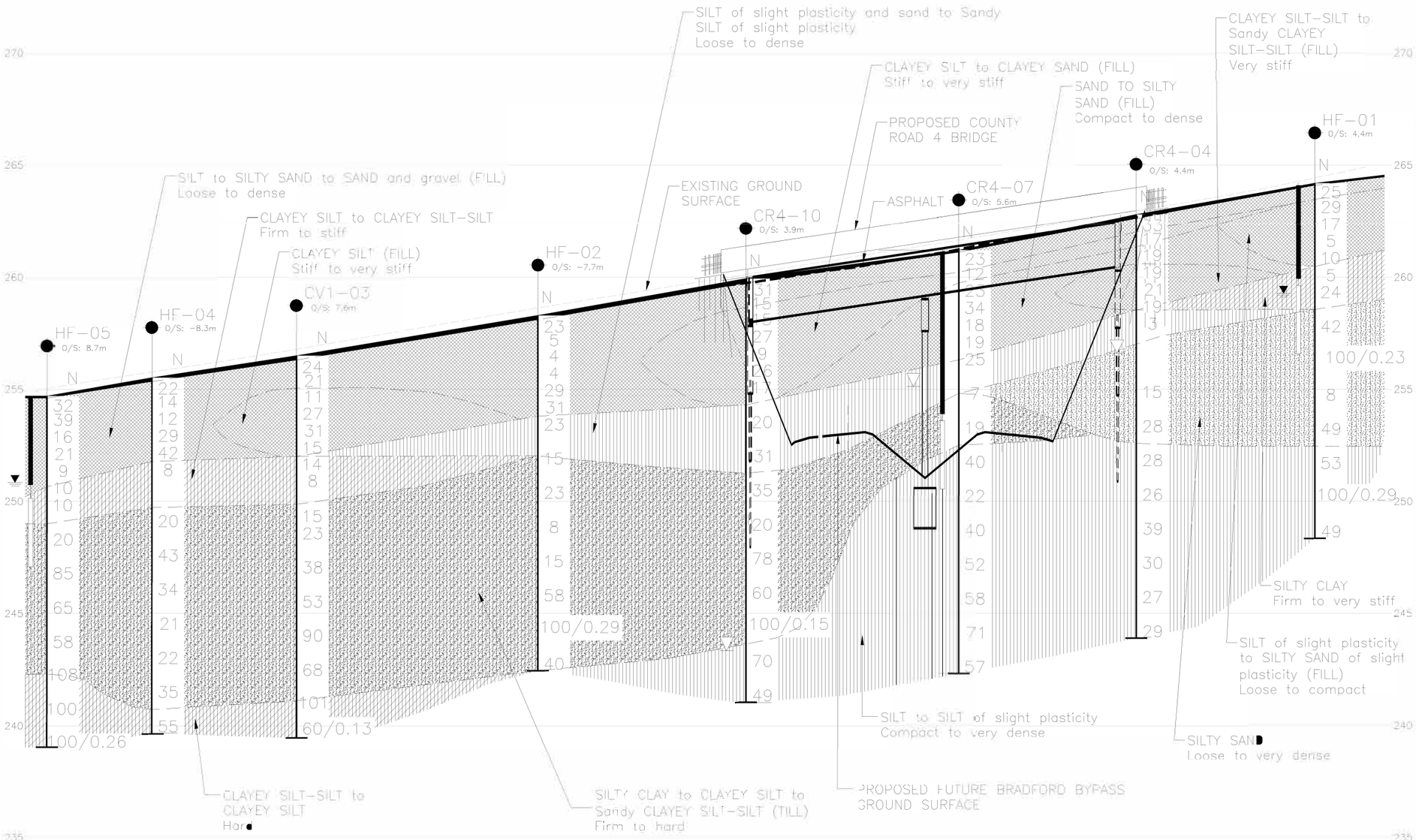
CONT No. 2021-2124
WP No. 2008-21-00

# BRADFORD BYPASS
SIMCOE COUNTY ROAD 4 BRIDGE AND WIDENING

## SOIL STRATA – PROFILE A-A'

SHEET

GOLDER




PROFILE A-A'
VERTICAL SCALE
2 0 2 4 m
HORIZONTAL SCALE
10 0 10 20 m


KEY PLAN
SCALE
500 0 500 1000 m

## 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 (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| CR4-04 | 262.8 | 4887956.2 | 299267.1 |
| CR4-07 | 261.3 | 4887917.5 | 299275.4 |
| CR4-10 | 259.9 | 4887870.4 | 299282.0 |
| CV1-03 | 256.5 | 4887772.3 | 299303.4 |
| HF-01 | 264.2 | 4887995.4 | 299260.2 |
| HF-02 | 258.3 | 4887822.6 | 299278.9 |
| HF-04 | 255.5 | 4887737.7 | 299293.4 |
| HF-05 | 254.7 | 4887717.7 | 299314.3 |

## NOTES

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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.

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| NO. | DATE | BY | REVISION |
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| | | | |

Geocres No. 31D-794

| | | | |
|---|---|---|---|
| HWY. BRADFORD BYPASS | PROJECT NO. 19136074 | | DIST. CENTRAL |
| SUBM'D. ACK | CHKD. ACK | DATE: 02/17/2022 | SITE: |
| DRAWN: DD | CHKD. KJB | APPD. KJB | DWG. 2 |

PLOT DATE: February 17, 2022
FILENAME: C:\Clients\M10\Bradford_Bypass\99_PROJ\19136074_Aecom\40_DRGS\000_Bridge and Hgts Fits 11X17\19136074-0001-BC-0002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

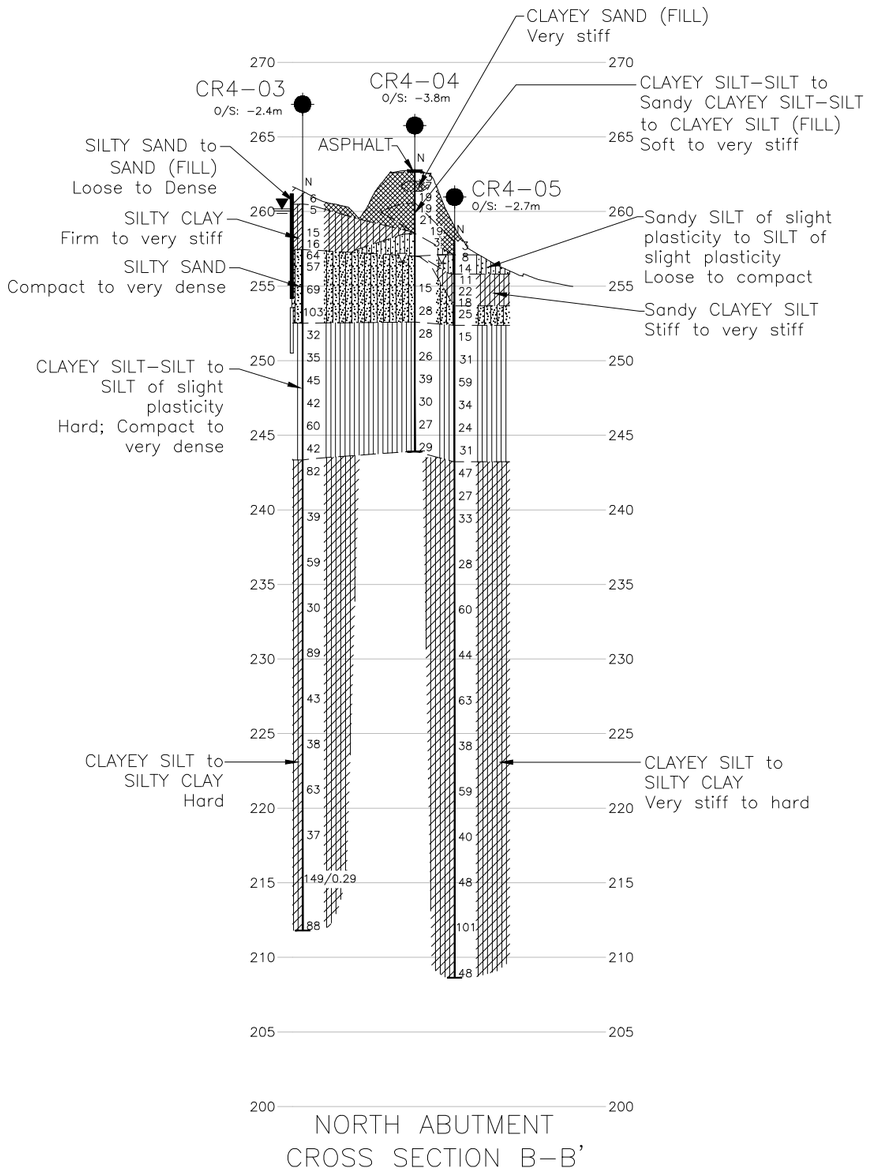
**METRIC**
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

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

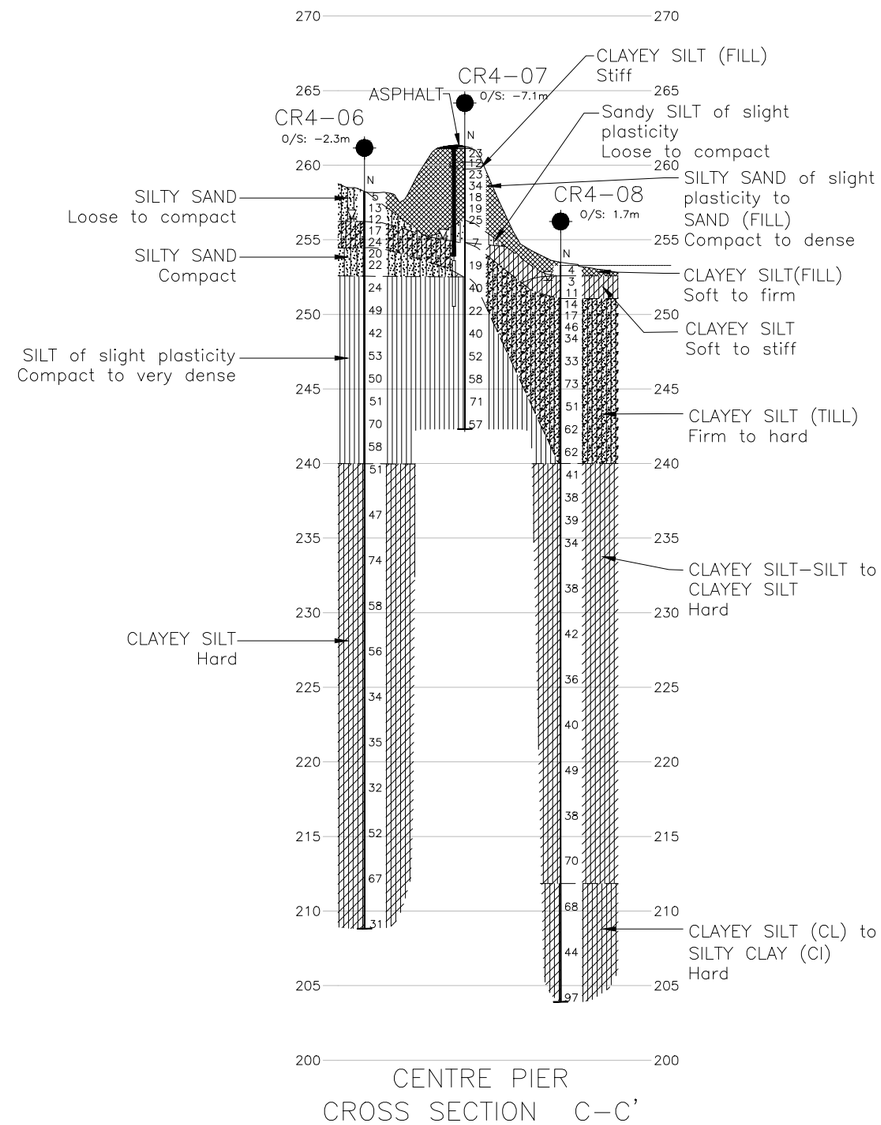
# BRADFORD BYPASS
SIMCOE COUNTY ROAD 4 BRIDGE AND WIDENING
## SOIL STRATA – CROSS SECTIONS B-B' AND C-C'

SHEET

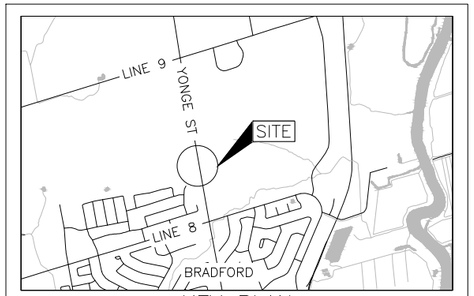
WSP GOLDER




NORTH ABUTMENT
CROSS SECTION B-B'




CENTRE PIER
CROSS SECTION C-C'




KEY PLAN
SCALE
500 0 500 1000 m

## 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 (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| CR4-03 | 261.2 | 4887945.5 | 299231.0 |
| CR4-04 | 262.8 | 4887956.2 | 299267.1 |
| CR4-05 | 258.0 | 4887958.5 | 299280.3 |
| CR4-06 | 258.2 | 4887904.5 | 299244.0 |
| CR4-07 | 261.3 | 4887917.5 | 299275.4 |
| CR4-08 | 253.3 | 4887916.9 | 299308.7 |

## NOTES
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General arrangement provided in digital format by Aecom, file no. 01_County RD. UP OVER BBP_ga.dwg, received June 6, 2021.

## CROSS SECTION B-B' AND C-C'
VERTICAL SCALE
4 0 4 8 m
HORIZONTAL SCALE
20 0 20 40 m

LICENSED PROFESSIONAL ENGINEER
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PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| . | . | . | . |

Geocres No. 31D-794

| | | | |
|---|---|---|---|
| HWY. BRADFORD BYPASS | PROJECT NO. 19136074 | | DIST. CENTRAL |
| SUBM'D. ACK | CHKD. ACK | DATE: 02/17/2022 | SITE: . |
| DRAWN: DD | CHKD. KJB | APPD. KJB | DWG. 3 |

PLOT DATE: February 17, 2022
FILENAME: S:\Clients\MTO\Bradford_Bypass\VA_PROJ\19136074_Aecom\60_PROD\0001_Bridge and High Fills FIDR\19136074-0001-BBC-0003.dwg

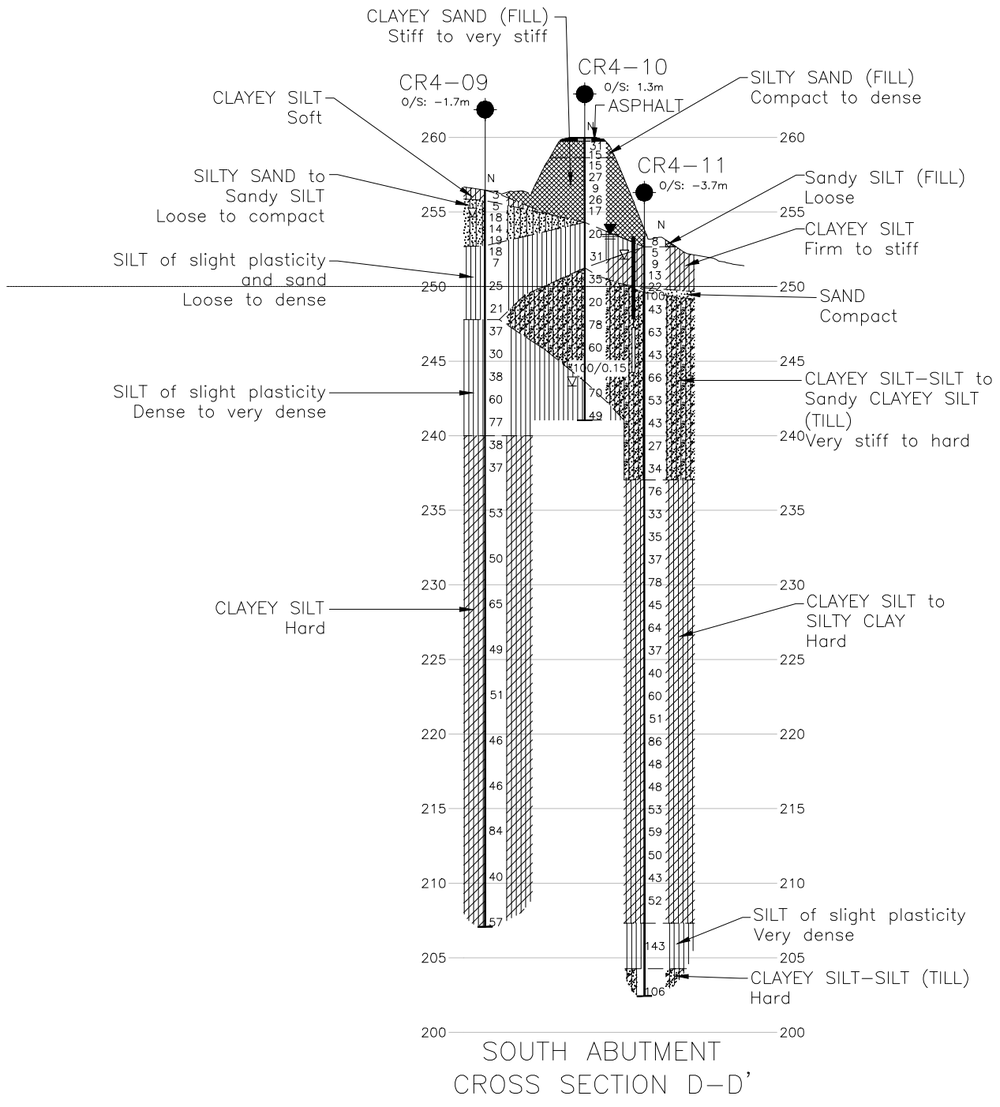
**METRIC**
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. 2021–2124
WP No. 2008–21–00

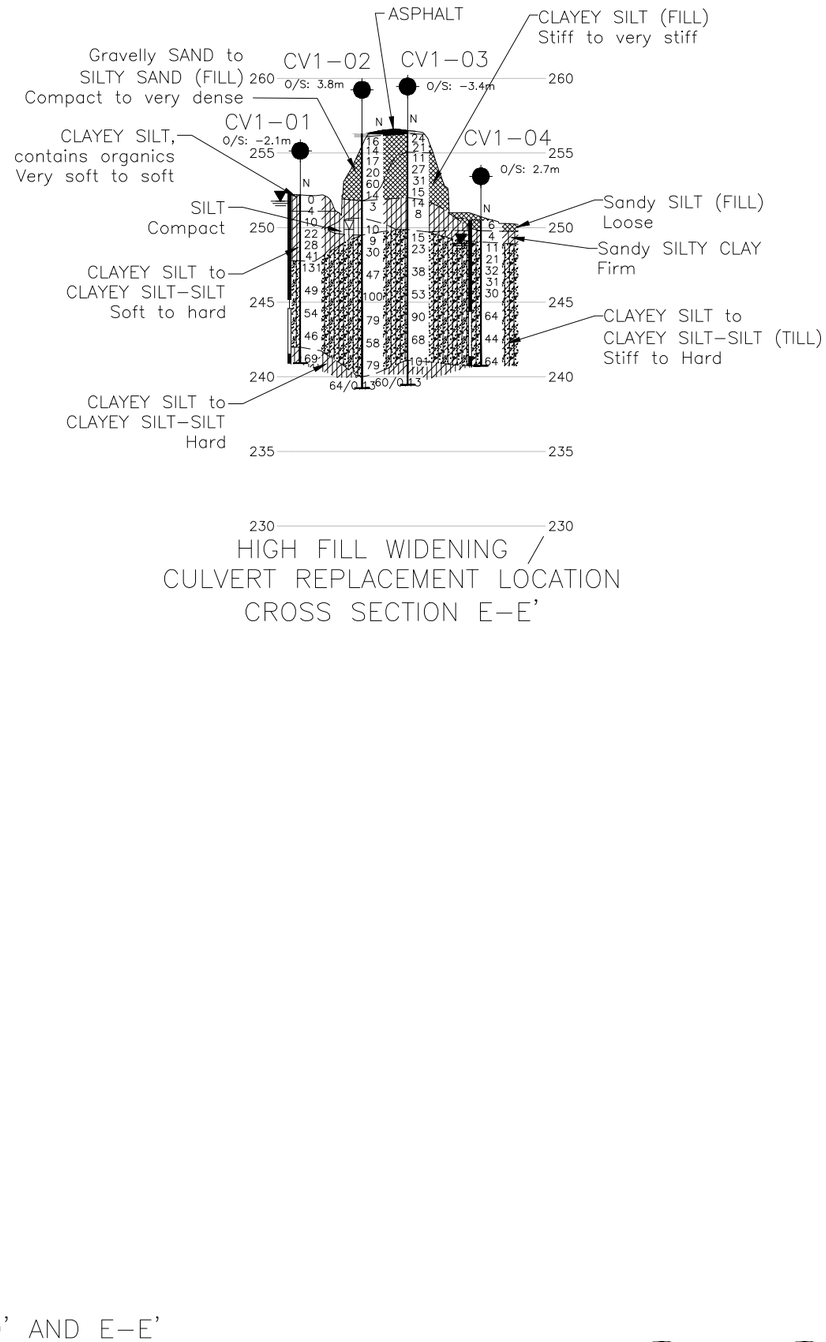
# BRADFORD BYPASS
SIMCOE COUNTY ROAD 4 BRIDGE AND WIDENING
## SOIL STRATA – CROSS SECTIONS D–D' AND E–E'

SHEET .

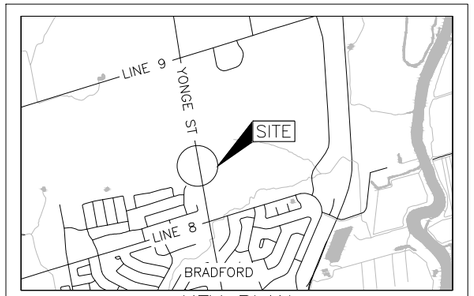
WSP GOLDER




SOUTH ABUTMENT
CROSS SECTION D–D'




HIGH FILL WIDENING / CULVERT REPLACEMENT LOCATION
CROSS SECTION E–E'




KEY PLAN
SCALE
500 0 500 1000 m

## 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 (MTM NAD83 ZONE 10)

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| CR4–09 | 256.5 | 4887864.9 | 299249.0 |
| CR4–10 | 259.9 | 4887870.4 | 299282.0 |
| CR4–11 | 253.3 | 4887880.1 | 299300.2 |
| 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 |

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CROSS SECTION D–D' AND E–E'
VERTICAL SCALE
4 0 4 8 m
HORIZONTAL SCALE
20 0 20 40 m

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| . | . | . | . |

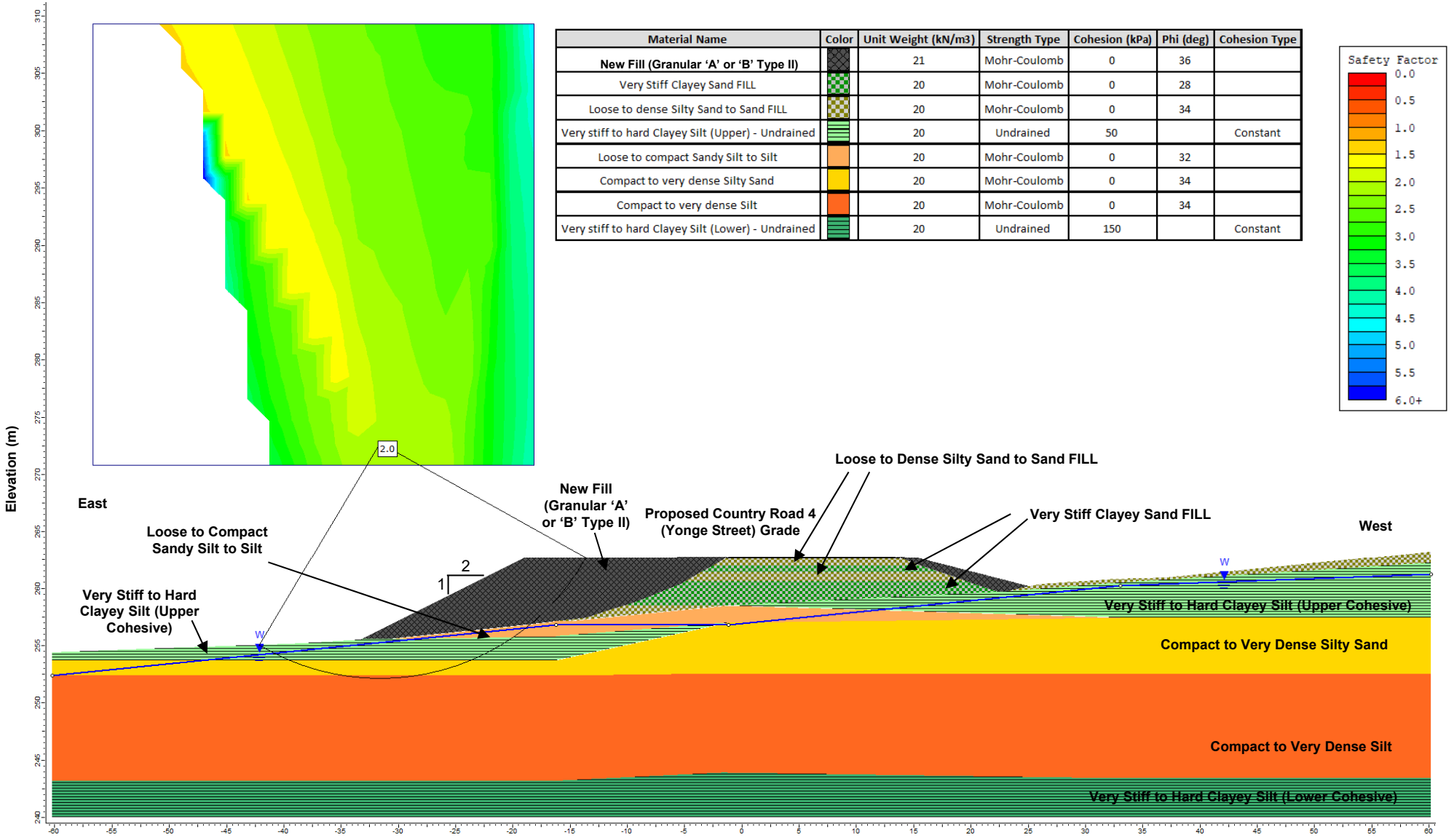
Geocres No. 31D–794

| | | | |
|---|---|---|---|
| HWY. BRADFORD BYPASS | PROJECT NO. 19136074 | | DIST. CENTRAL |
| SUBM'D. ACK | CHKD. ACK | DATE: 02/17/2022 | SITE: . |
| DRAWN: DD | CHKD. KJB | APPD. KJB | DWG. 4 |

# Figures

# Global Stability at County Road 4 North Abutment (East Side)
# Short-Term (Undrained) Condition

**Figure 1**




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 | |
| Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to dense Silty Sand to Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Very stiff to hard Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Loose to compact Sandy Silt to Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact to very dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 34 | |
| Compact to very dense Silt | | 20 | Mohr-Coulomb | 0 | 34 | |
| Very stiff to hard Clayey Silt (Lower) - Undrained | | 20 | Undrained | 150 | | Constant |

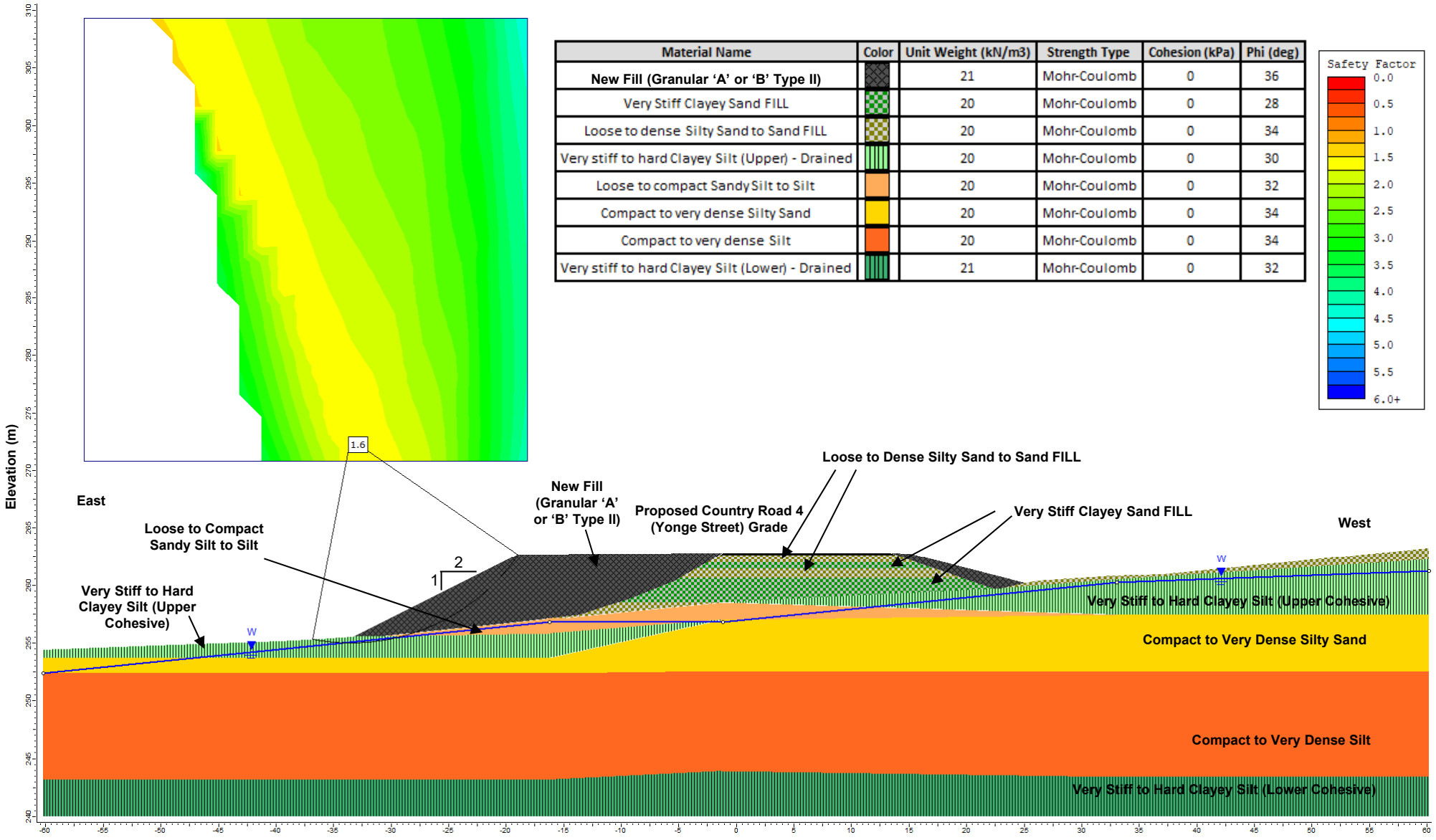
**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 North Abutment (East Side)
# Long-Term (Drained) Condition

**Figure 2**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 |
| Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 |
| Loose to dense Silty Sand to Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 |
| Very stiff to hard Clayey Silt (Upper) - Drained | | 20 | Mohr-Coulomb | 0 | 30 |
| Loose to compact Sandy Silt to Silt | | 20 | Mohr-Coulomb | 0 | 32 |
| Compact to very dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 34 |
| Compact to very dense Silt | | 20 | Mohr-Coulomb | 0 | 34 |
| Very stiff to hard Clayey Silt (Lower) - Drained | | 21 | Mohr-Coulomb | 0 | 32 |



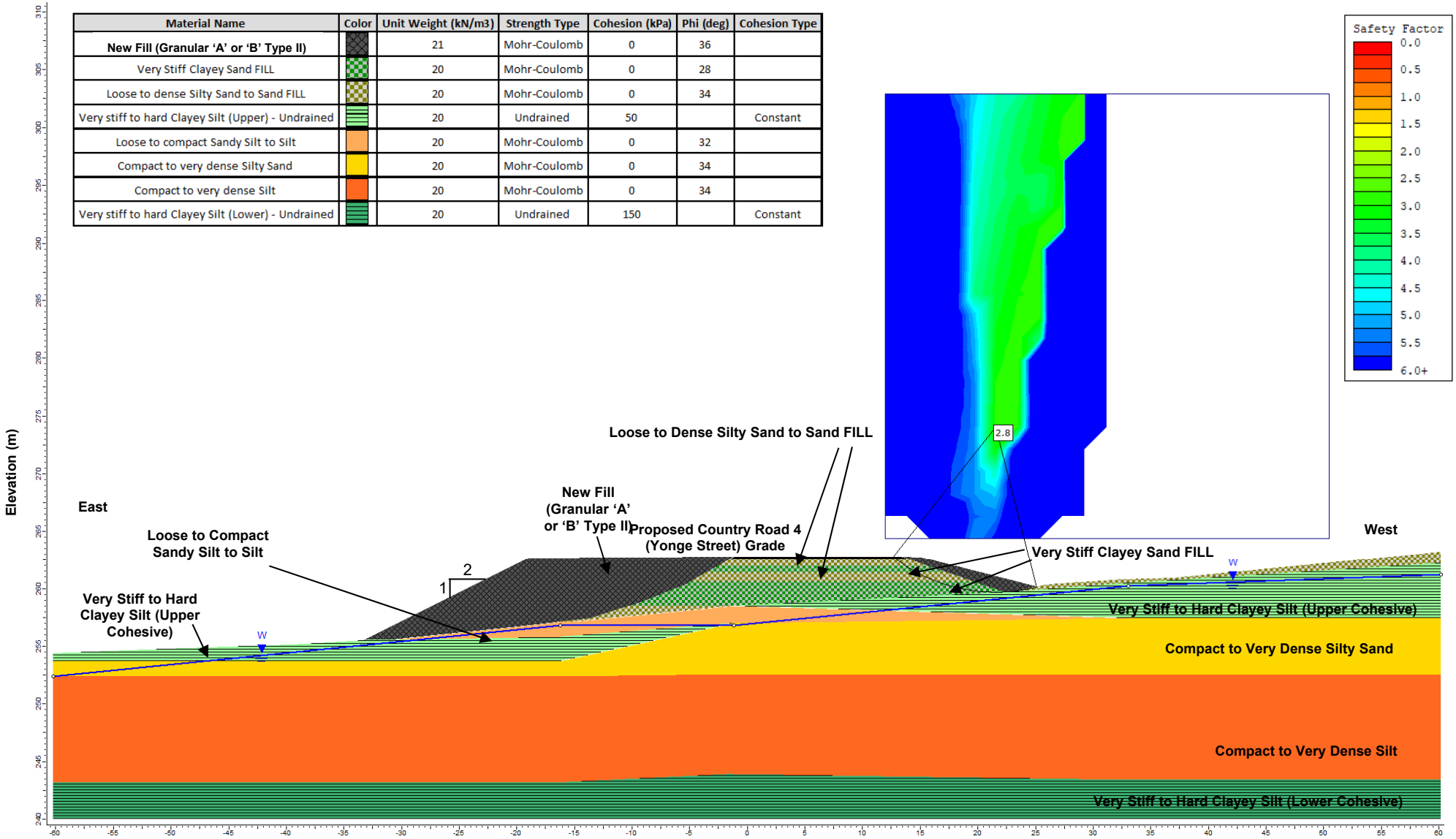

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 North Abutment (West Side)
# Short-Term (Undrained) Condition

**Figure 3**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 | |
| Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to dense Silty Sand to Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Very stiff to hard Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Loose to compact Sandy Silt to Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact to very dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 34 | |
| Compact to very dense Silt | | 20 | Mohr-Coulomb | 0 | 34 | |
| Very stiff to hard Clayey Silt (Lower) - Undrained | | 20 | Undrained | 150 | | Constant |



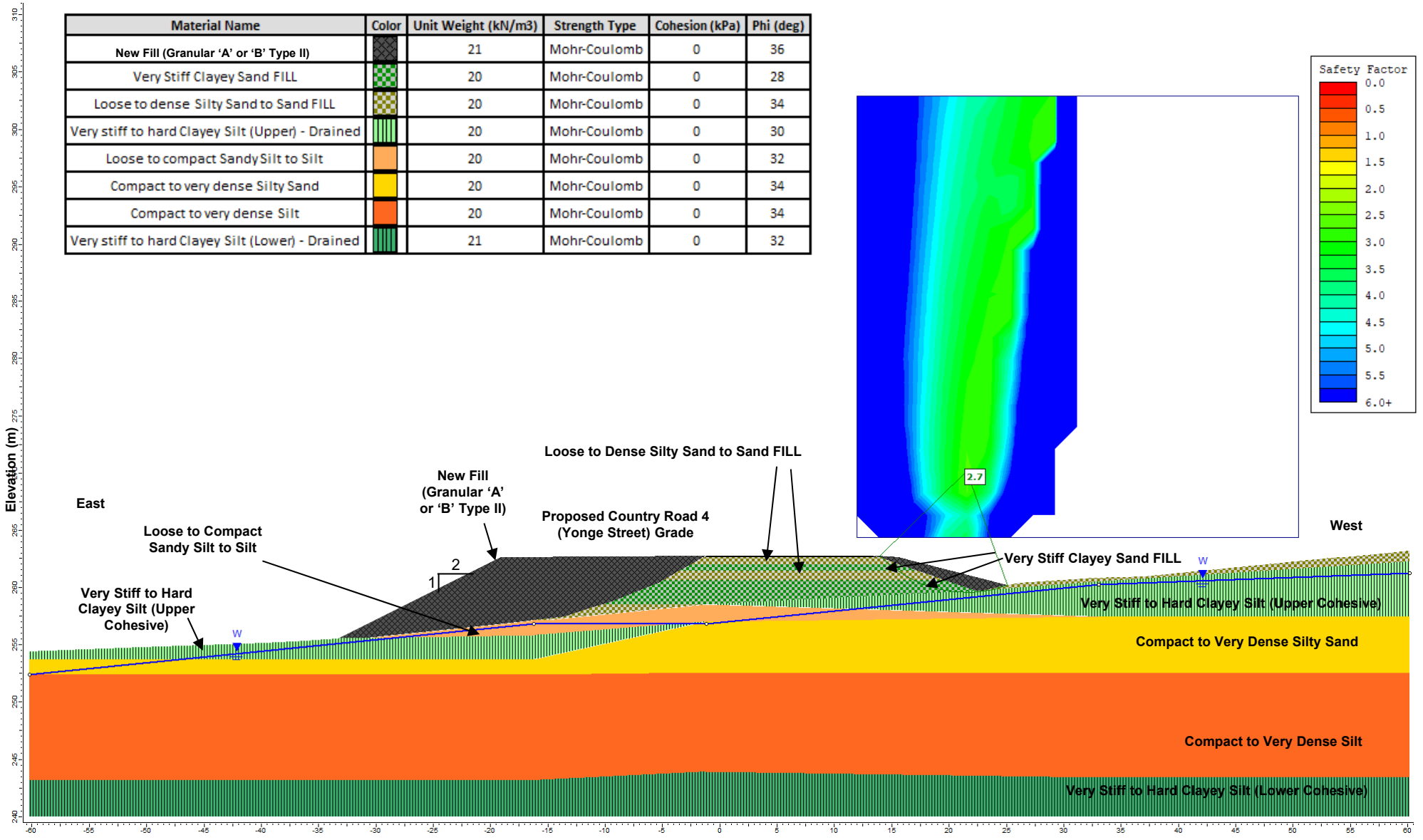

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 North Abutment (West Side)
# Long-Term (Drained) Condition

**Figure 4**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 |
| Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 |
| Loose to dense Silty Sand to Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 |
| Very stiff to hard Clayey Silt (Upper) - Drained | | 20 | Mohr-Coulomb | 0 | 30 |
| Loose to compact Sandy Silt to Silt | | 20 | Mohr-Coulomb | 0 | 32 |
| Compact to very dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 34 |
| Compact to very dense Silt | | 20 | Mohr-Coulomb | 0 | 34 |
| Very stiff to hard Clayey Silt (Lower) - Drained | | 21 | Mohr-Coulomb | 0 | 32 |



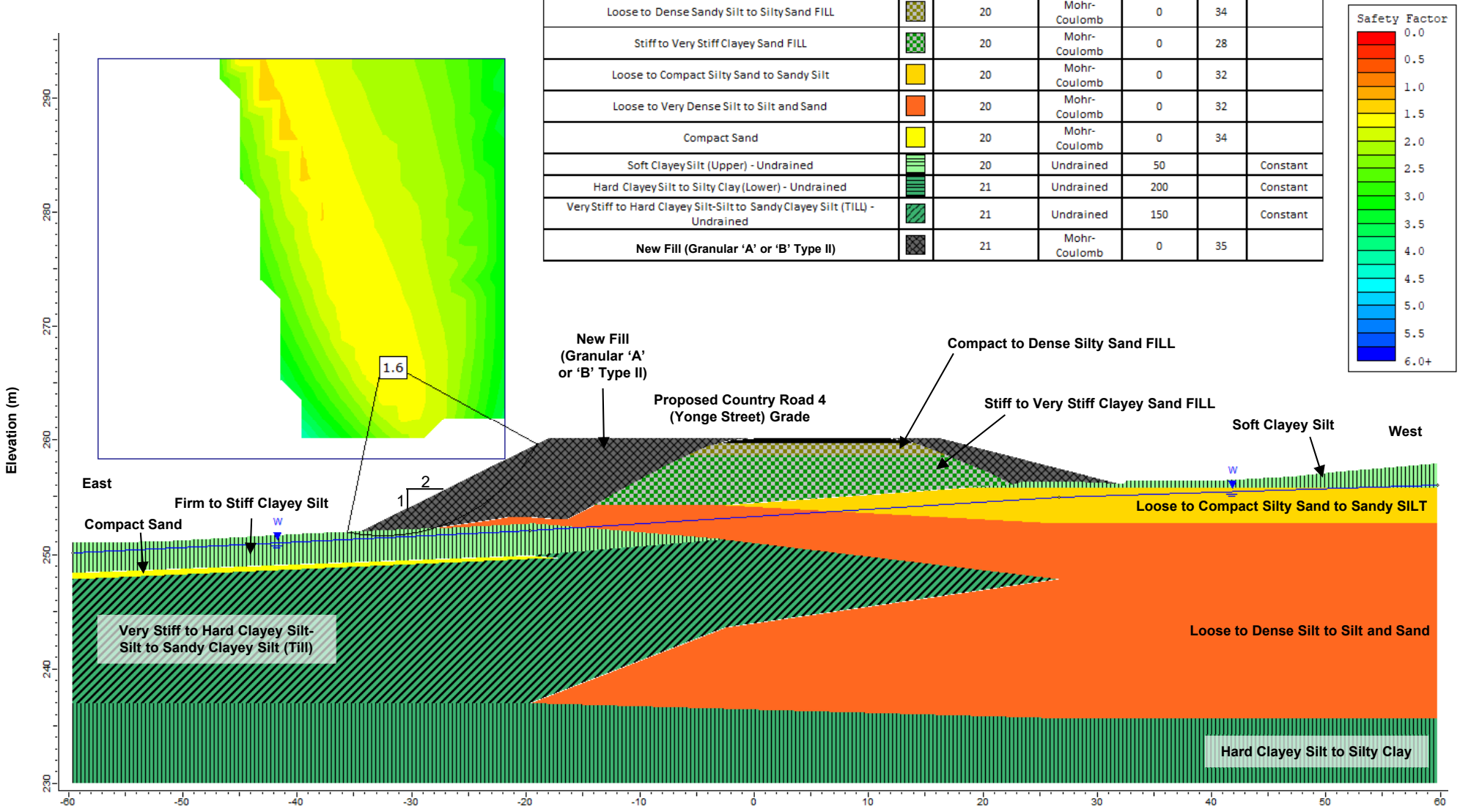

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 South Abutment (East Side)
# Short-Term (Undrained) Condition

**Figure 5**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to Compact Silty Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Loose to Very Dense Silt to Silt and Sand | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact Sand | | 20 | Mohr-Coulomb | 0 | 34 | |
| Soft Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Hard Clayey Silt to Silty Clay (Lower) - Undrained | | 21 | Undrained | 200 | | Constant |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Undrained | | 21 | Undrained | 150 | | Constant |
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 35 | |



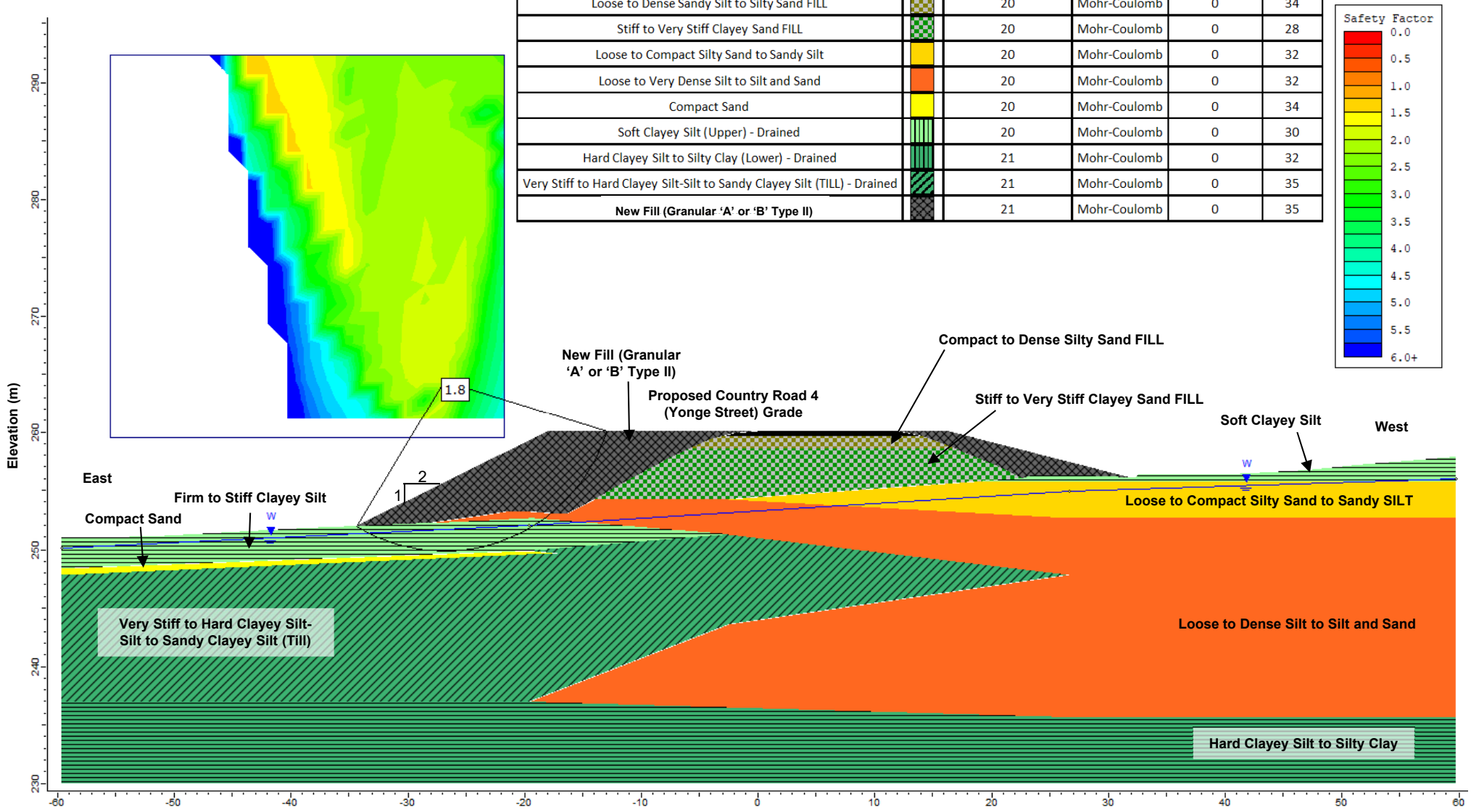

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 South Abutment (East Side)
# Long-Term (Drained) Condition

**Figure 6**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 |
| Loose to Compact Silty Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 |
| Loose to Very Dense Silt to Silt and Sand | | 20 | Mohr-Coulomb | 0 | 32 |
| Compact Sand | | 20 | Mohr-Coulomb | 0 | 34 |
| Soft Clayey Silt (Upper) - Drained | | 20 | Mohr-Coulomb | 0 | 30 |
| Hard Clayey Silt to Silty Clay (Lower) - Drained | | 21 | Mohr-Coulomb | 0 | 32 |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Drained | | 21 | Mohr-Coulomb | 0 | 35 |
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 35 |

