



FINAL REPORT

Preliminary Foundation Investigation and Design Report

Structural Culverts

Highway 400 to Highway 404 Link (Bradford Bypass)

Simcoe County and York Region

MTO Assignment No. 2019-E-0048

Submitted to:

AECOM Canada Ltd.

300 Water Street
Whitby, ON L1N 9J2

Submitted by:

WSP Canada Inc.

6925 Century Avenue, Suite 600, Mississauga, Ontario, L5N 7K2
+1 905 567 4444

GEOCRES No.: 31D04-003

Latitude: 44.142016°

Longitude: -79.487348°

19136074-BBP Culverts-Rev0

December 13, 2023



Distribution List

- 1 Electronic Copy - MTO Central Region
- 1 Electronic Copy - MTO Foundations Section
- 1 Electronic Copy - AECOM Canada Ltd.
- 1 Electronic Copy - WSP Canada Inc.

Table of Contents

PART A - PRELIMINARY FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
3.0 INVESTIGATION PROCEDURES	2
3.1 Previous Borehole Investigations.....	2
3.1.1 Bradford Bypass / Highway 400 Interchange Ramps (GEOCRE #31D-832)	2
3.1.2 Highway 400 / 9th Line (Golder 2001, GEOCRE #31D00-459)	3
3.1.3 Bradford Bypass Deep Cut / High Fill Areas (GEOCRE #31D04-004)	4
3.1.4 Highway 404 Extension (Golder 2010, GEOCRE #31D00-499)	4
3.2 Current Investigation	5
4.0 REGIONAL GEOLOGY AND SUBSURFACE CONDITIONS.....	7
4.1 Regional Geology.....	7
4.2 Subsurface Conditions	7
4.2.1 General	7
4.2.2 Culvert Site Nos. 30X-0566/C0, 30X-0874/C0 and 30X-0875/C0	8
4.2.3 Culvert Site Nos. 30X-0876/C0 and 30X-0877/C0	8
4.2.4 Culvert Site Nos. 30X-0878/C0, 30X-0879/C0, and 30X-0880/C0	9
4.2.5 Culvert Site No. 37X-2564/C0.....	10
4.2.6 Culvert Site No. 37X-2565/C0.....	10
4.2.7 Culvert (Bridge) Site No. 37X-2558/B1&B2	11
4.2.8 Wildlife Crossing Culvert at Station 24+080	12
4.2.9 Culvert Site No. 37X-2566/C1&C2.....	13
4.2.10 Culvert Site Nos. 37X-2567/C0 and 37X-2568/C0	14
4.3 Groundwater Conditions	14
4.4 Analytical Testing	15
5.0 CLOSURE	16

PART B - PRELIMINARY FOUNDATION DESIGN REPORT

6.0	DISCUSSION AND ENGINEERING RECOMMENDATIONS	17
6.1	General.....	17
6.2	Project Understanding.....	17
6.3	General Foundation Design Context.....	17
6.3.1	Consequences and Site Understanding Classification	17
6.4	Structural Culvert Foundations	18
6.4.1	General Foundation Options.....	18
6.4.2	Founding Elevations and Frost Protection Requirements	18
6.4.2.1	Precast Closed Box Culvert.....	18
6.4.2.2	Open Footing Culvert.....	18
6.4.3	Factored Geotechnical Resistances	19
6.4.3.1	Precast Closed Box Culvert.....	19
6.4.3.2	Open Footing Culvert – Shallow Foundations	19
6.4.3.3	Open Footing Culvert – Deep Foundations	19
6.4.4	Resistance to Lateral Loads / Sliding Resistance – Precast Box Culvert and Shallow Footings	21
6.4.5	Resistance to Lateral Loads – Deep Foundations.....	21
6.4.6	Downdrag Loads on Piles / Caissons	22
6.5	Embankment Stability and Settlement	23
6.6	Lateral Earth Pressures for Design.....	23
6.7	Corrosion Assessment and Protection.....	24
6.7.1	Potential for Sulphate Attack.....	24
6.7.2	Potential for Corrosion	24
6.8	Construction Considerations	25
6.8.1	Temporary Excavations / Temporary Protection Systems	25
6.8.2	Subgrade Preparation and Embankment Construction	26
6.8.3	Closed Box Culvert Bedding and Backfill	26
6.8.4	Erosion Protection.....	26

6.8.5	Groundwater / Surface Water Control	27
6.9	Recommendations for Additional Work.....	27
7.0	CLOSURE	29

REFERENCES

TABLES

Table 1	Proposed Structural Culvert Details
Table 2	Comparison of Foundation Options for Structural Culverts
Table 3	Preliminary Foundation Recommendations for Structural Culverts

DRAWINGS

Drawing 1	Index Plan
Drawing 2	Borehole Location Plan – BBP / Highway 400 Interchange
Drawing 3	Borehole Location Plan – BBP / Highway 400 E-N Ramp over 9 th Line
Drawing 4	Borehole Location Plan – BBP between Hwy 400 and 10 th Sideroad
Drawing 5	Borehole Location Plan – BBP between Yonge St. and 2 nd Concession
Drawing 6	Borehole Location Plan – BBP between 2 nd Concession and Leslie St. (Wildlife Crossing)
Drawing 7	Borehole Location Plan – BBP / Highway 404 Interchange
Drawing 8	Borehole Location Plan – BBP / Highway 404 Interchange Ramps

APPENDIX A Previous Investigation at BBP / Highway 400 Interchange Ramps (GEOCRE #31D-832)

Records of Boreholes	400-1 and 400-4
Figure A1	Plasticity Chart – CLAYEY SILT (CL) to SILTY CLAY (CI)
Figure A2	Grain Size Distribution – CLAYEY SILT (CL) to SILTY CLAY (CI)
Figure A3	Plasticity Chart – SILT (ML) to SILTY SAND (SM) (TILL)
Figure A4	Grain Size Distribution – SILT (ML) to SILTY SAND (SM) (TILL)
Figure A5	Plasticity Chart – Sandy CLAYEY SILT-SILT (CL-ML) (TILL) - Interlayers
Figure A6	Grain Size Distribution – Sandy CLAYEY SILT-SILT (CL-ML) (TILL) – Interlayers
Analytical Test Results	

APPENDIX B Previous Investigation at Highway 400 / 9th Line (Golder 2001, GEOCRE #31D00-459)

Lists of Symbols and Abbreviations	
Records of Boreholes	B4-1
Figure B1	Grain Size Distribution – Silty Sand Till

APPENDIX C Investigation at Bradford Bypass Deep Cut / High Fill Areas (GEOCRE #31D04-004)

Records of Borehole	DC-03
Figure C1	Plasticity Chart – SILT to Sandy SILT (ML)
Figure C2	Grain Size Distribution – Sandy SILT (ML) to SILTY SAND (SM)
Figure C3	Plasticity Chart – CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL)
Figure C4	Grain Size Distribution – CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL)

APPENDIX D Previous Investigation for Highway 404 Extension (Golder 2010, GEOCREC #31D00-499)

Lists of Symbols and Abbreviations

Records of Boreholes C2-1 and C2-6

Figure D1 Grain Size Distribution – Clayey Silt (Silty Clay Interlayer)

Figure D2 Plasticity Chart – Clayey Silt (Contains Silty Clay Inter-Layers)

Analytical Test Results on Groundwater

APPENDIX E Current Investigation

List of Symbols and Abbreviations

Structural Culverts Between Highway 400 and 10th Sideroad

Records of Boreholes R-BBP-6A and R-BBP-6B

Figure E1-1 Plasticity Chart – CLAYEY SILT (CL) (TILL)

Figure E1-2 Grain Size Distribution – CLAYEY SILT (CL) (TILL)

Figure E1-3 Plasticity Chart – SILT and Sand (ML) to SILTY SAND (SM) (TILL)

Figure E1-4 Grain Size Distribution – SILT and Sand (ML) to SILTY SAND (SM) (TILL)

Figure E1-5 Grain Size Distribution – Sandy SILT (ML) Interlayer

Structural Culverts Between Yonge Street and 2nd Concession

Records of Boreholes CL-BBP-9, CL-BBP-10, FD-01 and FD-02

Figure E2-1 Plasticity Chart – Cohesive Interlayers

Figure E2-2 Grain Size Distribution – Cohesive Interlayers

Figure E2-3 Plasticity Chart – Non-Cohesive Interlayers

Figure E2-4A/B Grain Size Distribution – Non-Cohesive Interlayers

Figure E2-5 Plasticity Chart – Lower Cohesive Deposit

Figure E2-6 Grain Size Distribution – Lower Cohesive Deposit

Structural Culverts at Highway 404 Interchange

Records of Boreholes R-404-2

Figure E3-1 Plasticity Chart – Sandy CLAYEY SILT-SILT (CL-ML) (TILL)

Figure E3-2 Grain Size Distribution – Sandy CLAYEY SILT-SILT (CL-ML) (TILL)

Figure E3-3 Plasticity Chart – SILT and Sand (ML) (TILL)

Figure E3-4 Grain Size Distribution – SILT and Sand (ML) (TILL)

Figure E3-5 Grain Size Distribution – SILT (ML)

Analytical Test Results

PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
STRUCTURAL CULVERTS
HIGHWAY 400 TO HIGHWAY 404 LINK (BRADFORD BYPASS)
MTO ASSIGNMENT NO. 2019-E-0048**

1.0 INTRODUCTION

WSP Canada Inc. (formerly Golder Associates Ltd., acquired by WSP Canada Inc. and hereafter referenced as WSP) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Bradford Bypass (BBP), a 16.3 km rural controlled access freeway connecting Highway 400 to Highway 404, in the County of Simcoe and Regional Municipality of York.

This report presents the results of a desktop study and supplemental foundation investigation carried out for planning and preliminary design of sixteen (16) structural culverts for watercourse and wildlife crossings as summarized in the following table and as shown on Drawing 1 – Index Plan.

Culvert ID	MTO Culvert Site Number	General Location	Reference Drawing No.
PR-CL-400-2	30X-0566/C0	BBP / Highway 400 Interchange Ramps	2
PR-R-BBP-10	30X-0874/C0	Bradford Bypass / Highway 400 Interchange Ramps	2
PR-R-BBP-11	30X-0875/C0	Bradford Bypass / Highway 400 Interchange Ramps	2
PR-R-BBP-4	30X-0876/C0	9 th Line near BBP / Hwy 400 E-N Ramp	3
PR-CL-2	30X-0877/C0	BBP / Highway 400 E-N Ramp south of 9 th Line	3
PR-R-BBP-6A	30X-0878/C0	BBP between Hwy 400 and 10 th Sideroad	4
PR-R-BBP-6B	30X-0879/C0	BBP between Hwy 400 and 10 th Sideroad	4
PR-R-BBP-8A/8B	30X-0880/CO	BBP between Hwy 400 and 10 th Sideroad	4
PR-CL-BBP-9	37X-2564/C0	BBP between Yonge St. and 2 nd Concession	5
PR-CL-BBP-10	37X-2565/C0	BBP between Yonge St. and 2 nd Concession	5
CL-BBP-11 (Flood Diversion Structure) ¹	37X-2558/B1&B2 (Flood Diversion Structure) ¹	BBP between Yonge St. and 2 nd Concession	5
Wildlife Crossing Culvert ²	Wildlife Crossing ² (Site No. To Be Determined)	BBP between 2 nd Concession and Leslie Street (Approximate Station 24+080 BBP centreline)	6
PR-R-404-2	37X-2566/C1 & C2 (2 Culverts)	BBP / Highway 404 Interchange Ramps	7
PR-R-404-10	37X-2567/C0	BBP / Highway 404 Interchange Ramps	8
PR-R-404-11	37X-2568/C0	BBP / Highway 404 Interchange Ramps	8

¹ During preliminary design, the proposed culvert at the flood diversion location was modified to a twin bridge structure but is referred to as a structural culvert for the purpose of this report.

² The wildlife crossing culvert is intended for passage over land and will not convey water, however, it is referred to as a structural culvert for the purpose of this report.

For planning and preliminary design, existing borehole information from previous investigations was used where existing boreholes were advanced within about 250 m from the proposed structure site. Where existing information was not available, supplemental boreholes were advanced near the proposed structure location as part of the current investigation. The exception is culvert 30X-0880/CO where the proposed boreholes were not advanced due to access and schedule constraints and the closest available borehole information is provided.

2.0 SITE DESCRIPTION

The proposed Bradford Bypass structural culverts are located within both the County of Simcoe and York Region.

The structural culverts are generally located within three distinct areas along the proposed Bradford Bypass corridor alignment described as follows:

- **Between Highway 400 and 10th Sideroad:** This section includes Culvert Site Nos. 30X-0566/C0, 30X-0874/C0, 30X-0875/C0, 30X-0876/C0, 30X-0877/C0, 30X-0878/C0, 30X-0879/C0, and 30X-0880/C0 (2 culverts). This area is generally flat and consists predominantly of farmland with the exception of the Highway 400 corridor. The proposed culverts near the Highway 400 Interchange are generally associated with carrying stormwater from the existing Highway 400 and proposed ramp ditches that eventually outlet west of Highway 400. Between Highway 400 and 10th Sideroad, there are two main watercourses that flow north to south across the proposed BBP highway corridor and eventually drain southwest of the site.
- **Between Yonge Street and east of 2nd Concession:** This section includes Culvert Site Nos. 37X-2564/C0, 37X-2565/C0, 37X-2558/B1&B2 and the wildlife crossing culvert. This low-lying area is located east of the Holland River East Branch and generally consists of flat farmland. This area is considered to be within the Holland River floodplain and groundwater is typically at or near ground surface, as evidenced by ponded water in the fields that was frequently observed during the geotechnical fieldwork. There is an existing open channel (for flood diversion associated with the Holland River East Branch) near the middle of this section that flows south to north across the proposed BBP highway corridor.
- **Between Leslie and Highway 404:** This section includes Culvert Site Nos. 37X-2566/C1 & C2, 37X-2567/C0, and 37X-2568/C0. This area generally consists of flat farmland with exception of the Highway 404 corridor, which has been constructed as a cut with the ground surface west of Highway 404 being about 10 m higher than the ground surface east of Highway 404. There is an existing watercourse and pond near the middle of this area that flows north to south below the proposed new BBP highway corridor. There is also an existing watercourse (Maskinonge River tributary) that flows southwest to northeast through an existing culvert below Highway 404, and for which new culverts are proposed below the new interchange ramps.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Borehole Investigations

3.1.1 Bradford Bypass / Highway 400 Interchange Ramps (GEOCREs #31D-832)

Two boreholes were advanced near the proposed culverts Site Nos. 30X-0566/C0, 30X-0874/C0 and 30X-0875/C0 as part of the investigation for the Bradford Bypass / Highway 400 Interchange Ramps (WSP Golder, 2023)¹. Borehole 400-4 was advanced north of culverts 30X-0566/C0 and 30X-0875/C0, and Borehole 400-1 was advanced north of culvert 30X-0874/C0. The Record of Boreholes and associated laboratory test results are provided in Appendix A and the borehole locations are shown on Drawing 2.

Boreholes were advanced using 210 mm outer diameter (O.D.) hollow stem augers followed by wash-rotary techniques (advancement of tricone with water/drilling mud). Soil samples were obtained at intervals of depth of

¹ WSP Golder, 2023. *Preliminary foundation investigation and design report, Bradford Bypass / Highway 400 Interchange Ramp Structures (E-S Ramp Over Highway 400, N-E Ramp Over Highway 400 / E-S Ramp), Simcoe County and York Region, MTO Assignment No. 2019-E-0048. Geocres No. 31D-832.*

about 0.75 m, 1.5 m and 3.0 m using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure.

The water levels in the open boreholes were observed throughout the drilling. The details of the borehole including location in MTM NAD83 (Zone 10) northing and easting coordinates, geographic (Latitude / Longitude) coordinates, ground surface elevation referenced to Geodetic datum and drilled depth are summarized below.

Borehole No.	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
400-1	4,886,282.5 (44.116458)	294,024.6 (-79.634623)	255.7	33.8
400-4	4886102.3 (44.114835)	293976.8 (-79.635217)	253.8	40.0

Note: Refusal on SPT “100-blow” soil achieved at termination depth in Borehole 400-1 and 400-4.

3.1.2 Highway 400 / 9th Line (Golder 2001, GEOCREs #31D00-459)

One borehole was advanced in the vicinity of the proposed culverts at culvert Site Nos. 30X-0876/C0 and 30X-0877/C0 as part of a previous Golder Associates Ltd. (Golder) geotechnical investigation in 2000 for the preliminary design of the Hwy 400 / 9th Line (formerly 9th Concession) overpass in support of the ultimate widening of Highway 400 (Golder, 2001)². Borehole B4-1 was advanced west of culvert 30X-0877/C0 and north of culvert 30X-0876/C0. The Record of Borehole and associated laboratory test results are provided in Appendix B and the borehole location is shown on Drawing 3.

Borehole B4-1 was advanced using 108 mm diameter solid stem augers. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure.

The water levels in the open borehole were observed throughout the drilling operations. The details of the borehole including location in MTM NAD83 (Zone 10) northing and easting coordinates, geographic (Latitude / Longitude) coordinates, ground surface elevation referenced to Geodetic datum and drilled depth are summarized below.

Borehole Number	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
B4-1	4,887,127.3 (44.124068)	293,870.9 (-79.636565)	271.7	23.3

Note: Refusal on SPT “100-blow” soil achieved at termination depth in Borehole B4-1.

² Golder Associates Ltd. 2001. *Preliminary foundation investigation and design report, Ninth concession overpass structure site 30-308, Highway 400 widening from York/Simcoe boundary to 1 km south of Highway 89, G.W.P. 40-00-00, Geocres No. 31D00-459.*

3.1.3 Bradford Bypass Deep Cut / High Fill Areas (GEOCRES #31D04-004)

One borehole was advanced near the proposed wildlife crossing as part of the investigation for the Bradford Bypass Deep Cut / High Fill Areas (WSP, 2023)³. Borehole DC-03 was advanced west of the proposed wildlife crossing culvert. The Record of Borehole and associated laboratory test results are provided in Appendix C and the borehole location is shown on Drawing 6.

Borehole DC-03 was advanced using 210 mm outer diameter (O.D.) hollow stem augers followed by wash-rotary techniques (advancement of tricone with water/drilling mud). Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure.

The water level in the open borehole was observed throughout the drilling and a piezometer was installed. The details of the borehole including location in MTM NAD83 (Zone 10) northing and easting coordinates, geographic (Latitude / Longitude) coordinates, ground surface elevation referenced to Geodetic datum and drilled depth are summarized below.

Borehole No.	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
DC-03	4889831.86 (44.148479)	307194.75 (-79.470065)	223.6	20.4

Note: Refusal on “100-blow” soil not achieved at termination depth in Borehole DC-03.

3.1.4 Highway 404 Extension (Golder 2010, GEOCRES #31D00-499)

Two boreholes were advanced in the vicinity of the proposed culverts at culvert Site Nos. 37X-2567/C0 and 37X-2568/C0 as part of a previous Golder geotechnical investigation in 2009 for the existing culvert and hydrogeological assessment for the Highway 404 extension (Golder, 2010)⁴. Borehole C2-1 is located near the north end of proposed culvert 37X-2568/C0 and Borehole C2-6 is located near the west end of culvert 37X-2567/C0. The Record of Boreholes and associated laboratory test results are provided in Appendix D and the borehole locations are shown on Drawing 8.

Boreholes C2-1 and C2-6 were advanced using 108 mm outer diameter solid stem augers. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure. A groundwater sample was collected from C2-1 for analytical testing.

The water levels in the open boreholes were observed throughout the drilling operations and piezometers were installed in Boreholes C2-1 and C2-6. The details of the boreholes including location in MTM NAD83 (Zone 10) northing and easting coordinates, geographic (Latitude / Longitude) coordinates, ground surface elevation referenced to Geodetic datum and drilled depth are summarized below.

³ WSP, 2023. *Preliminary foundation investigation and design report, Deep Cut and High Fill Areas, Highway 400 to Highway 404 Link (Bradford Bypass), Simcoe County and York Region, MTO Assignment No. 2019-E-0048. Geocres No. 31D04-004*

⁴ Golder Associates Ltd. 2010. *Hydrogeological investigation and Design Report, Highway 404 Extension from Queensville Sideroad to Ravenshoe Road, Town of East Gwillimbury, Ministry of Transportation Ontario, W.P. 2005-07-00. GEOCRES No. 31D00-499*

Borehole Number	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
C2-1	4890050.4 (44.150435)	309545.5 (-79.440678)	251.2	9.8
C2-6	4890149.3 (44.151324)	309640.6 (-79.439488)	248.0	9.8

Note: Refusal on “100-blow” soil achieved at termination depth in Borehole C2-1 and C2-6.

3.2 Current Investigation

The field work for the current investigation was carried out in two phases. Phase 1 was carried out between May 13 and 25, 2022, as part of the base scope investigation for the Bradford Bypass at which time two boreholes (designated Boreholes FD-01 and FD-02) were advanced near Site No. 37X-2558/B1&B2 (flood diversion structure). Phase 2 was carried out between August 3 and 16, 2023 for the structural culvert contingency scope at which time five boreholes (designated Boreholes R-BBP-6A, R-BBP-6B, CL-BBP-9, CL-BBP-10, and R-404-2) were advanced in the vicinity of the culverts at Site Nos. 30X-0878/C0, 30X-0879/C0, 30X-0880/C0, 37X-2564/C0, 37X-2565/C0, and 37X-2566/C1 & C2. A copy of the borehole records and laboratory testing are provided in Appendix E and the location of the boreholes advanced during the current investigation are shown on Drawings 4, 5, and 7.

Boreholes in Phase 1 were advanced using 210 mm outside diameter (O.D.) hollow stem augers followed by wash-rotary techniques (advancement of tricone with water/drilling mud) using an Acker Renegade track-mounted drill supplied and operated by Walker Drilling Inc. of Utopia, Ontario. Boreholes in Phase 2 were advanced using 210 mm outside diameter (O.D.) hollow stem augers using an Diedrich D120 track-mounted drill supplied and operated by Walker Drilling Inc. of Utopia, Ontario.

The wash-rotary technique was used in Boreholes FD-01 and FD-02 to counter-balance hydrostatic forces and reduce disturbance at the deeper sampling and testing interval. Soil samples were generally obtained at 0.75 m, 1.5 m, and 3.0 m intervals of depth using a 50 mm O.D. split spoon sampler driven with an automatic hammer in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586⁵), and using 76 mm O.D. thin-walled ‘Shelby’ Tube samplers (ASTM D1587)⁶ to obtain relatively undisturbed samples in the soil. The split-spoon samplers used in the investigation generally 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 shear tests were carried out using an MTO ‘N’-vane in the cohesive soils to assess shear strength (ASTM D2573)⁷.

The water level was generally observed during drilling; however, in some cases the water level was not measured due to the introduction of water during drilling operations. Water level observations are noted on the drilling records. Standpipe piezometers were installed in Boreholes FD-02, R-BBP-6A, R-BBP-6B, CL-BBP-9, CL-BBP-1-, and R-404-2. The installed piezometers consist of a 50 mm diameter PVC pipe, with a 1.5 m or 3 m long slotted screen within a filter sand pack. The boreholes and annulus surrounding the piezometer pipe above

⁵ ASTM D1586 Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

⁶ ASTM D1587 Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

⁷ ASTM D2573 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils.

the filter sand pack were backfilled to near ground surface with bentonite pellets in general accordance with Ontario Regulation 903 Wells (as amended)⁸. The monitoring wells were capped with monument casings.

The field work was monitored on a full-time basis by a member of WSP's engineering staff who located the boreholes in the field, directed the sampling and in-situ testing operations, logged the boreholes, and examined the soil samples. The soil samples were identified in the field, placed in labelled containers, and transported to WSP's laboratory in Mississauga for further visual review and geotechnical laboratory testing. Shelby tube samples were transported to the Ministry of Transportation, Ontario Foundations Laboratory in Toronto. Index and classification testing consisting of natural moisture content, Atterberg limits and grain size distribution were conducted on selected samples. All laboratory tests were carried out in general accordance with MTO and / or ASTM Standards, as applicable.

Select soil samples were submitted to a specialist analytical laboratory (Bureau Veritas Laboratories of Mississauga, Ontario) under chain of custody procedures for testing of electrical conductivity / resistivity, pH, and chemical analysis of sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel.

The borehole locations were surveyed in the field by Geoverra (a licensed surveyor) or WSP personnel using a Trimble Geo 7X Global Positioning System (GPS) unit. The locations given on the borehole records and shown on Drawings 4, 5 and 7 are positioned relative to NAD 83 MTM (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum (CGVD28 datum; HT2 Geoid Model). The borehole locations, including the geographic (Latitude / Longitude) coordinates, the ground surface elevations, and borehole depths are summarized below.

Borehole No.	NAD 83 MTM Northing (m) (Latitude, °)	NAD 83 MTM Easting (m) (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
FD-01	4,889,113.4 (44.142016)	305,812.2 (-79.487348)	220.0	40.2
FD-02	4,889,096.0 (44.14186)	305,757.4 (-79.488033)	221.8	34.1
R-BBP-6A	4,886,751.0 (44.120683)	294,571.6 (-79.627798)	262.5	18.9
R-BBP-6B	4,886,580.1 (44.119146)	294,711.9 (-79.626042)	259.6	18.9
CL-BBP-9	4,888,785.5 (44.139066)	305,001.4 (-79.497483)	220.1	12.8
CL-BBP-10	4,888,935.8 (44.140418)	305,357.0 (-79.493038)	220.0	12.8
R-404-2	4,890,382.1 (44.153425)	308,810.2 (-79.449867)	245.0	15.8

Note: Refusal on "100-blow" soil was not achieved at termination depth for any of the boreholes.

⁸ Ontario Regulation 903 Wells (as amended)

4.0 REGIONAL GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The regional geology varies along the proposed highway alignment and the proposed structural culverts are generally located in one of three physiographic areas known as the Peterborough Drumlin field, Schomberg Clay Plain, or Simcoe Lowlands, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984⁹).

The structural culverts located between Highway 400 and 10th Sideroad are located near or within all three physiographic regions (Peterborough Drumlin field, the Schomberg Clay Plains, and Simcoe Lowlands) which converge in this general area. The structural culverts located between Yonge St. and Highway 404 are generally located within the Simcoe Lowlands physiographic region. A brief description of each region is provided below.

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 Simcoe Lowlands physiographic region covers the central portion of the County of Simcoe. Following the retreat of the last glacial ice sheet, the lowland was flooded by the now extinct post-glacial Lake Algonquin. This past post-glacial lacustrine environment is marked by deep sand, silt and clay beds overlying glacial ground moraine material.

The subsurface conditions encountered during the previous and current investigations are generally consistent with the regional geology described above.

4.2 Subsurface Conditions

4.2.1 General

The detailed subsurface soil and groundwater conditions encountered in the boreholes from the current and previous investigations including piezometer installation details and water level readings, and the results of the in-situ and laboratory tests are provided on the borehole records and laboratory test results in Appendices A to E. The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4 are uncorrected and are based on use of an automatic hammer unless otherwise noted.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

⁹ 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.

A description of the major soil layers encountered in the boreholes closest to each structural culvert location are provided in the following sections.

4.2.2 Culvert Site Nos. 30X-0566/C0, 30X-0874/C0 and 30X-0875/C0

The structural culverts located in the southern portion of the BBP / Highway 400 Interchange Ramps (Culverts 30X-0566/C0, 30X-0874/C0 and 30X-0875/C0) are shown on Drawing 2 along with the closest boreholes (404-1 and 404-4). A copy of the relevant borehole records and associated laboratory test results are provided in Appendix A.

In general, boreholes 404-1 and 404-4 encountered a layer of firm to very stiff clayey silt to silty clay overlying a very loose to very dense non-cohesive till consisting of silt and sand, silty sand and gravelly silty sand.

A summary of the major soil deposits encountered in each borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values excluding surficial soils, laboratory moisture contents, and reference to figures containing the results of laboratory tests is provided below.

Idealized Stratigraphy	Borehole				SPT 'N'-Value Range	Moisture Content Range(%)	Laboratory Figures (Appendix A)
	400-1		400-4 ^a				
	Depth (m bgs)	Elevation (m)	Depth (m bgs)	Elevation (m)			
Firm to Very Stiff Clayey Silt to Silty Clay	0-11.7	255.7 - 244.0	0 - 9.8	253.8 - 244.0	5 to 29	7 to 28	A1 (<i>Plasticity Chart</i>) A2 (<i>Grain Size Distribution</i>)
Very Loose to Very Dense Silt and Sand to Silty Sand (Till)	11.7 - 33.8	244.0 - 221.9	9.8 - 40.0	244.0 - 213.8	3 to >100	4 to 12	A3 (<i>Plasticity Chart</i>) A4 (<i>Grain Size Distribution</i>)

Notes:

- a. In Borehole 400-4, interlayers of very loose to very dense silty sand and stiff to hard sandy clayey silt-silt till were encountered in both the clayey silt to silty clay deposit and silt and sand to silty sand (till) deposit. See Figure A5 and A6 for plasticity chart and grain size distribution for clayey silt-silt till interlayers in Borehole 400-4.

Groundwater was measured to be 1.6 m and 0.9 m below ground surface (Elevation 254.1 m and 252.9 m) in Borehole 400-1 and 400-4 prior to introducing water as part of mud rotary operations, respectively. No piezometers were installed in boreholes 400-1 and 400-4.

4.2.3 Culvert Site Nos. 30X-0876/C0 and 30X-0877/C0

The structural culverts located in the northern portion of the BBP / Highway 400 Interchange ramps (Culverts 30X-0876/C0 and 30X-0877/C0) are shown on Drawing 3 along with the closest borehole B4-1. A copy of the borehole record and associated laboratory test results are provided in Appendix B.

In general, the borehole encountered a layer of fill overlying a compact to very dense silty sand till.

A summary of the major soil deposits encountered in the borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole		SPT 'N'- value Range	Moisture Content Range (%)	Laboratory Figures (Appendix B)
	B4-1				
	Depth (m bgs)	Elevation (m)			
Loose to Compact Silty Sand to Sand and Gravel Fill	0 - 1.4	271.7 - 270.3	9 to 22	-	-
Compact to Very Dense Silty Sand Till	1.4 - 23.3	270.3 - 248.4	17 to >100	7 to 11	B1 (<i>Grain Size Distribution</i>)

Groundwater was measured to be 4.0 m below ground surface (El. 267.7 m) in the open borehole upon completion of drilling. A piezometer was not installed in the borehole.

4.2.4 Culvert Site Nos. 30X-0878/C0, 30X-0879/C0, and 30X-0880/CO

The structural culverts located between the east limit of the Highway 400 Interchange Ramps and 10th Sideroad (30X-0878/C0, 30X-0879/C0, and 30X-0880/CO) are shown on Drawing 4 along with the closest boreholes (R-BBP-6A and R-BBP-6B). The borehole records and associated figures containing laboratory test results are provided in Appendix E.

In general, boreholes R-BBP-6A and R-BBP-6B encountered a surficial layer of topsoil / firm clayey silt fill underlain by a very loose to compact non-cohesive till layer consisting of silt and sand to silty sand. In borehole R-BBP-6A, interlayers of firm to very stiff clayey silt and clayey silt till were encountered between the fill and non-cohesive till deposit.

A summary of the major soil deposits encountered in the boreholes including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole				SPT ‘N’-value Range	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	R-BBP-6A		R-BBP-6B				
	Depth (m bgs)	Elevation (m)	Depth (m bgs)	Elevation (m)			
Topsoil	0 - 0.13	262.5 – 262.4	0 – 0.15	259.6 – 259.4	-	-	-
Firm Clayey Silt Fill	0.13 - 0.6	262.4 - 262.0	0.15 - 1.6	259.4 - 257.9	4 to 8	19	-
Interlayered Firm to Very Stiff Clayey Silt and Clayey Silt Till	0.6 - 5.1	262.0 - 257.4	-	-	7 to 25	12 to 19	E1-1 (<i>Plasticity Chart</i>) E1-2 (<i>Grain Size Distribution</i>)
Very Loose to Compact Silt and Sand to Silty Sand Till ^a	5.1 - 18.9	257.4 - 243.6	1.6 - 18.9	257.9 - 240.6	3 to 28	10 to 20	E1-3 (<i>Plasticity Chart</i>) E1-4 (<i>Grain Size Distribution</i>)

Notes:

a. Deposit contains interlayer of wet compact sandy silt layer in borehole R-BBP-6B between Elevation 256.6 m and 255.0 m (see Figure E1-5 (Grain Size Distribution)).

A standpipe piezometer was installed in boreholes R-BBP-6A and R-BBP-6B and the measured water levels are provided in Section 4.3.

4.2.5 Culvert Site No. 37X-2564/C0

The structural culvert located between Yonge St. and 2nd Concession (Culvert 37X-2564/C0) is shown on Drawing 5 along with the closest borehole CL-BBP-9. A copy of the borehole record and associated laboratory test results are provided in Appendix E.

In general, the borehole encountered a surficial layer of topsoil / fill overlying layers of very loose to compact silty sand, sand, and silt. The silt is underlain by a deposit of very stiff clayey silt-silt which is underlain by a layer of dense sandy silt.

A summary of the major soil deposits encountered in the borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole		SPT 'N'- value Range (C _u - field vane)	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	CL-BBP-9				
	Depth (m bgs)	Elevation (m)			
Topsoil / Silty Sand Fill	0 – 0.2	220.1 – 219.8	-	-	-
Very Loose to Loose Silty Sand to Sand with Clayey Silt Interlayer	0.2 – 2.5	219.8 – 217.6	1 to 8 (60 kPa)	19 to 29	E2-3 (<i>Plasticity Chart</i>) E2-4 (<i>Grain Size Distribution</i>)
Loose to Compact Silt	2.5 – 9.6	217.6 – 210.6	5 to 24	16 to 21	E2-3 (<i>Plasticity Chart</i>) E2-4 (<i>Grain Size Distribution</i>)
Very Stiff Clayey Silt-Silt	9.6 – 11.7	210.6 – 208.4	17 to 24	18 to 21	E2-1 (<i>Plasticity Chart</i>) E2-2 (<i>Grain Size Distribution</i>)
Dense Sandy Silt	11.7 – 12.8	208.4 – 207.3	30	18	-

C_u – Insitu shear strength measured using field vane (kPa)

A standpipe piezometer was installed in borehole CL-BBP-9 and the measured water levels are provided in Section 4.3.

4.2.6 Culvert Site No. 37X-2565/C0

The structural culvert located between Yonge St. and 2nd Concession (Culvert 37X-2565/C0) is shown on Drawing 5 along with the closest borehole CL-BBP-10. A copy of the borehole record and associated laboratory test results are provided in Appendix E.

In general, the borehole encountered a surficial layer of topsoil / fill overlying a firm silty clay layer. Underlying the silty clay, a layer of silty sand was encountered which was underlain by alternating layers of compact silt and stiff to very stiff clayey silt-silt.

A summary of the major soil deposits encountered in the borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole		SPT ‘N’- value Range	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	CL-BBP-10				
	Depth (m bgs)	Elevation (m)			
Topsoil / Silty Sand Fill	0 – 0.8	220.0 – 219.2	-	-	-
Firm Silty Clay	0.8 – 1.8	219.2 – 218.3	5	28	E2-1 (<i>Plasticity Chart</i>)
Compact Silty Sand to Sand	1.8 – 3.5	218.3 – 216.5	13 to 18	19	E2-4 (<i>Grain Size Distribution</i>)
Compact Silt	3.5 – 5.6	216.5 – 214.4	12 to 29	18	E2-3 (<i>Plasticity Chart</i>) E2-4 (<i>Grain Size Distribution</i>)
Stiff to Very Stiff Clayey Silt to Clayey Silt-Silt	5.6 – 9.4	214.4 – 210.6	14 to 23	18	E2-1 (<i>Plasticity Chart</i>) E2-2 (<i>Grain Size Distribution</i>)
Compact Silt	9.4 – 11.7	210.6 – 208.3	15 to 21	17 to 20	E2-3 (<i>Plasticity Chart</i>) E2-4 (<i>Grain Size Distribution</i>)
Very Stiff Clayey Silt-Silt	11.7 – 12.8	208.3 – 207.2	23	-	-

A standpipe piezometer was installed in borehole CL-BBP-10 and the measured water levels are provided in Section 4.3.

4.2.7 Culvert (Bridge) Site No. 37X-2558/B1&B2

The previously proposed structural culvert at this location is now a proposed bridge structure (37X-2558/B1&B2) located between Yonge St. and 2nd Concession within the flood diversion channel and is shown on Drawing 5 along with the closest boreholes (FD-01 and FD-02). The borehole records and associated figures containing laboratory test results are provided in Appendix E.

In general, boreholes FD-01 and FD-02 encountered a near surface layer of very soft to soft clayey silt underlain by very loose to compact silty sand. In FD-02, a very loose to loose layer of silty sand containing clay seams and trace rootlets was encountered above the soft clayey silt, suggesting that this surficial silty sand layer be fill placed around the edge of the existing surface water channel. Underlying the soft clayey silt and loose silty sand deposits, interlayers of compact to very dense silt, sandy silt to silty sand and firm to very stiff clayey silt to clayey silt-silt were encountered, which were underlain by a deposit of firm to hard clayey silt to silty clay.

A summary of the major soil deposits encountered in the boreholes including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole				SPT 'N'-value Range (C _u - field vane)	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	FD-01		FD-02				
	Depth (m bgs)	Elevation (m)	Depth (m bgs)	Elevation (m)			
Very Loose to Loose Silty Sand (Possible Fill)	-	-	0 – 2.4	221.8 – 219.4	3 to 7	10	E2-4 (<i>Grain Size Distribution</i>)

Idealized Stratigraphy	Borehole				SPT 'N'-value Range (C _u - field vane)	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	FD-01		FD-02				
	Depth (m bgs)	Elevation (m)	Depth (m bgs)	Elevation (m)			
Very Soft to Soft Clayey Silt	0 – 1.4	220.0 – 218.6	2.4 – 3.0	219.4 – 218.8	2 to 3	20 to 27	E2-1 (<i>Plasticity Chart</i>) E2-2 (<i>Grain Size Distribution</i>)
Very Loose to Compact Silty Sand	1.4 - 5.6	218.6 – 214.3	3.0 – 4.9	218.8 – 216.9	3 to 27	15 to 20	E2-4 (<i>Grain Size Distribution</i>)
Stiff to Very Stiff Clayey Silt to Clayey Silt-Silt	5.6 – 12.5	214.3 – 207.5	4.9 – 6.3	216.9 – 215.4	9 to 26 (50 kPa)	15 to 20	E2-1 (<i>Plasticity Chart</i>) E2-2 (<i>Grain Size Distribution</i>)
Compact to Very Dense Sand and Silt ^a	12.5 – 20.1	207.5 – 199.8	6.3 – 23.2	215.4 – 198.6	6 to 133	15 to 20	E2-3 (<i>Plasticity Chart</i>) E2-4 (<i>Grain Size Distribution</i>)
Firm to Hard Clayey Silt-Silt to Silty Clay	20.1 – 40.2	199.8 – 179.7	23.2 – 34.1	198.6 – 187.6	3 to 32 (40 to >96 kPa)	22 to 40	E2-5 (<i>Plasticity Chart</i>) E2-6 (<i>Grain Size Distribution</i>)

Notes:

a. Deposit contains interlayers of firm to very stiff clayey silt-silt in FD-02 (see Figure E2-1 (*Plasticity Chart*)).

C_u – Insitu shear strength measured using field vane (kPa)

In FD-01, the water level was measured at 1.7 m bgs (El. 218.3 m) inside the hollow stem augers during drilling operations and before mud rotary advancement. A standpipe piezometer was installed in borehole FD-02 and the measured water levels are provided in Section 4.3.

4.2.8 Wildlife Crossing Culvert at Station 24+080

The approximate location of the proposed wildlife crossing is shown on Drawing 6 along with the closest borehole DC-03. The borehole record and associated figures containing laboratory test results are provided in Appendix C.

In general, borehole DC-03 encountered a surficial layer of topsoil underlain by a deposit of compact to very dense silty sand to sandy silt overlying a stiff to hard clayey silt-silt to clayey silt deposit containing interlayers of very dense silt.

A summary of the major soil deposits encountered in the borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole		SPT 'N'-value Range	Moisture Content Range (%)	Laboratory Figures (Appendix C)
	DC-03				
	Depth (m bgs)	Elevation (m)			
Topsoil	0 - 0.13	223.6 – 223.5	-	-	-

Idealized Stratigraphy	Borehole		SPT 'N'-value Range	Moisture Content Range (%)	Laboratory Figures (Appendix C)
	DC-03				
	Depth (m bgs)	Elevation (m)			
Compact to Very Dense Silty Sand to Sandy Silt	0.13 - 3.2	223.5 - 220.4	11 to 57	8 to 12	C1 (<i>Plasticity Chart</i>) C2 (<i>Grain Size Distribution</i>)
Stiff to Hard Clayey Silt-Silt to Clayey Silt ^a	3.2-20.4	220.4 - 203.2	11 to 115	10 to 24	C3 (<i>Plasticity Chart</i>) C4 (<i>Grain Size Distribution</i>)

Notes:

a. Deposit contains silt and sand seams and very dense silt layers were encountered between Elevation 214.9 m and 213.4 m and Elevation 211.9 and 210.3 m.

A standpipe piezometer was installed in borehole DC-03 and the measured water levels are provided in Section 4.3.

4.2.9 Culvert Site No. 37X-2566/C1&C2

The structural culvert located at the western limit of the BBP / Highway 404 Interchange Ramps (37X-2566/C1&C2) is shown on Drawing 7 along with the closest borehole R-404-2. The borehole record and associated figures containing laboratory test results are provided in Appendix E.

In general, borehole R-404-2 encountered a layer of topsoil and fill overlying a very soft to very stiff sandy clayey silt-silt till, which overlies a loose to dense silt and sand till, which in turn overlies a compact to very dense silt.

