



April 27, 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

**BORER'S CREEK CULVERT EXTENSIONS - SINGLE CELL (MTO
SITE No. 36-0302/C) AND TWIN CELL (MTO SITE No. 36-0430/C)
AND RETAINING WALLS
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE
CITY OF HAMILTON
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2112-05-00**

Submitted to:

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REPORT



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PART A

**FOUNDATION INVESTIGATION REPORT
BORER'S CREEK CULVERT EXTENSIONS AND RETAINING WALLS
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE
CITY OF HAMILTON
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the extension of the Borer's Creek Culverts and retaining walls on the east and west side of Highway 6. The proposed work is part of the future Highway 5 and Highway 6 Interchange (IC) and associated Municipal Roads in the City of Hamilton, Ontario, which includes high fill embankments for the Highway 5 and Highway 6 re-alignments and interchange ramps, rock cut slope assessment, high mast lighting and overhead signs.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2010, which forms part of the Consultant's Assignment Number (Number 2008-E-0038) for this project. Golder's proposal for foundation engineering services associated with the Highway 5/Highway 6 Interchange structure is contained in Section 6.8 of IBI's Technical Proposal for this assignment and subsequent scope change dated December 9, 2013. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated September 10, 2012.

This report addresses the investigation carried out for the Borer's Creek Culverts and retaining wall at both ends of the culverts. The purpose of this investigation is to establish the subsurface conditions at the proposed culverts and retaining walls, by borehole drilling, rock coring, in situ testing and laboratory testing on selected soil and rock core samples. The investigation area is shown in plan on Drawing 1.

2.0 SITE DESCRIPTION

The Borer's Creek culverts are located about 500 m north of the existing Highway 5 and Highway 6 intersection, which is located west of Waterdown and approximately 3 km north of the Highway 403/Highway 6 interchange, at Clappison's Corners in the City of Hamilton, Ontario. The existing Highway 5 alignment in this area is oriented generally in a west-east direction. The existing Highway 6 alignment is oriented generally in a north-south direction connecting with Highway 403 to the south and Highway 401 to the north of Highway 5, and it was last widened in 2005. At the location of the Borer's Creek culverts Highway 6 consists of two lanes in both the northbound and southbound directions with a centre median lane.

The existing Borer's Creek culverts are generally oriented perpendicular to Highway 6 and consist of two culvert structures: a twin cell box culvert (MTO Site No. 36-0430/C) centered at Station 20+492; and a single cell box culvert (MTO Site No. 36-0302/C) centered at Station 20+475. At the twin cell structure there is water flowing through the most northerly of the two sections and the southerly cell is used for pedestrian traffic. The single cell culvert is currently dry and it is understood that it is unused. The ends of the twin culverts and single cell culvert are about coincident with the toes of the existing highway embankment. In order to accommodate the roadway widening, the twin cell culvert is being fitted with a cantilever head wall, and the single cell culvert is being extended on both ends and will also be fitted with a cantilever head wall. A retaining wall is proposed between the twin cell box culvert and the single cell box culvert and to connect the headwalls at both ends of the culverts. Retaining walls, approximately 5 m to 7 m in length, are also proposed south of the single cell culvert and north of the twin cell culverts.

The topography at the site consists of relatively flat terrain which slopes downward further south of the intersection along Highway 6 down the Niagara Escarpment. The existing Highway 6 grade in the general area of the Borer's Creek culverts is at about Elevation 220.6 m and the ground surface at the toes of the highway



embankment is at about Elevations 218.5 m on the east side and 216.7 m on the west side of the highway. Approximately 3 m to the west of Borehole BC-1, bedrock outcrop is visible at ground surface.

3.0 INVESTIGATION PROCEDURES

The foundation investigation at the Borer's Creek culverts was carried out between October 8 and 28, 2014 during which time a total of five sampled boreholes were advanced at the locations shown of Drawing 1. In addition, Borehole OS-4, drilled in September 2013 for a proposed overhead sign at Station 20+480 and which is located in the vicinity of Borer's Creek, is also pertinent to the foundation investigation for the culverts.

The borehole investigation was carried out using a track-mounted CME 55 drill rig and a truck-mounted CME 75 drill rig, supplied and operated by DBW Drilling Ltd. of Ajax, Ontario. The boreholes were advanced through the overburden using 102 mm and 150 mm outside diameter solid stem augers. Soil samples were taken using 50 mm outer diameter split-spoon samplers driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the Soil). In general, split-spoon samples were obtained at ground surface and at depth intervals of about 0.75 m. Samples of the bedrock were obtained using NW casing and an NQ size rock core barrel and coring techniques.

The boreholes were advanced to auger and/or sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring in five selected boreholes. The boreholes were advanced to depths ranging from 3.5m to 6.4 m below existing ground surface, including coring of bedrock for core lengths between about 3.0 m and 3.7 m in Boreholes BC-1, BC-3A, BC-5, BC-6A and OS-4. Photographs of the recovered rock samples are provided in Appendix B.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. A piezometer was installed in Borehole BC-4 to permit monitoring of the ground water level at this location. The installed piezometer consists of 37 mm (1 ¼ inch) diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen and filter sand pack were backfilled to the ground surface with bentonite pellets. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. All open boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and rock core samples. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory. The rock core samples from the bedrock were placed in core boxes, logged in the field and transported to our Mississauga geotechnical laboratory. In the laboratory the soil samples and rock core samples underwent further detailed visual examination and geotechnical soil classification testing (water content, Atterberg limits and grain size distribution and rock core unconfined compression (uniaxial) strength testing). All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing are noted on the Record of Borehole and Drillhole sheets in Appendix A and are presented on the laboratory test sheets included in Appendix B.



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The as-drilled borehole location and ground surface elevation were surveyed by Callon Dietz, a licensed surveying company retained by Golder. The locations given in the Record of Borehole/Drillhole sheets and shown on Drawings 1 and 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

The as-drilled borehole location of OS-4 was measured relative to the existing on-site features and the overhead signs location shown on the digital terrain model for the site, provided by IBI. The approximate ground surface elevation at Borehole OS-4 was obtained from the topographic and contour maps provided by IBI.

The borehole locations, ground surface elevations and drilled depths are summarized below.

| Borehole No. | Location (MTM NAD 83) | | Ground Surface Elevation (m) | Borehole Depth (m)* |
|--------------|-----------------------|----------|------------------------------|---------------------|
| | Northing | Easting | | |
| BC-1 | 4797350.6 | 270543.7 | 218.0 | 6.0 |
| BC-3A | 4797364.8 | 270517.8 | 216.7 | 3.5 |
| BC-4 | 4797371.1 | 270573.8 | 220.7 | 3.9 |
| BC-5 | 4797387.0 | 270578.4 | 218.0 | 4.8 |
| BC-6A | 4797415.3 | 270555.1 | 218.5 | 5.5 |
| OS-4 | 4797368.3 | 270547.7 | 220.5 | 6.4 |

*Including between 3.0 m and 3.7 m bedrock coring

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The study area is located on the Niagara Escarpment¹, a topographic break that separates the two levels of the Niagara Peninsula, which is manifested in typically harder, resistant dolostone and limestone bedrock units forming vertical cliffs along the brow of the Escarpment, over the softer shale bedrock below. The Niagara Escarpment extends from the Niagara River to the northern tip of the Bruce Peninsula and is generally flanked by landscapes of glacial origin. Capping the Niagara Escarpment is the Lockport Formation consisting of white, grey and brown dolostone (Karrow, 1987)² at the crest underlain by the Rochester, Irondequoit, Reynales, Thorold, Grimsby and Cabot Head Formations consisting of grey to reddish brown shaley dolostone, limestone, siltstone and sandstone (Blair and McFarland, 1992)³.

Overburden within the study area is comprised primarily of glacial till, which is mapped as the Halton Till and extends as a sheet into the Hamilton area, terminating in the Waterdown Moraines east of the Niagara Escarpment between the Lake Iroquois and the Trafalgar Moraine. The Halton Till is generally considered a fine-grained diamicton with minor fine-grained lacustrine sediments incorporated within the body of the unit, likely from glacial reworking of underlying lacustrine sediments. The Halton Till also contains cobbles and

¹ 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

² Karrow, P.F. 1987. *Quaternary Geology of the Hamilton-Cambridge Area, Southern Ontario*, Ontario Geological Survey, Report 255. Ministry of Northern Development and Mines, Ontario.

³ Blair, R. and McFarland, S. 1993. *Regional Correlation of the Middle and Lower Silurian Stratigraphy of the Niagara Escarpment Area*, Proceedings of the 1992 Conference of the Canadian National Chapter, International Association of Hydrogeologists, Hamilton, Ontario, 659-696.



boulders and in some areas, "boulder pavements" (Watt, 1955)⁴ can be encountered where boulders are nested or concentrated within the till unit.

During the retreat of the last ice sheet, lakes were formed in depressions on the land surface in which were deposited sand, gravel, silt and clay materials. The last major meltwater system along the Escarpment occurred when the Waterdown Moraines were formed. Several channels among the Waterdown Moraines functioned at various times, feeding meltwaters southwest toward glacial lakes to create lacustrine and outwash sand deposits.

4.2 Subsurface Conditions

The detailed subsurface soil, bedrock, and groundwater conditions as encountered in the boreholes advanced during this investigation and the results of the laboratory tests carried out on selected soil and bedrock core samples are presented on the Record of Borehole and Drillhole sheets provided in Appendix A. The results of the in situ field tests (i.e. SPT 'N'-values) as presented on the Record of Borehole sheets and in Section 4.0 are uncorrected. The results of the laboratory tests carried out on selected soil and rock core samples are provided in Appendix B.

The stratigraphic boundaries shown on the Record of Boreholes and on the stratigraphic profile and cross-sections on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the record of Borehole and Drillhole sheets governs any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawing 2 is a simplification of the subsurface conditions.

In summary, the subsurface conditions in the area of the Borer's Creek culverts consist of topsoil underlain by fill consisting of cohesionless and cohesive materials associated with the construction Highway 6. The fill material at some locations is underlain by a till deposit comprised of clayey silt to silty clay which in turn is underlain by dolostone bedrock. In general, the bedrock surface as encountered or inferred in the area of the Borer's Creek culverts is fairly level to gently sloping upwards from northwest to southeast.

A detailed description of the subsurface conditions encountered in the boreholes at the proposed culvert extensions and retaining walls is provided in the following sections.

4.2.1 Topsoil

In Boreholes BC-1, BC-3A, BC-5 and BC-6A advanced at the toes of the embankment on either side of Highway 6 topsoil was encountered from ground surface. The thickness of the topsoil extends to depths between 0.1 m and 0.3 m below ground surface.