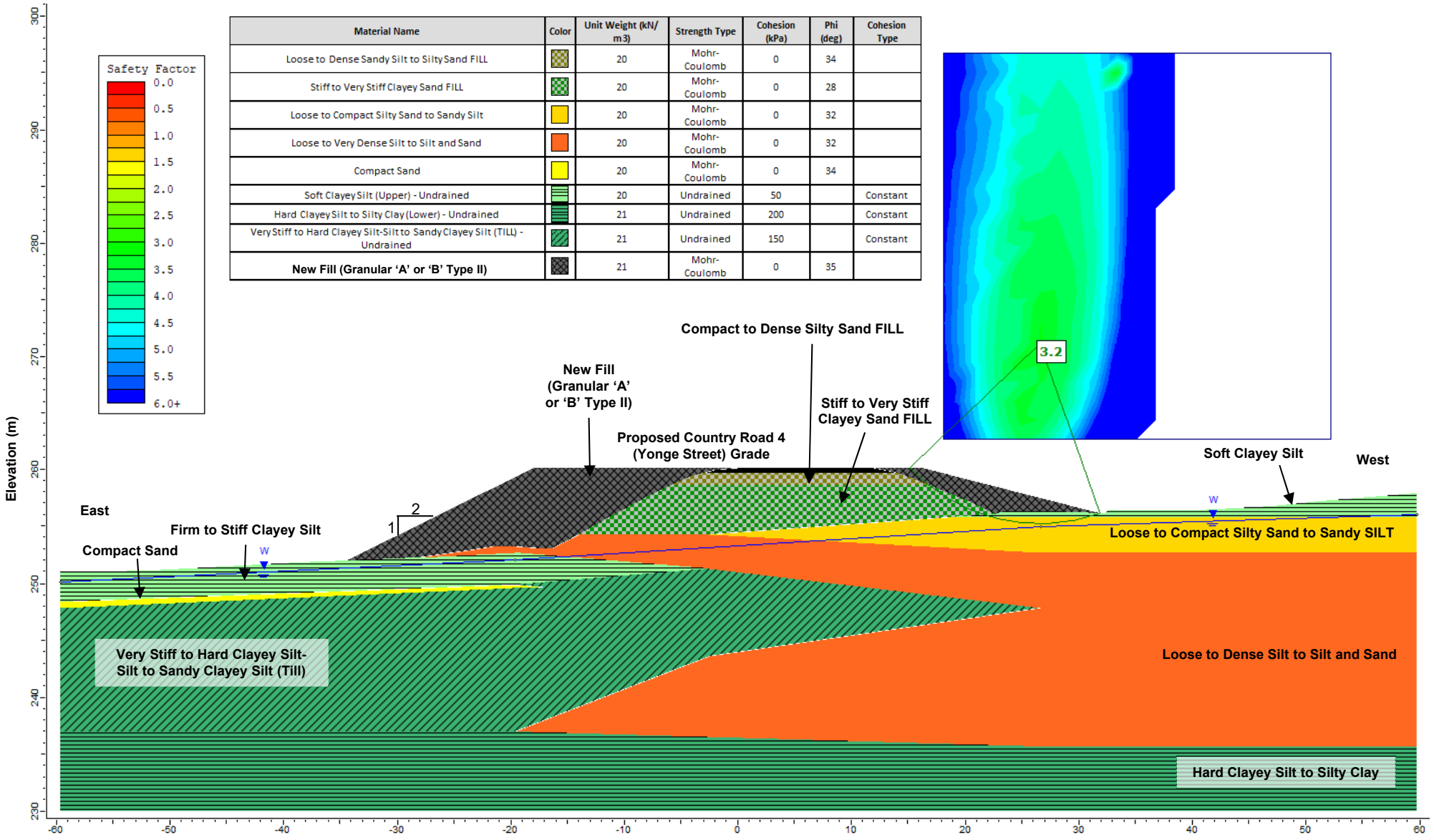



**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 South Abutment (West Side)
# Short-Term (Undrained) Condition

**Figure 7**




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to Compact Silty Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Loose to Very Dense Silt to Silt and Sand | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact Sand | | 20 | Mohr-Coulomb | 0 | 34 | |
| Soft Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Hard Clayey Silt to Silty Clay (Lower) - Undrained | | 21 | Undrained | 200 | | Constant |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Undrained | | 21 | Undrained | 150 | | Constant |
| **New Fill (Granular 'A' or 'B' Type II)** | | 21 | Mohr-Coulomb | 0 | 35 | |

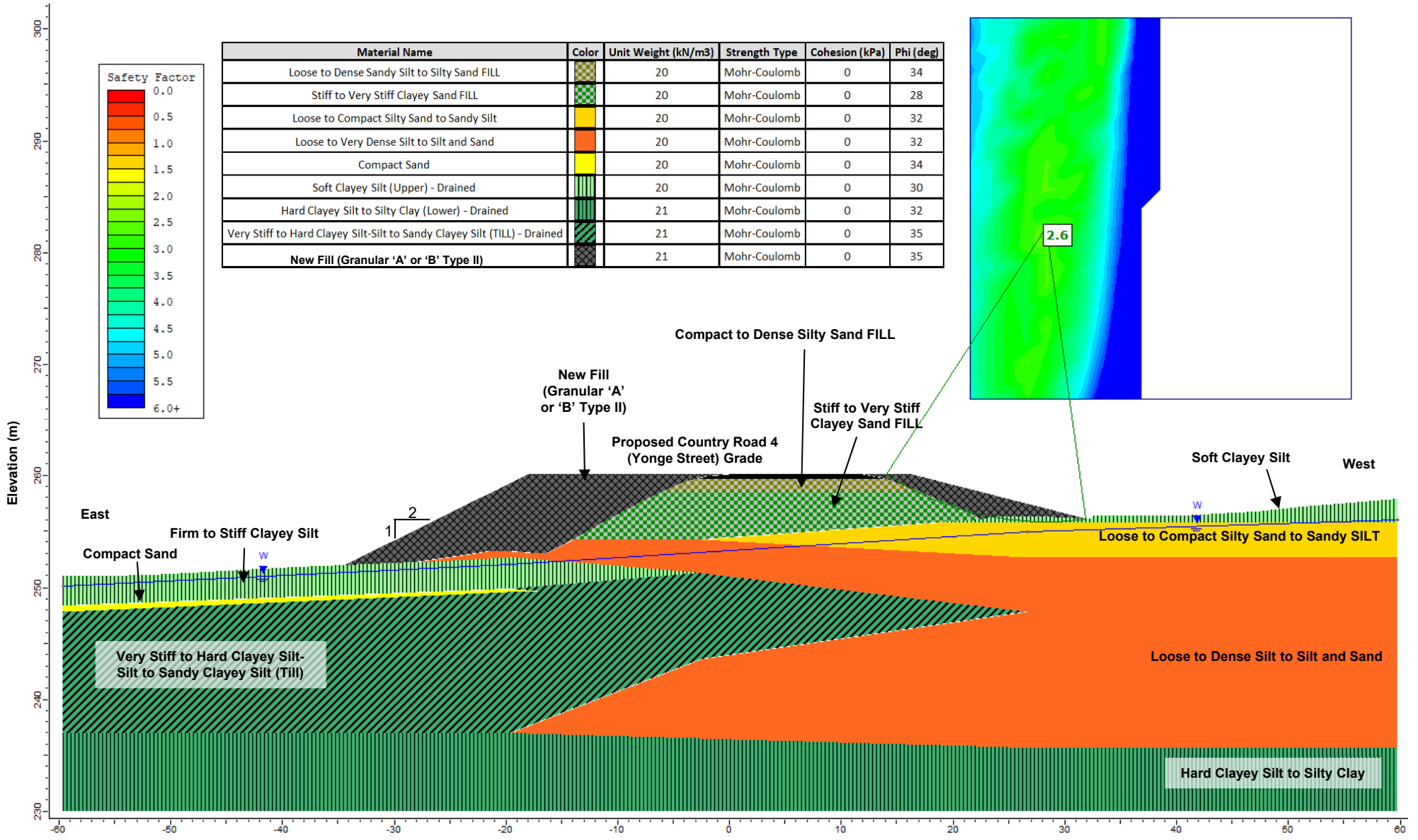
**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 South Abutment (West Side)
# Long-Term (Drained) Condition

**Figure 8**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 |
| Loose to Compact Silty Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 |
| Loose to Very Dense Silt to Silt and Sand | | 20 | Mohr-Coulomb | 0 | 32 |
| Compact Sand | | 20 | Mohr-Coulomb | 0 | 34 |
| Soft Clayey Silt (Upper) - Drained | | 20 | Mohr-Coulomb | 0 | 30 |
| Hard Clayey Silt to Silty Clay (Lower) - Drained | | 21 | Mohr-Coulomb | 0 | 32 |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Drained | | 21 | Mohr-Coulomb | 0 | 35 |
| **New Fill (Granular 'A' or 'B' Type II)** | | 21 | Mohr-Coulomb | 0 | 35 |



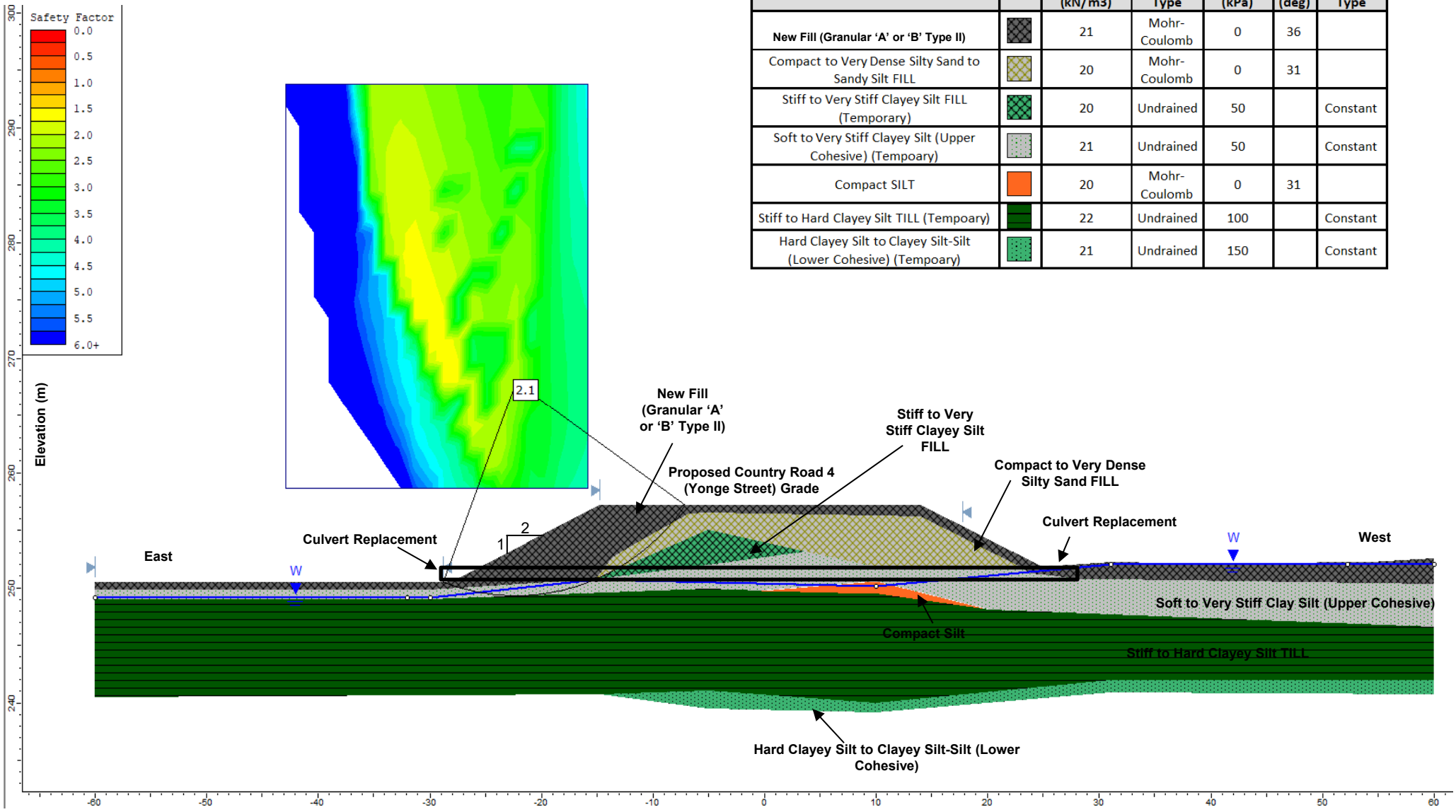

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 High Fill Near Culvert (East Side)
# Short-Term (Undrained) Condition

**Figure 9**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 | |
| Compact to Very Dense Silty Sand to Sandy Silt FILL | | 20 | Mohr-Coulomb | 0 | 31 | |
| Stiff to Very Stiff Clayey Silt FILL (Temporary) | | 20 | Undrained | 50 | | Constant |
| Soft to Very Stiff Clayey Silt (Upper Cohesive) (Tempoary) | | 21 | Undrained | 50 | | Constant |
| Compact SILT | | 20 | Mohr-Coulomb | 0 | 31 | |
| Stiff to Hard Clayey Silt TILL (Tempoary) | | 22 | Undrained | 100 | | Constant |
| Hard Clayey Silt to Clayey Silt-Silt (Lower Cohesive) (Tempoary) | | 21 | Undrained | 150 | | Constant |

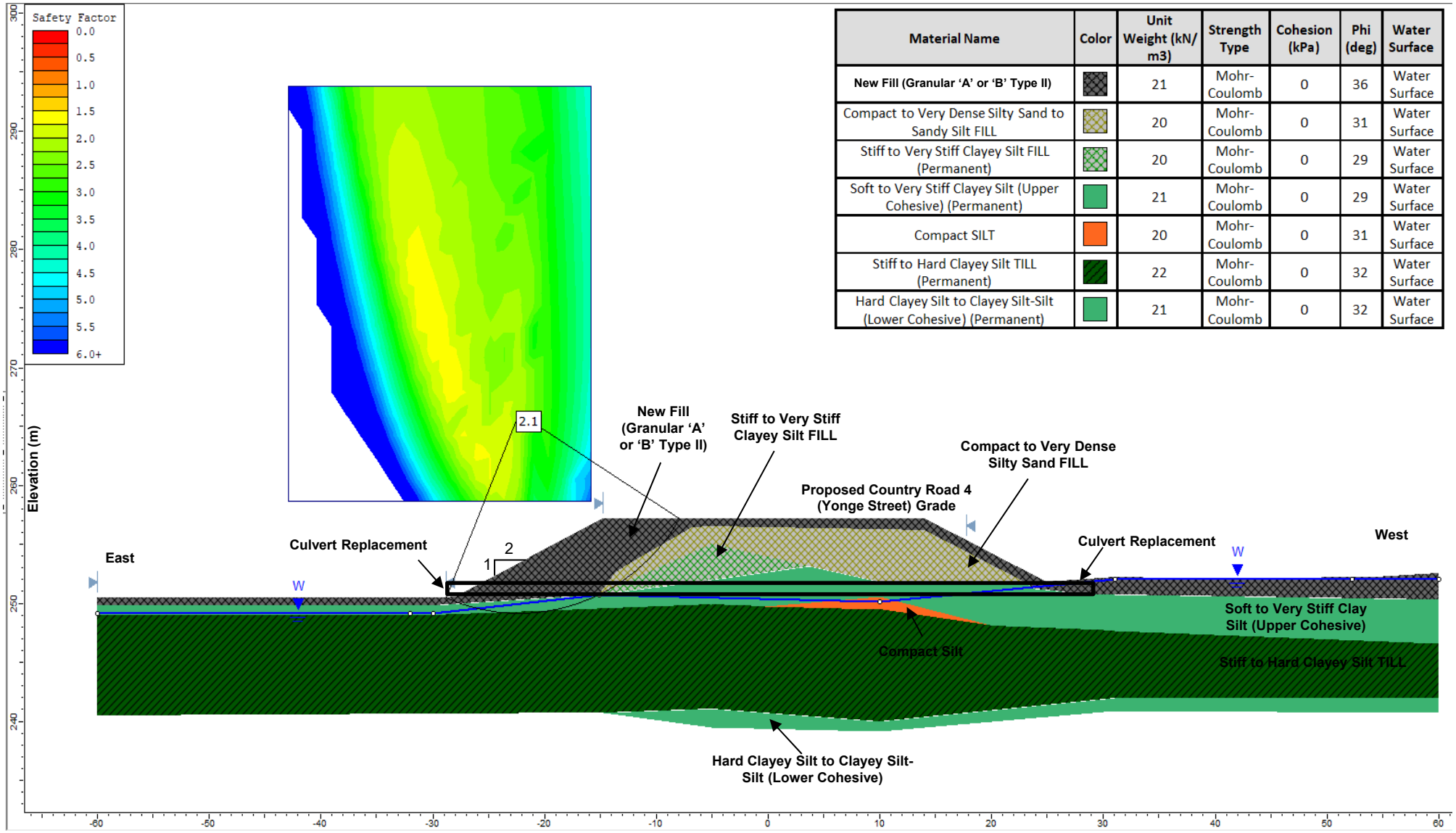



**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 High Fill Near Culvert (East Side)
# Long-Term (Drained) Condition

**Figure 10**




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface |
|---|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 | Water Surface |
| Compact to Very Dense Silty Sand to Sandy Silt FILL | | 20 | Mohr-Coulomb | 0 | 31 | Water Surface |
| Stiff to Very Stiff Clayey Silt FILL (Permanent) | | 20 | Mohr-Coulomb | 0 | 29 | Water Surface |
| Soft to Very Stiff Clayey Silt (Upper Cohesive) (Permanent) | | 21 | Mohr-Coulomb | 0 | 29 | Water Surface |
| Compact SILT | | 20 | Mohr-Coulomb | 0 | 31 | Water Surface |
| Stiff to Hard Clayey Silt TILL (Permanent) | | 22 | Mohr-Coulomb | 0 | 32 | Water Surface |
| Hard Clayey Silt to Clayey Silt-Silt (Lower Cohesive) (Permanent) | | 21 | Mohr-Coulomb | 0 | 32 | Water Surface |

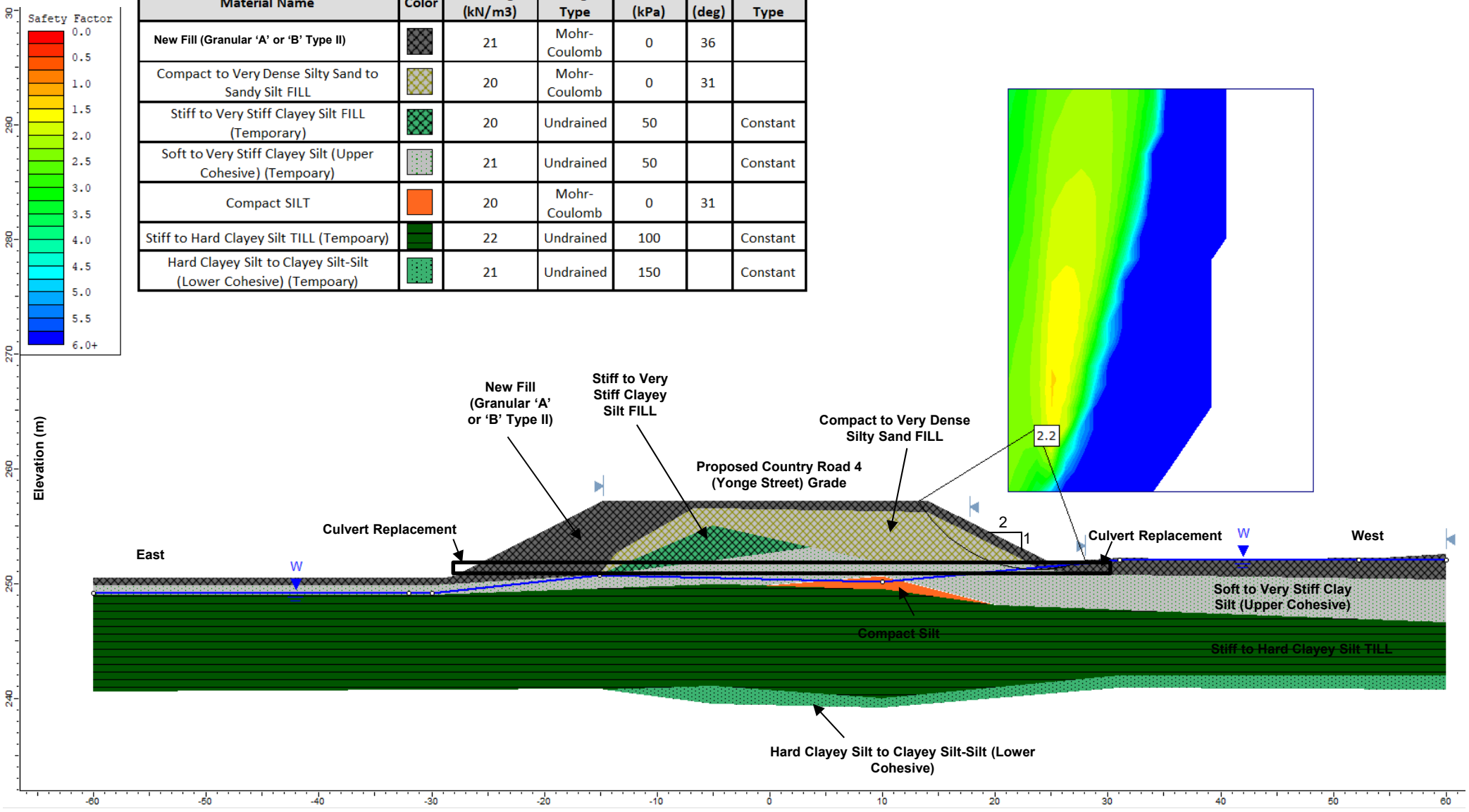
**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 High Fill Near Culvert (West Side)
# Short-Term (Undrained) Condition

**Figure 11**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| New Fill (Granular 'A' or 'B' Type II) | | 21 | Mohr-Coulomb | 0 | 36 | |
| Compact to Very Dense Silty Sand to Sandy Silt FILL | | 20 | Mohr-Coulomb | 0 | 31 | |
| Stiff to Very Stiff Clayey Silt FILL (Temporary) | | 20 | Undrained | 50 | | Constant |
| Soft to Very Stiff Clayey Silt (Upper Cohesive) (Tempoary) | | 21 | Undrained | 50 | | Constant |
| Compact SILT | | 20 | Mohr-Coulomb | 0 | 31 | |
| Stiff to Hard Clayey Silt TILL (Tempoary) | | 22 | Undrained | 100 | | Constant |
| Hard Clayey Silt to Clayey Silt-Silt (Lower Cohesive) (Tempoary) | | 21 | Undrained | 150 | | Constant |



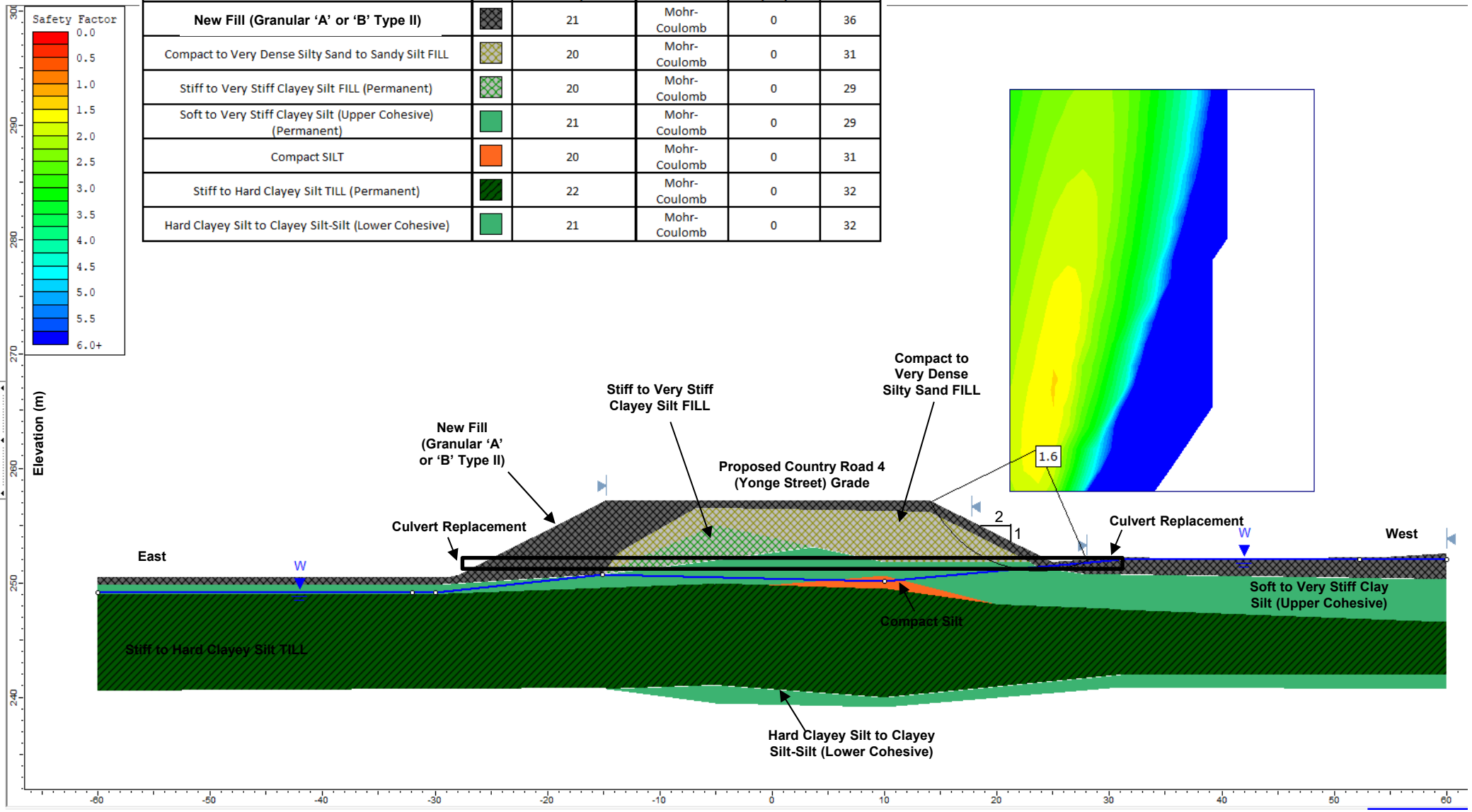

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability at County Road 4 High Fill Near Culvert (West Side)
# Long-Term (Drained) Condition

**Figure 12**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| **New Fill (Granular 'A' or 'B' Type II)** | | 21 | Mohr-Coulomb | 0 | 36 |
| Compact to Very Dense Silty Sand to Sandy Silt FILL | | 20 | Mohr-Coulomb | 0 | 31 |
| Stiff to Very Stiff Clayey Silt FILL (Permanent) | | 20 | Mohr-Coulomb | 0 | 29 |
| Soft to Very Stiff Clayey Silt (Upper Cohesive) (Permanent) | | 21 | Mohr-Coulomb | 0 | 29 |
| Compact SILT | | 20 | Mohr-Coulomb | 0 | 31 |
| Stiff to Hard Clayey Silt TILL (Permanent) | | 22 | Mohr-Coulomb | 0 | 32 |
| Hard Clayey Silt to Clayey Silt-Silt (Lower Cohesive) | | 21 | Mohr-Coulomb | 0 | 32 |



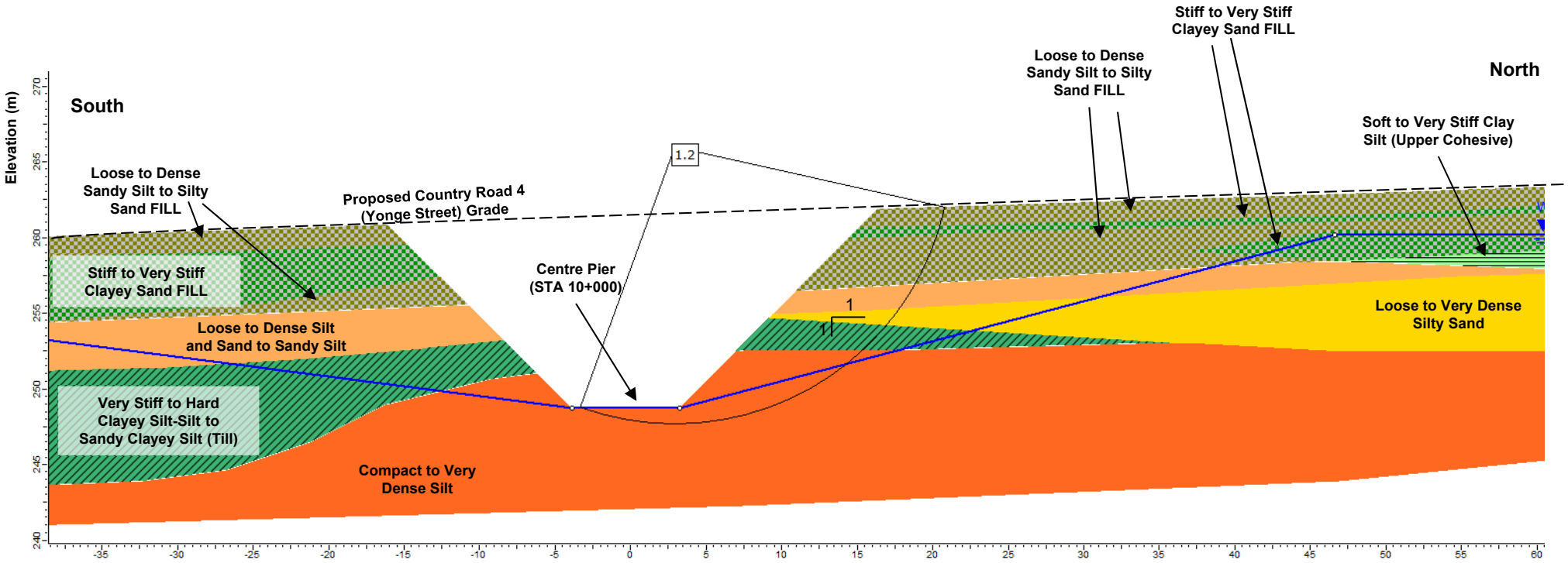

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability for Excavation at Centre Pier of Bridge (1H:1V Slope)
# Short-Term (Undrained) Condition

**Figure 13**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to Very Dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact to Very Dense Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Loose to Dense Silt and Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Soft Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Undrained | | 21 | Undrained | 150 | | Constant |



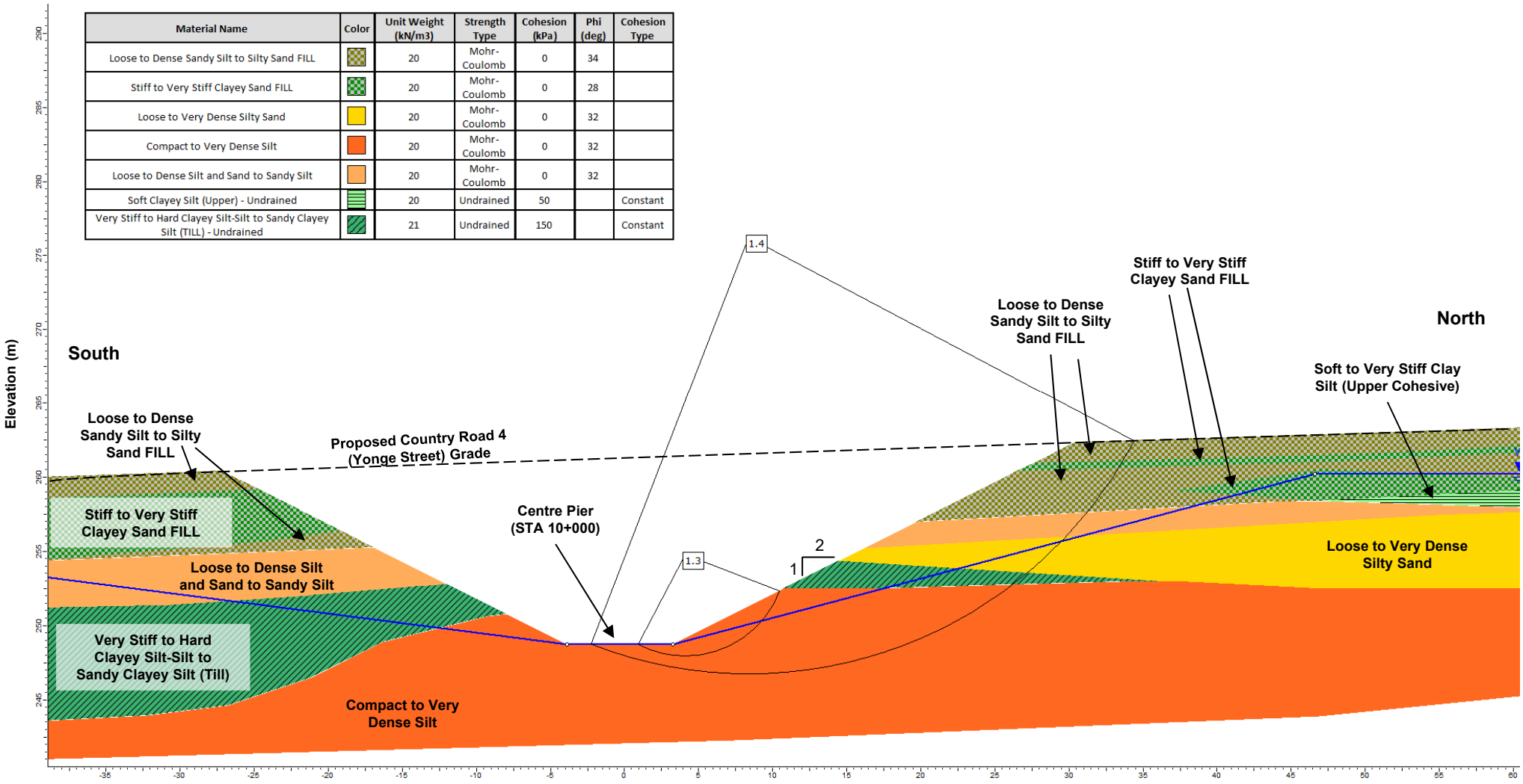

**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

# Global Stability for Excavation at Centre Pier of Bridge (2H:1V Slope)
# Short-Term (Undrained) Condition

**Figure 14**

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Cohesion Type |
|---|---|---|---|---|---|---|
| Loose to Dense Sandy Silt to Silty Sand FILL | | 20 | Mohr-Coulomb | 0 | 34 | |
| Stiff to Very Stiff Clayey Sand FILL | | 20 | Mohr-Coulomb | 0 | 28 | |
| Loose to Very Dense Silty Sand | | 20 | Mohr-Coulomb | 0 | 32 | |
| Compact to Very Dense Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Loose to Dense Silt and Sand to Sandy Silt | | 20 | Mohr-Coulomb | 0 | 32 | |
| Soft Clayey Silt (Upper) - Undrained | | 20 | Undrained | 50 | | Constant |
| Very Stiff to Hard Clayey Silt-Silt to Sandy Clayey Silt (TILL) - Undrained | | 21 | Undrained | 150 | | Constant |




**Date:** March 2022
**Project No:** 19136074/3000

**Prepared By:** ACK
**Reviewed By:** KJB

**APPENDIX A**

# Record of Boreholes

# 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<br>Fine | 19 to 75<br>4.75 to 19 | 0.75 to 3<br>(4) to 0.75 |
| SAND | Coarse<br>Medium<br>Fine | 2.00 to 4.75<br>0.425 to 2.00<br>0.075 to 0.425 | (10) to (4)<br>(40) to (10)<br>(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.e.,* SAND and gravel) |
| > 20 to 35 | Primary soil name prefixed with "gravelly, sandy" as applicable |
| > 10 to 20 | some (*i.e.,* some sand) |
| ≤ 10 | trace (*i.e.,* 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 $cm^2$ 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, Gs) |
| 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) |
| γ | unit weight |

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

## COARSE-GRAINED SOILS

**Compactness[1]**

| 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 |

1. 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 grainsize. 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.
2. 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 |

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. 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. |

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

## I. GENERAL

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

## II. STRESS AND STRAIN

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

## III. SOIL PROPERTIES

### (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 |
| $\gamma'$ | unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$) |
| $D_R$ | relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly $G_s$) |
| e | void ratio |
| n | porosity |
| S | degree of saturation |

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

### (a) Index Properties (continued)

| | |
|---|---|
| w | water content |
| $w_L$ or LL | liquid limit |
| $w_P$ or PL | plastic limit |
| $I_P$ or PI | plasticity index = $(w_l - w_p)$ |
| 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 |
| $C_{\alpha(e)}$ | secondary compression index |
| $C_\alpha$ | rate of secondary compression |
| $C_{\alpha(\varepsilon)}$ | 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 |
| $\sigma'_p$ | pre-consolidation stress |
| OCR | over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$ |

### (d) Shear Strength

| | |
|---|---|
| $\tau_p, \tau_r$ | peak and residual shear strength |
| c′ | effective cohesion |
| $\phi'$ | effective angle of internal friction |
| $\delta$ | angle of interface friction |
| $\mu$ | 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 |

**Notes:** 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING CLASSIFICATION

**Fresh (W1)**: no visible sign of rock material weathering.

**Slightly Weathered (W2):** discoloration indicates weathering of rock mass material on discontinuity surfaces. **Less than 5%** of rock mass is altered or weathered.

**Moderately Weathered (W3): less than 50%** of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

**Highly Weathered (W4): more than 50%** of the rock mass is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.

**Completely Weathered (W5): 100%** of the rock mass is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact.

**Residual Soil (W6): all rock material is converted to soil.** The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

## BEDDING THICKNESS

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

## JOINT OR FOLIATION SPACING

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

## GRAIN SIZE

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

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

## CORE CONDITION

### Total Core Recovery (TCR)

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

### Solid Core Recovery (SCR)

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

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

## DISCONTINUITY DATA

### Fracture Index

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

### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90$^{o}$ angle is horizontal.

### Description and Notes

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

### Abbreviations

AXJ Axial Joint
BD Bedding
BC Broken Core
CC Continuous Core
CL Closed
CO Contact
CU Curved
CT Coated
FLT Fault
FOL Foliation
FR Fracture
GO Gouge
IN Infilled
IR Irregular
JN Joint
KV Karstic Void
K Slickensided
LC Lost Core
MB Mechanical Break
PL Planar
PO Polished
RO Rough
SA Slightly Altered
SH Shear
SM Smooth
SR Slightly Rough
SY Stylolite
UN Undulating
VN Vein
VR Very Rough

### ISRM Intact Rock Material Strength Classification

| Grade | Description | Approx. Range of Uniaxial Compressive Strength (MPa) |
|---|---|---|
| R0 | Extremely weak rock | 0.25 – 1.0 |
| R1 | Very weak rock | 1.0 – 5.0 |
| R2 | Weak rock | 5.0 – 25 |
| R3 | Medium strong rock | 25 – 50 |
| R4 | Strong rock | 50 -100 |
| R5 | Very strong rock | 100 -250 |
| R6 | Extremely strong rock | >250 |

Ontario

GOLDER
MEMBER OF WSP

PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-01

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887968.8; E 299230.6 NAD83 / MTM zone 10 (LAT. 44.131693; LONG. -79.5696) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:262.80 m DATE Sep 30, 2021 - Sep 30, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| 0.0 | Gravelly CLAYEY SAND (SC), trace rootlets<br>Firm<br>Brown<br>Moist | | 1 | SS | 9 | | | | | | 22 | 36 | 37 | 5 | |
| 262.1 | | | | | | | | | | | | | | | |
| 0.7 | SILTY CLAY (CI) trace sand to SILTY CLAY (CI) and sand<br>Stiff to very stiff<br>Brown to grey<br>Moist | | 2 | SS | 12 | | 262 | | | | | | | | |
| | | | 3 | SS | 15 | | 261 | | | | | 1 | 52 | 47 | |
| | | | 4 | SS | 26 | | 260 | | | | | | | | |
| | | | 5 | SS | 28 | | | | | | | 48 | 40 | 12 | |
| | - 3.7 m: becoming grey | | 6 | SS | 25 | | 259 | | | | | | | | |
| | | | 7 | SS | 21 | | 258 | | | | | | | | |
| 256.9 | | | | | | | 257 | | | | | | | | |
| 5.9 | SILTY SAND (SM), trace gravel<br>Compact to very dense<br>Grey<br>Moist<br>- 5.9 to 6.0 m: - auger grinding noted | | 8 | SS | 18 | | | | | | 0 | 80 | 19 | 1 | |
| | | | 9 | SS | 75 | | 256 | | | | | | | | |
| 254.1 | | | | | | | 255 | | | | | | | | |
| 8.7 | SILT (ML) of slight plasticity, trace sand<br>Very Dense<br>Grey<br>Moist | | 10 | SS | 90 | | 254 | | | | | | | | |
| | | | | | | | 253 | | | | | | | | |

Continued on Next Page

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

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# RECORD OF BOREHOLE No. CR4-01 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887968.8; E 299230.6 NAD83 / MTM zone 10 (LAT. 44.131693; LONG. -79.5696) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:262.80 m DATE Sep 30, 2021 - Sep 30, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| 252<br>251.5 | SILT (ML) of slight plasticity, trace sand<br>Very Dense<br>Grey<br>Moist | | 11 | SS | 76 | | 252 | | θ | | 1 | 88 | 10 | | |
| 11.28 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 6.1 m (Elev. 256.7 m) during drilling.<br>2. Water level not recorded upon completion of drilling due to introduction of drilling mud. | | | | | | 251<br>250<br>249<br>248<br>247<br>246<br>245<br>244<br>243 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-02 Sheet 1 of 1 METRIC

G.W.P. 2008-21-00 LOCATION N 4887977.2; E 299274.4 NAD83 / MTM zone 10 (LAT. 44.13177; LONG. -79.569053) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:259.72 m DATE Sep 21, 2021 - Sep 21, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | SILTY SAND (SM), trace gravel, trace clay, trace rootlets (FILL)<br>Loose to compact<br>Brown to grey<br>Moist | | 1 | SS | 7 | | | | ○ | | 3 | 55 | 35 | 7 | |
| | | | 2 | SS | 13 | | 259 | | | | | | | | |
| 258.3 | | | | | | | | | | | | | | | |
| 1.4 | Sandy SILT (ML)<br>Compact<br>Grey<br>Moist | | 3 | SS | 19 | | 258 | | ○ | | NP | | | | |
| 257.4 | | | | | | ▽ | | | | | | | | | |
| 2.3 | SILTY SAND (SM), trace gravel to gravelly, trace clay<br>Compact<br>Brown to grey<br>Moist to wet | | 4 | SS | 11 | | 257 | | | | | | | | |
| | | | 5 | SS | 21 | | | | ○ | | | | | | |
| | | | 6 | SS | 29 | | 256 | | | | | | | | |
| | | | 7 | SS | 23 | | 255 | | ○ | | | 22 | 58 | 18 | 2 |
| | | | | | | | 254 | | | | | | | | |
| | | | 8 | SS | 30 | | 253 | | | | | | | | |
| 252.1 | | | | | | | | | | | | | | | |
| 7.6 | CLAYEY SILT-SILT (CL-ML), trace to some sand<br>Very stiff to hard<br>Grey<br>Moist | | 9 | SS | 21 | | 252 | | | | | | | | |
| | | | | | | | 251 | | | | | | | | |
| | | | 10 | SS | 47 | | | | ⊙ | | | | 3 | 83 | 14 |
| 9.75 | | | | | | | 250 | | | | | | | | |
| 250.0 | End of Borehole<br>Note: | | | | | | | | | | | | | | |

1. Water level measured at a depth of 2.1 m (Elev. 257.6 m) upon completion of drilling.

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# RECORD OF BOREHOLE No. CR4-03

Sheet 1 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887945.5; E 299231 NAD83 / MTM zone 10 (LAT. 44.131484; LONG. -79.569594) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.18 m DATE Sep 23, 2021 - Sep 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | 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; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| 0.0 | SILTY SAND (SM), trace gravel, trace rootlets (FILL)<br>Loose<br>Brown<br>Moist | | 1 | SS | 6 | | 261 | | | | | | | | |
| 260.5 | | | | | | | | | | | | | | | |
| 0.7 | SILTY CLAY (CI)<br>Firm to very stiff<br>Brown<br>Moist | | 2 | SS | 5 | | 260 | | | | | | | | |
| | | | 4 | SS | 15 | | 259 | | | | | | | | |
| | | | 5 | SS | 16 | | 258 | | | | | 0 | 32 | 68 | |
| 257.4 | | | | | | | | | | | | | | | |
| 3.7 | SILTY SAND (SM)<br>Very dense<br>Grey<br>Moist<br>- clayey silt pockets between depths of 3.7 m and 4.4 m | | 6 | SS | 64 | | 257 | | | | | | | | |
| | | | 7 | SS | 57 | | 256 | | | | | | | | |
| | | | 8 | SS | 69 | | 255 | | | | | 75 | 24 | 1 | |
| | | | 9 | SS | 103 | | 254 | | | | | | | | |
| 252.5 | | | | | | | 253 | | | | | | | | |
| 8.7 | CLAYEY SILT-SILT (CL-ML) to SILT (ML) of slight plasticity<br>Hard; dense to very dense<br>Grey<br>Moist | | 10 | SS | 32 | | 252 | | | | | 1 | 83 | 16 | |

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

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# RECORD OF BOREHOLE No. CR4-03

Sheet 2 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887945.5; E 299231 NAD83 / MTM zone 10 (LAT. 44.131484; LONG. -79.569594) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.18 m DATE Sep 23, 2021 - Sep 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT-SILT (CL-ML) to SILT (ML) of slight plasticity<br>Hard; dense to very dense<br>Grey<br>Moist | | | | | | 251 | | | | | | | | |
| | | | 11 | SS | 35 | | 250 | | | | | | | | |
| | | | 12 | SS | 45 | | 249 | | | | | | | | |
| | | | 13 | SS | 42 | | 248 | | | | | | 1 | 90 | 9 |
| | | | 14 | SS | 60 | | 247 | | | | | | | | |
| | | | 15 | SS | 42 | | 246 | | | | | | | | |
| 243.4<br>17.8 | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist to wet | | 16 | SS | 82 | | 245<br>244<br>243<br>242 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-03



METRIC

G.W.P. 2008-21-00 LOCATION N 4887945.5; E 299231 NAD83 / MTM zone 10 (LAT. 44.131484; LONG. -79.569594) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.18 m DATE Sep 23, 2021 - Sep 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR SA SI CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist to wet | | | | | | 241 | | | | | |
| | | | | | | | 240 | | o | | | |
| | | | 17 | SS | 39 | | 239 | | | | | |
| | | | | | | | 238 | | | | | |
| | | | | | | | 237 | | | | | |
| | | | 18 | SS | 59 | | 236 | | | | | |
| | | | | | | | 235 | | | | | |
| | | | | | | | 234 | | | | | |
| | | | 19 | SS | 30 | | 233 | | | | | |
| | | | | | | | 232 | | | | | |

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# RECORD OF BOREHOLE No. CR4-03

Sheet 4 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887945.5; E 299231 NAD83 / MTM zone 10 (LAT. 44.131484; LONG. -79.569594) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.18 m DATE Sep 23, 2021 - Sep 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT<br>γ<br>kN/m³ | GR | SA | SI | CL | REMARKS |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist to wet | | | | | | 231 | | | | | | | | |
| | | | 20 | SS | 89 | | | | | | | 0 | 54 | 46 | |
| | | | | | | | 230 | | | | | | | | |
| | | | | | | | 229 | | | | | | | | |
| | | | | | | | 228 | | | | | | | | |
| | | | 21 | SS | 43 | | | | | | | | | | |
| | | | | | | | 227 | | | | | | | | |
| | | | | | | | 226 | | | | | | | | |
| | | | | | | | 225 | | | | | | | | |
| | | | 22 | SS | 38 | | | | | | | | | | |
| | | | | | | | 224 | | | | | | | | |
| | | | | | | | 223 | | | | | | | | |
| | | | | | | | 222 | | | | | | | | |
| | | | 23 | SS | 63 | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-03

Sheet 5 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887945.5; E 299231 NAD83 / MTM zone 10 (LAT. 44.131484; LONG. -79.569594) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.18 m DATE Sep 23, 2021 - Sep 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist to wet | | | | | | 221 | | | | | | | | |
| | | | | | | | 220 | | | | | | | | |
| | | | | | | | 219 | | | | | | | | |
| | | | 24 | SS | 37 | | | | | | | | | | |
| | | | | | | | 218 | | | | | | | | |
| | | | | | | | 217 | | | | | | | | |
| | | | | | | | 216 | | | | | | | | |
| | | | 25 | SS | 149/283mm | | | | | | | | | | |
| | | | | | | | 215 | | | | | | | | |
| | | | | | | | 214 | | | | | | | | |
| | | | | | | | 213 | | | | | | | | |
| 211.8 | | | 26 | SS | 88 | | 212 | | | | | | 0 | 50 | 50 | |
| 49.38 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 1.6 m (Elev. 259.6 m) during drilling.<br>2. Water level in piezometer measured at a depth of 1.0 m (Elev. 260.2 m) on December 9, 2021. | | | | | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-04