A summary of the major soil deposits encountered in the borehole including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole		SPT 'N'-value Range	Moisture Content Range (%)	Laboratory Figures (Appendix E)
	R-404-2				
	Depth (m bgs)	Elevation (m)			
Topsoil	0 – 0.14	245.0 - 244.9	-	-	-
Loose Sandy Silt Fill	0.14 - 1.4	244.9 - 243.5	6 to 8	23	-
Very Soft to Very Stiff Sandy Clayey Silt-Silt Till	1.4 - 7.2	243.5 – 237.8	2 to 27	10 to 20	E3-1 (<i>Plasticity Chart</i>) E3-2 (<i>Grain Size Distribution</i>)
Loose to Dense Silt and Sand Till	7.2 - 13.3	237.8 - 231.7	9 to 37	9 to 11	E3-3 (<i>Plasticity Chart</i>) E3-4 (<i>Grain Size Distribution</i>)
Compact to Very Dense Silt	13.3 - 15.8	231.7 - 229.1	25 to 54	17	E3-5 (<i>Grain Size Distribution</i>)

A standpipe piezometer was installed in borehole R-404-2 and the measured water levels are provided in Section 4.3.

4.2.10 Culvert Site Nos. 37X-2567/C0 and 37X-2568/C0

The structural culverts located at the southern limit of the BBP / Highway 404 Interchange Ramps (37X-2567/C0 and 37X-2568/C0) are shown on Drawing 8 along with the closest boreholes (C2-1 and C2-6). The borehole records and associated figures containing laboratory test results are provided in Appendix D.

In general, boreholes C2-1 and C2-6 encountered a surficial layer of very soft to soft clayey silt with organics to organic silt, overlying a firm to hard clayey silt deposit, which overlies a very dense silt to silty sand deposit. In borehole C2-6, the silty sand deposit is underlain by a hard clayey silt layer.

A summary of the major soil deposits encountered in the boreholes including the range in depth and elevation, measured Standard Penetration Test (SPT) 'N'-values (excluding surficial soils), laboratory moisture contents, and reference to laboratory figures is provided below.

Idealized Stratigraphy	Borehole				SPT 'N'-value Range)	Moisture Content Range (%)	Laboratory Figures (Appendix D)
	C2-1		C2-6				
	Depth (m bgs)	Elevation (m)	Depth (m bgs)	Elevation (m)			
Very Soft to Soft Clayey Silt with Organics / Organic Silt	0 - 0.7	251.2 - 250.5	0 - 1.1	248.0 - 246.9	1 to 4	51	-
Firm to Hard Clayey Silt	0.7 - 7.2	250.5 - 244.0	1.1 - 7.2	246.9 - 240.8	11 to 181	19 to 33	D1 (Grain Size Distribution) D2 (Plasticity Chart)
Very Dense Silt to Silty Sand	7.2 - 9.8	244.0 - 241.5	7.2 - 9.5	240.8-238.5	83 to 118	19 to 22	-
Hard Clayey Silt	-	-	9.5 - 9.8	238.5 - 238.2	111	20	D2 (Plasticity Chart)

A standpipe piezometer was installed in borehole C2-1 and C2-6 and the measured water levels are provided in Section 4.3.

4.3 Groundwater Conditions

The water levels measured in the open boreholes at the time of the investigation are shown on the borehole records and are not considered representative of the hydrostatic water levels at the site due to the addition of drilling fluids/water into the boreholes and/or considering the water levels did not have sufficient time to stabilize.

Standpipe piezometers were installed in nine boreholes advanced during the current and previous investigations to allow monitoring of the groundwater level at this site. The groundwater levels recorded in the piezometers from the current and previous investigations are shown on the borehole records in Appendices A to E and are summarized below.

Culvert Site No.	Borehole No. (Piezometer)	Ground Surface Elevation (m)	Depth (Elevation) of Screen Interval / Sand Pack	Stratigraphy along Well Screen	Depth (bgs) to Water Level (m)	Water Level Elevation (m)	Date of Water Level Reading
30X-0878/C0	R-BBP-6A	262.5	15.2-18.3 (247.3-244.2)	Silty Sand Till	0.3	262.2	Dec. 8, 2023

Culvert Site No.	Borehole No. (Piezometer)	Ground Surface Elevation (m)	Depth (Elevation) of Screen Interval / Sand Pack	Stratigraphy along Well Screen	Depth (bgs) to Water Level (m)	Water Level Elevation (m)	Date of Water Level Reading
30X-0879/C0	R-BBP-6B	259.6	3.1-4.6 (256.5-255.0)	Sandy Silt	2.8	256.8	Dec. 8, 2023
37X-2564/C0	CL-BBP-9	220.1	6.1-7.6 (214.0-212.5)	Silt	0.3	219.8	Dec. 7, 2023
37X-2565/C0	CL-BBP-10	220.0	1.5-3.1 (218.5-216.9)	Silty Sand to Sand	0.5	219.5	Dec. 7, 2023
37X-2558/ B1&B2	FD-02	221.8	1.8-4.8 (220.0-217.0)	Silty Sand and Clayey Silt	0.9	220.9	Dec. 7, 2023
Wildlife Crossing	DC-03	223.6	6.2-7.7 (217.4-215.9)	Clayey Silt	7.2 ¹	216.4 ¹	Dec. 5, 2022
					1.5	222.1	Dec. 7, 2023
37X-2566/ C1&C2	R-404-2	245.0	12.2-15.2 (232.8-229.8)	Silt and Sand Till to Silt	2.8	242.2	Dec. 7, 2023
37X-2568/C0	C2-1	251.2	7.6-9.1 (243.6-242.1)	Silt	0.3	250.9	Jun. 12, 2009
37X-2567/C0	C2-6	248.0	7.6-9.1 (240.4-238.9)	Silty Sand	2.8	245.2	Jun. 12, 2009

Note: 1. Water level measured on date of well installation and is not considered to be representative of stabilized ground water levels.

The groundwater levels measured at all sites are subject to seasonal fluctuations and precipitation events; the water levels are expected to be higher during the spring season or during and following periods of heavy precipitation and snow melt.

4.4 Analytical Testing

Eight soil samples (six from the current investigation and two from the previous investigation at the BBP / Highway 400 site) were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. Detailed analytical test results are included in Appendix A and E and the test results are summarized below:

Borehole No. – Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Chlorides (µg/g)	Soluble Sulphates (µg/g)
400-1 – 3	7.77	1,100	893	480	< 20
400-4 – 3	7.88	2,300	435	180	< 20
R-BBP-6A – 3	7.75	9,200	108	<20	<20
R-BBP-6B – 3&4	7.9	9,700	103	<20	<20
CL-BBP-9 – 1&2	7.68	5,200	191	<20	61
CL-BBP-10 – 2	7.69	4,200	239	<20	73
FD-02 – 5	8.01	6,600	152	<20	51
R-404-2 – 3	7.64	6,800	148	<20	27

Groundwater samples were collected for analytical testing from the Golder 2010 investigation. The results are summarised in the table below and provided in Appendix D.

Borehole No.	pH	Chlorides (mg/L)	Sulphates (mg/L)
C2-1	7.95	19.3	24.8

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Madison Kennedy, P.Eng., a Geotechnical Engineer at WSP. Kevin Bentley, P.Eng., a Geotechnical Engineer with WSP and MTO Principal Foundations Contact conducted a technical and quality control review of the report.

WSP Canada Inc.



Madison Kennedy, P.Eng.
Geotechnical Engineer



Kevin Bentley, M.E.Sc., P.Eng.
MTO Principal Foundations Contact

MCK/KJB/al

PART B

**PRELIMINARY FOUNDATION DESIGN REPORT
STRUCTURAL CULVERTS
HIGHWAY 400 TO HIGHWAY 404 LINK (BRADFORD BYPASS)
MTO ASSIGNMENT NO. 2019-E-0048**

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation recommendations for planning and preliminary design of structural culverts related to the Bradford Bypass. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced as part of the previous and current subsurface explorations, which at some sites includes interpretation of boreholes that are greater than 250 m away from the proposed structure location.

The Preliminary Foundation Design Report (Part B of this report) including the discussion and preliminary recommendations are intended for the use of MTO and their designers for planning and preliminary design and shall not be 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 Preliminary Foundation Investigation Report (Part A of this report) and may need to subsidise this information with additional investigation based on borehole and structure locations. Where comments are made on construction, they are provided to highlight those aspects that could affect the concept and preliminary design of the project and for which special provisions may be required in the future Contract Documents. Those requiring information on aspects of detail design and 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.

6.2 Project Understanding

There are 16 proposed structural culverts (i.e. culverts with a span greater than 3 m) that will cross below the future Bradford Bypass and associated interchange ramp embankments for the project as shown on Drawings 1 to 8. There is one structural culvert that will be used for a wildlife crossing at about Station 24+080 and will not be used to convey water. Also, one of the originally proposed structural culverts was revised to a twin bridge structure (Site No. 37X-2558/B1&B2, referred to as the flood diversion structure) and is included in this report for preliminary design purposes.

The proposed structure dimensions and invert elevations, embankment height, closest relevant borehole(s) and reference drawing are summarized in Table 1 following the text of this report. The proposed culvert dimensions, invert elevations and locations were provided by AECOM on July 7 and confirmed December 8, 2023.

6.3 General Foundation Design Context

6.3.1 Consequences and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code CAN/CSA S6-19* (CHBDC, 2019) and its *Commentary*, the structural culverts and their associated foundation system(s) may be classified as having large traffic volumes and their performance as having potential impacts on other transportation corridors, resulting in a “typical consequence level” associated with exceeding limit states design.

Based on the preliminary level of foundation investigation completed to date (see Part A of this report) in comparison to the degree of site understanding, the level of confidence for design of the structure foundation elements and associated embankments has been assessed as a “low degree of site and prediction model understanding”. Where existing boreholes were located within 250 m of the proposed culvert location, the

existing borehole information was used for preliminary design and supplemental boreholes advanced at the remaining structure sites. At culvert 30X-0880/CO, access to the culvert site was restricted and as such, borehole information from greater than 250 m away from the site was used for preliminary design. The location and site number for the wildlife crossing was not confirmed at the time of this report, however, the approximate location was provided and used to provide preliminary foundation information. The recommendations contained in this report are generalized for planning and ongoing preliminary design and further investigation will be required during detail design.

Accordingly, the ultimate limit state (ULS) and serviceability limit state (SLS) consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} for a low degree of site understanding, from Tables 6.1 and 6.2 of CHBDC (2019) have been used at this stage of preliminary design. During detail design, additional investigation and testing must be performed to increase the level of confidence and the geotechnical resistance factors modified as appropriate. In addition, reference is made to the MTO Material Engineering and Research Office (MERO) Memorandum #2020-01 (dated March 23, 2020) for developing future geotechnical resistance values and settlement and stability analyses during detail design, as applicable.

6.4 Structural Culvert Foundations

6.4.1 General Foundation Options

Precast closed box culverts and cast-in-place open footing culverts have been considered for the structural culverts for the Bradford Bypass. The general advantages and disadvantages associated with each culvert type are summarised in Table 2, following the text of this report.

From a foundations perspective, precast closed box culverts with flexible joints to allow for differential movement / settlement are recommended for structural culverts with spans typically less than 12 m, provided competent foundation soils are present. Open footing culverts founded on deep foundations or shallow foundations (as applicable) are recommended for culverts with spans typically greater than 12 m due to the challenges associated with manufacturing and transporting precast box segments of this size. Precast closed box options are not considered feasible for spans greater than 12 m at this preliminary stage. The feasibility of the culvert options at each structural culvert site is summarized in Table 3.

6.4.2 Founding Elevations and Frost Protection Requirements

6.4.2.1 Precast Closed Box Culvert

It is generally not considered necessary to found a precast closed box culvert at or below the depth of frost penetration, as precast box structure segments are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. Consideration should be given to sealing joints to adequately control water and soil infiltration at locations of high frost susceptibility.

Table 3, following the text of this report, provides a summary of recommended founding elevations and founding soils for precast closed box options where feasible at each culvert site, assuming general culvert base thickness of about 0.3 m. It should be noted that bedding layer thickness, levelling pad, and actual culvert base thickness will need to be confirmed during detail design and the recommendations checked and revised as appropriate.

6.4.2.2 Open Footing Culvert

Shallow / strip footings and pile caps (for deep foundation option) for an open footing culvert 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*). Consideration could be given to using insulation for frost protection in lieu of soil cover, although consideration must be given to the effects of differential settlement, scour and erosion.

Table 3, following the text of this report, provides a summary of recommended founding elevations and founding soils for an open footing culvert option based on the invert elevations and nearest borehole information. For culverts with spans greater than 12 m, deep foundation options are also provided.

6.4.3 Factored Geotechnical Resistances

6.4.3.1 Precast Closed Box Culvert

Precast closed box culverts placed on properly prepared subgrade, at or below the founding elevations recommended in Table 3, should be designed based on the factored ultimate geotechnical resistances at Ultimate Limit States (ULS) as given in Table 3. These recommendations are based on the associated culvert width dimensions and assume all topsoil, soils containing excessive organics, and any existing fill soils have been stripped and the founding soils identified in Table 3 are confirmed. The factored serviceability geotechnical resistances at Serviceability Limit States (SLS) will need to be evaluated during detail design, although the anticipated settlement of the culverts will likely be governed by the adjacent embankment height and thickness of soil cover above the culvert which is discussed in Section 6.5.

The factored geotechnical resistances are dependent on the culvert width, founding soils / elevations, and embankment configuration and as such, the geotechnical resistances will need to be reviewed and revised as necessary during detail design.

The factored ultimate geotechnical resistances provided in Table 3 are based on loading applied perpendicular to the horizontal bottom of the foundation / base slab. Where load is not applied perpendicular to the horizontal founding level, inclination of the load should be taken into account.

6.4.3.2 Open Footing Culvert – Shallow Foundations

Shallow / strip footings placed on the properly prepared subgrade, at or below the founding elevations recommended in Table 3, should be designed based on the factored ultimate geotechnical resistance at ULS as given in Table 3. These recommendations are based on assumed footing widths of 0.6 m to 1.2 m for culverts with spans less than 12 m, and footing widths of 1.5 m to 5.0 m for culverts with spans greater than 12 m. The factored serviceability geotechnical resistances at SLS will need to be evaluated during detail design, although the anticipated settlement of the culverts will likely be governed by the adjacent embankment height and thickness of soil cover above the culvert which is discussed in Section 6.5.

The factored geotechnical resistance values are dependent on the culvert footing and founding soils / elevations and embankment configuration and as such, the geotechnical resistances will need to be reviewed and revised as necessary during detail design.

The factored ultimate geotechnical resistances provided in Table 3 are based on loading applied perpendicular to the surface of the horizontal footings. Where load is not applied perpendicular to the surface of the footings, inclination of the load should be taken into account.

6.4.3.3 Open Footing Culvert – Deep Foundations

Open footing culverts founded on deep foundations are considered a practical option for the large span (>12 m span) structural culverts. For preliminary design, the factored geotechnical resistance at ULS for a driven steel HP 310x110 pile are provided in Table 3. In most cases, the closest boreholes did not achieve

effective refusal upon the borehole termination depth and recommendations are limited to friction piles driven to the termination depth of the borehole. Where design geotechnical resistances are low, an estimated higher geotechnical resistance at ULS is provided for planning purposes only based on the deeper borehole information obtained from the closest proposed bridge location(s). The estimated factored ultimate geotechnical resistances provided are calculated based on both shaft and tip resistances, and assume piles have sufficient time to “set-up” and allow pore pressures to dissipate after initial driving in order to achieve the design geotechnical resistances. If higher factored geotechnical resistances are required, consideration can be given to increasing the pile size (e.g., HP 360x132 or larger tube piles) or using caissons and/or increasing the length of the deep foundations. The factored serviceability geotechnical resistances at SLS will need to be evaluated during detail design when more site specific and deeper borehole information is available. Downdrag loads due to adjacent embankments and soil cover above the culverts will also need to be considered during detail design.

For preliminary design, driven steel piles spaced at 3 pile diameters (centre-to-centre) can be assumed to act as single piles with no group interaction effects with regards to axial resistance. For piles spaced less than 3 diameters, the total pile axial resistance should be reduced by a group reduction factor (R_A) (Reese, 2006) as follows:

Pile Spacing (d = Pile Diameter)	Pile Axial Resistance Group Reduction Factor (R_A)
3.0 d	1.0
1.5 d	0.7
1.25 d	0.55

Pile installation should be carried out in accordance with Ontario Provincial Standard Specification (OPSS) PROV 903 (*Deep Foundations*) as amended by Special Provision 109F57 with High-Strain Dynamic testing specified on at least 20% of the piles or two piles at each foundation element (whichever is greater) in each stage of construction.

In order to optimize the design and reduce the risk of piles not achieving the design geotechnical resistance at the design tip elevation during construction, it is recommended that the contracting authority or the design-builder consider a combination of the following options:

- Advanced site-specific investigation during detail design to meet a minimum typical degree of understanding and confirm or adjust axial geotechnical resistances for design;
- Advanced static pile load test per ASTM D-1143, which would permit application of higher geotechnical resistance factors and may allow for evaluation of strength gain with time; and
- High-strain dynamic testing (PDA) on an appropriate percentage of piles at end-of-initial drive (EOID) and beginning-of-restrike (BOR) after a rest period of at least three to five days, and possibly up to 14 days in the cohesive and fine-grained nature of the foundation soils.

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 or advanced static pile load testing.

6.4.4 Resistance to Lateral Loads / Sliding Resistance – Precast Box Culvert and Shallow Footings

Resistance to lateral forces / sliding resistance between the base of the precast box culvert, or strip footings for the open footing culverts, and the subgrade should be calculated in accordance with Section 6.10.4 of CHBDC (2019). The following table provides the coefficients of friction ($\tan \delta$) between the base of the culverts/footings and potential interface materials encountered at the culvert sites.

Soil Type	Interface Material	Coefficient of Friction (Tan δ)
New Granular Fill (Granular 'A' or 'B' Type II)	Precast Concrete	0.45
	Mass Concrete	0.65
Firm to Stiff Clayey Silt	Precast Concrete	0.25
	Mass Concrete	0.35
Very Stiff to Hard Clayey Silt	Precast Concrete	0.25
	Mass Concrete	0.45
Loose to Compact Silty Sand Till	Precast Concrete	0.3
	Mass Concrete	0.45
Compact to Very Dense Silty Sand Till	Precast Concrete	0.3
	Mass Concrete	0.5
Stiff to Very Stiff Sandy Clayey Silt-Silt Till	Precast Concrete	0.3
	Mass Concrete	0.47
Very Loose to Compact Silty Sand to Sand	Precast Concrete	0.3
	Mass Concrete	0.35
Compact to Very Dense Silty Sand	Precast Concrete	0.3
	Mass Concrete	0.45
Loose to Compact Silt	Precast Concrete	0.25
	Mass Concrete	0.3

6.4.5 Resistance to Lateral Loads – Deep Foundations

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 level), the structural capacity of the pile to withstand bending moments and shear, the soil resistance that can be mobilized, the tolerable lateral deflections at the head of the pile and group effects. Lateral loading could be resisted fully or partially by the use of battered piles. For vertical piles, the resistance to lateral loading will have to be derived from the soil in front of the piles.

For design purposes, both the structural and geotechnical resistances should be evaluated to establish the governing case. Lateral pile / caisson analysis for detail design should be carried out using non-linear

methods (such as p-y curves) when the pile / caisson group configuration is established as per the CHBDC (2019).

For preliminary design, the resistance to static lateral loading in front of the piles may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k_h (kPa/m), is based on the following equations (CFEM, 2002 as referenced in CHBDC, 2006):

For non-cohesive soils:

$$k_h = \frac{n_h z}{B} \quad \text{Where } n_h \text{ is the constant of subgrade reaction (kPa/m);}$$

$$z \text{ is the depth (m); and}$$

$$B \text{ is the pile / caisson diameter or width (m).}$$

For cohesive soils:

$$k_h = \frac{67S_u}{B} \quad \text{Where } S_u \text{ is the undrained shear strength of the soil (kPa); and}$$

$$B \text{ is the pile / caisson diameter or width (m).}$$

For preliminary design purposes, the following values of n_h and S_u may be assumed in the structural analyses for a single vertical pile, using the interpreted stratigraphic conditions from the boreholes described in Section 4.0. The range in the values reflect the general variability of the subsurface conditions, the soil properties and groundwater level measured along the alignment, and the approximate nature of the linear-elastic subgrade reaction analysis. Values for each site should be checked and revised during detail design when additional subsurface information is available.

Soil Unit	n_h (kPa/m)		S_u (kPa)
	Above Water Table	Below Water Table	
New Granular Fill (Granular 'A' or 'B' Type II)	40,000 – 50,000	20,000 – 30,000	
Firm to Stiff Clayey Silt	-	-	50-75
Very Stiff to Hard Clayey Silt	-	-	75-100
Loose to Compact Silty Sand Till	15,000 - 25,000	10,000 - 15,000	-
Compact to Very Dense Silty Sand Till	20,000 – 30,000	15,000 - 20,000	-
Stiff to Very Stiff Sandy Clayey Silt-Silt Till	-	-	50-100
Very Loose to Compact Silty Sand to Sand	5,000 - 15,000	4,000 – 10,000	-
Compact to Very Dense Silty Sand	15,000 – 25,000	10,000 – 15,000	-
Loose to Compact Silt	3,000 – 5,000	2,500 – 4,000	-

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).

6.4.6 Downdrag Loads on Piles / Caissons

Based on the subsurface conditions and height of embankment at the culvert locations, post construction settlement is anticipated to be up to about 150 mm at some sites. As a result, downdrag loads will need to be assessed further during detailed design. Downdrag loads can likely be mitigated by designing piles to resist

the additional load in the structural design and/or reducing downdrag forces by preloading the foundation soil to induce settlements prior to driving piles or installing caissons.

6.5 Embankment Stability and Settlement

Given the limited borehole information and approximate location relative to the structures, detailed embankment settlement and stability was not carried at the culvert sites. However, based on stability analyses carried out at bridge structures near the structural culvert sites, an adequate factor of safety against global instability is anticipated for new embankments constructed with suitable granular fill with side slopes of 2 Horizontal to 1 Vertical (2H:1V) to 2.5H:1V (with mid-height 2 m wide benches for embankments higher than 8 m). Stability analyses at each culvert site will need to be carried out during detail design, and/or when additional subsurface information is available, to confirm that the required Factor of Safety is achieved. For preliminary design, it is assumed that prior to construction of the new approach embankments, all topsoil and peat/organic soil, existing fill materials, and near-surface softened / loosened soils be stripped from the footprint of the new embankments and replaced with suitable granular fill. In addition, a 2 m wide bench should be incorporated into the design of the embankment slopes as required for embankment heights greater than 8 m in height in accordance with OPSD 202.010 (*Slope Flattening*).

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 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. Long term (consolidation) settlement is anticipated at several of the culvert sites due to the presence of compressible clayey and fine-grained soils. Estimates of the magnitude of embankment settlement at each structural culvert site are provided in Table 3. The estimated settlements are based on the height of embankment fill, generalized subsurface information, and associated embankment settlement estimates at the adjacent bridge structures that was carried out for the overall project. Where the settlement performance criterion is not met, mitigations such as preloading, the use of a lightweight fill (e.g., lightweight slag, cellular concrete, or lightweight expanded polystyrene), or other ground improvement options could be considered. Embankment settlements and mitigation measures should be evaluated at each culvert location, along with differential settlement along the culvert induced by embankment construction, during detail design.

6.6 Lateral Earth Pressures for Design

The lateral earth pressures acting on the structural culvert walls and any associated concrete headwalls/retaining walls will depend on the type and method of placement of the backfill material, 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 culvert walls. 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.

- 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 culvert walls, and on top of the culvert for a thickness of not less than 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness and compacted. Longitudinal drains or weep holes, where applicable, 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*).

- For restrained walls (e.g. box culvert), 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 (e.g. open footing culvert), fill should be placed within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H: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)).

If the culvert structure does not allow for lateral yielding, at-rest earth pressures should be assumed for the foundation design. If the culvert structure allows for lateral yielding, active earth pressures should be used in the foundation design. The movement required to allow active pressures to develop within the backfill, and there by 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).

6.7 Corrosion Assessment and Protection

Soil corrosivity may affect the concrete and/or steel elements (e.g. reinforcing steel) of foundations or related structures buried in the soil. The long-term performance and durability of the foundations are directly related to their respective corrosion resistance. Generally, the corrosivity potential to a structure can be assessed based on indicators such as the soil resistivity / electrical conductivity, hydrogen ion concentration (pH), and salts (chloride and sulphate) concentrations. The analytical results for the soil and groundwater samples submitted for testing from the previous and current investigations are summarized in Section 4.4 and the analytical laboratory test reports are included in Appendices A, D and E.

6.7.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-19 Table 3 (*“Additional requirements for concrete subjected to sulphate attack”*) for potential sulphate attack on concrete. The soluble sulphate concentration measured in the tested soil samples ranged from less than 20 µg/g (< 0.002%) to 73 µg/g (0.0073%) and were about 25 mg/L in the sample of groundwater tested. The results of the analysis indicate that the sites are below the exposure class of S-3 (Moderate). Therefore, based on the soil and groundwater samples tested, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

6.7.2 Potential for Corrosion

The test results indicate a pH ranging from 7.6 to 8.0 and a resistivity ranging from 1,100 to 9,700 ohm-cm. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to durability. However, the resistivity indicates that the soil corrosiveness ranges from Very Low (10,000 ohm-cm > R > 6,000 ohm-cm) to Severe (R < 2,000 ohm-cm), as per Table 3.2 of the Gravity Pipe Design Guidelines (MTO, 2014). The corrosion potential in each area is summarized in the table below and the appropriate corrosion protection should be applied to the foundation element / materials. Further, given that the foundations are located adjacent to the highway shoulder and near/within ditches and will be exposed to de-icing salt, consideration should be given to selection of a “C” type exposure class as defined by CSA A23.1 Table 1.

Culvert/Structure	Resistivity (ohm-cm)	Corrosiveness ¹
30X-0566/C0 30X-0874/C0 30X-0875/C0 30X-0876/C0 ² 30X-0877/C0 ²	1100 – 2300	Severe
30X-0878/C0 30X-0879/C0 30X-0880/C0 ²	9,200-9,700	Very Low
37X-2564/C0 37X-2565/C0 37X-2558/B1&B2 (Flood Diversion Structure) Wildlife Crossing ²	4,200 -6,600	Low to Moderate
37X-2566/C1 & C2 (2 Culverts) 37X-2567/C0 ² 37X-2568/C0 ²	6,800	Very Low

Notes:

1. Classification based on National Cooperative Highway Research Program (NCHRP) ,Service Life of Drainage Pipe (1998); where: Very Low (6,000 ohm-cm < R < 10,000 ohm-cm); Low (,4500 ohm-cm < R < 6,000 ohm-cm); Moderate (2,000 ohm-cm < R < 6,000 ohm-cm); and Severe (R < 2,000 ohm-cm).
2. Analytical testing not available from borehole(s) related to culvert site, and as such results from the nearest culvert borehole were used. The corrosion potential at these sites should be evaluated in future investigations and during detail design.

These recommendations are provided as guidance only, particularly where boreholes were not advanced and data from adjacent structure boreholes were used; the design-builder should take the results of the laboratory testing into consideration for selecting appropriate materials and corrosion susceptibility for the design service of the structure foundations and determine the appropriate exposure class and ensure that all aspects of CSA A23.1 Section 4.1.1 “Durability Requirements” are followed.

6.8 Construction Considerations

6.8.1 Temporary Excavations / Temporary Protection Systems

In general, temporary excavations for the construction of shallow foundations and/or pile caps and temporary protection systems may be required for construction of the new culverts adjacent to or below existing roads or highways (i.e., Highway 400, Highway 404 and 9th Line).

All temporary excavations must be carried out in accordance with OPSS.PROV 902 (*Excavating and Backfilling*) and Ontario Regulation 213 of the Ontario Occupational Health and Safety Act for Construction Projects (OHSA), as amended. At this preliminary stage, the fill and native soils should be considered Type 3 to Type 4 above the water table and Type 4 below the water table. Temporary excavations (i.e., those open for a relatively short time period) in Type 3 soils should be made with side slopes of no steeper than 1H:1V sloped from the bottom of the excavation. For Type 4 soils, the excavation should be made with side slopes of no steeper than 3H:1V sloped from the bottom of the excavation. The soil types at each site should be reassessed during detail design or when additional geotechnical information is available.

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.

6.8.2 Subgrade Preparation and Embankment Construction

Prior to construction of the new embankments at the culvert locations, it is recommended that all unsuitable soils such as topsoil or organics, and existing surficial fill materials or loosened/softened soils (e.g. from farming activities) be stripped from the embankment footprint and replaced with OPSS Select Subgrade Material (SSM), Granular A or Granular B soils. Stripping requirements at the culvert sites must be confirmed following completion of additional boreholes during detail design.

Engineered fill for construction of the new embankments should consist of OPSS.PROV 1010 (*Aggregates*) granular materials (i.e., SSM, Granular A or Granular B). Earth fill consisting of suitable borrow material from elsewhere on the project may also be considered where sufficient volumes are available. The embankment fill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*) and OPSS.PROV 206 (*Grading*). The required permanent embankment side slopes should be confirmed during detail design.

In accordance with MTO's standard practice, a minimum 2 m wide bench should be provided where embankment slopes are greater than 8 m in height, such that the uninterrupted slope height does not exceed 8 m, consistent with OPSD 202.010 (*Slope Flattening*).

To reduce surface water erosion on the granular embankment side slopes, vegetative cover should be established as per OPSS.PROV 803 (*Vegetative Cover*). Depending on the time of year, temporary erosion control measures such as mulch, bonded fibre matrix (BFM), fiber reinforced matrix (FRM), or erosion control blankets (ECB), should be applied as per OPSS.PROV 804 (*Temporary Erosion Control*) as soon as possible after construction of the embankments.

6.8.3 Closed Box Culvert Bedding and Backfill

Culvert construction, including placement of bedding, cover and backfill should be placed in accordance with OPSS 912 (Precast Concrete Culverts with Spans Greater than 3.0 m) for precast box culverts, and as per OPSS 902 (Excavating and Backfilling – Structures) for open footing culverts.

The bedding, cover and backfill should be placed in lifts not exceeding 200 mm in loose thickness, and compacted to at least 95% of the Standard Proctor Maximum Dry Density (SPMDD) of the material as specified in OPSS.PROV 501 (*Compacting*).

The backfill behind the culvert walls should consist of granular material meeting the OPSS .PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II. The granular backfill should be placed and compacted with OPSS.PROV 501 (*Compacting*).

6.8.4 Erosion Protection

In order to prevent surface water from flowing either beneath the culverts, potentially causing undermining and scouring, or around the culverts, creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles, a clay seal or concrete cutoff wall should be provided at the upstream end of the culverts.

Provision should be made for scour and erosion protection at culvert inlets and outlets and should be designed by the hydraulics engineer during detail design. At a minimum, rip-rap treatment for the outlets of the culverts should be generally consistent with the standards presented in OPSD 810.010 (*General Rip-Rap Layout for Sewer and Culvert Outlets*). Erosion protection for the inlet of the culverts should follow the standard presented in OPSD 810.010 similar to the outlet, but with rip-rap placed up to the high water level, in combination with the cut-off measures noted above.

6.8.5 Groundwater / Surface Water Control

At this preliminary stage it is anticipated that temporary excavations for shallow foundations (if considered) or pile caps will extend below the shallow groundwater table at most of the culverts/structures except the wildlife crossing where the culvert is proposed to be founded on engineered fill, above the groundwater table.

Based on the relatively shallow groundwater levels (typically near ground surface), the fact that the culverts are generally located in active watercourses, and the general interlayered nature of the foundation soils that consist predominantly of cohesionless soils or cohesive soils containing seams/layers of non-cohesive soils, it is anticipated that dewatering and flow diversion efforts will be required to control groundwater seepage and flow into the foundation excavations. Dewatering / flow diversion methods will need to be evaluated further during detail design.

Surface water must be directed away from the excavations at all times, particularly where culvert construction is within active water courses. If required, temporary shoring and groundwater control in the form of a sheet-pile cut-off wall or cofferdam advanced to an appropriate depth to control groundwater inflow and prevent base heave / instability of the foundations subgrade will need to be considered. If temporary protection systems are not required or ground conditions do not allow for their installation, sand bag and/or bladder cofferdam systems could be considered. The need for such systems and their feasibility should be assessed at each culvert site during detail design.

If the excavation operations are carried out in the wet season, the groundwater level could be higher and more extensive groundwater control measures may be required depending on the excavation requirements.

Dewatering operations should be in accordance with OPSS.PROV 517 (*Dewatering*) as referenced in OPSS.PROV 902 (*Excavation and Backfilling – Structures*). Inclusion of a special provision (similar to SP 517F01) for foundation dewatering will need to be considered in the future contract documents during detail design to address potential instability / base heave of the foundation subgrade, temporary flow diversion and pre-construction survey requirements at each culvert and structure site, as applicable.

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.

6.9 Recommendations for Additional Work

The preliminary foundation recommendations provided in this report are based on the limited available subsurface information. Additional foundation investigation and assessment is recommended to be carried out such that boreholes are advanced at each structural culvert site and that the level of confidence for design meets a minimum "typical degree of site and prediction model understanding" for the ultimate culvert/structure configurations.

The additional investigation will need to explore the subsurface soil and groundwater conditions closer at the locations of the structure foundations and any associated retaining walls / headwalls. In particular, borehole(s) should be advanced at structure 30X-0880/C0 where the nearest boreholes are located about 700 m from the structure site. Additional boreholes should also be advanced to greater depths at structures 30X-0878/C0, 30X-0879/C0, 37X-2564/C0 and 37X-2565/C0 to support the design of deep foundations for

the large span (>12 m) structures. Select soil samples from new boreholes should be submitted for analytical testing to assess corrosivity potential where existing information is not available.

Deeper boreholes combined with Seismic Cone Penetration Testing (with dissipation testing at selected depths) is recommended at the Flood Diversion Structure (37X-2558/B1&B2) and surrounding area (high fill area between Yonge St. and 2nd Concession) to provide more detailed information to assess geotechnical resistances for deep foundations, anticipated settlement and rates of consolidation within this area. Pressuremeter testing is recommended in the very loose to compact non-cohesive and firm to very stiff cohesive soils to better predict actual magnitudes of settlement and risks associated with staged construction (i.e. differential settlement) and downdrag forces on deep foundations.

While the seismic site class was not evaluated at this preliminary stage, it is anticipated that geophysics testing, such as Multi-Channel Analysis of Surface Waves (MASW) or Vertical Seismic Profiling (VSP), may provide a more favourable seismic Site Class compared to averaging \bar{N}_{60} values at some sites, and such testing should be considered during detail design at the larger span structures.

After more detailed foundation investigation is complete, the global stability of the approach embankments and will need to be checked and the magnitude and time-rate of settlements (including mitigation measures) will need to be reassessed. Given the variable subsurface conditions along the Bradford Bypass alignment, differential settlement along the culverts, and across and between founding elements of the structure(s) will need to be assessed. When more details are known on actual loading conditions and additional subsurface information is available, the foundation types, sizes and geotechnical resistances will need to be checked and revised as necessary. Additionally, site specific lateral resistance values should be assessed for each structure during detail design.

Additional foundation investigation and design should meet the general requirements outlined in the latest version of the *Guideline for MTO Foundation Engineering Services*. The existing standpipe piezometers installed should be maintained operational to allow for continued monitoring of the groundwater level during detail design and up to construction, at which time the piezometers will need to be decommissioned in accordance with Ontario Regulation 903 (as amended). Additional piezometers should be installed during detail design, where existing wells are not present at the culvert/structure sites, to provide additional information for assessment of dewatering requirements.

7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Madison Kennedy, P.Eng. a geotechnical engineer with WSP. Mr. Kevin Bentley, P.Eng. a Geotechnical Engineer with WSP and MTO Foundations Principal Contact conducted a technical and quality control review of the report.

WSP Canada Inc.



Madison Kennedy, P.Eng.
Geotechnical Engineer



Kevin Bentley, M.E.Sc., P.Eng.
MTO Principal Foundations Contact

MCK/KJB/al

[https://golderassociates.sharepoint.com/sites/120387/project files/6 deliverables/foundations/structural culverts/final/19136074 -bbp structural culverts pfd final-rev0_12dec23.docx](https://golderassociates.sharepoint.com/sites/120387/project%20files/6%20deliverables/foundations/structural%20culverts/final/19136074-bbp%20structural%20culverts%20pfd%20final-rev0_12dec23.docx)

References

- Canadian *Geotechnical Society*. 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code (CHBDC (2019)) and Commentary on CAN/CSA-S6-19*.
- Canadian Standard Association (CSA) Group. Concrete Materials and Methods of Concrete Construction. CSA A23.1-14.
- 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.
- Golder Associates Ltd. 2001. Preliminary foundation investigation and design report, Ninth concession overpass structure site 30-308, Highway 400 widening from York/Simcoe boundary to 1 km south of Highway 89, G.W.P. 40-00-00, Geocres No. 31D00-459.
- Golder Associates Ltd. 2010. Hydrogeological investigation and Design Report, Highway 404 Extension from Queensville Sideroad to Ravenshoe Road, Town of East Gwillimbury, Ministry of Transportation Ontario, W.P. 2005-07-00. GEOCREs No. 31D00-499
- Transportation Research Board (TRB). 1998. "Synthesis of Highway Practice 254 – Service Life of Drainage Pipe", National Cooperative Highway Research Program, National Research Council.
- WSP Golder, 2023. Preliminary foundation investigation and design report, Bradford Bypass / Highway 400 Interchange Ramp Structures (E-S Ramp Over Highway 400, N-E Ramp Over Highway 400 / E-S Ramp), Simcoe County and York Region, MTO Assignment No. 2019-E-0048. Geocres No. 31D-832.
- WSP, 2023. Preliminary foundation investigation and design report, Deep Cut and High Fill Areas, Highway 400 to Highway 404 Link (Bradford Bypass), Simcoe County and York Region, MTO Assignment No. 2019-E-0048. Geocres No. 31D04-004.

ASTM International

ASTM D1586	Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils
ASTM D1587	Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
ASTM D2573	Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils
ASTM D1143	Standard Test Methods for Deep Foundation Elements Under Static Axial Compressive Load

Ontario Provisional Standard Drawing:

OPSD 202.010	Slope Flattening Using Excess Material on Earth or Rock Embankment
OPSD 803.010	Backfill and Cover for Concrete Culverts
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 206	Construction Specification for Grading
---------------	--

OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 803	Construction Specification for Vegetative Cover
OPSS.PROV 804	Construction Specification for Temporary Erosion Control
OPSS.PROV 902	Excavating and Backfilling - Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 912	Precast Concrete Culverts with Spans Greater than 3.0 m
OPSS.PROV 1002	Aggregates – Concrete
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1205	Clay Seal

Ontario Regulations

Ontario Regulation 213	Construction Projects (as amended)
Ontario Regulation 903	Wells (as amended)

Ministry of Transportation, Ontario

MTO Gravity Pipe Design Guidelines, Circular Culverts and Storm Sewers, April 2014.

MTO Foundations Guideline, Embankment Settlement Criteria for Design, July 2010.

Provincial Engineering Memorandum #20201, Material Engineering and Research Office (MERO), March 23, 2020.

Guideline for MTO Foundation Engineering Services, Version 3, dated April 2022.