4.2.2 Asphalt

Borehole OS-4, advanced through the pavement structure of the south bound lanes of Highway 6 encountered 200 mm asphalt from the roadway surface.

⁴ Watt, A.K. 1955. *Pleistocene Geology and Groundwater Resources of the Township of North York, York County, Ontario* Department of Mines, Sixty Fourth Annual report, Volume LXIV, Part 7.



4.2.3 Fill

Fill materials were encountered in Boreholes BC-1, BC-4, BC-5, BC-6A and OS-4. In Boreholes BC-4, BC-5 and OS-4 cohesionless fill comprised of brown sand to silty sand and gravel to sand and gravel was encountered, from immediately below ground surface at Borehole BC-4, underlying the topsoil at Borehole BC-5 and beneath the asphalt in Borehole OS-4. The cohesionless fill material extends to depths between 0.7 m and 1.4 m (between Elevation 219.5 m and 217.3 m).

Underlying the topsoil in Borehole BC-1 and BC-6A, the silty sand and gravel fill in Borehole BC-4 and the sand and gravel fill in Borehole OS-4, cohesive fill consisting of sandy clayey silt to silty clay was encountered at depths between 0.1 m and 1.4 m (between Elevations 219.5 m and 217.8 m). The cohesive fill layer is between 0.6 m and 2.1 m thick and extends to depths ranging from 0.7 to 3.2 m (between Elevations 217.8 m and 215.7 m). The sandy clayey silt fill encountered in Borehole BC-1 contains cobbles and/or boulders as inferred by grinding of the augers and in Borehole BC-1 cobbles were removed from the borehole to a depth of 0.6 m below ground surface.

The SPT "N"-values measured within the cohesionless fill material range between 14 and 33 blows per 0.3 m of penetration, indicating a dense relative density. The SPT "N"-values recorded within the cohesive fill ranges from 6 blows to 33 blows per 0.3 m of penetration, suggesting that the clayey silt to silty clay fill has a firm to hard consistency.

Grain size distribution tests were carried out on two samples of the cohesive fill and the results are presented on Figure B1, in Appendix B. Atterberg limits tests carried out on two samples of the cohesive fill measured liquid limits of about 30 per cent, plastic limits of 18 per cent and 16 per cent corresponding plasticity indexes of 14 per cent and 12 per cent. The results of the Atterberg limits test are shown on a plasticity chart on Figure B2 in Appendix B and indicate that the cohesive fill material consists of clayey silt of low plasticity.

A grain size distribution test was carried out on one sample of the cohesionless fill and the result is presented on Figure B3, in Appendix B.

The water content measured on two samples of the silty sand and gravel fill is 4 per cent and 5 per cent and the water content recorded on five samples of the cohesive fill ranges from 16 per cent to 28 per cent. The organic content measured on a sample of the cohesive fill material from Borehole OS-4 is 1.5 per cent.

4.2.4 Clayey Silt to Silty Clay Till

A till deposit consisting of clayey silt to silty clay was encountered underlying the fill in Boreholes BC-4, BC-5, and BC-6A. The top of the till was encountered at a depth of 2.9 m (Elevation 217.8 m) in Borehole BC-4 and at depths of 0.7 m in Boreholes BC-5 (Elevation 217.3 m) and BC-6 (Elevation 217.8 m). The till deposit extends to depths between 1.2 m and 3.9 m (between Elevations 216.8 m and 216.6 m) and the deposit is between 0.5 m and 1.2 m thick.

The SPT "N"-values measured within the till deposit range from 21 blows to 106 blows per 0.3 m of penetration, suggesting that the clayey silt to silty clay till has a very stiff to hard consistency.

The till deposit is generally comprised of clayey silt some sand to silty clay, trace to some sand and trace gravel. Although cobbles and/or boulders were not encountered within the till deposit and grinding of the augers during drilling was not evident, the till deposits in southern Ontario typically contain such materials and they should be expected within such glacial deposits. Grain size distribution tests were carried out on two selected samples of the clayey silt to silty clay till deposit and the results are shown on Figure B4 in Appendix B.



Atterberg limits tests were carried out on three selected samples of this cohesive till deposit and measured liquid limits ranging from about 27 per cent to 37 per cent, plastic limits ranging from about 16 per cent to 17 per cent and plasticity indices ranging from about 11 per cent to 20 per cent. These results, which are plotted on a plasticity chart on Figure B5 in Appendix B, indicate that the till deposit consists of clayey silt of low plasticity to silty clay of intermediate plasticity.

The natural water content measured on three selected samples of the clayey silt to silty clay till ranges from 12 per cent to 18 per cent.

4.2.5 Dolostone Bedrock

Bedrock was encountered and core samples were recovered in Boreholes BC-1, BC-3A, BC-5, BC-6A and OS-4. The bedrock surface is inferred from split-spoon and auger refusal in Borehole BC-4. The depths to bedrock or refusal below ground surface and the corresponding bedrock surface or refusal elevation are summarized below.

| Foundation Element | Borehole | Depth to Bedrock Surface / Refusal (m) | Bedrock Surface / Refusal Elevation (m) | Comments |
|---|-----------------|---|--|-------------------------------|
| West Extension of Single Cell Culvert | BC-1 | 2.3 | 215.7 | Bedrock Cored |
| East Extension of Single Cell Culvert | BC-5 | 1.2 | 216.8 | Bedrock Cored |
| North End of West Retaining Wall - Toe | BC-3A | 0.3 | 216.4 | Bedrock Cored |
| North End of East Retaining Wall - Toe | BC-6A | 1.9 | 216.6 | Bedrock Cored |
| South End of East Retaining Wall - Crest | BC-4 | 3.9 | 216.8 | Auger and Split-Spoon Refusal |
| West Edge of Highway 6 between Single Cell and Twin Cell Culverts | OS-4 | 3.2 | 217.3 | Bedrock Cored |

In general, the bedrock surface as encountered or inferred in the area of the Borer's Creek Culvert is fairly level to gently sloping upwards from northwest to southeast. A bedrock outcrop is present at ground surface near Boreholes BC-1 and BC-3A.

Based on a review of the bedrock core samples, the bedrock consists of dolostone of the Lockport formation. In general, the bedrock core samples are described as slightly weathered to fresh, thinly to thickly bedded, fine to coarse grained, faintly to highly porous, medium strong to strong, grey, as presented in the Record of Drillhole sheets in Appendix A, and shown on the photographs of the recovered core samples on Figures B6 and B7 in Appendix B. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2), and the strength classification of the intact rock mass based on field identification (i.e. medium strong to strong –



R3 to R4) are described in accordance with the International Society for Rock Mechanics (ISRM⁵) standard classification system.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 85 per cent and 100 per cent and between 7 per cent and 100 per cent (but generally between 72 and 100 per cent), respectively. The Rock Quality Designation (RQD) measured on the core samples ranges from 0 per cent to 100 per cent (but generally ranges from 82 to 100 per cent), indicating a rock mass of poor to excellent quality as per Table 3.10 of CFEM (2006)⁵.

Point load strength index tests (ASTM D5731 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification) were carried out on eight selected samples of the bedrock core. The point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1. The axial tests carried out on four samples of the dolostone bedrock measured Is_{50} values ranging from about 1.8 MPa to 16.0 MPa. The diametral tests carried out on four samples of the dolostone bedrock measured Is_{50} values ranging from about 4.9 MPa to 18.3 MPa.

Two Unconfined Compression (UC) tests (ASTM D7012)⁶ were carried out on core samples of the dolostone bedrock obtained in BC-6A and Boreholes OS-4 and measured a compressive strength of about 119 MPa and 96 MPa, respectively. The laboratory UC test results are presented on Figures B8 and B9 and are summarized in Table B2.

Based on the laboratory UC test, in accordance with Table 3.5 in CFEM (2006)⁵, the dolostone bedrock is classified as strong (R4, 50 MPa < UCS < 100 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

4.2.6 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets, in Appendix A. The overburden samples taken in the boreholes were generally dry to moist. The water level in BC-1 was measured at a depth of 2.3 m (Elevation 215.7 m). Boreholes BC-3A, BC-4, BC-5 and BC-6A were dry upon completion of drilling and prior to rock coring operations.

The groundwater level measured in the piezometer in Borehole BC-4 on October 2, 2014 is at a depth of 3.7 m (Elevation 217.0 m).

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

⁵ International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

⁶ ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

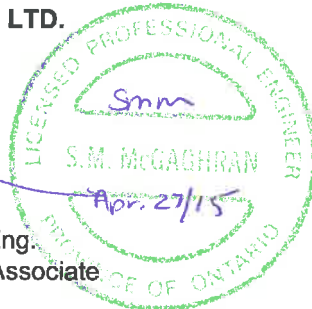


5.0 CLOSURE

Mr. Alex Szot, E.I.T., a geotechnical engineer-in-training with Golder directed the field drilling program. This report was prepared by Ms. Sandra McGaghran, P.Eng., a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder, conducted a technical and quality control review of the report.

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SMM/JMAC/LCC/sm

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15apr27 borer's creek culvert and retaining wall.docx



PART B

**FOUNDATION DESIGN REPORT
BORER'S CREEK CULVERT EXTENSIONS AND RETAINING WALLS
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE
CITY OF HAMILTON
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2112-05-00**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundations engineering recommendations for the detail design for the proposed culvert extensions and retaining wall on the east and west sides of Highway 6, as part of the future construction of the Highway 5 and Highway 6 Interchange (IC) and associated Municipal Roads in the City of Hamilton, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the detail design of the structure foundations and approach embankments. Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Foundations for Culvert Extensions

6.2.1 Foundation Options

The existing Borer's Creek culverts are generally perpendicular to Highway 6 and consist of two culvert structures: a twin cell box culvert centered on Station 20+492 and a single cell box culvert centered on Station 20+475. Borer's Creek currently flows through the most northerly cell of the twin cell culvert, flowing towards the west. The south cell of the twin culvert is used for pedestrian traffic. The end of the twin culvert currently is currently about coincident with the extent of the future widening of Highway 6 and therefore it does not require extension; however, a cantilever concrete headwall will be required to provide lateral support to the widened road. In order to accommodate the widening, the single cell culvert, located about 25 m south of the twin culvert, requires an extension on the east and west sides of Highway 6. On the east side of Highway 6 the culvert will be extended between 3 m and 3.2 m, and on the west side Highway 6 the culvert will be extended between 2.7 m and 3 m. The single cell culvert is currently dry and it is understood that the culvert is not required based on a drainage assessment carried out by IBI; however MTO would prefer to extend the culvert to accommodate the widening instead of removing or filling the culvert. The existing single cell and twin culverts are all open footing structures, with footings that are 800 mm wide. Details regarding the proposed extension of the single cell culvert are provided in the following table.

| Culvert | Approximate Existing Embankment Height | Existing Culvert | | | Approximate Existing Inlet/Outlet Invert Elevation (m) |
|------------------------|--|------------------|--------------------------|--------|--|
| | | Type | Size | Length | |
| Single Cell Sta 20+475 | 4 m | Open Footing | 4.3 m wide 1.7 m high | 34 m | 217.8 m |

A retaining wall is proposed between the two culverts and will connect to the headwalls on the east and west sides of Highway 6. The retaining walls will also extend south of the single cell culvert and north of the twin culvert and will be between about 4 m and 8 m long. The retaining wall will have an overall length of 35.5 m on the east side and 38.5 m on the west side of Highway 6.