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887956.2; E 299267.1 NAD83 / MTM zone 10 (LAT. 44.13158; LONG. -79.569143) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:262.80 m DATE Jul 14, 2021 - Jul 14, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (180mm) | | | | | | | | | | | | | | |
| 262.6 / 0.2 / 262.0 | SAND (SP), some gravel (FILL)<br>Dense<br>Brown<br>Dry | | 1 | SS | 33 | | 262 | | | | | | | | |
| 0.8 / 261.4 | CLAYEY SAND (SC), trace gravel (FILL)<br>Very stiff<br>Grey<br>Moist | | 2 | SS | 17 | | | | | | 5 | 55 | 31 | 9 | |
| 1.4 / 260.6 | SAND (SP), trace gravel, trace fines, containing silt pockets (FILL)<br>Compact<br>Brown<br>Moist | | 3 | SS | 19 | | 261 | | | | | | | | |
| 2.2 / 258.5 | CLAYEY SILT-SILT (CL-ML) to Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (FILL)<br>Very stiff<br>Brown<br>Moist | | 4 | SS | 19 | | 260 | | | | | | | | |
| | | | 5 | SS | 21 | | | | | | 4 | 4 | 44 | 49 | |
| | | | 6A | SS | 19 | | 259 | | | | | | | | |
| 4.3 / 257.0 | Sandy SILT (ML) of slight plasticity, trace organics<br>Loose<br>Brown<br>Moist | | 6B | | | | | | | | | | | | |
| | | | 7 | SS | 3 | | 258 | | | | 1 | 28 | 65 | 6 | |
| 5.8 | SILTY SAND (SM), trace gravel<br>Compact<br>Grey<br>Wet | | 8 | SS | | ▼ | 257 | | | | | | | | |
| | | | 9 | SS | 15 | | 256 | | | | | | | | |
| | | | 10 | SS | 28 | | 255 | | | | 5 | 68 | 24 | 3 | |
| | | | | | | | 254 | | | | | | | | |
| | | | | | | | 253 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-04

Sheet 2 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887956.2; E 299267.1 NAD83 / MTM zone 10 (LAT. 44.13158; LONG. -79.569143) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:262.80 m DATE Jul 14, 2021 - Jul 14, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | 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; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| 252.6 | SILTY SAND (SM), trace gravel<br>Compact<br>Grey<br>Wet | | | | | | | | | | | | | | |
| 10.2 | SILT (ML)<br>Compact to dense<br>Grey<br>Wet | | 11 | SS | 28 | | 252 | | ⊕ | | | | | | |
| | | | | | | | 251 | | | | | | | | |
| | | | 12 | SS | 26 | | 250 | | | | | | | | |
| | | | | | | | 249 | | ○ | | | | | | |
| | | | 13 | SS | 39 | | 248 | | | | | | | | |
| | | | | | | | 247 | | ⊕ | | | | 0 | 90 | 10 |
| | | | 14 | SS | 30 | | 246 | | | | | | | | |
| | | | 15 | SS | 27 | | 245 | | | | | | | | |
| | | | | | | | 244 | | | | | | | | |
| 243.9 | | | 16 | SS | 29 | | | | | | | | | | |
| 18.90 | End of Borehole<br>Note:<br>1. Borehole caved to a depth of 5.9 m upon removal of hollow stem augers.<br>2. Water level measured at a depth of 5.9 m (Elev. 256.9 m) upon completion of drilling | | | | | | 243 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-05

Sheet 1 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887958.5; E 299280.3 NAD83 / MTM zone 10 (LAT. 44.131601; LONG. -79.568978) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.01 m DATE Sep 15, 2021 - Sep 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ — NMC W — LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| 0.0 | CLAYEY SILT (CL), some sand, trace gravel, trace organics (FILL)<br>Soft<br>Brown to black<br>Moist | | 1 | SS | 3 | | | | | | | | | | |
| 257.1 | | | 2A | | | | | | | | | | | | |
| 0.9 | SILT (ML) of slight plasticity, some sand<br>Loose to compact<br>Grey<br>Wet | | 2B | SS | 8 | | 257 | | | | | | | | |
| | | | 3 | SS | 14 | | | | | | 0 | 18 | 77 | 4 | |
| 255.8 | | | | | | | 256 | | | | | | | | |
| 2.2 | Sandy CLAYEY SILT (CL). trace gravel<br>Stiff to very stiff<br>Grey<br>Moist | | 4 | SS | 11 | | | | | | | | | | |
| | | | 5 | SS | 22 | | 255 | | | | 7 | 31 | 38 | 23 | |
| 253.7 | | | 6 | SS | 18 | | 254 | | | | | | | | |
| 4.3 | SILTY SAND (SM), some gravel<br>Compact<br>Brown<br>Wet | | 7 | SS | 25 | | | | | | 11 | 75 | 13 | 1 | |
| 252.4 | | | | | | | 253 | | | | | | | | |
| 5.6 | SILT (ML) of slight plasticity, trace sand<br>Compact to very dense<br>Grey<br>Wet | | 8 | SS | 15 | | 252 | | | | | | | | |
| | | | 9 | SS | 31 | | 251 | | | | | | | | |
| | | | | | | | 250 | | | | | | | | |
| | | | | | | | 249 | | | | | | | | |
| | | | 10 | SS | 59 | | | | | | 0 | 4 | 90 | 6 | |

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# RECORD OF BOREHOLE No. CR4-05

Sheet 2 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887958.5; E 299280.3 NAD83 / MTM zone 10 (LAT. 44.131601; LONG. -79.568978) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.01 m DATE Sep 15, 2021 - Sep 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | 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; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | SILT (ML) of slight plasticity, trace sand<br>Compact to very dense<br>Grey<br>Wet | | | | | | 247 | | | | | | | | |
| | | | 11 | SS | 34 | | | | | | | | | | |
| | | | | | | | 246 | | | | | | | | |
| | | | 12 | SS | 24 | | | | | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 13 | SS | 31 | | 244 | | ○ | | | | | | |
| 243.2 | | | | | | | | | | | | | | | |
| 14.8 | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Very stiff to hard<br>Grey<br>Moist | | | | | | 243 | | | | | | | | |
| | | | 14 | SS | 47 | | | | ○ | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 15 | SS | 27 | | 241 | | | | | | | | |
| | | | | | | | 240 | | | | | | | | |
| | | | 16 | SS | 33 | | | | ⊢⊙⊣ | | | 0 | 71 | 29 | |
| | | | | | | | 239 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-05

Sheet 3 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887958.5; E 299280.3 NAD83 / MTM zone 10 (LAT. 44.131601; LONG. -79.568978) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.01 m DATE Sep 15, 2021 - Sep 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Very stiff to hard<br>Grey<br>Moist | | | | | | 237<br>236<br>235<br>234<br>233<br>232<br>231<br>230<br>229 | | | | | | | | |
| | | | 17 | SS | 28 | | | | | | | | | | |
| | | | 18 | SS | 60 | | | | | | | | | | |
| | | | 19 | SS | 44 | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-05

Sheet 4 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887958.5; E 299280.3 NAD83 / MTM zone 10 (LAT. 44.131601; LONG. -79.568978) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.01 m DATE Sep 15, 2021 - Sep 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT<br>γ<br>kN/m³ | GR | SA | SI | CL | REMARKS |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Very stiff to hard<br>Grey<br>Moist | | 20 | SS | 63 | | 227 | | | | 0 | 65 | 35 | | |
| | | | 21 | SS | 38 | | 226 | | | | | | | | |
| | | | 22 | SS | 59 | | 225 | | | | | | | | |
| | | | 23 | SS | 40 | | 224 | | | | | | | | |
| | | | | | | | 223 | | | | | | | | |
| | | | | | | | 222 | | | | | | | | |
| | | | | | | | 221 | | | | | | | | |
| | | | | | | | 220 | | | | | | | | |
| | | | | | | | 219 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-05

Sheet 5 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887958.5; E 299280.3 NAD83 / MTM zone 10 (LAT. 44.131601; LONG. -79.568978) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.01 m DATE Sep 15, 2021 - Sep 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) ○ Unconfined ● Quick Triaxial ■ Pocket Pen ⊕ Remoulded × Field Vane; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | UNIT WEIGHT γ kN/m³ | | | | | |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Very stiff to hard<br>Grey<br>Moist | | | | | | 217<br>216<br>215<br>214<br>213<br>212<br>211<br>210<br>209 | | | | | | | | |
| | | | 24 | SS | 48 | | | | | | | | | | |
| | | | 25 | SS | 101 | | | | | | | | | | |
| 208.6 | | | 26 | SS | 48 | | | | | | 0 | 38 | 62 | | |
| 49.38 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 1.2 m (Elev. 256.8 m) during drilling.<br>2. Water level not recorded upon completion of drilling due to introduction of drilling mud. | | | | | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-06

Sheet 1 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887904.5; E 299244 NAD83 / MTM zone 10 (LAT. 44.131114; LONG. -79.569432) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.20 m DATE Oct 01, 2021 - Oct 06, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | SILTY SAND (SM), trace rootlets, trace gravel<br>Loose to compact<br>Dark brown to brown<br>Moist to wet | | 1 | SS | 5 | | 258 | | | | | | | | |
| | | | 2 | SS | 13 | | 257 | | | | | | | | |
| 256.2 | | | 3A | SS | 12 | | | | | | | | | | |
| 2.0 | CLAYEY SILT (CL), trace sand to sandy, trace gravel, (TILL)<br>Stiff to Very Stiff<br>Brownish Grey<br>Moist | | 3B | | | | 256 | | | | 4 | 29 | 44 | 24 | |
| | | | 4 | SS | 17 | | | | | | | | | | |
| 254.5 | | | 5 | SS | 24 | | 255 | | | | | | | | |
| 3.7 | SILTY SAND (SM), some gravel<br>Compact<br>Grey<br>Moist to Wet | | 6 | SS | 20 | | 254 | | | | | | | | |
| | | | 7 | SS | 22 | | | | | | 11 | 74 | 13 | 2 | |
| 252.6 | | | | | | | 253 | | | | | | | | |
| 5.6 | SILT (ML) of slight plasticity, trace sand, trace gravel to CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | 8 | SS | 24 | | 252 | | | | 3 | 7 | 80 | 10 | |
| | | | 9 | SS | 49 | | 251 | | | | | | | | |
| | | | 10 | SS | 42 | | 250 | | | | | | | | |
| | | | | | | | 249 | | | | 9 | 5 | 78 | 8 | |

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-06

Sheet 2 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887904.5; E 299244 NAD83 / MTM zone 10 (LAT. 44.131114; LONG. -79.569432) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.20 m DATE Oct 01, 2021 - Oct 06, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | SILT (ML) of slight plasticity, trace sand, trace gravel to CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 248 | | | | | | | | |
| | | | 11 | SS | 53 | | | | | | | | | | |
| | | | | | | | 247 | | | | | | | | |
| | | | 12 | SS | 50 | | 246 | | | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 13 | SS | 51 | | 244 | | | | | | | | |
| | | | 14 | SS | 70 | | 243 | | | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 15 | SS | 58 | | 241 | | | | | | 1 | 5 | 79 | 14 | |
| | | | 16 | SS | 51 | | 240 | | | | | | | | |
| | | | | | | | 239 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-06

Sheet 3 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887904.5; E 299244 NAD83 / MTM zone 10 (LAT. 44.131114; LONG. -79.569432) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.20 m DATE Oct 01, 2021 - Oct 06, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ — NMC W — LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | SILT (ML) of slight plasticity, trace sand, trace gravel to CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |
| | | | 17 | SS | 47 | | | | | | | | | | |
| | | | | | | | 236 | | | | | | | | |
| | | | | | | | 235 | | | | | | | | |
| | | | | | | | 234 | | | | | | | | |
| | | | 18 | SS | 74 | | | | | | | 0 | 72 | 28 | |
| | | | | | | | 233 | | | | | | | | |
| | | | | | | | 232 | | | | | | | | |
| | | | | | | | 231 | | | | | | | | |
| | | | 19 | SS | 58 | | | | | | | | | | |
| | | | | | | | 230 | | | | | | | | |
| | | | | | | | 229 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-06

Sheet 4 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887904.5; E 299244 NAD83 / MTM zone 10 (LAT. 44.131114; LONG. -79.569432) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.20 m DATE Oct 01, 2021 - Oct 06, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR SA SI CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | |
| | SILT (ML) of slight plasticity, trace sand, trace gravel to CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | 20 | SS | 56 | | 228 | | | | | |
| | | | | | | | 227 | | | | | |
| | | | | | | | 226 | | | | | |
| | | | 21 | SS | 34 | | 225 | | ○ | | | |
| | | | | | | | 224 | | | | | |
| | | | | | | | 223 | | | | | |
| | | | | | | | 222 | | | | | |
| | | | 22 | SS | 35 | | 221 | | | | | |
| | | | | | | | 220 | | | | | |
| | | | | | | | 219 | | | | | |
| | | | 23 | SS | 32 | | | | ○ | | | |

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

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-06

Sheet 5 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887904.5; E 299244 NAD83 / MTM zone 10 (LAT. 44.131114; LONG. -79.569432) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.20 m DATE Oct 01, 2021 - Oct 06, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | SILT (ML) of slight plasticity, trace sand, trace gravel to CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 218 | | | | | | | | |
| | | | | | | | 217 | | | | | | | | |
| | | | | | | | 216 | | | | | | | | |
| | | | 24 | SS | 52 | | | | | | | | | | |
| | | | | | | | 215 | | | | | | | | |
| | | | | | | | 214 | | | | | | | | |
| | | | | | | | 213 | | | | | | | | |
| | | | 25 | SS | 67 | | | | | | | | | | |
| | | | | | | | 212 | | | | | | 0 | 53 | 47 |
| | | | | | | | 211 | | | | | | | | |
| | | | | | | | 210 | | | | | | | | |
| | | | 26 | SS | 31 | | | | | | | | | | |
| 208.8 | | | | | | | 209 | | | | | | | | |
| 49.38 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 1.5 m (Elev. 256.7 m) during drilling.<br>2. Water level not recorded upon completion of drilling due to introduction of drilling mud. | | | | | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-07

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887917.5; E 299275.4 NAD83 / MTM zone 10 (LAT. 44.131232; LONG. -79.569039) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.29 m DATE Jul 13, 2021 - Jul 15, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (100 mm) | | | | | | | | | | | | | | |
| 261.2 / 0.1 | SAND (SP), trace fines, trace gravel (FILL)<br>Compact<br>Brown<br>Moist | | 1 | SS | 23 | | 261 | | ○ | | | | | | |
| 260.3 | | | 2a | SS | 12 | | | | | | | | | | |
| 1.0 | CLAYEY SILT (CL), some sand, trace gravel (FILL)<br>Stiff<br>Grey<br>Moist | | 2b | | | | 260 | | ○ | | | | | | |
| 259.8 | | | | | | | | | | | | | | | |
| 1.5 | SILTY SAND (SM) of slight plasticity, trace gravel (FILL)<br>Compact to Dense<br>Brown to grey<br>Moist | | 3 | SS | 23 | | | | | | | | | | |
| | | | 4 | SS | 34 | | 259 | | ○ | | | 6 | 55 | 31 | 8 |
| | | | 5 | SS | 18 | | 258 | | | | | | | | |
| | | | 6 | SS | 19 | | 257 | | | | | | | | |
| 256.4 | | | 7a | SS | 25 | | | | ○ | | | | | | |
| 4.9 | Sandy SILT (ML) of slight plasticity, trace sand, trace gravel, trace organics<br>Firm to very stiff<br>Dark brown to grey<br>Moist | | 7b | | | | 256 | | ○ | | | | | | |
| 254.9 | | | 8a | SS | 7 | | 255 | | ○ | | | | | | |
| 6.4 | CLAYEY SILT (CL), trace sand to sandy, trace gravel (TILL)<br>Firm to Very Stiff<br>Grey<br>Moist | | 8b | | | | | | ○ | | | | | | |
| | | | 9 | SS | 19 | | 254 | | ⊖ | | | 9 | 30 | 36 | 25 |
| 252.6 | | | | | | | 253 | | | | | | | | |
| 8.7 | SILT (ML), trace to some sand, trace to some clay<br>Very Stiff to Hard<br>Grey<br>Moist | | 10 | SS | 40 | | 252 | | | | | | | | |

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

Ontario

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-07 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887917.5; E 299275.4 NAD83 / MTM zone 10 (LAT. 44.131232; LONG. -79.569039) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:261.29 m DATE Jul 13, 2021 - Jul 15, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
| | SILT (ML), trace to some sand, trace to some clay<br>Very Stiff to Hard<br>Grey<br>Moist | | | | | | 251 | | | | | | | | |
| | | | 11 | SS | 22 | | 250 | | ○ | | | | | | |
| | | | 12 | SS | 40 | | 249 | | | | | | | | |
| | | | 13 | SS | 52 | | 248 | | ◐ | | | 2 | 93 | 5 | |
| | | | 14 | SS | 58 | | 247 | | | | | | | | |
| | | | 15 | SS | 71 | | 246 | | | | | | | | |
| | | | 16 | SS | 57 | | 245 | | ◑ | | | 0 | 88 | 12 | |
| 242.4 | | | | | | | 244 | | | | | | | | |
| 18.90 | End of Borehole<br>Note:<br>1. Water level measured at a depth of 6.1 m (Elev. 255.2 m) during drilling. | | | | | | 243 | | | | | | | | |
| | | | | | | | 242 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-08

Sheet 1 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887916.9; E 299308.7 NAD83 / MTM zone 10 (LAT. 44.131227; LONG. -79.568623) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.27 m DATE Sep 09, 2021 - Sep 13, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | CLAYEY SILT (CL), some sand, trace rootlets (FILL)<br>Soft to firm<br>Brown<br>Moist | | 1 | SS | 4 | | 253 | | | | | | | | |
| 252.6 | | | | | | | | | | | | | | | |
| 0.7 | CLAYEY SILT (CL), trace sand to sandy, trace gravel<br>Soft to stiff<br>Brown<br>Moist | | 2 | SS | 3 | | | | | | 0 | 28 | 40 | 32 | |
| | | | | | | | 252 | | | | | | | | |
| | | | 3 | SS | 11 | | | | | | | | | | |
| 251.1 | | | | | | | | | | | | | | | |
| 2.2 | CLAYEY SILT (CL), trace to some sand, trace gravel (TILL)<br>Stiff to Hard<br>Grey<br>Moist | | 4 | SS | 14 | | 251 | | | | | | | | |
| | | | 5 | SS | 17 | | 250 | | | | | 18 | 54 | 28 | |
| | | | 6 | SS | 46 | | 249 | | | | | | | | |
| | | | 7 | SS | 34 | | | | | | | | | | |
| | - 5.5 m: - casing grinding at a depth of 5.5 m (Elev. 247.8 m) | | | | | | 248 | | | | | | | | |
| | | | 8 | SS | 33 | | 247 | | | | | | | | |
| | | | 9A<br>9B | SS | 73 | | 246 | | | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 10 | SS | 51 | | 244 | | | | NP | 4 | 84 | 12 | |
| | - 9.5 m: contains silt seams/interlayers | | | | | | | | | | | | | | |

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

Ontario

GOLDER
MEMBER OF WSP

PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-08

Sheet 2 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887916.9; E 299308.7 NAD83 / MTM zone 10 (LAT. 44.131227; LONG. -79.568623) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.27 m DATE Sep 09, 2021 - Sep 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT (CL), trace to some sand, trace gravel (TILL)<br>Stiff to Hard<br>Grey<br>Moist | | | | | | 243 | | | | | | | | |
| | | | 11 | SS | 62 | | | | ○ | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 12 | SS | 62 | | 241 | | ○ | | | | | | |
| 240.0 | | | | | | | | | | | | | | | |
| 13.3 | CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), trace sand<br>Hard<br>Grey<br>Moist | | | | | | 240 | | | | | | | | |
| | | | 13 | SS | 41 | | | | ⊞ | | | | 1 | 77 | 22 |
| | | | | | | | 239 | | | | | | | | |
| | | | 14 | SS | 38 | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |
| | | | 15 | SS | 39 | | 236 | | | | | | | | |
| | | | | | | | 235 | | | | | | | | |
| | | | 16 | SS | 34 | | | | ○ | | | | | | |
| | | | | | | | 234 | | | | | | | | |

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

Ontario

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-08

Sheet 3 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887916.9; E 299308.7 NAD83 / MTM zone 10 (LAT. 44.131227; LONG. -79.568623) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.27 m DATE Sep 09, 2021 - Sep 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), trace sand<br>Hard<br>Grey<br>Moist | | | | | | 233 | | | | | | | | |
| | | | | | | | 232 | | | | | | | | |
| | | | 17 | SS | 38 | | | | | | | | | | |
| | | | | | | | 231 | | | | | | | | |
| | | | | | | | 230 | | | | | | | | |
| | | | | | | | 229 | | | | | | | | |
| | | | 18 | SS | 42 | | | | | | | | | | |
| | | | | | | | 228 | | | | | | | | |
| | | | | | | | 227 | | | | | | | | |
| | | | | | | | 226 | | | | | | | | |
| | | | 19 | SS | 36 | | | | | | | | 0 | 59 | 41 |
| | | | | | | | 225 | | | | | | | | |
| | | | | | | | 224 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-08

Sheet 4 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887916.9; E 299308.7 NAD83 / MTM zone 10 (LAT. 44.131227; LONG. -79.568623) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.27 m DATE Sep 09, 2021 - Sep 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR SA SI CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | |
| | CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), trace sand<br>Hard<br>Grey<br>Moist | | | | | | 223 | | | | | |
| | | | 20 | SS | 40 | | | | | | | |
| | | | | | | | 222 | | | | | |
| | | | | | | | 221 | | | | | |
| | | | | | | | 220 | | O | | | |
| | | | 21 | SS | 49 | | | | | | | |
| | | | | | | | 219 | | | | | |
| | | | | | | | 218 | | | | | |
| | | | | | | | 217 | | | | | |
| | | | 22 | SS | 38 | | | | | | | |
| | | | | | | | 216 | | | | | |
| | | | | | | | 215 | | | | | |
| | | | | | | | 214 | | | | | |
| | | | 23 | SS | 70 | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-08

Sheet 5 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887916.9; E 299308.7 NAD83 / MTM zone 10 (LAT. 44.131227; LONG. -79.568623) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.27 m DATE Sep 09, 2021 - Sep 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL), trace sand<br>Hard<br>Grey<br>Moist | | | | | | 213 | | | | | | | | |
| 211.8 | | | | | | | 212 | | | | | | | | |
| 41.4 | CLAYEY SILT (CL) to SILTY CLAY (CI), trace sand, trace gravel<br>Hard<br>Grey<br>Moist | | | | | | 211 | | | | | | | | |
| | | | 24 | SS | 68 | | | | | | 0 | 49 | 51 | | |
| | | | | | | | 210 | | | | | | | | |
| | | | | | | | 209 | | | | | | | | |
| | | | | | | | 208 | | | | | | | | |
| | | | 25 | SS | 44 | | | | | | | | | | |
| | | | | | | | 207 | | | | | | | | |
| | | | | | | | 206 | | | | | | | | |
| | | | | | | | 205 | | | | | | | | |
| 203.9 | | | 26 | SS | 97 | | 204 | | | | | | | | |
| 49.38 | End of Borehole<br>Notes:<br>1. Water level in casing installed to a depth of 3.0 m measured to be at a depth of 0.7 m (Elev. 252.6 m) before beginning mud rotary.<br>2. Water level not recorded upon completion of drilling due to introduction of drilling mud. | | | | | | | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-09

Sheet 1 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887864.9; E 299249 NAD83 / MTM zone 10 (LAT. 44.130758; LONG. -79.569369) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:256.46 m DATE Oct 06, 2021 - Oct 12, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| 0.0 | CLAYEY SILT (CL), some sand, trace rootlets<br>Soft<br>Brown<br>Moist | | 1 | SS | 3 | | 256 | | | | | | | | |
| 255.8 | | | | | | | | | | | | | | | |
| 0.7 | SILTY SAND (SM)<br>Loose<br>Brown<br>Moist | | 2 | SS | 5 | | | | | | | | | | |
| 255.0 | | | | | | | 255 | | | | | | | | |
| 1.4 | Sandy SILT (ML) of slight plasticity, trace gravel<br>Compact<br>Brown<br>Moist | | 3 | SS | 18 | | | | | | 8 | 21 | 67 | 5 | |
| 254.2 | | | | | | | | | | | | | | | |
| 2.2 | SILTY SAND (SM) , trace gravel<br>Compact<br>Grey<br>Moist to Wet | | 4 | SS | 14 | | 254 | | | | | | | | |
| | | | 5 | SS | 19 | | 253 | | | | 1 | 60 | 38 | 2 | |
| 252.7 | | | | | | | | | | | | | | | |
| 3.7 | SILT (ML) and sand<br>Loose to compact<br>Grey<br>Moist | | 6 | SS | 18 | | 252 | | | | | | | | |
| | | | 7 | SS | 7 | | | | | | 2 | 40 | 50 | 9 | |
| | | | | | | | 251 | | | | | | | | |
| | | | 8 | SS | 25 | | 250 | | | | | | | | |
| | | | | | | | 249 | | | | | | | | |
| | | | 9 | SS | 21 | | 248 | | | | | | | | |
| 247.8 | | | | | | | | | | | | | | | |
| 8.7 | SILT (ML) of slight plasticity<br>Dense to very dense<br>Grey<br>Moist | | 10 | SS | 37 | | 247 | | | | | 1 | 93 | 6 | |

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

Ontario

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# RECORD OF BOREHOLE No. CR4-09

Sheet 2 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887864.9; E 299249 NAD83 / MTM zone 10 (LAT. 44.130758; LONG. -79.569369) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:256.46 m DATE Oct 06, 2021 - Oct 12, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | SILT (ML) of slight plasticity<br>Dense to very dense<br>Grey<br>Moist | | | | | | 246 | | | | | | | | |
| | | | 11 | SS | 30 | | | | ○ | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 12 | SS | 38 | | 244 | | | | | | | | |
| | | | | | | | 243 | | | | | | | | |
| | | | 13 | SS | 60 | | | | ⊠ | | | | 0 | 92 | 7 |
| | | | | | | | 242 | | | | | | | | |
| | | | 14 | SS | 77 | | 241 | | | | | | | | |
| 240.0 | | | | | | | | | | | | | | | |
| 16.5 | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 240 | | | | | | | | |
| | | | 15 | SS | 38 | | 239 | | | | | | | | |
| | | | 16 | SS | 37 | | 238 | | ○ | | | | | | |
| | | | | | | | 237 | | | | | | | | |

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

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-09

Sheet 3 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887864.9; E 299249 NAD83 / MTM zone 10 (LAT. 44.130758; LONG. -79.569369) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:256.46 m DATE Oct 06, 2021 - Oct 12, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane ⊕ Remoulded ■ Pocket Pen ● Quick Triaxial ○ Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 236 | | | | | | | | |
| | | | 17 | SS | 53 | | 235 | | | | | | | | |
| | | | | | | | 234 | | | | | | | | |
| | | | | | | | 233 | | | | | | | | |
| | | | 18 | SS | 50 | | 232 | | | | | | | | |
| | | | | | | | 231 | | | | | | | | |
| | | | | | | | 230 | | | | | | | | |
| | | | 19 | SS | 65 | | 229 | | H O | | | 0 | 77 | 23 | |
| | | | | | | | 228 | | | | | | | | |
| | | | | | | | 227 | | | | | | | | |

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

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-09

Sheet 4 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887864.9; E 299249 NAD83 / MTM zone 10 (LAT. 44.130758; LONG. -79.569369) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:256.46 m DATE Oct 06, 2021 - Oct 12, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | 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; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | |
| | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | 20 | SS | 49 | | 226 | | | | | |
| | | | | | | | 225 | | | | | |
| | | | | | | | 224 | | | | | |
| | | | 21 | SS | 51 | | 223 | | | | | |
| | | | | | | | 222 | | | | | |
| | | | | | | | 221 | | | | | |
| | | | 22 | SS | 46 | | 220 | | o | | | |
| | | | | | | | 219 | | | | | |
| | | | | | | | 218 | | | | | |
| | | | | | | | 217 | | | | | |
| | | | 23 | SS | 46 | | | | | | | |

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

Ontario

GOLDER
MEMBER OF WSP

PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-09

Sheet 5 of 5

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887864.9; E 299249 NAD83 / MTM zone 10 (LAT. 44.130758; LONG. -79.569369) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:256.46 m DATE Oct 06, 2021 - Oct 12, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ — NMC W — LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 216 | | | | | | | | |
| | | | | | | | 215 | | | | | | | | |
| | | | | | | | 214 | | | | | | | | |
| | | | 24 | SS | 84 | | | | | | 0 | 51 | 48 | | |
| | | | | | | | 213 | | | | | | | | |
| | | | | | | | 212 | | | | | | | | |
| | | | | | | | 211 | | | | | | | | |
| | | | 25 | SS | 40 | | | | | | | | | | |
| | | | | | | | 210 | | | | | | | | |
| | | | | | | | 209 | | | | | | | | |
| | | | | | | | 208 | | | | | | | | |
| | | | 26 | SS | 57 | | | | | | | | | | |
| 207.1 | | | | | | | | | | | | | | | |
| 49.38 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 1.5 m (Elev. 255 m) during drilling.<br>2. Water level not recorded upon completion of drilling due to introduction of drilling mud. | | | | | | 207 | | | | | | | | |

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-10

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887870.4; E 299282 NAD83 / MTM zone 10 (LAT. 44.130808; LONG. -79.568956) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:259.94 m DATE Jul 13, 2021 - Jul 13, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | | | | | |
| 259.7 / 0.2 | SILTY SAND (SM), trace gravel (FILL)<br>Compact to dense<br>Brown<br>Dry to moist | | 1 | SS | 31 | | 259 | | | | | | | | |
| 258.6 | | | 2A | SS | 15 | | | | ○ | | 9 | 65 | 22 | 3 | |
| 1.3 | CLAYEY SAND (SC), trace gravel (FILL)<br>Stiff to very stiff<br>Brown to grey<br>Moist | | 2B | | | | | | | | | | | | |
| | | | 3 | SS | 15 | | 258 | | ○ | | | | | | |
| | | | 4 | SS | 27 | | 257 | | | | | | | | |
| | | | 5 | SS | 9 | | | | ⊕ | | 4 | 47 | 38 | 12 | |
| | | | 6 | SS | 26 | | 256 | | | | | | | | |
| | | | 7 | SS | 17 | | 255 | | ○ | | | | | | |
| 254.3 | | | | | | | | | | | | | | | |
| 5.6 | SILT (ML) of slight plasticity, trace sand<br>Compact to dense<br>Grey<br>Wet | | 8 | SS | 20 | | 254 | | ⊕ | | 0 | 5 | 90 | 5 | |
| | - 7.6 to 8.2 m: no sample recovered | | 9 | SS | 31 | | 253 | | | | | | | | |
| 251.3 | | | | | | | 252 | | | | | | | | |
| 8.7 | CLAYEY SILT (CL), some sand, trace gravel (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | 10 | SS | 35 | | 251 | | | | | | | | |

Continued on Next Page

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

Ontario

GOLDER
MEMBER OF WSP

PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-10

Sheet 2 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887870.4; E 299282 NAD83 / MTM zone 10 (LAT. 44.130808; LONG. -79.568956) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:259.94 m DATE Jul 13, 2021 - Jul 13, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLAYEY SILT (CL), some sand, trace gravel (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | | | | | | | | | | | | | |
| | | | 11 | SS | 20 | | 249 | | ⊕ | | 3 | 13 | 53 | 31 | |
| 248.2 | | | | | | | | | | | | | | | |
| 11.7 | Sandy CLAYEY SILT (CL), trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | | | | | 248 | | | | | | | | |
| | | | 12 | SS | 78 | | 247 | | | | | | | | |
| | | | 13 | SS | 60 | | 246 | | ○ | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 14 | SS | 100/ 152 mm | | | | | | | | | | |
| 243.6 | | | | | | ▽ | 244 | | | | | | | | |
| 16.3 | SILT (ML) of slight plasticity, trace sand<br>Dense to very dense<br>Grey<br>Wet | | | | | | | | | | | | | | |
| | | | 15 | SS | 70 | | 243 | | ⊕ | | 0 | 1 | 88 | 11 | |
| | | | | | | | 242 | | | | | | | | |
| | | | 16 | SS | 49 | | | | | | | | | | |
| 241.0 | | | | | | | | | | | | | | | |
| 18.90 | End of Borehole<br>Note:<br>1. Water level measured at a depth of 16.3 m (Elev. 243.6 m) during drilling. | | | | | | 241 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-11

Sheet 1 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | Sandy SILT (ML), trace gravel, trace organics (FILL)<br>Loose<br>Brown<br>Moist | | 1 | SS | 8 | | 253 | | ○ | | 8 | 30 | 56 | 6 | |
| 252.7 | | | | | | | | | | | | | | | |
| 0.7 | CLAYEY SILT (CL), trace sand, trace gravel<br>Firm to stiff<br>Grey to Brown<br>Moist<br><br>-Grey below a depth of 2.3m (Elev. 251.0 m) | | 2 | SS | 5 | | 252 | | | | | | | | |
| | | | 3 | SS | 9 | | | | ⊢○⊣ | | 0 | 9 | 59 | 31 | |
| | | | 4 | SS | 13 | | 251 | | | | | | | | |
| 249.9 | | | 5A | SS | 22 | | 250 | | | | | | | | |
| 3.4 | SAND (SP), trace gravel<br>Compact<br>Grey<br>Wet | | 5B | | | | | | | | | | | | |
| 249.6 | | | | | | | | | | | | | | | |
| 3.7 | CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel to CLAYEY SILT-SILT (CL-ML) and sand, trace gravel (TILL)<br>Very stiff to hard<br>Grey<br>Moist to wet | | 6 | SS | 100/ 152mm | | | | | | | | | | |
| | | | 7 | SS | 43 | | 249 | | ⊢○⊣ | | 7 | 39 | 42 | 12 | |
| | | | 8 | SS | 63 | | 248 | | | | | | | | |
| | | | 9A | | | | 247 | | | | | | | | |
| | | | 9B | SS | 43 | | | | | | | | | | |
| | | | | | | | 246 | | ○ | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 10 | SS | 66 | | 244 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-11

Sheet 2 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel to CLAYEY SILT-SILT (CL-ML) and sand, trace gravel (TILL)<br>Very stiff to hard<br>Grey<br>Moist to wet | | 11 | SS | 53 | | 243 | | | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 12 | SS | 43 | | 241 | | | | | | | | |
| | | | | | | | 240 | | | | | | | | |
| | | | 13 | SS | 27 | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| 237.0 | | | 14 | SS | 34 | | | | | | 9 | 31 | 48 | 12 | |
| 16.3 | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | 15 | SS | 76 | | 237 | | | | | | | | |
| 235.5 | | | | | | | 236 | | | | 1 | 2 | 66 | 31 | |
| 17.8 | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist | | 16 | SS | 33 | | 235 | | | | | | | | |
| | | | | | | | 234 | | | | | | | | |

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

Ontario

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-11

Sheet 3 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ — NMC W — LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist | | 17 | SS | 35 | | 233 | | | | | | | | |
| | | | | | | | 232 | | | | | | | | |
| | | | 18 | SS | 37 | | | | H⊖I | | 0 | 0 | 61 | 38 | |
| | | | | | | | 231 | | | | | | | | |
| | | | 19 | SS | 78 | | 230 | | | | | | | | |
| | | | | | | | 229 | | | | | | | | |
| | | | 20 | SS | 45 | | | | | | | | | | |
| | | | | | | | 228 | | | | | | | | |
| | | | 21 | SS | 64 | | 227 | | | | | | | | |
| | | | | | | | 226 | | | | | | | | |
| | | | 22 | SS | 37 | | | | ○ | | | | | | |
| | | | | | | | 225 | | | | | | | | |
| | | | 23 | SS | 40 | | 224 | | | | | | | | |

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# RECORD OF BOREHOLE No. CR4-11

Sheet 4 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT<br>γ<br>kN/m³ | GR | SA | SI | CL | REMARKS |
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist | | | | | | 223 | | | | | | | | |
| | | | 24 | SS | 60 | | | | | | | | | | |
| | | | | | | | 222 | | | | | | | | |
| | | | 25 | SS | 51 | | 221 | | | | | | | | |
| | | | | | | | 220 | | | | | | | | |
| | | | 26 | SS | 86 | | | | | | 0 | 0 | 49 | 51 | |
| | | | | | | | 219 | | | | | | | | |
| | | | 27 | SS | 48 | | 218 | | | | | | | | |
| | | | | | | | 217 | | | | | | | | |
| | | | 28 | SS | 48 | | | | | | | | | | |
| | | | | | | | 216 | | | | | | | | |
| | | | 29 | SS | 53 | | 215 | | | | | | | | |
| | | | | | | | 214 | | | | | | | | |
| | | | 30 | SS | 59 | | | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-11

Sheet 5 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLAYEY SILT (CL) to SILTY CLAY (CI)<br>Hard<br>Grey<br>Moist | | | | | | 213 | | | | | | | | |
| | | | 31 | SS | 50 | | 212 | | | | 0 | 0 | 45 | 54 | |
| | | | | | | | 211 | | | | | | | | |
| | | | 32 | SS | 43 | | 210 | | | | | | | | |
| | | | | | | | 209 | | | | | | | | |
| 207.3 | | | 33 | SS | 52 | | 208 | | | | | | | | |
| 46.0 | SILT (ML) of slight plasticity, some sand<br>Very dense<br>Grey<br>Moist | | | | | | 207 | | | | | | | | |
| | | | 34 | SS | 143 | | 206 | | | | 0 | 15 | 80 | 5 | |
| 204.3 | | | | | | | 205 | | | | | | | | |
| 49.1 | CLAYEY SILT-SILT (CL-ML), some sand, trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | | | | | 204 | | | | | | | | |

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

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-11

Sheet 6 of 6

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887880.1; E 299300.2 NAD83 / MTM zone 10 (LAT. 44.130896; LONG. -79.56873) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:253.34 m DATE Aug 30, 2021 - Sep 02, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| 50.90 | CLAYEY SILT-SILT (CL-ML), some sand, trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | 35 | SS | 106 | | 203 | | | | 3 | 16 | 64 | 18 | |
| 202.4 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 1.2 m (Elev. 252.1 m) end of drilling.<br>2. Water level in piezometer measured at a depth of -0.2 m (Elev. 253.5 m). | | | | | | 202<br>201<br>200<br>199<br>198<br>197<br>196<br>195<br>194 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-12

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887846.8; E 299256 NAD83 / MTM zone 10 (LAT. 44.130596; LONG. -79.569281) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:255.23 m DATE Oct 13, 2021 - Oct 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ — NMC W — LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| 0.0 | SILTY SAND (SM), trace rootlets, trace gravel, Very loose to loose, Brown, Moist | | 1 | SS | 3 | | 255 | | | | | | | | |
| | | | 2 | SS | 7 | | 254 | | | | | | | | |
| 253.8 | | | | | | | | | | | | | | | |
| 1.4 | CLAYEY SILT (CL), trace sand to sandy, trace gravel, (TILL), Stiff to Hard, Grey, Moist | | 3 | SS | 8 | | | | | | 4 | 24 | 39 | 33 | |
| | | | 4 | SS | 12 | | 253 | | | | | | | | |
| | | | 5 | SS | 9 | | 252 | | | | | | | | |
| | | | 6 | SS | 30 | | 251 | | | | | | | | |
| | | | 7 | SS | 69 | | 250 | | | | | | | | |
| | | | 8 | SS | 96 | | 249 | | | | | | | | |
| | | | 9 | SS | 31 | | 248 | | | | | | 0 | 64 | 36 |
| 246.5 | | | | | | | 247 | | | | | | | | |
| 8.7 | SILT (ML), Very dense, Grey, Moist to Wet | | 10 | SS | 68 | | 246 | | | | | | | | |

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

Ontario

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PROJECT 19136074

# RECORD OF BOREHOLE No. CR4-12 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887846.8; E 299256 NAD83 / MTM zone 10 (LAT. 44.130596; LONG. -79.569281) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:255.23 m DATE Oct 13, 2021 - Oct 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | SILT (ML)<br>Very dense<br>Grey<br>Moist to Wet | | | | | | 245 | | | | | | | | |
| 244.0 | | | 11 | SS | 56 | | 244 | | O NP | | 1 | 92 | 7 | | |
| 11.28 | End of Borehole<br>Notes:<br>1. Water level measured at a depth of 2.7 m (Elev. 252.5 m) during drilling.<br>2. Water level not recorded upon completion of drilling. | | | | | | 243<br>242<br>241<br>240<br>239<br>238<br>237<br>236 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. CR4-13

Sheet 1 of 1

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887854.7; E 299305.7 NAD83 / MTM zone 10 (LAT. 44.130667; LONG. -79.56866) ORIGINATED BY DP

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger; Mud Rotary COMPILED BY ACK

DATUM CGVD28 Surface Elevation:252.75 m DATE Aug 27, 2021 - Aug 27, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | Sandy SILT (ML), trace organics, trace rootlets (FILL)<br>Compact<br>Brown<br>Moist | | 1 | SS | 17 | | | | ○ | | 5 | 22 | 66 | 8 | |
| 252.1 | | | | | | | | | | | | | | | |
| 0.7 | SILTY CLAY (CI), trace sand<br>Firm<br>Brown<br>Moist | | 2 | SS | 4 | | 252 | | ⊢○⊣ | | 1 | 13 | 47 | 39 | |
| | | | 3 | SS | 8 | | 251 | | | | | | | | |
| 250.5 | | | | | | | | | | | | | | | |
| 2.2 | Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | 4 | SS | 17 | | 250 | | | | | | | | |
| | -Grey below a depth of 3.8m below ground surface (Elev. 248.7m) | | 5 | SS | 40 | | 249 | | ⊢○⊣ | | 6 | 32 | 50 | 12 | |
| | | | 6 | SS | 33 | | | | | | | | | | |
| | | | 7 | SS | 27 | | 248 | | ○ | | | | | | |
| | | | | | | | 247 | | | | | | | | |
| | | | 8 | SS | 30 | | | | | | | | | | |
| | | | | | | | 246 | | | | | | | | |
| | | | 9 | SS | 47 | ▽ | 245 | | ⊢○⊣ | | | | | | |
| | | | | | | | 244 | | | | | | | | |
| | | | 10 | SS | 33 | | | | | | | | | | |
| 9.75 | | | | | | | | | | | | | | | |
| 243.0 | End of Borehole<br>Note: | | | | | | 243 | | | | | | | | |

1. Water level measured at a depth of 7.6 m (Elev. 245.2 m) in hollow stem augers upon completion of drilling.
2. Borehole caved to ground surface upon removal of hollow stem augers.