TABLES

Table 1: Proposed Structural Culvert Details

MTO Site Number	Approximate Height of Embankment ¹	Proposed Dimensions ²			Approximate Invert Elevation ²		Closest Relevant Borehole(s)	Reference Drawing
		Width / Span (m)	Height / Rise (m)	Length (m)	Upstream	Downstream		
30X-0566/C0	Up to 2.5 m grade raise (west limit) but typically less than 1 m grade change from existing ground surface across length of culvert. Less than 1.5 m embankment fill on top of culvert.	5.0	1.5	91	253.0	252.4	400-4	2
30X-0874/C0	Up to 3 m embankment fill. Less than 2.1 m fill on top of culvert.	5.0	1.5	28	253.6	253.6	400-1	2
30X-0875/C0	Up to 6 m embankment fill. Less than 2.9 m fill on top of culvert.	5.5	2.7	32	252.3	252.1	400-4	2
30X-0876/C0	Up to 5 m Up to 3.3 m fill on top of culvert	5	2.7	33	266.7	265.6	B4-1	3
30X-0877/C0	0.5 m cut to lower 9 th Line profile	5	Varies (Minimum 1.8 m)	12.1	269.0	269.0	B4-1	3
30X-0878/C0	Up to 5 m Up to 2.1 m fill on top of culvert	12	2.4	46	258.4	257.8	CL-BBP-6A	4
30X-0879/C0	Up to 9 m Up to 6.0 m fill on top of culvert	12	2.4	70	256.4	255.6	CL-BBP-6B	4
30X-0880/CO	Up to 6.5 m Up to 3.7 m fill on top of culvert	12	2.4	90	263.7	262.8	CL-BBP-6A	4

MTO Site Number	Approximate Height of Embankment ¹	Proposed Dimensions ²			Approximate Invert Elevation ²		Closest Relevant Borehole(s)	Reference Drawing
		Width / Span (m)	Height / Rise (m)	Length (m)	Upstream	Downstream		
37X-2564/C0	Up to 8.5 m Up to 5 m fill on top of culvert	20	3	83	219.6	219.5	CL-BBP-9	5
37X-2565/C0	Up to 6.5 m Up to 2.9 m fill on top of culvert	20	3	74	219.7	219.5	CL-BBP-10	5
37X-2558/B1&B2 (Twin Bridge Structure)	Up to 3 m No fill on top as this culvert has been converted to a twin bridge structure	Twin Bridges, 14 m (interim) 26 m (ultimate)	n/a	32 m single span	Ground surface at about 219.5 m		FD-01 and FD-02	5
Wildlife Culvert (TBD – located at Station 24+080)	Up to 16 m Up to 5.5 m fill on top of culvert (culvert perched in embankment)	12	5	100	232	232	DC-03	6
37X-2566/C1 & C2	Up to 7 m for BBP WBL and W-N and W-S Ramps Up to 3.1 m and 5.3 m on top of culvert along WBL and Ramps	5.4	2.7	64 (under WBL) 77 (under W-N and W-S Ramps)	243.0	242.4	R-404-2	7
37X-2567/C0	Up to 9 m Up to 3.8 m fill on top of culvert	4.9	3.4	49	247.4	246.7	C2-6	8
37X-2568/C0	Up to 5 m Up to 2.2 m fill on top of culvert	4.9	3.4	34	252.3	251.8	C2-1 and C2-6	8

Notes:

1. Relative to existing ground surface adjacent to culvert
2. Culvert dimensions, invert elevations and embankment details provided by AECOM on October 6, November 30 and December 8, 2023

Table 2: Comparison of Foundation Options for Structural Culverts

Option	Advantages	Disadvantages	Risks / Consequences
Precast Closed Box Culvert	<ul style="list-style-type: none">- Minimizes depth of excavation, excavation support and dewatering requirements compared to cast-in-place open footing culverts;- Compared to cast-in-place open footings, the use of precast box segments is expected to allow for faster construction, resulting in shorter duration for dewatering and surface water diversion / pumping (as required);- Precast segments are more tolerant of total and differential settlement than cast-in-place open footings.	<ul style="list-style-type: none">- Cut-off wall or clay seal with erosion protection may be required at inlet to mitigate potential for scour under/along culvert, although erosion protection will also be required to protect open footings;- May require oversizing or deeper founding level to accommodate substrate requirements for fisheries;- Single span precast closed box culverts are not practical for large spans (i.e. ≥12 m), although multi-cell box segments could be considered.	<ul style="list-style-type: none">- Depending on actual soil conditions within footprint, subexcavation of organic or soft / loose soils may be required although subgrade can be re-established with granular engineered fill or increased thickness of bedding;- Differential settlements can likely be accommodated by limiting precast segment lengths and joint tolerance, and designing a camber;- Low risk of requiring extensive dewatering measures due to limited depth.- If multiple adjacent culverts are considered for larger span crossings, differential settlement between culverts as well as along length should be evaluated
Open Footing Culvert	<ul style="list-style-type: none">- May be preferred from fisheries perspective;- Do not need to be oversized to meet fisheries requirements for substrate conditions at the invert;- Cast-in-place or precast culvert segments (e.g. arch) may be considered to be placed on foundations;- Allows for deep foundations options without the need for a structural slab below the culvert base.	<ul style="list-style-type: none">- Deeper excavations that may require temporary excavation support and dewatering compared to precast box culvert for construction of shallow foundations and/or pile caps;- Additional time will be required to implement dewatering system for construction and placement of concrete in the dry;- Higher geotechnical resistances are required for larger span culverts and foundation soils may not provided sufficient resistance.	<ul style="list-style-type: none">- Risk of disturbing native founding soil deposits at some sites with relatively high groundwater during construction, thus, dewatering measures are likely required;- Risk of differential settlement causing post-construction cracks in cast-in-place concrete may require mitigation measures (e.g. preloading or ground improvement) at some sites. A camber may also be incorporated into the design.- A cast-in-place open footing culvert is generally less tolerant of total and differential settlement compared to precast segments with joints.- Deep foundations likely need to extend beyond currently available geotechnical information to achieve the required geotechnical resistances.

Table 3: Preliminary Foundation Recommendations for Structural Culverts

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
30X-0566/C0	Up to 2.5 m grade raise (west limit) but typically less than 1 m grade change from existing ground surface across length of culvert.	5.0	1.5	91	253.0	252.4	400-4 (Groundwater at 1 m bgs El. 253 m)	Precast Closed Box	252.7 / 252.1	Firm to Stiff Clayey Silt to Very Loose to Compact Silty Sand	5.6 base width	175 – 225 kPa	Settlements up to 50 mm (west limit) but typically less than 25 mm	Feasible – culvert segments to be designed to accommodate differential settlement (about 50 mm over 10 m length) near outlet (west side) or preload footprint (less than 3 months)
	Less than 1.5 m embankment fill on top of culvert.							Open Footing - Shallow Foundation	251.5 / 250.9	Stiff to Very Stiff Clayey Silt	0.6 to 0.9 m wide footings	125 – 175 kPa	Settlements up to 40 mm (west limit) but typically less than 25 mm	Feasible – preloading (less than 3 months) recommended near outlet (west side) and near existing east ditch of Hwy 400, dewatering required
30X-0874/C0	Up to 3 m embankment fill.	5.0	1.5	28	253.6	253.6	400-1 (Groundwater at 1.5 m bgs El. 254.2 m)	Precast Closed Box	253.3 / 253.3	Firm to Very Stiff Silty Clay to Clayey Silt	5.6 m base width	150 – 175 kPa	Settlements up to 100 mm (about 25 mm immediate and 75 mm consolidation)	Feasible – culvert segments can be designed and profile cambered to accommodate differential settlements
	Less than 2.1 m fill on top of culvert.							Open Footing - Shallow Foundation	252.1 / 252.1	Firm to Stiff Clayey Silt	0.6 to 0.9 m wide footings	125 – 150 kPa	Settlements up to 50 mm (about 15 mm immediate and 35 mm consolidation)	Feasible – preloading (less than 3 months) recommended along culvert foundation footprint
30X-0875/C0	Up to 6 m embankment fill.	5.5	2.7	32	252.3	252.1	400-4 (Groundwater at 0.9 m bgs El. 252.9 m)	Precast Closed Box	252.0 / 251.8	Compact Silty Sand over Stiff to Very Stiff Clayey Silt	6.1 m base width	175 – 225 kPa	Settlements up to 75 mm (about 35 mm immediate and 40 mm consolidation)	Feasible – culvert segments can be designed and profile cambered to accommodate differential settlements
	Less than 2.9 m fill on top of culvert.							Open Footing - Shallow Foundation	250.8 / 250.6	Stiff to Very Stiff Clayey Silt	0.6 to 0.9 m wide footings	125 – 175 kPa	Settlements up to 60 mm (about 25 mm immediate and 35 mm consolidation)	Feasible – preloading (less than 3 months) recommended along culvert foundation footprint, dewatering required

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
30X-0876/C0	Up to 5 m Up to 3.3 m fill on top of culvert	5	2.7	33	266.7	265.6	B4-1 (Groundwater at 2.0 m bgs El. 269.7 m)	Precast Closed Box	266.4 / 265.3	Compact Silty Sand Till	5.6 m base width	350 – 500 kPa	Less than 25 mm	Feasible
								Open Footing - Shallow Foundation	265.2 / 264.1	Compact Silty Sand Till	0.6 to 0.9 m wide footings	250 – 300 kPa	Less than 25 mm	Feasible
30X-0877/C0	0.5 m cut to lower 9 th Line profile	5	Varies (Minimum 1.8 m)	12.1	269.0	269.0	B4-1 (Groundwater at 2.0 m bgs El. 269.7 m)	Precast Closed Box	268.7 / 268.7	Compact to Very Dense Silty Sand Till	5.6 m base width	350 – 500 kPa	Less than 25 mm	Feasible
								Open Footing – Shallow Foundation	267.5 / 267.5	Compact to Very Dense Silty Sand Till	0.6 to 0.9 m wide footings	250 – 300 kPa	Less than 25 mm	Feasible
30X-0878/C0	Up to 5 m Up to 2.1 m fill on top of culvert	12	2.4	46	258.4	257.8	CL-BBP-6A (Groundwater at 0.3 m bgs, El. 262.2)	Precast Closed Box	258.1 / 257.5	Very Stiff Clayey Silt to Loose Silty Sand Till	12.6 m wide	200 – 250 kPa	Settlements up to 100 mm (immediate or shortly after construction)	Marginally Feasible – conventional single precast box culverts are not anticipated to be practical for this large span. Multiple adjacent precast culverts may be feasible from a geotechnical perspective and should be evaluated during detail design. Culvert(s) will need to be designed to accommodate differential settlement along the length and between adjacent culvert sections. Preloading entire footprint not considered practical.
								Open Footing – Shallow Foundation	256.9 / 256.3	Loose Silty Sand Till	1.5 to 3 m wide footings	150 – 200 kPa	Settlements up to 75 mm (immediate or shortly after construction)	Marginally Feasible – differential settlement up to 50 mm between foundation elements is estimated based on embankment loading. Preloading likely not feasible near watercourse, although soil improvement could be considered. High lateral resistance required for arch structures and may not be feasible with conventional shallow footings. Dewatering required.
								Open Footing - Deep Foundation	244 (borehole termination depth)	Loose to Compact Silty Sand Till	>13 m long pile (HP 310x110)	>350 kN	Downdrag loads and settlement of piles to be assessed	Feasible – longer driven steel piles will provide higher geotechnical resistance (about 800 kN for 30 m long friction pile) and can be battered to resist horizontal forces for arch structures. Additional deeper boreholes will need to be

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
													during detail design	advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Caissons may also be considered.
30X-0879/CO	Up to 9 m Up to 6.0 m fill on top of culvert	12	2.4	70	256.4	255.6	CL-BBP-6B (Groundwater at 2.8 m bgs, El. 256.8 m)	Precast Closed Box	256.1 / 255.3	Compact Sandy Silt over Loose to Compact Silty Sand Till	12.6 m wide	300 – 400 kPa	Settlements up to 125 mm (immediate or shortly after construction)	Marginally Feasible – conventional single precast box culverts are not anticipated to be practical for this large span. Multiple adjacent precast culverts may be feasible from a geotechnical perspective and should be evaluated at detail design stage. Culvert(s) will need to be designed to accommodate differential settlements along the length and between adjacent culvert sections. Preloading entire footprint not considered practical.
								Open Footing Culvert – Shallow Foundation	254.9 / 254.1	Loose to Compact Silty Sand Till	1.5 to 3 m wide footings	150 – 200 kPa	Settlements up to 100 mm (immediate or shortly after construction)	Marginally Feasible – anticipated high loads combined with low geotechnical resistance in deep loose deposits may eliminate this option. Differential settlement up to 75 mm will also need to be accommodated in design. Dewatering required
								Open Footing Culvert - Deep Foundation	240 (borehole termination depth)	Very Loose to Compact Silt and Sand	>15 m long pile (HP 310x110)	>350 kN	Downdrag loads and settlement of piles to be assessed during detail design	Feasible – longer driven steel piles will provide higher geotechnical resistance (about 800 kN for 30 m long friction pile) and can be battered to resist horizontal forces for arch structures. Additional deeper boreholes will need to be advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Dewatering required for pile caps Caissons may also be considered.
30X-0880/CO	Up to 6.5 m Up to 3.7 m fill on top of culvert	12	2.4	90	263.7	262.8	CL-BBP-6A located about 700 m from site (Groundwater estimated at about 7 m bgs, El. 256.8 m)	Precast Closed Box	263.4 / 262.5	Firm to Very Stiff Clayey Silt	12.6 m wide	125 kPa	Settlements up to 125 mm (immediate or shortly after construction)	Marginally Feasible – conventional single precast box culverts are not anticipated to be practical for this large span. Multiple adjacent precast culverts may be feasible from a geotechnical perspective and should be evaluated at detail design stage. Culvert(s) will need to be designed to accommodate differential settlements along the length and between adjacent culvert sections. Preloading entire footprint not considered practical.

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
								Open Footing Culvert – Shallow Foundation	262.2 / 261.3	Firm to Very Stiff Clayey Silt	1.5 to 3 m wide footings	125 kPa	Settlements up to 100 mm (immediate or shortly after construction)	Feasible – although geotechnical resistances may not be adequate and site-specific investigation required during detail design. Preloading (up to about 3 months) or soil improvement could be considered along culvert foundation footprint and approach embankment to reduce risk of differential settlement. High lateral resistance required for arch structures and may not be feasible with conventional shallow footings.
								Open Footing Culvert - Deep Foundation	244 (borehole termination depth)	Loose to Compact Silty Sand Till	>18 m long pile (HP 310x110)	>500 kN	Downdrag loads and settlement of piles to be assessed during detail design	Feasible – longer driven steel piles will provide higher geotechnical resistance (about 800 kN for 30 m long friction pile) and can be battered to resist horizontal forces for arch structures. Additional deeper boreholes will need to be advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Caissons may also be considered.
37X-2564/C0	Up to 8.5 m Up to 5 m fill on top of culvert	20	3	83	219.6	219.5	CL-BBP-9 (Groundwater at 0.3 m bgs, El. 219.8 m)	Precast Closed Box	219.3 / 219.2	Very Soft to Stiff Clayey Silt over Loose to Compact Silt and Sand	20.6 m wide	500 kPa	Settlements up to 300 mm (about 150 mm immediate and 150 mm consolidation)	Not Feasible – single precast box culverts not anticipated to be available with this span. Multiple adjacent precast culverts may be considered from a geotechnical perspective and should be evaluated at detail design stage.
								Open Footing Culvert – Shallow Foundation	218.1 / 218.0	Loose to Compact Silt over Clayey Silt-Silt	3 m wide footings	175 kPa	Settlements up to 300 mm (about 150 mm immediate and 150 mm consolidation)	Feasible – Preloading (6 months to 1 year) or soil improvement recommended along culvert foundation footprint and approach embankment to reduce total and differential settlement, dewatering required. Risk of differential settlement between foundation elements. High lateral resistance required for arch structures and may not be feasible with conventional shallow footings.

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
								Open Footing Culvert - Deep Foundation	207 (borehole termination depth)	Dense Sandy Silt	>11 m long pile (HP 310x110)	>300 kN	Downdrag loads and settlement of piles to be assessed during detail design	Feasible – longer driven steel piles will provide higher geotechnical resistance (approx. 800 kN for 30 m long friction pile) and can be battered to resist horizontal forces for arch structures. Additional deeper boreholes will need to be advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Caissons may also be considered.
37X-2565/C0	Up to 6.5 m Up to 2.9 m fill on top of culvert	20	3	74	219.7	219.5	CL-BBP-10 (Groundwater at 0.5 m bgs, El. 219.5 m)	Precast Closed Box	219.4 / 219.2	Firm Silty Clay over Compact Silty Sand to Sand	20.6 m wide	500 kPa	Settlements up to 200 mm (100 mm immediate and 100 mm consolidation)	Not Feasible – single precast box culverts not anticipated to be available for this large span. Multiple adjacent precast culverts may be considered from a geotechnical perspective and should be evaluated at detail design stage.
								Open Footing Culvert – Shallow Foundation	218.2 / 218.0	Compact Silty Sand to Sand	3 m wide footings	200 kPa	Settlements up to 200 mm (100 mm immediate and 100 mm consolidation)	Feasible – Preloading (6 months to 1 year) or soil improvement recommended along culvert foundation footprint and approach embankment to reduce total and differential settlement, dewatering required. Risk of differential settlement between foundation elements. High lateral resistance required for arch structures and may not be feasible with conventional shallow footings.
								Open Footing Culvert - Deep Foundation	207 (borehole termination depth)	Very Stiff Clayey Silt-Silt	>11 m long pile (HP 310x110)	>300 kPa	Downdrag loads and settlement of piles to be assessed during detail design	Feasible – longer driven steel piles will provide higher geotechnical resistance (approx. 800 kN for 30 m long friction pile) and can be battered to resist horizontal forces for arch structures. Additional deeper boreholes will need to be advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Caissons may also be considered.

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
37X-2558/B1&B2	Up to 3 m No fill on top as this culvert has been converted to a twin bridge structure	Twin bridges, each 14 m to 26 m wide for interim and ultimate layout	n/a	32 m single span	Ground surface at about 219.5 m		FD-01 & FD-02 (Groundwater at 1 m bgs, El. 221.0 m)	Shallow Foundation	218	Very Loose to Compact Silty Sand over Stiff to Very Stiff Clayey Silt	3 m to 5 m wide footings	175 – 200 kPa	Settlement up to 100 mm (70 mm immediate and 30 mm consolidation)	Not Feasible – high loads and relatively low geotechnical resistance combined with high risk of post-construction differential settlements.
								Deep Foundation	188	Very Stiff to Hard Silty Clay	30 m long pile (HP 310x110)	800 kN	Downdrag loads and settlement of piles to be assessed during detail design	Feasible – longer driven steel piles and/or larger pile sections will provide higher geotechnical resistances and can be battered to resist horizontal forces. Additional deeper boreholes will need to be advanced during detail design to assess soil conditions and confirm or increase design geotechnical resistance. Caissons may also be considered.
Wildlife Culvert (TBD – located at Station 24+080)	Up to 16 m Up to 5.5 m fill on top of culvert (culvert perched in embankment)	12	5	100	232	232	DC-03 (Groundwater at 1.5 m bgs, El. 222.1 m)	Shallow Foundations on Native Soil	223	Compact to Very Dense Silty Sand over Stiff to Hard Clayey Silt	1.5 to 3 m wide footings	200 - 400 kPa	Settlement of less than 100 mm (immediate or shortly after construction).	Feasible – culvert expected to settle with overall high fill embankment. Culvert can be cambered to accommodate differential settlement.
								Shallow Foundations “Perched” within High Fill Embankment	232	New Compacted Granular Fill	1.5 to 3 m wide footings	300 - 600 kPa	Settlement of less than 100 mm (immediate or shortly after construction).	Feasible – topsoil will need to be stripped prior to placing compacted granular fill meeting OPSS.PROV 501. Culvert expected to settle with overall high fill embankment. Culvert can be cambered to accommodate differential settlement.
								Open Footing - Deep Foundation	212 to 207	Very Dense Silt to Hard Clayey Silt-Silt	10 m to 15 m long pile (HP 310x110)	300 – 500 kN	Downdrag loads and settlement of piles to be assessed during detail design	Feasible –larger pile sections will provide higher geotechnical resistances and can be battered to resist horizontal forces. May be difficult to reach target founding elevations due to the very dense silt and hard clayey silt deposits.

Culvert Designation (MTO Site Number)	Approximate Height of New Embankment ¹	Proposed Dimensions (m) ²			Approximate Invert Elevation (m) ²		Closest Borehole(s) and Estimated Groundwater Level	Culvert Foundation Option	Founding Elevation (m) Upstream / Downstream ^{3,4}	Founding Soil Conditions ^{3,4}	Assumed Foundation Width or Pile Length (m)	Factored Ultimate Geotechnical Resistance at ULS ^{5,6}	Estimated Settlement at Founding Level Induced by Embankment Loading ¹	Feasibility of Culvert Option and Risks / Mitigation Option(s)
		Width / Span	Height / Rise	Length	U/S	D/S								
37X-2566/C1 & C2	Up to 7 m for BBP WBL and W-N and W-S Ramps	5.4	2.7	64 (under WBL)	243.0	242.4	R-404-2 (Groundwater at 2.8 m bgs El. 242.2 m)	Precast Closed Box	242.7 / 242.1	Stiff to Very Stiff Sandy Clayey Silt-Silt Til	6.6 m base width	175 – 225 kPa	Settlements up to 75 mm (immediate or shortly after construction)	Feasible – culvert segments can be designed and profile cambered to accommodate differential settlements
	Up to 3.1 m and 5.3 m on top of culvert along WBL and Ramps			77 (under W-N and W-S Ramps)				Open Footing – Shallow Foundation	241.5 / 240.9	Stiff to Very Stiff Sandy Clayey Silt-Silt Til	0.9 to 1.2 m wide footings	125 – 175 kPa	Settlements up to 50 mm (immediate or shortly after construction)	Feasible – culvert profile can be cambered to accommodate differential settlement, dewatering required
37X-2567/C0	Up to 9 m	4.9	3.4	49	247.4	246.7	C2-6 (Groundwater at 2.5 m bgs El. 245.5 m)	Precast Closed Box	246.7 / 246.0	Very Stiff to Hard Clayey Silt	5.8 m wide	150 – 250 kPa	25 to 50 mm (immediate or shortly after construction)	Feasible
	Up to 3.8 m fill on top of culvert							Open Footing - Shallow Foundation	245.9 / 245.2	Hard Clayey Silt to Very Dense Silty Sand	0.9 to 1.2 m wide footings	200 -250 kPa	25 to 50 mm (immediate or shortly after construction)	Feasible
37X-2568/C0	Up to 5 m	4.9	3.4	34	252.3	251.8	C2-1 / C2-6 (Groundwater at 1.5 m bgs at culvert location El. 250.8-251.8 m)	Precast Closed Box	252.0 / 251.5	Stiff to Very Stiff Clayey Silt	5.5 m wide	150 -250 kPa	25 mm to 50 mm (immediate or shortly after construction)	Feasible - *may require subexcavation of surficial organic material
	Up to 2.2 m fill on top of culvert							Open Footing - Shallow Foundation	250.8 / 250.3	Stiff to Very Stiff Clayey Silt	0.6 to 0.9 m wide footings	200 – 250 kPa	25 mm to 50 mm (immediate or shortly after construction)	Feasible

Notes:

1.

Relative to existing ground surface adjacent to culvert

2.

Culvert dimensions, invert elevations and embankment details provided by AECOM on October 6, November 30 and December 8, 2023

3.

Bedding thickness for closed box culverts not considered at this preliminary stage.

4.

Assumes box culvert base is approximate thickness shown on preliminary GA drawing and open footings are founded at frost depth (1.5 m below ground surface)

5.

ULS factored resistances assume low degree of understanding. SLS values to be determined during detail design.

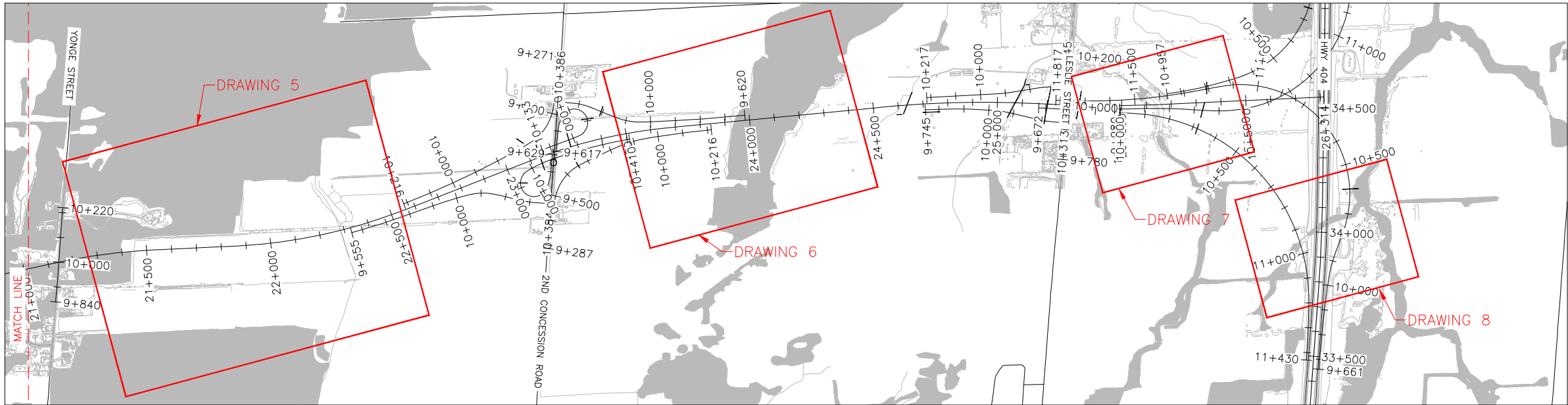
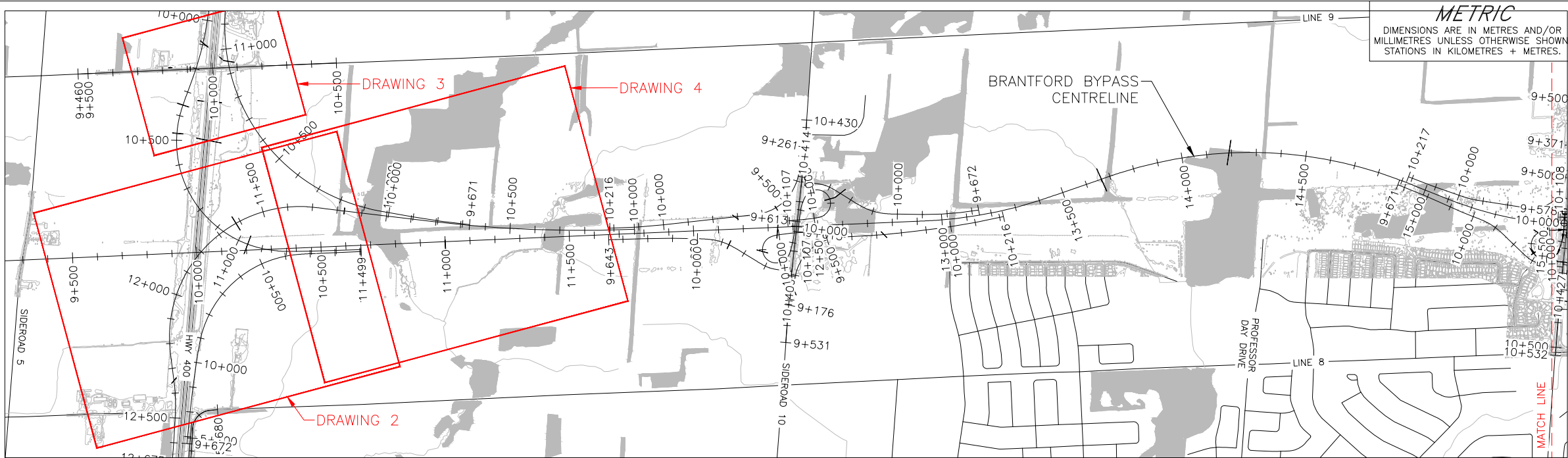
6.

Pile geotechnical resistance is based on HP310x110 pile.

7.

Closed box and shallow foundation supported culverts if constructed concurrently with the embankments are anticipated to settle relatively uniformly with the embankments, with some differential settlement along the culvert edges perpendicular to the highway / ramp alignments.

DRAWINGS



CONT No.
WP No.

BRADFORD BYPASS
STRUCTURAL CULVERTS
INDEX PLAN



SHEET



PLAN

SCALE
200 0 200 400 m

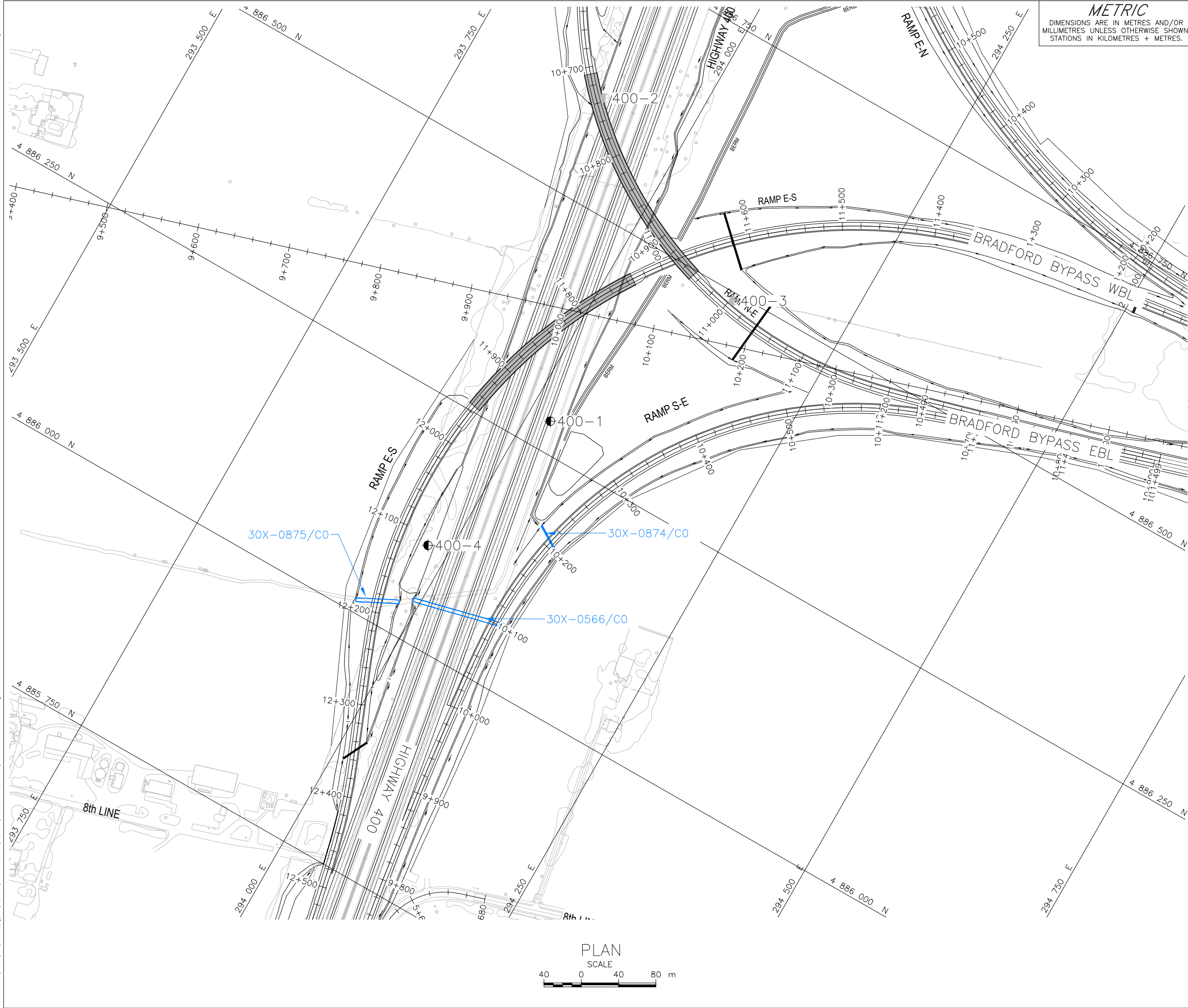
NOTES

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.

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
1	12/12/2023	SA	1
Geocres No. 31D04-003			
HWY.	PROJECT NO. 19136074		DIST.
SUBM'D.	CHKD. MCK	DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 1

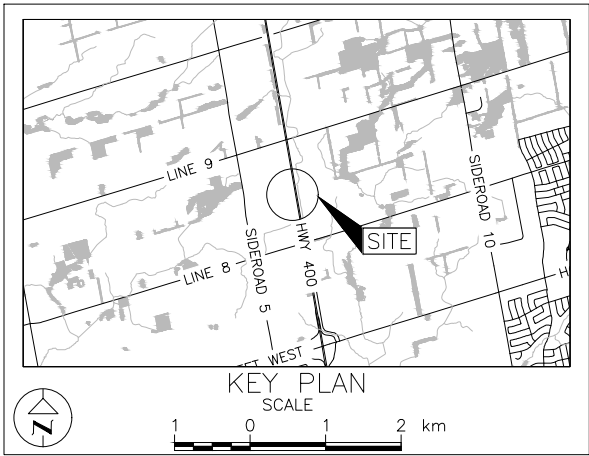


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP / HWY 400 INTERCHANGE
STRUCTURAL CULVERT
BOREHOLE LOCATIONS PLAN

SHEET



LEGEND	
	Borehole - GEOCRES NO. 31D00-832

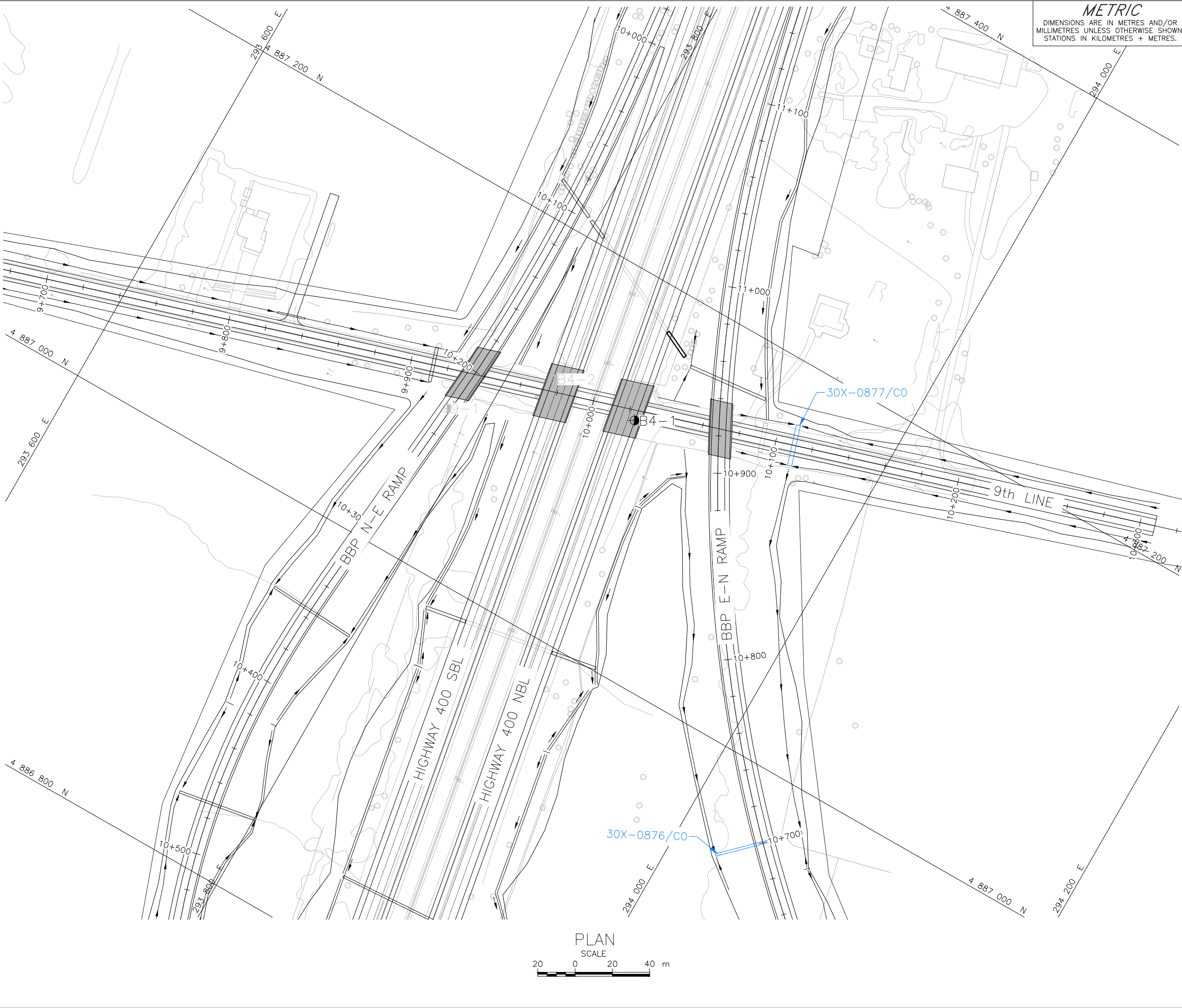
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
400-1	255.7	4886282.5	294024.6
400-4	253.8	4886102.0	293976.8



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.

REFERENCE
Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.		PROJECT NO. 19136074	DIST.
SUBM'D.		CHKD. MCK	DATE: 12/12/2023
DRAWN: SA		CHKD. MCK	APPD. KJB
			SITE: .
			DWG. 2

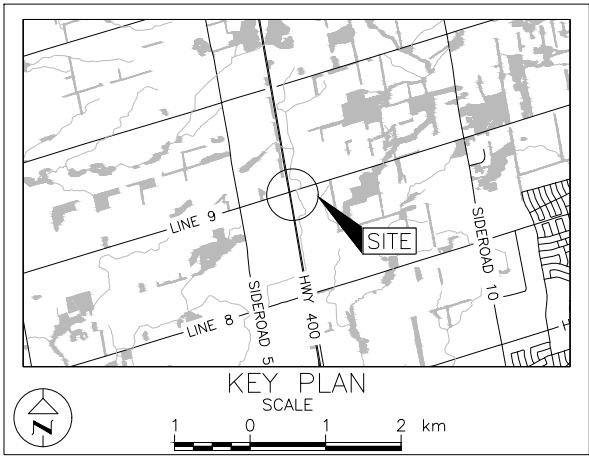


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP / HWY 400 E-N RAMP OVER 9TH LINE
STRUCTURAL CULVERTS
BOREHOLE LOCATIONS PLAN

SHEET



LEGEND

Borehole - GEOCRES NO. 31D00-459

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
B4-1	271.7	4887127.3	293870.9



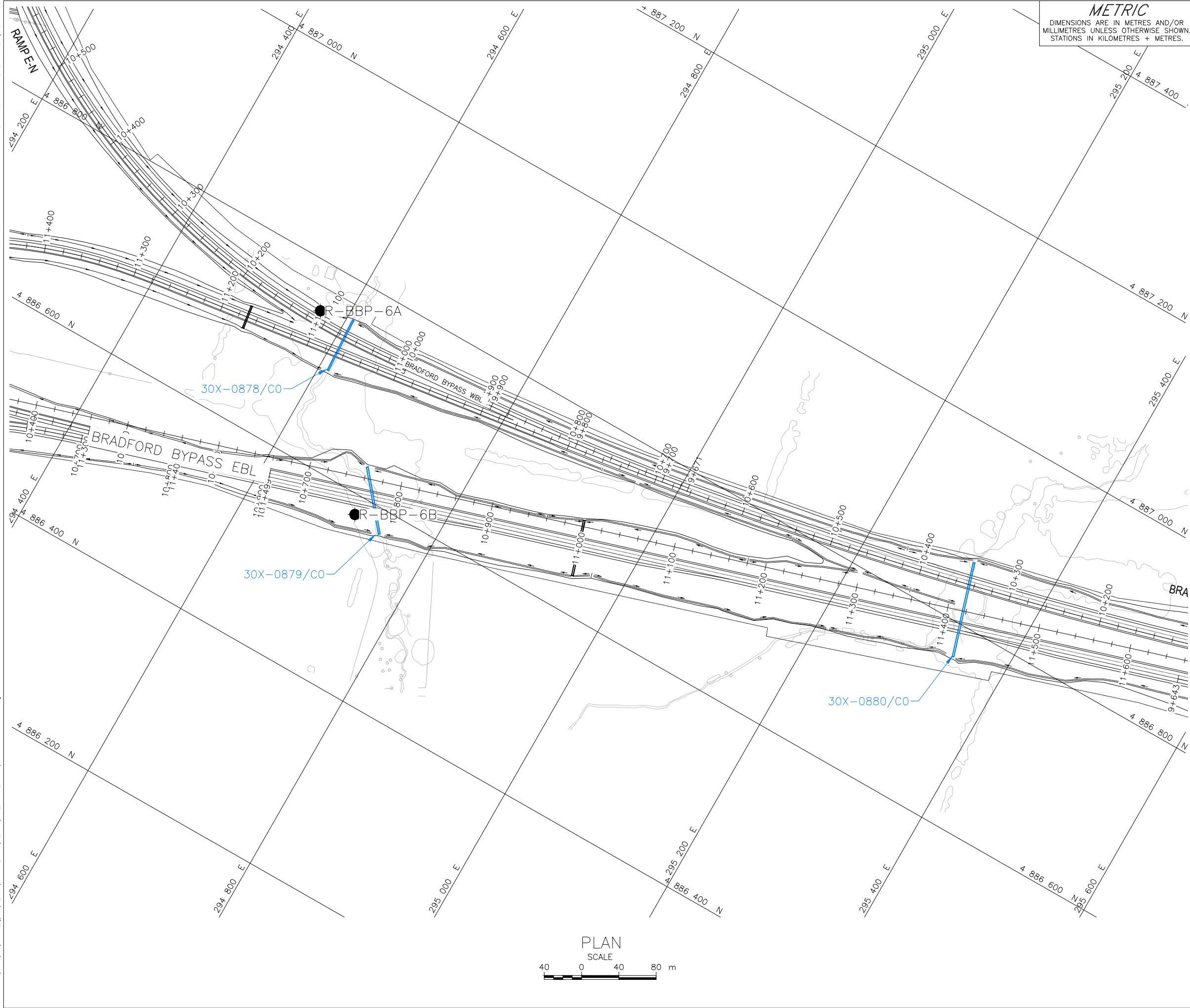
NOTES

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.