Although it is recognized that the culvert extensions will likely be required to match the existing culverts, in accordance with the MTO Terms of Reference for this assignment, this section of the report presents advantages, disadvantages and geotechnical recommendations for box culvert extensions and open footing culvert extensions.

Either box culverts or “open footing” (shallow foundation) concrete culverts are feasible for extension of the single cell structure. The proposed retaining walls should be supported on shallow foundations; deep foundations are not required, as shallow foundations will provide sufficient bearing resistance and acceptable settlement performance. Both pre-cast concrete elements (box culvert segments or footing elements) and cast-in-place concrete elements are also feasible from a foundations perspective.

The advantages and disadvantages associated with both the pre-cast box culvert and cast-in-place open footing options are summarized in Table 1, following the text of this report. It is understood that the preferred alternative is to use an open footing for the culvert extension as the existing culvert is supported by an open footing. From a foundations perspective, pre-cast box culvert replacements are preferred over cast-in-place open footing culvert extensions as it would minimize the excavation depth; however since the culvert is “dry” this concern is not significant.

Recommendations for box culvert and shallow foundation (open footing) culvert extensions are provided in the following sections.

6.2.2 Founding Elevations and Sub-excavation Requirements

6.2.2.1 Box Culvert – Extensions

It is not necessary to found box culvert extensions at the standard depth for frost protection purposes, as the box structures are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. However box culvert extensions should be founded below any existing fill and surficial organic materials. In accordance with SP 422S01 (Construction Specification for Precast Concrete Culverts), box culvert extensions should be provided with at least 300 mm of OPSS 1010 Granular A material for bedding purposes.

Based on Borehole BC-1 (advanced at the toe of the slope on the west side of Highway 6) and Borehole BC-5 (advanced at the toe of the slope on the east side of Highway 6), fill material was encountered below the existing culvert invert of Elevation 217.8 m, extending to the bedrock surface at Elevation 215.7 m and 217.3 m, respectively. However, as discussed in Section 4.2.5, a bedrock outcrop is present approximately 3 m west of Borehole BC-1; therefore the bedrock surface in the west extension area is variable. Based on an assumed base slab thickness of 300 mm and a bedding thickness of 300 mm, subexcavation of approximately 1.5 m below the proposed underside of the bedding elevation will be required on the west side of Highway 6. Subexcavation is not required for the culvert extension on the east side of Highway 6; based on Borehole BC-5 the underside of the bedding will be founded on a very stiff to hard clayey silt till deposit.

The width of the required sub-excavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert base slab, outward and downward at 1H:1V, as shown schematically on Figure 1 following the text of this report. Depending on the depth of sub-excavation required relative to the existing culvert base or footings, temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during sub-excavation.

The box culvert subgrade should be inspected by a Quality Verification Engineer following sub-excavation to ensure that all existing topsoil and fill or other unsuitable material have been removed, in accordance with OPSS 902 (Construction Specification for Excavating and Backfilling Structures). Following inspection, the sub-



excavated area should be backfilled with granular material meeting OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material) Granular A or Granular B Type II that is placed and compacted in accordance with OPSS 501 (Compaction).

The culvert was dry at the time of Golder's geotechnical investigation and it is understood that it is not relied upon for surface water drainage. The water level in the monitoring well installed as part of the borehole investigation was at about the bedrock surface elevation; therefore groundwater control will likely be limited to directing surface water from rainfall events away from the excavations (See Section 6.5.2 for further details).

The till subgrade for the box culvert extension on the east side of Highway 6 will be susceptible to loosening/softening and degradation on exposure to water and construction traffic. As discussed further in Section 6.5.3, as an alternative to the placement of 300 mm of granular bedding material on the native soil below the base slab, a 100 mm thick mass concrete slab could be placed on the subgrade to protect it from degradation. In this case, a 75 mm thick layer of OPSS.PROV 1010 Granular A or concrete fine aggregate meeting the gradation requirements set out in OPSS.PROV 1002 (Material Specification for Aggregates - Concrete) should be placed on top of the mass concrete slab to provide a "levelling pad" for the box culvert replacement or extension. An NSSP for the mass concrete slab is included in Appendix C.

6.2.2.2 Open Footing Culvert Extensions

Strip footings for open footing culvert extensions should extend below any existing fill and surficial organic materials, where present. As discussed in Section 6.2.2.1, on the west side of Highway 6 fill material extends to the bedrock surface and must be subexcavated. The width of the required sub-excavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert footings, outward and downward at 1H:1V similar to that shown schematically on Figure 1 following the text of this report. Depending on the depth of sub-excavation required relative to the existing culvert base or footings, temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during sub-excavation. The sub-excavated area should be backfilled with granular material meeting OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material) Granular A or Granular B Type II that is placed and compacted in accordance with OPSS 501 (Compaction). Strip footings for open footing culvert extensions should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration, as per Ontario Provincial Standard Drawing (OPSD) 3090.101 (Foundation Frost Depths for Southern Ontario).

For the culvert extension on the east side of Highway 6, the bedrock surface is within 1.0 m of the existing invert of the culvert, based on information obtained from Borehole BC-5. Although this depth is less than the foundation frost depth for this area of Ontario, the dolostone bedrock is not frost-susceptible, and therefore cast-in-place strip footings may be founded on the bedrock surface. If pre-cast footings are adopted, it is recommended that a nominal 75 mm thick levelling layer be placed on the bedrock surface to permit seating and levelling of the pre-cast elements; however, due to the potential for bedrock variability at the site, cast-in-place footings are preferred over pre-cast footings at this location. The levelling layer should meet the requirements of OPSS.PROV 1010 Granular A or concrete fine aggregate meeting the gradation requirements set out in OPSS.PROV 1002 (Material Specification for Aggregates - Concrete).

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with OPSS 902 (Excavating and Backfilling Structures) to check that all existing fill and surficial organic soils or other unsuitable material have been removed, and that the subgrade soil or bedrock has been properly prepared.



As discussed in Section 6.2.2.1 the culvert was dry at the time of Golder's geotechnical investigation and it is understood that it is not relied upon for drainage. The water level in the monitoring wall was at about the bedrock surface elevation; therefore groundwater control will likely be limited to directing surface water from rainfall events away from the excavations (See Section 6.5.2 for further details).

6.2.3 Geotechnical Resistance

6.2.3.1 Box Culverts – Extensions

Box culverts extensions placed on the properly prepared subgrade as discussed above should be designed based on the recommended factored geotechnical resistances at Ultimate Limit States (ULS) and the geotechnical reactions at Serviceability Limit States (SLS) (for 25 mm of settlement) as provided below. These recommendations are based on the existing box culvert span of 5.2 m.

| Culvert Extension | Sub-excavation Required? | Highest Base Slab Founding Elevation² | Founding Material | Factored Geotechnical Resistance at ULS³ | Geotechnical Resistance at SLS (25 mm of settlement)³ |
|--------------------------|---|---|---|--|---|
| West side of Hwy 6 | Yes, additional 1.8 m below underside of slab | 217.5 m | Compacted Granular A or Granular B Type II | 300 kPa | 450 kPa |
| East side of Hwy 6 | No | 217.3 m | Hard Clayey Silt Till (0.5 m thick overlying bedrock) | 8,000 kPa ⁴ | See Note 5 |

NOTES:

1. Proposed culvert invert elevations provided by IBI Group.
2. Highest founding elevation based on an assumed base slab thickness of 300 mm. Per Section 6.1.5, it is recommended that the base slab be founded on either a 300 mm thick layer of compacted OPSS Granular A, or a 100 mm thick concrete working slab overlain by 75 mm of OPSS.PROV 1010 Granular A or OPSS.PROV 1002 concrete fine aggregate.
3. The geotechnical resistances given in the above table are based on the culvert span (width) as listed above for each culvert. The recommended geotechnical resistances should be reviewed if the footing founding elevation and/or culvert span (width) differ significantly from those given above.
4. The ULS and SLS values are reflective of the underside of base slab being within about 0.5 m of the bedrock surface.
5. The ULS resistance will govern as the anticipated settlement at this load is less than 15 mm.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the founding elevation differs significantly from that given above. The geotechnical resistances/reactions provided above are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the Canadian Highway Bridge Design Code (CHBDC).

6.2.3.2 Open Footing Culvert Extensions

Strip footings placed on the properly prepared subgrade as discussed above should be designed based on the factored geotechnical resistances at ULS and the geotechnical reactions at SLS (for 25 mm of settlement) as given below. These recommendations are based on an assumed footing width of 0.6 m.



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| Culvert Extension | Proposed Culvert Invert Elevation ¹ | Sub-excavation Required? | Highest Founding Elevation ² | Founding Material | Factored Geotechnical Resistance at ULS ³ | Geotechnical Reaction at SLS ³ |
|--------------------|--|---|---|--|--|---|
| West side of Hwy 6 | 217.8 m | Yes, additional 0.9 m below underside of footing. | 216.6 m | Compacted Granular A or Granular B Type II | 400 kPa | See Note 4 |
| East side of Hwy 6 | 217.8 m | No | 216.8 m ² | Dolostone Bedrock | 10,000 kPa ⁴ | See Note 4 |

NOTES:

1. Proposed culvert invert elevations provided by IBI Group.
2. Highest founding elevation based on minimum footing depth of 1.2 m below lowest surrounding grade, for frost protection purposes, except for the culvert extension on the east side of Highway 6 where the bedrock surface is within 1.0 m of the lowest surrounding grade.
3. The geotechnical resistances given in the above table are based on an assumed footing width of 0.6 m. The recommended geotechnical resistances should be reviewed if the footing founding elevation and/or footing width differ significantly from those given above.
4. The ULS resistance will govern as the anticipated settlement at this load is less than 15 mm.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances/reactions should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given above. The geotechnical resistances/reactions provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the CHBDC.