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

Ontario

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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 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT<br>γ<br>kN/m³ | GR | SA | SI | CL | REMARKS |
| 0.0 | CLAYEY SILT (CL), trace sand to sandy, trace gravel, trace to some organics, containing organic pockets and rootlets/vegetation<br>Very soft to soft<br>Dark brown<br>Moist | | 1 | SS | 0 | | 252 | | | | | | | | |
| | | | 2 | SS | 4 | | 251 | | | | | | | | |
| 1.4 | | | | | | | | | | | | | | | |
| 250.7 | CLAYEY SILT (CL), trace sand to sandy, trace gravel<br>Stiff to hard<br>Brown to grey<br>Moist | | 3 | SS | 10 | | | | | | 4 | 21 | 45 | 30 | |
| | | | 4 | SS | 22 | | 250 | | | | | | | | |
| | | | 5 | SS | 28 | | 249 | | | | | | | | |
| | - 3.8 m: becoming grey (Elev. 248.4 m) | | 6 | SS | 41 | | 248 | | | | 1 | 2 | 56 | 42 | |
| 247.7 | | | | | | | | | | | | | | | |
| 4.5 | CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | 7 | SS | 131 | | 247 | | | | | | | | |
| | - 5.8 to 6.0 m: grinding of augers noted | | 8 | SS | 49 | | 246 | | | | | | | | |
| | | | 9 | SS | 54 | | 245 | | | | 2 | 28 | 52 | 19 | |
| | | | | | | | 244 | | | | | | | | |
| | | | 10 | SS | 46 | | 243 | | | | | | | | |

Continued on Next Page

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

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# 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 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
| 242.0<br>10.2 | CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | | | | | 242 | | | | | | | | |
| | CLAYEY SILT-SILT (CL-ML), trace sand<br>Hard<br>Grey<br>Moist | | 11 | SS | 69 | | | | ⊕ | | 2 | 79 | 19 | | |
| 240.9 | | | | | | | 241 | | | | | | | | |
| 11.28 | End of Borehole | | | | | | 240 | | | | | | | | |
| | | | | | | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |
| | | | | | | | 236 | | | | | | | | |
| | | | | | | | 235 | | | | | | | | |
| | | | | | | | 234 | | | | | | | | |
| | | | | | | | 233 | | | | | | | | |

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# 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

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | | | | | |
| 256.1 / 0.2 | SILTY SAND (SM) of slight plasticity, some gravel to gravelly SILTY SAND (SM) (FILL)<br>Compact to very dense<br>Brown<br>Moist<br>- 0.8 to 1.0 m: pocket of clayey silt (CL) (between Elev. 255.5 m and Elev. 255.3 m) | | 1 | SS | 16 | | 256 | | ○ | | 27 | 60 | 10 | 2 | |
| | | | 2a / 2b | SS | 14 | | 255 | | | | | | | | |
| | | | 3 | SS | 17 | | | | ○ | | 16 | 54 | 24 | 6 | |
| | - 2.5 to 2.9 m: layer of sandy silt (ML) (between Elev. 253.8 m and Elev. 253.4 m) | | 4a / 4b | SS | 20 | | 254 | | | | | | | | |
| | - 3.0 to 3.2 m: layer of sandy silt (ML) (between Elev. 253.2 m and Elev. 253.1 m) | | 5a / 5b | SS | 60 | | 253 | | ○ | | | | | | |
| 4.5 | | | 6 | SS | 14 | | 252 | | | | | | | | |
| 251.8 | CLAYEY SILT-SILT (CL-ML), trace sand, trace gravel, trace organics, trace rootlets<br>Soft to firm<br>Brown<br>Moist | | 7 | SS | 3 | | | | ⊟ | | | | | | |
| 250.6 / 5.6 | SILT (ML), trace sand<br>Compact<br>Grey<br>Wet | | 8 | SS | 10 | ▽ | 251 | ⊕ × ⊕ × ⊕ × | | | | | | | |
| 249.5 / 6.8 | CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL)<br>Stiff to hard<br>Brown to grey<br>Moist | | 9 | SS | 9 | | 250 | | ○ | | | | | | |
| | | | 10 | SS | 30 | | 249 | | ⊢○⊣ | | 1 | 9 | 46 | 44 | |
| | - 9.1 m: becoming grey (Elev. 247.2 m) | | 11 | SS | 47 | | 248 | | | | | | | | |
| | | | | | | | 247 | | | | | | | | |

Continued on Next Page

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

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# 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

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace gravel (TILL)<br>Stiff to hard<br>Brown to grey<br>Moist | | | | | | 246 | | | | | | | | |
| | | | 12 | SS | 100 | | | | | | | | | | |
| | | | | | | | 245 | | | | | | | | |
| | | | 13 | SS | 79 | | 244 | | OH | | 8 | 33 | 46 | 13 | |
| | | | | | | | 243 | | | | | | | | |
| | | | 14 | SS | 58 | | 242 | | | | | | | | |
| | | | 15 | SS | 79 | | 241 | | | | | | | | |
| 240.0 | | | | | | | | | | | | | | | |
| 16.3 | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | 240 | | | | | | | | |
| 239.2 | | | 16 | SS | 64/130mm | | | | OH | | 0 | 0 | 74 | 25 | |
| 17.04 | End of Borehole | | | | | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |

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# 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

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | | | | | |
| 256.3 / 0.2 | Gravelly SAND (SP) to SAND (SP), some gravel (FILL)<br>Compact<br>Brown<br>Moist | | 1 | SS | 24 | | 256 | | ○ | | | | | | |
| | - 1.1 to 1.4 m: layer of clayey sand (SC) (between Elev. 255.4 m and Elev. 255.1 m) | | 2a<br>2b | SS | 21 | | | | | | | | | | |
| 255.0 / 1.4 | CLAYEY SILT (CL), trace sand to sandy, some to trace gravel (FILL)<br>Stiff to very stiff<br>Brown to dark brown<br>Moist | | 3a<br>3b | SS | 11 | | 255 | | | | | | | | |
| | - 2.1 to 2.3 m: containing trace organics and dark brown (between Elev. 254.4 m and Elev. 254.2 m) | | 4a<br>4b | SS | 27 | | 254 | | ○ | | | | | | |
| | | | 5 | SS | 31 | | 253 | | | | | | | | |
| | - 3.8 to 4.1 m: layer of silty sand (SM), some gravel (between Elev. 252.7 m and Elev. 252.4 m) | | 6a<br>6b | SS | 15 | | | | ○H | | | 11 | 49 | 31 | 9 |
| | - 4.1 to 4.4 m: cotaining rootlets and asphalt pieces (between Elev. 252.4 m and Elev. 252.1 m) | | | | | | | | | | | | | | |
| 252.0 / 4.5 | CLAYEY SILT-SILT (CL-ML), some sand, trace gravel<br>Firm to stiff<br>Brown<br>Moist | | 7 | SS | 14 | | 252 | | | | | | | | |
| | | | 8 | SS | 8 | | 251 | | | | | | | | |
| | - 6.1 to 6.7 m: no sample recovery | | 9 | SS | 15 | | 250 | ⊕ | × | | | | | | |
| 249.7 / 6.8 | CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace to some gravel (TILL)<br>Very stiff to hard<br>Grey<br>Moist | | 10 | SS | 15 | | | | | HO | | 1 | 8 | 41 | 50 |
| | | | 11 | SS | 23 | | 249 | | | | | | | | |
| | | | | | | | 248 | | | | | | | | |
| | | | 12 | SS | 38 | | 247 | | | | | | | | |

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# 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 | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | WATER CONTENT (%) | UNIT WEIGHT | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH (kPa) ○ Unconfined ● Quick Triaxial ■ Pocket Pen ⊕ Remoulded × Field Vane; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | GR | SA | SI | CL | |
| | CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace sand to sandy, trace to some gravel (TILL)<br>Very stiff to hard<br>Grey<br>Moist | | | | | | 246 | | | | | | | | |
| | | | 13 | SS | 53 | | 245 | | | | | | | | |
| | | | 14 | SS | 90 | | 244 | | | | | | | | |
| | | | | | | | 243 | | | | | | | | |
| | | | 15 | SS | 68 | | | | | | 10 | 34 | 44 | 12 | |
| 241.1 | | | | | | | 242 | | | | | | | | |
| 15.4 | CLAYEY SILT-SILT (CL-ML)<br>Hard<br>Grey<br>Moist | | 16a<br>16b | SS | 101 | | 241 | | | | | | | | |
| | | | | | | | 240 | | | | | | | | |
| 239.5 | | | 17 | SS | 60/130mm | | | | | | | 1 | 81 | 18 | |
| 17.04 | End of Borehole | | | | | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |

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# 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

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | Sandy SILT (ML), trace clay, trace organics (FILL)<br>Brown<br>Moist<br>Loose | | 1 | SS | 6 | | 250 | | | | 0 | 32 | 65 | 3 | |
| 249.8 | | | | | | | | | | | | | | | |
| 0.7 | Sandy SILTY CLAY (CI), trace organics<br>Brown<br>Moist<br>Soft to firm | | 2 | SS | 4 | | | | | | | 17 | 37 | 46 | |
| 249.0 | | | | | | | 249 | | | | | | | | |
| 1.4 | CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), some sand to sandy, trace gravel (TILL)<br>Brown to grey<br>Moist<br>Stiff to hard | | 3 | SS | 11 | | | | | | | | | | |
| | | | 4 | SS | 21 | | 248 | | | | 8 | 17 | 39 | 35 | |
| | | | 5 | SS | 32 | | | | | | | | | | |
| | - 3.8 m: becoming grey (Elev. 246.7m) | | | | | | 247 | | | | | | | | |
| | | | 6 | SS | 31 | | | | | | | | | | |
| | - 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) | | 7 | SS | 30 | | 246 | | | | 5 | 34 | 47 | 14 | |
| | | | | | | | 245 | | | | | | | | |
| | | | 8 | SS | 64 | | 244 | | | | | | | | |
| | | | | | | | 243 | | | | | | | | |
| | | | 9 | SS | 44 | | | | | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 10 | SS | 64 | | 241 | | | | | | | | |
| 240.7 | | | | | | | | | | | | | | | |
| 9.75 | End of Borehole | | | | | | | | | | | | | | |

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

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# RECORD OF BOREHOLE No. HF-01

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887995.4; E 299260.2 NAD83 / MTM zone 10 (LAT. 44.131934; LONG. -79.56923) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:264.20 m DATE Jul 19, 2021 - Jul 20, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (100 mm) | | | | | | | | | | | | | | |
| 264.1 / 0.1 | SAND (SP) some gravel to gravelly, trace fines (FILL)<br>Compact<br>Brown<br>Moist | | 1a | SS | 25 | | 264 | | | | | | | | |
| 263.5 | | | 1b | | | | | | | | | | | | |
| 0.7 | SILT (ML) of slight plasticity, some sand to SILTY SAND (ML), of slight plasticity, trace gravel (FILL)<br>Loose to compact<br>Brown to Grey<br>Moist | | 2 | SS | 29 | | 263 | | | | | | | | |
| | | | 3 | SS | 17 | | | | | | | | | | |
| | | | 4 | SS | 5 | | 262 | | | | | | | | |
| | | | 5a | SS | 10 | | 261 | | | | | | | | |
| 260.5 | | | 5b | | | | | | | | | | | | |
| 3.7 | SILTY CLAY (CI), trace sand<br>Firm to very stiff<br>Brown<br>Moist | | 6 | SS | 5 | | 260 | | | | | | 3 | 54 | 43 |
| | | | 7 | SS | 24 | | | | | | | | | | |
| 258.6 | | | | | | | 259 | | | | | | | | |
| 5.6 | SILTY SAND (SM)<br>Loose to very dense<br>Brown to Grey<br>Wet | | 8 | SS | 42 | | 258 | | | | | | 1 | 70 | 30 | 0 |
| | | | 9 | SS | 100/231mm | | 257 | | | | | | | | |
| | | | | | | | 256 | | | | | | | | |
| | | | 10 | SS | 8 | | 255 | | | | | | | | |

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

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# RECORD OF BOREHOLE No. HF-01

Sheet 2 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887995.4; E 299260.2 NAD83 / MTM zone 10 (LAT. 44.131934; LONG. -79.56923) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:264.20 m DATE Jul 19, 2021 - Jul 20, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT<br>SHEAR STRENGTH (kPa)<br>Field Vane<br>Remoulded<br>Pocket Pen<br>Quick Triaxial<br>Unconfined<br>20 40 60 80 100 | WATER CONTENT (%)<br>PL $W_p$ NMC W LL $W_l$<br>NP Nonplastic<br>20 40 60 80 | UNIT WEIGHT<br>γ<br>kN/m³ | GR | SA | SI | CL | REMARKS |
| | SILTY SAND (SM)<br>Loose to very dense<br>Brown to Grey<br>Wet<br>- 10.2 m: - grey below a depth of 10.2 m<br>- 10.7 m: Wet sands and difficult advancement with augers. Borehole moved 1.0 m south, obstruction encountered at a depth of 0.3 m. Borehole moved approximately 2.7 m south of original location, sampling resumed at a depth of 10.7 m. | | 11 | SS | 49 | | 254<br>253 | | | | | | | | |
| 252.5<br>11.7 | SILT (ML) of slight plasticity, trace sand<br>Dense to very dense<br>Grey<br>Wet | | 12 | SS | 53 | | 252<br>251 | | ⊕ | | | 1 | 91 | 8 | |
| | | | 13 | SS | 100/283mm | | 250<br>249 | | | | | | | | |
| 248.4<br>15.85 | End of Borehole<br>Note:<br>1. Borehole moved 1 m south due to flowing sands in hollow stem augers at a depth of 4.6 m.<br>2. Water level in piezometer measured at a depth of 4.93 m (Elev. 259.3 m) on December 9, 2021. | | 14 | SS | 49 | | 248<br>247<br>246<br>245 | | | | | | | | |

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

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PROJECT 19136074

# RECORD OF BOREHOLE No. HF-02

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887822.6; E 299278.9 NAD83 / MTM zone 10 (LAT. 44.130378; LONG. -79.568995) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.30 m DATE Jul 06, 2021 - Jul 09, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | | | | | |
| 258.1 0.2 | Gravelly SAND (SP-SW), some fines (FILL)<br>Loose to compact<br>Brown<br>Moist | | 1 | SS | 23 | | 258 | | ○ | | 29 | 60 | 10 | 2 | |
| 257.3 1.0 | SILTY SAND (SM) of slight plasticity, some gravel (FILL)<br>Loose to dense<br>Brown<br>Moist<br>- trace organics, trace rootlets between a depth of 1.0 m and 2.2 m | | 2a<br>2b | SS | 5 | | 257 | | | | | | | | |
| | | | 3 | SS | 4 | | | | | | | | | | |
| | | | 4 | SS | 4 | | 256 | | ○ | | 13 | 54 | 27 | 6 | |
| | | | 5 | SS | 29 | | 255 | | | | | | | | |
| | | | 6a<br>6b<br>6c | SS | 31 | | | | ○ | | | | | | |
| 4.5 253.8 | SILT (ML) of slight plasticity and sand, trace gravel, trace organics<br>Compact<br>Brown<br>Moist | | 7 | SS | 23 | | 254 | | ○ | | 4 | 44 | 42 | 9 | |
| | | | | | | | 253 | | | | | | | | |
| 252.0 6.3 | SILTY CLAY (CI) to sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)<br>Stiff to hard<br>Brown to grey<br>Moist | | 8a<br>8b | SS | 15 | | 252 | | | | | | | | |
| | | | | | | | 251 | | | | | | | | |
| | | | 9 | SS | 23 | | | | | | | 4 | 35 | 61 | |
| | - 8.7 m: - grey below a depth of 8.7 m | | | | | | 250 | | | | | | | | |
| | | | 10 | SS | 8 | | 249 | | | | | | | | |

Continued on Next Page

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

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# RECORD OF BOREHOLE No. HF-02 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887822.6; E 299278.9 NAD83 / MTM zone 10 (LAT. 44.130378; LONG. -79.568995) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.30 m DATE Jul 06, 2021 - Jul 09, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (⊕ Field Vane, ■ Remoulded, ● Pocket Pen, ○ Quick Triaxial, × Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | SILTY CLAY (CI) to sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)<br>Stiff to hard<br>Brown to grey<br>Moist | | | | | | 248 | ⊕ × | | | | | | | |
| | | | 11 | SS | 15 | | 247 | | | | | | | | |
| | | | 12 | SS | 58 | | 246 | CH | | | | 2 | 28 | 55 | 14 |
| | | | 13 | SS | 100/283mm | | 245 | | | | | | | | |
| | | | | | | | 244 | | | | | | | | |
| 242.4 | | | 14 | SS | 40 | | 243 | ○ | | | | | | | |
| 15.85 | End of Borehole | | | | | | 242 | | | | | | | | |
| | | | | | | | 241 | | | | | | | | |
| | | | | | | | 240 | | | | | | | | |
| | | | | | | | 239 | | | | | | | | |

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# RECORD OF BOREHOLE No. HF-03 Sheet 1 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887823.7; E 299292.2 NAD83 / MTM zone 10 (LAT. 44.130388; LONG. -79.568829) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.40 m DATE Jul 12, 2021 - Jul 13, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (200 mm) | | | | | | | | | | | | | | |
| 258.2 0.2 | SAND (SP), some gravel, trace fines (FILL)<br>Compact to dense<br>Brown<br>Moist | | 1 | SS | 34 | | 258 | | | | | | | | |
| | | | 2 | SS | 17 | | | | ○ | | 18 | 74 | 7 | 1 | |
| 256.9 | | | | | | | 257 | | | | | | | | |
| 1.5 | Sandy CLAYEY SILT-SILT (CL-ML), trace to some gravel (FILL)<br>Firm to stiff<br>Grey<br>Moist | | 3 | SS | 8 | | | | | | | | | | |
| | | | 4 | SS | 14 | | 256 | | ○H | | 15 | 34 | 41 | 10 | |
| 255.4 | | | | | | | | | | | | | | | |
| 3.0 | SILT (ML) of slight plasticity, some sand, trace gravel<br>Loose to compact<br>Brown<br>Moist | | 5 | SS | 20 | | 255 | | | | | | | | |
| | | | 6 | SS | 25 | | | | ○ | | | | | | |
| | | | 7 | SS | 25 | | 254 | | ○H | | | | | | |
| | | | | | | | 253 | | | | | | | | |
| | | | 8 | SS | 9 | | 252 | | ○ | | | | | | |
| 251.2 | | | | | | | | | | | | | | | |
| 7.2 | CLAYEY SILT-SILT (CL-ML) to SILTY CLAY (CI), trace sand, trace gravel, containing silty sand interlayers (TILL)<br>Very stiff to hard<br>Moist<br>Grey | | | | | | 251 | | | | | | | | |
| | | | 9 | SS | 24 | | | | | | | | | | |
| | | | | | | | 250 | | | | | | | | |
| | | | 10 | SS | 23 | | 249 | | ⊖ | | 1 | 9 | 44 | 46 | |

Continued on Next Page

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# RECORD OF BOREHOLE No. HF-03 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887823.7; E 299292.2 NAD83 / MTM zone 10 (LAT. 44.130388; LONG. -79.568829) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:258.40 m DATE Jul 12, 2021 - Jul 13, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| | CLAYEY SILT-SILT (CL-ML) to SILTY CLAY (CI), trace sand, trace gravel, containing silty sand interlayers (TILL)<br>Very stiff to hard<br>Moist<br>Grey | | | | | | 248 | | | | | | | | |
| | | | 11 | SS | 16 | | | | | | | | | | |
| | | | | | | | 247 | | | | | | | | |
| | | | 12 | SS | 81 | | 246 | | | | | | | | |
| | - 13.5 to 14.8 m: - silty sand, some gravel interlayer between depths of 13.5 m and 14.8 m | | | | | | 245 | | | | | | | | |
| | | | 13 | SS | 37 | | | | H | | 12 | 39 | 39 | 10 | |
| | | | | | | | 244 | | | | | | | | |
| | | | 14 | SS | 69 | | 243 | | | | | | | | |
| 242.0 | | | | | | | | | | | | | | | |
| 16.4 | CLAYEY SILT (CL) trace sand, trace gravel (TILL)<br>Hard<br>Grey<br>Moist | | | | | | 242 | | | | | | | | |
| | | | 15 | SS | 37 | | | | O | | | | | | |
| 240.6 | | | | | | | 241 | | | | | | | | |
| 17.8 | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | | | | | | | | | | | | | |
| | | | 16 | SS | 100/255mm | | 240 | | | | | | | | |
| 18.69 | | | | | | | | | | | | | | | |
| 239.7 | End of Borehole | | | | | | 239 | | | | | | | | |

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# RECORD OF BOREHOLE No. HF-04

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887737.7; E 299293.4 NAD83 / MTM zone 10 (LAT. 44.129614; LONG. -79.568812) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:255.52 m DATE Jun 29, 2021 - Jun 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) (Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | | | | | | | | |
| 0.0 | ASPHALT (180 mm) | | | | | | | | | | | | | | |
| 255.3 / 0.2 | SILTY SAND (SM), some gravel (FILL)<br>Compact<br>Brown<br>Moist | | 1 | SS | 22 | | 255 | | | | | | | | |
| | | | 2 | SS | 14 | | | | ○ | | 19 | 62 | 16 | 3 | |
| 254.1 | | | | | | | 254 | | | | | | | | |
| 1.5 | SILT (ML), some sand to SILTY SAND (SM) some gravel (FILL)<br>Compact to Dense<br>Brown<br>Moist | | 3 | SS | 12 | | | | | | | | | | |
| | | | 4 | SS | 29 | | 253 | | | | | | | | |
| | | | 5a | SS | 42 | | | | ○ | NP | | | | | |
| 251.8 | | | 5b | | | | 252 | | | | | | | | |
| 3.7 | CLAYEY SILT (CL), trace sand, trace gravel, trace organics<br>Firm<br>Dark brown<br>Moist | | 6 | SS | 8 | | | | ○ | | | | | | |
| | | | | | | | 251 | ⊠ | | | | | | | |
| | | | | | | | 250 | ⊕ | × | | | | | | |
| 249.7 | | | | | | | | | | | | | | | |
| 5.8 | CLAYEY SILT (CL), trace gravel to gravelly, some sand to sandy (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | 7 | SS | 20 | | 249 | | ⊖⊣ | | 5 | 16 | 47 | 32 | |
| | | | | | | | 248 | | | | | | | | |
| | | | 8 | SS | 43 | | | | | | | | | | |
| | | | | | | | 247 | | | | | | | | |
| | | | 9 | SS | 34 | | 246 | | ○ | | | | | | |

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# RECORD OF BOREHOLE No. HF-04 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887737.7; E 299293.4 NAD83 / MTM zone 10 (LAT. 44.129614; LONG. -79.568812) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:255.52 m DATE Jun 29, 2021 - Jun 29, 2021 CHECKED BY KJB

| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT (CL), trace gravel to gravelly, some sand to sandy (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | | | | | 245 | | | | | | | | |
| | | | 10 | SS | 21 | | 244 | | | | | | | | |
| | | | 11 | SS | 22 | | 243 | | | | | | | | |
| | | | | | | | 242 | | | | | | | | |
| | | | 12 | SS | 35 | | 241 | | o | | | | | | |
| 240.7<br>14.8 | CLAYEY SILT-SILT (CL-ML)<br>Hard<br>Grey<br>Moist | | 13 | SS | 55 | | 240 | | o-H | | | 0 | 81 | 18 | |
| 239.7<br>15.85 | End of Borehole | | | | | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |
| | | | | | | | 236 | | | | | | | | |

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# RECORD OF BOREHOLE No. HF-05

Sheet 1 of 2

**METRIC**

G.W.P. 2008-21-00 LOCATION N 4887717.7; E 299314.3 NAD83 / MTM zone 10 (LAT. 44.129434; LONG. -79.568551) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:254.70 m DATE Jun 24, 2021 - Jun 24, 2021 CHECKED BY KJB

| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | GROUNDWATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) 20 40 60 80 100 | WATER CONTENT (%) PL $W_p$ NMC W LL $W_l$ NP Nonplastic 20 40 60 80 | UNIT WEIGHT γ kN/m³ | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | ASPHALT (100 mm) | | | | | | | | | | | | | | |
| 254.6<br>0.1 | SAND (SP) and Gravel, trace fines (FILL)<br>Dense<br>Brown<br>Moist | | 1 | SS | 32 | | 254 | | ○ | | 36 | 53 | 10 | 2 | |
| 253.7 | | | 2a | | | | | | | | | | | | |
| 1.0 | SILTY SAND (SM) of slight plasticity, some gravel (FILL)<br>Loose to dense<br>Brown<br>Moist | | 2b | SS | 39 | | | | | | | | | | |
| | | | 3 | SS | 16 | | 253 | | ○ | | | | | | |
| | | | 4 | SS | 21 | | 252 | | | | | | | | |
| | | | 5 | SS | 9 | | 251 | | ○H | | 18 | 45 | 30 | 7 | |
| 250.6 | | | 6a | | | | | | | | | | | | |
| 4.0 | CLAYEY SILT (CL), trace sand, trace organics<br>Firm<br>Dark brown<br>Moist | | 6b | SS | 10 | | | | | | | | | | |
| | | | 7 | SS | 10 | | 250 | | ○ | | | | | | |
| 249.0 | | | | | | | 249 | | | | | | | | |
| 5.7 | CLAYEY SILT (CL), some sand, trace gravel to Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist<br><br>Grey below a depth of 9.1m | | 8 | SS | 20 | | | | ⊖H | | 4 | 19 | 49 | 28 | |
| | | | | | | | 248 | | | | | | | | |
| | | | 9 | SS | 85 | | 247 | | | | | | | | |
| | | | | | | | 246 | | | | | | | | |
| | | | 10 | SS | 65 | | | | ○H | | 5 | 32 | 49 | 14 | |
| | | | | | | | 245 | | | | | | | | |

Continued on Next Page

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# RECORD OF BOREHOLE No. HF-05 Sheet 2 of 2 METRIC

G.W.P. 2008-21-00 LOCATION N 4887717.7; E 299314.3 NAD83 / MTM zone 10 (LAT. 44.129434; LONG. -79.568551) ORIGINATED BY MM

DIST Central HWY Bradford Bypass - County Road 4 BOREHOLE TYPE 210 mm O.D. Hollow Stem Auger COMPILED BY ACK

DATUM CGVD28 Surface Elevation:254.70 m DATE Jun 24, 2021 - Jun 24, 2021 CHECKED BY KJB

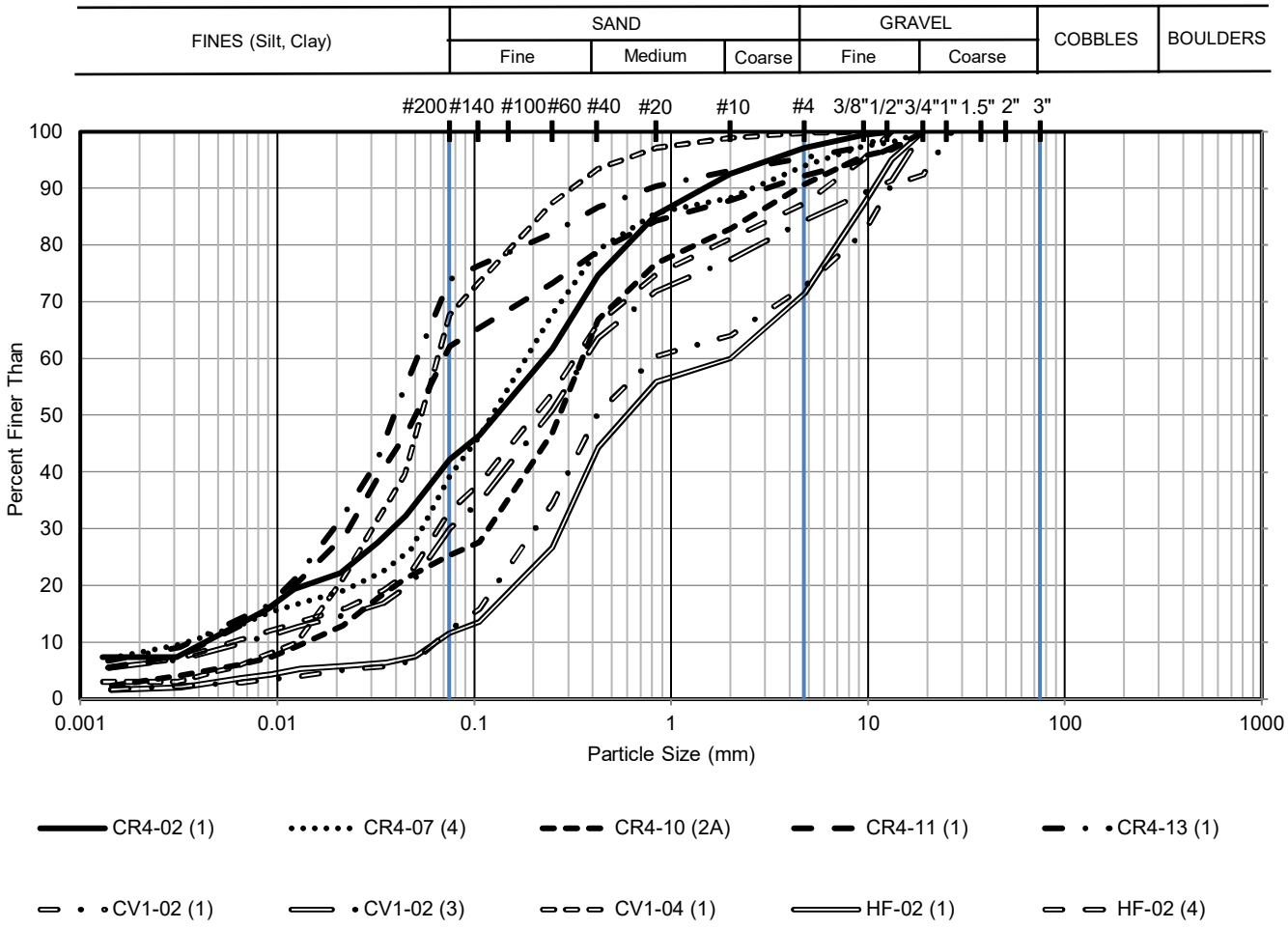
| SOIL PROFILE | | | SAMPLES | | | GROUNDWATER CONDITIONS | ELEVTION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) | WATER CONTENT (%) | UNIT WEIGHT | GR | SA | SI | CL | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | "N" VALUES | | | Field Vane, Remoulded, Pocket Pen, Quick Triaxial, Unconfined; 20 40 60 80 100 | PL $W_p$ NMC W LL $W_l$; NP Nonplastic; 20 40 60 80 | γ kN/m³ | | | | | |
| | CLAYEY SILT (CL), some sand, trace gravel to Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)<br>Very stiff to hard<br>Brown to grey<br>Moist | | | | | | 244 | | | | | | | | |
| | Grey below a depth of 9.1m | | 11 | SS | 58 | | 243 | | | | | | | | |
| 242.3 | | | 12a | SS | 108 | | | | | | | | | | |
| 12.4 | CLAYEY SILT (CL)<br>Hard<br>Grey<br>Moist | | 12b | | | | 242 | | | | | | | | |
| | | | 13 | SS | 100 | | 241 | | | | 0 | 71 | 29 | | |
| | | | | | | | 240 | | | | | | | | |
| 239.0 | | | 14 | SS | 100/255mm | | | | | | | | | | |
| 15.65 | End of Borehole<br>Note:<br>1. Water level in piezometer measured at a depth of 3.86 m (Elev. 250.8 m). | | | | | | 239 | | | | | | | | |
| | | | | | | | 238 | | | | | | | | |
| | | | | | | | 237 | | | | | | | | |
| | | | | | | | 236 | | | | | | | | |
| | | | | | | | 235 | | | | | | | | |

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

**APPENDIX B**

# Geotechnical and Analytical Test Results

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-02 | 1 | 0.0 - 0.6 | 259.7 to 259.1 |
| CR4-07 | 4 | 2.3 - 2.9 | 259.0 to 258.4 |
| CR4-10 | 2A | 0.8 - 1.3 | 259.1 to 258.6 |
| CR4-11 | 1 | 0.0 - 0.6 | 253.3 to 252.7 |
| CR4-13 | 1 | 0.0 - 0.6 | 252.8 to 252.1 |
| CV1-02 | 1 | 0.2 - 0.8 | 256.1 to 255.5 |
| CV1-02 | 3 | 1.5 - 2.1 | 254.8 to 254.2 |
| CV1-04 | 1 | 0.0 - 0.6 | 250.5 to 249.9 |
| HF-02 | 1 | 0.2 - 0.8 | 258.1 to 257.5 |
| HF-02 | 4 | 2.3 - 2.9 | 256.0 to 255.4 |

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Bradford Bypass County Road 4

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|---|---|
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

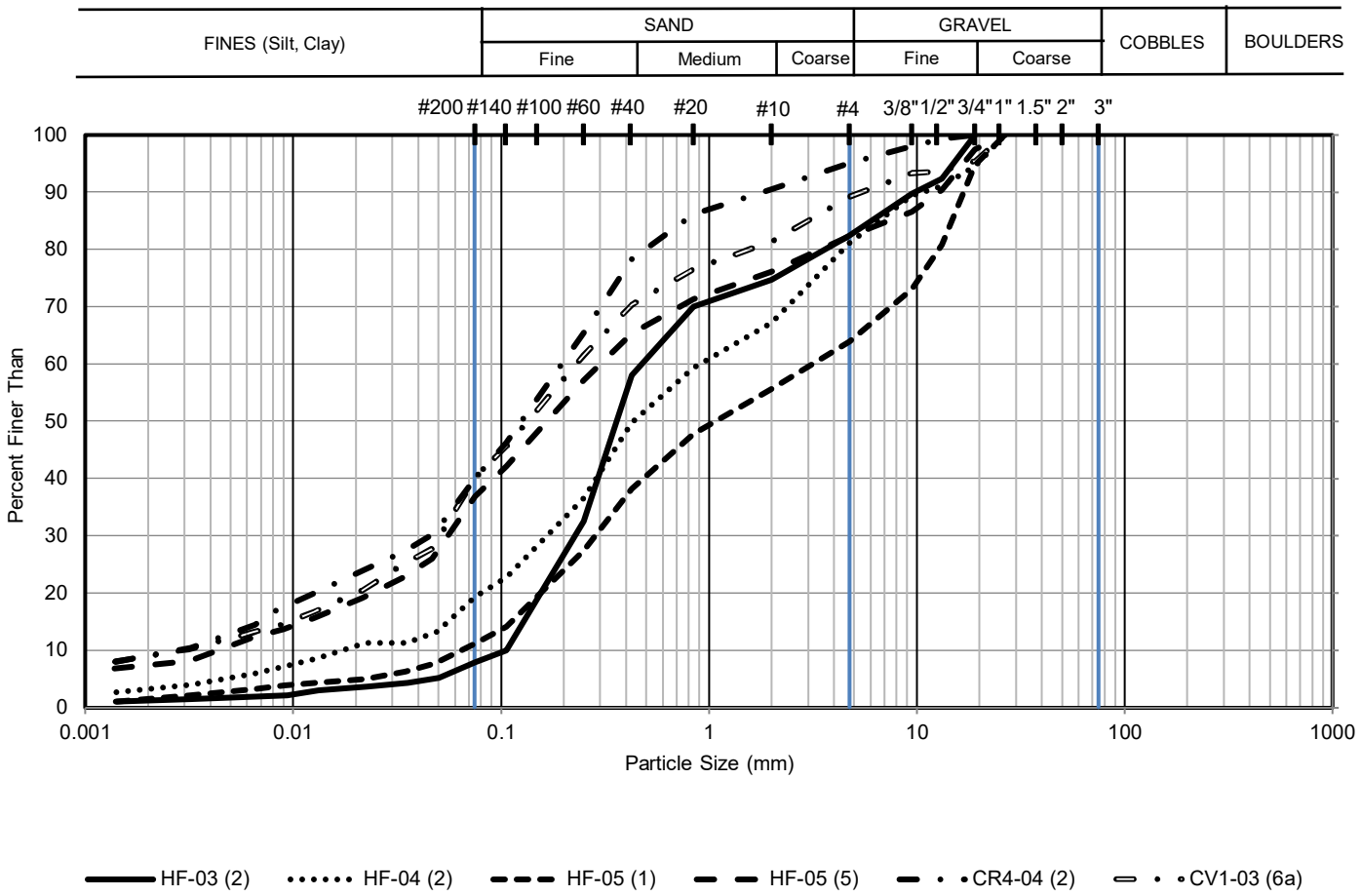
TITLE

Sandy SILT (ML) to SILTY SAND (SM) to SAND (SP) and Gravel (FILL)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B1A |

PATH: https://golderassociates-my.sharepoint.com/personal/akobylinski_golder_com/Documents/19136074 - Bradford Bypass/OGC Lab Figures | FILE NAME: Grain Size Output MTO for Bradford Bypass.xlsm

# GRAIN SIZE DISTRIBUTION




| Location ID | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| HF-03 | 2 | 0.8 - 1.4 | 257.6 to 257.0 |
| HF-04 | 2 | 0.8 - 1.4 | 254.7 to 254.1 |
| HF-05 | 1 | 0.1 - 0.7 | 254.6 to 254.0 |
| HF-05 | 5 | 3.1 - 3.7 | 251.7 to 251.0 |
| CR4-04 | 2 | 0.8 - 1.4 | 262.0 to 261.4 |
| CV1-03 | 6a | 3.8 - 4.1 | 252.7 to 252.4 |
| | | | |
| | | | |
| | | | |
| | | | |

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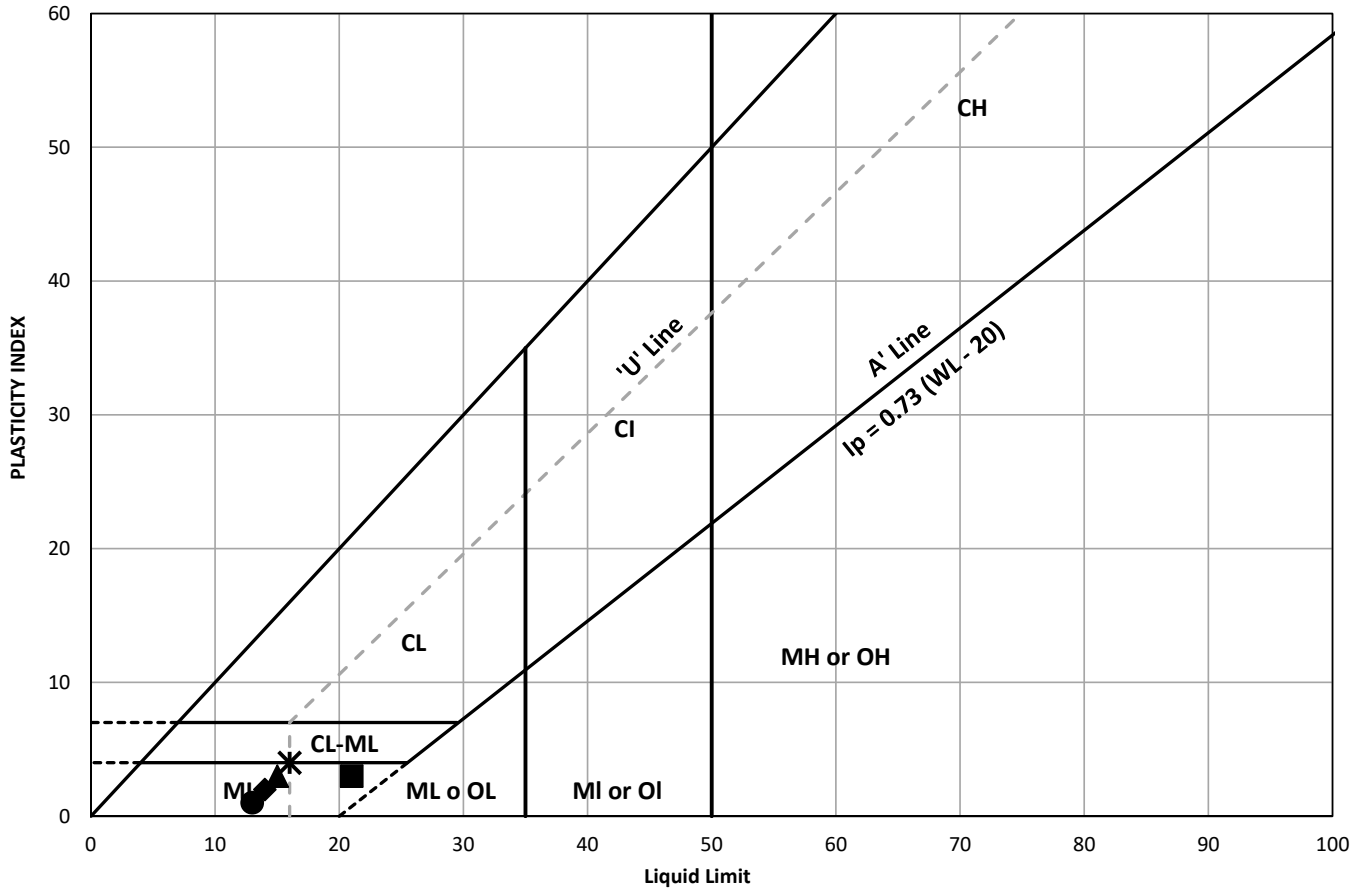
| | |
|---|---|
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

Sandy SILT (ML) to SILTY SAND (SM) to SAND (SP) and Gravel (FILL)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B1B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | HF-01 | 4 | 261.91 to 261.30 | 14.7 | 21 | 18 | 3 |
| ◆ | HF-02 | 4 | 256.01 to 255.40 | 10.2 | 14 | 12 | 2 |
| ▲ | HF-05 | 5 | 251.65 to 251.04 | 8.9 | 15 | 12 | 3 |
| ● | CR4-07 | 4 | 259.00 to 258.39 | 7.9 | 13 | 12 | 1 |
| ✳ | CV1-03 | 6a | 252.69 to 252.38 | 8.3 | 16 | 12 | 4 |
| | | | | | | | |
| | | | | | | | |
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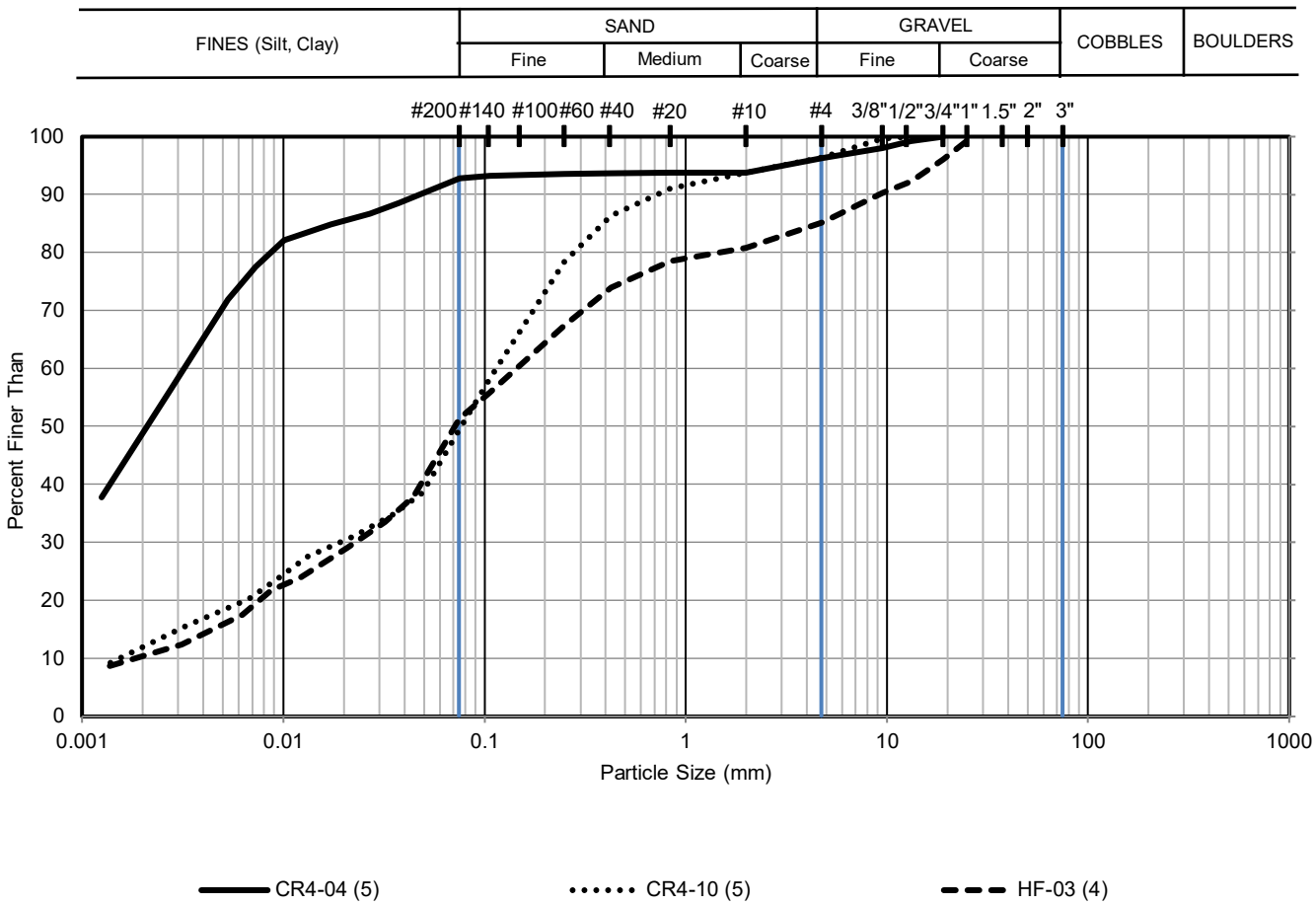
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

Sandy SILT (ML) of slight plasticity to SILTY SAND (SM) of slight plasticity (FILL)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B2 |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-04 | 5 | 3.1 - 3.7 | 259.8 to 259.1 |
| CR4-10 | 5 | 3.1 - 3.7 | 256.9 to 256.3 |
| HF-03 | 4 | 2.3 - 2.9 | 256.1 to 255.5 |
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Bradford Bypass County Road 4

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MEMBER OF WSP

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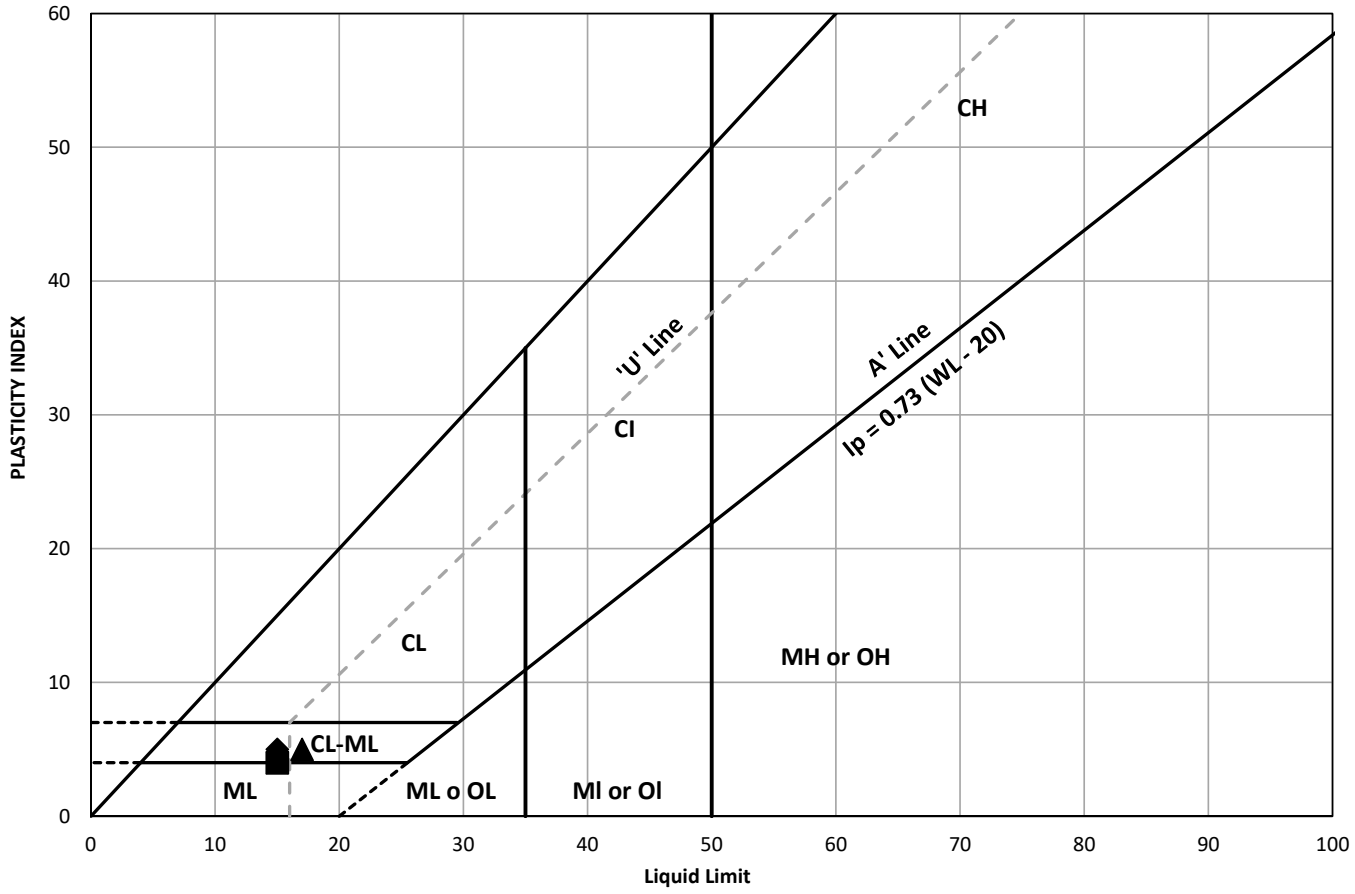
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SAND (SC) (FILL)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B3 |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-04 | 5 | 259.75 to 259.14 | 7.6 | 15 | 11 | 4 |
| ◆ | CR4-10 | 5 | 256.89 to 256.28 | 9.5 | 15 | 10 | 5 |
| ▲ | HF-03 | 4 | 256.11 to 255.50 | 9.4 | 17 | 12 | 5 |
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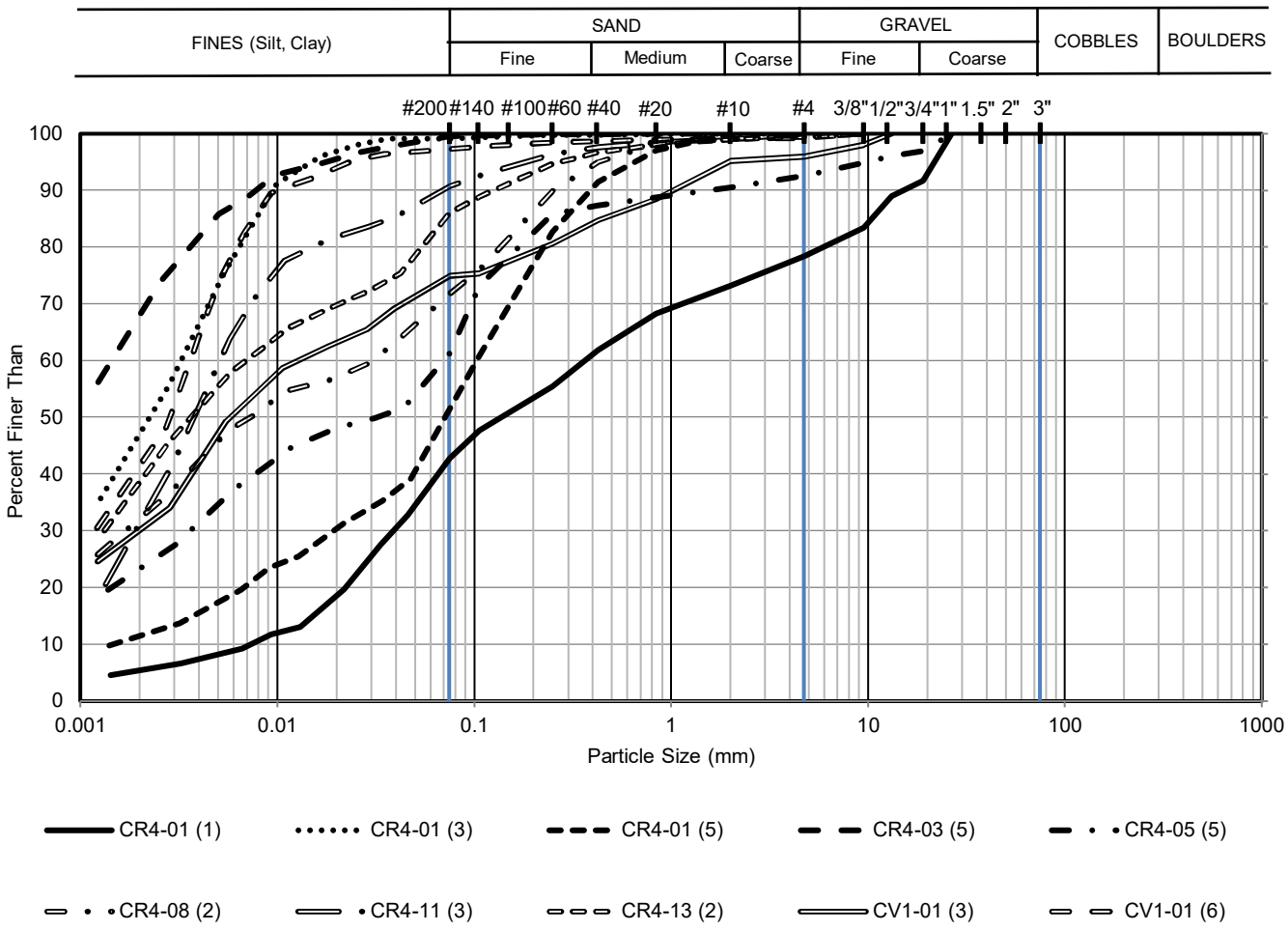
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to Sandy CLAYEY SILT-SILT (CL-ML) to CLAYEY SAND (SC) (FILL)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B4 |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-01 | 1 | 0.0 - 0.6 | 262.8 to 262.2 |
| CR4-01 | 3 | 1.5 - 2.1 | 261.3 to 260.7 |
| CR4-01 | 5 | 3.1 - 3.7 | 259.8 to 259.1 |
| CR4-03 | 5 | 3.1 - 3.7 | 258.1 to 257.5 |
| CR4-05 | 5 | 3.1 - 3.7 | 255.0 to 254.4 |
| CR4-08 | 2 | 0.8 - 1.4 | 252.5 to 251.9 |
| CR4-11 | 3 | 1.5 - 2.1 | 251.8 to 251.2 |
| CR4-13 | 2 | 0.8 - 1.4 | 252.0 to 251.4 |
| CV1-01 | 3 | 1.7 - 2.3 | 250.5 to 249.9 |
| CV1-01 | 6 | 3.8 - 4.4 | 248.4 to 247.8 |