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.		PROJECT NO. 19136074	DIST.
SUBM'D.	CHKD. MCK	DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 3

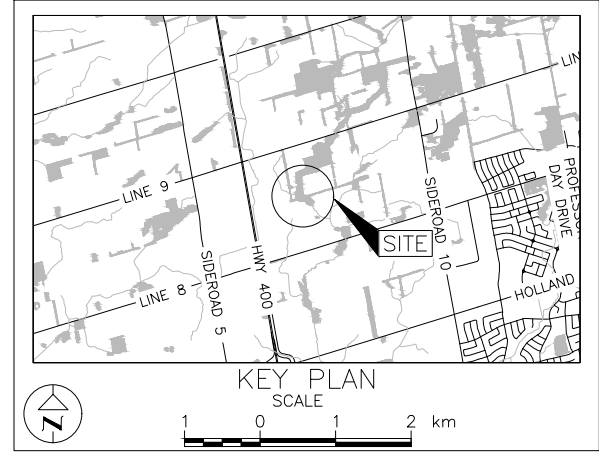


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP – BETWEEN HWY 400 AND 10TH SIDEROAD
STRUCTURAL CULVERTS
BOREHOLE LOCATIONS PLAN

SHEET



LEGEND

Borehole – Current Investigation

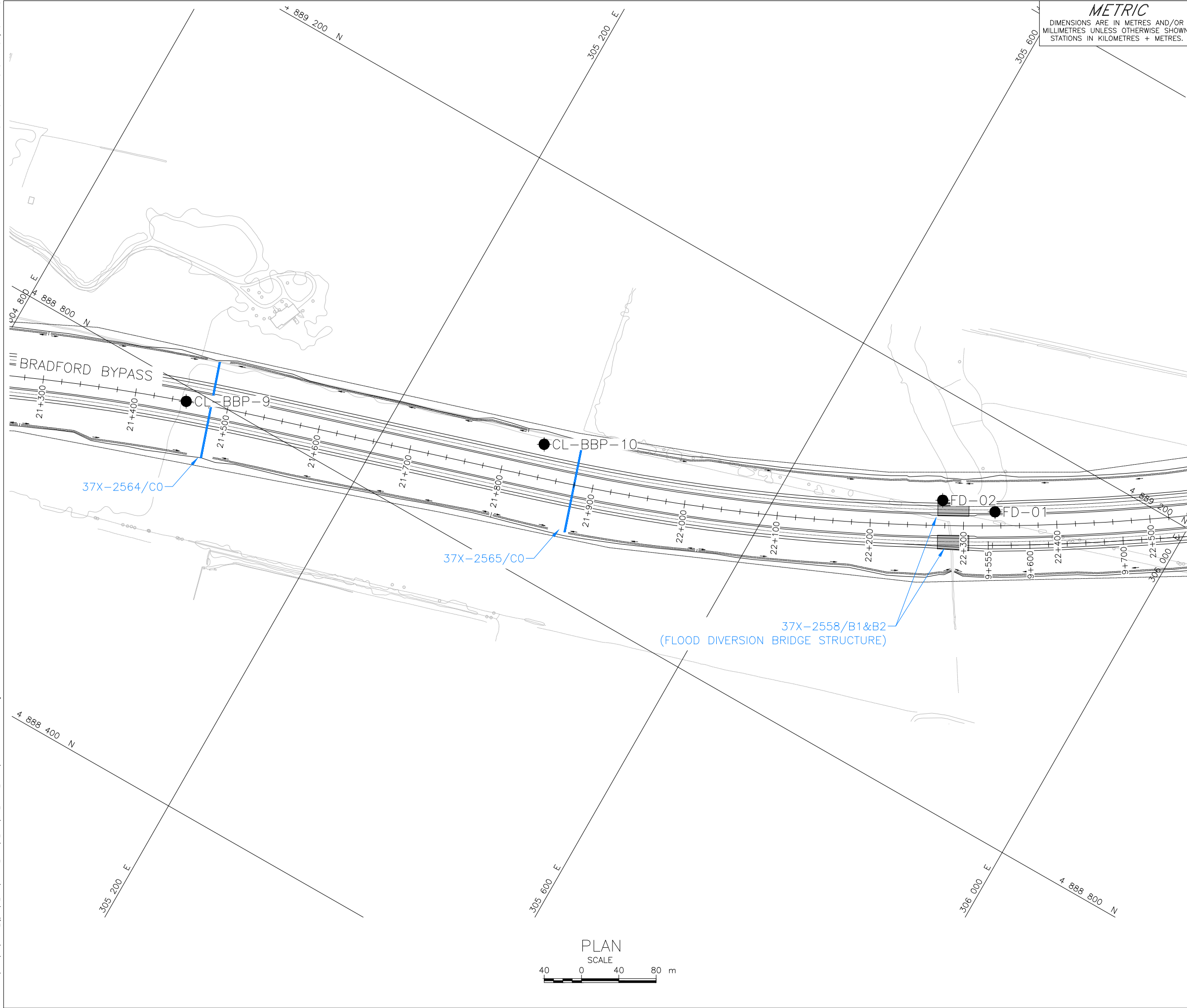
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
R-BBP-6A	262.5	4886751.0	294571.6
R-BBP-6B	259.6	4886580.0	294711.9



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.

REFERENCE
Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.		PROJECT NO.	19136074
SUBM'D.		DATE:	12/12/2023
DRAWN: SA		APPD: KJB	

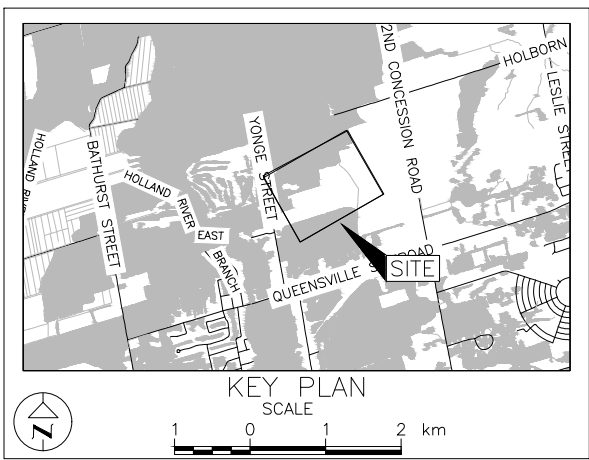


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP – BETWEEN YONGE ST. AND 2ND CON.
STRUCTURAL CULVERTS
BOREHOLE LOCATIONS PLAN

SHEET



LEGEND	
	Borehole – Current Investigation

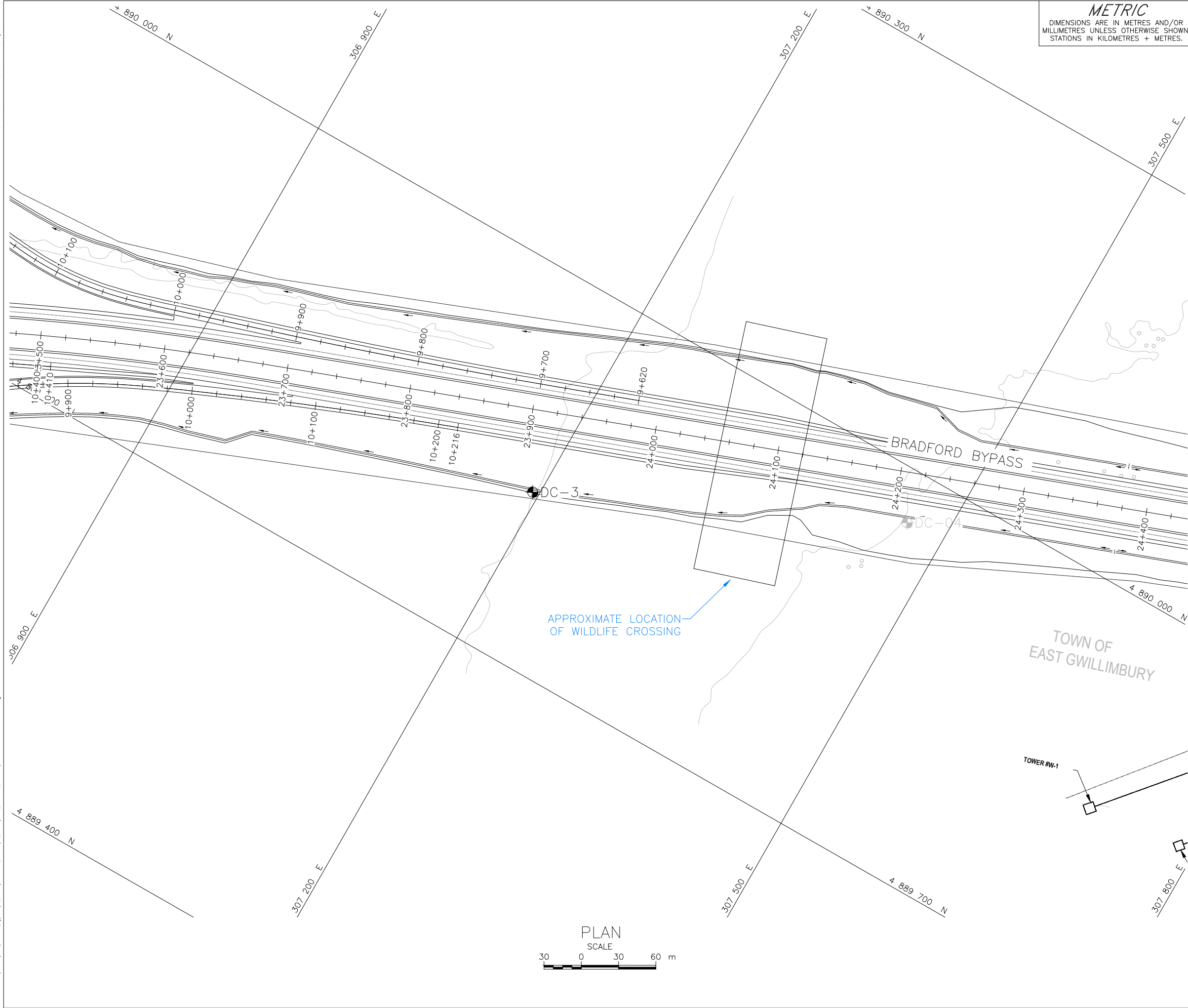
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
CL-BBP-9	220.1	4888785.5	305001.4
CL-BBP-10	220.0	4888936.0	305357.0
FD-01	220.0	4889113.0	305812.2
FD-02	221.8	4889096.0	305757.4



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

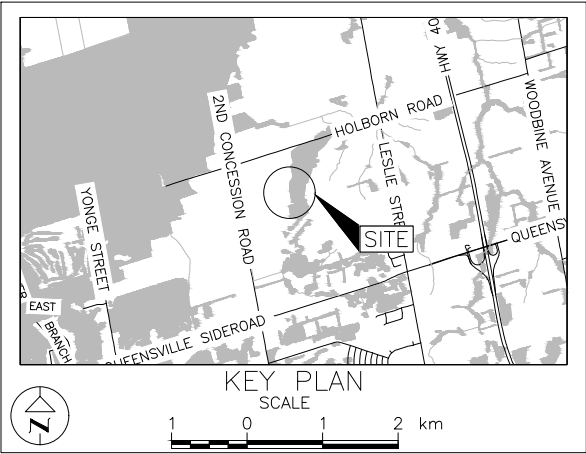
REFERENCE
Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.	PROJECT NO. 19136074		DIST.
SUBM'D.	CHKD. MCK	DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 5



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

CONT No.		
WP No.		
BBP – BETWEEN 2ND CON. AND LESLIE ST.		SHEET
STRUCTURAL CULVERT		
BOREHOLE LOCATIONS PLAN		



LEGEND			
	Borehole	–	GEOCRIS NO. 31D04–004

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DC-3	223.6	4889831.9	307194.8



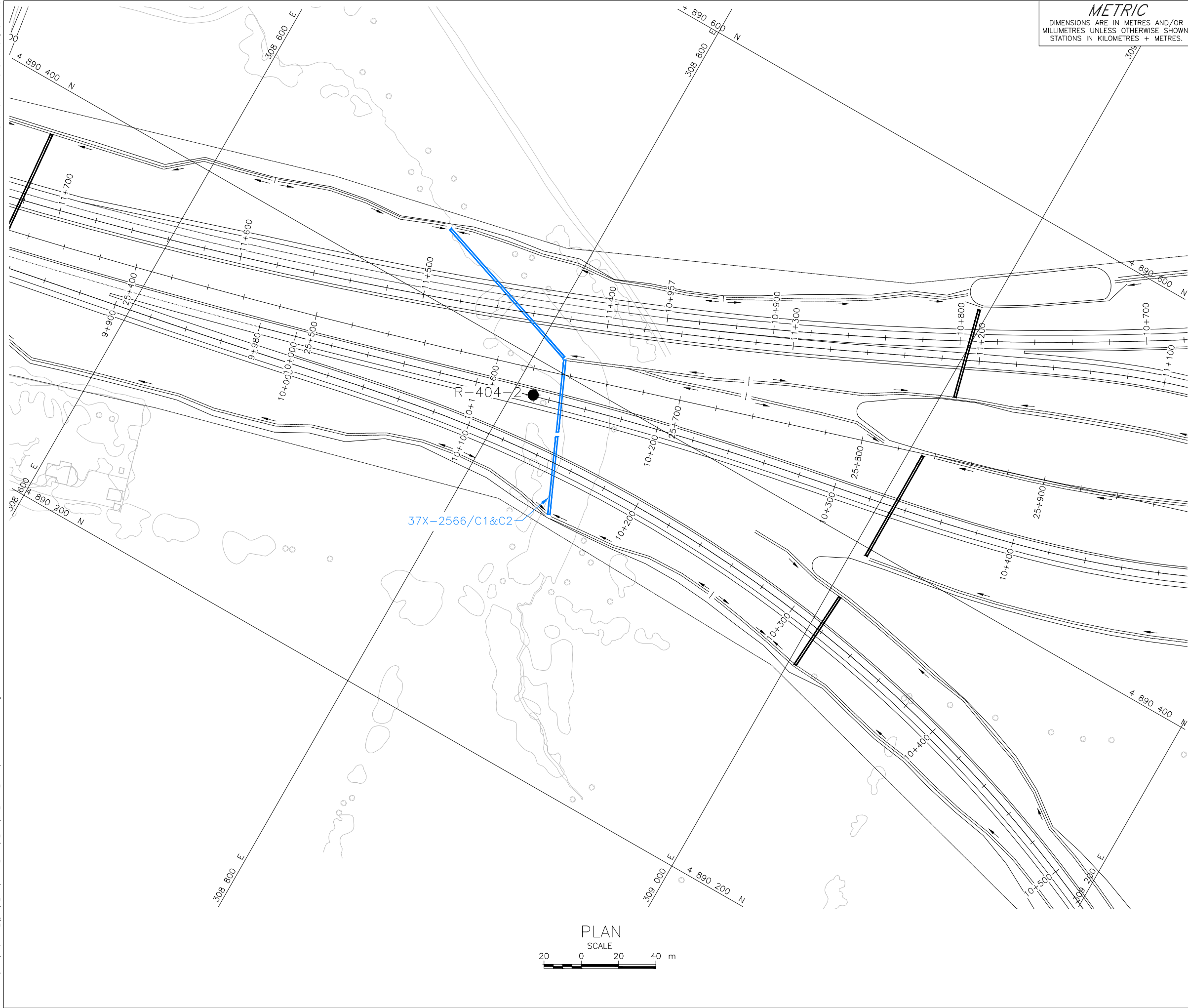
NOTES

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.

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocris No. 31D04–003			
HWY.	PROJECT NO. 19136074		DIST.
SUBM'D.	CHKD. MCK	DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 6

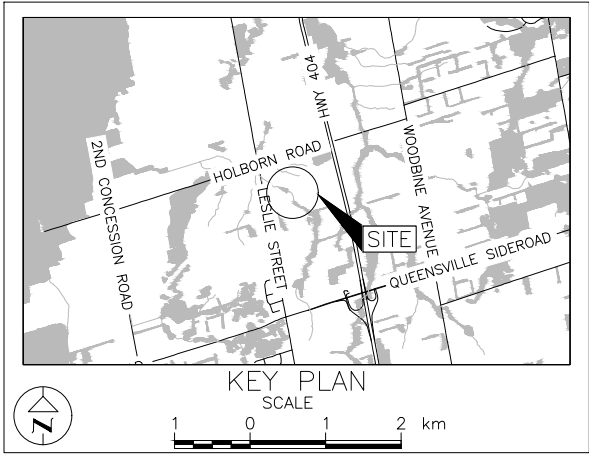


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP / HWY 404 INTERCHANGE RAMP
STRUCTURAL CULVERTS
BOREHOLE LOCATIONS PLAN

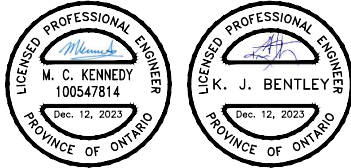
SHEET



LEGEND

Borehole – Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
R-404-2	245.0	4890382.1	308810.2



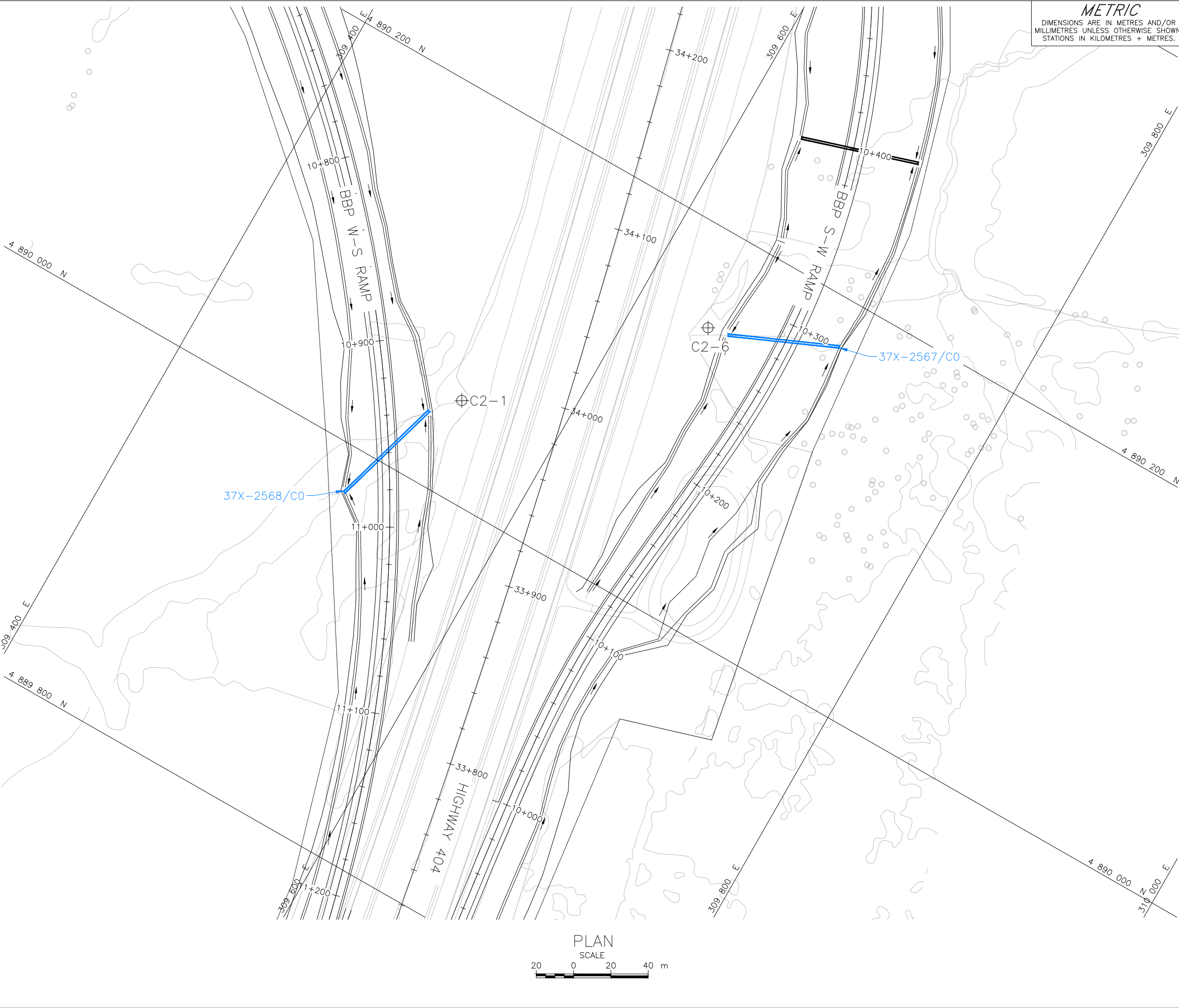
NOTES

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.

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.		PROJECT NO. 19136074	DIST.
SUBM'D.		DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 7

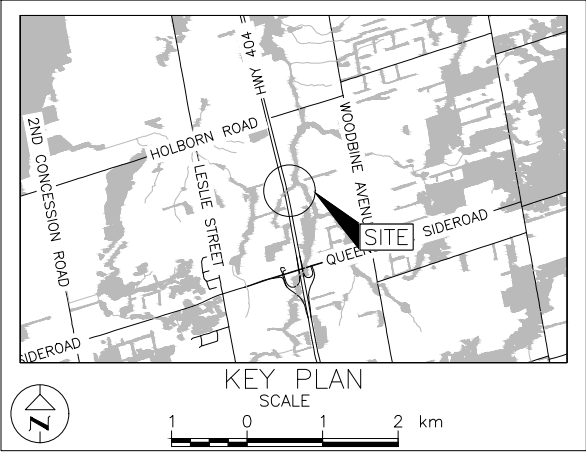


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

BBP / HWY 404 INTERCHANGE RAMP
STRUCTURAL CULVERTS
BOREHOLE LOCATIONS PLAN

SHEET



LEGEND

Borehole - GEOCRES No. 31D00-499

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C2-1	251.2	4890050.0	309545.5
C2-6	248.0	4890149.3	309640.6



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.

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. X-Base_Bradford Bypass.dwg and BRADFORD BY-PASS OG_Combined.xml, received January 11, 2022.
Vertical alignment provided in digital format by Aecom, drawing file no. ACAD-X-60636190-C-DES-BBP Mainline Align and Profile.dwg, received September 9, 2022.
Horizontal alignment provided in digital format by Aecom, drawing file no. X-60636190-C-DES-All Alignments.xml, received September 14, 2022.
Design plan provided in digital format by Aecom, drawing file no. BBP Mainline Plan and Profile_To WSP_230705, received July 05, 2023.

NO.	DATE	BY	REVISION
Geocres No. 31D04-003			
HWY.	PROJECT NO. 19136074		DIST.
SUBM'D.	CHKD. MCK	DATE: 12/12/2023	SITE:
DRAWN: SA	CHKD. MCK	APPD. KJB	DWG. 8

APPENDIX A

**Previous Investigation at BBP / Highway 400
Interchange Ramps (GEOCREC #31D-832)**

PROJECT	19136074	RECORD OF BOREHOLE	No. 400-1	Sheet 1 of 4	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4886282.5; E 294024.6 NAD83 / MTM Zone 10 (LAT. 44.116458; LONG. -79.634623)	ORIGINATED BY	MTI
DIST	Central	HWY	BBP - HWY 400	BOREHOLE TYPE	210 mm Hollow Stem Auger, Mud Rotary
DATUM	CGVD28 Surface Elevation:255.7 m	DATE	Dec 07, 2021 - Dec 09, 2021	COMPILED BY	MCK
				CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
0.0	CLAYEY SILT (CL), some sand, trace rootlets, trace organics Firm Brown Moist		1	SS	5																
							255														
254.2	- 1.4 to 2.3 m: Oxidation staining		2	SS	6																
1.4	SILTY CLAY (CI), trace sand, trace gravel, containing rootlets to a depth of 2.1 m Stiff to very stiff Dark brown Moist - 1.6 m: Becoming light brown		3	SS	12		254														
			4	SS	17		253										0	0	49	51	
252.7	CLAYEY SILT (CL), trace sand, trace gravel Firm to stiff Grey Moist		5	SS	10		252														
			6	SS	7		251										0	0	69	31	
																					C
			7	TO			250														
			8	SS	5		249														
			9	TO			248														C
			10	SS	5		247										0	2	50	48	
			11	SS	7		246														

Continued on Next Page

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

PROJECT 19136074

RECORD OF BOREHOLE No. 400-1

Sheet 2 of 4

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4886282.5; E 294024.6 NAD83 / MTM Zone 10 (LAT. 44.116458; LONG. -79.634623)

ORIGINATED BY MTI

DIST Central HWY BBP - HWY 400

BOREHOLE TYPE 210 mm Hollow Stem Auger, Mud Rotary

COMPILED BY MCK

DATUM CGVD28 Surface Elevation:255.7 m

DATE Dec 07, 2021 - Dec 09, 2021

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
	CLAYEY SILT (CL), trace sand, trace gravel Firm to stiff Grey Moist						245														
	- 11.0 to 11.1 m: Becoming sandy		12	SS	5																
244.0							244														
11.7	SILT (ML) and sand, trace gravel (TILL) Very loose to compact Grey Moist		13	SS	8		243														
							242														
			14	SS	24		241														
							240														
			15	SS	11		239														
							238														
			16	SS	6		237														
							236														
236.4																					
19.4	SILTY SAND (SM), trace gravel (TILL) Very loose to compact Grey Wet		17	SS	3																

Continued on Next Page

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

PROJECT 19136074

RECORD OF BOREHOLE No. 400-1

Sheet 3 of 4

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4886282.5; E 294024.6 NAD83 / MTM Zone 10 (LAT. 44.116458; LONG. -79.634623)

ORIGINATED BY MTI

DIST Central HWY BBP - HWY 400

BOREHOLE TYPE 210 mm Hollow Stem Auger, Mud Rotary

COMPILED BY MCK

DATUM CGVD28 Surface Elevation:255.7 m

DATE Dec 07, 2021 - Dec 09, 2021

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
	SILTY SAND (SM), trace gravel (TILL) Very loose to compact Grey Wet		18	SS	3		235														
			19	SS	6		234														
							233														
							232														
			20	SS	13		231										9	50	31	10	
							230														
							229														
			21	SS	7		228														
							227														
226.4																					
29.3	Gravelly SILTY SAND (SM) (TILL) Very dense Grey Moist						226														

Continued on Next Page

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

PROJECT	19136074	RECORD OF BOREHOLE	No. 400-1	Sheet 4 of 4	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4886282.5; E 294024.6 NAD83 / MTM Zone 10 (LAT. 44.116458; LONG. -79.634623)	ORIGINATED BY	MTI
DIST	Central	HWY	BBP - HWY 400	BOREHOLE TYPE	210 mm Hollow Stem Auger, Mud Rotary
DATUM	CGVD28 Surface Elevation:255.7 m	DATE	Dec 07, 2021 - Dec 09, 2021	COMPILED BY	MCK
				CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
	Gravelly SILTY SAND (SM) (TILL) Very dense Grey Moist		22	SS	103/0.23		225											21	47	26	6
							224														
							223														
221.9 33.8	End of Borehole		23	SS	101/0.15		222														
	Notes: 1. Water level measured at a depth of 1.6 m (Elev. 254.1 m) prior to initiation of mud rotary drilling for borehole advancement below a depth of 3.0 m below ground surface. 2. Water level not recorded upon completion of drilling due to the introduction of drilling mud.						221														
							220														
							219														
							218														
							217														
							216														

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

PROJECT	19136074	RECORD OF BOREHOLE	No. 400-4	Sheet 1 of 5	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4886102.3; E 293976.8 NAD83 / MTM Zone 10 (LAT. 44.114835; LONG. -79.635217)	ORIGINATED BY	MTI
DIST	Central HWY BBP - HWY 400	BOREHOLE TYPE	210 mm Hollow Stem Auger, Mud Rotary	COMPILED BY	MCK
DATUM	CGVD28 Surface Elevation:253.8 m	DATE	Dec 14, 2021 - Dec 16, 2021	CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
0.0	CLAYEY SILT (CL), some sand, trace rootlets, trace organics Soft Brown Moist		1	SS	3		253	20	40	60	80	100	20	40	60						
252.9																					
0.9	SILTY SAND (SM) of slight plasticity, trace to some gravel Very loose to compact Brown Wet		2	SS	3																
			3	SS	15		252														
251.6	- 2.0 m: Large pieces of gravel encountered around auger																				
2.2	CLAYEY SILT (CL), some sand, trace gravel Stiff to very stiff Brown to brownish grey Moist		4	SS	11		251														
			5	SS	28																
							250														
			6	SS	29																
			7	SS	21		249														
248.2																					
5.6	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel, (TILL) Stiff Grey Moist		8	SS	12		248														
	- 6.5 to 6.7 m: Increased sand content																				
							247														
246.6																					
7.2	CLAYEY SILT (CL), trace sand, trace gravel Firm to stiff Grey Moist to wet		9	SS	8		246														
							245														
			10	SS	6																
244.0	SILT (ML) and sand, trace gravel, (TILL) Loose to compact Grey Moist						244														
9.8	- 9.9 to 10.5 m: Sample 11 recovery 50%																				

Continued on Next Page

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

PROJECT 19136074

RECORD OF BOREHOLE No. 400-4

Sheet 2 of 5

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4886102.3; E 293976.8 NAD83 / MTM Zone 10 (LAT. 44.114835; LONG. -79.635217)

ORIGINATED BY MTI

DIST Central HWY BBP - HWY 400

BOREHOLE TYPE 210 mm Hollow Stem Auger, Mud Rotary

COMPILED BY MCK

DATUM CGVD28 Surface Elevation:253.8 m

DATE Dec 14, 2021 - Dec 16, 2021

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE ELEVATION m	DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH (kPa)					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	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					
	SILT (ML) and sand, trace gravel, (TILL) Loose to compact Grey Moist		11	TO			243														
			12	SS	5		242														
			13	SS	6		241														
			14	SS	5		240														
			15	SS	12		239														
			16	SS	9		238														
			17	SS	7		237														
							236														
							235														
							234														

Continued on Next Page

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

PROJECT	19136074	RECORD OF BOREHOLE	No. 400-4	Sheet 3 of 5	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4886102.3; E 293976.8 NAD83 / MTM Zone 10 (LAT. 44.114835; LONG. -79.635217)	ORIGINATED BY	MTI
DIST	Central	HWY	BBP - HWY 400	BOREHOLE TYPE	210 mm Hollow Stem Auger, Mud Rotary
DATUM	CGVD28 Surface Elevation:253.8 m	DATE	Dec 14, 2021 - Dec 16, 2021	COMPILED BY	MCK
				CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION 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)					PL W _p	NMC W	LL W _L						
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
	SILT (ML) and sand, trace gravel, (TILL) Loose to compact Grey Moist						233														
			18	SS	10		232														
							231														
							230														
			19	SS	9		229														
							228														
							227														
			20	SS	9		226														
	- 27.9 to 28.0 m: Gravelly seam encountered						225														
							224														

Continued on Next Page

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

PROJECT	19136074	RECORD OF BOREHOLE	No. 400-4	Sheet 4 of 5	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4886102.3; E 293976.8 NAD83 / MTM Zone 10 (LAT. 44.114835; LONG. -79.635217)	ORIGINATED BY	MTI
DIST	Central HWY BBP - HWY 400	BOREHOLE TYPE	210 mm Hollow Stem Auger, Mud Rotary	COMPILED BY	MCK
DATUM	CGVD28 Surface Elevation:253.8 m	DATE	Dec 14, 2021 - Dec 16, 2021	CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS																							
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL	NMC	LL																													
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined	20	40	60	80	100	W _p	W							W _L																						
														NP Nonplastic								-----○-----																						
223.0	SILT (ML) and sand, trace gravel, (TILL) Loose to compact Grey Moist		21 A	SS	13		223																																					
30.8	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL) Stiff to hard Grey Moist		21 B																																									
220.0		22 A	SS	87																220																								
33.8	SILTY SAND (SM), trace gravel Very dense Grey Moist to wet	22 B																																										
218.5							219																																					
35.3	SILTY SAND (SM), trace gravel (TILL) Compact to very dense Grey Moist																																	218										
																				217																								
			23	SS																												26												
								215																																				
																																214												
			24	SS	102/0.26																																							

Continued on Next Page

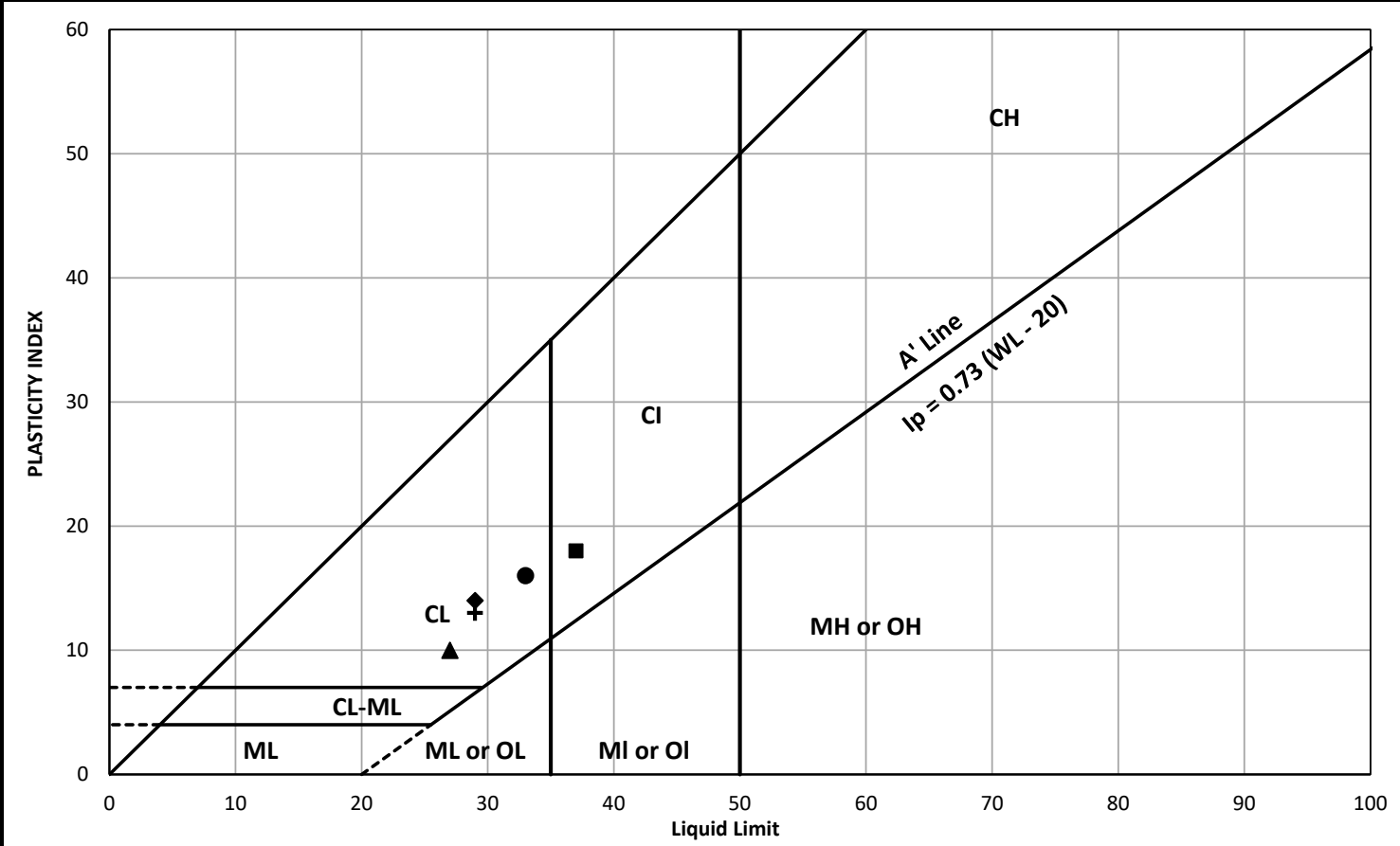
+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

METRIC


CHECKED BY KJB

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

PLASTICITY CHART

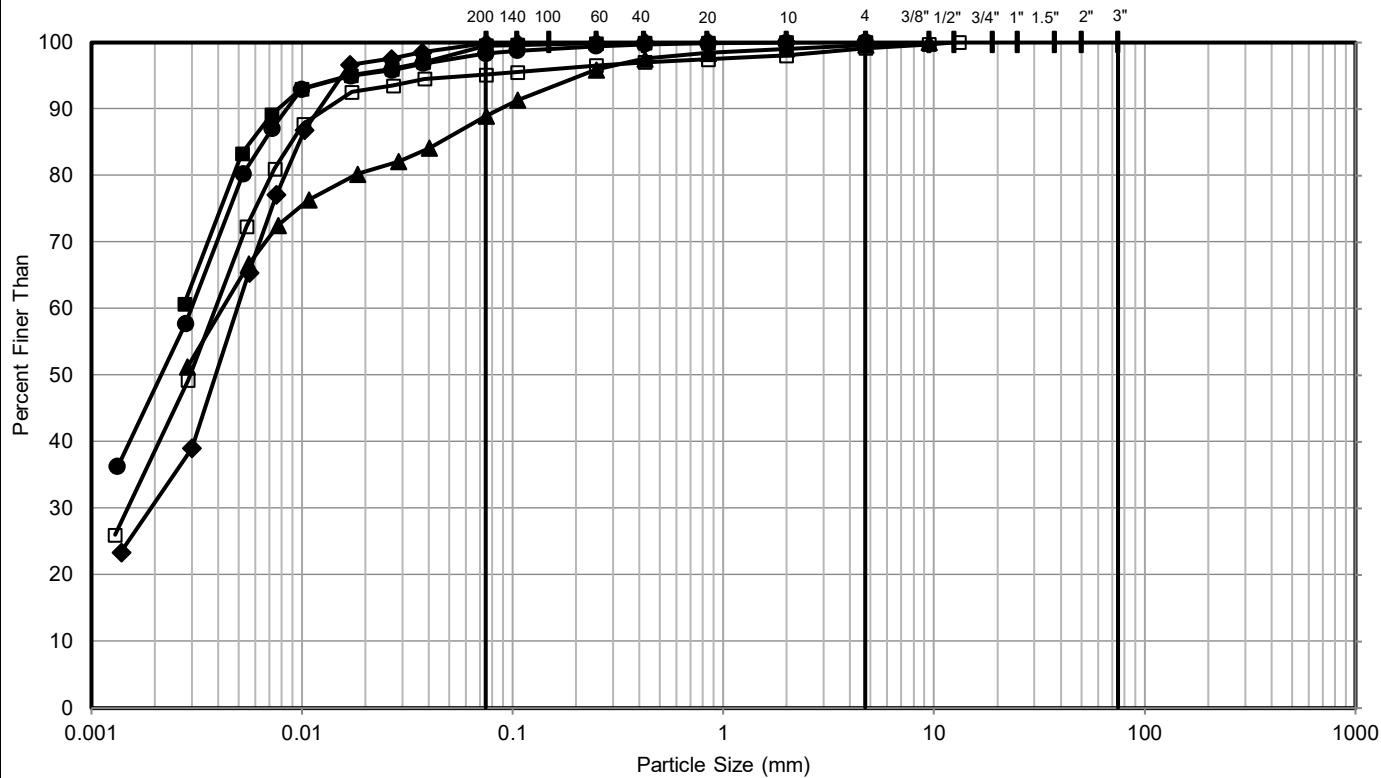


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	400-1	4	253.4 to 252.8	24.5	37	19	18
◆	400-4	5	250.8 to 250.1	15.9	29	15	14
▲	400-1	6	251.9 to 251.3	23.2	27	17	10
●	400-1	10	248.1 to 247.5	26.5	33	17	16
+	400-4	9	246.2 to 245.6	28	29	16	13

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
		DESIGNED N/A
		PREPARED MCK
		REVIEWED KJB
		APPROVED KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - CLAYEY SILT (CL) to SILTY CLAY (CI)			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	A1

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	400-1	4	2.3 - 2.9	253.4 to 252.8
◆	400-1	6	3.8 - 4.4	251.9 to 251.3
▲	400-4	5	3.1 - 3.7	250.8 to 250.1
●	400-1	10	7.6 - 8.2	248.1 to 247.5
□	400-4	9	7.6 - 8.2	246.2 to 245.6

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - CLAYEY SILT (CL) to SILTY CLAY (CI)

PROJECT NO.

19136074

CONTROL

1002.001

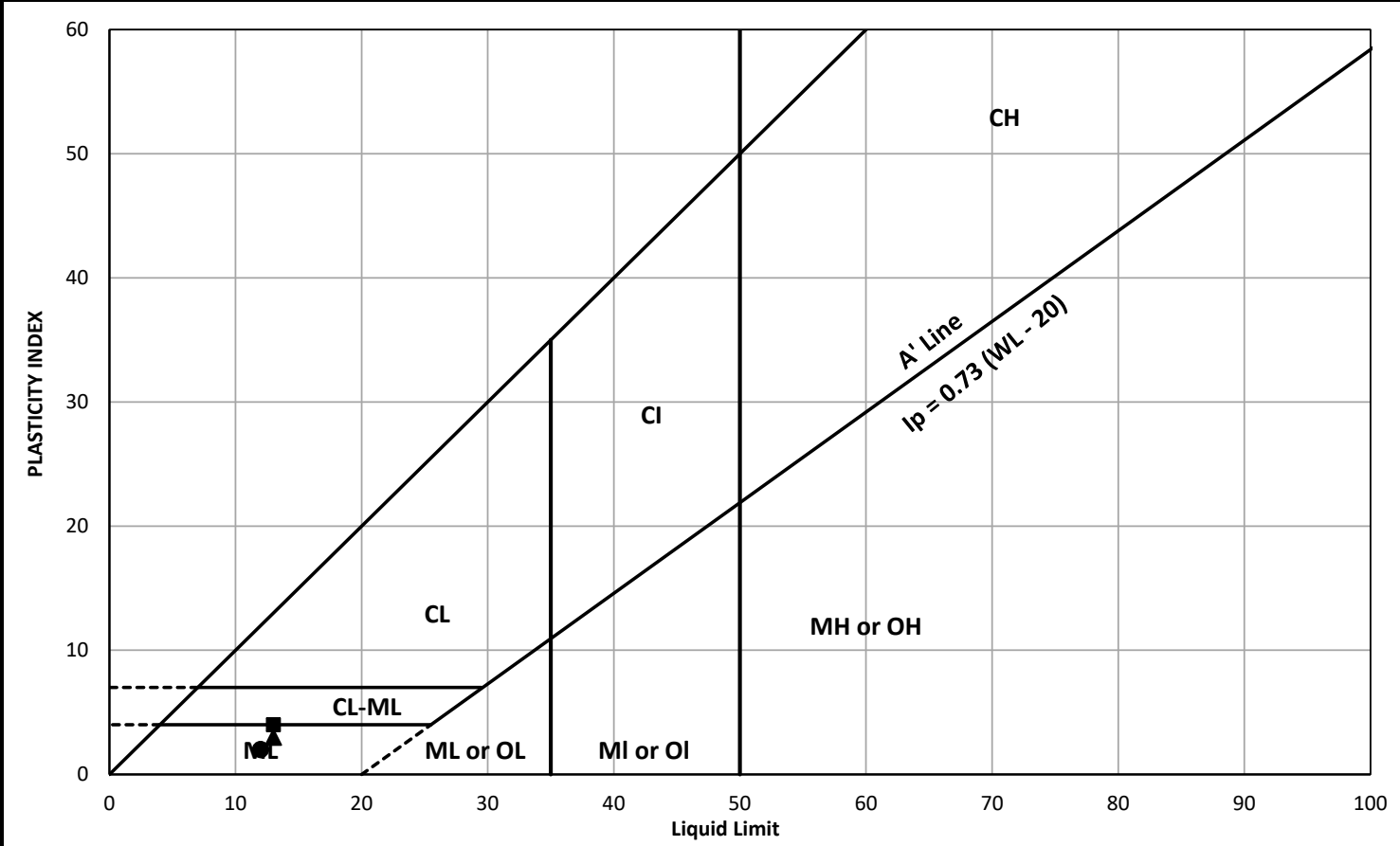
REV.