6.2.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the base slab or concrete footings for the culvert extensions and the subgrade should be calculated in accordance with Section 6.7.5 of the CHBDC. The following table provides recommended coefficients of friction between pre-cast concrete box culvert sections and OPSS 1010 Granular A material, between cast-in-place concrete footings and the native subgrade soils and between cast-in-place concrete footings and the dolostone bedrock.



| Culvert Extension | Pre-Cast Concrete Box Culverts | | Cast-in-Place Concrete Footings | |
|--------------------|--|------------------------------------|---|----------------------------------|
| | <i>Coefficient of Friction, $\tan \delta$</i> | <i>Base Slab Founding Material</i> | <i>Coefficient of Friction, $\tan \phi'$</i> | <i>Footing Founding Material</i> |
| West side of Hwy 6 | 0.45 | Compacted granular fill (bedding) | 0.6 | Compacted granular fill |
| East side of Hwy 6 | 0.45 | Compacted granular fill (bedding) | 0.7 | Dolostone |

6.2.5 Culvert Bedding and Backfill

For a box culvert extension, the bedding levelling pad and backfill requirements should be in accordance with OPSS 422 (Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut) for pre-cast rigid frame culverts. Box culvert extensions should be provided with at least 300 mm of OPSS 1010 Granular A material for bedding purposes, or alternatively a 100 mm thick concrete working slab with 75 mm of bedding material.

Backfill and cover for concrete culverts should be completed in accordance with OPSD 803.010 (Backfill and Cover for Concrete Culverts). Backfill to culvert walls should consist of granular fill meeting the requirements of OPSS.PROV 1010 Granular A or Granular B Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill and bedding should be placed and compacted in accordance with OPSS 501 (Compacting). The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 500 mm. The culvert extensions should be designed for the full overburden and hydrostatic pressures, and live load, assuming that the embankment fill has a unit weight of 22 kN/m³ for Granular A, and 21 kN/m³ for Granular B Type II or select earth fill above and/or surrounding the culvert.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

6.2.6 Erosion Protection

The culvert was dry at the time of Golder's investigation and it is understood that it is currently not relied upon for drainage; therefore it is expected that surface water flow will be minimal. Temporary drainage ditches should be constructed in order to direct water from rainfall events away from the excavation. As this culvert is generally dry, a concrete cut-off wall is not considered necessary upstream; however it is understood that the culvert may convey water in the event that the rainfall from a major storm event occurs. Therefore as a precaution, it is recommended that a clay seal be provided at the upstream end of the open footing culvert extension. Clay seals should also be placed adjacent to the culvert inlet opening for both box culvert and open footing structure types. The clay material should meet the requirements of OPSS 1205 (Material Specification for Clay Seal). The clay seal should have a thickness of 1 m, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including treatment of the adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high water level, whichever is higher.



In the event that the rainfall from a major storm event exceeds the predictions, provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) at the culvert inlet and outlet, including in front of any wing walls/retaining walls adjacent to the creek channel. The requirements for and design of erosion protection measures for the culvert inlet should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSD 810.010 (Rip-Rap Treatment for Sewer and Culvert Outlets), with the rip-rap placed in front of the retaining wall, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket if adopted, including the creek side slopes and the retaining walls adjacent to the culverts.

6.2.7 Settlement

The existing Highway 6 embankment will be widened by up to 9.2 m at the culvert extension locations, which will require placement of a vertical thickness of up to approximately 4 m of additional fill atop the existing embankment side slopes. A headwall is proposed atop of the culvert extension to accommodate the widening. This widening/additional load will induce some nominal settlement in the granular soils placed within the subexcavated area and in the hard clayey silt till on the west and east sides of Highway 6, respectively.

The settlement analysis for the culvert extension locations under the widened Highway 6 loading was carried out using hand calculations and elastic deformation moduli as given in the table below, based on correlations with the Atterberg limits and SPT 'N' values and engineering judgement from experience with similar soils in this region of Ontario.

| Culvert Extension Area | Soil Deposit | Bulk Unit Weight | Elastic Modulus |
|-------------------------------|---|-------------------------|------------------------|
| West Side of Highway 6 | Compacted Granular A or Granular B Type II fill (new) | 21 kN/m ³ | 25 MPa |
| East Side of Highway 6 | Very stiff to hard clayey silt to silty clay till | 21 kN/m ³ | 50 MPa |

The settlement of the foundation soils beneath the culvert extensions, under the approximately 4 m thickness of additional fill that may be placed on the existing embankment side slope, is estimated to be less than 10 mm under the widening area.

6.3 Retaining Structure Options

In order to accommodate the proposed widening of Highway 6 in the vicinity of Borer's Creek culverts retaining structures up to 4 m high are required.

Given that bedrock is quite shallow at the site, the wall types and reinforced earth options outlined below are considered appropriate. The use of deep foundations for support of a concrete retaining wall option is not required at this site, as adequate bearing resistance and settlement performance can be achieved on the dolostone bedrock with the use of shallow foundations.

- **Concrete Retaining Wall on Shallow Foundations:** A concrete retaining wall supported on shallow foundations (concrete strip footings) is geotechnically feasible for the proposed retaining structure. Due to the shallow bedrock conditions the strip footings would be founded on the dolostone bedrock, with the exception of the retaining wall section south of the culvert extension on the west side of



Highway 6. The borehole in the vicinity of this section of retaining wall encountered fill material overlying the bedrock and subexcavation and replacement with OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material) Granular A or Granular B Type II will be required. Temporary excavations to allow for construction of the spread footings would be required and a temporary protection system is expected to be required along Highway 6 to accommodate traffic staging during construction. The presence of strong dolostone bedrock at relatively shallow depth must be considered in the design and construction of the protection system, as socketing or otherwise fixing the toe of the soldier piles or sheetpiles into/to the bedrock will be required. It is recommended that the traffic staging on Highway 6 be examined carefully to maximize the work zone and thus optimize protection system requirements, or alternate “top-down” proprietary protection systems be investigated; further discussion on this aspect is provided in Section 6.5.

- **Reinforced Soil System (RSS) Wall:** An RSS wall is geotechnically feasible for the proposed retaining structure. Due to the shallow bedrock conditions at the toe of the slope, excavations depths for this option would be similar to the shallow foundations option. However, depending on the design by the supplier of the RSS wall the excavation for the zone of the reinforced soil mass (typically about 80 per cent of the wall height) may be slightly wider compared to a concrete retaining wall on shallow foundations (typically about 60 to 70 per cent of the wall height). As with the concrete retaining wall option, a temporary protection system is expected to be required along Highway 6 to facilitate excavation for and construction of the reinforced soil mass, and the presence of the strong dolostone bedrock must again be considered, as socketing or fixing the toe of conventional protection systems into the bedrock will be required. It is recommended that the traffic staging on Highway 6 be examined carefully to maximize the work zone and thus optimize protection system requirements, or alternate “top-down” proprietary protection systems be investigated; further discussion on this aspect is provided in Section 6.5.
- **Soldier Pile and Concrete Panel Walls:** A soldier pile and concrete panel wall may be considered for the proposed retaining structure. This type of wall is generally more advantageous in “top-down” construction applications (i.e., as part of a cut, rather than new fill construction), or in areas where their use can minimize excavation into existing embankments to construct conventional footings or reinforced zones, as could be the case for the walls at this site. The soldier piles would need to be installed with equipment at the toe of the slope, and therefore there needs to be sufficient area within the MTO road allowance. This option would eliminate the requirement for a temporary protection system along Highway 6 and would allow fill placement to proceed above the existing ground surface behind the proposed wall alignment. However, as for a conventional temporary protection system, socketing the soldier piles into the strong dolostone bedrock would require special coring or churn drilling equipment.
- **Reinforced Earth Slope:** Consideration of the use of a reinforced earth slope (i.e. with slopes oriented at 1.5 or 1 horizontal to 1 vertical (1.5H:1V or 1H:1V)) would require further extension of the single cell culvert and as well extension of the twin cell culvert on the east and west sides of Highway 6. From a cost perspective it is understood that this option is not being considered.

The feasibility, advantages and disadvantages for the various retaining wall and reinforced earth options are summarized in Table 2 following the text of this report. From a geotechnical/foundations perspective, the use of a concrete retaining wall founded on shallow foundations or an RSS wall would be preferred, and both would



perform well and meet aesthetic requirements. It is recommended that the choice be made on the basis of cost and of the option which will require a narrower footing or reinforced soil mass (i.e., lesser excavation into the existing Highway 6 embankment, and lesser impact on traffic staging on Highway 6).

The following sections of this report provide geotechnical recommendations for the feasible options.

6.3.1 Concrete Retaining Wall on Shallow Foundations

6.3.1.1 Founding Elevation

For support of a concrete retaining wall, strip footings should be founded at a minimum depth of 1.2 m below the lowest surrounding grade or on bedrock to provide adequate protection against frost penetration (per OPSD 3090.101 – *Foundation Frost Depths for Southern Ontario*).

As discussed in Section 6.2, the following provides the invert elevation of the single and twin cell culverts, which were provided by IBI and represent the lowest surrounding grade adjacent to the proposed retaining walls.

| Culvert | | Upstream Elevation (West side of Highway 6) | Downstream Elevation (East side of Highway 6) |
|----------------|---------------|--|--|
| Single Cell | | 217.8 m | 217.8 m |
| Twin Cell | South Culvert | 216.6 m | 216.4 m |
| | North Culvert | 215.9 m | 215.7 m |

With the exception of the south end of the retaining wall section on the west side of Highway 6, the bedrock surface is within or above 1.2 m below the lowest grade presented in the table above. Therefore the strip footings may be founded on the bedrock surface. The following provides a summary of the borehole for each section of retaining wall and the bedrock surface as encountered in the boreholes.

| Retaining Structure | Section of Retaining Wall | Corresponding Borehole | Bedrock Surface Elevation (m) |
|----------------------------|----------------------------------|-------------------------------|--------------------------------------|
| West Side of Highway 6 | South of Single Culvert | BC-1 | 215.7 |
| | Between Single and Twin Culvert | OS-4 | 217.4 |
| | North of Twin Culvert | BC-3A | 216.4 |
| East Side of Highway 6 | South of Single Culvert | BC-5 | 216.8 |
| | Between Single and Twin Culvert | BC-5, BC-6A | 216.6 |
| | North of Twin Culvert | BC-6A | 216.6 |

For the retaining wall section on the west side of Highway 6 south of the single cell culvert extension, fill material was encountered in Borehole BC-1 extending to the bedrock surface at Elevation 215.7 m. For this retaining wall section, strip footings would be required to be founded at Elevation 216.6 m; therefore subexcavation of approximately 0.9 m of fill material below the proposed underside of the strip footing elevation is required. The width of the required sub-excavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert base slab, outward and downward at 1H:1V, as shown schematically on Figure 1 following the text of this report. Depending on the depth of sub-excavation required relative to the existing culvert base or footings, temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during sub-excavation. Alternatively, the concrete retaining



wall footing could be founded directly on the dolostone bedrock following subexcavation; however this would require a longer reinforced concrete wall stem, in the order of about 0.9 m longer.