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| YYYY-MM-DD | 2022-01-20 |
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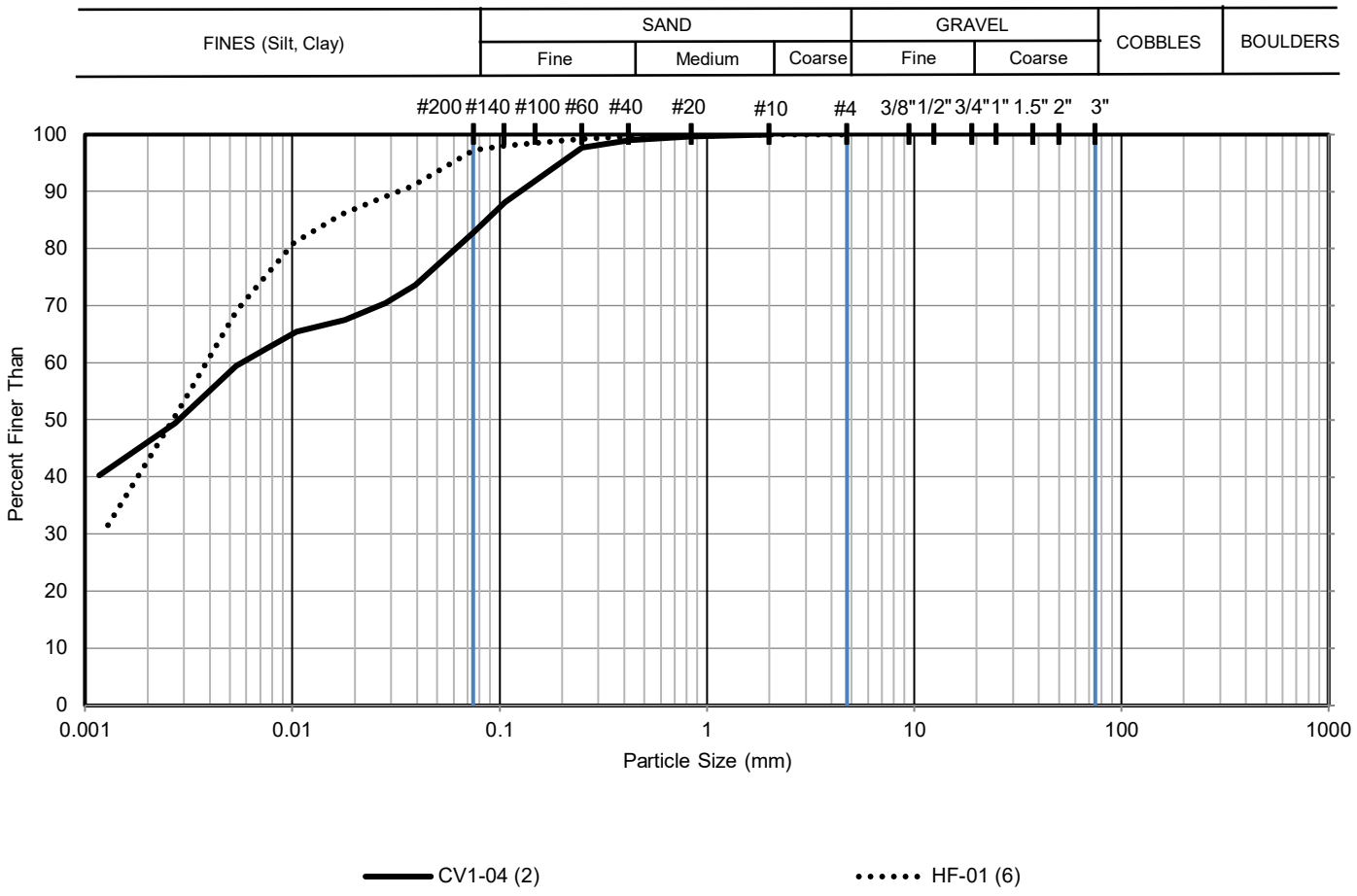
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) to Gravelly CLAYEY SAND (SC) - Upper Cohesive

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B5A |

# GRAIN SIZE DISTRIBUTION




| Location ID | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CV1-04 | 2 | 0.8 - 1.4 | 249.7 to 249.1 |
| HF-01 | 6 | 3.8 - 4.4 | 260.4 to 259.8 |
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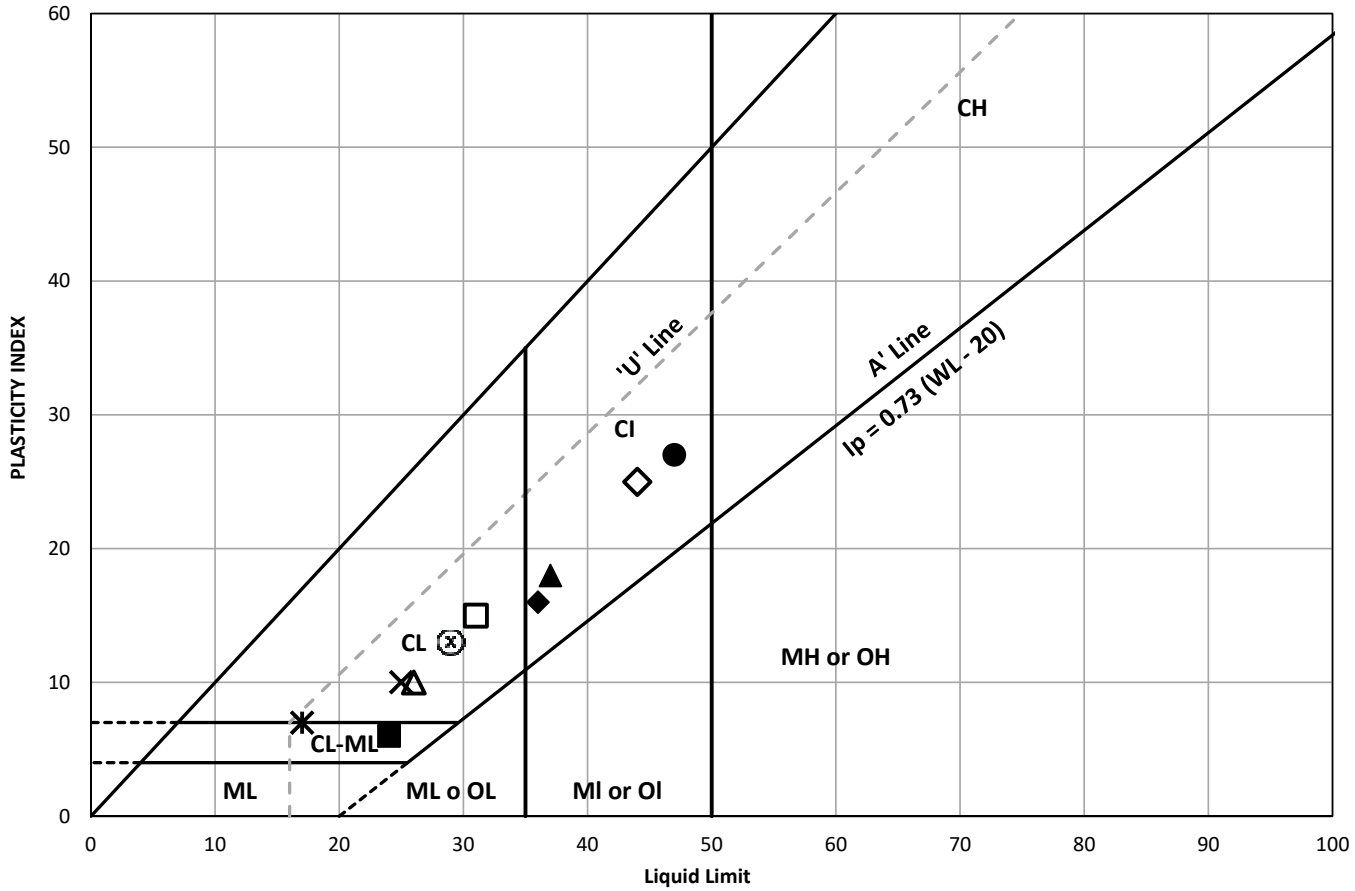
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) to Gravelly CLAYEY SAND (SC) - Upper Cohesive

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B5B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-01 | 1 | 0.0 - 0.6 | 21.7 | 24 | 18 | 6 |
| ◆ | CR4-01 | 3 | 261.28 to 260.67 | 26.1 | 36 | 20 | 16 |
| ▲ | CR4-01 | 5 | 259.75 to 259.14 | 22.3 | 37 | 19 | 18 |
| ● | CR4-03 | 5 | 258.13 to 257.52 | 28.6 | 47 | 20 | 27 |
| ✳ | CR4-05 | 5 | 254.96 to 254.35 | 17.6 | 17 | 10 | 7 |
| ⊗ | CR4-08 | 2 | 252.51 to 251.90 | 22 | 29 | 16 | 13 |
| □ | CR4-11 | 3 | 251.82 to 251.21 | 22.3 | 31 | 16 | 15 |
| ◇ | CR4-13 | 2 | 251.99 to 251.38 | 32 | 44 | 19 | 25 |
| △ | CV1-01 | 3 | 250.51 to 249.90 | 17.3 | 26 | 16 | 10 |
| × | CV1-01 | 6 | 248.38 to 247.82 | 19.9 | 25 | 15 | 10 |

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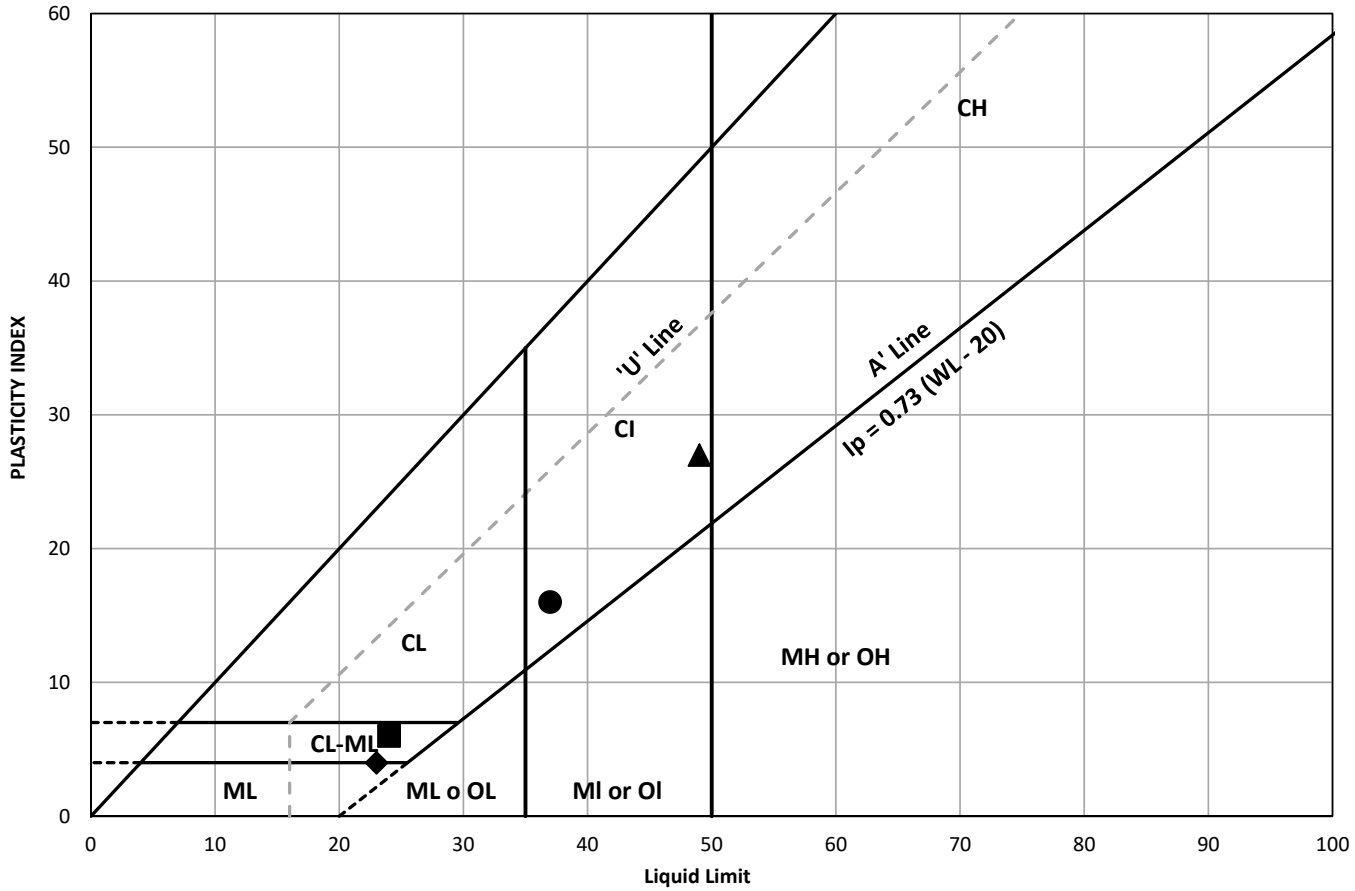
TITLE

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

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B6A |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CV1-02 | 7 | 251.71 to 251.10 | 24.3 | 27 | 20 | 7 |
| ◆ | CV1-03 | 8 | 251.17 to 250.66 | 19.2 | 23 | 19 | 4 |
| ▲ | CV1-04 | 2 | 249.72 to 249.11 | 32.6 | 49 | 22 | 27 |
| ● | HF-01 | 6 | 260.39 to 259.78 | 28.4 | 37 | 21 | 16 |
| | | | #N/A | | | | |
| | | | #N/A | | | | |
| | | | #N/A | | | | |
| | | | #N/A | | | | |
| | | | #N/A | | | | |
| | | | #N/A | | | | |

CLIENT: MTO / AECOM

PROJECT: Bradford Bypass County Road 4

CONSULTANT: GOLDER, MEMBER OF WSP

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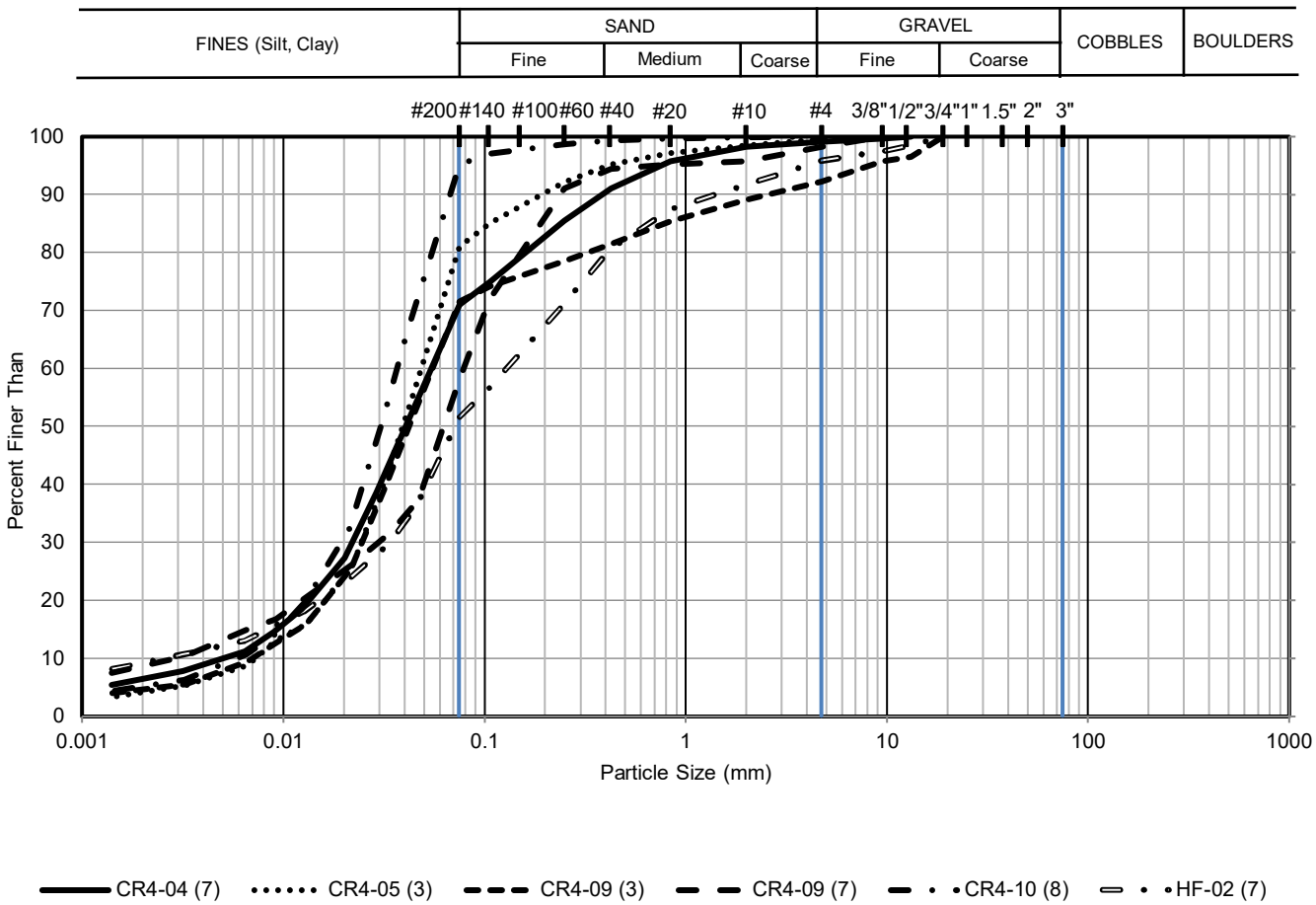
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

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

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B6B |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-04 | 7 | 4.6 - 5.2 | 258.2 to 257.6 |
| CR4-05 | 3 | 1.5 - 2.1 | 256.5 to 255.9 |
| CR4-09 | 3 | 1.5 - 2.1 | 254.9 to 254.3 |
| CR4-09 | 7 | 4.6 - 5.2 | 251.9 to 251.3 |
| CR4-10 | 8 | 6.1 - 6.7 | 253.8 to 253.2 |
| HF-02 | 7 | 4.6 - 5.2 | 253.7 to 253.1 |
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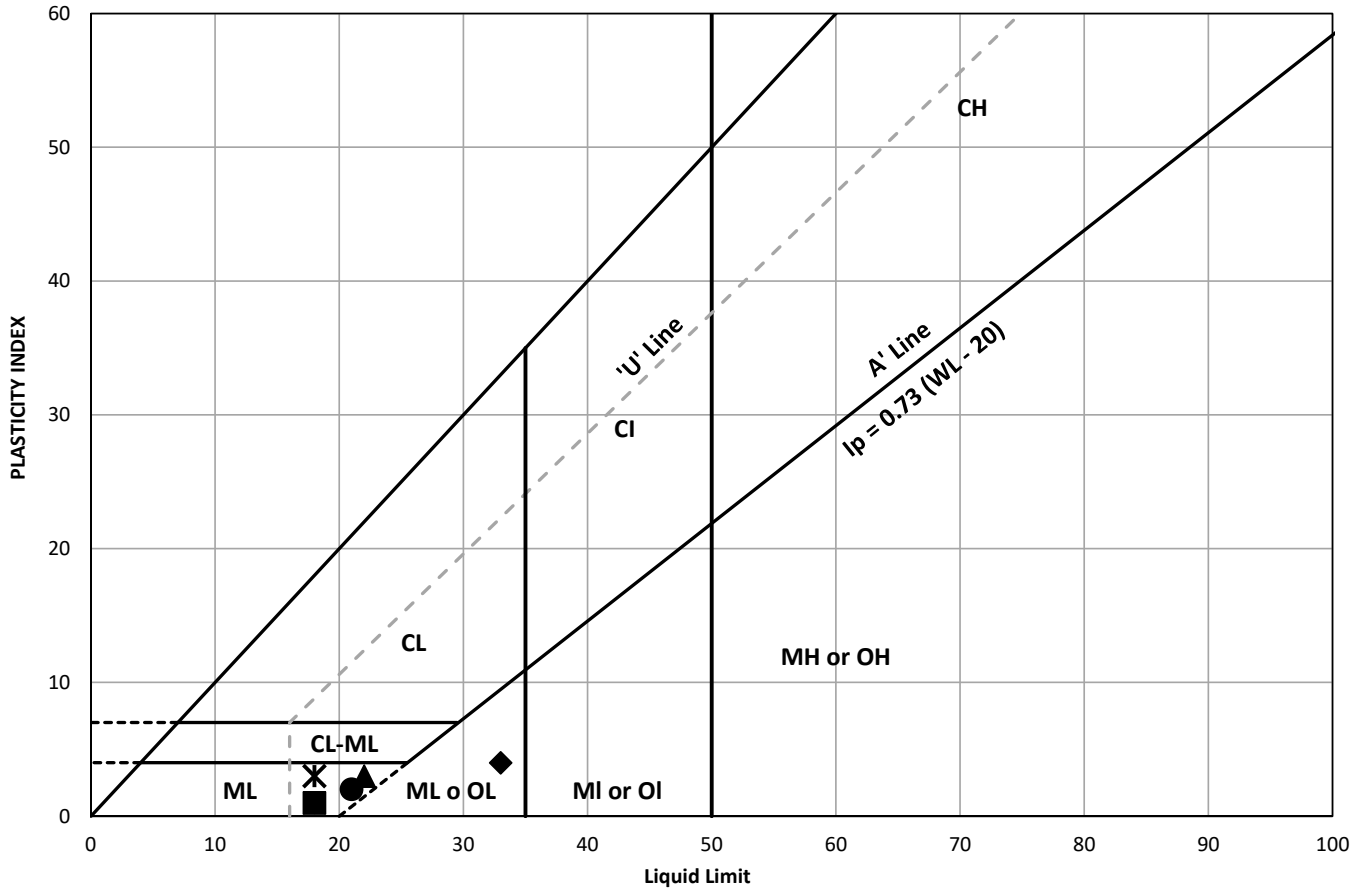
| APPROVED | KJB |

TITLE

SILT (ML) to Sandy SILT (ML)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B7 |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-05 | 3 | 256.49 to 255.88 | 17.7 | 18 | 17 | 1 |
| ◆ | CR4-04 | 7 | 258.23 to 257.62 | 34.8 | 33 | 29 | 4 |
| ▲ | CR4-09 | 3 | 254.94 to 254.33 | 18.1 | 22 | 19 | 3 |
| ● | CR4-10 | 8 | 253.84 to 253.23 | 20.7 | 21 | 19 | 2 |
| ✳ | HF-02 | 7 | 253.73 to 253.12 | 14.1 | 18 | 15 | 3 |
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Bradford Bypass County Road 4

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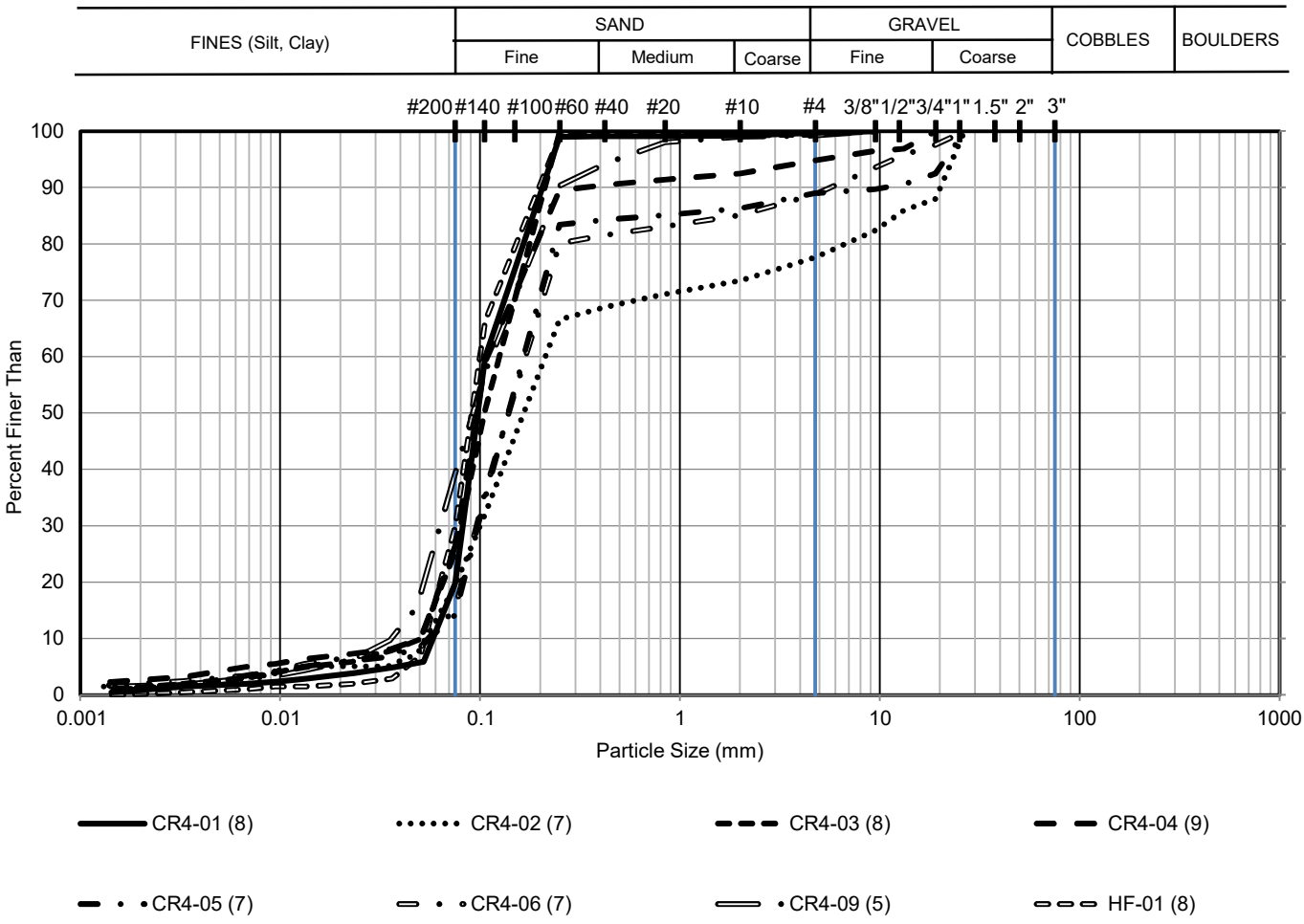
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE
SILT (ML) of slight plasticity

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B8 |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-01 | 8 | 6.1 - 6.7 | 256.7 to 256.1 |
| CR4-02 | 7 | 4.6 - 5.2 | 255.2 to 254.5 |
| CR4-03 | 8 | 6.1 - 6.7 | 255.1 to 254.5 |
| CR4-04 | 9 | 7.6 - 8.2 | 255.2 to 254.6 |
| CR4-05 | 7 | 4.6 - 5.2 | 253.4 to 252.8 |
| CR4-06 | 7 | 4.6 - 5.2 | 253.6 to 253.0 |
| CR4-09 | 5 | 3.1 - 3.7 | 253.4 to 252.8 |
| HF-01 | 8 | 6.1 - 6.7 | 258.1 to 257.5 |
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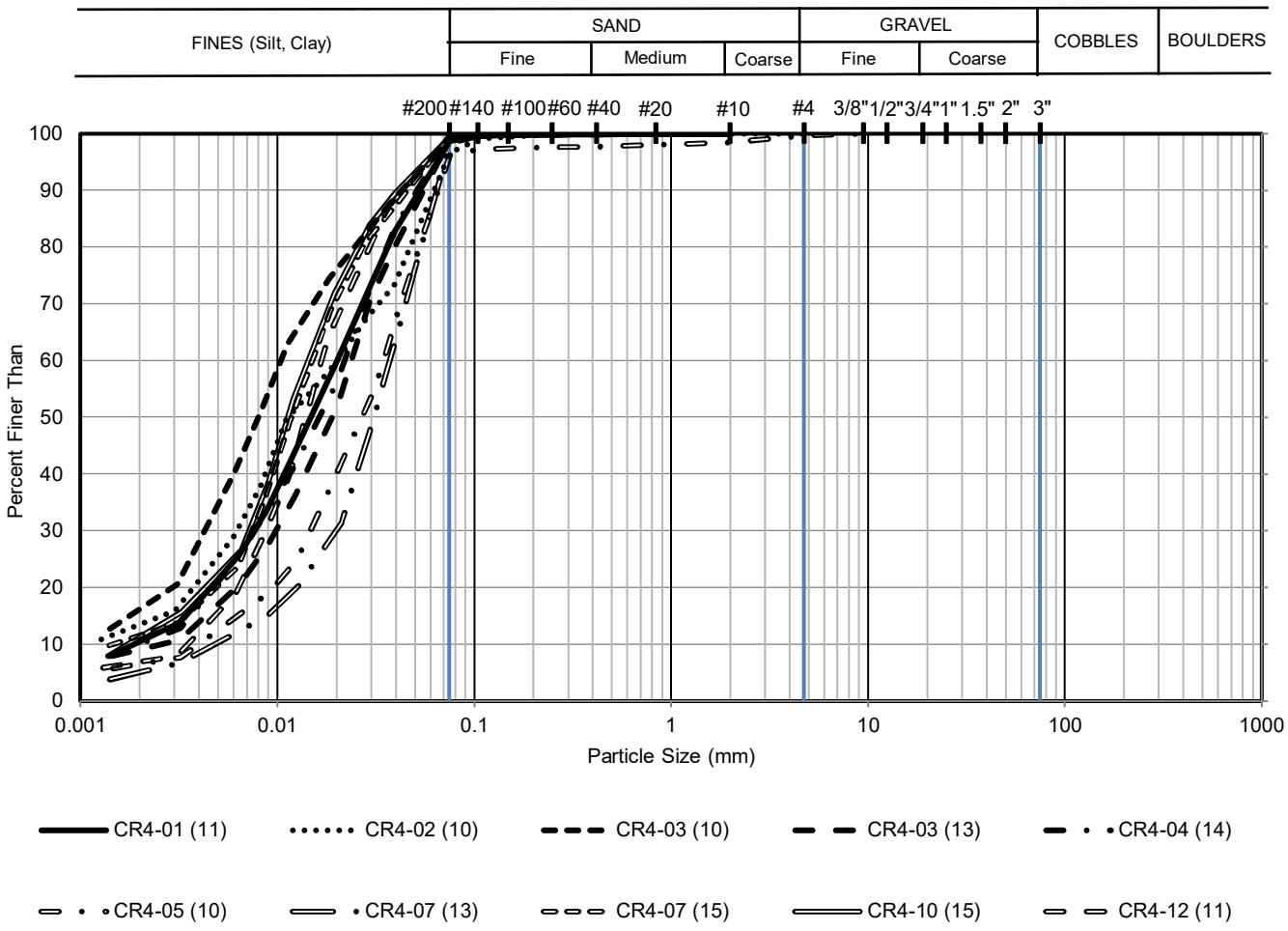
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILTY SAND (SM) to Gravelly SILTY SAND (SM)

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B9 |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-01 | 11 | 10.7 - 11.3 | 252.1 to 251.5 |
| CR4-02 | 10 | 9.1 - 9.8 | 250.6 to 250.0 |
| CR4-03 | 10 | 9.1 - 9.8 | 252.0 to 251.4 |
| CR4-03 | 13 | 13.7 - 14.3 | 247.5 to 246.9 |
| CR4-04 | 14 | 15.2 - 15.9 | 247.6 to 247.0 |
| CR4-05 | 10 | 9.1 - 9.8 | 248.9 to 248.3 |
| CR4-07 | 13 | 13.7 - 14.3 | 247.6 to 247.0 |
| CR4-07 | 15 | 16.8 - 17.4 | 244.5 to 243.9 |
| CR4-10 | 15 | 16.8 - 17.4 | 243.2 to 242.6 |
| CR4-12 | 11 | 10.7 - 11.3 | 244.6 to 244.0 |

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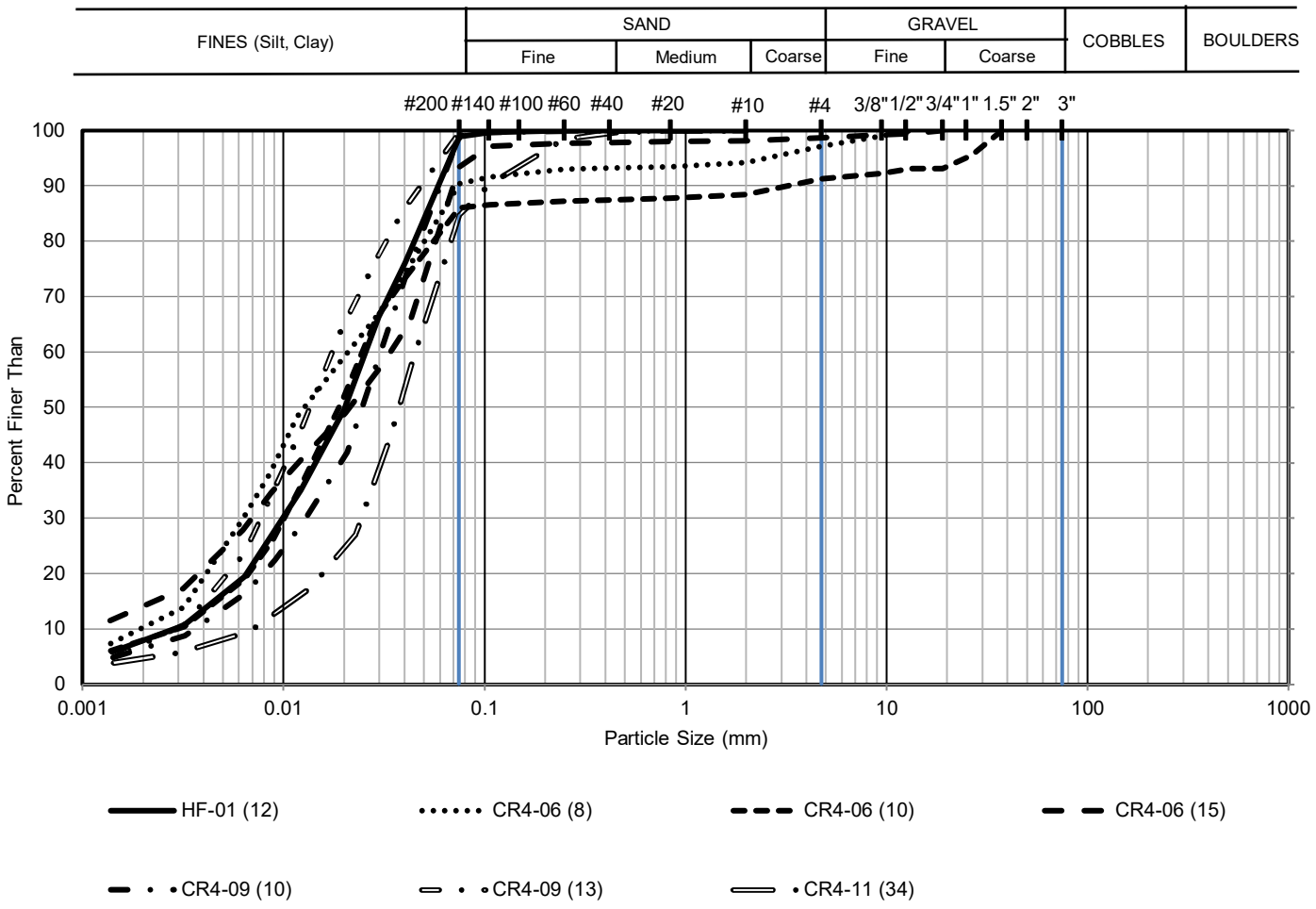
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILT (ML) of slight plasticity

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B10A |

# GRAIN SIZE DISTRIBUTION




| Location ID | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| HF-01 | 12 | 12.2 - 12.8 | 252.0 to 251.4 |
| CR4-06 | 8 | 6.1 - 6.7 | 252.1 to 251.5 |
| CR4-06 | 10 | 9.1 - 9.8 | 249.1 to 248.5 |
| CR4-06 | 15 | 16.8 - 17.4 | 241.4 to 240.8 |
| CR4-09 | 10 | 9.1 - 9.8 | 247.3 to 246.7 |
| CR4-09 | 13 | 13.7 - 14.3 | 242.7 to 242.1 |
| CR4-11 | 34 | 47.2 - 47.9 | 206.1 to 205.5 |
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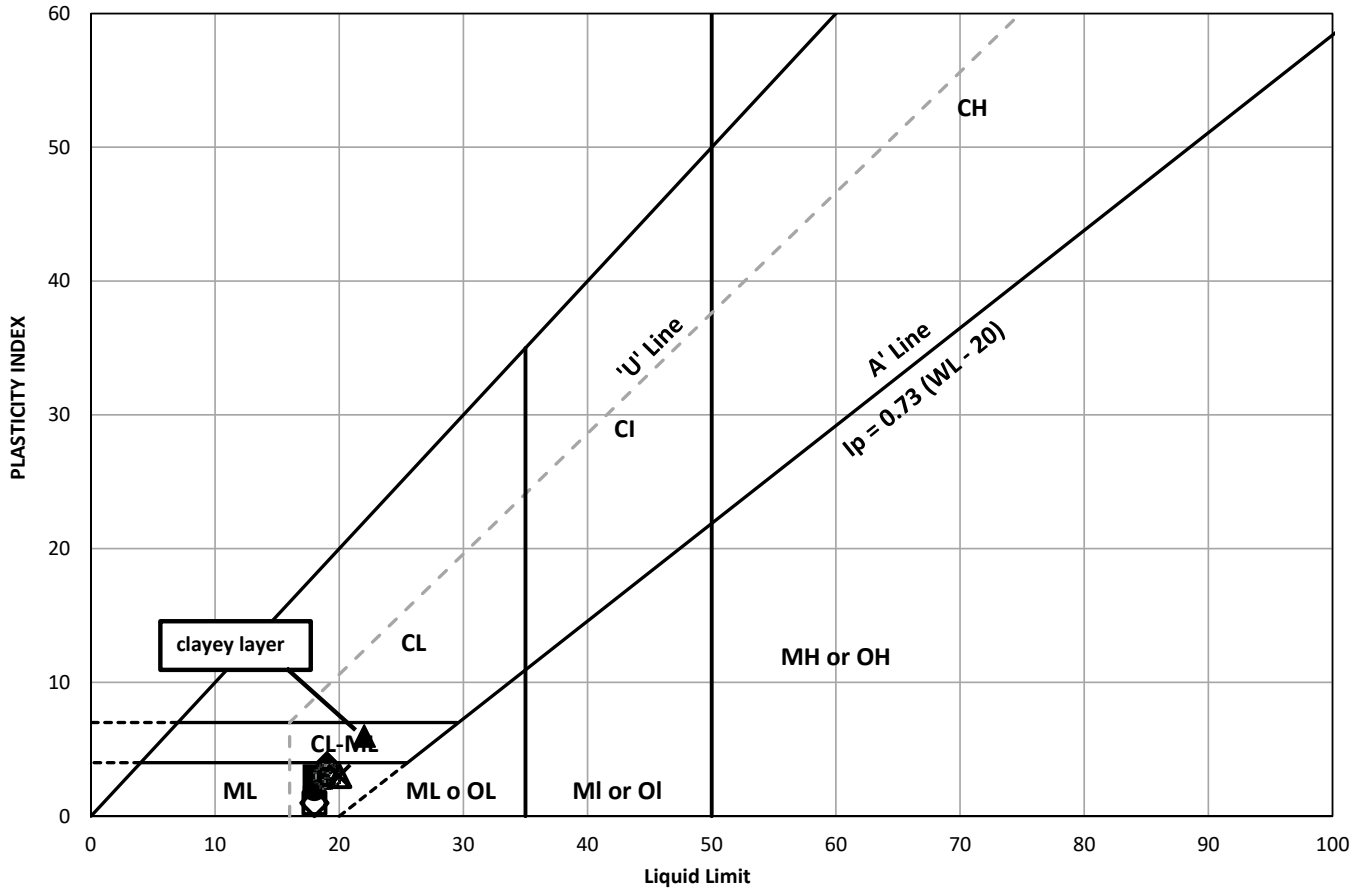
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILT (ML) of slight plasticity

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B10B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-01 | 11 | 252.13 to 251.52 | 16.7 | 18 | 15 | 3 |
| ◆ | CR4-02 | 10 | 250.58 to 249.97 | 19.3 | 19 | 15 | 4 |
| ▲ | CR4-03 (clayey layer) | 10 | 252.04 to 251.43 | 19.5 | 22 | 16 | 6 |
| ● | CR4-03 | 13 | 247.46 to 246.85 | 19.4 | 18 | 16 | 2 |
| ✳ | CR4-04 | 11 | 252.13 to 251.52 | 17.2 | 19 | 16 | 3 |
| ⊗ | CR4-04 | 14 | 247.56 to 246.95 | 19.4 | 19 | 16 | 3 |
| □ | CR4-05 | 10 | 248.87 to 248.26 | 16.8 | 18 | 17 | 1 |
| ◇ | CR4-07 | 13 | 247.57 to 246.96 | 17.7 | 18 | 17 | 1 |
| △ | CR4-07 | 15 | 244.53 to 243.92 | 17.9 | 20 | 17 | 3 |
| × | CR4-10 | 15 | 243.18 to 242.57 | 19.4 | 20 | 17 | 3 |

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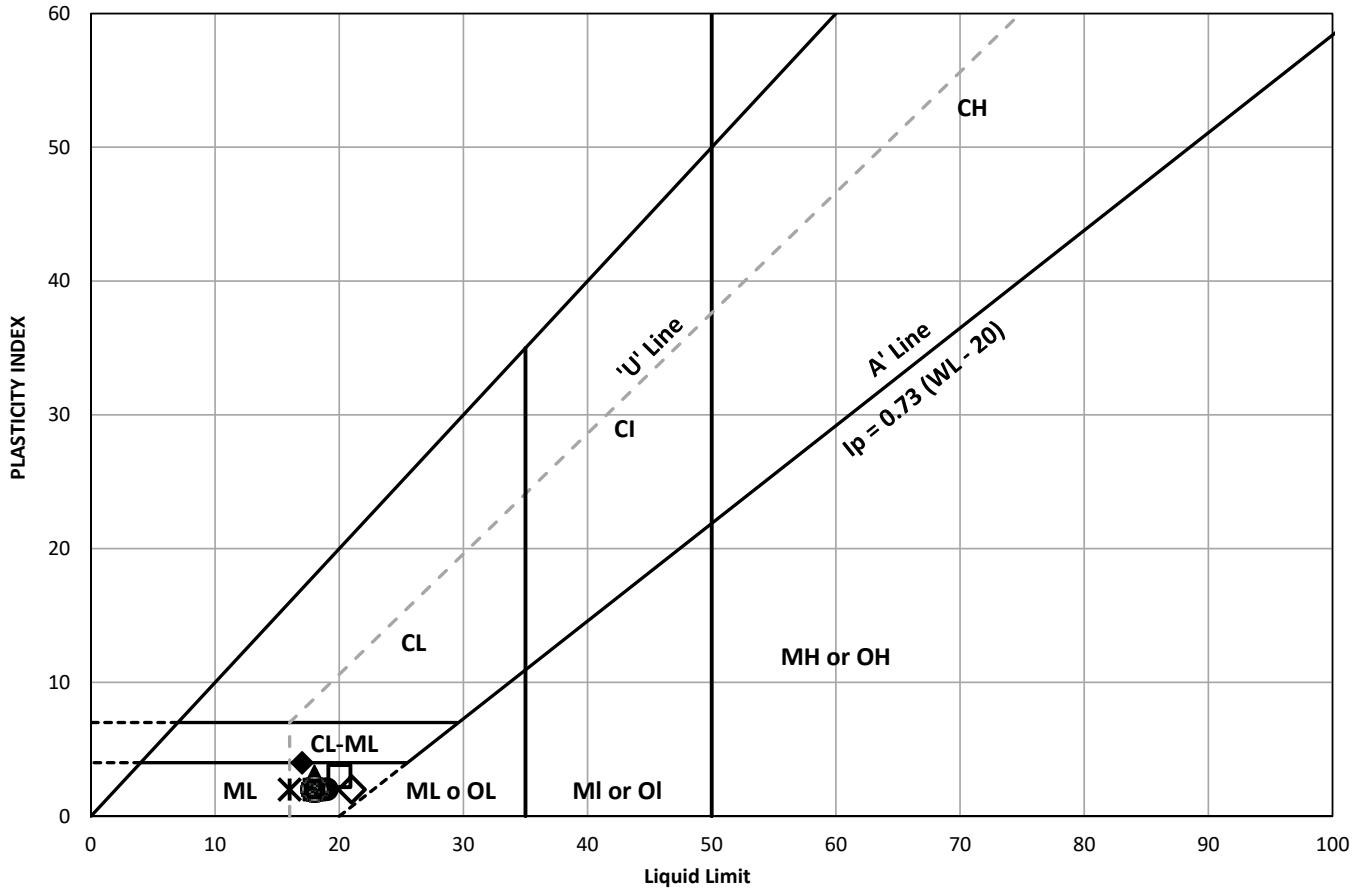
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE
SILT (ML) of slight plasticity

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | 11A |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | HF-01 | 12 | 252.01 to 251.40 | 16.7 | 18 | 16 | 2 |
| ◆ | HF-03 | 7 | 253.83 to 253.22 | 7.9 | 17 | 13 | 4 |
| ▲ | CR4-06 | 8 | 252.10 to 251.49 | 18.8 | 18 | 15 | 3 |
| ● | CR4-06 | 10 | 249.06 to 248.45 | 17.6 | 19 | 17 | 2 |
| ✳ | CR4-06 | 15 | 241.44 to 240.83 | 19.7 | 16 | 14 | 2 |
| ⊗ | CR4-09 | 10 | 247.32 to 246.71 | 17.5 | 18 | 16 | 2 |
| □ | CR4-09 | 13 | 242.74 to 242.13 | 20.2 | 20 | 17 | 3 |
| ◇ | CR4-11 | 34 | 206.10 to 205.49 | 18.8 | 21 | 19 | 2 |
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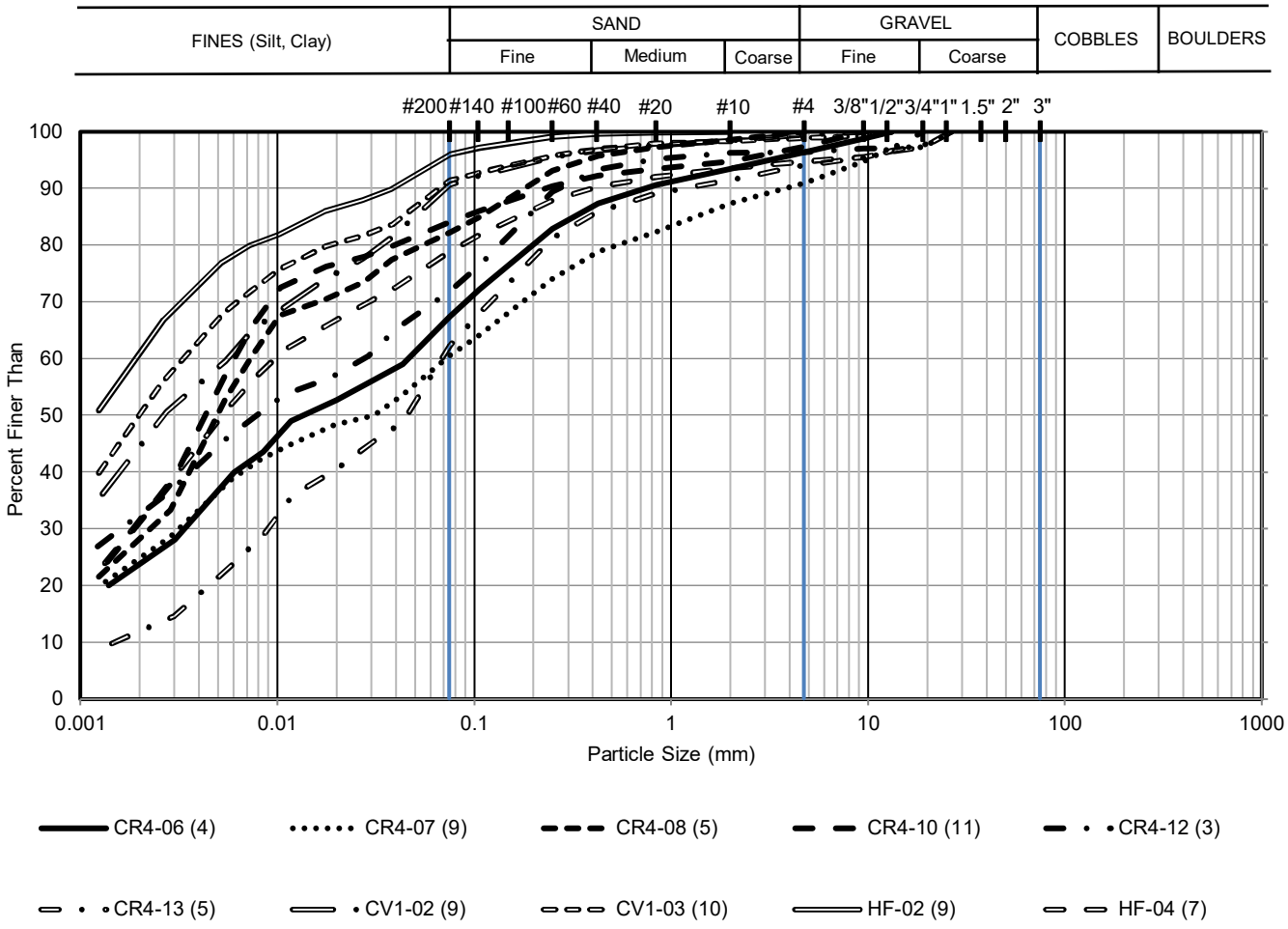
| APPROVED | KJB |