0

FIGURE

A2

PLASTICITY CHART




Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	400-4	14	240.1 to 239.5	9.1	13	9	4
◆	400-1	16	238.9 to 238.3	9.7	12	10	2
▲	400-1	18	235.9 to 235.3	10.3	13	10	3
●	400-4	18	232.5 to 231.9	10.3	12	10	2
+	400-1	20	231.3 to 230.7	11.2	12	10	2

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD

2023-12-06

DESIGNED

N/A

PREPARED

MCK

REVIEWED

KJB

APPROVED

MCK

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Plasticity Chart - SILT (ML) to SILTY SAND (SM) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

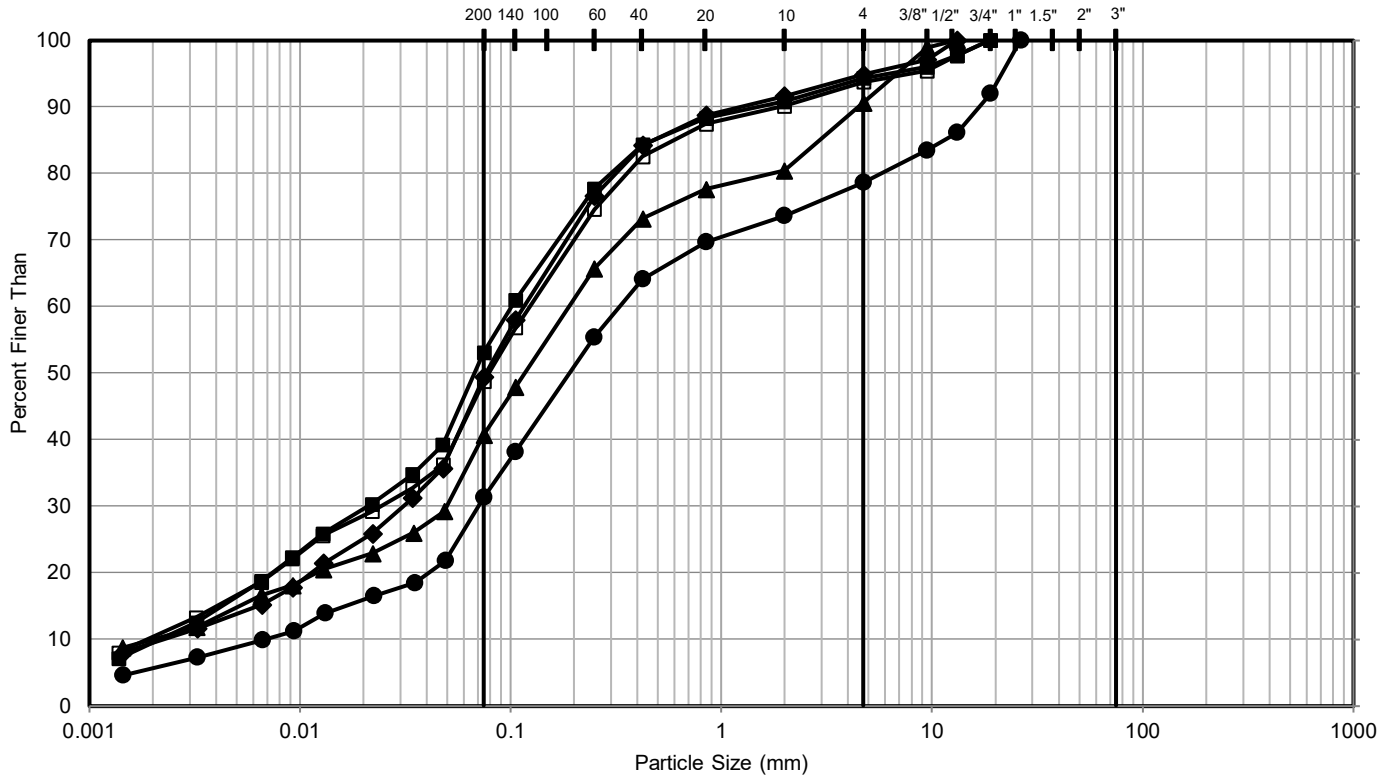
REV.

0

FIGURE

A3

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	400-4	14	13.7 - 14.3	240.1 to 239.5
◆	400-1	16	16.8 - 17.4	238.9 to 238.3
▲	400-1	20	24.4 - 25.0	231.3 to 230.7
●	400-1	22	30.5 - 30.9	225.2 to 224.8
□	400-4	23	36.6 - 37.2	217.2 to 216.6

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - SILT to Sandy SILT (ML) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

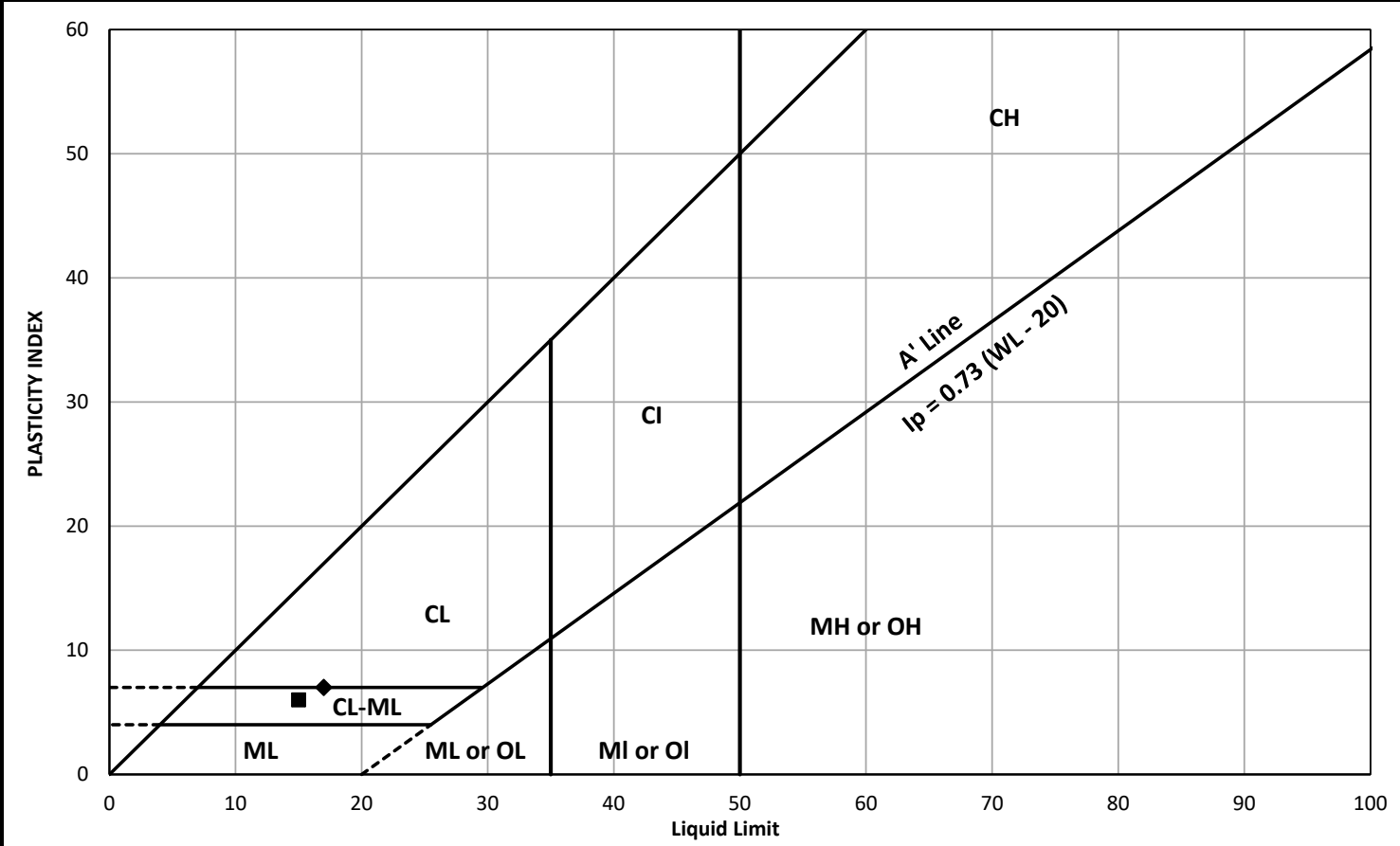
REV.

0

FIGURE

A4

PLASTICITY CHART




Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	400-4	8	247.7 to 247.1	11.1	15	9	6
◆	400-4	21B	223.0 to 222.7	8.5	17	10	7

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD

2023-12-06

DESIGNED

N/A

PREPARED

MCK

REVIEWED

KJB

APPROVED

MCK

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Plasticity Chart - Sandy CLAYEY SILT-SILT (CL-ML) (TILL) - Interlayers

PROJECT NO.

19136074

CONTROL

1002.001

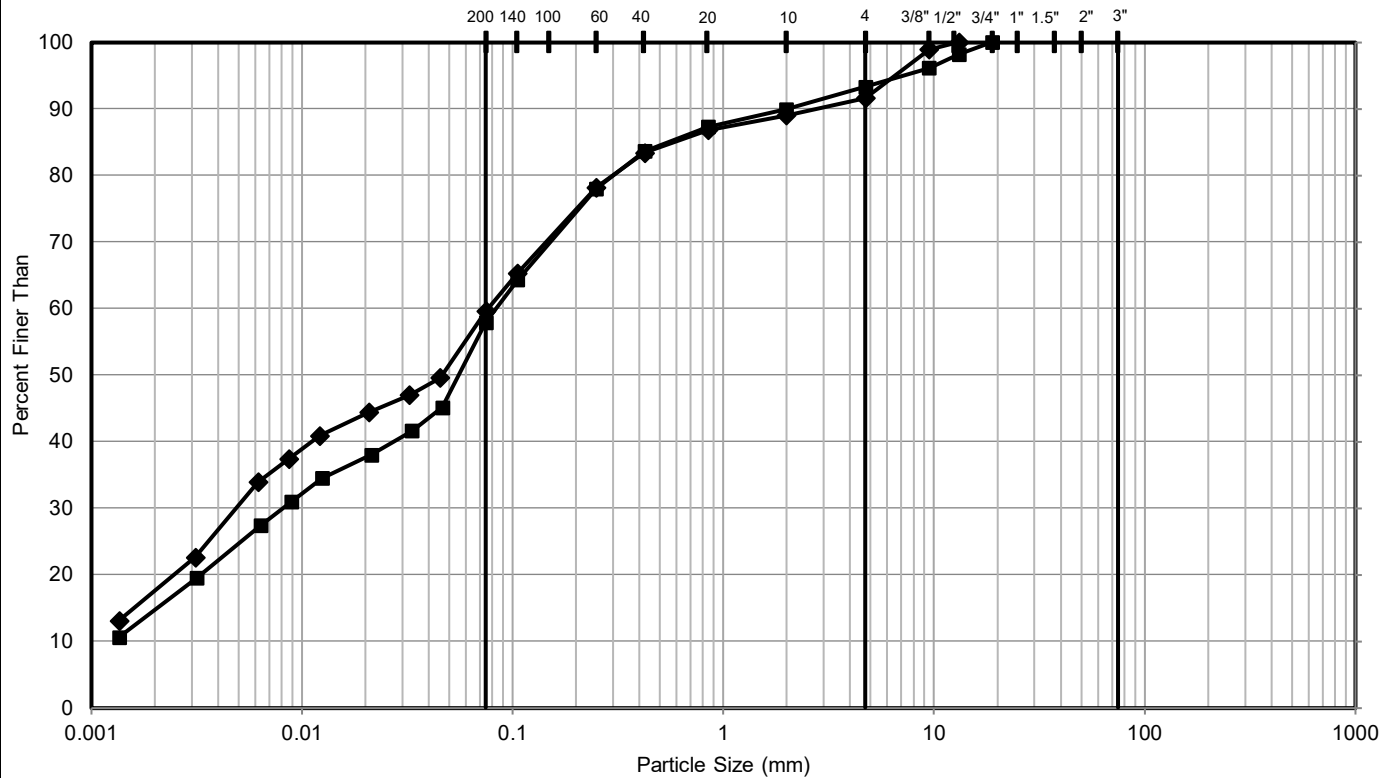
REV.

0

FIGURE

A5

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	400-4	8	6.1 - 6.7	247.7 to 247.1
◆	400-4	21B	30.8 - 31.1	223.0 to 222.7

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass - Structural Culverts



YYYY-MM-DD	2023-12-06
DESIGNED	N/A
PREPARED	MCK
REVIEWED	KJB
APPROVED	KJB

TITLE Grain Size Distribution - Sandy CLAYEY SILT-SILT (CL-ML) (TILL) - Interlayers			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	A6



Your Project #: 19136074
 Site Location: BRADFORD BYPASS
 Your C.O.C. #: n/a

Attention: Manisha Ahuja

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

Report Date: 2022/01/07
 Report #: R6953535
 Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1Z9994

Received: 2021/12/20, 17:36

Sample Matrix: Soil
 # Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	3	2021/12/29	2022/01/06	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	3	2021/12/29	2021/12/29	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	3	N/A	2021/12/23	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	3	N/A	2021/12/22	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	2	2021/12/22	2021/12/22	CAM SOP-00413	EPA 9045 D m
pH CaCl2 EXTRACT	1	2021/12/23	2021/12/23	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2021/12/20	2021/12/29	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	3	2021/12/29	2022/01/07	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

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

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

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

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

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

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



Your Project #: 19136074
Site Location: BRADFORD BYPASS
Your C.O.C. #: n/a

Attention: Manisha Ahuja

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

Report Date: 2022/01/07
Report #: R6953535
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1Z9994

Received: 2021/12/20, 17:36

Encryption Key



AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas

07 Jan 2022 18:58:33

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: emese.gitej@bureauveritas.com

Phone# (905)817-5829

=====

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

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



BUREAU
VERITAS

Bureau Veritas Job #: C1Z9994

Report Date: 2022/01/07

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		RLD018		RLD019		
Sampling Date		2021/12/07		2021/12/17		
COC Number		n/a		n/a		
	UNITS	BH400-1 SA-03 5'-7'	QC Batch	BH400-3 SA-02 2'6"-4'6"	RDL	QC Batch
Calculated Parameters						
Resistivity	ohm-cm	1100	7744133	5300		7744133
Inorganics						
Soluble (20:1) Chloride (Cl-)	ug/g	480	7756920	<20	20	7756920
Conductivity	umho/cm	893	7757558	188	2	7757558
Available (CaCl2) pH	pH	7.77	7748024	7.63		7750875
Soluble (20:1) Sulphate (SO4)	ug/g	<20	7756946	<20	20	7756946
Sulphide	mg/kg	3.3 (1)	7752526	5.8	0.5	7752526
Physical Testing						
Moisture-Subcontracted	%	23	7752565	21	0.30	7752565
RDL = Reportable Detection Limit						
QC Batch = Quality Control Batch						
(1) Sample extracted past method-specified hold time. Analyzed past method specified hold time						

Bureau Veritas ID		RLD019			RLD020		
Sampling Date		2021/12/17			2021/12/14		
COC Number		n/a			n/a		
	UNITS	BH400-3 SA-02 2'6"-4'6" Lab-Dup	RDL	QC Batch	BH400-4 SA-03 5'-7'	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm				2300		7744133
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	7756920	180	20	7756920
Conductivity	umho/cm				435	2	7757558
Available (CaCl2) pH	pH	7.66		7750875	7.88		7748024
Soluble (20:1) Sulphate (SO4)	ug/g				<20	20	7756946
Sulphide	mg/kg				4.1 (1)	0.5	7752526
Physical Testing							
Moisture-Subcontracted	%				12	0.30	7752565
RDL = Reportable Detection Limit							
QC Batch = Quality Control Batch							
Lab-Dup = Laboratory Initiated Duplicate							
(1) Sample extracted past method-specified hold time. Analyzed past method specified hold time							



BUREAU
VERITAS

Bureau Veritas Job #: C1Z9994

Report Date: 2022/01/07

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

TEST SUMMARY

Bureau Veritas ID: RLD018
Sample ID: BH400-1 SA-03 5'-7'
Matrix: Soil

Collected: 2021/12/07
Shipped:
Received: 2021/12/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7756920	2021/12/29	2022/01/06	Alina Dobreanu
Conductivity	AT	7757558	2021/12/29	2021/12/29	Kien Tran
Moisture (Subcontracted)	BAL	7752565	N/A	2021/12/23	Parveer Singh
Sulphide in Soil	SPEC	7752526	N/A	2021/12/22	Bailey Morrison
pH CaCl2 EXTRACT	AT	7748024	2021/12/22	2021/12/22	Taslina Aktar
Resistivity of Soil		7744133	2021/12/29	2021/12/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7756946	2021/12/29	2022/01/07	Avneet Kour Sudan

Bureau Veritas ID: RLD019
Sample ID: BH400-3 SA-02 2'6"-4'6"
Matrix: Soil

Collected: 2021/12/17
Shipped:
Received: 2021/12/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7756920	2021/12/29	2022/01/06	Alina Dobreanu
Conductivity	AT	7757558	2021/12/29	2021/12/29	Kien Tran
Moisture (Subcontracted)	BAL	7752565	N/A	2021/12/23	Parveer Singh
Sulphide in Soil	SPEC	7752526	N/A	2021/12/22	Bailey Morrison
pH CaCl2 EXTRACT	AT	7750875	2021/12/23	2021/12/23	Taslina Aktar
Resistivity of Soil		7744133	2021/12/29	2021/12/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7756946	2021/12/29	2022/01/07	Avneet Kour Sudan

Bureau Veritas ID: RLD019 Dup
Sample ID: BH400-3 SA-02 2'6"-4'6"
Matrix: Soil

Collected: 2021/12/17
Shipped:
Received: 2021/12/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7756920	2021/12/29	2022/01/06	Alina Dobreanu
pH CaCl2 EXTRACT	AT	7750875	2021/12/23	2021/12/23	Taslina Aktar

Bureau Veritas ID: RLD020
Sample ID: BH400-4 SA-03 5'-7'
Matrix: Soil

Collected: 2021/12/14
Shipped:
Received: 2021/12/20

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7756920	2021/12/29	2022/01/06	Alina Dobreanu
Conductivity	AT	7757558	2021/12/29	2021/12/29	Kien Tran
Moisture (Subcontracted)	BAL	7752565	N/A	2021/12/23	Parveer Singh
Sulphide in Soil	SPEC	7752526	N/A	2021/12/22	Bailey Morrison
pH CaCl2 EXTRACT	AT	7748024	2021/12/22	2021/12/22	Taslina Aktar
Resistivity of Soil		7744133	2021/12/29	2021/12/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7756946	2021/12/29	2022/01/07	Avneet Kour Sudan



BUREAU
VERITAS

Bureau Veritas Job #: C1Z9994

Report Date: 2022/01/07

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

GENERAL COMMENTS

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

Package 1	2.7°C
-----------	-------

Results relate only to the items tested.



BUREAU
VERITAS
1828

Bureau Veritas Job #: C1Z9994
Report Date: 2022/01/07

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 19136074
Site Location: BRADFORD BYPASS
Sampler Initials: AM

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7748024	Available (CaCl ₂) pH	2021/12/22			100	97 - 103			0.25	N/A
7750875	Available (CaCl ₂) pH	2021/12/23			100	97 - 103			0.44	N/A
7752526	Sulphide	2021/12/22	106	75 - 125	108	75 - 125	<0.5	mg/kg		
7752565	Moisture-Subcontracted	2021/12/23					<0.30	%		
7756920	Soluble (20:1) Chloride (Cl ⁻)	2022/01/06	114	70 - 130	103	70 - 130	<20	ug/g	NC	35
7756946	Soluble (20:1) Sulphate (SO ₄)	2022/01/07	NC	70 - 130	107	70 - 130	<20	ug/g	3.8	35
7757558	Conductivity	2021/12/29			98	90 - 110	<2	umho/cm	3.0	10

N/A = Not Applicable

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

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

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

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

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

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



BUREAU
VERITAS

Bureau Veritas Job #: C1Z9994

Report Date: 2022/01/07

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

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

Orla Jorgensen, Organics Lab Manager

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



6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/6

WORK ORDER CHAIN OF CUSTODY RECORD

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required								
Company Name: Golder Associates Ltd.	Company Name: Golder Associates Ltd.	Quotation #:	<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses		<input type="checkbox"/> PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS									
Contact Name: Canada Accounts Payable	Contact Name: Manisha Ahuja	P.O. #/ AFE#:	Rush TAT (Surcharges will be applied)		<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days									
Address: 6925 Century Ave. Suite 100	Address: 6925 Century Ave. Suite 100	Project #:	19136074											
Mississauga, ON	Mississauga, ON L5N 7K2	Site Location:	Bradford Bypass											
Phone: 905-567-4444 Fax: 905-567-6561	Phone: 365-292-1471 Fax: 905-567-6561	Site #:												
Email: canadaaccounts payableinvoices@golder.com	Email: Manisha.Ahuja@golder.com	Site Location Province:	Bradford Ontario		Date Required:									
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS DRINKING WATER CHAIN OF CUSTODY		Sampled By:	AM		Rush Confirmation #:									
Regulation 153		Other Regulations		Analysis Requested		LABORATORY USE ONLY								
<input checked="" type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine	<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw					CUSTODY SEAL								
<input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse	<input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw					Y / N								
<input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other	<input type="checkbox"/> PWQU <input type="checkbox"/> Region					Present: Intact								
<input type="checkbox"/> Table	<input type="checkbox"/> Other (Specify)					COOLER TEMPERATURES								
FOR RSC (PLEASE CIRCLE) Y / N	<input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)					412/2								
Include Criteria on Certificate of Analysis: Y / N	<input type="checkbox"/> REG 406 Table					COOLING MEDIA PRESENT: Y / N								
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS						COMMENTS								
SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / Cr VI	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	
1 BH 400-1 SA-03 5'-7'	2021-12-07	PM	SOIL	2								X		2 Jars, no redox.
2 BH 400-3 SA-02 2'6"-4'6"	2021-12-17	PM	SOIL	1								X		1 Jar, no redox.
3 BH 400-4 SA-03 5'-7'	2021-12-14	PM	SOIL	2								X		2 Jars, no redox.
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)	BV JOB #						
[Signature] / Alhoben M		2021/12/20	18:00	[Signature] M. VEDH BHASKAR		2021/12/20	17:36							

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.

APPENDIX B

Previous Investigation at Highway 400 / 9th Line
(Golder 2001, GEOCREs #31D00-459)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Consistency

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

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

LIST OF SYMBOLS

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

I GENERAL

π	= 3.1416
$\ln x$,	natural logarithm of x
$\log_{10} x$ or $\log x$,	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

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

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) 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

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

ON MOT 001-1151.GPJ ON MOT.GDT 7/12/01

+³, X³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

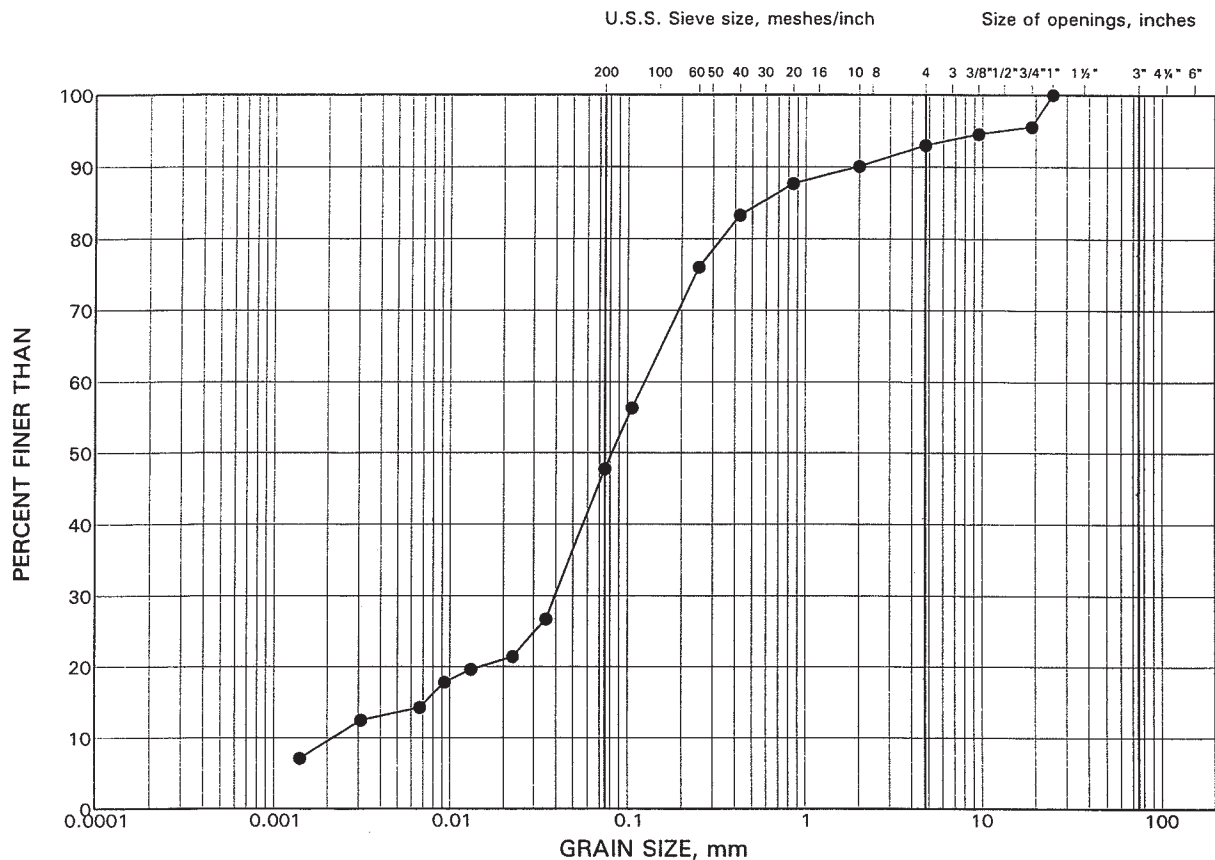
PROJECT 001-1151				RECORD OF BOREHOLE No B4-1				2 OF 2				METRIC					
W.P. 40-00-00				LOCATION N 4887127.3; E 293870.9				ORIGINATED BY SB									
DIST SW HWY 400				BOREHOLE TYPE 108mm Diameter Solid Stem Augers				COMPILED BY LCC									
DATUM Geodetic				DATE December 21-22, 2000				CHECKED BY ASP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N* VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
248.4	Silty Sand, trace to some gravel, trace to some clay (Till) Dense to very dense Grey Moist		17	SS	48												
			18	SS	120												
			19	SS	107												
23.3	END OF BOREHOLE																
	Note: Water level in open borehole on completion of drilling at 4.0m depth (Elev.267.7m).																

ON_MOT 001-1151.GPJ ON_MOT.GDT 7/12/01

GRAIN SIZE DISTRIBUTION TEST RESULT

~~Sand and Silt Till~~
Silty Sand

FIGURE 1
B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	B4-1	3	269.6

APPENDIX C

**Investigation at Bradford Bypass Deep Cut / High Fill
Areas (GEOCRES #31D04-004)**

PROJECT 19136074

RECORD OF BOREHOLE No. DC-03

Sheet 1 of 3

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4889831.9; E 307194.8 NAD83 / MTM Zone 10 (LAT. 44.148479; LONG. -79.470065)

ORIGINATED BY DR

DIST Central HWY BBP - Deep Cut

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY AM

DATUM CGVD28 Surface Elevation:223.6 m

DATE Dec 01, 2022 - Dec 02, 2022

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL	NMC	LL						
								Field Vane	Remoulded	Pocket Pen	Quick Triaxial	Unconfined	W _p	W	W _L						
														NP Nonplastic							
0.0 223.5 0.1	Sandy SILT (TOPSOIL 130 mm) SILTY SAND (SM) Compact to very dense Brown; oxidation staining present Moist		1A																		
			1B	SS	13		223														
			2	SS	20																
			3	SS	57		222														
221.4																					
2.2	Sandy SILT (ML) of slight plasticity, trace gravel Compact Grey Moist		4	SS	11		221														
			5A																		
220.4			5B	SS	11		220														
			6	SS	19																
			7	SS	115		219														
			8	SS	109		218														
			9	SS	109		217														
							216														
214.9							215														
8.7	SILT (ML), some sand Very Dense Grey Moist		10	SS	78		214														

Continued on Next Page

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

PROJECT	19136074	RECORD OF BOREHOLE	No. DC-03	Sheet 2 of 3	METRIC
G.W.P.	Assignment No 2019-E-0048	LOCATION	N 4889831.9; E 307194.8 NAD83 / MTM Zone 10 (LAT. 44.148479; LONG. -79.470065)	ORIGINATED BY	DR
DIST	Central HWY BBP - Deep Cut	BOREHOLE TYPE	210 mm O.D. Hollow Stem Augers; Mud Rotary	COMPILED BY	AM
DATUM	CGVD28 Surface Elevation:223.6 m	DATE	Dec 01, 2022 - Dec 02, 2022	CHECKED BY	KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
213.4 10.2	SILT (ML), some sand Very Dense Grey Moist CLAYEY SILT (CL), contains silt seams Hard Grey Moist		11	SS	57		213	20 40 60 80 100					20 40 60								
211.9 11.7	SILT (ML), trace sand Very dense Grey Wet		12	SS	112		211														
210.3 13.3	CLAYEY SILT-SILT (CL-ML), contains silt and sand seams Hard Grey Moist		13	SS	70		210														
							209														
			14	SS	57		208										0	0	77	23	
							207														
			15	SS	83		206														
							205														
			16	SS	56		204														

Continued on Next Page

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

METRIC

ORIGINATED BY DR

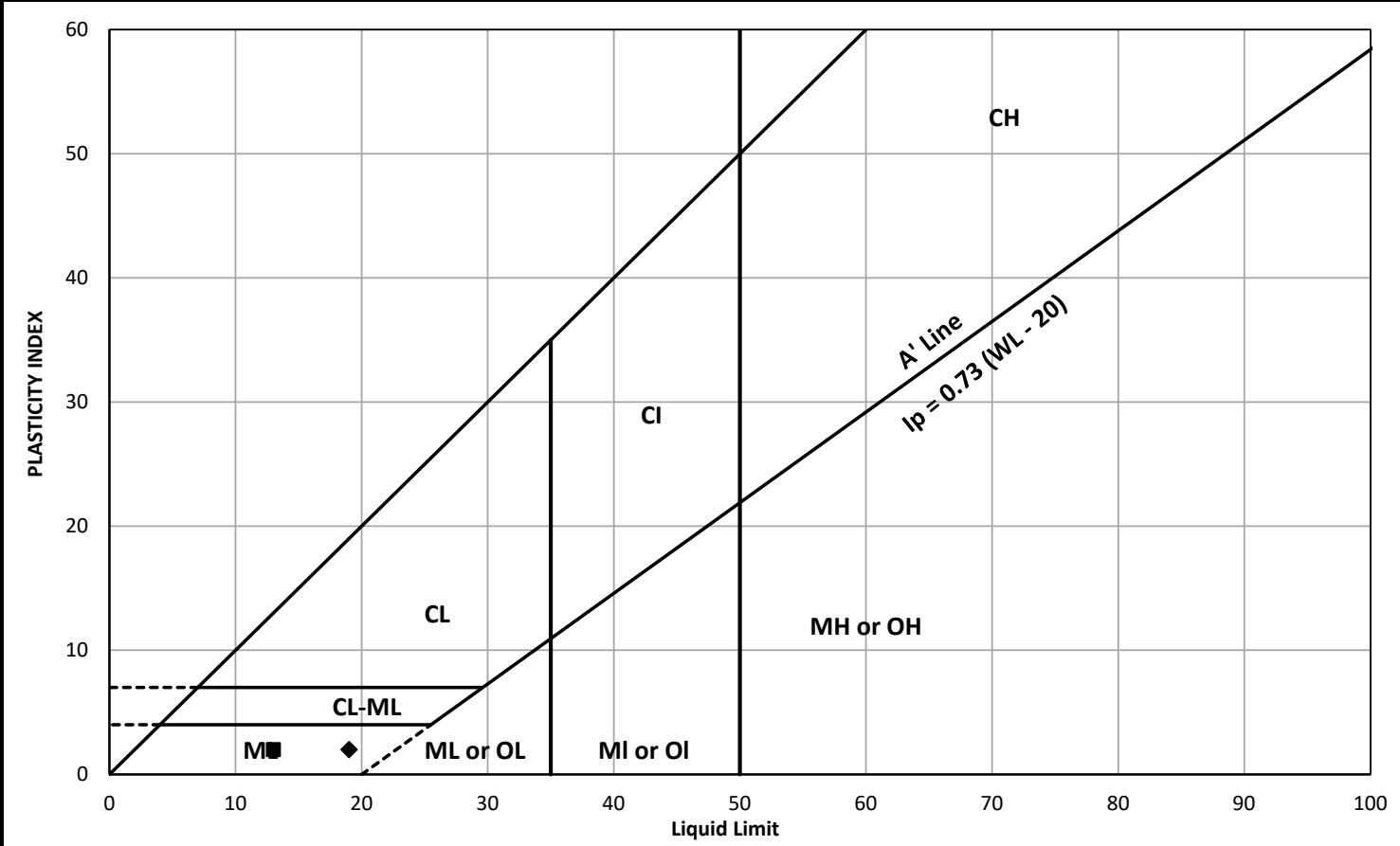
COMPILED BY AM

CHECKED BY KJB


[illegible]

⁺, x³ : Numbers refer to Sensitivity o^{3%} STRAIN AT FAILURE

PLASTICITY CHART

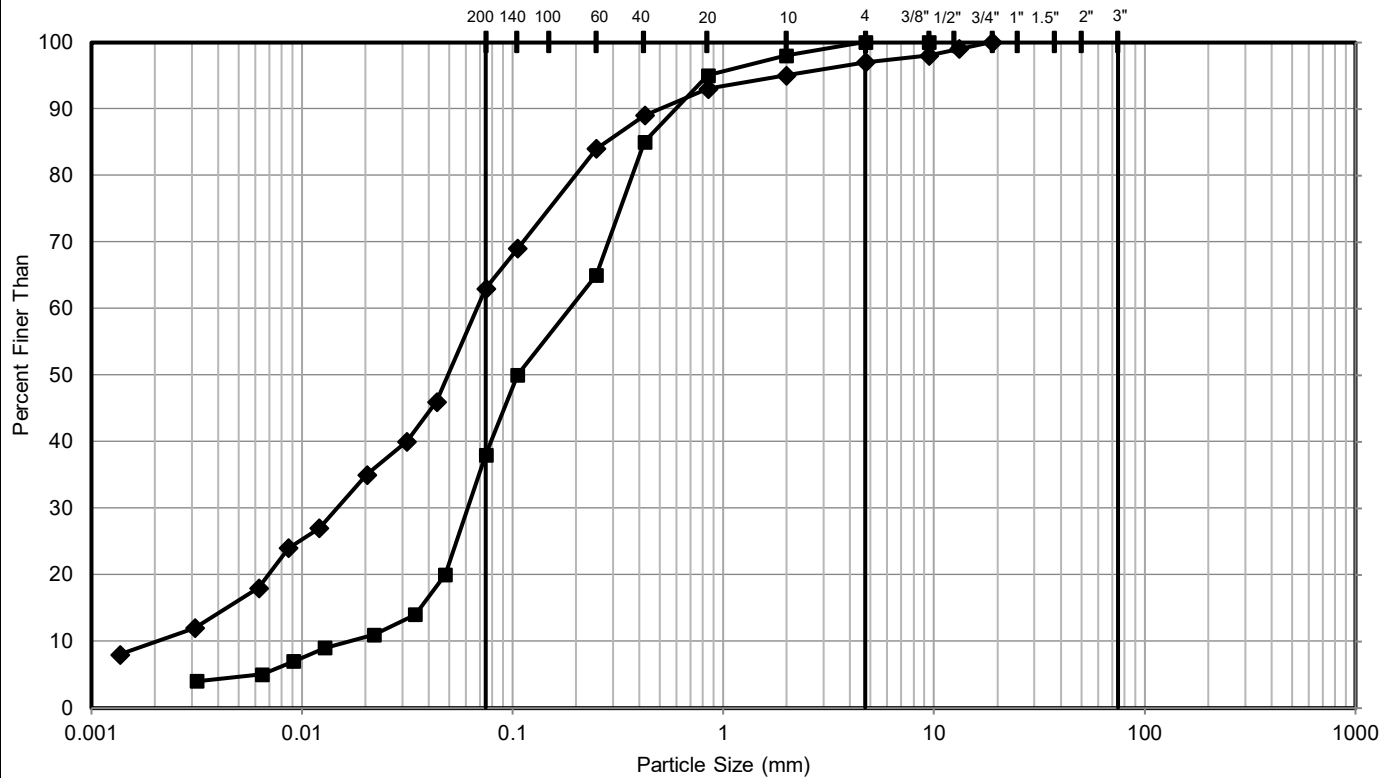


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	DC-03	4	221.3 to 220.7	10	13	11	2
◆	DC-03	10	214.5 to 213.9	19.6	19	17	2

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - SILT to Sandy SILT (ML)			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	C1

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	DC-03	3	1.5 - 2.1	222.1 to 221.5
◆	DC-03	4	2.3 - 2.9	221.3 to 220.7

CLIENT
AECOM / MTO

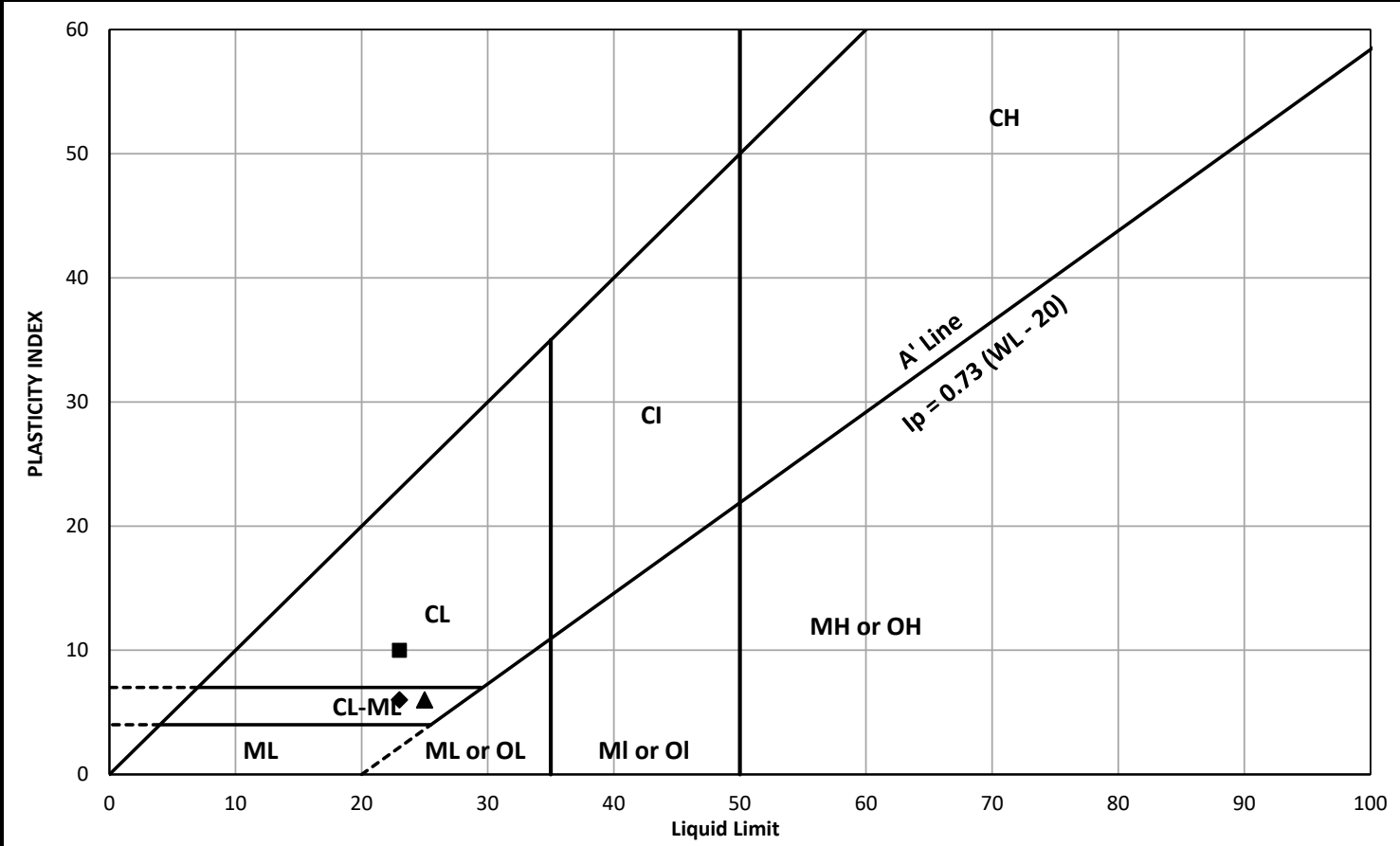
PROJECT
Bradford Bypass - Structural Culverts




YYYY-MM-DD 2023-12-06
DESIGNED N/A
PREPARED MCK
REVIEWED KJB
APPROVED KJB

TITLE
Grain Size Distribution - Sandy SILT (ML) to SILTY SAND (SM)
PROJECT NO. 19136074
CONTROL 1002.001
REV. 0
FIGURE C2

PLASTICITY CHART

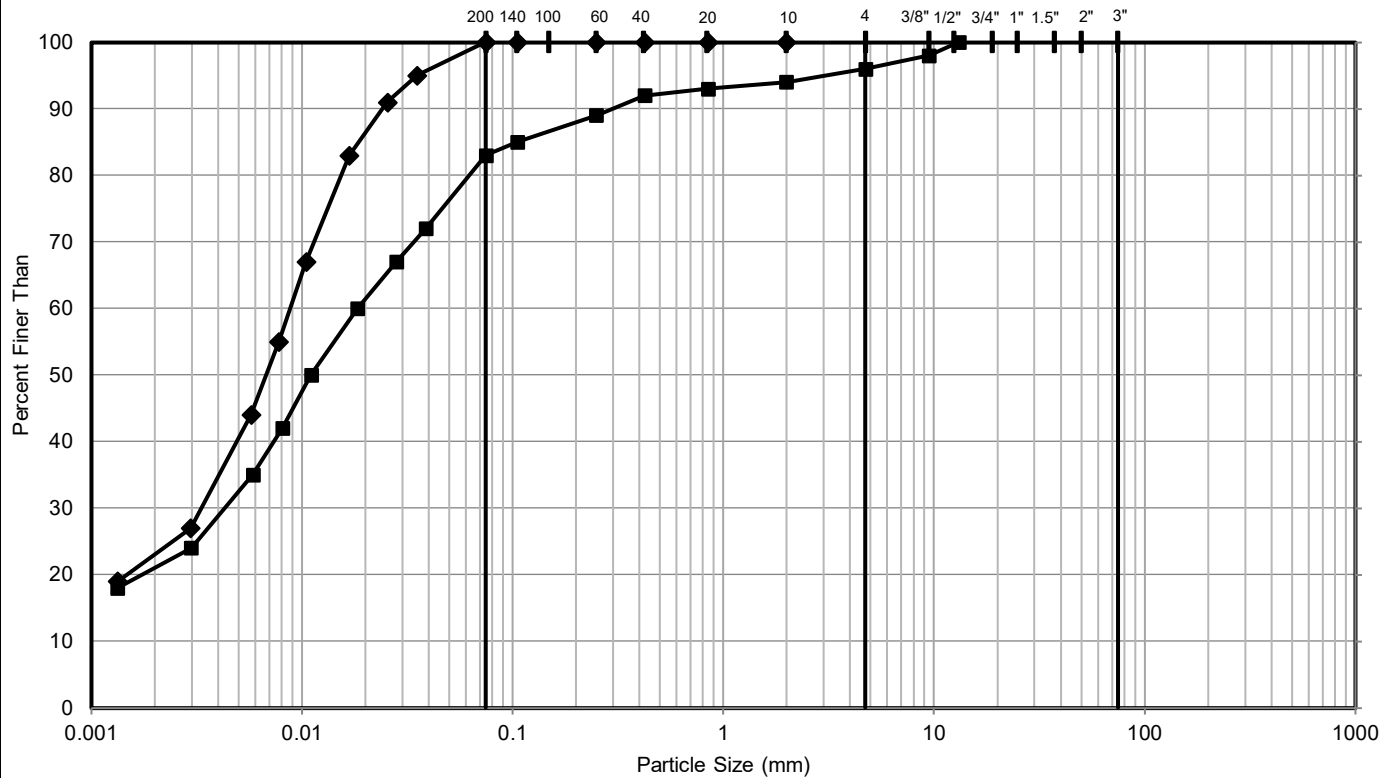


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	DC-03	7	219.0 to 218.5	11.3	23	13	10
◆	DC-03	14	208.4 to 207.8	21.8	23	17	6
▲	DC-03	17	203.8 to 203.2	23.1	25	19	6

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL)			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	C3

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	DC-03	7	4.6 - 5.2	219.0 to 218.5
◆	DC-03	14	15.2 - 15.9	208.4 to 207.8

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass - Structural Culverts



YYYY-MM-DD 2023-12-06
DESIGNED N/A
PREPARED MCK
REVIEWED KJB
APPROVED KJB

TITLE
Grain Size Distribution - CLAYEY SILT-SILT (CL-ML) to CLAYEY SILT (CL)
PROJECT NO. 19136074
CONTROL 1002.001
REV. 0
FIGURE C4

APPENDIX D

**Previous Investigation for Highway 404 Extension
(Golder 2010, GEOCREC #31D00-499)**



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

T_p, T_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

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

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



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

PROJECT 08-1111-0022			RECORD OF BOREHOLE No C2-1			1 OF 1 METRIC											
G.W.P. 2005-07-00			LOCATION N 4890050.4 ; E 309545.5			ORIGINATED BY TB											
DIST _____ HWY 404			BOREHOLE TYPE 108 mm O.D. Solid Stem Auger			COMPILED BY JFC											
DATUM Geodetic			DATE June 5, 2009			CHECKED BY KJB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30					
251.2	GROUND SURFACE																
0.0	CLAYEY SILT with organics, trace to some sand, containing rootlets, oxidation staining and layers of silty clay		1	SS	1		251										
250.5	Very soft Dark brown Moist		2	TO	PH		250										
0.7	CLAYEY SILT, trace to some sand, containing oxidation staining and interlayers of silty clay and sandy silt		3	SS	11		249										
	Firm to very stiff Brown to grey Moist		4	SS	13		248										
			5	SS	19		247										
247.4	Sandy SILT, trace clay		6	SS	37		246										
247.1	Dense Grey Wet		7	SS	26		245										
4.1	CLAYEY SILT, trace sand, containing interlayers of silty clay		8	SS	39		244										
	Very stiff to hard Grey Moist		9	SS	83		243										
			10	SS	116		242										
244.0	SILT, trace sand, containing interlayers of clayey silt and silty clay																
7.2	Very dense Grey Moist																
241.5	END OF BOREHOLE																
9.8	NOTES: 1. Water level in open borehole at ground surface upon completion of drilling. 2. Water level in piezometer at a depth of 0.3 m below ground surface (Elev. 250.9 m) on June 12, 2009. 3. Laboratory Consolidation Test performed on clayey soil taken from Sample No. 2. 4. Water level in piezometer at a depth of 0.3 m (Elev. 250.9 m) below ground surface on June 12, 2009.																