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with OPSS 902 (*Excavating and Backfilling Structures*) to check that the bedrock surface has been appropriately prepared and that any loose/degraded material has been removed prior to forming and pouring of the concrete footings. For the retaining wall section south of the single cell culvert extension on the west side of Highway 6, the footings may be placed directly on the bedrock, or compacted granular fill (meeting the requirements of OPSS.PROV 1010 Granular A or Granular B Type II) may be placed to raise the grade to form a subgrade level that meets the minimum frost depth of 1.2 m.

6.3.1.2 Geotechnical Resistance/Reaction

Strip footings placed on the properly prepared subgrade, at or below the design elevations given in the preceding section, should be designed based on the factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS, for 25 mm of settlement) given below:

| Footing Width (m) | Founding Stratum | Factored Geotechnical Resistance at ULS | Geotechnical Reaction at SLS* (kPa) |
|--------------------------|---|--|--|
| 2.0 | Compacted Granular A or Granular B Type II (south of single cell culvert on west side of Highway 6) | 500 kPa | -- |
| 3.0 | | 600 kPa | -- |
| 2.0, 3.0 m and 4.0 m | Dolostone Bedrock | 10,000 kPa | -- |

* For 25 mm of settlement

The bedrock is an unyielding material and the condition for 25 mm of settlement at SLS is higher than the ULS value. Therefore, for this site, for strip footings founded on the bedrock or where the bedrock surface is at a depth of less than 1 times the footing width, the ULS case governs. The geotechnical reaction should, however, be reviewed if the selected footing width or founding elevation differs from those given above.

The geotechnical resistances provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC)*.

6.3.1.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footing for the retaining wall and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed on compacted Granular A or Granular B Type II, the coefficient of friction, $\tan \phi'$, can be taken as 0.6. For cast-in-place concrete footings constructed on dolostone bedrock the coefficient of friction, $\tan \phi'$, can be taken as 0.7.



6.3.1.4 Global Stability

Slope stability analyses were carried out for the retaining wall section (having a height of about 2.8 m) on the west side of Highway 6 and south of the single cell culvert extension, where the strip footing would be founded on compacted Granular A or Granular B Type II, due to the required subexcavation of existing fill materials. This is considered to be the critical section as the other retaining wall sections are founded on sound dolostone bedrock.

The slope stability analysis was carried out using the commercially available program SLIDE, produced by Rocscience Inc., employing the Morgenstern Price method of analysis, to check that a minimum factor of safety of 1.5 is achieved for the proposed retaining wall height and geometry under static conditions. This minimum factor of safety is considered appropriate for the proposed wall on this project, considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the static global stability analyses, based on field and laboratory test data and geotechnical correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

| Soil Deposit | Bulk Unit Weight (kN/m³) | Effective Friction Angle |
|---------------------|--|---------------------------------|
| New fill | 20 | 30° |
| Existing fill | 20 | 28° |
| Dolostone bedrock | 24 | Modelled as bedrock |

The results of the global stability analyses indicate a minimum factor of safety of greater than 1.5 is achieved for a 2.8 m high concrete retaining wall at this location. The results of the global stability analysis for the concrete retaining wall option are provided on Figure 2.

6.3.2 Retained Soil System (RSS) Walls

6.3.2.1 Founding Elevations

A typical RSS wall has front facing panels supported on a narrow footing or compacted granular levelling pad founded at a shallow depth below the ground surface in front of the wall. The levelling pad should consist of compacted Granular A material soils meeting the requirements set out in OPSS.PROV 1010 (*Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material*), that is placed and compacted in accordance with the requirements of OPSS.PROV 501 (*Construction Specification for Compacting*), and should extend at least 0.5 m beyond the outside edge of the facing panels, then outward/downward at 1 horizontal to 1 vertical (1H:1V).

The facing panels/levelling pad and the reinforced soil mass should be founded below any existing topsoil or existing firm/stiff fill soils. Based on the borehole information, the following founding elevations are recommended:



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| Retaining Structure | Section of Retaining Wall and Corresponding Borehole | Maximum (Highest) Founding Elevation (m) | Founding Stratum | Approximate Excavation Depth Relative to Existing Ground Surface (m) |
|------------------------|--|--|--|--|
| West Side of Highway 6 | South of Single Culvert BC-1 | 215.7 | Requires Subexcavation (Found on compacted granular) | 2.3 |
| | Between Single and Twin Culvert OS-4 | 217.4 | Bedrock | 0.6 |
| | North of Twin Culvert BC-3A | 216.4 | Bedrock | 0.3 |
| East Side of Highway 6 | South of Single Culvert BC-5 | 217.3 | Clayey Silt Till | 0.7 |
| | Between Single and Twin Culvert BC-5, BC-6A | 217.5 | Clayey Silt Till | 0.7 |
| | North of Twin Culvert BC-6A | 217.8 | Clayey Silt Till | 0.7 |

For this site, RSS walls should be designed for high performance and appearance in accordance with MTO Special Provision (SP) 599S22.

The estimated settlement under the placement of 2.5 m to 4 m of new fill behind the retaining wall will be less than 10 mm.

6.3.2.2 Geotechnical Resistance

For the RSS facing panels supported on a compacted granular pad, the wall design may be completed based on a factored geotechnical resistance at ULS of 200 kPa and a geotechnical reaction at SLS (for 25 mm of settlement) of 150 kPa.

The height of the RSS wall may vary from about 2.8 m to 4 m depending on the final ground surface in front of the RSS wall; therefore, the reinforced width (taken as 0.8 times the wall height for design) will vary from about 1.7 m to about 3.2 m. Assuming that the RSS wall acts as a unit and uses the full width of the reinforced soil mass, a factored geotechnical resistance at ULS of 250 kPa may be used for design of the reinforced soil mass founded on the properly prepared compacted granular material or clayey silt till, as discussed above. Considering the bedrock surface is at shallow depth below the RSS, the condition for 25 mm of settlement at SLS will not be reached at this site, and therefore the ULS case governs.

6.3.2.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the compacted fill of the RSS wall and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The coefficient of friction, $\tan \phi'$, between the compacted granular fill of the RSS wall and the properly prepared native subgrade may be taken as 0.6. The coefficient of friction, $\tan \phi'$, between the compacted granular fill of the RSS wall and the properly prepared dolostone bedrock may be taken as 0.7. The actual values used should be reviewed and revised, if necessary, by the proprietary RSS wall designer during detail design.



6.3.2.4 Global Stability

As discussed in Section 6.3.1.4, a minimum factor of safety of 1.5 is considered appropriate for the proposed RSS wall on this site, considering the design requirements and the available field and laboratory testing data.

As the width of the reinforced soil mass is about the same as that for a footing for the concrete retaining wall, the Factor of Safety against global slope instability for the reinforced soil mass would be similar to that of the concrete retaining wall. Therefore, the results of the global slope stability analyses for the concrete wall as provided on Figure 2 are applicable for the reinforced soil mass, and the results indicates that a minimum factor of safety of 1.5 is achieved.

It should be noted that the internal stability of a reinforced earth structure is to be designed and assessed by the proprietary product designer.

6.3.3 Soldier Pile and Concrete Panel Wall

A soldier pile and concrete panel wall could be adopted at this site, and would minimize excavation into the existing Highway 6 embankment as compared with a concrete retaining wall or RSS wall option. Coring of the sockets in the dolostone bedrock for placement of the permanent soldier piles would be required, although this option may eliminate the need temporary roadway protection along Highway 6 (which would also likely require bedrock coring to socket temporary soldier piles) for the concrete retaining wall and RSS wall option.

This wall system would consist of soldier piles socketed to sufficient depth to provide the necessary passive resistance for the maximum retained soil height. Additional lateral support to the soldier pile and concrete panel wall system could be provided in the form of permanent soil anchors located at strategic locations along the retaining wall, where required for higher wall sections.

The concrete panels should be installed such that the unsupported height does not exceed 1.2 m at any time, and the space behind the concrete panels should be immediately packed with granular material to aid in achieving proper drainage. If sufficient thickness of free-draining granular soil is not provided behind the concrete panels to provide adequate drainage and frost protection, consideration should be given to using a drainage sheet. An insulation layer could also be provided immediately behind the wall to enhance frost protection.

6.3.3.1 Passive Resistance for Soldier Pile Sockets

If soldier pile and concrete panel walls are adopted at this site, the resistance to lateral loading would have to be developed by socketing into the bedrock, as the overburden soils are relatively shallow (i.e., bedrock is typically present within the depth of frost penetration, and so the passive resistance provided by the overburden soils would be neglected in design).

A factored lateral geotechnical resistance at Ultimate Limit States (ULS) of 10 MN per metre length of socket may be used in design of the rock sockets for soldier piles. This assumes a nominal rock socket diameter of 0.5 m for a 310x110 soldier pile.

6.3.3.2 Permanent Rock Anchors

For a proposed wall height of up to 4 m, it is anticipated that lateral support will be required in the higher wall sections. Because the existing fill material is not considered suitable for soil anchors and given the relatively shallow depth to bedrock at this site, it is recommended that rock anchors be installed. Rock anchor support can be designed to accommodate the loads applied from lateral earth pressures and surcharge pressures from area,



line or point loads and take into account any sloping ground behind the retaining wall system. The rock anchors may be sized based on the following unfactored bond stress acting between the grout and dolostone bedrock:

| Bedrock | Estimated Ultimate Load Transfer |
|-----------|----------------------------------|
| Dolostone | 1,400 kPa |

The sustained working load should not be greater than 60 per cent of the ultimate tensile strength of the anchor tendons or bars. The fixed length (bond zone) of the anchors should be maintained behind a line drawn upward at 45 degrees from the base of the piles. The permanent rock anchors should be provided with suitable corrosion protection.

Anchor installation, grouting and testing should be carried out in accordance with OPSS 942 (*Construction Specification for Pre-Stressed Soil and Rock Anchors*).

6.3.4 Reinforced Earth Slopes

It is understood that property limits and space requirements for the proposed access road and carpool lot do not allow for a conventional 2H:1V slope between the proposed access road and carpool lot. A steeper reinforced earth slope could be considered if there is sufficient space, with slopes oriented at 1.5 or 1 horizontal to 1 vertical (1.5H:1V or 1H:1V). This option could be less expensive than a vertical retaining structure solution if space permits, and it would likely reduce the requirements for a temporary protection system (with socketing of soldier piles into the dolostone bedrock) as compared with vertical wall options.