TITLE
SILT (ML) of slight plasticity

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | 11B |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-06 | 4 | 2.3 - 2.9 | 255.9 to 255.3 |
| CR4-07 | 9 | 7.6 - 8.2 | 253.7 to 253.1 |
| CR4-08 | 5 | 3.1 - 3.7 | 250.2 to 249.6 |
| CR4-10 | 11 | 10.7 - 11.3 | 249.3 to 248.7 |
| CR4-12 | 3 | 1.5 - 2.1 | 253.7 to 253.1 |
| CR4-13 | 5 | 3.1 - 3.7 | 249.7 to 249.1 |
| CV1-02 | 9 | 6.9 - 7.5 | 249.4 to 248.8 |
| CV1-03 | 10 | 6.9 - 7.5 | 249.6 to 249.0 |
| HF-02 | 9 | 7.6 - 8.2 | 250.7 to 250.1 |
| HF-04 | 7 | 6.1 - 6.7 | 249.4 to 248.8 |

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| YYYY-MM-DD | 2022-01-20 |
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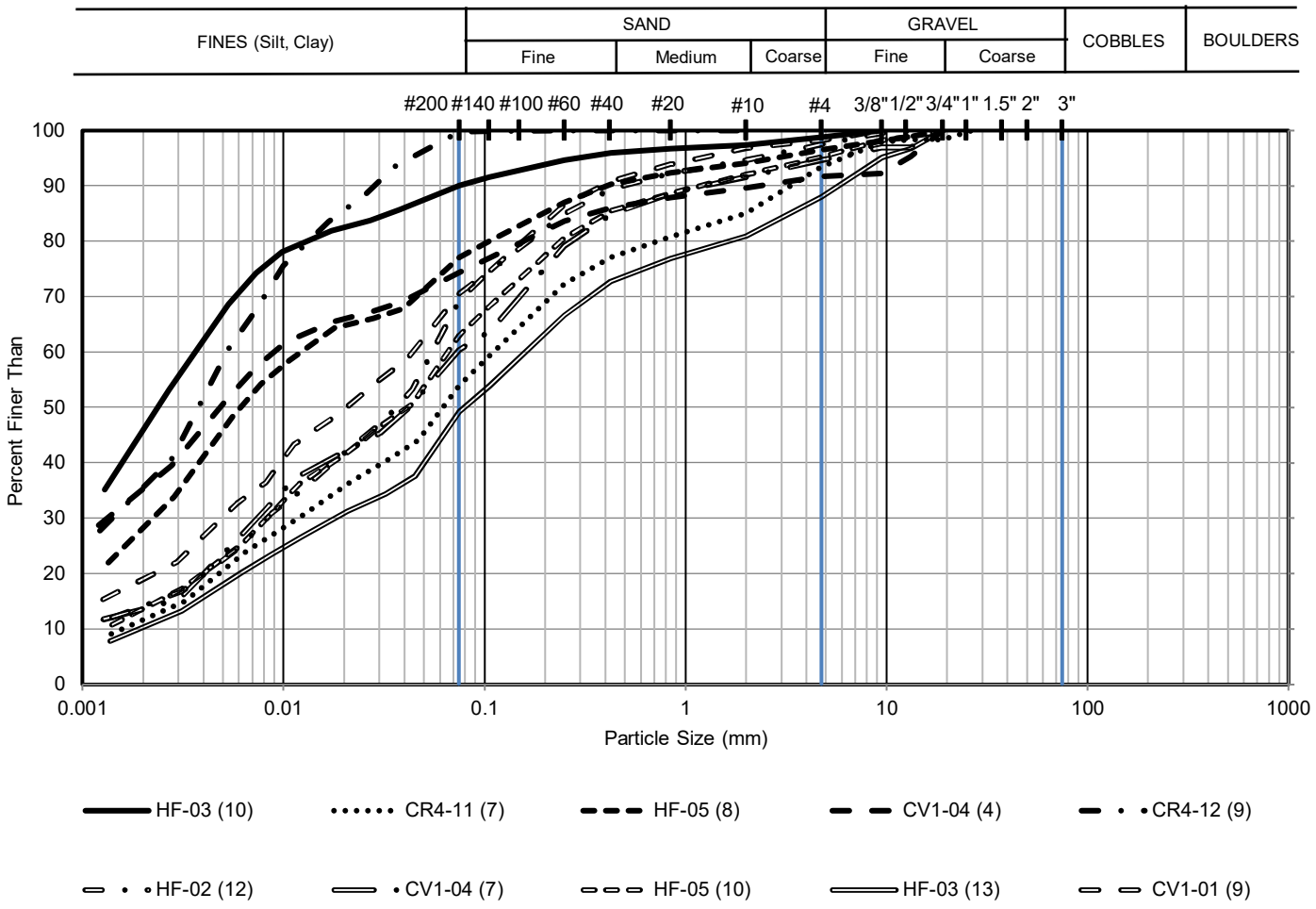
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B12A |

# GRAIN SIZE DISTRIBUTION




| Location ID | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| HF-03 | 10 | 9.1 - 9.8 | 249.3 to 248.7 |
| CR4-11 | 7 | 4.6 - 5.2 | 248.8 to 248.2 |
| HF-05 | 8 | 6.1 - 6.7 | 248.6 to 248.0 |
| CV1-04 | 4 | 2.3 - 2.9 | 248.2 to 247.6 |
| CR4-12 | 9 | 7.6 - 8.2 | 247.6 to 247.0 |
| HF-02 | 12 | 12.2 - 12.8 | 246.1 to 245.5 |
| CV1-04 | 7 | 4.6 - 5.2 | 245.9 to 245.3 |
| HF-05 | 10 | 9.1 - 9.8 | 245.6 to 245.0 |
| HF-03 | 13 | 13.7 - 14.3 | 244.7 to 244.1 |
| CV1-01 | 9 | 7.6 - 8.2 | 244.6 to 244.0 |

CLIENT

MTO / AECOM

PROJECT

Bradford Bypass County Road 4

CONSULTANT

GOLDER
MEMBER OF WSP

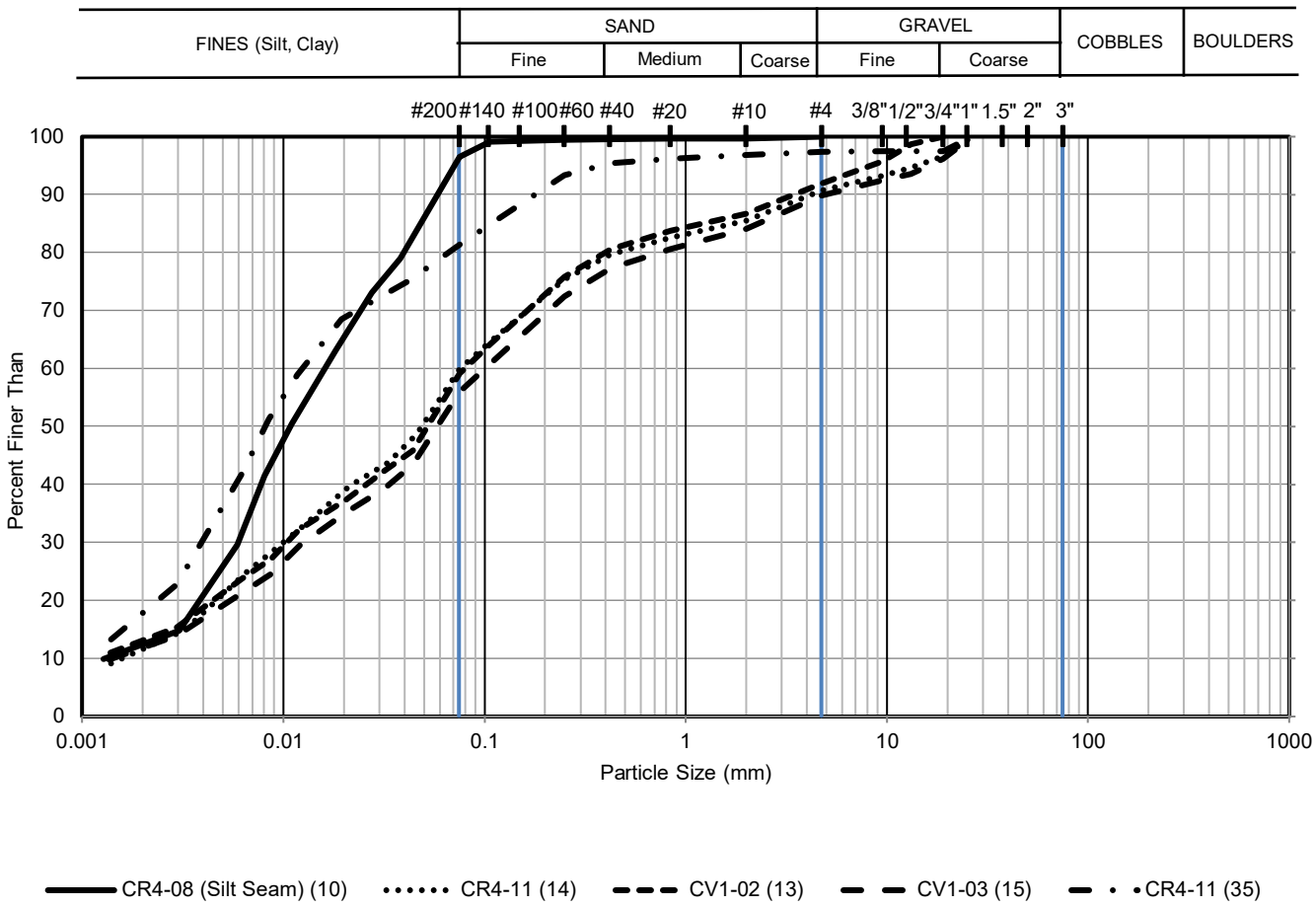
| | |
|---|---|
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B12B |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-08 (Silt Seam) | 10 | 9.1 - 9.8 | 244.1 to 243.5 |
| CR4-11 | 14 | 15.2 - 15.9 | 238.1 to 237.5 |
| CV1-02 | 13 | 12.2 - 12.8 | 244.1 to 243.5 |
| CV1-03 | 15 | 13.7 - 14.3 | 242.8 to 242.2 |
| CR4-11 | 35 | 50.3 - 50.9 | 203.1 to 202.4 |
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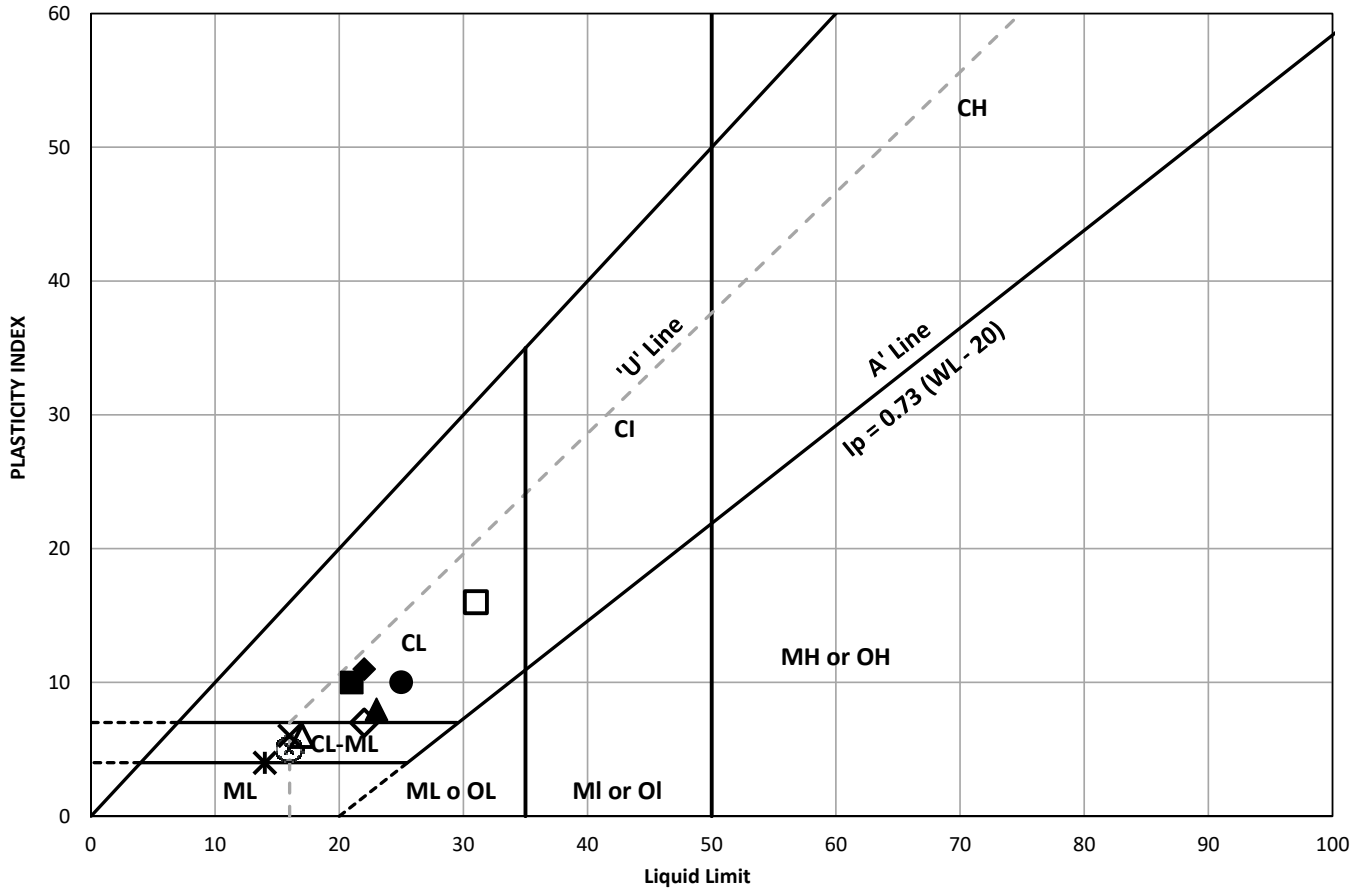
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B12C |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-06 | 4 | 255.91 to 255.30 | 12.9 | 21 | 11 | 10 |
| ◆ | CR4-07 | 9 | 253.67 to 253.06 | 13 | 22 | 11 | 11 |
| ▲ | CR4-08 | 5 | 250.22 to 249.61 | 11.4 | 23 | 15 | 8 |
| ● | CR4-10 | 11 | 249.27 to 248.66 | 16 | 25 | 15 | 10 |
| ✳ | CR4-11 | 7 | 248.77 to 248.16 | 10.8 | 14 | 10 | 4 |
| ⊗ | CR4-11 | 14 | 238.10 to 237.49 | 9.9 | 16 | 11 | 5 |
| □ | CR4-12 | 3 | 253.71 to 253.10 | 18.1 | 31 | 15 | 16 |
| ◇ | CR4-12 | 9 | 247.61 to 247.00 | 22.4 | 22 | 15 | 7 |
| △ | CR4-13 | 5 | 249.70 to 249.09 | 9.1 | 17 | 11 | 6 |
| × | CR4-13 | 9 | 245.13 to 244.52 | 7.3 | 16 | 10 | 6 |

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Bradford Bypass County Road 4

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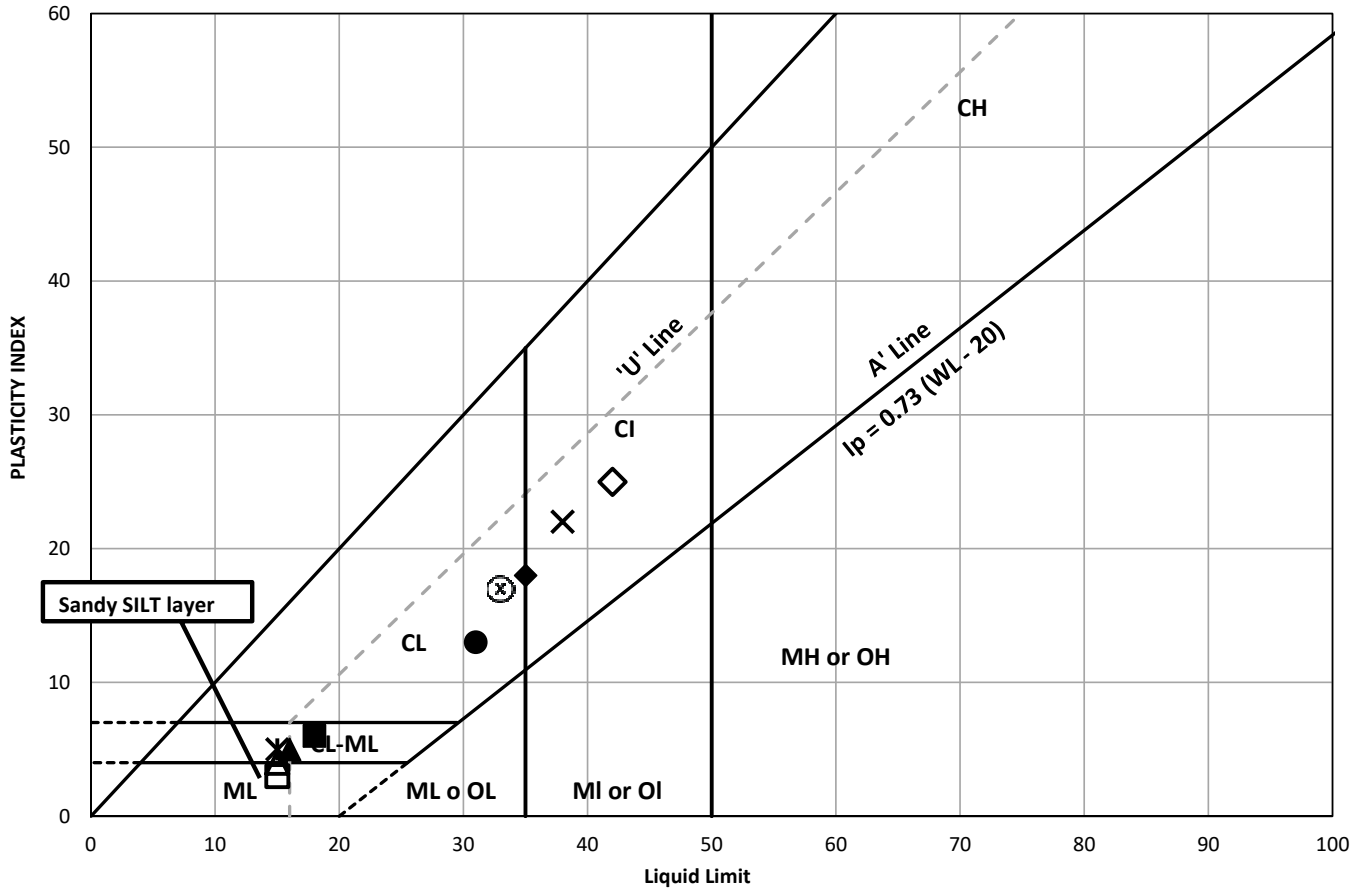
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B13A |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CV1-01 | 9 | 244.57 to 243.96 | 10.5 | 18 | 12 | 6 |
| ◆ | CV1-02 | 9 | 249.42 to 248.81 | 22.9 | 35 | 17 | 18 |
| ▲ | CV1-02 | 13 | 244.09 to 243.48 | 7.1 | 16 | 11 | 5 |
| ● | CV1-03 | 10 | 249.64 to 249.03 | 24 | 31 | 18 | 13 |
| ✳ | CV1-03 | 15 | 242.78 to 242.17 | 8 | 15 | 10 | 5 |
| ⊗ | CV1-04 | 4 | 248.19 to 247.58 | 23.9 | 33 | 16 | 17 |
| □ | CV1-04 (Sandy SILT layer) | 7 | 245.91 to 245.30 | 9.1 | 15 | 12 | 3 |
| ◇ | HF-02 | 9 | 250.68 to 250.07 | 23.7 | 42 | 17 | 25 |
| △ | HF-02 | 12 | 246.11 to 245.50 | 8.2 | 15 | 11 | 4 |
| × | HF-03 | 10 | 249.26 to 248.65 | 18.8 | 38 | 16 | 22 |

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PROJECT: Bradford Bypass County Road 4

CONSULTANT: GOLDER MEMBER OF WSP

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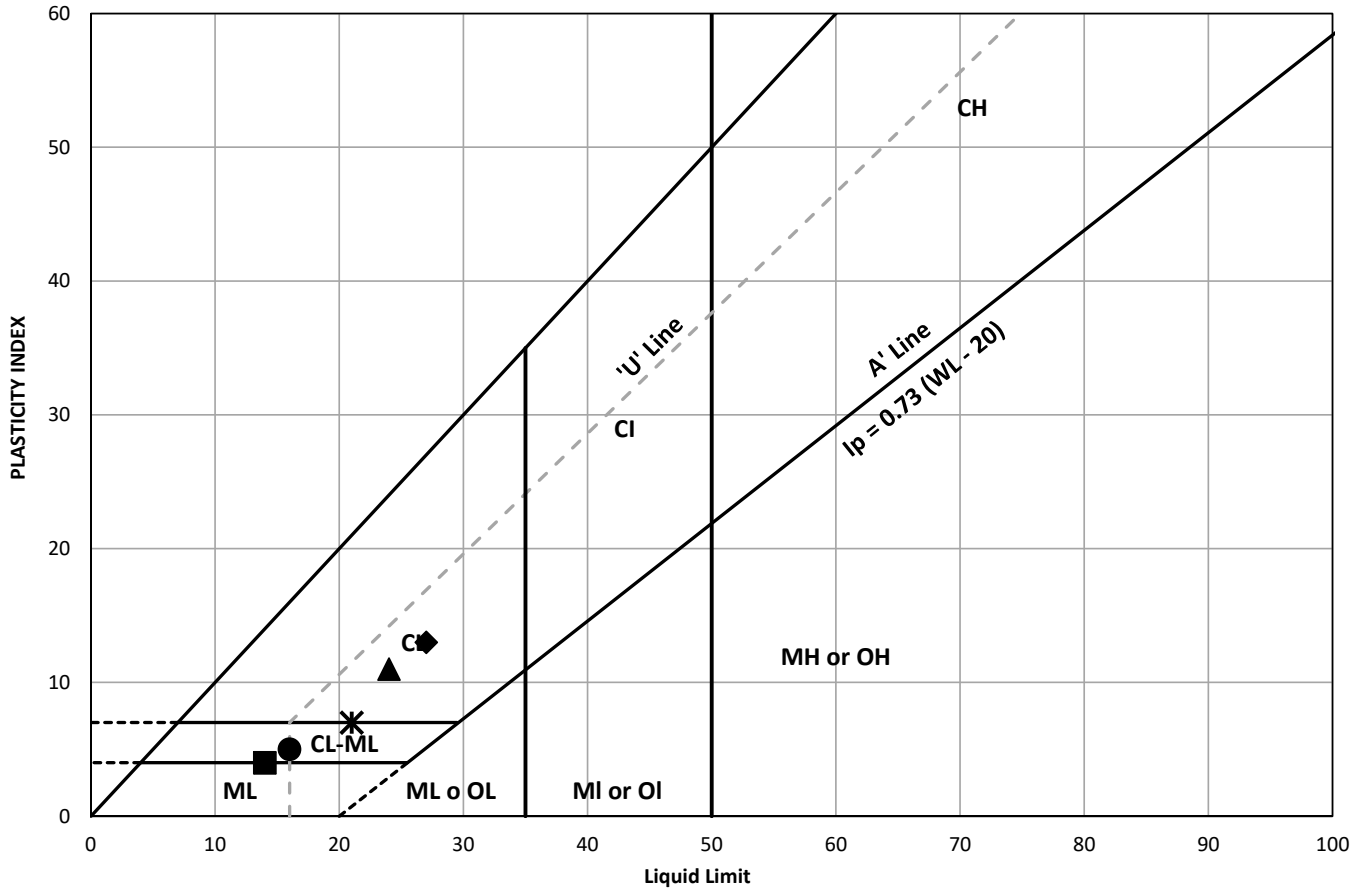
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE: CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B13B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | HF-03 | 13 | 244.68 to 244.07 | 7.6 | 14 | 10 | 4 |
| ◆ | HF-04 | 7 | 249.42 to 248.81 | 16 | 27 | 14 | 13 |
| ▲ | HF-05 | 8 | 248.60 to 247.99 | 14.2 | 24 | 13 | 11 |
| ● | HF-05 | 10 | 245.56 to 244.95 | 8.8 | 16 | 11 | 5 |
| ✳ | CR4-11 | 35 | 203.05 to 202.44 | 12.8 | 21 | 14 | 7 |
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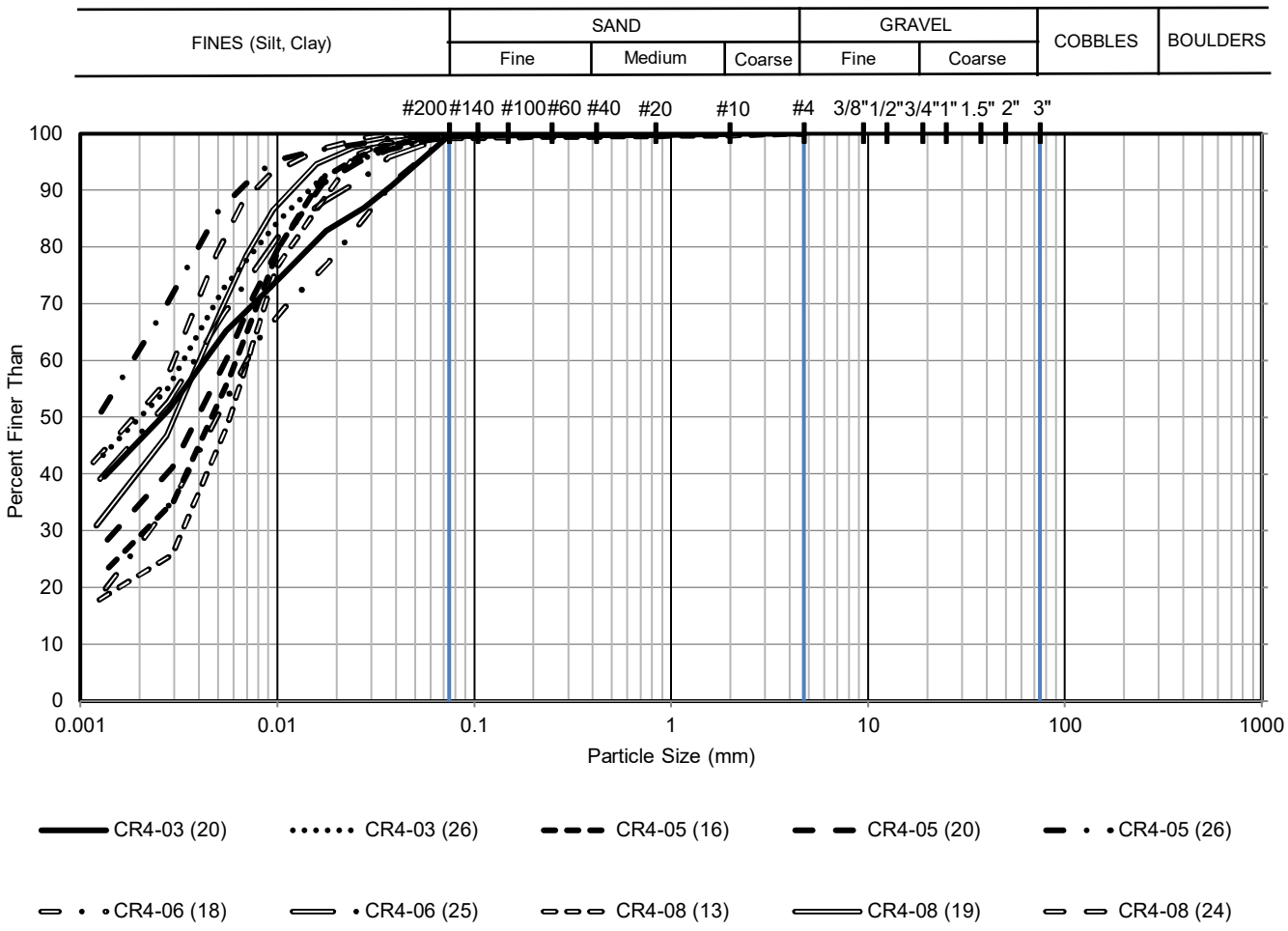
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE
CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - TILL

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B13C |

# GRAIN SIZE DISTRIBUTION




| Sample Location | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-03 | 20 | 30.5 - 31.0 | 230.7 to 230.1 |
| CR4-03 | 26 | 48.8 - 49.4 | 212.4 to 211.8 |
| CR4-05 | 16 | 18.3 - 18.9 | 239.7 to 239.1 |
| CR4-05 | 20 | 30.5 - 31.1 | 227.5 to 226.9 |
| CR4-05 | 26 | 48.8 - 49.4 | 209.2 to 208.6 |
| CR4-06 | 18 | 24.4 - 25.0 | 233.8 to 233.2 |
| CR4-06 | 25 | 45.7 - 46.3 | 212.5 to 211.9 |
| CR4-08 | 13 | 13.7 - 14.3 | 239.6 to 238.9 |
| CR4-08 | 19 | 27.4 - 28.0 | 225.8 to 225.2 |
| CR4-08 | 24 | 42.7 - 43.3 | 210.6 to 210.0 |

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Bradford Bypass County Road 4

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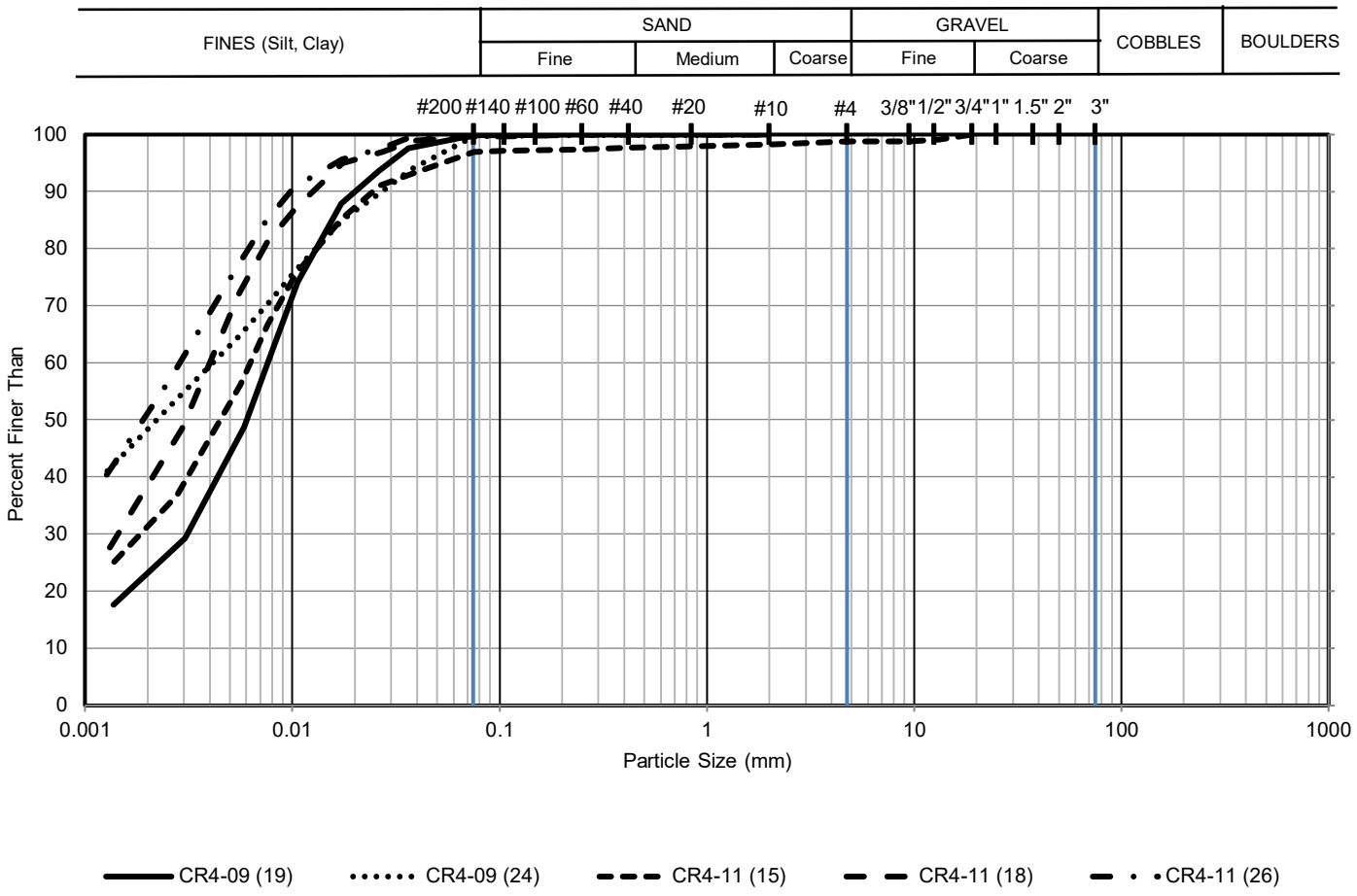
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

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

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B14A |

# GRAIN SIZE DISTRIBUTION




| Location ID | Sample Number | Depth (m) | Elevation (m) |
|---|---|---|---|
| CR4-09 | 19 | 27.4 - 28.0 | 229.0 to 228.4 |
| CR4-09 | 24 | 42.7 - 43.2 | 213.8 to 213.3 |
| CR4-11 | 15 | 16.8 - 17.4 | 236.6 to 236.0 |
| CR4-11 | 18 | 21.3 - 22.0 | 232.0 to 231.4 |
| CR4-11 | 26 | 33.5 - 34.1 | 219.8 to 219.2 |
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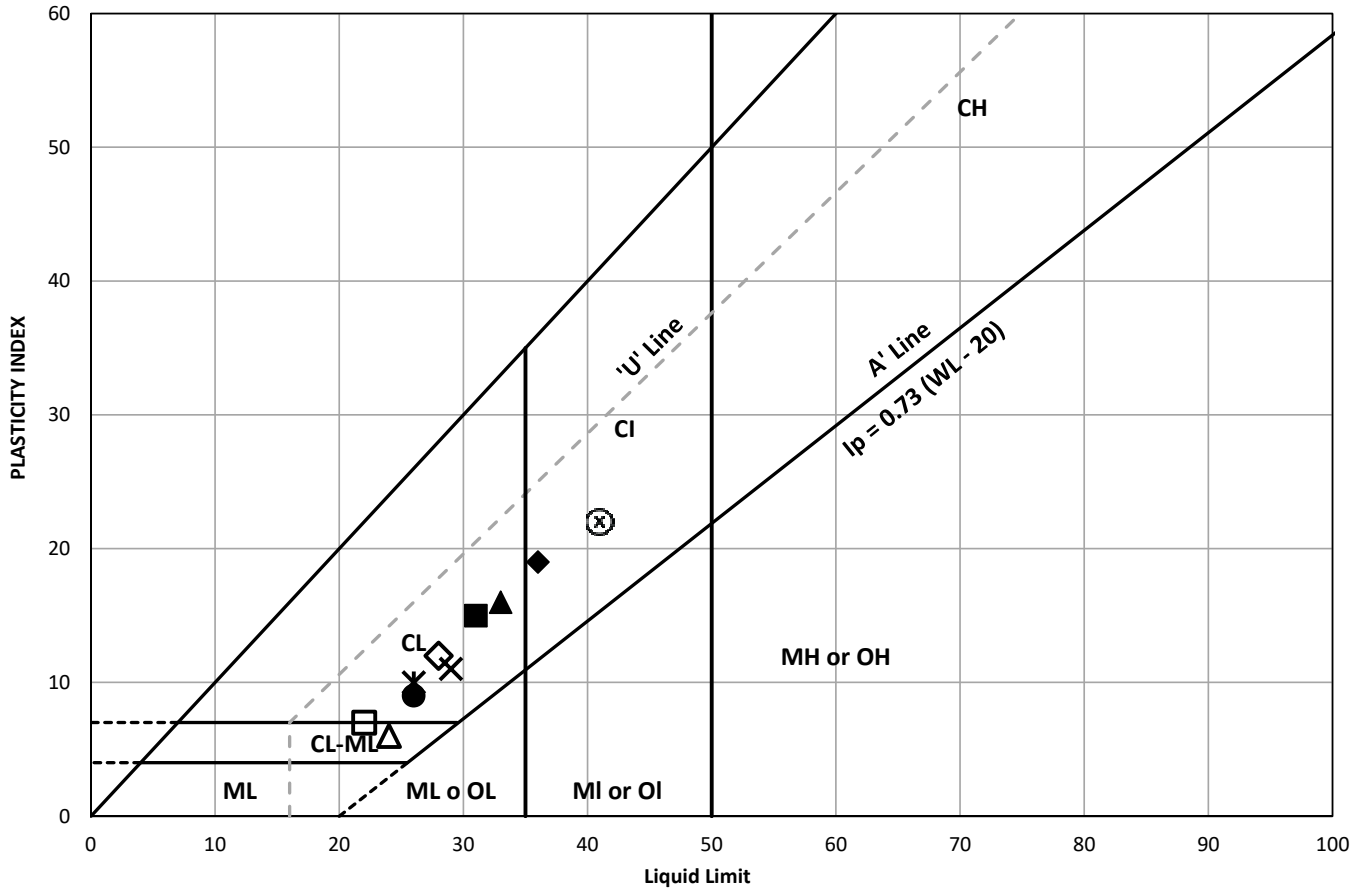
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

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

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B14B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-03 | 20 | 230.70 to 230.14 | 23.3 | 31 | 16 | 15 |
| ◆ | CR4-03 | 23 | 221.56 to 220.95 | 21.5 | 36 | 17 | 19 |
| ▲ | CR4-03 | 26 | 212.41 to 211.83 | 26.7 | 33 | 17 | 16 |
| ● | CR4-05 | 16 | 239.72 to 239.11 | 22.2 | 26 | 17 | 9 |
| ✳ | CR4-05 | 20 | 227.53 to 226.92 | 25.4 | 26 | 16 | 10 |
| ⊗ | CR4-05 | 26 | 209.24 to 208.63 | 27.3 | 41 | 19 | 22 |
| □ | CR4-06 | 18 | 233.82 to 233.21 | 20.9 | 22 | 15 | 7 |
| ◇ | CR4-06 | 25 | 212.48 to 211.87 | 25.3 | 28 | 16 | 12 |
| △ | CR4-08 | 13 | 239.55 to 238.94 | 20.9 | 24 | 18 | 6 |
| × | CR4-08 | 19 | 225.84 to 225.23 | 26.8 | 29 | 18 | 11 |

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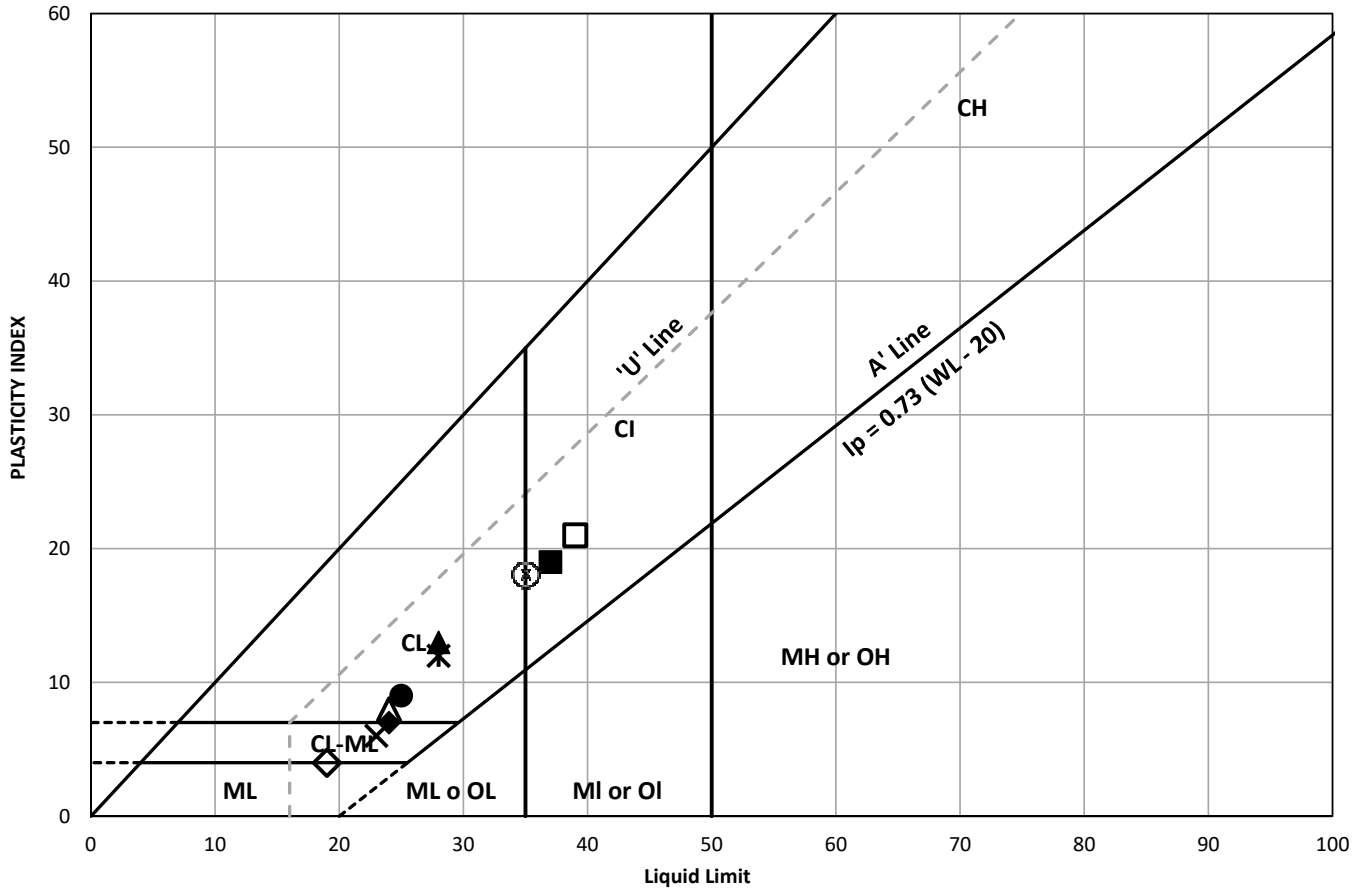
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILT (ML) of slight plasticity to CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - Lower Cohesive

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B15A |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | CR4-08 | 24 | 210.60 to 209.99 | 31 | 37 | 18 | 19 |
| ◆ | CR4-09 | 19 | 229.03 to 228.42 | 24.8 | 24 | 17 | 7 |
| ▲ | CR4-09 | 24 | 213.79 to 213.25 | 24.9 | 28 | 15 | 13 |
| ● | CR4-11 | 15 | 236.58 to 235.97 | 21.1 | 25 | 16 | 9 |
| ✳ | CR4-11 | 18 | 232.00 to 231.39 | 23.7 | 28 | 16 | 12 |
| ⊗ | CR4-11 | 26 | 219.81 to 219.20 | 22.2 | 35 | 17 | 18 |
| □ | CR4-11 | 31 | 212.19 to 211.58 | 25.4 | 39 | 18 | 21 |
| ◇ | CV1-01 | 11 | 241.52 to 240.91 | 15.7 | 19 | 15 | 4 |
| △ | CV1-02 | 16 | 239.52 to 239.24 | 17.2 | 24 | 16 | 8 |
| × | CV1-03 | 17 | 239.74 to 239.46 | 14.8 | 23 | 17 | 6 |

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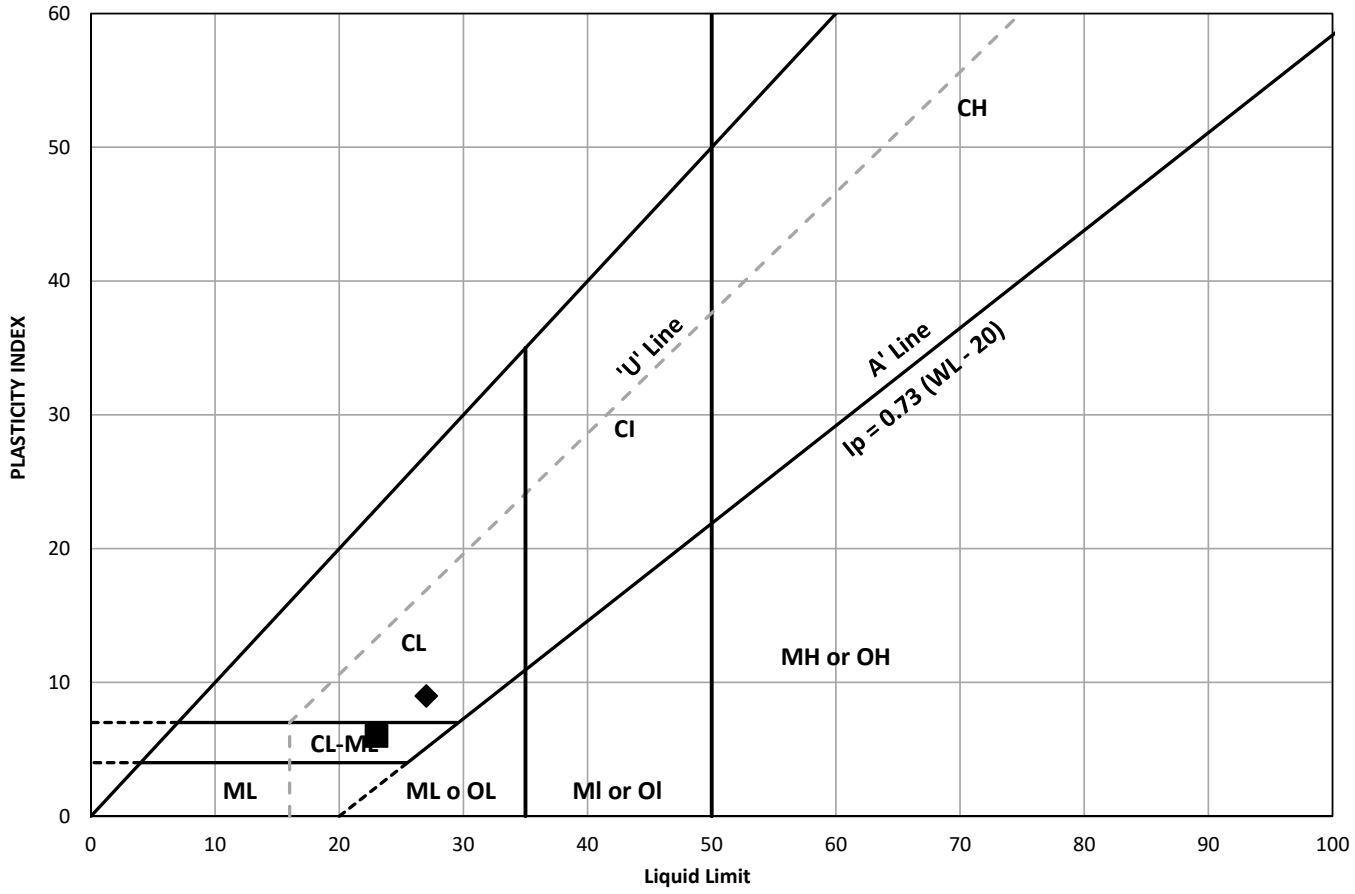
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILT (ML) of slight plasticity to CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - Lower Cohesive

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B15B |

# PLASTICITY CHART




| | Sample Location | Sample / Specimen Number | Elevation (m) | Natural Water Content (%) | Liquid Limit | Plastic Limit | Plasticity Index |
|---|---|---|---|---|---|---|---|
| ■ | HF-04 | 13 | 240.28 to 239.67 | 14.9 | 23 | 17 | 6 |
| ◆ | HF-05 | 13 | 240.98 to 240.53 | 16.9 | 27 | 18 | 9 |
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|---|---|
| YYYY-MM-DD | 2022-01-20 |
| DESIGNED | ACK |
| PREPARED | ACK |
| REVIEWED | ACK |
| APPROVED | KJB |

TITLE

SILT (ML) of slight plasticity to CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL) to SILTY CLAY (CI) - Lower Cohesive

| PROJECT NO. | CONTROL | REV. | FIGURE |
|---|---|---|---|
| 19136074 | 0 | 0 | B15C |

**APPENDIX C**

# Analytical Laboratory Test Report

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 Extracted | Date Analyzed | Laboratory Method | Analytical Method |
|---|---|---|---|---|---|
| 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.