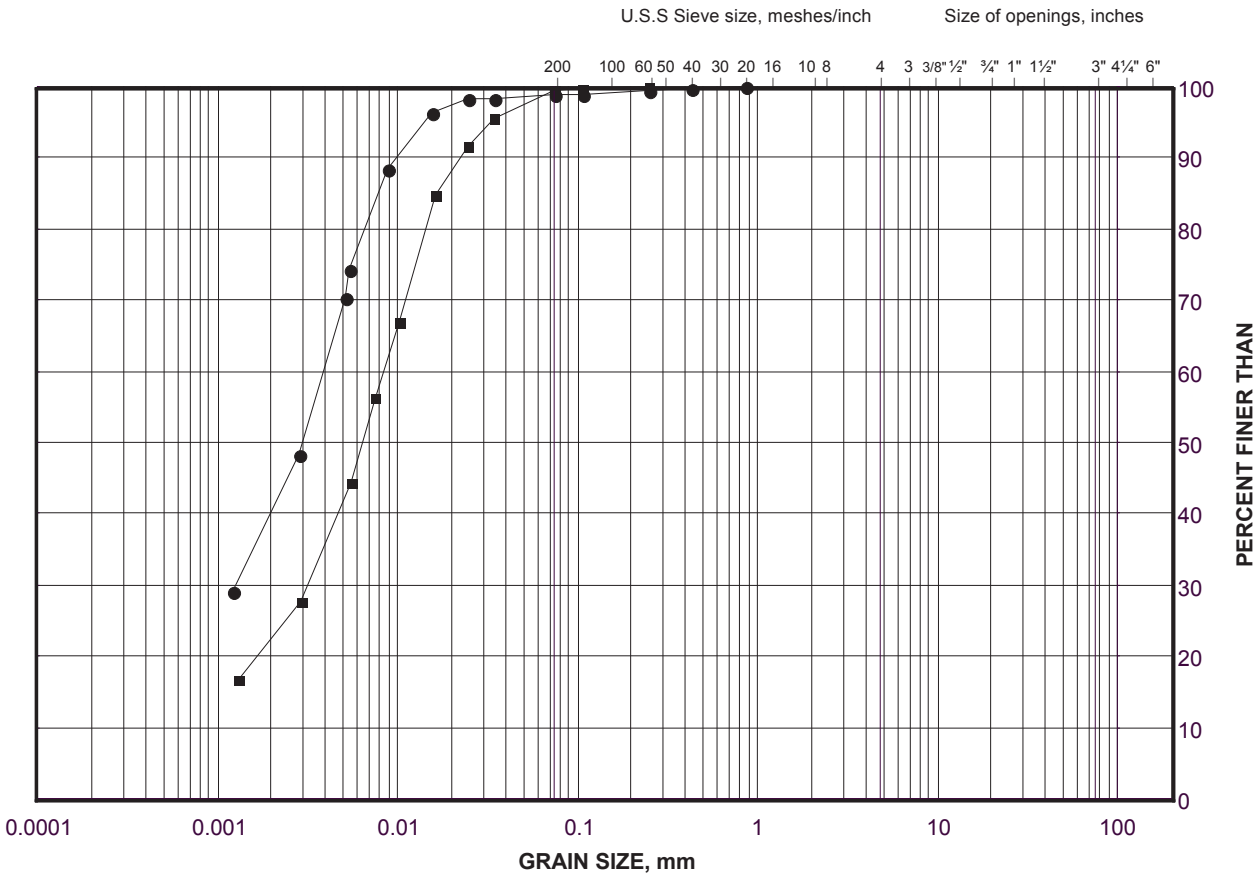
MIS-MTO 001 08-1111-0022.GPJ GAL-MASS.GDT 10/3/10 DD/SAC

PROJECT 08-1111-0022			RECORD OF BOREHOLE No C2-6			1 OF 1 METRIC																				
G.W.P. 2005-07-00			LOCATION N 4890149.3 ; E 309640.6			ORIGINATED BY TB																				
DIST _____ HWY 404			BOREHOLE TYPE 108 mm O.D. Solid Stem Auger			COMPILED BY JFC																				
DATUM Geodetic			DATE June 7, 2009			CHECKED BY KJB																				
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					W _p W W _L			WATER CONTENT (%)			γ			GR SA SI CL				
248.0	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30																
0.0	Organic SILT with clay, some sand, containing rootlets, oxidation staining and sand interlayers Very soft to soft Dark brown Moist to wet		1	SS	2																					
246.9			2A	SS	4																					
1.1	CLAYEY SILT, trace to some sand, trace gravel, containing interlayers of silty clay and oxidation staining to a depth of 4.6 m Firm to hard Brown to grey Moist		2B																							
			3	SS	19																					
			4	SS	31																					
			5	SS	31																					
			6	SS	31																					
			7	SS	51																					
			8	SS	181																					
240.8																										
7.2	Silty SAND, trace clay Very dense Grey Wet		9	SS	118																					
238.5			10A	SS	111																					
9.8	CLAYEY SILT, trace to some sand Hard Grey Moist END OF BOREHOLE		10B																							
NOTES:																										
1. Water level in open borehole at a depth of 0.1 m below ground surface (Elev. 247.9 m) upon completion of drilling.																										
2. Water level in piezometer at a depth of 2.8 m below ground surface (Elev. 245.2 m) on June 12, 2009.																										

GRAIN SIZE DISTRIBUTION

Clayey Silt (Silty Clay Interlayer)

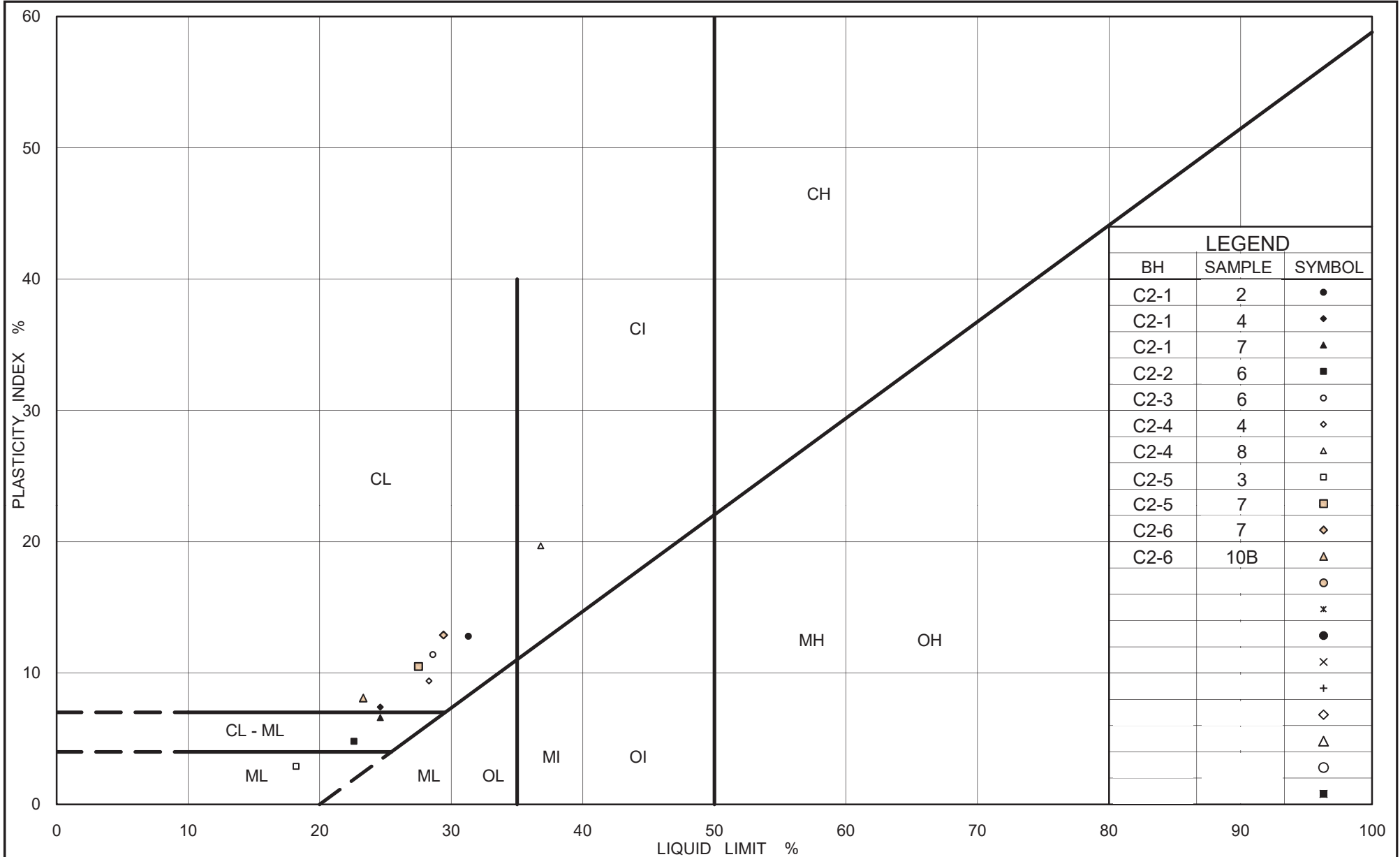
FIGURE C1-4
D1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C2-5	7	243.8
■	C2-1	7	246.3



Ministry of
Transportation
Ontario

PLASTICITY CHART

Clayey Silt (Contains Silty Clay Inter-Layers)

Figure No. ~~C1-5~~ **D2**

Project No. 08-1111-0022E

Checked By: KJB



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 10T379342

PROJECT NO: 08-1111-0022

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: Gregory Meek

Groundwater General Chemistry

DATE SAMPLED: Jan 07, 2010

DATE RECEIVED: Jan 08, 2010

DATE REPORTED: Jan 18, 2010

SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	BR3 1630746	BR8 1630747	C2-1 1630755	HD2-1A 1630756	HD5-2 1630757	HD7-1 1630765	HD3-1 1630773
Electrical Conductivity	uS/cm		2	542	473	760	591	744	671	535
pH	NA		NA	8.03	8.09	7.95	8.07	8.15	8.07	8.10
Total Dissolved Solids	mg/L		20	348	302	476	396	478	488	452
Alkalinity (as CaCO ₃)	mg/L		5	182	235	381	250	304	295	261
Chloride	mg/L	250	0.10	48.3	1.36	19.3	9.10	39.2	7.42	4.69
Nitrate as N	mg/L	10	0.05	<0.05	<0.05	<0.05	<0.05	3.61	<0.05	0.30
Sulphate	mg/L		0.10	33.3	28.9	24.8	63.6	42.8	85.4	32.6
Ammonia as N	mg/L		0.02	0.14	0.25	0.12	0.03	0.05	0.04	0.95
Calcium	mg/L		0.05	57.1	54.7	114	80.5	99.2	112	91.2
Magnesium	mg/L		0.05	17.9	22.3	19.4	25.2	33.6	27.3	22.2
Sodium	mg/L	200	0.05	24.7	7.13	21.6	6.53	10.5	9.81	6.05
Barium	mg/L	1.0	0.002	0.100	0.085	0.090	0.082	0.069	0.056	0.065
Boron	mg/L	5.0	0.010	0.040	0.026	0.015	<0.010	0.013	0.011	<0.010
Iron	mg/L		0.010	1.20	0.297	<0.010	<0.010	<0.010	0.167	<0.010

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T2(PGW)

Certified By:

Elizabeth Potokowska

APPENDIX E

Current Investigation

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

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

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

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (*q_t*), porewater pressure (*u*) and sleeve friction (*f_s*) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

SAMPLES

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

SOIL TESTS

w	water content
PL, w _p	plastic limit
LL, w _L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

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

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 grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

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.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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

I. GENERAL

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

II. STRESS AND STRAIN

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

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

III. SOIL PROPERTIES

(a) Index Properties

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

* Density symbol is ρ . Unit weight symbol is γ .
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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	modified secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q or q'	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1
2

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

Structural Culverts Between Highway 400 and 10th Sideroad

PROJECT 19136074

RECORD OF BOREHOLE No. R-BBP-6A Sheet 1 of 2

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4886751; E 294571.6 NAD83 / MTM Zone 10 (LAT. 44.120683; LONG. -79.627798)

ORIGINATED BY TC

DIST Central HWY BBP - Culvert

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:262.5 m

DATE Aug 14, 2023

CHECKED BY MCK

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
0.0 262.4	TOPSOIL (127 mm)							20	40	60	80	100	20	40	60						
0.1 262.0	CLAYEY SILT (CL), trace rootlets, (FILL) Firm Dark brown Moist		1	SS	7		262														
0.6 261.0	CLAYEY SILT (CL), trace sand pockets, trace gravel Firm Brown to grey Moist		2	SS	7		261														
1.5 260.1	CLAYEY SILT (CL), trace sand, trace gravel (TILL) Stiff Brown, trace oxidation staining Moist - 1.5 m: Auger grinding Containing sandy silt till layers		3	SS	10		260														
2.4 259.5	CLAYEY SILT (CL) trace sand Very stiff Brown Moist		4A	SS	17		259														
3.0 258.7	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Very stiff Brown Moist		4B				258														
3.8 257.4	CLAYEY SILT (CL) Very stiff Grey Moist		5	SS	25		257										9	26	47	18	
5.1 257.4	SILTY SAND (SM), trace to some gravel, trace clay (TILL) Loose to compact Grey Moist to wet - 5.1 to 5.7 m: Wet spoon		6A	SS	17		256														
			6B				255														
			6C	TO			254														
			7	SS	8		253														
			8	SS	8																
			9	SS	7												11	41	40	8	
			10	SS	12																
	- 9.8 m: Auger grinding																				

Continued on Next Page

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

METRIC

ORIGINATED BY TC

COMPILED BY MTI

CHECKED BY MCK

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

PROJECT 19136074

RECORD OF BOREHOLE No. R-BBP-6B Sheet 1 of 2

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4886580.1; E 294711.9 NAD83 / MTM Zone 10 (LAT. 44.119146; LONG. -79.626042)

ORIGINATED BY TC

DIST Central HWY BBP - Culvert

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:259.6 m

DATE Aug 16, 2023


CHECKED BY MCK

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
0.0 259.4	TOPSOIL (150 mm)							20	40	60	80	100	20	40	60						
0.2	CLAYEY SILT (CL), trace sand, trace gravel, containing rootlets, (FILL) Firm Dark brown to brown Moist		1	SS	8		259														
			2	SS	4																
258.1 1.4	SILTY SAND (SM) (FILL)		3A				258														
257.9 1.6	Compact Brown Moist		3B	SS	10																
	SILT and Sand (ML), trace gravel, some clay (TILL) Compact Brown Moist		4A	SS	28		257						OH				6	42	40	12	
	- 2.7 to 2.8 m: containing more gravel in Sample 4B		4B																		
256.6			4C																		
3.0	Sandy SILT (ML) Compact Brown to greyish brown Wet		5	SS	28		256														
			6	SS	18											NP	0	24	76	0	
255.0			7A				255														
	SILTY SAND (SM), trace gravel (TILL) Loose to compact Grey Moist to wet		7B	SS	12																
			7C																		
			8	SS	5		253										9	42	39	10	
251.7 7.8	SILT and Sand (ML), trace gravel, trace clay (TILL) Very loose to compact Grey Moist to Wet		9	SS	4		251														
	- 9.1 to 9.8 m: containing more sand (SILTY SAND)		10	SS	5		250														

Continued on Next Page

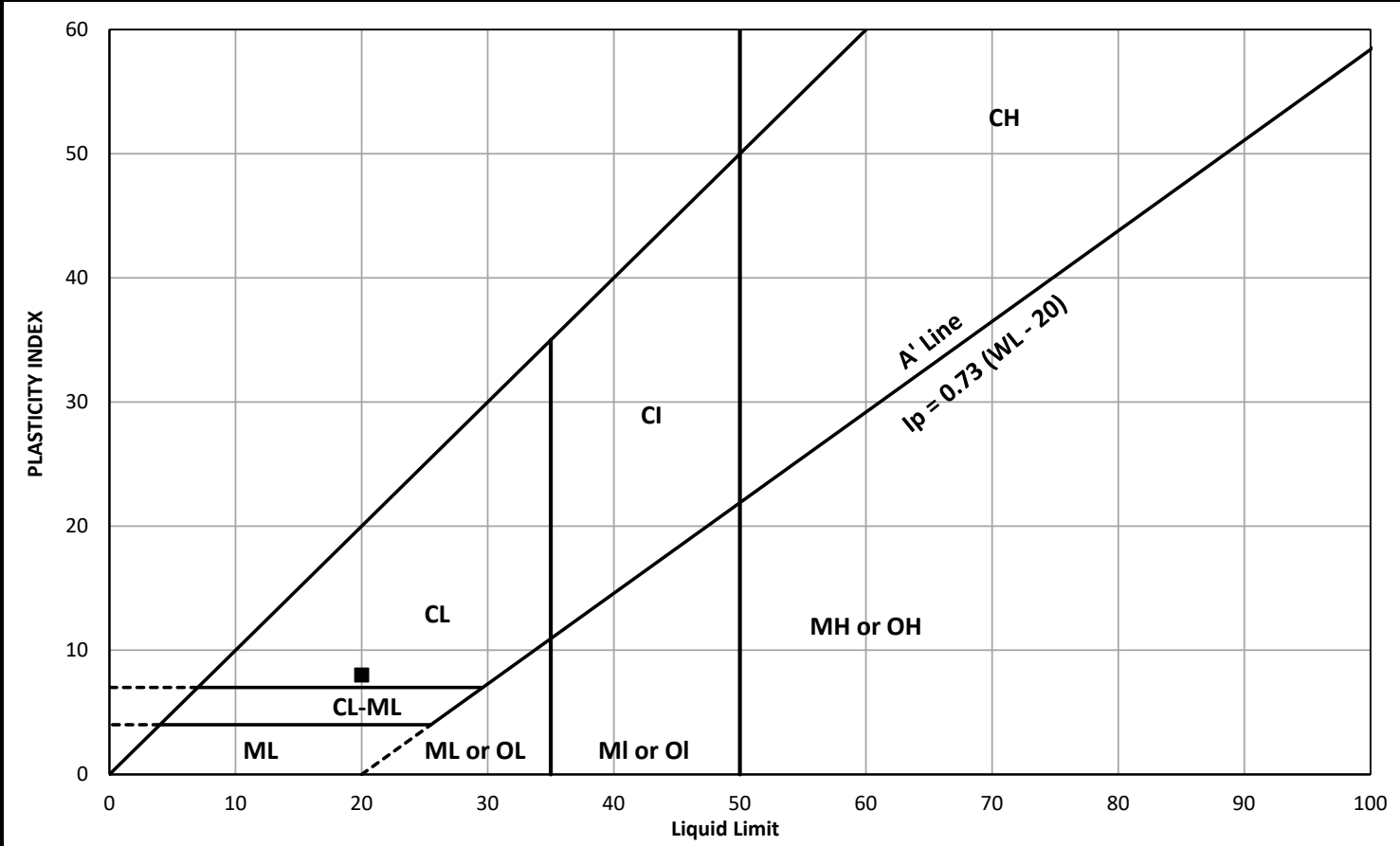
+³, x³ : Numbers refer to Sensitivity o³⁰% STRAIN AT FAILURE

PROJECT 19136074		RECORD OF BOREHOLE No. R-BBP-6B		Sheet 2 of 2		METRIC	
G.W.P. Assignment No 2019-E-0048		LOCATION N 4886580.1; E 294711.9 NAD83 / MTM Zone 10 (LAT. 44.119146; LONG. -79.626042)		ORIGINATED BY TC			
DIST Central HWY BBP - Culvert		BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers		COMPILED BY MTI			
DATUM CGVD28 Surface Elevation:259.6 m		DATE Aug 16, 2023		CHECKED BY MCK			

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION 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)					PL	NMC	LL						
								Field Vane	Remoulded	Pocket Pen	Quick Triaxial	Unconfined	W _p	W	W _L						
							20	40	60	80	100										
	SILT and Sand (ML), trace gravel, trace clay (TILL) Very loose to compact Grey Moist to Wet						249														
			11	SS	6																
							248														
			12	SS	10		247						○								
							246														
			13	SS	3								⊕				4	45	41	10	
			13A	TO			245														
	- 15.7 to 18.0 m: Auger grinding		14	SS	7		244						○								
							243														
			15	SS	7																
							242														
			16	SS	5		241						○								
240.6																					
18.9	End of Borehole																				
	Notes: 1. No water measured inside hollow stem augers during drilling. 2. A monitoring well was installed approximately 2.3 m northeast of borehole. 3. Water level in piezometer measured at a depth of 2.8 m (Elev. 256.8 m) on December 8, 2023						240														

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

PLASTICITY CHART




Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	R-BBP-6A	5	259.5 to 258.9	11.7	20	12	8

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD

2023-12-06

DESIGNED

N/A

PREPARED

MCK

REVIEWED

KJB

APPROVED

MCK

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Plasticity Chart - CLAYEY SILT (CL) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

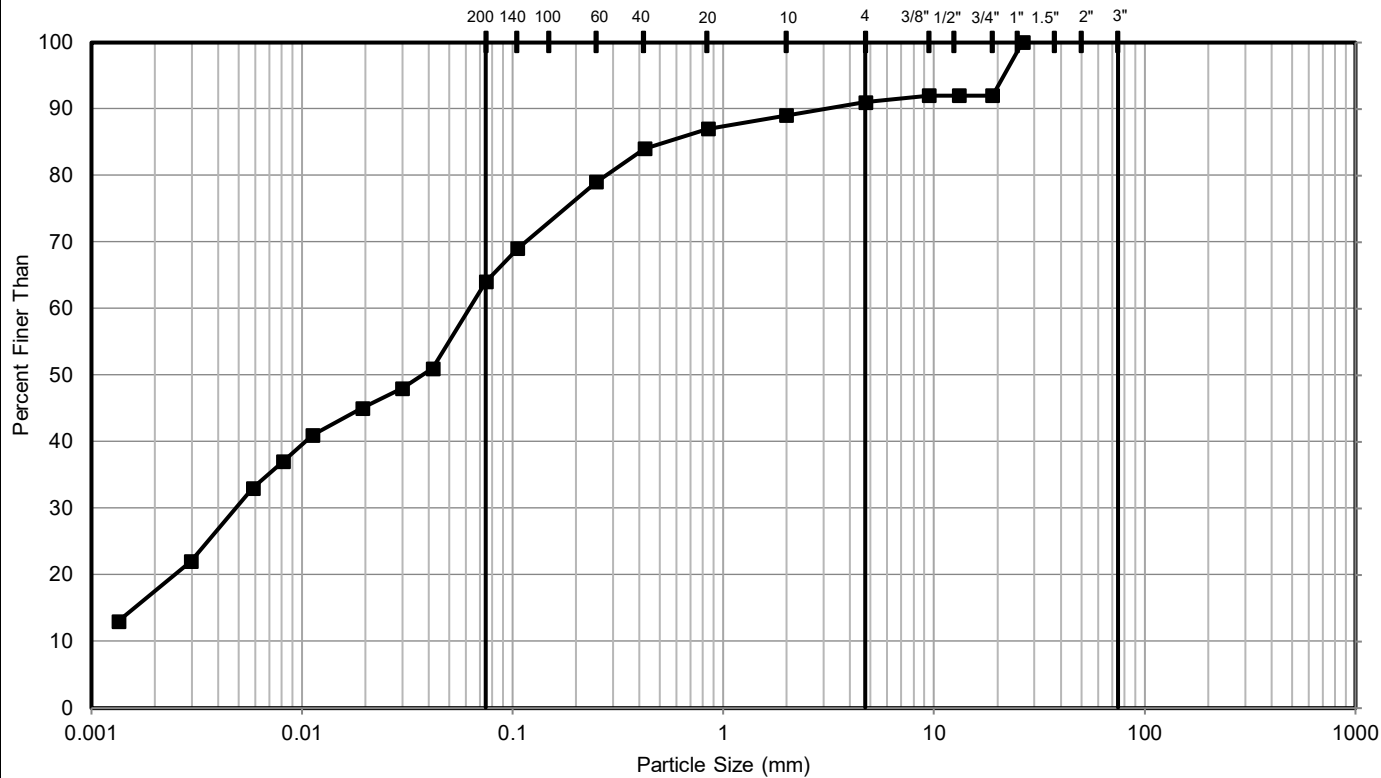
REV.

0

FIGURE

E1-1

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	R-BBP-6A	5	3.1 - 3.7	259.5 to 258.9

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - CLAYEY SILT (CL) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

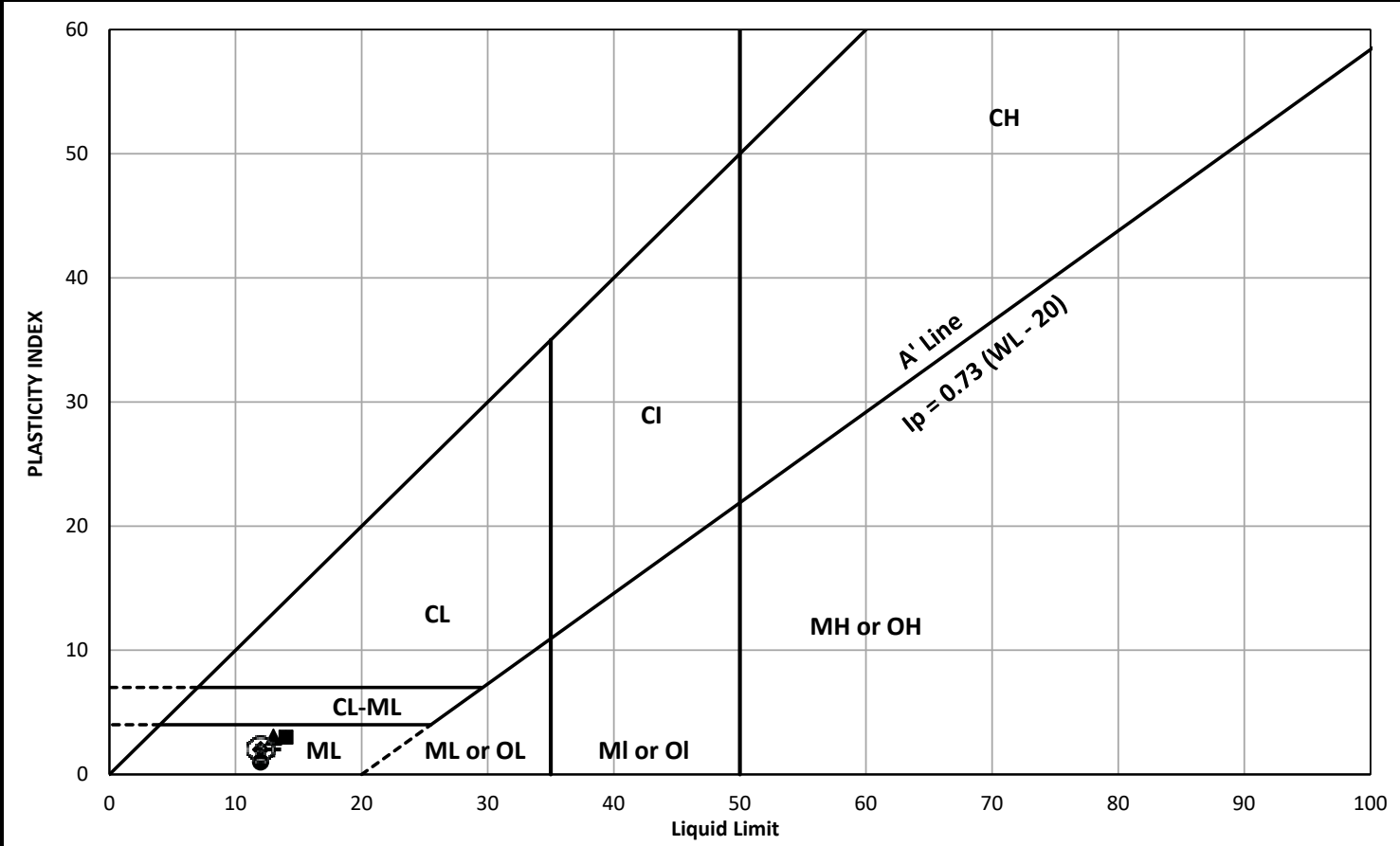
REV.

0

FIGURE

E1-2

PLASTICITY CHART

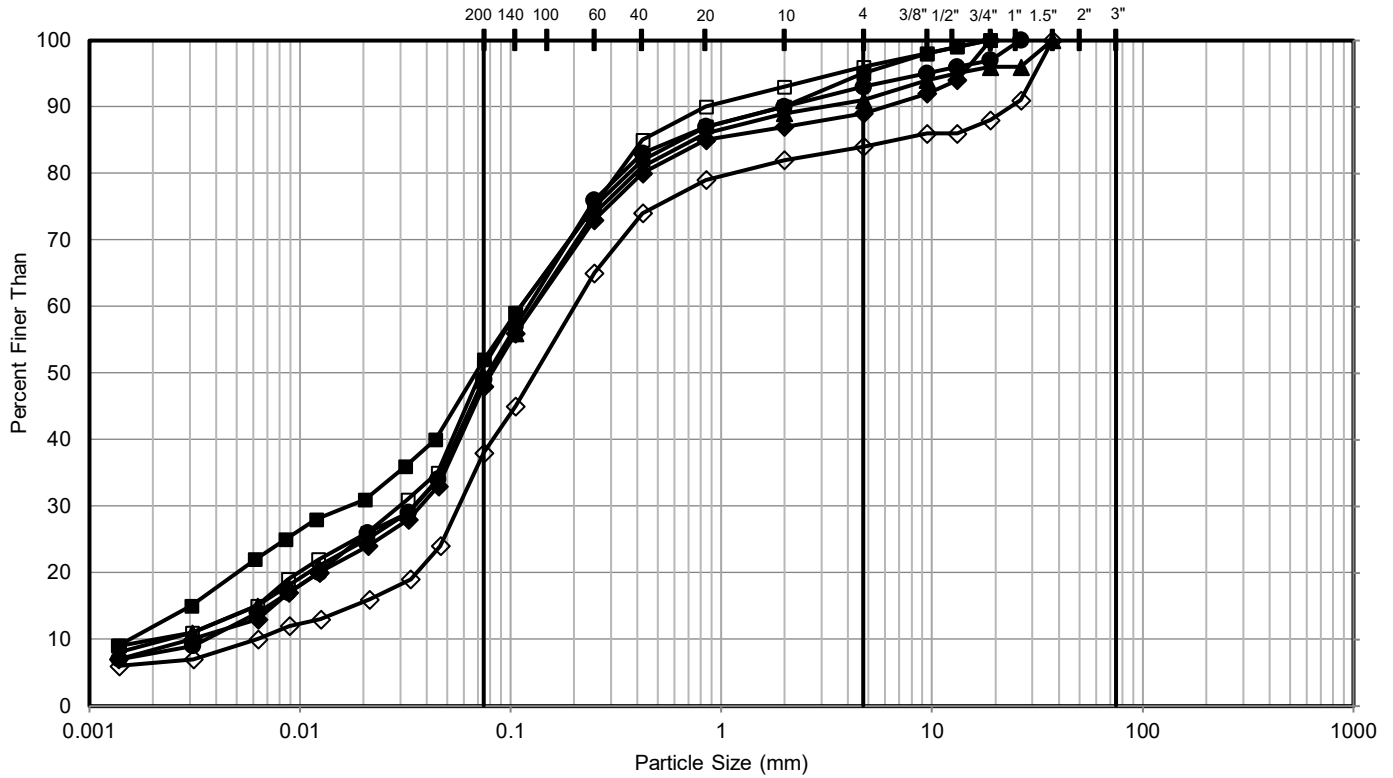


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	R-BBP-6B	4A	257.3 to 256.9	9.6	14	11	3
◆	R-BBP-6A	9	254.9 to 254.3	9.5	12	10	2
▲	R-BBP-6B	8	253.5 to 252.8	10.6	13	10	3
●	R-BBP-6A	13	248.8 to 248.2	11.3	12	11	1
+	R-BBP-6B	13	245.8 to 245.2	12.5	13	11	2
⊗	R-BBP-6A	16	244.2 to 243.6	9.7	12	10	2

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
		DESIGNED N/A
		PREPARED MCK
		REVIEWED KJB
		APPROVED MCK

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - SILT and Sand (ML) to SILTY SAND (SM) (TILL)			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E1-3

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	R-BBP-6B	4A	2.3 - 2.7	257.3 to 256.9
◆	R-BBP-6A	9	7.6 - 8.2	254.9 to 254.3
▲	R-BBP-6B	8	6.1 - 6.7	253.5 to 252.8
●	R-BBP-6A	13	13.7 - 14.3	248.8 to 248.2
□	R-BBP-6B	13	13.7 - 14.3	245.8 to 245.2
◇	R-BBP-6A	16	18.3 - 18.9	244.2 to 243.6

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - SILT and Sand (ML) to SILTY SAND (SM) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

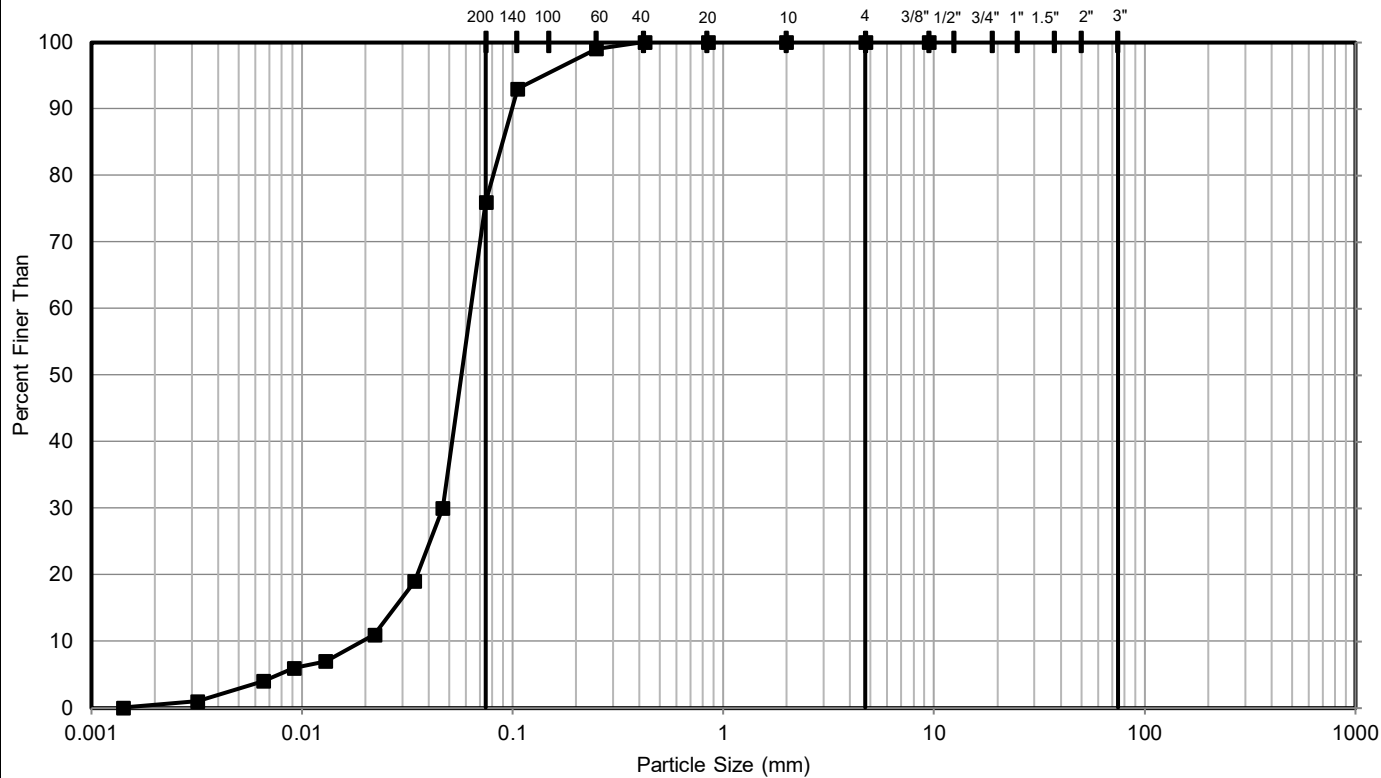
REV.