Vegetation cover should be established on the slope face to protect against surficial erosion, as per OPSS 572 (*Seeding and Cover*). Appropriate treatment of the steepened slope face will be required to allow vegetation to become established and to maintain the vegetation cover. It is recommended that a concrete curb be used along Highway 6 or that an interceptor ditch be constructed along the crest of the slope to minimize surface water flow over the crest and slope face, and to reduce surface erosion potential.

6.3.5 Settlement

Depending on construction staging requirements, the existing Highway 6 could be widened by up to 9.2 m at the culvert and retaining wall locations, which would require placement of a vertical thickness of up to approximately 2.5 m to 4 m of additional fill atop the existing embankment side slopes.

The settlement analysis for culvert and retaining wall locations was carried out using hand calculations and elastic deformation moduli as given in the table below, based on correlations with the Atterberg limits and SPT 'N' values and engineering judgement from experience with similar soils in this region of Ontario.

| Soil Deposit | Bulk Unit Weight | Elastic Modulus | Estimated Deformation Properties |
|---|----------------------|-----------------|---|
| Embankment fill (new) | 21 kN/m ³ | – | – |
| Compact to dense silty sand to sand and gravel fill | 19 kN/m ³ | 20 MPa | -- |
| Firm to stiff clayey silt fill | 20 kN/m ³ | -- | $m_v = 1 \times 10^{-4} \text{ kPa}^{-1}$ |
| Very stiff to hard clayey silt to silt clay (till) | 21 kN/m ³ | 50 MPa | -- |



The settlement of the foundation soils under the approximately 4 m thickness of additional fill that may be placed on the embankment side slope is estimated to be less than 10 mm to 15 mm under the actual widening area, decreasing to less than 10 mm under the shoulder of the existing embankment and at the toe of the widened embankment.

6.4 Lateral Earth Pressures for Design

6.4.1 Static Considerations

The lateral earth pressures acting on the culvert walls and on associated retaining walls and headwalls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of the 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 and retaining walls at this site. These design recommendations and parameters assume level backfill and ground surface behind the walls.

- Select, free-draining granular fill meeting the specifications of OPSS.PROV 1010 Granular A or Granular B Type II (but with less than 5 percent passing the 200 sieve) should be used as backfill behind the walls.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with *CHBDC* Section 6.9.3 and Figure 6.6. Other surcharge loadings should be accounted for in the design as required.
- The granular fill may be placed either in a zone with the width equal to at least 1.2 m behind the back of the walls (see Case A in Figure C6.20(a) of the *Commentary* to the *CHBDC*), or 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 (see Case B in Figure C6.20(b) of the *Commentary* to the *CHBDC*).
- For Case A, the pressures are based on the existing embankment fill materials and the existing overburden soils and the following parameters or coefficients may be used:

| | Existing Fill |
|--|----------------------|
| Soil unit weight: | 20 kN/m ³ |
| Coefficients of static lateral earth pressure: | |
| Active, K_a | 0.33 |
| At rest, K_o | 0.50 |

- For Case B, where the pressures are based on OPSS.PROV 1010 Granular A or Granular B Type II fill behind the wall, the following parameters or coefficients may be assumed:

| | Granular A | Granular B Type II |
|---|----------------------|----------------------|
| Soil unit weight | 22 kN/m ³ | 21 kN/m ³ |
| Coefficients of static lateral earth pressure | | |
| Active, K_a | 0.27 | 0.27 |
| At rest, K_o | 0.43 | 0.43 |



Where the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for the geotechnical design. Where the wall support allows lateral yielding of the stem, active earth pressures should be used in the geotechnical design of the wall structure(s). The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the *Commentary* to the CHBDC.

6.4.2 Seismic Considerations

For seismic design purposes, the Site Coefficient (S) for this site may be taken as 1.0, consistent with Soil Profile Type I. The soil profile is based on the guidelines in Section 4.4.6 and Table 4.4 of the CHBDC (2006). According to Table A3.1.1 of the CHBDC, this site is located in Seismic Zone 1.

The site-specific zonal acceleration ratio for the City of Hamilton is 0.05. Based on the subsurface conditions at this site, and the Site Coefficient, ($S = 1.0$ for Soil Profile I from Table 4.4 of CHBDC), the peak horizontal ground acceleration (PHA) is equal to 0.05g at the ground surface and a design seismic coefficient value of 0.025g (50% of the PGA). Based on Section 4.4.4 of the CHBDC, this bridge structure is assigned Seismic Performance Zone 1. Given this, and in accordance with Section 4.4.5.1 of the CHBDC, no seismic analysis is required for structures located in Seismic Performance Zone 1.

6.5 Construction Considerations

6.5.1 Excavation and Temporary Protection Systems

The foundation excavations for culvert extensions, retaining wall strip footings and RSS walls would extend through the existing fill and into or through the stiff to hard clayey silt till, potentially reaching the bedrock. If space permits, open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities. Existing firm to stiff fill soils would be classified as Type 3 soil, according to the OHSA, while the very stiff to hard clayey silt till would be classified as a Type 2 material. Temporary excavations (i.e. those that are open for a relatively short time period) should be made with side slopes no steeper than 1H:1V.

It is expected that temporary protection systems will be required along the existing Highway 6 embankments during construction of the new retaining walls. These protection systems should be designed and constructed in accordance with OPSS 539 (*Construction Specification for Temporary Protection Systems*). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

Based on the geometry at the site and the anticipated excavation requirements, the protection system will be required to retain a maximum height of up to approximately 5 m. Although the selection and design of the protection system will be the responsibility of the Contractor, it is considered that a soldier pile and timber lagging system or a driven, interlocking sheetpile system could be adopted for the roadway protection at this site. However, a soldier pile and lagging system would likely require the formation of soldier pile sockets within the strong dolostone bedrock, which is a disadvantage to this type of protection system at this site. Driven sheetpiling would require some means of fixing the sheetpile toes at the bedrock surface to attain the necessary lateral restraint; in addition, it is noted that cobbles and boulders are present in the fill and till deposit at the site, and some sheetpile sections may encounter refusal during driving. The Contractor should be alerted to the presence of cobble and boulder size material within the rock fill or granular fill and the presence of cobbles and boulders within the native cohesionless soils; a Non-Standard Special Provision (NSSP) to be included in the



Contract is presented in Appendix C. Lateral support to the sheetpiles or soldier piles could be provided in the form of rakers or temporary anchors.

If the traffic staging on Highway 6 can be adjusted during construction to provide a wide temporary working zone, it may be possible to place the protection system line at sufficient distance behind the back of the retaining wall footings or RSS wall reinforcing zone, such that a zone of soil remains following excavation to provide lateral restraint to the toe of the soldier piles or sheetpile walls, thus minimizing or eliminating the need for the protection system to penetrate into bedrock. Alternatively, the Contractor may investigate the possible use of proprietary reinforced soil systems installed “top-down” as a temporary protection system measure,

6.5.2 Groundwater Control

The excavations for the proposed retaining structure are expected to be maintained at or above the groundwater level at the site. However, some seepage may be encountered from granular fill materials “perched” on top of the less permeable clayey silt fill or clayey silt till deposit. The water seepage volume is expected to be relatively small, such that the water inflow can be handled by pumping from filtered sumps placed at the base of the excavation. A Permit to Take Water (PTTW) is not anticipated to be required for the temporary groundwater control at this site.

6.5.3 Subgrade Preparation / Protection

Where foundations will be placed on soil or compacted granular fill rather than bedrock, the subgrade soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade. This requirement can be addressed with a note on the General Arrangement drawing and/or with an NSSP. An NSSP is included in Appendix C for inclusion in the Contract Documents.

Where footings for open footing culvert extensions or retaining walls are founded on the bedrock, the surface of the bedrock is expected to contain some irregularities and could be variable. Consideration could be given to placing a concrete working slab for the purpose of levelling the bedrock surface prior to forming and pouring the footings. Alternatively, the footings may be founded and poured directly on the bedrock surface.

6.5.4 Embankment Widening

Based on the borehole results, approximately 100 mm to 300 mm of topsoil was encountered immediately below the ground surface. It is recommended that all surficial topsoil and/or organic matter be removed from within the footprint of the Highway 6 embankment widening to minimize settlement and improve the long-term performance of the widened highway. In these areas, the exposed subgrade soils should be proof-rolled prior to fill placement, and the new fill should be placed in accordance with OPSS.PROV 206 (*Grading*).

Benching of the existing embankment side slopes should be carried out to “key in” the new fill materials, in accordance with OPSD 208.010 (*Benching of Earth Slopes*). The use of granular fill for construction of the widened embankments is recommended, as the majority of settlement of granular fills would occur during construction; however, suitable earth fill may also be used recognizing that some minor settlement of cohesive fills, if used, could occur post-construction.

Where the new fill placement is constructed of rock fill (from the escarpment rock cuts), placement of rock fill material should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (*Grading*) and SP 206SF04 (*Rock Excavation, Grading*). The rock fill should be carefully placed and compacted (not



dumped), and blading, dozing and 'chinking' of the rock to form a dense, compact mass will be required to minimize voids and bridging.

6.5.5 Vibration Monitoring During Soldier Pile Installation

Commercial and residential structures are present in the vicinity of the proposed Borer's Creek culvert extension and retaining walls. The closest structure is a commercial development located approximately 50 m to the southwest of the site. Depending on the vibration tolerance of the buried utilities and structures, vibration monitoring may be warranted during advancement of rock sockets for temporary protection systems or for a soldier pile and concrete panel wall option, to ensure that the vibration levels at the adjacent utilities/structures are maintained below tolerable levels. A maximum peak particle velocity (PPV) of 50 mm/s is generally considered applicable for commercial structures, but this requires further assessment by the structural engineer. It is considered that vibrations induced by conventional construction activities such as coring/churn drilling, or hoe-ramming will not reach this threshold level; however, the monitoring of vibrations during construction should be considered to defend against potential damage claims by the owners of the nearby utilities/structures.

In the event that vibration monitoring is determined to be necessary, an example NSSP for such monitoring is provided in Appendix C for inclusion in the Contract Documents.



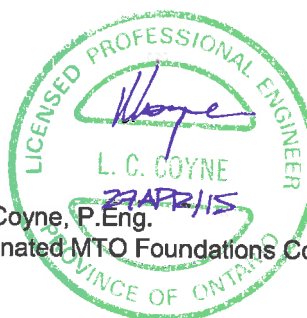
7.0 CLOSURE

This report was prepared by Ms. Sandra McGaghran, P. Eng., a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P. Eng., a Designated MTO Foundations Contact and Principal with Golder, conducted a technical and quality control review of the report.

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ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

ASTM D7012 Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Commercial Software

Slide (Version 6.0) by Rocscience Inc.

Settle^{3D} (Version 2.0) by Rocscience Inc.