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 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**

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.

BV Labs Job #: C1O9516
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 Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: C1O9516
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 |



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BV Labs Job #: C1O9516
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.**



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BV Labs Job #: C1O9516
Report Date: 2021/09/11

## QUALITY ASSURANCE REPORT

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

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | UNITS | Value (%) | QC Limits |
| 7559086 | Available (CaCl2) 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 (SO4) | 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)



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BV Labs Job #: C1O9516
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.



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BUREAU VERITAS

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 #: | [X] 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) |
| Missisauga, ON | | Site Location: Bradford, ON | [ ] 1 Day [ ] 2 Days [ ] 3-4 Days |
| Phone: 647-239-0174 Fax: | Phone: Fax: | Site #: | |
| Email: akobylinski@golder.com ; canadaaccountspayableinvoices@golder.com | Email: akobylinski@golder.com | Site Location Province: ONTARIO | Date Required: |
| 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 | Rush Confirmation #: |

**Regulation 153**
[ ] Table 1 [ ] Res/Park [ ] Med/ Fine
[ ] Table 2 [ ] Ind/Comm [ ] Coarse
[ ] Table 3 [ ] Agri/ Other
[ ] Table _____
FOR RSC (PLEASE CIRCLE) Y / N

**Other Regulations**
[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] MISA [ ] Storm Sewer Bylaw
[ ] PWQO Region _____
[ ] Other (Specify) _____
[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

**SAMPLES MUST BE KEPT COOL ( < 10 °C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS**

**LABORATORY USE ONLY**

| CUSTODY SEAL Y / N | | COOLER TEMPERATURES |
|---|---|---|
| Present | Intact | |
| N | N | 4/6/6 |
| | | |
| | | |

COOLING MEDIA PRESENT: (Y) / N

| | SAMPLE IDENTIFICATION | DATE SAMPLED (YYYY/MM/DD) | TIME SAMPLED (HH:MM) | MATRIX | # OF CONTAINERS SUBMITTED | FIELD FILTERED (CIRCLE) Metals / Hg / CrVI | BTEX/ PHC F1 | PHCs F2 - F4 | VOCs | REG 153 METALS & INORGANICS | REG 153 ICPMS METALS | REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) | CORROSIVITY PACKAGE | HOLD- DO NOT ANALYZE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CV1-04 SS2 | 2021-08-28 | PM | Soil | 2 | -- | | | | | | | X | | 2 jars. |
| 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 Alysha Kobylinski | 2021/08/31 | 4:00 PM | [signature] | 2021/08/31 | 17:09 |
| | | | | | |

31-Aug-21 17:09
Ema Gitej
C109516

*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 c terms available at http://www.bvlabs.com/terms-and-conditions*

DSG ENV 005

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: 2021/10/07**
Report #: R6844702
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**BV LABS JOB #: C1S2015**
**Received: 2021/09/29, 11:46**

Sample Matrix: Soil
# Samples Received: 1

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Analytical Method |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | 1 | 2021/10/04 | 2021/10/04 | CAM SOP-00463 | SM 23 4500-Cl E m |
| Conductivity | 1 | 2021/10/04 | 2021/10/04 | CAM SOP-00414 | OMOE E3530 v1 m |
| Moisture (Subcontracted) (1, 2) | 1 | N/A | 2021/10/07 | AB SOP-00002 | CCME PHC-CWS m |
| Sulphide in Soil (1) | 1 | N/A | 2021/10/06 | AB SOP-00080 | EPA9030B/SM4500S2-DF |
| pH CaCl2 EXTRACT | 1 | 2021/10/04 | 2021/10/04 | CAM SOP-00413 | EPA 9045 D m |
| Resistivity of Soil | 1 | 2021/09/30 | 2021/10/05 | CAM SOP-00414 | SM 23 2510 m |
| Sulphate (20:1 Extract) | 1 | 2021/10/04 | 2021/10/04 | 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.

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 Kobylinski**

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

**Report Date: 2021/10/07**
Report #: R6844702
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**BV LABS JOB #: C1S2015**
**Received: 2021/09/29, 11:46**

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.
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BV Labs Job #: C1S2015
Report Date: 2021/10/07

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

## SOIL CORROSIVITY PACKAGE (SOIL)

| BV Labs ID | | QUG190 | | | QUG190 | | |
|---|---|---|---|---|---|---|---|
| Sampling Date | | 2021/09/23 | | | 2021/09/23 | | |
| COC Number | | n/a | | | n/a | | |
| | UNITS | CR4-3 SS4 | RDL | QC Batch | CR4-3 SS4 Lab-Dup | RDL | QC Batch |
| **Calculated Parameters** | | | | | | | |
| Resistivity | ohm-cm | 6100 | | 7609931 | | | |
| **Inorganics** | | | | | | | |
| Soluble (20:1) Chloride (Cl-) | ug/g | <20 | 20 | 7615852 | | | |
| Conductivity | umho/cm | 165 | 2 | 7616568 | | | |
| Available (CaCl2) pH | pH | 7.69 | | 7616636 | | | |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 20 | 7615862 | | | |
| Sulphide | mg/kg | 3.2 (1) | 0.5 | 7623256 | | | |
| **Physical Testing** | | | | | | | |
| Moisture-Subcontracted | % | 24 | 0.30 | 7625505 | 23 | 0.30 | 7625505 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
(1) Analyzed past method specified hold time



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BV Labs Job #: C1S2015
Report Date: 2021/10/07

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

## TEST SUMMARY

**BV Labs ID:** QUG190
**Sample ID:** CR4-3 SS4
**Matrix:** Soil

**Collected:** 2021/09/23
**Shipped:**
**Received:** 2021/09/29

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 7615852 | 2021/10/04 | 2021/10/04 | Alina Dobreanu |
| Conductivity | AT | 7616568 | 2021/10/04 | 2021/10/04 | Neil Dassanayake |
| Moisture (Subcontracted) | BAL | 7625505 | N/A | 2021/10/07 | Salini Vidhyadharan |
| Sulphide in Soil | SPEC | 7623256 | N/A | 2021/10/06 | Bailey Morrison |
| pH CaCl2 EXTRACT | AT | 7616636 | 2021/10/04 | 2021/10/04 | Taslima Aktar |
| Resistivity of Soil | | 7609931 | 2021/10/05 | 2021/10/05 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 7615862 | 2021/10/04 | 2021/10/04 | Avneet Kour Sudan |

**BV Labs ID:** QUG190 Dup
**Sample ID:** CR4-3 SS4
**Matrix:** Soil

**Collected:** 2021/09/23
**Shipped:**
**Received:** 2021/09/29

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Moisture (Subcontracted) | BAL | 7625505 | N/A | 2021/10/07 | Salini Vidhyadharan |



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BV Labs Job #: C1S2015
Report Date: 2021/10/07

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

## GENERAL COMMENTS

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

| | |
|---|---|
| Package 1 | 6.0°C |

**Results relate only to the items tested.**



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BV Labs Job #: C1S2015
Report Date: 2021/10/07

## QUALITY ASSURANCE REPORT

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

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | UNITS | Value (%) | QC Limits |
| 7615852 | Soluble (20:1) Chloride (Cl-) | 2021/10/04 | 116 | 70 - 130 | 107 | 70 - 130 | <20 | ug/g | NC | 35 |
| 7615862 | Soluble (20:1) Sulphate (SO4) | 2021/10/04 | 125 | 70 - 130 | 98 | 70 - 130 | <20 | ug/g | NC | 35 |
| 7616568 | Conductivity | 2021/10/04 | | | 100 | 90 - 110 | <2 | umho/cm | 0.36 | 10 |
| 7616636 | Available (CaCl2) pH | 2021/10/04 | | | 100 | 97 - 103 | | | 1.3 | N/A |
| 7623256 | Sulphide | 2021/10/06 | 63 (1) | 75 - 125 | 100 | 75 - 125 | <0.5 | mg/kg | 3.9 | 30 |
| 7625505 | Moisture-Subcontracted | 2021/10/07 | | | | | <0.30 | % | 7.2 | 20 |

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 (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).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.



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BV Labs Job #: C1S2015
Report Date: 2021/10/07

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

## VALIDATION SIGNATURE PAGE

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

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

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

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

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For Service Group specific validation please refer to the Validation Signature Page.



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# WORK ORDER

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



| Invoice Information | Report Information (if differs from invoice) | Project Information (where applicable) | Turnaround Time (TAT) Required |
|---|---|---|---|
| Company Name: Golder Associates Ltd. | Company Name: same | Quotation #: Golder rates | [X] Regular TAT (5-7 days) Most analyses |
| Contact Name: Alysha Kobylinski | Contact Name: | P.O. #/ AFE#: 19136074 | 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 | [ ] 1 Day [ ] 2 Days [ ] 3-4 Days |
| Phone: 647-239-0174 Fax: | Phone: Fax: | Site #: | Date Required: |
| Email: canadaaccountspayableinvoices@golder.com; akobylinski@golder.com | Email: akobylinski@golder.com; 120387@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: | LABORATORY USE ONLY |

**Regulation 153**

[ ] Table 1 [ ] Res/Park [ ] Med/ Fine
[ ] Table 2 [ ] Ind/Comm [ ] Coarse
[ ] Table 3 [ ] Agri/ Other
[ ] Table ____
FOR RSC (PLEASE CIRCLE) Y / N

**Other Regulations**

[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] MISA [ ] Storm Sewer Bylaw
[ ] PWQO Region
[ ] Other (Specify)
[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

CUSTODY SEAL Y / N (Present / Intact) — COOLER TEMPERATURES: 6 1 6 6

COOLING MEDIA PRESENT:

SAMPLES MUST BE KEPT COOL ( < 10 °C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

Analysis Requested

| | SAMPLE IDENTIFICATION | DATE SAMPLED (YYYY/MM/DD) | TIME SAMPLED (HH:MM) | MATRIX | # OF CONTAINERS SUBMITTED | FIELD FILTERED (CIRCLE) Metals / Hg / CrVI | BTEX/ PHC F1 | PHCs F2 - F4 | VOCs | REG 153 METALS & INORGANICS | REG 153 ICPMS METALS | REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) | CORROSIVITY PACKAGE (+ SULPHIDE) | HOLD- DO NOT ANALYZE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CR4-3 SS4 | 2021-09-23 | PM | Soil | 2 | | | | | | | | X | | 2 JARS. NO REDOX POTENTIAL. |
| 2 | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | |
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| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |

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.

| RELINQUISHED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) | RECEIVED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) |
|---|---|---|---|---|---|
| Muhammad Irshad (alha) | 2021-09-29 | 11:45 | | | 11:46 |
| | | | | | |

29-Sep-21 11:46
Ema Gitej
C1S2015
RJM ENV-1078

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: 2021/10/21**
Report #: R6863600
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**BV LABS JOB #: C1T6201**
**Received: 2021/10/12, 18:32**

Sample Matrix: Soil
# Samples Received: 2

| Analyses | Quantity | Date Extracted | Date Analyzed | Laboratory Method | Analytical Method |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | 2 | 2021/10/18 | 2021/10/19 | CAM SOP-00463 | SM 23 4500-Cl E m |
| Conductivity | 2 | 2021/10/18 | 2021/10/18 | CAM SOP-00414 | OMOE E3530 v1 m |
| Moisture (Subcontracted) (1, 2) | 2 | N/A | 2021/10/21 | AB SOP-00002 | CCME PHC-CWS m |
| Sulphide in Soil (1) | 2 | N/A | 2021/10/21 | AB SOP-00080 | EPA9030B/SM4500S2-DF |
| pH CaCl2 EXTRACT | 2 | 2021/10/18 | 2021/10/18 | CAM SOP-00413 | EPA 9045 D m |
| Resistivity of Soil | 2 | 2021/10/13 | 2021/10/18 | CAM SOP-00414 | SM 23 2510 m |
| Sulphate (20:1 Extract) | 2 | 2021/10/18 | 2021/10/19 | 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.

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 Kobylinski**

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

**Report Date: 2021/10/21**
Report #: R6863600
Version: 1 - Final

# CERTIFICATE OF ANALYSIS

**BV LABS JOB #: C1T6201**
**Received: 2021/10/12, 18:32**

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 Job #: C1T6201
Report Date: 2021/10/21

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

## SOIL CORROSIVITY PACKAGE (SOIL)

| Bureau Veritas ID | | QXJ269 | QXJ270 | | |
|---|---|---|---|---|---|
| Sampling Date | | 2021/10/06 | 2021/10/02 | | |
| COC Number | | n/a | n/a | | |
| | UNITS | CR4-09-SS4 | CR4-06-SS4 | RDL | QC Batch |
| **Calculated Parameters** | | | | | |
| Resistivity | ohm-cm | 14000 | 5500 | | 7635285 |
| **Inorganics** | | | | | |
| Soluble (20:1) Chloride (Cl-) | ug/g | <20 | <20 | 20 | 7642526 |
| Conductivity | umho/cm | 72 | 182 | 2 | 7643284 |
| Available (CaCl2) pH | pH | 7.94 | 7.96 | | 7642675 |
| Soluble (20:1) Sulphate (SO4) | ug/g | <20 | 45 | 20 | 7642529 |
| Sulphide | mg/kg | <0.5 (1) | <0.5 (2) | 0.5 | 7652772 |
| **Physical Testing** | | | | | |
| Moisture-Subcontracted | % | 14 | 15 | 0.30 | 7652952 |

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) Analyzed past method specified hold time
(2) Analyzed past method specified hold time
Sample contained greater than 10% headspace at time of extraction.



Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Bureau Veritas Job #: C1T6201
Report Date: 2021/10/21

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

## TEST SUMMARY

**Bureau Veritas ID:** QXJ269
**Sample ID:** CR4-09-SS4
**Matrix:** Soil

**Collected:** 2021/10/06
**Shipped:**
**Received:** 2021/10/12

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 7642526 | 2021/10/18 | 2021/10/19 | Alina Dobreanu |
| Conductivity | AT | 7643284 | 2021/10/18 | 2021/10/18 | Massarat Jan |
| Moisture (Subcontracted) | BAL | 7652952 | N/A | 2021/10/21 | Parveer Singh |
| Sulphide in Soil | SPEC | 7652772 | N/A | 2021/10/21 | Bailey Morrison |
| pH CaCl2 EXTRACT | AT | 7642675 | 2021/10/18 | 2021/10/18 | Taslima Aktar |
| Resistivity of Soil | | 7635285 | 2021/10/18 | 2021/10/18 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 7642529 | 2021/10/18 | 2021/10/19 | Avneet Kour Sudan |

**Bureau Veritas ID:** QXJ270
**Sample ID:** CR4-06-SS4
**Matrix:** Soil

**Collected:** 2021/10/02
**Shipped:**
**Received:** 2021/10/12

| Test Description | Instrumentation | Batch | Extracted | Date Analyzed | Analyst |
|---|---|---|---|---|---|
| Chloride (20:1 extract) | KONE/EC | 7642526 | 2021/10/18 | 2021/10/19 | Alina Dobreanu |
| Conductivity | AT | 7643284 | 2021/10/18 | 2021/10/18 | Massarat Jan |
| Moisture (Subcontracted) | BAL | 7652952 | N/A | 2021/10/21 | Parveer Singh |
| Sulphide in Soil | SPEC | 7652772 | N/A | 2021/10/21 | Bailey Morrison |
| pH CaCl2 EXTRACT | AT | 7642675 | 2021/10/18 | 2021/10/18 | Taslima Aktar |
| Resistivity of Soil | | 7635285 | 2021/10/18 | 2021/10/18 | Automated Statchk |
| Sulphate (20:1 Extract) | KONE/EC | 7642529 | 2021/10/18 | 2021/10/19 | Avneet Kour Sudan |



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Bureau Veritas Job #: C1T6201
Report Date: 2021/10/21

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

## GENERAL COMMENTS

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

| | |
|---|---|
| Package 1 | 1.3°C |

**Results relate only to the items tested.**



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Bureau Veritas Job #: C1T6201
Report Date: 2021/10/21

# QUALITY ASSURANCE REPORT

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

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % Recovery | QC Limits | % Recovery | QC Limits | Value | UNITS | Value (%) | QC Limits |
| 7642526 | Soluble (20:1) Chloride (Cl-) | 2021/10/19 | NC | 70 - 130 | 103 | 70 - 130 | <20 | ug/g | 6.9 | 35 |
| 7642529 | Soluble (20:1) Sulphate (SO4) | 2021/10/19 | NC | 70 - 130 | 99 | 70 - 130 | <20 | ug/g | 5.6 | 35 |
| 7642675 | Available (CaCl2) pH | 2021/10/18 | | | 100 | 97 - 103 | | | 2.8 | N/A |
| 7643284 | Conductivity | 2021/10/18 | | | 101 | 90 - 110 | <2 | umho/cm | 0.12 | 10 |
| 7652772 | Sulphide | 2021/10/21 | 49 (1) | 75 - 125 | 85 | 75 - 125 | <0.5 | mg/kg | NC | 30 |
| 7652952 | Moisture-Subcontracted | 2021/10/21 | | | | | <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).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.



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Bureau Veritas Job #: C1T6201
Report Date: 2021/10/21

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

## VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

Sze Yeung Fock, B.Sc., 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.



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BUREAU VERITAS

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



| Invoice Information | | Report Information (if differs from invoice) | | Project Information (where applicable) | |
|---|---|---|---|---|---|
| Company Name: | Golder Associates Ltd. | Company Name: | same | Quotation #: | Golder rates |
| Contact Name: | Alysha Kobylinski | Contact Name: | | P.O. #/ AFE#: | 19136074 |
| Address: | 6925 Century Ave., Suite 100 Mississauga, ON | Address: | | Project #: | 19136074 |
| Phone: | 647-239-0174 Fax: | Phone: | Fax: | Site Location: | Bradford |
| Email: | canadaaccountspayableinvoices@golder.com; akobylinski@golder.com | Email: | akobylinski@golder.com; 120387@golder.com | Site #: | |
| | | | | Site Location Province: | Ontario |
| | | | | Sampled By: | |

**Turnaround Time (TAT) Required**

[X] Regular TAT (5-7 days) Most analyses

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Rush TAT (Surcharges will be applied)

[ ] 1 Day [ ] 2 Days [ ] 3-4 Days

Date Required:

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

**Regulation 153**

[ ] Table 1 [ ] Res/Park [ ] Med/ Fine
[ ] Table 2 [ ] Ind/Comm [ ] Coarse
[ ] Table 3 [ ] Agri/ Other
[ ] Table ____
FOR RSC (PLEASE CIRCLE) Y / N

**Other Regulations**

[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] MISA [ ] Storm Sewer Bylaw
[ ] PWQO Region
[ ] Other (Specify)
[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

**Analysis Requested**

LABORATORY USE ONLY

CUSTODY SEAL (Y) / N — Present | Intact

COOLER TEMPERATURES: 1 | 2 | 1

COOLING MEDIA PRESENT: (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 (CIRCLE) Metals / Hg / CrVI | BTEX/ PHC F1 | PHCs F2 - F4 | VOCs | REG 153 METALS & INORGANICS | REG 153 ICPMS METALS | REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) | CORROSIVITY PACKAGE (+ SULPHIDE) | HOLD- DO NOT ANALYZE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CR4-09 SS 4 | 2021/10/06 | PM | SOIL | | | | | | | | | X | | 2 JARS. NO REDOX POTENTIAL. |
| 2 | CR4-06 SS 4 | 2021/10/07 | PM | SOIL | | | | | | | | | X | | 2 JARS. NO REDOX POTENTIAL. |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |

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.

| RELINQUISHED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) | RECEIVED BY: (Signature/Print) | DATE: (YYYY/MM/DD) | TIME: (HH:MM) |
|---|---|---|---|---|---|
| Alysha Kobylinski | 2021/10/12 | 6:29 PM | Roj Masani | 2021/10/12 | 18:32 |
| | | | | | |

12-Oct-21 18:32
Ema Gitej
C1T6201

KSF ENV-685

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 Extracted | Date Analyzed | Laboratory Method | Analytical Method |
|---|---|---|---|---|---|
| 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.

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 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**

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 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 Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

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 Lugue |
| Sulphide in Soil | SPEC | 7655839 | N/A | 2021/10/22 | Bailey Morrison |
| pH CaCl2 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 Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

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 Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

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

| | | | Matrix Spike | | SPIKED BLANK | | Method Blank | | RPD | |
|---|---|---|---|---|---|---|---|---|---|---|
| QC Batch | Parameter | Date | % 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 (SO4) | 2021/10/22 | 102 | 70 - 130 | 101 | 70 - 130 | <20 | ug/g | NC | 35 |
| 7653702 | Available (CaCl2) 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 Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

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

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# WORK ORDER

BUREAU VERITAS

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 Ltd. | Company Name: same | Quotation #: Golder rates | [X] Regular TAT (5-7 days) Most analyses |
| Contact Name: Alysha Kobylinski | Contact Name: | P.O. #/ AFE#: 19136074 | PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS |
| Address: 6925 Century Ave., Suite 100 | Address: | Project #: 19136Q74 | Rush TAT (Surcharges will be applied) |
| Mississauga, ON | | Site Location: Bradford | [ ] 1 Day [ ] 2 Days [ ] 3-4 Days |
| Phone: 647-239-0174 Fax: | Phone: Fax: | Site #: | Date Required: |
| Email: canadaaccountspayableinvoices@golder.com; akobylinski@golder.com | Email: akobylinski@golder.com; 120387@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: | LABORATORY USE ONLY |

| Regulation 153 | Other Regulations |
|---|---|
| [ ] Table 1 [ ] Res/Park [ ] Med/ Fine | [ ] CCME [ ] Sanitary Sewer Bylaw |
| [ ] Table 2 [ ] Ind/Comm [ ] Coarse | [ ] MISA [ ] Storm Sewer Bylaw |
| [ ] Table 3 [ ] Agri/ Other | [ ] PWQO Region |
| [ ] Table ____ | [ ] Other (Specify) |
| FOR RSC (PLEASE CIRCLE) Y / N | [ ] REG 558 (MIN. 3 DAY TAT REQUIRED) |

Include Criteria on Certificate of Analysis: Y / N

CUSTODY SEAL Y (N) — Present — Intact — COOLER TEMPERATURES

N N 11/14/13

COOLING MEDIA PRESENT: (Y) / N

SAMPLES MUST BE KEPT COOL ( < 10 °C ) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS

Analysis Requested

| | SAMPLE IDENTIFICATION | DATE SAMPLED (YYYY/MM/DD) | TIME SAMPLED (HH:MM) | MATRIX | # OF CONTAINERS SUBMITTED | FIELD FILTERED (CIRCLE) Metals / Hg / CrVI | BTEX/ PHC F1 | PHCs F2 - F4 | VOCs | REG 153 METALS & INORGANICS | REG 153 ICPMS METALS | REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) | CORROSIVITY PACKAGE (+ SULPHIDE) | HOLD- DO NOT ANALYZE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CV1-01 SS #01 | 2021-10-14 | PM | Soil | 2 | | | | | | | | X | | 2 JARS. NO REDOX POTENTIAL. |
| 2 | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | |
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| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |

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.

| 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 |
| Talha | | | | | |

19-Oct-21 17:12
Ema Gitej
C1U4508

*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 acknc*
*at http://www.bvlabs.com/terms-and-conditions*

**APPENDIX D**

# Non-Standard Special Provisions

**DRILLED SHAFTS (CAISSON PILES) - Item No.**
**SUPPLY EQUIPMENT FOR INSTALLING DRILLED SHAFTS - Item No.**
**DRILLED SHAFTS –1200mm DIAMETER - Item No.**
**SHAFT INSPECTION - Item No.**
**CROSS-HOLE SONIC LOGGING (CSL) TESTING - Item No.**

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Non-Standard Special Provision

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## 1.0 SCOPE

This specification covers the requirements for the supply and installation of cast-in-place concrete drilled shaft (caisson pile) deep foundation units for the County Road 4 bridge (30X-0866/B0).

### 1.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

## 2.0 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

This specification refers to the following specifications, standards, or publications:

**Ontario Provincial Standard Specifications, Construction**

| | |
|---|---|
| OPSS.PROV 904 | Concrete Structures |
| OPSS.PROV 905 | Steel Reinforcement for Concrete |
| OPSS.PROV 909 | Prestressed Concrete - Precast members |
| OPSS.PROV 911 | Coating Structural Steel Systems |

**Ontario Provincial Standard Specifications, Material**

| | |
|---|---|
| OPSS.PROV 1350 | Concrete - Materials and Production |
| OPSS.PROV 1440 | Steel Reinforcement for Concrete |

**CSA Standards**

| | |
|---|---|
| G40.20-04/G40.21-04 (R2009) | General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel |

| | |
|---|---|
| W47.1-03 (R2008) | Certification of Companies for Fusion Welding of Steel |
| W48-06 | Filler Materials and Allied Materials for Shielded Metal Arc Welding |
| W59-03(R2008) | Welded Steel Construction (Metal Arc Welding) |
| W178.1-08 | Certification of Welding Inspection Organizations |
| W178.2-08 | Certification of Welding Inspectors |

**Canadian General Standards Board (CGSB)**

| | |
|---|---|
| 48.9712-2006 | Non-destructive Testing, Qualification and Certification of Personnel |

**ASTM International**

| | |
|---|---|
| A 252-98(2007) | Welded and Seamless Steel Pipe Piles |
| A 328/A 328M-07 | Steel Sheet Piling |

**American Petroleum Institute (API)**

| | |
|---|---|
| API 13A | Drilling Fluid Materials, 19th Edition, 10.00.08 |
| RP 13B-1 | Standard Procedure for Field Testing Water Based Drilling Fluids, 5th Edition, |

**Steel Structures Painting Council (SSPC)**

SP10/NACE No.2-Jan. 1, 2001 Near-White Blast Cleaning

**International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)**

| | |
|---|---|
| 17025 | General Requirements for the Competence of the Testing and Calibration Laboratories |

## 3.0 DEFINITIONS

For the purpose of this specification, the following definitions apply:

**Casing** means open ended enclosing cylindrical steel tubing or pipe permanently installed in the ground. Casings are structurally required and can be used to stabilize an excavated hole.

**Crosshole Sonic Logging (CSL)** is a non-destructive testing method to measure the structural integrity of drilled shafts and other concrete piles by means of measuring energy and waveform generated by a signal emitter. The method is used to determine the structural soundness of concrete within the steel reinforcement cage, facilitated by the installation of hollow tubes bundled to the interior of the rebar cage.

**Deep Foundation Unit** means a structural member, driven or otherwise, installed in the ground to transfer the loads from a structure to soil or rock and derives supporting resistance from the surrounding soil or rock or from the soil or rock strata below its tip or a combination of both.

**Drilled Shaft or Caisson Pile** means a cast in place deep foundation unit with or without an enclosing liner formed by placing concrete in a bored or excavated hole.

**Drilled Shaft or Caisson Pile Cap** means a footing or some other structural component used to transfer the load to the caisson piles as well as maintaining them in position.

**Liner** means open ended enclosing steel tubing or pipe temporarily installed to facilitate the construction of drilled shafts or caisson piles.

**Obstruction** means a material and/or objects that cannot be removed from a shaft during normal excavation operations with the drilling equipment adequate to excavate earth materials found on the project, and which necessitate the use of other method and/or equipment to remove. Such obstructions may be rock fragments, boulders, waterlogged timbers, or any material, natural or man-made which requires use of special tools or procedures not otherwise required for excavation of rock or earth materials on the project.

**Pile Integrity Test (PIT) or Low Strain Impact Integrity Test** is a non-destructive testing method to measure the structural integrity of drilled shafts and other concrete piles by means of transient dynamic response. It is a simple and rapid test method to determine the uniformity of concrete within the drilled shaft but is less accurate than other types of testing for drilled shafts.

**Pumped Concrete** means a method of transporting concrete through hose or pipe by means of positive and continuous pressure.

**Slurry** means a drilling fluid, consisting of water or water mixed with one or more of various solids or polymers, used to maintain the stability of the side walls and bottom of an excavation.

**Tremie** means a hopper with a vertical pipe used for placing concrete under water. The foot of the pipe is always submerged in concrete except during commencement of concreting and the upper level of the concrete in the pipe is always above water level.

## 4.0 SUBSURFACE CONDITIONS

The subsurface conditions are described elsewhere in the contract.

1. The installation method and equipment must be capable of dislodging, removing or otherwise penetrating pockets of gravel, cobbles and boulders in the native soils as per Contract Documents.

2. Drilled shafts excavation will extend through water-bearing non-cohesive sand and silt deposits, firm to hard cohesive soils, and till materials containing pockets of gravel, cobbles and boulders. Equipment supplied to advance the drilled shafts must be able to penetrate these materials to advance each drilled shaft to the design tip elevation.

3. Drilled shafts will extend through firm to hard cohesive soils. Equipment supplied must be able to support the excavation walls in the cohesive overburden soils.

4. Drilled shafts will extend through non-cohesive overburden soils below the groundwater level. The selected installation methods and equipment must be able to support the excavation walls and base in the non-cohesive overburden soils and prevent materials from collapsing and/or heaving.

## 5.0 DESIGN AND SUBMISSION REQUIREMENTS

### 5.01 Design Requirements

#### 5.01.01 Concrete

The Contractor is responsible for providing concrete with suitable characteristics for installation. The concrete shall be flow able, non-segregating concrete that does not exhibit rapid slump loss. The concrete mix shall satisfy the requirements specified herein.

### 5.02 Submission Requirements

#### 5.02.01 General

All submissions shall bear the seal and signature of an Engineer experienced in the field of deep foundations. All submissions shall be submitted to the Contract Administrator as specified in the Contract Documents. In lieu of any specified timeline in the Contract Documents, all submissions shall be submitted 30 days prior to construction.

When welded field splices are used, welding procedures according to the Canadian Welding Bureau shall be submitted to the Contract Administrator.

##### 5.02.01.01 Casing

If the use of casing is applicable to the project, the Contractor is responsible for providing casing of sufficient size and strength to facilitate the excavation whilst maintaining sidewall stability.

#### 5.02.02 Preconstruction Survey

If required by the Contract Documents, a condition survey of property and structures that may be affected by the work shall be submitted to the Contract Administrator prior to commencing the work. The survey shall be conducted in accordance with the Contract Documents as specified and include the locations and conditions of adjacent properties; buildings; underground structures; above ground and underground utilities; and structures, such as existing culverts.

#### 5.02.03 Materials

##### 5.02.03.01 Mill Certificates

One copy of the mill certificates, indicating that the steel meets the requirements for the appropriate standards for casings shall be submitted to the Contract Administrator at the time of delivery.

Where mill test certificates originate from a mill outside Canada or the United States of America, the information on the mill certificates shall be verified by testing by a Canadian laboratory. The laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date (i.e., yyyy-mm-dd), and the signature of an authorized officer of the Canadian testing laboratory.

**5.02.03.02 Concrete**

Submissions of concrete mix shall follow OPSS.PROV 1350 requirement.

**5.02.04 Installation**

**5.02.04.01 Drilled Shaft Pre-Construction**

The drilled shaft pre-construction submittal shall be comprised of the following four components:

a) construction experience
b) shaft installation work plan
c) shaft slurry technical assistance (if applicable) and
d) non-destructive QC testing personnel.

**5.02.04.01.01 Construction Experience**

The Contractor's experience and qualifications in the construction of drilled shaft shall include at least three separate drilled shaft projects with:

- Ground conditions similar to those as specified in the Contract Documents.
- Drilled shaft diameters and depths similar or larger to those as specified in the Contract Documents.

The on-site drilled shaft supervisors shall have a minimum 10 years experience in supervising construction of drilled shafts of similar size (diameter and depth), scope and subsurface conditions to those as specified in the Contract Documents. Work experience shall be direct supervisory responsibility for the on-site drilled shaft construction operations. Project management level positions indirectly supervising on-site shaft construction operations are not acceptable for this experience requirement.

The drill rig operators shall have a minimum of five years experience in construction of drilled shaft foundations.

A Request to Proceed with the work of drilled shaft pre-construction shall be submitted to the Contract Administrator with:

- A project reference list for the Contractor's experience and qualifications, and
- Individual's experience lists for the on-site supervisors and drill rig operators assigned to the work.

The project reference list shall contain a description of each listed project with the name and current phone number of the projects' owner(s) or the owner's Contractor(s).

The individual's experience lists shall be limited to a single page for each supervisor or operator and contain a description of the on-site experience in drilled shaft excavation operations and placement of assembled steel reinforcing bar cages and concrete in shafts.

The drilled shaft installation shall not proceed until a Notice of Proceed has been received from the Contract Administrator.

**5.02.04.01.02 Drilled Shaft Installation Work Plan**

The Contractor shall submit a drilled shaft installation Work Plan to the Contract Administrator at least 4

weeks prior to the start of drilled shaft installation. In preparing the Work Plan, the Contractor shall reference the available subsurface information presented elsewhere in the contract. This Work Plan shall provide at least the following information:

a) Proposed overall construction operation schedule and sequence.

b) Means of access to the drilling site and details of concrete delivery to site. Description, size, and capacities of proposed equipment, including but not limited to, cranes, drills, auger, coring equipment to get through obstructions or hard rock, bailing buckets, final cleaning equipment, and drilling unit. The Work Plan shall describe why the equipment was selected and describe equipment suitability to the anticipated site conditions and work methods. The Work Plan shall include a project history of the drilling equipment demonstrating the successful use of the equipment on shafts of equal or greater size in similar soil/rock conditions. The Work Plan shall also include details of shaft excavation and cleanout methods.

c) Details of the method(s) to be used to ensure shaft stability (i.e., prevention of caving, bottom heave, using temporary casing, slurry, or other means) during excavation (including pauses and stoppages during excavation) and concrete placement, placement of temporary and permanent casings and removal of temporary casings. If casings are required, casing dimensions and detailed procedures for installation shall be provided.

d) Details of casings to be used, including calculations showing that the casing can withstand stresses due to installation without undue deformation. Details shall include methods for casing handling, splicing, straightening and out-of-round correction.

e) A slurry mix design, including all additives and their specific purpose in the slurry mix, with a discussion of its suitability to the anticipated subsurface conditions, shall be submitted and include the procedures for mixing, using, and maintaining the slurry.

f) A detailed plan for quality control of the selected slurry, including tests to be performed, test methods to be used, and minimum and/or maximum property requirements which must be met to ensure the slurry functions as intended, considering the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and this project special provision shall be included. As a minimum, the slurry quality control plan shall include the tests specified in Sections 6.07.01, 6.07.02 and 6.07.03.

g) Description of an emergency construction joint method.

h) Methods for dewatering of the site as necessary.

i) Description of the method used to fill or eliminate all voids below the top of shaft between the plan shaft diameter and excavated shaft diameter when permanent casing is specified.

j) The proposed concrete mix to be used.

k) Details of concrete placement, including proposed operational procedures for pumping methods, and a sample uniform yield form to be used by the Contractor for plotting the approximate volume of concrete placed versus the depth of shaft for all shaft concrete placement (except concrete placement in the dry).

l) Methods to prevent and handle delays in concrete batching and delivery to site.

m) When shafts are constructed in water, the submittal shall include seal thickness calculations, seal placement procedure, and descriptions of provisions for casing, shoring, and dewatering.

n) Description and details of the containment, storage and disposal plan for excavated material and drilling slurry (if applicable).

o) A contingency plan for containment and clean-up of any spill or discharge of material which might contaminate public waters. The plan shall address the plan for regular day-to-day operations and for unplanned emergency situations.

p) Reinforcing steel shop drawings with details of reinforcement placement, including bracing, centering, and lifting methods, and the method to ensure the reinforcing cage position is maintained during construction, including use of bar boots and/or rebar cage base plates, and including placement of rock backfill below the bottom of shaft elevation.

q) Contingency plan to remedy sinking of the reinforcing cage into concrete.

The reinforcing steel shop drawings and shaft installation plan shall include, at a minimum:

a) Procedure and sequence of steel reinforcing bar cage assembly.
b) The tie pattern, tie types, and tie wire gages for all ties on permanent reinforcing and temporary bracing.
c) Number and location of primary handling steel reinforcing bars used during lifting operations.
d) Type and location of all steel reinforcing bar splices.
e) Details and orientation of all internal cross-bracing, including a description of connections to the steel reinforcing bar cage.
f) Description of how temporary bracing is to be removed.
g) Location of support points during transportation.
h) Cage weight and location of the center of gravity.
i) Number and location of pick points used for lifting for installation and for transport (if assembled off-site).
j) Crane charts and a description and/or catalog cuts for all spreaders, blocks, sheaves, and chockers used to equalize or control lifting loads.
k) The sequence and minimum inclination angle at which intermediate belly rigging lines (if used) are released.
l) Pick point loads at 0, 45, 60, and 90 degrees and at all intermediate stages of inclination where rigging lines are engaged or slackened.
m) Methods and temporary supports required for cage splicing.
n) For picks involving multiple cranes, the relative locations of the boom tips at various stages of lifting, along with corresponding net horizontal forces imposed on each crane.
o) A description of spacers and supports to be used for the reinforcement.

The Contract Administrator will evaluate the shaft installation Work Plan for conformance with the Drawings, Specifications, and project special provisions, within the review time specified. If deemed necessary by the Contract Administrator, a Shaft Installation Work Plan Submittal Meeting will be scheduled by the Contract Administrator.

**5.02.04.01.03 Slurry Methodology**

If slurry other than water slurry is used to construct the shafts, the Contractor shall provide or arrange for technical assistance in the use of the slurry. The Contractor shall submit the following to the Contract Administrator:

a) The name and current phone number of the slurry manufacturer's technical representative assigned to the project, and the frequency of scheduled visits to the project site by the slurry manufacturer's representative.

b) The name(s) of the Contractor's personnel assigned to the project and trained by the slurry manufacturer in the proper use of the slurry. The submittal shall include a signed training letter from the slurry manufacturer for each trained Contractor's employee listed, including the date of the training.

The following shall be submitted:

a) The type, source, and physical and chemical properties of the bentonite (mineral) or polymer (synthetic) slurry.

b) The source of water.

c) Method of mixing slurry.

d) The water solids ratio and the mass and volumes of the constituent parts, including any chemical admixtures or physical treatment employed to produce slurry with the required physical properties.

e) Details of procedure to be used for monitoring the quality of the slurry.

f) A test report showing the properties of the slurry and certifying that the slurry meets the requirements of API RP 13B-1.

g) Method of disposal of the slurry.

### 5.02.04.01.04 Cage Lift

The Contractor is responsible for providing proper lift procedure for rebar cage. Contractor shall submit a proposed procedure the Contract Administrator at least 4 weeks prior to the start of drilled shaft installation.

## 5.03 Drilled Shaft Pre-Construction Meeting

A shaft preconstruction meeting shall be held at least 14 working days prior to the Contractor beginning any shaft construction work at the site to discuss construction procedures, personnel, and equipment to be used, and other elements of the approved shaft installation narrative. As a minimum the following shall represent the Contractor at the meeting:

a) Project Manager
b) Project Engineer
c) Project Superintendent
d) On site supervisors, and all foremen in charge of excavating the shaft, placing the casing and slurry as applicable, placing the steel reinforcing bars and placing the concrete.
e) If slurry is used to construct the shafts, the slurry manufacturer's representative or approved Contractor's employees trained in the use of the slurry shall also attend.

## 5.04 Acceptance of Submissions

The Contract Administrator will review the Submissions for the purpose of verifying compliance to contract requirements, within 7 calendar days after the Pre-Construction Meeting and provide written comments if changes are necessary to meet Contract requirements. The Contractor shall submit to the Contract Administrator a final installation plan which meets all Contract requirements within 7 calendar days.

If revisions in the previously reviewed Work Plans are required to accommodate site conditions, or for other reasons, the Contractor shall submit the revised Work Plans to the Contract Administrator prior to

implementation. The proposed final shaft installation work plan shall be submitted to the Contract Administrator with a Request to Proceed. The Contractor shall not proceed with the shaft installation work plan until a Notice to Proceed is given by the Contract Administrator.

The Contract Administrator's approval of the installation plan does not relieve the Contractor of full responsibility for the safe and successful completion of construction of the drilled shafts.

## 6.0 MATERIALS

### 6.01 Casing or Liner for Drilled Shafts

#### 6.01.01 General

Casings shall be according to ASTM A36, ASTM A 252, Grade 2 or 3, ASTM A572, or ASTM A588.

Casings shall be continuous wherever possible or practical. Casings shall be installed as per the Contract requirements. Casing shall be installed to stabilize the shaft excavation against collapse.

If welded, casing shall be welded by the electric arc method according to CSA W59.

The casing wall thickness specified is the minimum that shall be supplied.

Steel casings and liners shall conform to a straightness tolerance of 1.5 mm maximum per meter of length.

The casings must be of ample strength to withstand handling stresses, driving (installation) stresses, internal pressure of fluid concrete, external pressure of surrounding earth and water, and be watertight.

Where drilled shafts are located in open water areas, casings shall be extended with due consideration of risk from fluctuating water levels and flood events to the specified bottom of casing elevation to protect the shaft concrete from water action during placement and curing of concrete unless otherwise specified in the contract documents.

#### 6.01.02 Permanent Casing

For permanent casing, the outside surface of the casing shall be smooth to not over cut soil during casing advancement (i.e., driving shoe should not be installed on the outside).

Casings shall be non-corrugated, smooth, clean, and watertight and free of hardened concrete. Casings shall be protected from corrosion during construction.

Inspection of welds will be of a visual nature on 30% of the welds. If the sample welds do not pass the visual inspection and need to be repaired, the visual inspection by the Contract Administrator may be increased up to 100% of the welds.

If evidence indicating poor welding is found, radiographic or ultrasonic testing shall be carried out by the Contract Administrator using procedures according to CSA W59 on 10% of the welds.

All welds that have been repaired shall be visually inspected and shall undergo non-destructive testing performed by the Contract Administrator.

### 6.01.03 Temporary Casing or Liner

Temporary casing or liner is defined as casing installed to facilitate shaft construction only, which is not designed as part of the shaft structure, and which shall be completely removed after shaft construction is complete unless otherwise shown on the Contract Drawings. All temporary casing shall be of ample strength to resist damage and deformation from transportation and handling, installation and extraction stresses, and all pressures and forces acting on the casing. The casing shall be capable of being removed without deforming and causing damage to the completed shaft and without disturbing the surrounding soil.

## 6.02 Steel Reinforcement

Steel reinforcement shall be according to OPSS.PROV 1440 unless otherwise specified in the project specifications or drawings.

## 6.03 Concrete

### 6.03.01 General

Concrete shall be according to OPSS.PROV 1350 and CSA A23.1-19. Concrete shall also comply with the additional requirements specified in Tables 1.1.1 and 1.1.2 below:

**Table 1.1.1**
**Concrete for Tremie Placement Method (Wet Excavation)**

| Property | Test | Test Procedure | Specified Value |
|---|---|---|---|
| Workability | Slump | CSA A23.1-19C | 190+/-40 mm<br>Stability of concrete shall be assessed, as mixes with such high slump would be prone to segregation and bleeding |
| Workability Retention | - | - | Minimum of slump flow of 350 mm at the end of concrete placement (including removal of temporary casing, if necessity) |
| Maximum Coarse Aggregate Size | - | - | 19 mm or not more than one quarter of the reinforcement clear spacing, whichever is smaller |
| Maximum Water/Cement Ratio | - | - | 0.40 |

**Table 1.1.2.**
**Concrete for Free Fall Placement Method (Dry Excavation)**

| Property | Test | Test Procedure | Specified Value |
|---|---|---|---|
| Workability | Slump | CSA A23.2-C | 150 to 190 mm |
| Workability Retention | - | - | Minimum slump of 130 mm at the end of temporary casing removal (if applicable) |
| Maximum Water/Cement Ratio | - | - | 0.45 |

### 6.03.02 Concrete Making Materials:

Concrete making materials shall be according to Section 1350.05 of OPSS.PROV 1350, CSA A3000 and CSA A23.1-19.

### 6.04 Reinforcing bar Spacers and Support Devices

Rebar spacers, centralizers and other support devices shall be according to OPSS.PROV 905.

### 6.05 Crosshole Sonic Logging (CSL) Access Tubes and Caps

Crosshole Sonic Logging (CSL) access tubes shall be round steel pipe with a minimum inside diameter of 38 mm (the inside diameter should be enough to allow the easy passage of the ultrasonic probes over the entire length of the access tube). The access tube shall be watertight with clean internal and external faces to ensure good bond between the concrete and the access tube. PVC access tubes are not allowed, unless approved by the Contract Administrator.

The access tubes shall be fitted with watertight threated steel of PVC caps on the bottom and top. The access tubes shall be filled with water prior to the start of concrete placement.

### 6.06 Grout for filling CSL Access Tubes

Grout for filling CSL Access Tubes at the completion of the cross sonic logging shall be a homogeneous mixture of neat cement and potable water with the maximum water/cement ratio of 0.45. The grout mix design shall be approved by the Contract Administrator.

### 6.07 Slurry

Bentonite (mineral) slurry shall be according to API Spec 13A.

Polymer (synthetic) slurry shall be according to Guide to Support Fluids for Deep Foundations, First Edition EFFC and DFIEFFC/DFI Support Fluids Task Group.

The slurry shall consist of a stable colloidal suspension of pulverized solids or polymers thoroughly mixed with water.

Drilling slurry will be defined as water, bentonite, polymer slurry formed during the drilling process, or other fluids used to maintain stability of the drilled shaft excavation to aid in the drilling process or to maintain the quality of the shaft excavation. In addition, the term polymer slurry will be defined as the final mixed composite of all additives, including polymer slurry additives required to produce the acceptable drilling slurry.

Bentonite drilling slurry shall not be used in shaft excavations at the County Road 4 bridge, unless approved by the Contract Administrator.

A slurry manufacturer representative shall be onsite for the first application of slurry and can be onsite as requested by the Contractor on subsequent applications. Drilling slurry, when used, will be non-compensable and effect on time of performance due to the use of the slurry will be non-excusable.

The material used to make the slurry shall not be detrimental to the concrete or surrounding ground strata. Polymer slurries shall have appropriate viscosity and gel characteristics to transport excavated material to suitable screening systems or settling tanks. The percentage and specific gravity of the material used to make the slurry shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. The entire fluid column shall be replaced with fresh slurry after drilling and during final clean-out with an airlift or other approved method; a clean-out bucket is not sufficient for final cleanout.