0

FIGURE


E1-4

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	R-BBP-6B	6	3.8 - 4.4	255.7 to 255.1

CLIENT		PROJECT	
AECOM / MTO		Bradford Bypass - Structural Culverts	
	CONSULTANT	TITLE	
	YYYY-MM-DD 2023-12-06	Grain Size Distribution - Sandy SILT (ML) Interlayer	
	DESIGNED N/A	PROJECT NO. CONTROL REV. FIGURE	
	PREPARED MCK	19136074 1002.001 0 E1-5	
	REVIEWED KJB		
APPROVED KJB			

Structural Culverts Between Yonge Street and 2nd Concession

PROJECT 19136074

RECORD OF BOREHOLE No. CL-BBP-9

Sheet 1 of 2

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4888785.5; E 305001.4 NAD83 / MTM Zone 10 (LAT. 44.139066; LONG. -79.497483)

ORIGINATED BY TC

DIST Central HWY BBP - Culvert

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:220.1 m

DATE Aug 11, 2023

CHECKED BY MCK

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m³	GR	SA	SI	CL	REMARKS
ELEV. ----- DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL	NMC	LL						
								Field Vane					W _p	W	W _L						
								Remoulded Pocket Pen Quick Triaxial Unconfined					NP Nonplastic								
							20	40	60	80	100	20	40	60							
220.0	TOPSOIL (50 mm)		1A	SS	8		220														
0.2	SILTY SAND (SM), trace organics, (FILL)		1B																		
219.8	Loose Blackish brown to greyish brown Moist																				
219.3	SILTY SAND (SM) Very loose to loose		2A	SS	1		219	⊕	X			H	⊙								
0.8	Brown to greyish brown with oxidation staining Moist to wet CLAYEY SILT (CL), trace sand		2B																		
218.7	Very soft to stiff																				
1.4	Grey Wet SAND (SP), trace silt			SS	7		218						○				0	94	6	0	
	Loose Grey Wet		3																		
217.6			4A	SS	5		217						○								
2.5	SILT (ML) of slight plasticity, trace sand Loose to compact Grey Wet		4B																		
			5	SS	5						X ⁻⁹⁶										
			6	TO			216														
			7	SS	11		215					H	○				0	9	80	11	
	- 6.1 to 6.2 m: Silty sand seam		8A	SS	11		214														
			8B																		

Continued on Next Page

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

METRIC

CHECKED BY MCK

[illegible]

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

PROJECT 19136074

RECORD OF BOREHOLE No. CL-BBP-10

Sheet 1 of 2

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4888935.8; E 305357 NAD83 / MTM Zone 10 (LAT. 44.140418; LONG. -79.493038)

ORIGINATED BY TC

DIST Central HWY BBP - Culvert

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

COMPILED BY MCK

DATUM CGVD28 Surface Elevation:220.0 m

DATE Aug 10, 2023 - Aug 11, 2023

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
0.0 220.0	TOPSOIL (50 mm) SILTY SAND (SM), trace clay, trace rootlets (FILL) Loose Brown Moist		1	SS	7			20	40	60	80	100	20	40	60						
219.2 0.8	SILTY CLAY (CI) Firm Brown; oxidation staining present Moist		2	SS	5		219														
218.3 1.8	SILTY SAND (SM) to SAND, some silt (SM-SP) Compact Grey Moist		2A	TO																	
			3	SS	13		218														
			4	SS	18																
			5A	SS	18		217														
216.5 3.5	SILT (ML) of slight plasticity, some sand Compact, Grey Wet		5B																		
			6	SS	12		216														
			7	SS	29		215														
214.4 5.6	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), contains silt pockets Stiff to very stiff Grey Wet		8	SS	14		214														
			9	SS	23		213														
			10A				212														
210.6 9.4	SILT (ML) of slight plasticity, trace sand Compact Grey Wet		10B	SS	15		211														

Continued on Next Page

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

PROJECT 19136074		RECORD OF BOREHOLE No. CL-BBP-10		Sheet 2 of 2		METRIC	
G.W.P. Assignment No 2019-E-0048		LOCATION N 4888935.8; E 305357 NAD83 / MTM Zone 10 (LAT. 44.140418; LONG. -79.493038)		ORIGINATED BY TC			
DIST Central HWY BBP - Culvert		BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers		COMPILED BY MCK			
DATUM CGVD28 Surface Elevation:220.0 m		DATE Aug 10, 2023 - Aug 11, 2023		CHECKED BY KJB			

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								NP Nonplastic													
									20	40	60	80	100	20	40	60					
208.3	SILT (ML) of slight plasticity, trace sand Compact Grey Wet		11	SS	21		209							HO			0	6	81	13	
11.7	CLAYEY SILT-SILT (CL-ML) with intermittent sand lenses Very stiff Grey Wet		12	SS	23		208														
207.2	End of Borehole						207														
12.8	Notes: 1. Groundwater level inside hollow stem augers measured at 0.6 m below ground surface (El. 219.4 m) during drilling and prior to introducing water inside hollow stem augers. 2. Standpipe piezometer installed about 1.2 m west of borehole. 3. Water level measured in piezometer at 0.5 m bgs (El. 219.5 m) on December 7, 2023.						206														
							205														
							204														
							203														
							202														
							201														

PROJECT 19136074

RECORD OF BOREHOLE No. FD-01

Sheet 1 of 5

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4889113.4; E 305812.2 NAD83 / MTM Zone 10 (LAT. 44.142016; LONG. -79.487348)

ORIGINATED BY PT

DIST Central HWY 37X-2558/B1&B2

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:220.0 m

DATE May 13, 2022 - May 16, 2022

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
0.0	CLAYEY SILT (CL), trace sand, trace organics/rootlets, Very soft Brown and grey, oxidation staining Moist		1	SS	2																
			2	SS	2		219										0	13	72	15	
218.6																					
1.4	SILTY SAND (SM), trace gravel Very loose to compact Brown to grey Moist to wet		3	SS	12		218										0	72	27	1	
			4	SS	6		217														
			5	SS	3																
			6	SS	7		216														
			7	SS	7		215										0	73	25	2	
214.3																					
5.6	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel Stiff to very stiff		8	SS	20		214														
							213														
			9	SS	9		212														
			10	SS	22		211										0	19	67	14	

Continued on Next Page

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

PROJECT 19136074

RECORD OF BOREHOLE No. FD-01

Sheet 2 of 5

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4889113.4; E 305812.2 NAD83 / MTM Zone 10 (LAT. 44.142016; LONG. -79.487348)

ORIGINATED BY PT

DIST Central HWY 37X-2558/B1&B2

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:220.0 m

DATE May 13, 2022 - May 16, 2022

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel Stiff to very stiff		11	SS	17		209														
							208														
207.5			12A	SS	13																
12.5	SAND (SP), some fines Compact Grey Wet		12B				207														
206.7																					
13.3	SILT (ML), trace to some sand, trace gravel Dense to very dense Grey Moist		13	SS	46		206														
							205														
204.4			14A	SS	33																
15.5	SILTY SAND (SM) Dense to very dense Grey Moist		14B				204										0	63	34	3	
							203														
202.1							202														
17.8	SILT (ML) Compact Grey Moist		16	SS	19		201														

Continued on Next Page

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

METRIC

ORIGINATED BY PT

COMPILED BY MTI

CHECKED BY KJB

[illegible]

Continued on Next Page

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

METRIC

ORIGINATED BY PT

COMPILED BY MTI

CHECKED BY KJB

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

PROJECT 19136074

RECORD OF BOREHOLE No. FD-02

Sheet 1 of 4

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4889096; E 305757.4 NAD83 / MTM Zone 10 (LAT. 44.14186; LONG. -79.488033)

ORIGINATED BY DP

DIST Central HWY 37X-2558/B1&B2

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY ML

DATUM CGVD28 Surface Elevation:221.8 m

DATE May 20, 2022 - May 25, 2022

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT					REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L		GR	SA	SI	CL	
								Field Vane Remoulded Pocket Pen Quick Triaxial Unconfined													
								20 40 60 80 100					20 40 60								
0.0	SILTY SAND (SM), trace rootlets (Possible FILL) Brown Moist Very loose to loose		1	SS	3																
			2	SS	5												0	64	30	6	
	- 1.5 m: contains clay seams		3	SS	7																
219.4			4A																		
2.4	CLAYEY SILT (CL), trace sand, trace organics ,rootlets Soft Brown Moist		4B	SS	3																
218.8																					
3.0	SILTY SAND (SM), trace gravel Compact Brown to grey Moist		5	SS	20												0	74	25	1	
			6	SS	27																
	- 4.5 m: contains some clay		7A	SS	13												2	69	19	10	
216.9			7B																		
4.9	CLAYEY SILT (CL), trace gravel, trace sand to sandy Stiff to very stiff Grey Moist		8A																		
215.4			8B	SS	26												1	58	29	12	
6.3	SILTY SAND (SM) to Sandy SILT (ML), trace gravel, contains clayey silt seams Compact to dense Grey Moist																				
			9	SS	14																
			10	SS	46												0	36	60	4	

Continued on Next Page

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

PROJECT 19136074

RECORD OF BOREHOLE No. FD-02

Sheet 2 of 4

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4889096; E 305757.4 NAD83 / MTM Zone 10 (LAT. 44.14186; LONG. -79.488033)

ORIGINATED BY DP

DIST Central HWY 37X-2558/B1&B2

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; Mud Rotary

COMPILED BY ML

DATUM CGVD28 Surface Elevation:221.8 m

DATE May 20, 2022 - May 25, 2022

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
211.6 10.2	SILTY SAND (SM) to Sandy SILT (ML), trace gravel, contains clayey silt seams Compact to dense Grey Moist							20	40	60	80	100	20	40	60						
	CLAYEY SILT-SILT (CL-ML), trace sand, Grey Moist Very Stiff		11	SS	15																
210.0																					
11.7	Sandy SILT (ML) Compact Grey Moist																				
209.3																					
12.4	CLAYEY SILT-SILT (CL-ML), trace sand Very stiff Grey Moist		12	SS	20																
208.6																					
13.2	SILT (ML) of slight plasticity, some sand to sandy Dense to very dense Grey Moist		13	SS	36																
			14	SS	53																
			15	SS	61																
203.9																					
17.8	CLAYEY SILT-SILT (CL-ML), trace sand Firm to stiff Grey Moist		16	SS	6																

Continued on Next Page

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

METRIC

CHECKED BY KJB

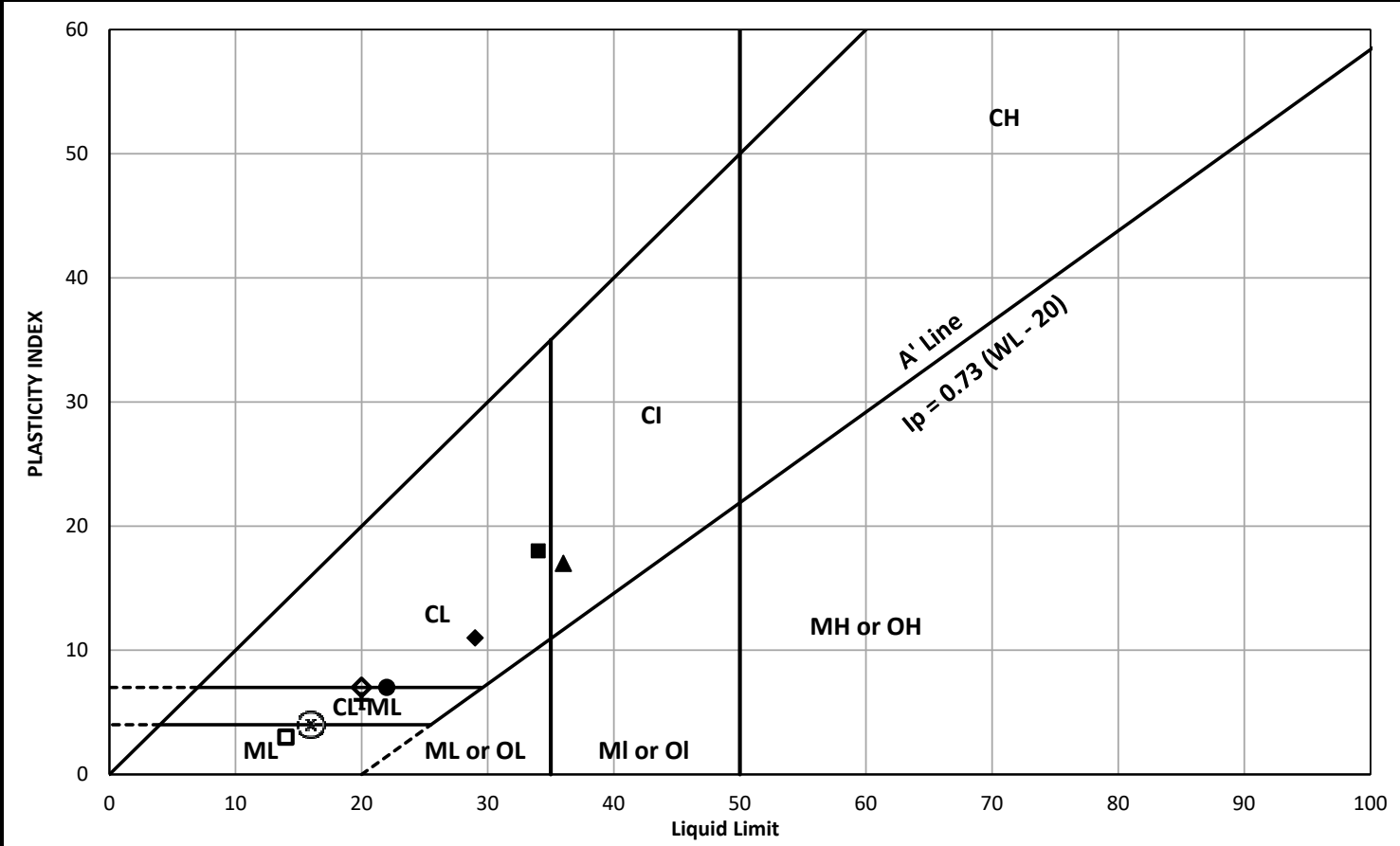
+³, x³ : Numbers refer to Sensitivity o³% STRAIN AT FAILURE

METRIC


CHECKED BY KJB

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

PLASTICITY CHART

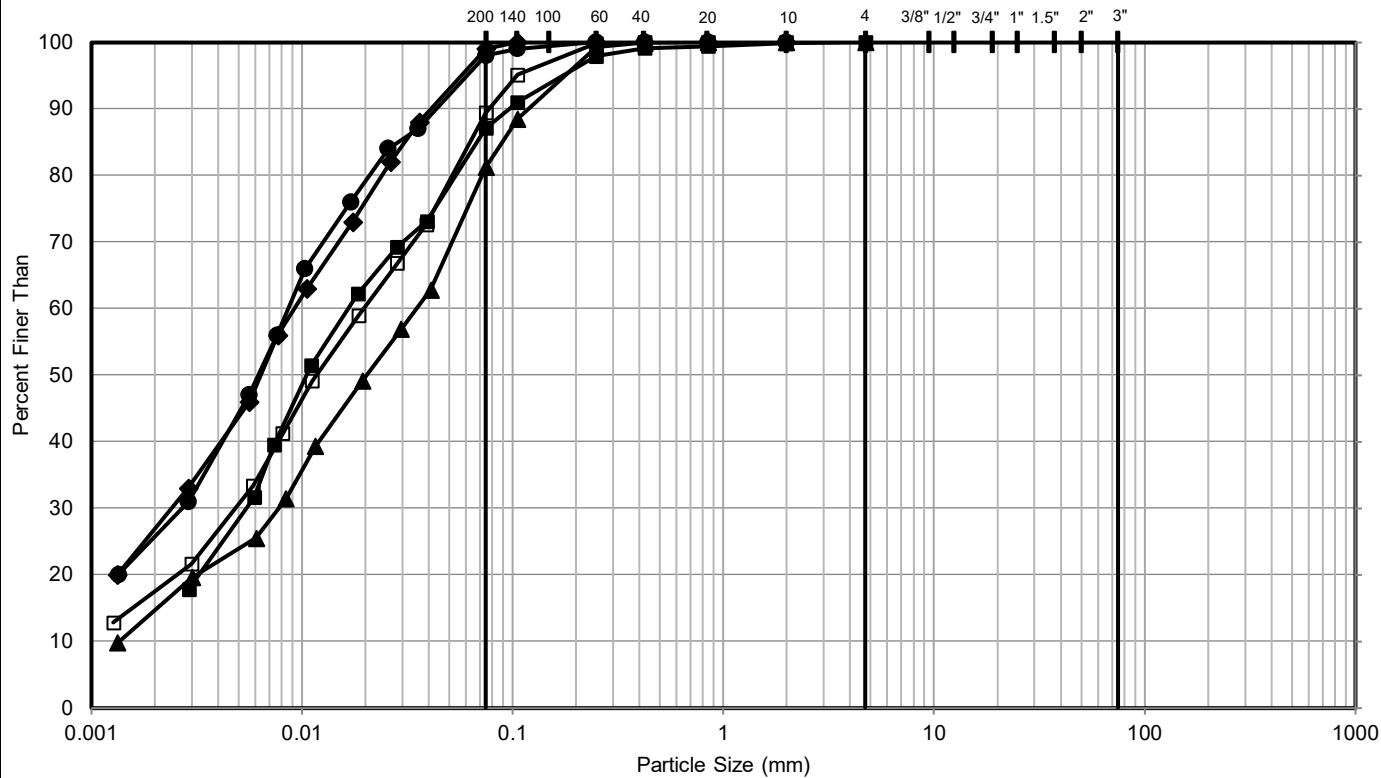


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	FD-02	4B	219.4 to 218.9	26.8	34	16	18
◆	CL-BBP-9	2B	219.3 to 218.7	28.9	29	18	11
▲	CL-BBP-10	2	219.3 to 218.7	27.4	36	19	17
●	FD-01	2	219.2 to 218.6	20.2	22	15	7
+	CL-BBP-10	8	213.9 to 213.3	17.8	20	14	6
⊗	FD-02	11	211.1 to 210.5	17.4	16	12	4
□	FD-01	10	210.8 to 210.2	16	14	11	3
◇	CL-BBP-9	11	209.4 to 208.8	21.3	20	13	7
△	FD-02	16	203.5 to 202.9	18.3	16	12	4

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - Cohesive Interlayers			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E2-1

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	FD-01	2	0.8 - 1.4	219.2 to 218.6
◆	CL-BBP-10	8	6.1 - 6.7	213.9 to 213.3
▲	FD-01	10	9.1 - 9.8	210.8 to 210.2
●	CL-BBP-9	11	10.7 - 11.3	209.4 to 208.8
□	FD-02	16	18.3 - 18.9	203.5 to 202.9

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - Cohesive Interlayers

PROJECT NO.

19136074

CONTROL

1002.001

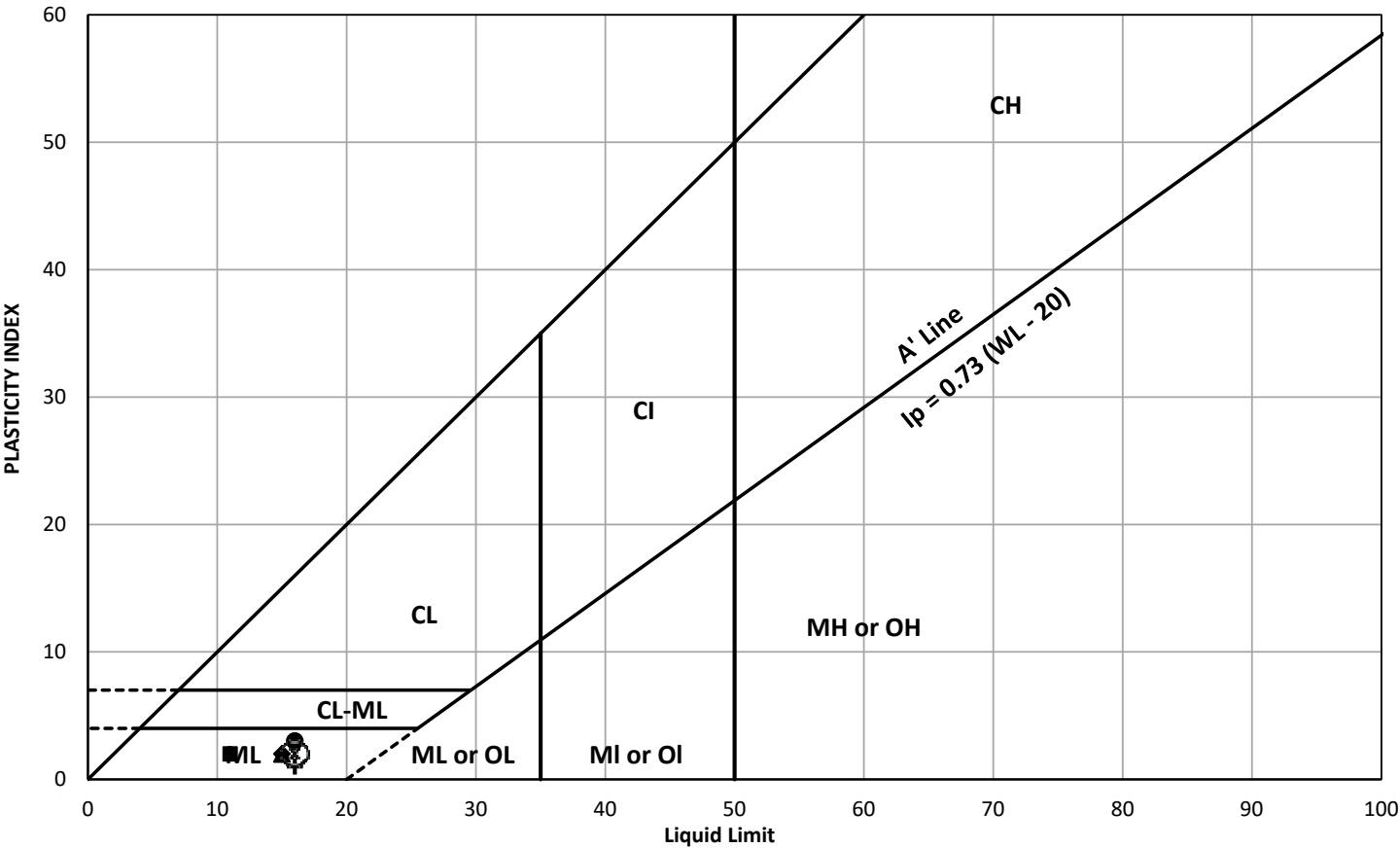
REV.

0


FIGURE

E2-2

PLASTICITY CHART

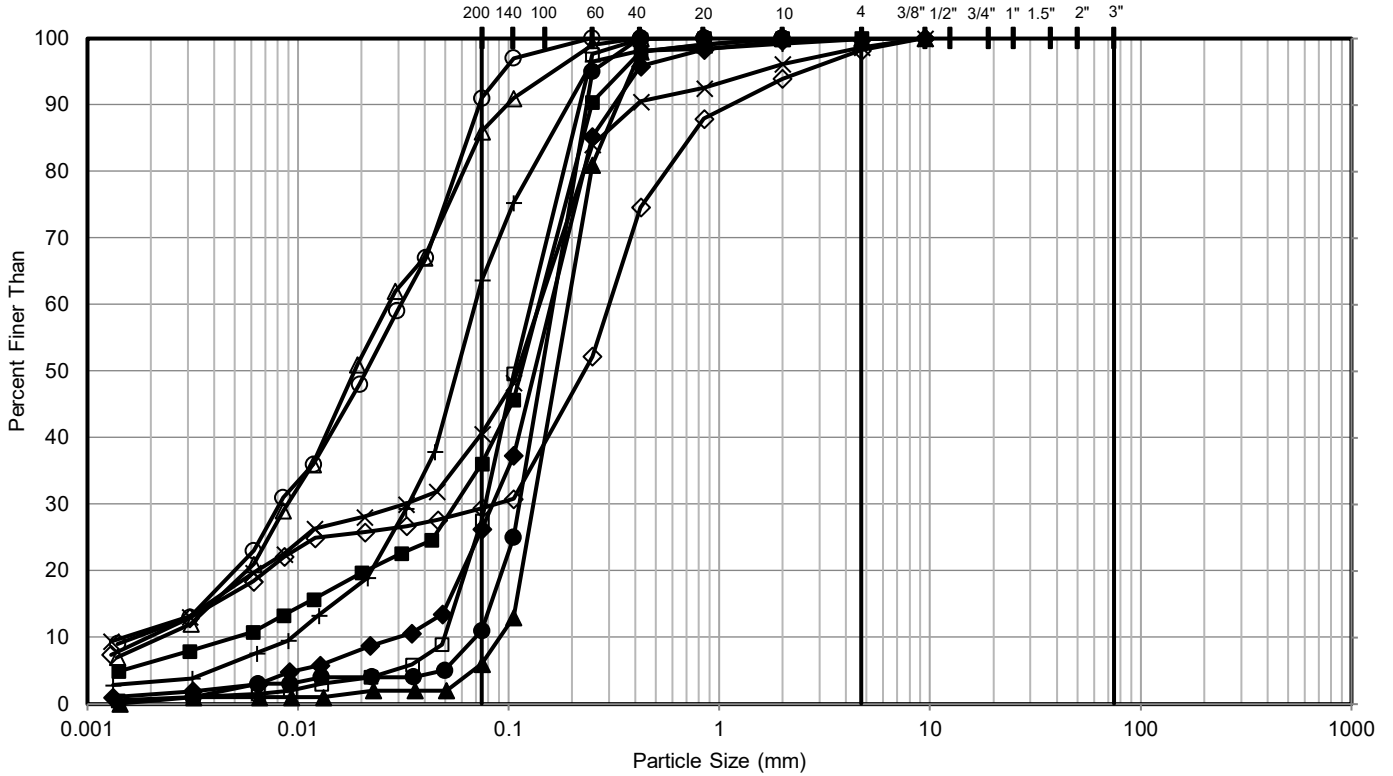


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	FD-02	7A	217.2 to 216.9	15.4	11	9	2
◆	CL-BBP-10	6	216.2 to 215.6	18.2	15	13	2
▲	CL-BBP-9	7	215.5 to 214.9	19.4	15	13	2
●	CL-BBP-10	11	209.4 to 208.8	18.4	16	13	3
+	FD-01	13	206.2 to 205.6	15	16	15	1
⊗	FD-01	16	201.7 to 201.1	19.7	16	14	2

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - Non-Cohesive Interlayres			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E2-3

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	FD-02	2	0.8 - 1.4	221.0 to 220.4
◆	FD-02	5	3.1 - 3.7	218.7 to 218.1
▲	CL-BBP-9	3	1.5 - 2.1	218.6 to 218.0
●	CL-BBP-10	4	2.3 - 2.9	217.8 to 217.1
□	FD-01	4	2.3 - 2.9	217.7 to 217.1
◇	FD-02	7A	4.6 - 4.9	217.2 to 216.9
△	CL-BBP-10	6	3.8 - 4.4	216.2 to 215.6
○	CL-BBP-9	7	4.6 - 5.2	215.5 to 214.9
×	FD-02	8B	6.3 - 6.7	215.4 to 215.1
+	FD-02	10	9.1 - 9.8	212.6 to 212.0

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD 2023-12-06

DESIGNED N/A

PREPARED MCK

REVIEWED KJB

APPROVED KJB

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Grain Size Distribution - Non-Cohesive Interlayers

PROJECT NO.

19136074

CONTROL

1002.001

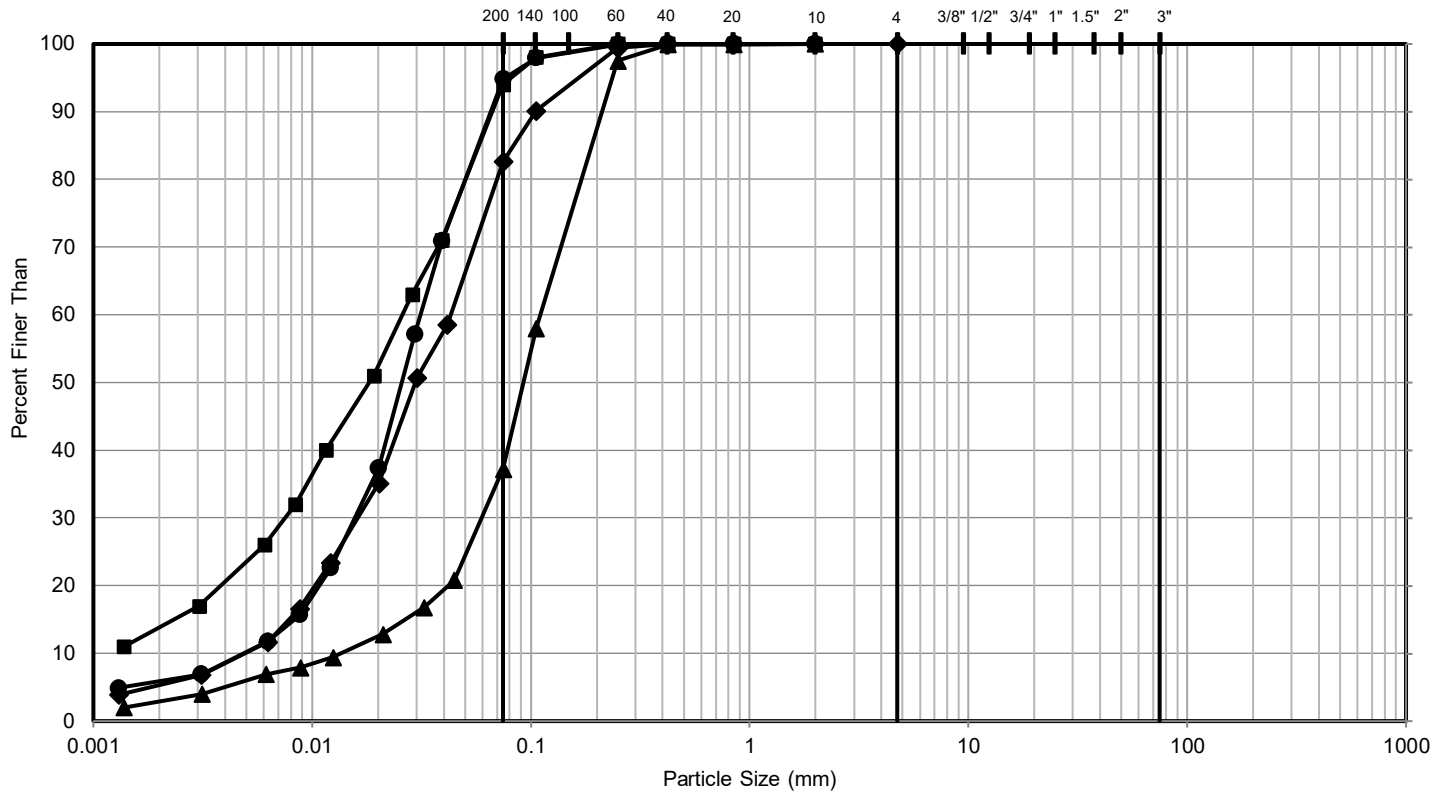
REV.

0

FIGURE

E2-4A

GRAIN SIZE DISTRIBUTION



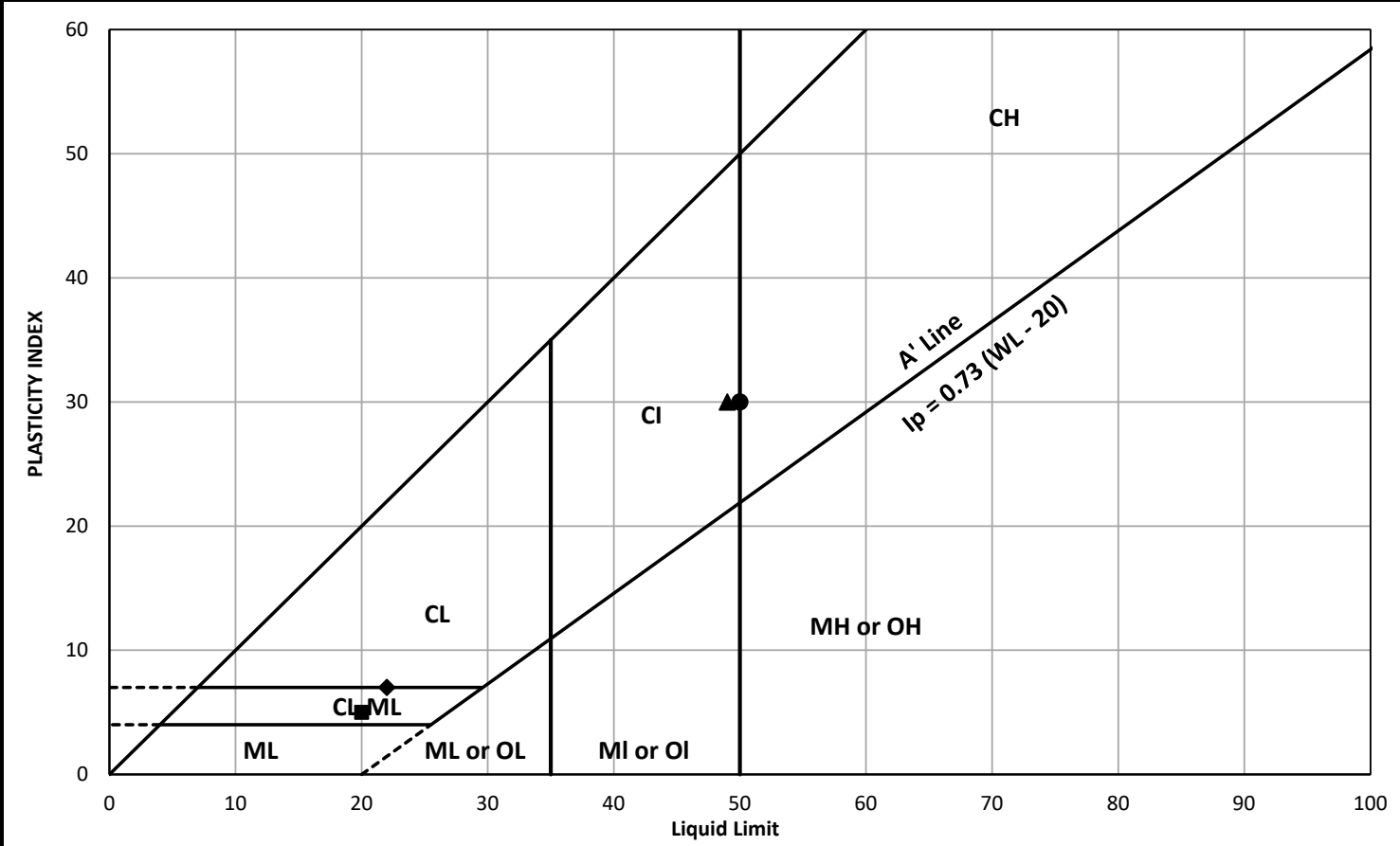
FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	CL-BBP-10	11	10.7 - 11.3	209.4 to 208.8
◆	FD-02	13	13.7 - 14.3	208.0 to 207.4
▲	FD-01	14B	15.5 - 15.9	204.4 to 204.1
●	FD-02	17	21.3 - 22.0	200.4 to 199.8


CLIENT		PROJECT	
AECOM / MTO		Bradford Bypass - Structural Culverts	
	CONSULTANT	TITLE	
	YYYY-MM-DD 2023-12-06	Grain Size Distribution - Non-Cohesive Interlayers	
	DESIGNED N/A	PROJECT NO. 19136074	
	PREPARED MCK	CONTROL 1002.001	REV. 0
	REVIEWED KJB	FIGURE E2-4B	
	APPROVED KJB		

PATH: https://wsponline-my.sharepoint.com/personal/imadison_kennedy_wsp_com/Documents/Documents/19136074 - Bradford Bypass/CO - Structural Culverts | FILE NAME: LabFigures_PSD_Culvert.xlsm

PLASTICITY CHART



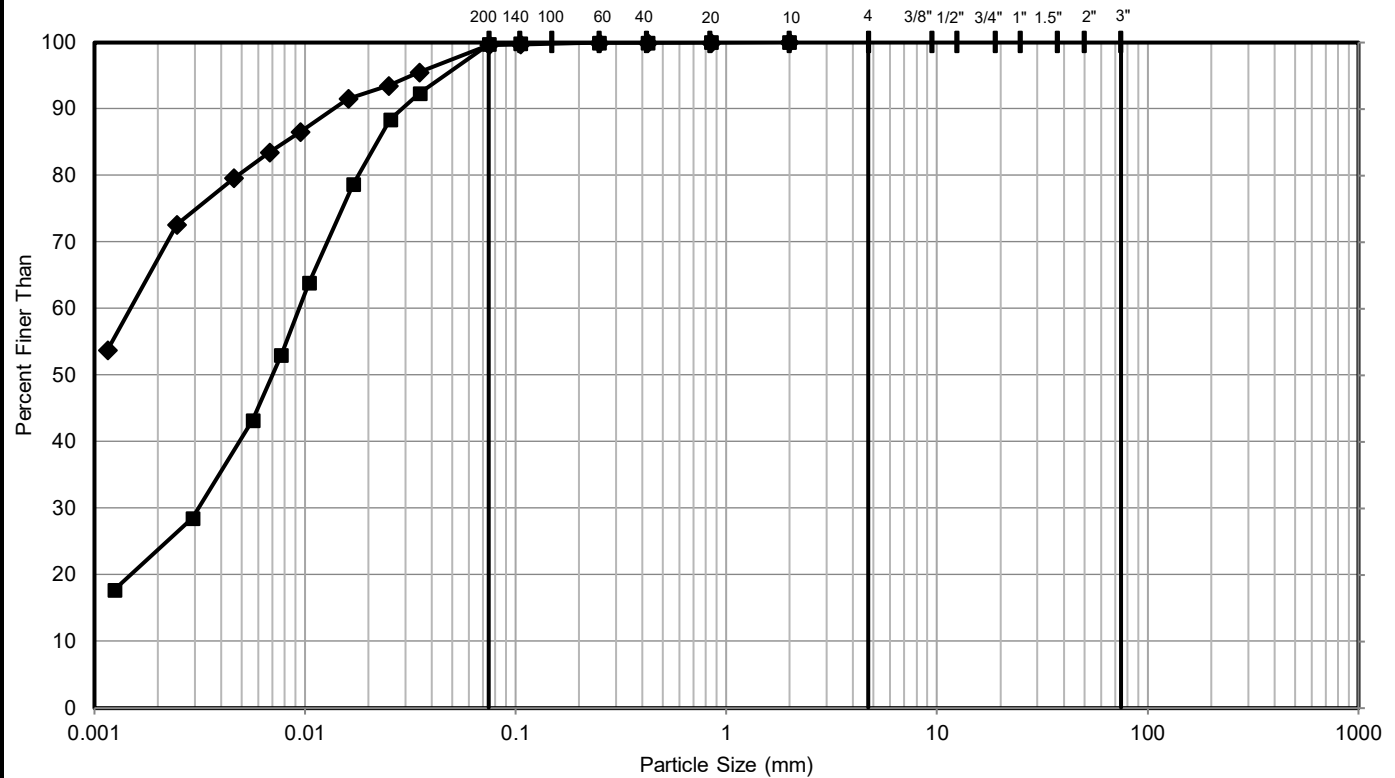
Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	FD-02	18	197.4 to 196.8	22.5	20	15	5
◆	FD-01	18	195.6 to 195.0	21.9	22	15	7
▲	FD-01	20	189.5 to 188.9	40.1	49	19	30
●	FD-02	21	188.2 to 187.6	39.9	50	20	30

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	KJB

PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - Lower Cohesive Deposit			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E2-5


PATH: https://wsp.onlinemy.sharepoint.com/personal/madison_kennedy_wsp_com/Documents/Documents/19136074 - Bradford Bypass/CO - Structural Culverts | FILE NAME: LabFigures_PSD_Culvert.xlsm

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	FD-02	18	24.4 - 25.0	197.4 to 196.8
◆	FD-01	20	30.5 - 31.1	189.5 to 188.9

CLIENT		PROJECT	
AECOM / MTO		Bradford Bypass - Structural Culverts	
<div>CONSULTANT</div> <div></div>	YYYY-MM-DD	2023-12-06	
	DESIGNED	N/A	
	PREPARED	MCK	
	REVIEWED	KJB	
	APPROVED	KJB	
TITLE		Grain Size Distribution - Lower Cohesive Deposit	
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E2-6

Structural Culverts at Highway 404 Interchange

PROJECT 19136074

RECORD OF BOREHOLE No. R-404-2

Sheet 1 of 2

METRIC

G.W.P. Assignment No 2019-E-0048

LOCATION N 4890382.1; E 308810.2 NAD83 / MTM Zone 10 (LAT. 44.153425; LONG. -79.449867)

ORIGINATED BY TC

DIST Central HWY BBP - Culvert

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers

COMPILED BY MTI

DATUM CGVD28 Surface Elevation:245.0 m

DATE Aug 03, 2023

CHECKED BY MCK

SOIL PROFILE			SAMPLES			GROUNDWATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)			UNIT WEIGHT Y kN/m ³	GR	SA	SI	CL	REMARKS
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					PL W _p	NMC W	LL W _L						
0.0 244.8	TOPSOIL (140 mm)							20	40	60	80	100	20	40	60						
0.1	Sandy SILT (ML), containing rootlets (FILL) Loose Brown Moist		1	SS	8																
			2	SS	6		244														
243.5	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL) Very soft to very stiff Brown to grey Moist to wet		3	SS	2		243														
1.4			4	SS	7		242										1	25	58	16	
			5	SS	11																
			6	SS	13		241														
			7	SS	13		240														
							239														
			8	SS	27												6	30	57	7	
							238														
237.8	SILT and Sand (ML), trace gravel, trace clay (TILL) Loose to Dense Grey Moist to wet		9	SS	19		237														
							236														
			10	SS	9												3	38	52	7	

Continued on Next Page

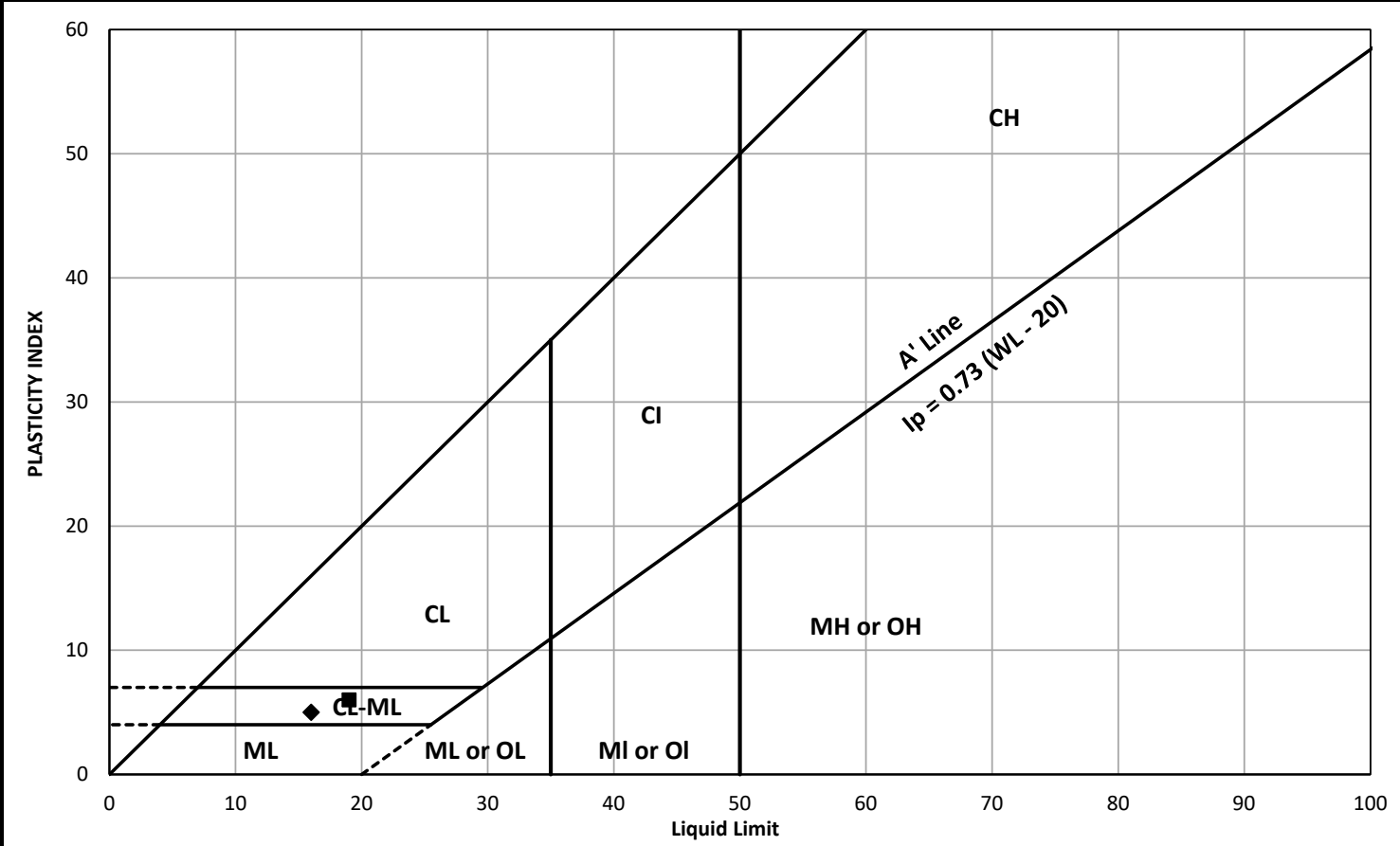
+³, x³ : Numbers refer to Sensitivity o³⁰% STRAIN AT FAILURE

PROJECT 19136074		RECORD OF BOREHOLE No. R-404-2		Sheet 2 of 2		METRIC	
G.W.P. Assignment No 2019-E-0048		LOCATION N 4890382.1; E 308810.2 NAD83 / MTM Zone 10 (LAT. 44.153425; LONG. -79.449867)		ORIGINATED BY TC			
DIST Central HWY BBP - Culvert		BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers		COMPILED BY MTI			
DATUM CGVD28 Surface Elevation:245.0 m		DATE Aug 03, 2023		CHECKED BY MCK			

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

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

PLASTICITY CHART




Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	R-404-2	4	242.7 to 242.1	15.1	19	13	6
◆	R-404-2	8	238.9 to 238.3	9.8	16	11	5

CLIENT

AECOM / MTO

CONSULTANT



YYYY-MM-DD

2023-12-06

DESIGNED

N/A

PREPARED

MCK

REVIEWED

KJB

APPROVED

MCK

PROJECT

Bradford Bypass - Structural Culverts

TITLE

Plasticity Chart - Sandy CLAYEY SILT-SILT (CL-ML) (TILL)

PROJECT NO.