Ontario Provincial Standard Specifications

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS 539 Construction Specification for Temporary Protection Systems



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OPSS 902 Construction Specification for Excavating and Backfilling Structures
Construction Specification for Pre-Stressed Soil and Rock Anchors OPSS 942

OPSS.PROV 1002 Material Specification for Aggregates - Concrete

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill
Material

OPSS 1205 Material Specification for Clay Seal

Ontario Provincial Standard Drawings

OPSD 208.010 Benching of Earth Slopes

OPSD 803.010 Backfill and Cover for Concrete Culverts

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

OPSD 3090.101 Foundation Frost Depths for Southern Ontario

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

SP 422S01 Precast Box Concrete Culvert

SP 599S22 Retained Soil System

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ministry of Transportation Ontario:

Ministry of Transportation Engineering Standards Branch. RSS Design Guidelines. September 2008



TABLES



FOUNDATION REPORT - BORER'S CREEK CULVERT EXTENSIONS AND RETAINING WALLS, HIGHWAY 5/6 INTERCHANGE, GWP 2112-05-00

Table 1: Comparison Of Foundation Alternatives For Culvert Extensions

| Option | Advantages | Disadvantages | Risks/Consequences |
|--------------------------------|--|---|---|
| Box culvert extension | <ul style="list-style-type: none">■ Minimizes depth of excavation, excavation support and dewatering requirements compared to open footing option.■ Pre-cast box sections expected to allow faster construction than cast-in-place open footings, with shorter duration for dewatering and surface water pumping, and shorter-term impacts on traffic staging on Highway 6. | <ul style="list-style-type: none">■ Where excavation extends below the groundwater level, some (limited) dewatering would still be required. | <ul style="list-style-type: none">■ Some risk of disturbance of the sensitive silty clay to clayey silt subgrade, and loose granular materials during construction. |
| Open footing culvert extension | <ul style="list-style-type: none">■ May be feasible to build culvert replacement on pre-cast footing sections, to accelerate construction schedule and reduce time for dewatering and surface water pumping, as well as impacts on traffic staging on Highway 6 | <ul style="list-style-type: none">■ Excavation depths are greater than for box culvert option, resulting in increased excavation support.■ Cast-in-place footings may require a longer duration for construction, as compared with pre-cast culvert segments or footing elements | <ul style="list-style-type: none">■ Some risk of disturbance of the sensitive silty clay to clayey silt subgrade, and loose granular materials during construction |

Prepared by: SMM Reviewed by: LCC



Table 2 – Comparison of Feasible Retaining Structure Alternatives

| Foundation Option | Feasibility | Advantages | Disadvantages | Relative Costs |
|---|---|---|--|---|
| Reinforced soil system (RSS) wall | Feasible, although a temporary protection system would be required to allow excavation through the existing Highway 6 embankment to construct the reinforced zone | <ul style="list-style-type: none">• Shallower excavation as compared with concrete retaining wall option• Relatively faster construction time as compared with concrete retaining wall, and thus lesser impact on traffic staging on Highway 6• More tolerance to post-construction settlement, although such settlement will be relatively small | <ul style="list-style-type: none">• Larger excavation area required than for soldier pile and concrete panel wall (similar to excavation area required for concrete retaining wall)• Will require excavation through the existing Highway 6 embankment; a temporary protection system is expected to be required, and this could involve soldier piles requiring sockets into the strong bedrock, although alternate protection system schemes may be available depending on traffic staging on Highway 6 | <ul style="list-style-type: none">• Lower cost than concrete retaining wall |
| Reinforced earth slope (if sufficient space is available) | Feasible provided sufficient space is available for 1.5H:1V or 1H:1V | <ul style="list-style-type: none">• Relative ease of construction but proprietary product required, with specialized design of internal stability of proprietary system• Vegetated surface could be used to improve aesthetics | <ul style="list-style-type: none">• Special treatment of reinforced earth slope surfaces likely required to allow vegetation to grow and minimize erosion• May not fit the geometric requirements for the widening (i.e., a vertical wall may be required) | <ul style="list-style-type: none">• Lower cost than RSS wall |



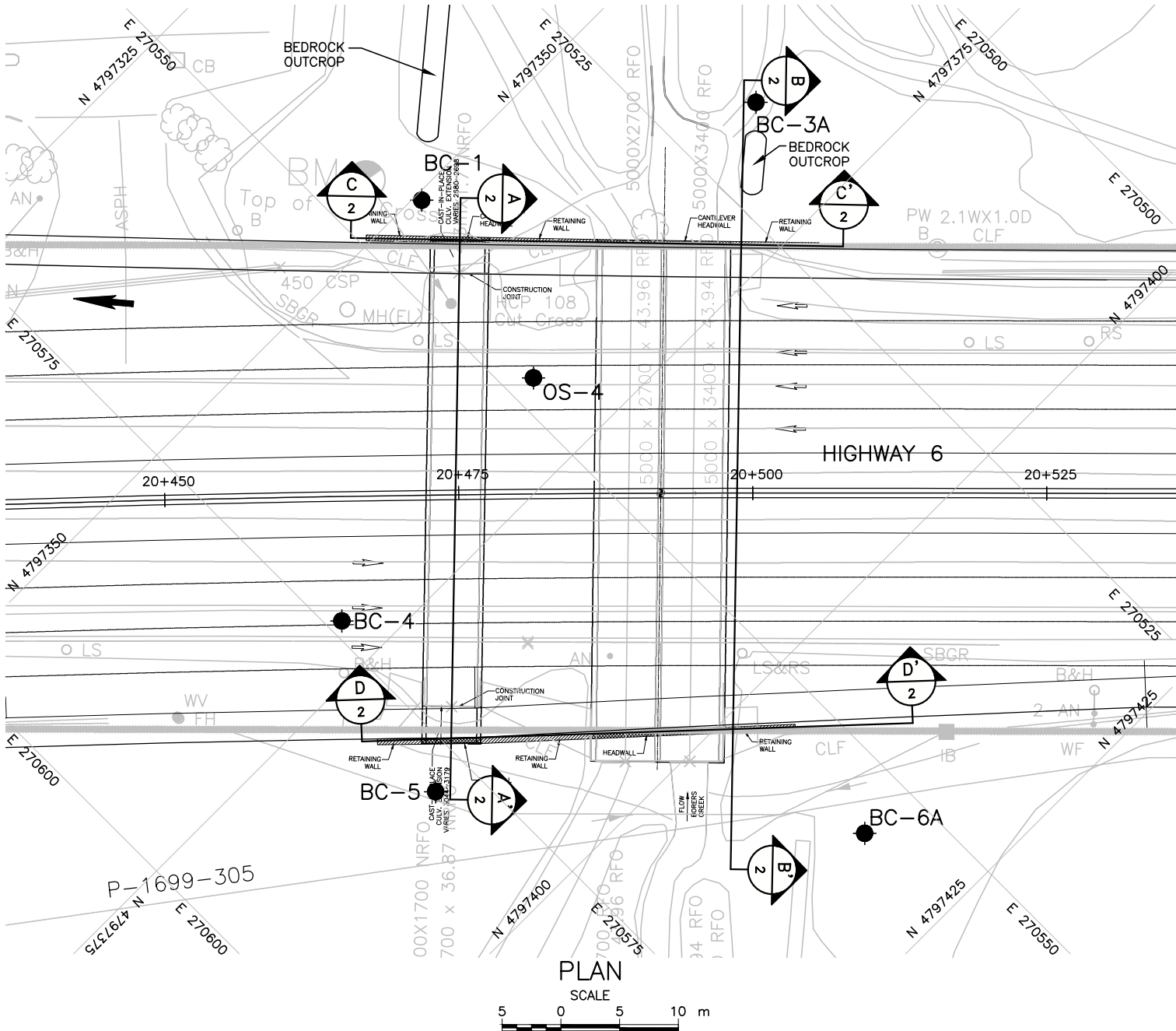
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| Foundation Option | Feasibility | Advantages | Disadvantages | Relative Costs |
|--|---|--|---|--|
| Soldier pile and concrete panel wall | Feasible, and could eliminate temporary protection system requirements | <ul style="list-style-type: none"> • Most advantageous in “top-down” construction applications, such as cut sections, which is not the case at this site • At this site, would minimize temporary excavation support requirements through the existing Highway 6 embankment (i.e., this type of wall could be installed without prior excavation, then additional fill placed behind the proposed wall to achieve the highway widening) • Minimize subexcavation requirements • Soldier piles could be installed from the toe of the existing embankment as opposed to construction equipment at the highway level | <ul style="list-style-type: none"> • Rock anchors required to extend under highway embankment on each side of the highway • May not meet desired aesthetic requirements • Soldier piles would require socket formation in strong dolostone bedrock (this may be required for temporary protection systems with other retaining wall types; however, alternate protection systems may be considered as well) • Risk of ground loss during Installation of rock anchors beneath existing highway embankment | <ul style="list-style-type: none"> • Comparable costs to concrete retaining wall, but higher than RSS wall; however the cost to core socket holes into the strong dolostone to allow for installation the soldier piles may be more costly than protection system schemes for other options |
| Concrete retaining wall on shallow foundations | Feasible, although a temporary protection system will be required to allow excavation through the existing Highway 6 embankment | <ul style="list-style-type: none"> • Conventional excavation and construction techniques • Excellent settlement performance on dolostone bedrock or compacted granular fill | <ul style="list-style-type: none"> • Deeper excavation required than for RSS wall; larger excavation area required than for soldier pile and concrete panel wall • Will require excavation through the existing Highway 6 embankment; a temporary protection system is expected to be required, and this could involve soldier piles requiring sockets into the strong bedrock, although alternate protection system schemes may be available depending on traffic staging on Highway 6 | <ul style="list-style-type: none"> • Higher cost relative to RSS wall |

Prepared by: SMM Reviewed by: LCC



DRAWINGS

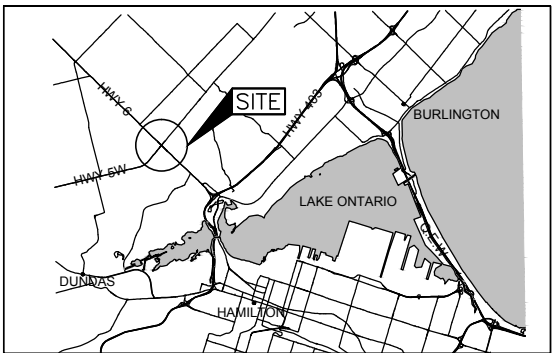


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
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CONT No. .
GWP No. 2112-05-00