Prior to introduction into the shaft excavation, the manufactured polymer slurry admixture shall be pre-mixed thoroughly with clean, fresh water and for adequate time in accordance with the slurry admixture manufacturer’s recommendations allotted for hydration. Water used for mixing shall be potable. Slurry tanks of adequate capacity will be required for slurry mixing, circulation, storage and treatment. No excavated slurry pits will be allowed in lieu of slurry tanks. Adequate equipment will be required as necessary to control slurry properties during the drilled shaft excavation in accordance with the values provided in the table below.

#### 6.07.01 Water Slurry

Water without site soils or soil additive can be used as slurry when casing is used for the entire length of hole. Clean water may be used as a drilling fluid when entire length of the shaft excavation is cased. Water slurry shall conform to the following requirements:

| Property | Test Procedure | Specified Value |
|---|---|---|
| Density | Mud Weight (Density) API 13B-1, Section 1 | 1040 ($kg/m^3$) Maximum |
| Sand Content | Sand API 13B-1, Section 5 | 1.0 (%) Maximum |
| Temperature (prior to concrete placement) | - | 5.0 ($^oC$) Minimum |

### 6.07.02 Polymer (Synthetic) Slurry

Polymer slurry shall be used as per manufacturers recommendations and shall conform to the following requirements:

| Property | Test Procedure | Specified Value |
|---|---|---|
| Density | Mud Weight (Density) API 13B-1, Section 1 | 1040 ($kg/m^3$) Maximum |
| Sand Content | Sand API 13B-1, Section 5 | 1.0 (%) Maximum |
| Temperature (prior to concrete placement) | - | 5.0 ($^oC$) Minimum |
| Viscosity | Marsh Funnel and Cup API 13b-1, Section 2.2 | 32 to 135 |
| pH | Glass Electrode, pH Meter, or pH Paper | 8 to 10 |

### 6.07.03 Bentonite (Mineral) Slurry

The use of bentonite slurry is not permitted for shaft excavation at the County Road 4 bridge unless approved by the Contract Administrator. If approved for use, bentonite slurry shall conform to the following requirements:

| Property | Test Procedure | Specified Value |
|---|---|---|
| Density | Mud Weight (Density) API 13B-1, Section 1 | 1010 ($kg/m^3$) to 1200 ($kg/m^3$) |
| Sand Content (prior to final cleaning and immediately prior to placing concrete) | Sand API 13B-1, Section 5 | 4.0 (%) Maximum |

| | | |
|---|---|---|
| Temperature (prior to concrete placement) | - | 5.0 (ºC) Minimum |
| Viscosity | Marsh Funnel and Cup API 13b-1, Section 2.2 | 26 to 50 |
| pH | Glass Electrode, pH Meter, or pH Paper | 8 to 11 |

## 7.0 EQUIPMENT

### 7.01 Drilling and Excavation Equipment

Drilling equipment used to perform the drilled shaft work shall have the capability of providing sufficient torque and down-thrust for drilling and excavating shafts. Appropriate drilling and coring equipment must be available to drill through obstructions.

The excavation equipment shall be capable of excavating the drilled shaft to the dimensions required in the plan with a level bottom. The cutting edges of the excavation tools used to form the base of the drilled shaft must be normal to the vertical axis of the equipment within a tolerance of (±13mm) per (305 mm) of shaft diameter.

### 7.02 Concrete Placement Equipment

Tremie pipe to place concrete underwater shall be completely watertight and of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. The tremie must not contain aluminum parts that will have contact with the concrete. The tremie inside diameter must not be less than 250 mm for an open system or 125 mm for a closed system. The inside and outside surfaces of the tremie must be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concrete placement. The discharge end of the tremie must be constructed to permit the free radial flow of concrete. Wall thickness of the tremie must be adequate to prevent crimping or sharp bends that may restrict concrete placement.

A plug shall be placed at the top of the tremie or pump line to separate the concrete from the water/slurry until the concrete is flowing through the orifice. Plugs, if left in the shaft concrete, must be of a material approved by the Contract Administrator. Tremie pipe sections must have connections that will not loosen and separate and remain watertight if a portion of the tremie becomes stuck.

## 8.0 CONSTRUCTION

### 8.01 Transporting, Storing, and Handling Piles, Casings, Liners, and Reinforcing Steel Reinforcement Cages

#### 8.01.01 General

Casings, liners, and steel reinforcement shall be transported, stored, and handled in such a manner that damage is prevented and the strength of the components is not affected by deterioration or deformation.

Components shall be lifted and placed using appropriate lifting equipment, temporary bracing, guys, or stiffening devices so that the components are at no time overloaded, unstable, or unsafe.

Material shall be supported to prevent unequal settlement when stacked.

### 8.01.02 Drilled Shaft Casings and Liners

Casings and liners shall be handled and stored in such a manner to avoid damage or distortion to them. The casings and liners shall be maintained circular within ± 2% of the casing or liner diameter.

## 8.02 Shaft Excavation

### 8.02.01 General

The Contractor shall submit Requests to Proceed prior to construction and at the milestones specified. Construction of drilled shafts shall commence only after Notices to Proceed have been given by the Contract Administrator.

Shafts shall be excavated to the required depth as shown on the Contract Drawings. Shaft excavation operations shall conform to this section and the shaft installation Work Plan.

### 8.02.02 Continuity of Shaft Excavation Operations

Once the excavation operation has been started, the excavation shall be conducted in a continuous operation until the excavation of the shaft is completed, except for pauses and stops as noted, using approved equipment capable of excavating through the type of material expected. Pauses during the excavation operation, except for casing splicing, tooling changes, slurry maintenance, and removal of obstructions, are not allowed.

Pauses, defined as momentary interruptions of the excavation operation, will be allowed only for casing splicing, tooling changes, slurry maintenance, and removal of obstructions. Shaft excavation operation interruptions not conforming to this definition shall be considered stops. Stops for uncased excavations (including partially cased excavations) shall not exceed 16 hours duration. Stops for fully cased excavations shall not exceed 48 hours duration unless approved by the Contract Administrator.

For stops exceeding the time durations specified above, the Contractor shall stabilize the excavation using the following method:

For both a cased and uncased excavation, backfill the hole with either Lean Concrete or granular material. The Contractor shall backfill the hole to the ground surface, if the excavation is not cased, or to a minimum of 1.5 m above the bottom of casing (temporary or permanent), if the excavation is cased. Backfilling of shafts with casing fully seated into rock, as determined by the Contract Administrator, will not be required.

During stops, the Contractor shall protect the base of the shaft from weathering and stabilize the shaft excavation to prevent bottom heave, caving, head loss, and loss of ground. The Contractor bears full responsibility for selection and execution of the method(s) of stabilizing and maintaining the shaft excavation. Shaft stabilization shall conform to the shaft installation Work Plan.

If slurry is present in the shaft excavation, the Contractor shall conform to the requirements of OPSS.PROV 903.07.05. regarding the maintenance of the slurry and the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation and shall recondition the slurry to the required slurry properties prior to recommencing shaft excavation operations.

If applicable, once the excavation of the rock socket reaches the target depth, over-ream the shaft side walls, prior to placement of the reinforcing cage. The duration from the time of base inspection to the start of concreting shall not exceed 6 hours.

If applicable, rock socket side walls shall be roughened if specified on the Contract Drawings.

### 8.02.03 General Shaft Casing or Liner Requirements

#### 8.02.03.01 General

Shaft casing or liner shall be watertight and clean prior to placement in the excavation. The outside diameter of the casing shall not be less than the specified diameter of the shaft. The diameter of the casing shall not be greater than the specified diameter of the shaft plus 150 mm.

The Contractor shall conduct casing installation and removal operations and shaft excavation operations such that the adjacent soil outside the casing and shaft excavation for the full height of the shaft is not disturbed. Disturbed soil is defined as soil whose geotechnical properties have been changed from those of the original in situ soil, and whose altered condition adversely affects the capacity and structural integrity of the shaft foundation.

#### 8.02.03.02 Permanent Shaft Casing

Permanent casing is defined as casing designed as part of the shaft structure and installed to remain in place after construction is complete. All permanent casing shall be of ample strength to resist damage and deformation from transportation and handling, installation stresses, and all pressures and forces acting on the casing. Where the minimum thickness of permanent casing is specified in the Contract Drawings, it is specified to satisfy structural design requirements only. The Contractor shall increase the casing thickness as necessary to satisfy the requirements of this section.

The outside surface of the casing should be smooth, so it does not overcut soil during advancement (creating a void behind casing). Should the void between casing and a wall of shaft excavation occur, the void shall be filled with a material which approximates the geotechnical properties of the in-situ soils, in accordance with the shaft installation work plan.

The cutting tools and driving shoes of permanent casing shall not overcut the ground and the cutting tools and driving shoes shall be flush with the outside diameter of the casing.

#### 8.02.03.03 Temporary Shaft Casing or Liner

Temporary casing or liner is defined as casing installed to facilitate shaft construction only, which is not designed as part of the shaft structure, and which shall be completely removed after shaft construction is complete unless otherwise shown on the Contract Drawings. All temporary casing shall be of ample strength to resist damage and deformation from transportation and handling, installation and extraction stresses, and all pressures and forces acting on the casing. The casing shall be capable of being removed without deforming and causing damage to the completed shaft and without disturbing the surrounding soil.

To maintain stable excavations and to facilitate construction, the Contractor may furnish and install temporary casing in addition to the required casing specified on the Contract Drawings. The Contractor shall provide temporary casing at the site in sufficient quantities to meet the needs of the anticipated construction method.

The Contractor shall use the temporary casing method at all sites where it is inappropriate to use the dry or wet construction methods without the use of temporary casings other than surface casings. In this method, the casing is advanced prior to excavation and withdrawn after concrete placement. In the event seepage conditions prevent use of the dry method, the excavation and concrete placement shall be carried out using wet methods. Wet non-plastic soil shall not be considered as impervious, regardless of permeability.

Where drilling through materials that are susceptible to sloughing, the Contractor shall use appropriate means and method to prevent sidewall and basal instability including but not limited to or a combination of slurry and temporary casing. The Contractor shall take the necessary steps as required to prevent caving during shaft excavation. Should the Contractor select to remove a casing and replace it with a longer casing through caving soils, the excavation shall be backfilled. The Contractor may use soil previously excavated or soil from the site to backfill the excavation. Contractor may use other acceptable methods which will control the size of the excavation and protect the integrity of the foundation soils to excavate through caving layers.

Temporary casing must not be withdrawn until the head of concrete inside the casing is at a sufficient level that the concrete pressure at the bottom of casing exceeds the fluid pressure (e.g., groundwater pressure) on the outside of the casing at all times.

When conditions warrant, the Contractor may pull the casing in partial stages. Before withdrawing the casing, ensure that the level of fresh concrete is at such a level that the fluid trapped behind the casing is displaced upward. As the casing is withdrawn, maintain the level of concrete within the casing so that fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete.

All temporary casing shall be removed. The Contractor shall ensure that permanent casings installed below the shaft cut-off elevation remains in position as a permanent part of the drilled shaft. When casings that are to be removed become bound in the shaft excavation and cannot be practically removed, a proposal shall be submitted to the Contract Administrator for review and acceptance.

As applicable for rock sockets, if temporary casing is advanced deeper than the minimum top of rock socket elevation shown on the Contract Drawings or actual top of rock elevation if deeper, the Contractor shall withdraw the casing from the rock socket and overream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, the rock socket shall be extended below the design tip to maintain a full socket depth. When the shaft extends above ground or through a body of water, the Contractor may form the exposed portion with removable casing except when the Permanent Casing Method is specified. For permanent casings, the Contractor shall remove the portion of metal casings in accordance with the Contract Drawings. The Contractor shall dismantle casings removed to expose the concrete as required above in a manner which will not damage the drilled shaft concrete.

Temporary casing shall be removed gradually as concrete is placed in the shaft. The proposed method of extraction shall be submitted to the Contract Administrator with a Request to Proceed. The Contractor shall not proceed with the extraction until a Notice to Proceed is given by the Contract Administrator.

Contract Administrator may permit movement of the casing by rotating, oscillating or extraction with a vibratory hammer. The extraction method should be coordinated with the Contract Administrator. The Contractor shall extract casing at a slow, uniform rate while the concrete remains fluid.

Expandable or split casings that are removable are not permitted for use below water.

### 8.02.03.04 Temporary Telescopic Casing

If permitted by the Contract Administrator, the Contractor shall submit a temporary telescoping casing proposal for drilled shafts with a Request to Proceed to the Contract Administrator, subject to the following conditions:

a) A maximum of two telescoping casing diameter changes will be allowed.

b) The maximum diameter change at each casing diameter transition shall be 300 mm.

The Contractor shall not proceed until a Notice to Proceed is given by the Contract Administrator.

### 8.02.04 Cleaning of Bottom of Shaft Excavation and Inspection

### 8.02.04.01 Cleaning

The Contractor is responsible for cleaning the base of the drilled shafts to comply with the requirements of the specification. Shaft and base cleanliness will be verified by the Contract Administrator.

The Contractor shall use appropriate means such as a cleanout bucket (bailing bucket) and air lift or other devices to clean the bottom of the excavation of all shafts to achieve direct contact between the concrete and undisturbed end bearing formation. The entire slurry column shall be exchanged during final clean-out for wet excavations. A clean-out bucket alone is not sufficient for final clean-out for wet excavations.

The following cleaning criteria must be followed for thickness of sediments at the time of concrete placement:

a) End Bearing Drilled shafts in Soil: The average thickness of the sediments shall be less than 13 mm. At least 50 percent of the base of each shaft shall have less than 13 mm of sediment. The maximum thickness of sediment at any place on the base of the shaft shall not exceed 25 mm.

b) End Bearing Drilled shafts in rock: The average thickness of the sediments shall be less than 8 mm. At least 50 percent of the base of each shaft shall have less than 8 mm of sediment. The maximum thickness of sediment at any place on the base of the shaft shall not exceed 15 mm.

c) Friction shaft without any end bearing: The maximum thickness of sediment at any place on the base of the shaft shall not exceed 50 mm.

### 8.02.04.02 Inspection

Each excavated shaft shall be inspected and accepted by the Contract Administrator prior to proceeding with construction. The bottom of each excavated shaft shall be inspected using both Shaft Inspection Device (SID) and Shaft Quantitative Inspection Device (SQUID) (or-an approved alternate down-hole equipment) to verify shaft bottom cleanliness and thickness of debris/sediment prior to concreting as specified in the Contract Documents.

After installation for the rebar cage and immediately before placement of the concrete, the bottom of the shaft shall be sounded with an airlift pipe, a tape with a heavy weight attached to the end of the tape, or other means acceptable by Contract Administrator to determine that the shaft bottom meets the requirements.

The Contractor shall cooperate with the Contract Administrator in using this inspection device, including placing the inspection device in position for inspection and removing it after the inspection. If any of the SID inspections indicate the cleanliness or bearing material requirements are not achieved, reinspection after additional cleaning or drilling will be required at no additional cost.

The Contractor shall submit a request to proceed before placing reinforcing cage and concreting and shall not proceed until a Notice to Proceed is received from the Contract Administrator.

After completion of the inspection of a shaft, the Contract Administrator will direct the Contractor as to whether additional clean-out is necessary.

Both SID and SQUID method of base inspection shall be used for each drilled shaft.

**8.02.04.02.01 Shaft Inspection Device (SID)**

The SID shall be provided and operated by the Contract Administrator. The Contractor shall cooperate with the Contract Administrator in conducting the SID.

The Contractor shall provide a means to position and lower the SID into the shaft excavation to enable the bell housing to rest vertically on the bottom of the excavation. The inspection of each drilled shaft excavation after final cleaning shall be continuously videotaped.

For Contractor's information, the Contract Administrator will furnish a SID device satisfying the following requirements:

a) A remotely operated, high resolution, color video camera sealed inside a watertight bell housing.

b) Provides a clear view of the bottom inspection on a video monitor at the surface in real time.

c) Provides a permanent record of the entire inspection with voice annotation with a resolution of not less than 720 x 480.

d) Provides a minimum field of vision of 710 $cm^2$, with at least two graduated measuring devices to record the thickness of debris/sediment on the bottom of the shaft excavation to a minimum accuracy of 12 mm and a length greater than 37 mm.

e) Provides sufficient lighting to illuminate the entire field of vision at the bottom of the shaft for the operator and inspector to clearly see the depth measurement scale on the video monitor and to produce a clear recording of the inspection.

f) Provides a compressed air or gas system to displace drilling fluids from the bell housing and a pressurized water system to assist in determination of bottom sedimentation depth.

For shafts with diameter of up to 2 m, the thickness of debris/sediment will be measured at least in five locations, one in the center of the shaft as well as in the four quadrants surrounding the shaft center. If the diameter of the shaft is between 2 m to 3 m, five measurement of the thickness shall be performed on the middle 2 m diameter of the shaft (similar to the shafts with 2 m diameter) and at least six thickness measurements shall be performed on the perimeter beyond the middle portion.

**8.02.04.02.02 Shaft Quantitative Inspection Device (SQUID)**

The SQUID shall be provided and operated by the Contract Administrator. The Contractor shall cooperate with the Contract Administrator to supply and install the Kelly bar adapter and to execute the test.

For Contractor's information, the device shall include the following components:

SQUID Unit – Unless updated by the equipment manufacturer, the SQUID Unit shall be a hexagonal shaped device with a height of approximately 630 mm, a diagonal of approximately 650 mm, and a weight of approximately 188 kg. The unit shall include three penetrometers each having a surface area of 10 $cm^2$ to measure force and three displacement plates each having a diameter of 152 mm and a weight of 7.75 kg to determine displacements. The unit shall also be supplied with two downhole data transmission cables and two transmitter boxes for signal conditioning.

Kelly Bar Adapter – Drill rig Kelly bar dimensions vary depending upon the manufacturer and require an adapter to attach to the SQUID unit. For each drilling rig on the project, the Contractor shall submit to the Contract Administrator a completed adaptor detail to the SQUID equipment supplier two weeks prior to installing the initial drilled shaft with that drill rig.

The SQUID Unit shall be pin-connected to the Kelly bar using a properly sized adapter provided by the SQUID equipment supplier or Contractor. After the pin-connection and prior to testing, the verticality of the SQUID Unit shall be checked and confirmed. The signal transmission from the SQUID Unit to the SQUID Tablet shall also be confirmed prior to commencing the test. Signal transmission shall be checked by manually lifting each displacement plate and observing the increasing displacement on the SQUID Tablet. After verticality and signal transmission checks are completed, the SQUID Unit shall be moved over the open shaft excavation and lowered without rotation until the unit is approximately 0.6 m above the shaft base.

The test shall proceed by slowly lowering the Kelly bar without rotation until the entire weight of the Kelly bar is transferred to, and is resting on, the SQUID Unit. Penetrometer force and plate displacement measurements shall be continuously acquired, displayed, and stored on the SQUID Tablet during the test process. A test run shall be terminated once two of the three penetrometers have registered a force greater than 2.2 kN or the maximum penetrometer travel of 152 mm is reached for any one of the penetrometers.

Sediment, loose material, or debris at the base of the shaft is defined as a material that has a minimum resistance to penetrometer force of 0.089 kN. Natural soils are defined as materials that have a resistance to penetrometer force greater than 0.71 kN. The thickness of sediment, loose material, or debris at the base of the drilled shaft is defined as the difference in the displacement plate measurements that occurs between a penetrometer force of 0.089 kN to 0.71 kN.

If the shaft base diameter is 0.9 m or less, a single SQUID run shall be performed at the shaft center. At least five SQUID runs shall be performed for the shafts with diameter of up to 2 m, one in the center of the shaft as well as in the four quadrants surrounding the shaft center. If the diameter of the shaft is between 2 m to 3 m, at least five SQUID runs shall be performed on the middle 2 m diameter of the shaft (similar to the shafts with 2 m diameter) and at least six SQUID runs shall be performed on the perimeter beyond the middle portion.

Following the testing at the center, the SQUID Unit shall be repositioned in one of the four perimeter quadrants (North, South, East, or West) around the shaft center and the process described above repeated. For each SQUID run, the average debris thickness determined using the force versus displacement results

from a minimum of two penetrometers shall be used to determine if the drilled shaft base condition meets the specified base cleanliness criteria or whether additional cleaning and retesting is required.

A drilled shaft base often contains irregularities from a level surface due to pilot holes or grooves from cutting teeth on drilling tools. Therefore, a SQUID run shall be considered complete provided the debris thickness can be determined from a minimum of two force versus displacement plots. Interpretation of reading for determination of the thickness of debris/sediment and reporting shall be based on the manufacture's recommended procedure.

### 8.02.05 Shaft Obstruction

When obstructions are encountered, the Contractor shall notify the Contract Administrator promptly. An obstruction is defined as a specific object encountered during the shaft excavation operation which prevents or hinders the advance of the shaft excavation.

An obstruction will be classified as material and/or objects that cannot be efficiently removed from a shaft during normal excavation operations with the drilling equipment adequate to excavate earth materials found on the project, and which necessitate the use of other methods and/or equipment to remove not otherwise required for excavation of rock or earth materials on the project. Such obstructions may be rock fragments or layers, boulders, waterlogged timbers, or any material, natural or man-made, which requires use of special tools or procedures.

For this project, the following are *not* classified as obstructions and, if present, must be removed by the Contractor with no additional compensation.

1. Material present which is:
    a. required to be removed by the Contract; or
    b. known to the Contractor or readily visible upon site investigation and which can be removed by conventional surface excavation methods.
2. Boulders that are one-fourth, or less, of the casing shaft diameter

When efforts to advance past the obstruction to the design shaft tip elevation result in the rate of advance of the shaft drilling equipment being significantly reduced relative to the rate of advance for the portion of the shaft excavation in the geological unit that contains the obstruction, then the Contractor shall remove, break up, or push aside the obstruction.

Subsurface obstructions at drilled shaft locations shall be removed, broken or pushed aside by the Contractor. The Contractor shall employ special procedures or tools when the hole cannot be advanced using conventional equipment. Blasting will not be permitted. Except as provided in this section, all cost and time effects, direct, indirect and cumulative of subsurface obstruction of whatever nature, will be conclusively deemed fully compensated under the pay items in accordance with the contract. Encountering unexpected obstructions will be considered inherent risks in this work, both as to type and extent as is variability in material encountered in the work as to effort required to drill through or excavate the material. In the event the Contractor encounters at the site of a drilled shaft location a subsurface or latent physical condition that differs materially from that indicated in the contract documents, the Contractor shall strictly follow the procedure provided for a differing site condition set forth in Contract Documents. Any adjustment to the contract amount or time will only be those expressly permitted by the Contract Documents and only to the extent expressly provided in the Contract Documents. Drilling tools lost in the excavation will not be considered obstructions and shall be promptly removed by the Contractor. All work required to

remove lost tools or to perform associated corrective work, including but not limited to repair of hole degradation due to removal operations and any effect on time, will be non-compensable.

### 8.02.06 Use of Slurry in Shaft Excavation

The Contractor shall use slurry to maintain a stable excavation during excavation and concrete placement operations once water begins to enter the shaft excavation at an infiltration rate of 300 mm of depth or more in an hour. If concrete is to be placed in the dry, the Contractor shall pump all accumulated water in the shaft excavation down to a 75 mm maximum depth prior to beginning concrete placement operations. The concrete shall not be placed in the dry for wet non-plastic soils.

Use of specially designed polymer slurry may be permitted to stabilize uncased excavations, if approved by the Contract Administrator.

#### 8.02.06.01 Slurry Technical Assistance

If slurry other than water is used, the slurry manufacturer's representative, shall:

a) Provide technical assistance for the use of the slurry,

b) Be at the site prior to introduction of the slurry into the first drilled hole requiring slurry, and,

c) Remain at the site during the construction of at least the first shaft excavated to adjust the slurry mix to the specific site conditions.

After the manufacturer's representative is no longer present at the site, the Contractor's employee trained in the use of the slurry, as identified to the Contract Administrator shall be present at the site throughout the remainder of shaft slurry operations for this project to perform the duties specified in items a) through c) above.

#### 8.02.06.02 Minimum Level of Slurry in the Excavation

When slurry is used in a shaft excavation the following is required:

a) The height of the slurry shall be as required to provide and maintain a stable excavation to prevent bottom heave, caving or sloughing of all unstable zones.

b) The slurry level in the shaft while excavating shall be maintained above the groundwater level the greater of the following dimensions:

   i. Not less than 1.5 m for bentonite (mineral) slurries.

   ii. Not less than 1.5 m for water slurries.

   iii. Not less than 1.5 m for polymer (synthetic) slurries.

c) The slurry level in the shaft throughout all stops and during concrete placement shall be no lower than the water level elevation outside the shaft.

#### 8.02.06.03 Slurry Sampling and Testing

Bentonite slurry and polymer slurry shall be mixed and thoroughly hydrated in slurry tanks, ponds, or storage areas. Mixing in the shaft excavation is not permitted.

The Contractor shall draw sample sets from the slurry storage facility and test the samples for conformance with the specified viscosity and pH properties before beginning slurry placement in the drilled hole. A sample set shall be composed of samples taken at mid-height and within 600 mm of the bottom of the storage area. The Contractor shall keep a written record of all additives and concentrations of the additives in the polymer slurry. These records shall be submitted to the Contract Administrator once the slurry system has been established in the first drilled shaft on the project. The Contractor shall provide revised data to the Contract Administrator if changes are made to the type or concentration of additives during construction.

The date, time, names of the persons sampling and testing the slurry, and the results of the tests shall be recorded. A copy of the recorded slurry test results shall be submitted to the Contract Administrator at the completion of each shaft, and during construction of each shaft when requested by the Contract Administrator. Sample sets of all slurry, composed of samples taken at mid-height and within 600 mm of the bottom of the shaft and the storage area, shall be taken and tested once every 4 hours minimum at the beginning and during drilling shifts and prior to cleaning the bottom of the hole to verify the control of the viscosity and pH properties of the slurry. Sample sets of all slurry shall be taken and tested at least once every 2 hours if the previous sample set did not have consistent viscosity and pH properties. All slurry shall be recirculated, or agitated with the drilling equipment, when tests show that the sample sets do not have consistent viscosity and pH properties. Cleaning of the bottom of the hole shall not begin until tests show that the samples taken at mid-height and within 600 mm of the bottom of the hole have consistent viscosity and pH properties. Sample sets of all slurry, as specified, shall be taken and tested to verify control of the viscosity, pH, density, and sand content properties after final cleaning of the bottom of the hole just prior to placing concrete. Placement of the concrete shall not start until tests show that the samples taken at mid-height and within 600 mm of the bottom of the hole have consistent specified properties.

### 8.02.06.04 Maintenance of a Stable Excavation

The Contractor shall demonstrate to the satisfaction of the Contract Administrator that stable conditions are being maintained. If the Contract Administrator determines that stable conditions are not being maintained, the Contractor shall immediately take action to stabilize the shaft. The Contractor shall submit to the Contract Administrator a revised shaft installation plan that addresses the problem and prevents future instability. The Contractor shall not continue with the shaft construction until the damage that has already occurred is repaired in accordance with the specifications, and until receiving the Contract Administrator's review of the revised shaft installation Work Plan.

### 8.02.06.05 Disposal of Slurry and Drill Cuttings

Disposal of the soil/rock cutting, slurry, and slurry contacted spoils shall be in accordance with all applicable regulatory requirements.

## 8.03 Assembly and Placement of Reinforcing Steel

### 8.03.01 Reinforcing Bar Cage Assembly

The Contractor shall assemble the drilled shaft reinforcement cage and place as a unit in accordance with the installation plan. The drilled shaft reinforcement shall be placed immediately after the shaft excavation is inspected and accepted, and just prior to shaft concrete placement.

All reinforcing steel in the shaft shall be double-wire tied and supported such that the steel remains within the allowable tolerances specified herein during placement of concrete. Splices shall be located in

accordance with and as shown on the Contract Drawings. Mechanical bar splices meeting the requirements specified in the contract documents shall be used. Mechanical bar splices in adjacent bars shall be staggered not less than 3'-6" (1067 mm) apart. Welding of reinforcing steel will not be permitted.
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The reinforcing cage shall be rigidly braced to retain its configuration during handling and construction. The Contractor shall show bracing and any extra reinforcing steel required for fabrication of the cage on the shop drawings. Shaft reinforcing bar cages shall be supported on a continuous surface to the extent possible. All rigging connections shall be located at primary handling bars, as identified in the reinforcing steel assembly and installation plan. Internal bracing is required at each support and lift point. When lifting the cage for placement in the shaft, the Contractor shall provide sufficient pick points to prevent bending of the cage that will cause deformation of the reinforcement bars and damage to inspection cables.

Damaged bars and inspection cables must be replaced at the Contractor's expense.

The reinforcement shall be carefully positioned and securely fastened to provide the minimum clearances listed below, and to ensure no displacement of the reinforcing steel bars occurs during placement of the concrete.

### 8.03.02 Reinforcing Bar Cage Centralizers and Template

Rolling centralizers for reinforcing steel shall be used to minimize disturbance of the shaft sidewalls. The reinforcing steel centralizers at each longitudinal space plane shall be placed in accordance with the following minimum criteria:

a) A plane of centralizers shall be provided within 0.5 m of bottom of the shaft.

b) A plane of centralizers shall be provided within 1.5 m of top of the shaft.

c) Planes of centralizers shall be provided at a maximum longitudinal spacing of either 2.5 times the shaft diameter or 4.5 m, whichever is less.

d) Each plane of centralizers shall consist of either one centralizer per 0.3 m diameter of the shaft or four centralizers whichever is more.

The Contractor shall furnish and install additional centralizers as required to maintain the specified concrete cover throughout the length of the shaft.

The Contractor shall provide a template at the top of each shaft to locate and align vertical shaft reinforcement bars to match that shown on the Contract Drawings.

### 8.03.03 Reinforcing Bar Cage Installation and Support

Reinforcing bar cage should be securely held in the position immediately before, during and after the concrete placement. The reinforcing cage bottom supports shall be positioned such that the reinforcing steel is not allowed to come into contact with the soil or rock and to ensure that the bottom of the cage is maintained at the proper distance above the base as identified in the contract documents.

The Contractor shall laterally support the reinforcement cage at the top during placement of the concrete. The support system must be concentric to prevent racking and displacement of the cage. Temporary internal cage stiffeners shall be removed as the cage is placed in the shaft such that interference with the placement of concrete does not occur.

The rebar cage can be released only when the concrete achieved sufficient strength to support the weight of the cage. For smaller diameter drilled shafts the entire weight of the cage may be supported by bar boots. Information about the type and number of bar boots along with shop drawings shall be submitted to the Contract Administrator.

The elevation of the top of the reinforcing cage shall be checked before and after the concrete is placed. The reinforcing cage shall be maintained within the specified tolerances, and the Contractor shall make corrections to those tolerances, as required, to the satisfaction of the Contract Administrator.

No additional shafts shall be constructed until the Contractor has modified the reinforcing cage support to obtain the required tolerances.

If after placement of the reinforcement the Contract Administrator determines that the condition of the shaft is unsuitable or if concrete placement does not immediately follow the reinforcing steel placement, the Contractor shall remove the cage from the shaft as directed by the Contract Administrator so that the integrity of the excavation, including accumulation of loose material in the bottom of the shaft and the condition of the sides of the shaft, can be determined by inspection. If the reinforcement cage moves up or down from its original position by more than 75 mm, the Contractor shall submit a proposal to the Contract Administrator for approval to address the out of tolerance reinforcement installation.

## 8.04 Concrete Placement

### 8.04.01 General

Concrete should be placed as soon as possible but not to exceed 6 hours after completing cleaning of the shaft excavation, inspecting and finding it satisfactory, and immediately after placing reinforcing steel.

The full-depth drilled shaft shall be open no more than 96 hours prior to receiving concrete, including all the necessary time to clean the base, exchange the slurry, inspect the base, and place the cage

The concrete shall be placed continuously at a rate to prevent cold joints within the drilled shaft. An unplanned stoppage of work may require an emergency construction joint during the shaft construction. A detailed plan for an emergency construction joint shall be included in the installation plan.

During concrete placement, the Contractor shall monitor, and minimize, the difference in the level of concrete inside and outside of the steel reinforcing bar cage.

If temporary casing is used, it is important to establish sufficient head of concrete prior to breaking the casing seal, so that the concrete pressure exceeds the fluid pressure on the outside of the casing. The concrete level should always be maintained a minimum of 2.0 m and 5.0 m above the bottom of the casing during a concrete placement for dry and wet method, respectively.

Upward and downward movement of the reinforcing cage should be monitored during the pour.

### 8.04.02 Concrete Placement in Dry Excavations (Free Fall Method)

If not more than 50 mm of water is present in the shaft excavation and the water inflow into the excavation is less than 0.3 m per hour (or 5 mm per minute), the concrete placement in dry excavation method can be

used. Concrete placement in dry excavation method is not permitted in non-plastic soil below groundwater levels.

The concrete shall be deposited through the center of the reinforcement cage using the free fall method. The concrete shall be placed using drop chute or any acceptable device such that the free-fall is vertical down the center of the shaft without hitting the sides, the steel reinforcing bars or the reinforcing bar cage bracing. The height of concrete free fall should be limited to 25 m. Use of a flexible hose is not permitted.

Continuously place concrete in the shaft to the target elevation. If the top of the shaft is near the ground surface, upper contaminated concrete should be removed until clean fresh concrete is revealed. Upper 1.5 m of concrete should be consolidated using vibrators (after complete removal of temporary casing, if temporary casing is used).

The theoretical volume of concrete required to fill the shaft excavation should be computed prior to the concrete placement. If the actual volume installed (based on delivery tickets) is considerably less than the theoretical volume, the Contract Administrator should be informed immediately, as immediate concrete removal (before concrete sets) and reinstallation may be necessary.

For this project, all drilled shafts shall be not concreted using free fall method.

### 8.04.03 Concrete Placement in Wet Excavation (Tremie Method)

When more than 50 mm of water is present in the excavation or water inflow rate exceeds 0.3 m per hour (or 5 mm per minute) or for shaft within non-plastic soils below groundwater table concrete should be placed using tremie method. Concrete used for tremie placement method should have the ability to achieve sufficient compaction by gravity when placed by a tremie pipe and should have the ability to displace the drilling fluid inside the shaft excavation without intermixing and segregation.

Drilling fluid level should be maintained constant during the concrete placement.

The tremie pipe should be pressure fed by a pump; gravity tremie pipe (open tremie pipe) should not be used, unless approved by the Contract Administrator. Tremie pipe used for concrete placement should comply with the following requirements:

a) Should be watertight;

b) Should have a minimum inside diameter of:

   i. Pressurized tremie pipe – 100 mm or three times of maximum coarse aggregate size, whichever is larger;

   ii. Gravity tremie pipe – 200 mm or eight times of maximum coarse aggregate size, whichever is larger;

c) Should be sufficiently robust (not flexible);

d) Should be made of steel (aluminum or PVC should not be used);

e) Should have clean inner surface to minimize drag on the concrete flow.

The tremie pipe should be embedded into previously placed concrete at all times during the concrete placement. The tremie pipe embedment should be within the range of 3 m to 4m.

The discharge end of the tremie pipe shall be sealed using a sacrificial plate prior to lowering the tremie pipe into the excavation. Alternatively, the Contractor may use a plug that is inserted from the top end of the tremie pipe and travels through the tremie to keep the concrete separated from the slurry in the shaft excavation. The concrete should only get into contact with the slurry once it flows out of the tremie pipe.

During the start of the placement operations, ensure that the discharge end of the tremie pipe is within 150±50 mm of the bottom of the shaft excavation until at least 3.0 m of concrete embedment has been established (tremie pipe should first be placed to rest on the bottom of the shaft and then raised approximately 150 mm).

Volume of concrete sufficient to fill at least 5 m of the shaft length should be available on site before the pour can start. The concrete pour shall be continuous.

A minimum of 5 m of the shaft length, should be place prior to the first spilt of the tremie.

Depths of top of the concrete, discharge end of the tremie pipe, bottom of the casing should be continuously monitored during concrete placement. These depths should be plotted against concrete volume and compared to theoretical values computed prior to concrete placement. These graphs should later be provided to the Contract Administrator.

At the completion of the concrete placement there is usually up to a meter of contaminated laitance concrete at the upper portion of the shaft, which should later be removed. Therefore, it is often advised to over-pour the shaft by approximately 1 m above the target cut-off elevation.

Slurry should be kept above the top of the concrete for at least 24 hours after the pour completion.

If tremie concrete placement operation is interrupted, the Contract Administrator may require the Contractor to prove that the quality of the final product was not affected. The methodology of the investigation shall be specified by the Contract Administrator. All costs related to such investigation shall be responsibility of the Contractor.

If at any time during the concrete pour the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete surface, the entire drilled shaft will be considered defective. In such a case, the Contractor shall either: 1) remove the reinforcing cage and concrete, complete any necessary sidewall cleaning or overreaming and repair the shaft; or 2) construct an emergency construction joint if the level of the concrete is high enough in the permanent casing to allow entry into the shaft after the concrete cures.

If Option 2 is performed, the emergency cold joint shall be properly prepared by chipping away the surface of the concrete until sound, competent concrete is exposed and accepted by the Contract Administrator. The remainder of the shaft shall then be poured in the dry by methods approved by the Contract Administrator. All costs related to such investigation shall be responsibility of the Contractor.

For this Contract, all drilled shafts shall be concreted using tremie method.

### 8.04.04 Protection of Fresh and Immature Concrete

No construction operations capable of producing excessive ground vibrations or ground loss (e.g. drilling operations) should be performed in the radius of 10 meters or three shaft diameters, whichever is larger, from the freshly place concrete for first 48 hours or until concrete reaches a compressive strength of 14.0 MPa, whichever happens first. Construction equipment capable of producing excessive ground vibration

includes vibratory hammers, pile drivers (hydraulic hammers and vibratory pile drivers), machine mounted impact tools, large drilling rigs, roller compactors and other large pieces of equipment.

Cold and hot weather concreting practices should be as per OPSS.PROV 904.

### 8.04.05 Concrete Quality Control Testing

Concrete Quality Control testing should be performed as per requirements specified in OPSS.PROV 1350.

## 8.05 Tolerances

During excavation of the shaft, the Contractor shall perform plumbness, alignment and dimensional checks of the shaft at 1500 mm increments. Any deviation exceeding the allowable construction tolerances specified herein shall be corrected by the Contractor.

Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances will not be accepted.

When a shaft excavation is completed with unacceptable tolerances, the Contractor shall propose, develop and, submit a plan to the Contract Administrator describing the procedure for the corrective work. The Contractor shall submit a Request to Proceed and shall not continue with the work until a Notice to Proceed is given.

When a shaft excavation is completed with unacceptable tolerances, the Contractor shall propose, develop and, submit a plan to the Contract Administrator describing the procedure for the corrective work.

The following construction tolerances will apply to drilled shafts unless stated otherwise in the contract documents:

a) Shafts shall be constructed such that the center of the top of the shaft is within 75mm of plan position in the horizontal plane at the plan elevation for the top of the shaft.

b) The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more 6 mm per 305 mm of depth. The overall plumbness, including the drilled shaft and column, shall be within 75 mm of the vertical alignment of the shaft and column.

c) Shaft steel reinforcing bar concrete cover tolerance shall be 13 mm. Ensure that the reinforcing cage is concentric with the shaft within a tolerance of 25 mm.

d) After placing all the concrete, ensure that the top of the reinforcing steel cage is no more than 75 mm above or below the plan position.

e) All casing diameters shall conform to the Plan dimensions. The Contractor may use different casing diameter if it can be proved the diameter of the drilled shaft meets the design and it must be preapproved by the Contract Administrator. When conditions are such that a series of telescoping casings are used, provide the casing sized to maintain the minimum shaft diameters.

f) Use excavation equipment and methods designed so that the completed shaft excavation will have a flat bottom. Ensure that the cutting edges of excavation equipment are normal to the vertical axis of the equipment within a tolerance of plus or minus 100 mm.

## 8.06 Repair of Welds

Any section of weld that does not meet the requirements of the Contract Documents shall be removed and rewelded.

## 8.07 Quality Control

### 8.07.01 Inspection and Testing of Welds

#### 8.07.01.01 Qualifications of Companies and Individuals

An independent testing company with no corporate affiliation with the Contractor shall be employed to carry out the non-destructive testing of welds. The independent testing company shall be certified by the Canadian Welding Bureau to the requirements of CSA W178.1 for bridge structures by radiographic or ultrasonic test methods.

Testing shall be done by a non-destructive testing technician employed by an independent testing company. The non-destructive testing technician shall have documented evidence of training and professional knowledge, skill, and experience in non-destructive testing of structural steel welds and material and have a valid certificate showing qualification to a Level II or III according to CAN/CGSB-48.9712 and the Canadian Welding Bureau for the non-destructive testing specified.

Visual inspections shall be performed by a welding inspector employed by an independent testing company. The welding inspector shall have documented evidence of training, professional knowledge, skill and experience in the visual inspection of structural steel welds and material, and have a valid certificate showing qualification to Level II or III according to CSA W178.2.

#### 8.07.01.02 Visual Inspection of Welds

A representative sample of not less than 30% of the welds, as determined by the Contract Administrator, shall be visually inspected for conformance to the requirements of CSA W59, the Contract Documents, and the Working Drawings.

#### 8.07.01.03 Non-Destructive Testing of Welds

Radiographic or ultrasonic testing shall be carried out using procedures according to CSA W59.

Ultrasonic or radiographic testing shall be carried out on the entire length of selected splice welds chosen at random by the Contract Administrator or the Welding Inspector assigned to carry out visual inspection.

#### 8.07.01.04 Repaired Welds

All welds that have been repaired shall be visually inspected and shall undergo non-destructive testing.

## 8.08 Non-Destructive Post Construction Testing

Non-destructive QC concrete integrity testing of shafts will include Pile Integrity Testing (PIT) in accordance with ASTM D5882 and Crosshole Sonic Logging (CSL) in accordance with ASTM D6760.

The Contractor is responsible for the supply and assembly of access tubes for the testing, as well as the decommissioning of the access tubes upon completion of testing. The Contractor shall coordinate this work with the Contract Administrator, who will carry out the testing. Coordination efforts associated with testing are considered part of the work and no additional payment will be made by the Owner.

For this assignment, Pile Integrity Testing (PIT) shall be carried out on all drilled shaft and that Crosshole Sonic Logging (CSL) shall carried out on at least one drilled shaft per foundation element.

### 8.08.01 Pile Integrity Testing (PIT) or Low Strain Impact Integrity Testing

PIT shall be performed in accordance with ASTM D5882.

The PIT shall be carried by the Contract Administrator on all production drilled shafts. The Contractor shall coordinate this work with the Contract Administrator. Coordination efforts associated with PIT are considered part of the work and no additional payment will be made by the Owner.

#### 8.08.01.01 Preparation of the Surface of the Drilled Shaft

The Contractor shall ensure that the pile head surface is accessible, above water, and clean of loose concrete, soil or other foreign materials resulting from construction. The Contractor shall remove sufficient pile section to reach sound concrete, and to prepare a smooth surface for sensor attachment and impact.

#### 8.08.01.02 Procedure

The PIT testing shall be carried at least 7 days after shaft concrete placement or after the concrete has achieved 75% of the design strength, whichever occurs earlier.

### 8.08.02 Cross-Hole Sonic Logging (CSL)

CSL shall be performed in accordance with ASTM D6760.

The CSL shall be carried by the Contract Administrator on the following number production drilled shafts:

| Structure | Foundation Element | Number of Test(s) |
|---|---|---|
| County Road 4 Bridge | TBD | 1 |
| | TBD | 1 |

The Contractor shall coordinate this work with the Contract Administrator. Coordination efforts associated with CSL are considered part of the work and no additional payment will be made by the Owner.

When a shaft contains three or four tubes, test shall be carried out at every possible tube combination. For shafts with five or more tubes, test all pairs of adjacent tubes around the perimeter, and one-half of the remaining number of tube combinations, chosen randomly but always including the diametrically opposite tube.

#### 8.08.02.01 Access Tubes Supply, Assembly and Decommissioning

The Contractor shall securely attach the access tubes to the interior of the reinforcement cage of the shaft. The following number of access tubes shall be furnished and installed for each test:

| Diameter of Drilled Shaft | Number of Access Tubes |
|---|---|
| Less than 1000 mm | 3 |
| 1000 mm to less than 1500 mm | 4 |
| 1500 mm to 2100 mm | 6 |

The access tubes shall be placed around the shaft, inside the spiral or hoop reinforcement, and bundled with the vertical reinforcement. Where circumferential components of the rebar cage bracing system prevent bundling the access tubes directly to the vertical reinforcement, the access tubes shall be placed inside the circumferential components of the rebar cage bracing system as close as possible to the nearest vertical steel reinforcement bar.

The access tubes shall be installed in straight alignment and as near to parallel to the vertical axis of the reinforcement cage as possible. The access tubes shall extend from the bottom of the reinforcement cage to at least 600 mm above the top of the shaft. Splice joints in the access tubes, if required to achieve full length access tubes, shall be watertight. The Contractor shall clear the access tubes of all debris and extraneous materials before installing the access tubes. The tops of access tubes shall be deburred. Care shall be taken to prevent damaging the access tubes during reinforcement cage installation and concrete placement operations in the shaft excavation.

The access tubes shall be filled with potable water before concrete placement, and the top watertight caps shall be reinstalled and secured. The Contractor shall keep all access tubes full of water through the completion of non-destructive QA testing of that shaft. When temperatures below freezing are possible, the Contractor shall protect the access tubes against freezing by wrapping the exposed tubes with insulating material, adding antifreeze to the water in the tubes, or other methods acceptable to the Contract Administrator.

After acceptance of production shafts by the Contract Administrator, the Contractor shall remove all water from the access tubes, fill the tubes with a structural non-shrinkable grout from the bottom via tremie tube. Place the grout utilizing enough pressure to fill the tubes completely.

### 8.08.02.01 Procedure

The CSL testing shall be carried at least 5 days after shaft concrete placement and after the concrete has achieved 65% of the design strength. Additional curing time prior to testing may sometimes be required. The Contractor shall furnish information regarding the shaft, tube lengths and depths, construction dates, and other pertinent shaft installation observations and details to the Contract Administrator prior to testing. The Contractor shall verify access tube lengths and their condition prior to CSL testing. If the access tubes do not provide access over the full length of the shaft, the Contractor shall repair the existing tube(s) or core additional hole(s), as directed by the Contract Administrator.

## 8.09 Non-Destructive Quality Control Test Results Submittals

The Contract Administrator will evaluate the PIT and CSL results to determine if the shaft is acceptable. If the Contract Administrator determines additional evaluation is necessary, the Contract Administrator will

specify the requirements. If repair is necessary, the Contractor is responsible for developing and submitting a repair plan to the Contract Administrator for approval as well as executing the approved plan.

**8.10 Milestone Inspections**

The Contract Administrator shall witness the following interim inspections of the work for drilled shaft:

a) Excavation

b) Steel reinforcement installation

c) Placing of concrete

A Request to Proceed shall be submitted to the Contract Administrator after the excavation and prior to steel reinforcement installation and after the steel reinforcement installation and prior to concreting.

The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

**9.0 QUALITY ASSURANCE - Not Used**

**10.0 MEASUREMENT FOR PAYMENT**

**10.01 Actual Measurement**

**10.01.01 Supply Equipment for Installing Drilled Shaft – Item**

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

For payment purposes, 50% of the work under this item shall be paid when the satisfactory performance of the equipment has been demonstrated to the Contract Administrator by the installation of 5% of drilled shafts.

Another 40% shall be paid by progress payments proportional to the work completed. The remaining 10% shall be paid on the satisfactory completion of the installation of drilled shafts.

**10.02 Drilled Shafts – Item**
**Cross Hole Sonic Logging Access Tubes and Caps – Item**

**Drilled Shafts – Item**

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

**Cross Hole Sonic Logging Access Tubes and Caps – Item**

Payment at the Contract Price for the above tender items shall be full compensation for all Labour, Equipment and Material to do the work.

**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 bridge 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.

**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.

**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.

**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.

Seven standpipe piezometers were installed in Boreholes HF-01, CR4-03, CR4-07, CR4-11, CV1-01, CV1-04, and HF-05. 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, °) | | |
| HF-01 | 4,887,995.4 (44.131934) | 299,260.2 (-79.56923) | 50 mm / 210 mm | 7.6 m |
| CR4-03 | 4,887,945.5 (44.131484) | 299,231.1 (-79.569594) | 50 mm / 210 mm | 10.7 m |
| CR4-07 | 4,887,917.5 (44.131232) | 299,275.4 (-79.569039) | 50 mm / 210 mm | 10.7 m |
| CR4-11 | 4,887,880.1 (44.130896) | 299,300.2 (-79.56873) | 50 mm / 210 mm | 9.1 m |
| 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 |
| HF-05 | 4,887,717.7 (44.129434) | 299,314.3 (-79.568551) | 50 mm / 210 mm | 7.6 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.


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