19136074

CONTROL

1002.001

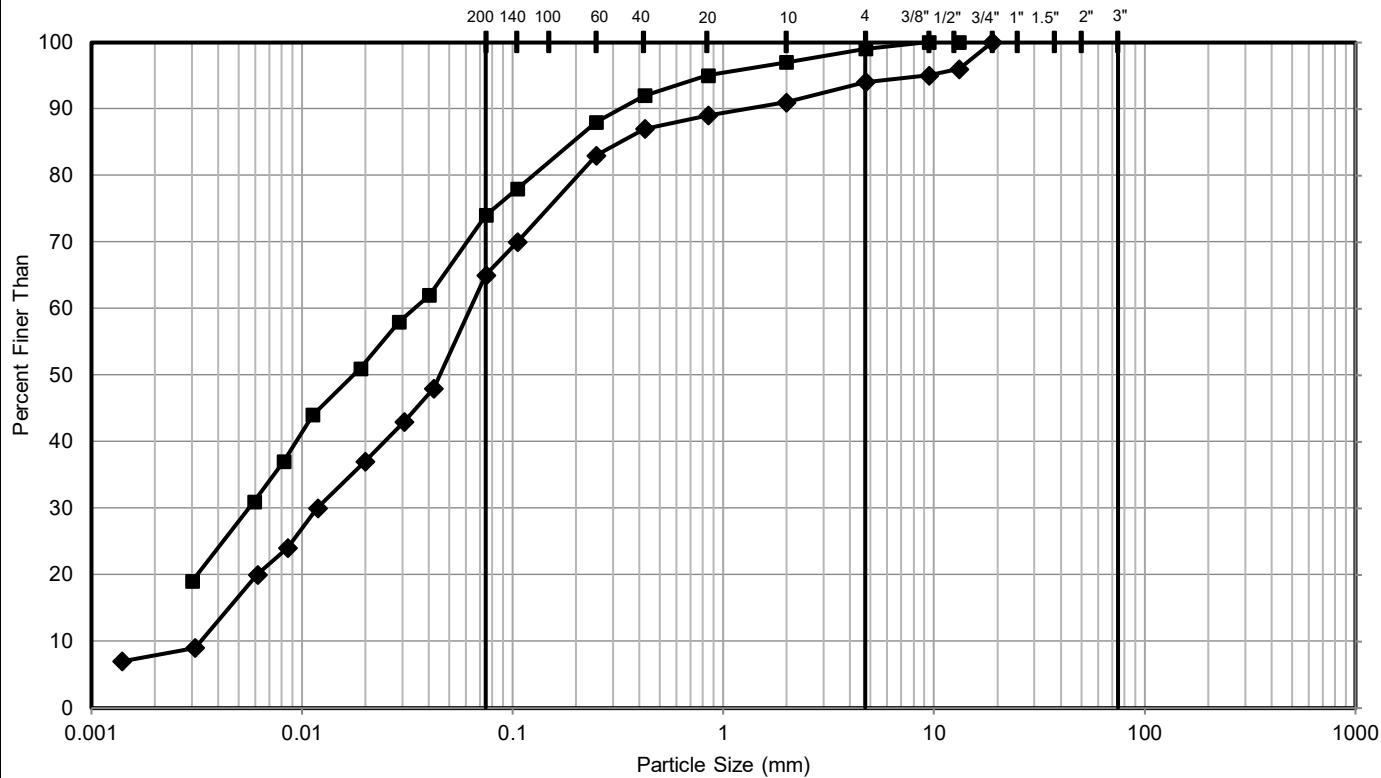
REV.

0

FIGURE

E3-1

GRAIN SIZE DISTRIBUTION



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	R-404-2	4	2.3 - 2.9	242.7 to 242.1
◆	R-404-2	8	6.1 - 6.7	238.9 to 238.3

CLIENT
AECOM / MTO

PROJECT
Bradford Bypass - Structural Culverts

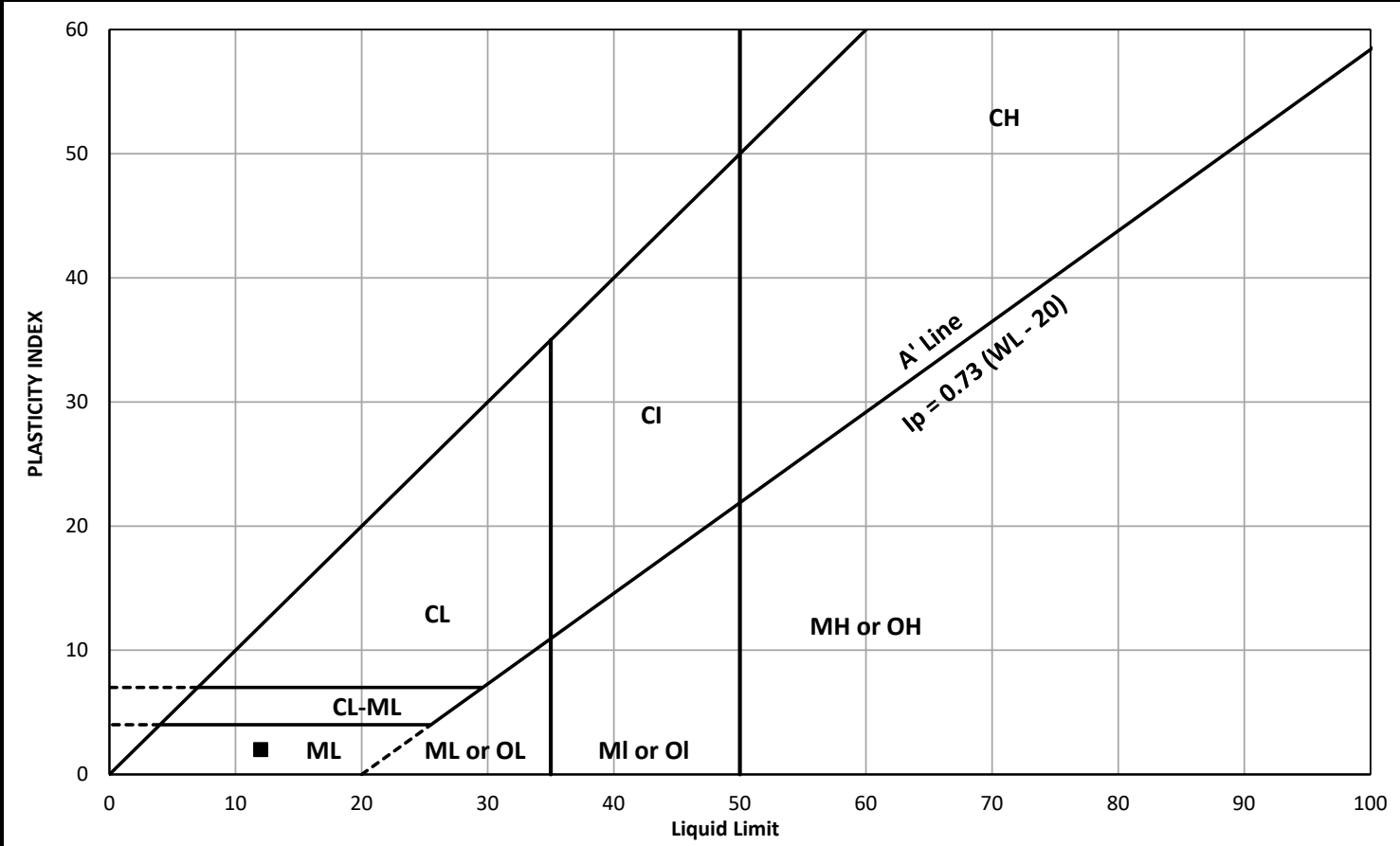


YYYY-MM-DD 2023-12-06
DESIGNED N/A
PREPARED MCK
REVIEWED KJB
APPROVED KJB

TITLE
Grain Size Distribution - Sandy CLAYEY SILT-SILT (CL-ML) (TILL)

PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E3-2

PLASTICITY CHART

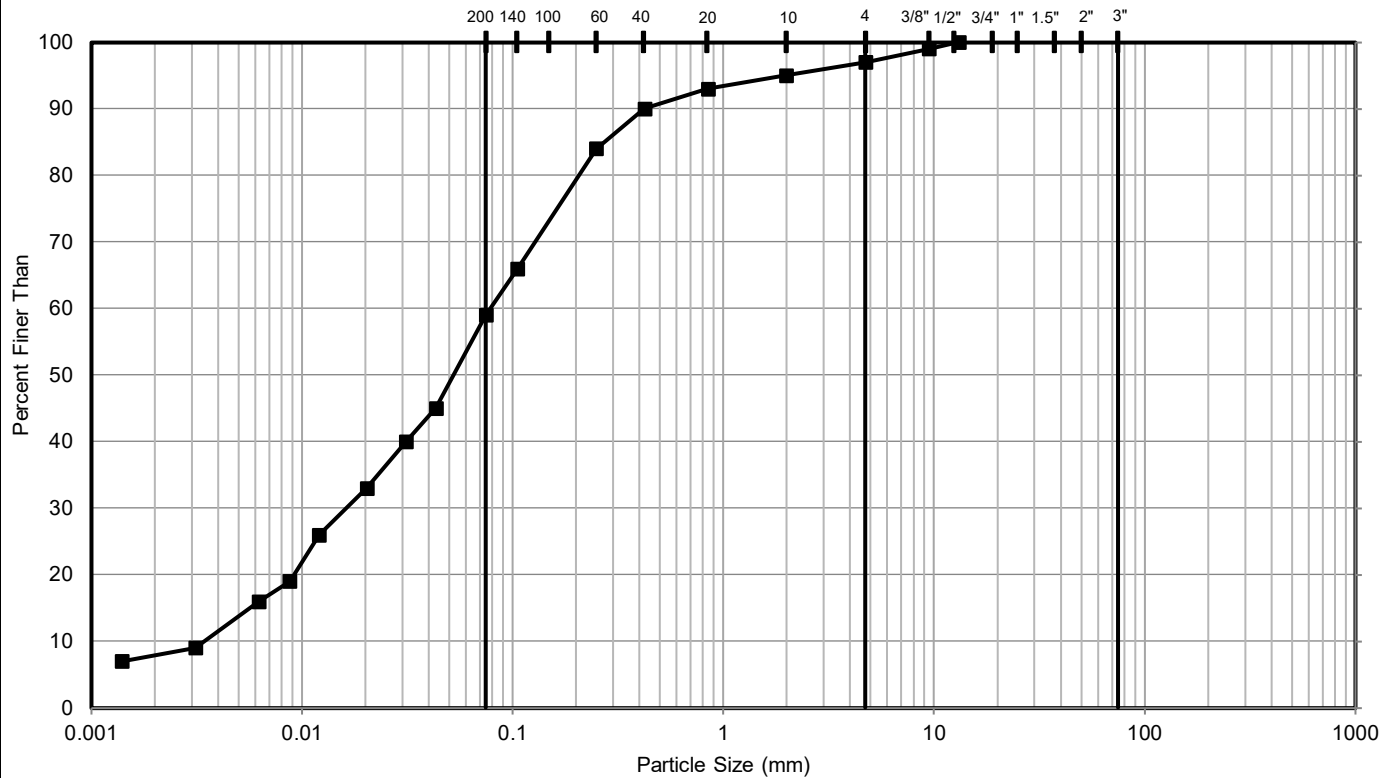


Symbol	Sample Location	Sample / Specimen Number	Elevation (m)	Natural Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
■	R-404-2	10	235.8 to 235.2	11.1	12	10	2

CLIENT		
AECOM / MTO		
	CONSULTANT	YYYY-MM-DD
		2023-12-06
	DESIGNED	N/A
	PREPARED	MCK
	REVIEWED	KJB
	APPROVED	MCK


PROJECT			
Bradford Bypass - Structural Culverts			
TITLE			
Plasticity Chart - SILT and Sand (ML) (TILL)			
PROJECT NO.	CONTROL	REV.	FIGURE
19136074	1002.001	0	E3-3

GRAIN SIZE DISTRIBUTION

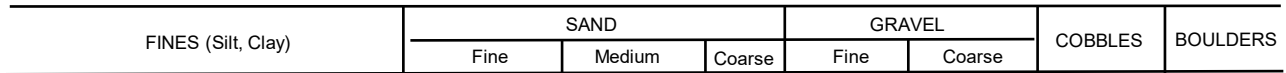



FINES (Silt, Clay)	SAND			GRAVEL		COBBLES	BOULDERS
	Fine	Medium	Coarse	Fine	Coarse		

Symbol	Sample Location	Sample Number	Depth (m)	Elevation (m)
■	R-404-2	10	9.1 - 9.8	235.8 to 235.2

CLIENT		PROJECT	
AECOM / MTO		Bradford Bypass - Structural Culverts	
	CONSULTANT	TITLE	
	YYYY-MM-DD 2023-12-06	Grain Size Distribution - SILT and Sand (ML) (TILL)	
	DESIGNED N/A	PROJECT NO. 19136074	
	PREPARED MCK	CONTROL 1002.001	REV. 0
	REVIEWED KJB	FIGURE E3-4	
	APPROVED KJB		

PATH: https://wsonline-my.sharepoint.com/personal/madison_kennedy_wsp_com/Documents/Documents/19136074 - Bradford Bypass/CO - Structural Culverts | FILE NAME: LabFigures_PSD_Culvert.xlsm



CLIENT		PROJECT			
AECOM / MTO		Bradford Bypass - Structural Culverts			
CONSULTANT	YYYY-MM-DD	2023-12-06		TITLE	
	DESIGNED	N/A		Grain Size Distribution - SILT (ML)	
	PREPARED	MCK			
	REVIEWED	KJB			
	APPROVED	KJB			
		PROJECT NO.	CONTROL	REV.	FIGURE
		19136074	1002.001	0	E3-5

Analytical Test Results



Your Project #: 19136074
Site Location: BRADFORD BYPASS
Your C.O.C. #: na

Attention: Manisha Ahuja

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

Report Date: 2022/06/15
Report #: R7169980
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C2F2723

Received: 2022/06/04, 11:23

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2022/06/08	2022/06/08	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2022/06/09	2022/06/09	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2022/06/10	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2022/06/07	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2022/06/10	2022/06/10	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2022/06/04	2022/06/09	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2022/06/08	2022/06/09	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

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

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

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

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

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

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



Your Project #: 19136074
Site Location: BRADFORD BYPASS
Your C.O.C. #: na

Attention: Manisha Ahuja

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

Report Date: 2022/06/15
Report #: R7169980
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C2F2723

Received: 2022/06/04, 11:23

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ankita Bhalla, Project Manager

Email: Ankita.Bhalla@bureauveritas.com

Phone# (905) 817-5700

=====

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

Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.

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



BUREAU
VERITAS

Bureau Veritas Job #: C2F2723

Report Date: 2022/06/15

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		SUP307		
Sampling Date		2022/05/27		
COC Number		na		
	UNITS	BH FD-02 (10'-12)	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	6600		8034057
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	8039979
Conductivity	umho/cm	152	2	8042774
Available (CaCl2) pH	pH	8.01		8045115
Soluble (20:1) Sulphate (SO4)	ug/g	51	20	8039982
Sulphide	mg/kg	0.5 (1)	0.5	8044591
Physical Testing				
Moisture-Subcontracted	%	16	0.30	8055462
RDL = Reportable Detection Limit QC Batch = Quality Control Batch (1) Sample contained greater than 10% headspace at time of extraction. Analyzed past method specified hold time				



BUREAU
VERITAS

Bureau Veritas Job #: C2F2723

Report Date: 2022/06/15

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

TEST SUMMARY

Bureau Veritas ID: SUP307
Sample ID: BH FD-02 (10'-12)
Matrix: Soil

Collected: 2022/05/27
Shipped:
Received: 2022/06/04

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8039979	2022/06/08	2022/06/08	Alina Dobreanu
Conductivity	AT	8042774	2022/06/09	2022/06/09	Roya Fathitil
Moisture (Subcontracted)	BAL	8055462	N/A	2022/06/10	Margarita Aguilera
Sulphide in Soil	SPEC	8044591	N/A	2022/06/07	Bailey Morrison
pH CaCl2 EXTRACT	AT	8045115	2022/06/10	2022/06/10	Taslima Aktar
Resistivity of Soil		8034057	2022/06/09	2022/06/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8039982	2022/06/08	2022/06/09	Alina Dobreanu



BUREAU
VERITAS

Bureau Veritas Job #: C2F2723

Report Date: 2022/06/15

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

GENERAL COMMENTS

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

Package 1	2.7°C
-----------	-------

Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C2F2723

Report Date: 2022/06/15

QUALITY ASSURANCE REPORT

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8039979	Soluble (20:1) Chloride (Cl ⁻)	2022/06/08	NC	70 - 130	105	70 - 130	<20	ug/g	3.7	35
8039982	Soluble (20:1) Sulphate (SO ₄)	2022/06/09	NC	70 - 130	110	70 - 130	<20	ug/g	16	35
8042774	Conductivity	2022/06/09			100	90 - 110	<2	umho/cm	5.0	10
8044591	Sulphide	2022/06/07	39 (1)	75 - 125	90	75 - 125	<0.5	mg/kg		
8045115	Available (CaCl ₂) pH	2022/06/10			100	97 - 103			0.17	N/A
8055462	Moisture-Subcontracted	2022/06/10					<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)

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



BUREAU
VERITAS

Bureau Veritas Job #: C2F2723

Report Date: 2022/06/15

Golder Associates Ltd

Client Project #: 19136074

Site Location: BRADFORD BYPASS

Sampler Initials: AM

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

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

Bureau Veritas 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.



Your Project #: 19136074; 1002..001
Site Location: BRAFORD AND EAST GWILLUMBURY
Your C.O.C. #: n/a

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/08/24
Report #: R7779931
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C306308

Received: 2023/08/15, 13:39

Sample Matrix: Soil
Samples Received: 5

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	5	2023/08/21	2023/08/21	CAM SOP-00463	MOE E3013 m
Conductivity	5	2023/08/21	2023/08/21	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	5	N/A	2023/08/23	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	5	N/A	2023/08/24	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	5	2023/08/18	2023/08/18	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	5	2023/08/15	2023/08/21	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	5	2023/08/21	2023/08/21	CAM SOP-00464	MOE E3013 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, MELCCFP, EPA, APHA.

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

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

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

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

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

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

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

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

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



Your Project #: 19136074; 1002..001
Site Location: BRAFORD AND EAST GWILLUMBURY
Your C.O.C. #: n/a

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/08/24
Report #: R7779931
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C306308

Received: 2023/08/15, 13:39

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:

Ankita Bhalla, Project Manager

Email: Ankita.Bhalla@bureauveritas.com

Phone# (905) 817-5700

=====

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

Bureau Veritas 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 Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

**SOIL CORROSIVITY PACKAGE (SOIL)**

Bureau Veritas ID		WRQ490	WRQ491	WRQ492	WRQ493		
Sampling Date		2023/08/03	2023/08/04	2023/08/14	2023/08/10		
COC Number		n/a	n/a	n/a	n/a		
	UNITS	R-BBP-404-2 SS3	404-1 SS3	R-BBP-6A SS3	CL-BBP-9 1'-4'6"	RDL	QC Batch

Calculated Parameters							
Resistivity	ohm-cm	6800	5800	9200	5200		8854345
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	<20	<20	<20	<20	20	8865507
Conductivity	umho/cm	148	173	108	191	2	8865793
Available (CaCl2) pH	pH	7.64	7.70	7.75	7.68		8861593
Soluble (20:1) Sulphate (SO4)	ug/g	27	43	<20	61	20	8865517
Sulphide	mg/kg	2.3 (1)	3.6 (1)	3.1 (2)	4.0 (2)	0.5	8874652
RDL = Reportable Detection Limit							
QC Batch = Quality Control Batch							
(1) Extracted past method specified hold time							
(2) Sample contained greater than 10% headspace at time of extraction.							

Bureau Veritas ID		WRQ493			WRQ494		
Sampling Date		2023/08/10			2023/08/11		
COC Number		n/a			n/a		
	UNITS	CL-BBP-9 1'-4'6" Lab-Dup	RDL	QC Batch	CL-BBP-10 SS2	RDL	QC Batch

Calculated Parameters							
Resistivity	ohm-cm				4200		8854345
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	8865507	<20	20	8865507
Conductivity	umho/cm	198	2	8865793	239	2	8865793
Available (CaCl2) pH	pH				7.69		8861593
Soluble (20:1) Sulphate (SO4)	ug/g	64	20	8865517	73	20	8865517
Sulphide	mg/kg				4.9 (1)	0.5	8874652
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

Bureau Veritas Job #: C3O6308

Report Date: 2023/08/24

WSP Canada Inc.

Client Project #: 19136074; 1002..001

Site Location: BRAFORD AND EAST GWILLUMBURY

Sampler Initials: TJ

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		WRQ490	WRQ491	WRQ492	WRQ493	WRQ494		
Sampling Date		2023/08/03	2023/08/04	2023/08/14	2023/08/10	2023/08/11		
COC Number		n/a	n/a	n/a	n/a	n/a		
	UNITS	R-BBP-404-2 SS3	404-1 SS3	R-BBP-6A SS3	CL-BBP-9 1'-4'6"	CL-BBP-10 SS2	RDL	QC Batch
Physical Testing								
Moisture-Subcontracted	%	15	22	13	22	3.2	0.30	8874653
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								



**BUREAU
VERITAS**

Bureau Veritas Job #: C3O6308

Report Date: 2023/08/24

WSP Canada Inc.

Client Project #: 19136074; 1002..001

Site Location: BRAFORD AND EAST GWILLUMBURY

Sampler Initials: TJ

TEST SUMMARY

Bureau Veritas ID: WRQ490
Sample ID: R-BBP-404-2 SS3
Matrix: Soil

Collected: 2023/08/03
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Moisture (Subcontracted)	BAL	8874653	N/A	2023/08/23	Navpreet Kaur Bajwa
Sulphide in Soil	SPEC	8874652	N/A	2023/08/24	Princess Nicole Hernaez
pH CaCl2 EXTRACT	AT	8861593	2023/08/18	2023/08/18	Gurparteek KAUR
Resistivity of Soil		8854345	2023/08/21	2023/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law

Bureau Veritas ID: WRQ491
Sample ID: 404-1 SS3
Matrix: Soil

Collected: 2023/08/04
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Moisture (Subcontracted)	BAL	8874653	N/A	2023/08/23	Navpreet Kaur Bajwa
Sulphide in Soil	SPEC	8874652	N/A	2023/08/24	Princess Nicole Hernaez
pH CaCl2 EXTRACT	AT	8861593	2023/08/18	2023/08/18	Gurparteek KAUR
Resistivity of Soil		8854345	2023/08/21	2023/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law

Bureau Veritas ID: WRQ492
Sample ID: R-BBP-6A SS3
Matrix: Soil

Collected: 2023/08/14
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Moisture (Subcontracted)	BAL	8874653	N/A	2023/08/23	Navpreet Kaur Bajwa
Sulphide in Soil	SPEC	8874652	N/A	2023/08/24	Princess Nicole Hernaez
pH CaCl2 EXTRACT	AT	8861593	2023/08/18	2023/08/18	Gurparteek KAUR
Resistivity of Soil		8854345	2023/08/21	2023/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law

Bureau Veritas ID: WRQ493
Sample ID: CL-BBP-9 1'-4'6"
Matrix: Soil

Collected: 2023/08/10
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Moisture (Subcontracted)	BAL	8874653	N/A	2023/08/23	Navpreet Kaur Bajwa
Sulphide in Soil	SPEC	8874652	N/A	2023/08/24	Princess Nicole Hernaez
pH CaCl2 EXTRACT	AT	8861593	2023/08/18	2023/08/18	Gurparteek KAUR



TEST SUMMARY

Bureau Veritas ID: WRQ493
Sample ID: CL-BBP-9 1'-4'6"
Matrix: Soil

Collected: 2023/08/10
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Resistivity of Soil		8854345	2023/08/21	2023/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law

Bureau Veritas ID: WRQ493 Dup
Sample ID: CL-BBP-9 1'-4'6"
Matrix: Soil

Collected: 2023/08/10
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law

Bureau Veritas ID: WRQ494
Sample ID: CL-BBP-10 SS2
Matrix: Soil

Collected: 2023/08/11
Shipped:
Received: 2023/08/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8865507	2023/08/21	2023/08/21	Samuel Law
Conductivity	AT	8865793	2023/08/21	2023/08/21	Gurparteek KAUR
Moisture (Subcontracted)	BAL	8874653	N/A	2023/08/23	Navpreet Kaur Bajwa
Sulphide in Soil	SPEC	8874652	N/A	2023/08/24	Princess Nicole Hernaez
pH CaCl2 EXTRACT	AT	8861593	2023/08/18	2023/08/18	Gurparteek KAUR
Resistivity of Soil		8854345	2023/08/21	2023/08/21	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8865517	2023/08/21	2023/08/21	Samuel Law



GENERAL COMMENTS

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

Package 1	5.3°C
-----------	-------

Results relate only to the items tested.

BUREAU
VERITAS

Bureau Veritas Job #: C3O6308

Report Date: 2023/08/24

QUALITY ASSURANCE REPORT

WSP Canada Inc.

Client Project #: 19136074; 1002..001

Site Location: BRAFORD AND EAST GWILLUMBURY

Sampler Initials: TJ

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8861593	Available (CaCl ₂) pH	2023/08/18			101	97 - 103			0.50	N/A
8865507	Soluble (20:1) Chloride (Cl ⁻)	2023/08/21	107	70 - 130	102	70 - 130	<20	ug/g	NC	35
8865517	Soluble (20:1) Sulphate (SO ₄)	2023/08/21	NC	70 - 130	101	70 - 130	<20	ug/g	4.5	35
8865793	Conductivity	2023/08/21			103	90 - 110	<2	umho/cm	3.7	10
8874652	Sulphide	2023/08/24	43 (1)	75 - 125	95	75 - 125	<0.5	mg/kg	6.6	30
8874653	Moisture-Subcontracted	2023/08/23					<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 (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.



BUREAU
VERITAS

Bureau Veritas Job #: C3O6308

Report Date: 2023/08/24

WSP Canada Inc.

Client Project #: 19136074; 1002..001

Site Location: BRAFORD AND EAST GWILLUMBURY

Sampler Initials: TJ

VALIDATION SIGNATURE PAGE

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

Cristina Carriere, Senior Scientific Specialist

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

Suwan (Sze Yeung) Fock, B.Sc., Scientific Specialist

Bureau Veritas 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 Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by {0}, {1} responsible for {2} {3} laboratory operations.



www.BVNA.com

6740 Campbell Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266

CHAIN OF CUSTODY RECORD

ENV COC - 00014v3

Page 1 of 1

Invoice Information				Report Information (if differs from invoice)				Project Information							
Company: WSP Canada Inc.				Company: WSP Canada Inc.				Quotation #:							
Contact Name: Kevin Bentley				Contact Name: Madison Kennedy				P.O. #/ A/E/R:							
Street Address: 6925 Century Ave, #600				Street Address: 6925 Century Ave, #600				Project #:							
City: Mississauga Prov: ON Postal Code: L5N 7K2				City: Mississauga Prov: ON Postal Code: L5N 7K2				Site #:							
Phone: 905-567-4444				Phone: 905-302-1162				Site Location: Bradford and East Gwillumbury							
Email: kevin.bentley@wsp.com				Email: madison.kennedy@wsp.com				Site Location Province: Ontario							
Copies:				Copies: muhammad.irshad@wsp.com				Sampled By: TJ; MTI							
Regulatory Criteria															
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/Fine <input type="checkbox"/> CCME <input type="checkbox"/> Reg 406, Table: <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Course <input type="checkbox"/> Reg 558* <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/other <input type="checkbox"/> For RSC <input type="checkbox"/> *min 3 day TAT <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> Table <input type="checkbox"/> MISA <input type="checkbox"/> Municipality <input type="checkbox"/> PWQO <input type="checkbox"/> Other:															
Include Criteria on Certificate of Analysis (check if yes): <input type="checkbox"/>															
SAMPLES MUST BE KEPT COOL (<10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS															
Sample Identification				Date Sampled		Time (24hr)		Matrix							
				YY	MM	DD	HH	MM							
1	R-BBP-404-2 SS 3			23	08	03			Soil						
2	404-1 SS 3			23	08	04			Soil						
3	R-BBP-6A SS 3			23	08	14			Soil						
4	CL-BBP-9 1'- 4'6"			23	08	10			Soil						
5	CL-BBP-10 SS 2			23	08	11			Soil						
6															
7															
8															
9															
10															
11															
12															
*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS-AND-CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY															
LAB USE ONLY				LAB USE ONLY				LAB USE ONLY				Temperature reading by:			
Seal present				Seal present				Seal present							
Seal intact				Seal intact				Seal intact							
Cooling media present				Cooling media present				Cooling media present							
Relinquished by: (Signature/ Print)				Received by: (Signature/ Print)				Special Instructions							
M. Talha Irshad				M. Talha Irshad											
Date: 23 08 15				Date: 23 08 15											
Time: 13 35				Time: 13 35											

15-Aug-23 13:39

Ankita Bhalla



C306308

JK

ENV-1705



Your Project #: 19136074;1002.001

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/09/19

Report #: R7820297

Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3R4092

Received: 2023/09/07, 08:40

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2023/09/11	2023/09/12	CAM SOP-00463	MOE E3013 m
Conductivity	1	2023/09/12	2023/09/12	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 2)	1	N/A	2023/09/18	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2023/09/13	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2023/09/11	2023/09/11	CAM SOP-00413	EPA 9045 D m
Redox Potential (3)	1	2023/09/11	2023/09/12	CAM SOP-00421	SM 2580 B
Resistivity of Soil	1	2023/09/08	2023/09/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2023/09/11	2023/09/12	CAM SOP-00464	MOE E3013 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, MELCCFP, EPA, APHA.

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

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

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

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

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

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

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

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

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



Your Project #: 19136074;1002.001

Attention: Madison Kennedy

WSP Canada Inc.
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2023/09/19

Report #: R7820297

Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3R4092

Received: 2023/09/07, 08:40

(3) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode. The test is therefore, not SCC accredited for this matrix.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:

Ankita Bhalla, Project Manager

Email: Ankita.Bhalla@bureauveritas.com

Phone# (905) 817-5700

=====

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

Bureau Veritas 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 Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.

Total Cover Pages : 2

Page 2 of 9

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

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.



SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		WXP824			WXP824		
Sampling Date		2023/08/16			2023/08/16		
	UNITS	CL-BBO-6B 44-3B	RDL	QC Batch	CL-BBO-6B 44-3B Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	9700		8904860			
CONVENTIONALS							
Redox Potential	mV	230	N/A	8908461			
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	8907988			
Conductivity	umho/cm	103	2	8910743	103	2	8910743
Available (CaCl2) pH	pH	7.90		8908869			
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	8907991			
Sulphide	mg/kg	2.3 (1)	0.5	8915322			
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate N/A = Not Applicable (1) Sample contained greater than 10% headspace at time of extraction. Extracted past method specified hold time							



**BUREAU
VERITAS**

Bureau Veritas Job #: C3R4092
Report Date: 2023/09/19

WSP Canada Inc.
Client Project #: 19136074;1002.001
Sampler Initials: TJ

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		WXP824		
Sampling Date		2023/08/16		
	UNITS	CL-BBO-6B 44-3B	RDL	QC Batch
Physical Testing				
Moisture-Subcontracted	%	10	0.30	8924775
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				



BUREAU
VERITAS

Bureau Veritas Job #: C3R4092
Report Date: 2023/09/19

WSP Canada Inc.
Client Project #: 19136074;1002.001
Sampler Initials: TJ

TEST SUMMARY

Bureau Veritas ID: WXP824
Sample ID: CL-BBO-6B 44-3B
Matrix: Soil

Collected: 2023/08/16
Shipped:
Received: 2023/09/07

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	8907988	2023/09/11	2023/09/12	Massarat Jan
Conductivity	AT	8910743	2023/09/12	2023/09/12	Leily Karimi
Moisture (Subcontracted)	BAL	8924775	N/A	2023/09/18	Manthan Patel
Sulphide in Soil	SPEC	8915322	N/A	2023/09/13	Bailey Morrison
pH CaCl2 EXTRACT	AT	8908869	2023/09/11	2023/09/11	Taslina Aktar
Redox Potential	COND	8908461	2023/09/11	2023/09/12	Gurparteek KAUR
Resistivity of Soil		8904860	2023/09/12	2023/09/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	8907991	2023/09/11	2023/09/12	Massarat Jan

Bureau Veritas ID: WXP824 Dup
Sample ID: CL-BBO-6B 44-3B
Matrix: Soil

Collected: 2023/08/16
Shipped:
Received: 2023/09/07

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	8910743	2023/09/12	2023/09/12	Leily Karimi



GENERAL COMMENTS

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

Package 1	5.7°C
-----------	-------

Results relate only to the items tested.

BUREAU
VERITAS

Bureau Veritas Job #: C3R4092

Report Date: 2023/09/19

QUALITY ASSURANCE REPORT

WSP Canada Inc.

Client Project #: 19136074;1002.001

Sampler Initials: TJ

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8907988	Soluble (20:1) Chloride (Cl-)	2023/09/12	NC	70 - 130	95	70 - 130	<20	ug/g	6.7	35
8907991	Soluble (20:1) Sulphate (SO4)	2023/09/12	99	70 - 130	97	70 - 130	<20	ug/g	NC	35
8908461	Redox Potential	2023/09/12			102	95 - 105			14	35
8908869	Available (CaCl2) pH	2023/09/11			101	N/A			0.21	N/A
8910743	Conductivity	2023/09/12			99	90 - 110	<2	umho/cm	0.39	10
8915322	Sulphide	2023/09/13	90	75 - 125	98	75 - 125	<0.5	mg/kg	17	30
8924775	Moisture-Subcontracted	2023/09/18					<0.30	%	2.0	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 (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

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



BUREAU
VERITAS

Bureau Veritas Job #: C3R4092
Report Date: 2023/09/19

WSP Canada Inc.
Client Project #: 19136074;1002.001
Sampler Initials: TJ

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

Cristina Carriere, Senior Scientific Specialist

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

Sandy Yuan, M.Sc., QP, Scientific Specialist

Bureau Veritas 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 Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Rodney Major, General Manager responsible for Ontario Environmental laboratory operations.



www.BVNA.com

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

CHAIN OF CUSTODY RECORD

ENV COC - 00014v3

Page _____ of _____

Invoice Information				Report Information (if differs from invoice)				Project Information			
Company: WSP Canada Inc.				Company: WSP Canada Inc.				Quotation #:			
Contact Name: Kevin Bentley				Contact Name: Madison Kennedy				P.O. #/ AFER:			
Street Address: 6925 Century Ave, #600				Street Address: 6925 Century Ave, #600				Project #: 19136074; 1002.001			
City: Mississauga	Prov: ON	Postal Code: L5N 7K2		City: Mississauga	Prov: ON	Postal Code: L5N 7K2		Site #:			
Phone: 905-567-4444				Phone: 778-228-5756				Site Location: Town of Bradford			
Email: kevin.bentley@wsp.com				Email: muhammad.irshad@wsp.com;				Site Location Province: Ontario			
Copies:				Copies: madison.kennedy@wsp.com				Sampled By: TJ			

Regulatory Criteria											
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Med/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Reg 406, Table:							
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Course	<input type="checkbox"/> Reg 558*	<input type="checkbox"/> Sanitary Sewer Bylaw							
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/other	<input type="checkbox"/> For RSC	<input type="checkbox"/> *min 3 day TAT	<input type="checkbox"/> Storm Sewer Bylaw							
<input type="checkbox"/> Table			<input type="checkbox"/> MISA	<input type="checkbox"/> Municipality							
			<input type="checkbox"/> PWQO	<input type="checkbox"/> Other:							

Include Criteria on Certificate of Analysis (check if yes): ☐

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

Sample Identification	Date Sampled			Time (24hr)		Matrix	FIELD FILTERED	FIELD PRESERVED	LAB FILTRATION REQUIRED	Corrosivity Package	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	YY	MM	DD	HH	MM																											
1 CL-BBP-68 SS-3B	23	08	16			Soil				X																						
2						Soil																										
3						Soil																										
4						Soil																										
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																

*UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BUREAU VERITAS STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS AND CONDITIONS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVNA.COM/TERMS AND CONDITIONS OR BY CALLING THE LABORATORY LISTED ABOVE TO OBTAIN A COPY

LAB USE ONLY				LAB USE ONLY				LAB USE ONLY				LAB USE ONLY			
Seal present	Yes	No		Seal present	Yes	No		Seal present	Yes	No		Seal present	Yes	No	
Seal intact				Seal intact				Seal intact				Seal intact			
Cooling media present				Cooling media present				Cooling media present				Cooling media present			

Relinquished by: (Signature/ Print)				Received by: (Signature/ Print)				Special Instructions			
M. Talha Irshad				[Signature]							
YY	MM	DD	HH	MM	YY	MM	DD	HH	MM		
23	09	07	08		23	09	07	08	40		

07-Sep-23 08:40
Ankita Bhalla
C3R4092
AJH ENV-1348



wsp.com