HIGHWAY 5 OVER HIGHWAY 6
BORER'S CREEK CULVERT EXTENSIONS AND
RETAINING WALLS
BOREHOLE LOCATIONS



KEY PLAN
SCALE 3 0 3 6 km

LEGEND

● Borehole - Current Investigation

| BOREHOLE CO-ORDINATES | | | |
|-----------------------|-----------|-----------|----------|
| No. | ELEVATION | NORTHING | EASTING |
| BC-1 | 218.0 | 4797350.6 | 270543.7 |
| BC-3A | 216.7 | 4797364.8 | 270517.8 |
| BC-4 | 220.7 | 4797371.1 | 270573.8 |
| BC-5 | 218.0 | 4797387.0 | 270578.4 |
| BC-6A | 218.5 | 4797415.3 | 270555.1 |
| OS-4 | 220.5 | 4797368.0 | 270547.7 |

NOTES

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

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

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

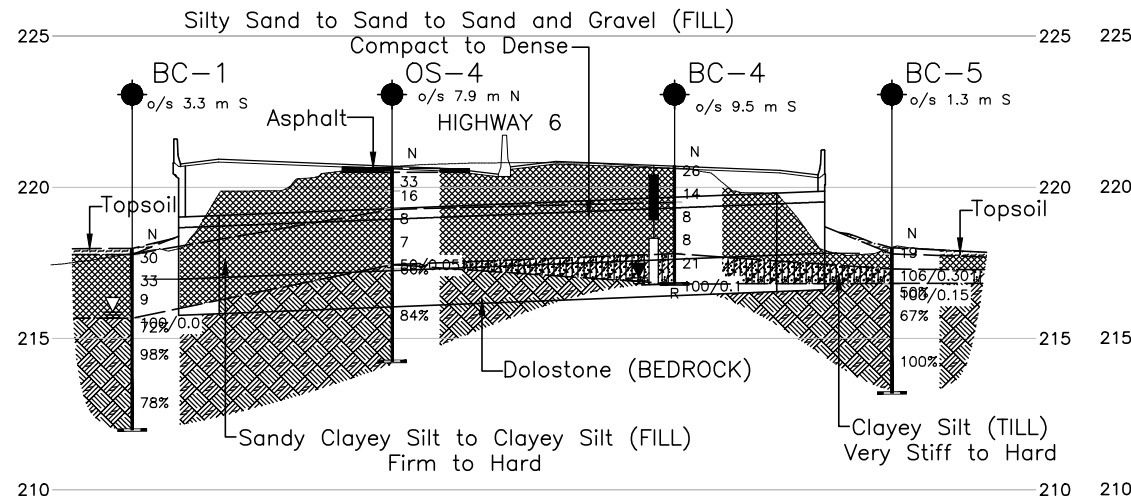
REFERENCE

Base plans provided in digital format by IBI, drawing file nos. 21_br_hwy5_6_culv_ga.dwg, T5&6-MPM-5lane-New STA.dwg and hwy6_5-SWM-2-New.dwg, received January 16, 2015.

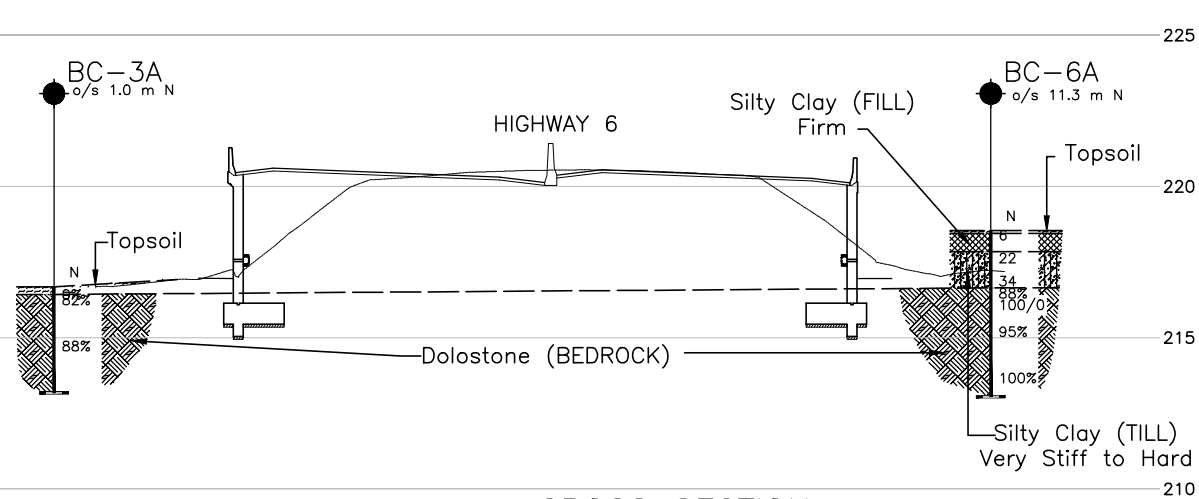


| NO. | DATE | BY | REVISION |
|----------------------|-----------|--------------------------|----------|
| | | | |
| Geocres No. 30M5-311 | | | |
| HWY. 5 & 6 | | PROJECT NO. 10-1184-0016 | DIST. . |
| SUBM'D. AJS | CHKD. SMM | DATE: 1/28/2015 | SITE: . |
| DRAWN: JFC | CHKD. SMM | APPD. LCC | DWG. 1 |

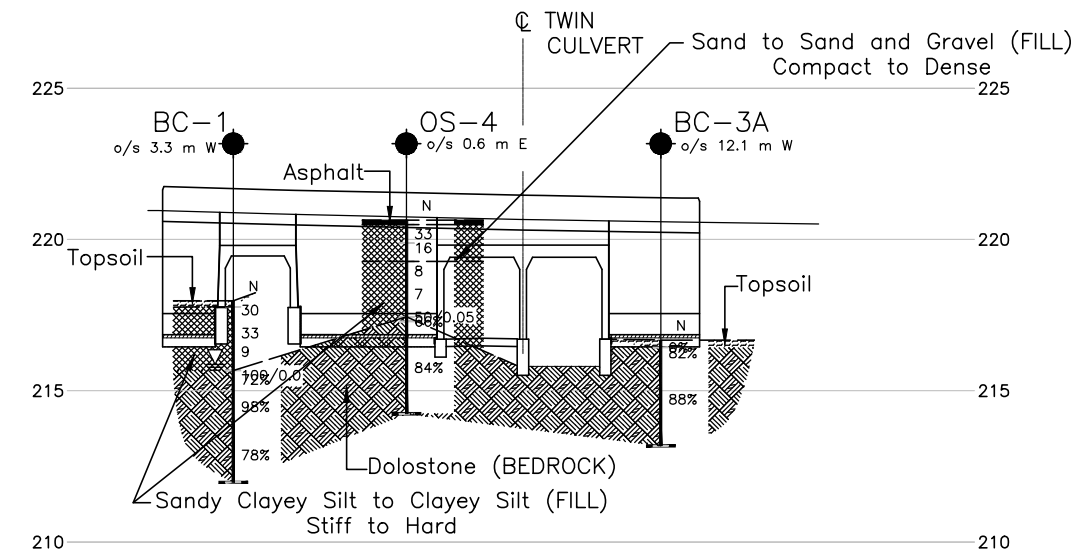
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.



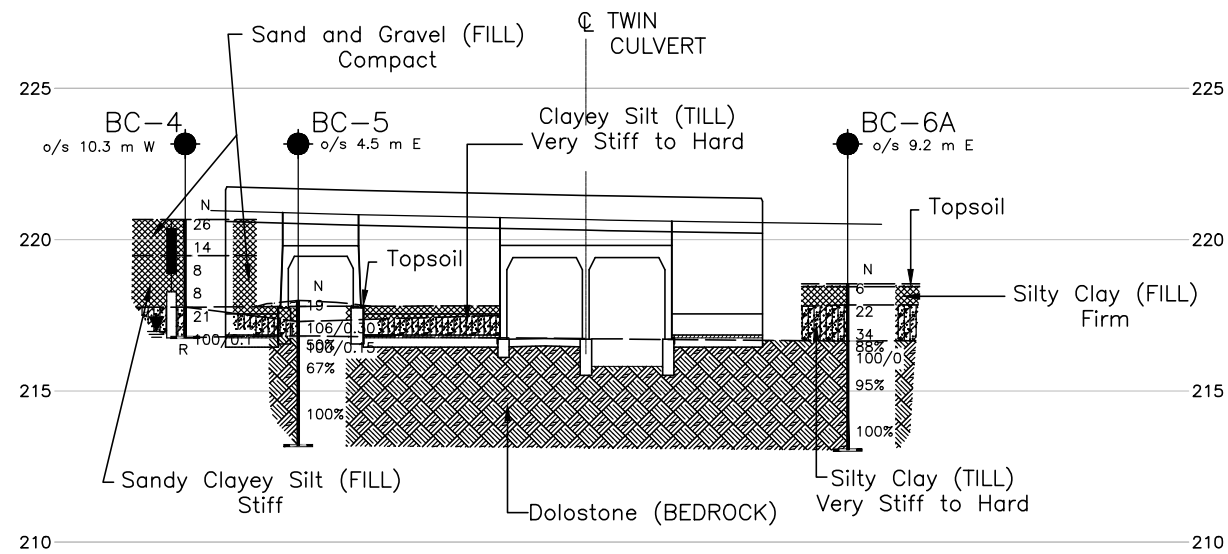
PROFILE
CULVERT AT STATION 20+475
HIGHWAY 6



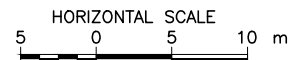
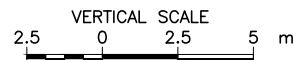
CROSS SECTION
EAST AND WEST RETAINING WALL
HIGHWAY 6



PROFILE - WEST RETAINING WALL
HIGHWAY 6



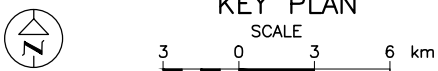
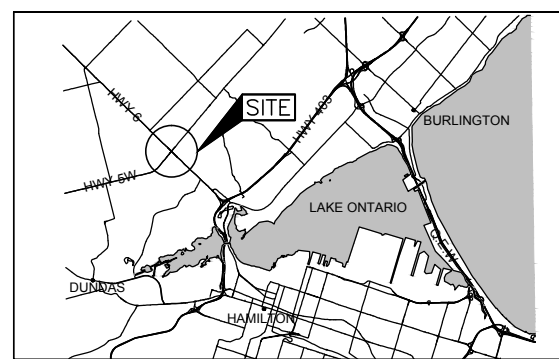
PROFILE - EAST RETAINING WALL
HIGHWAY 6



CONT No.
GWP No. 2112-05-00

HIGHWAY 5 OVER HIGHWAY 6
BORER'S CREEK CULVERT EXTENSIONS AND
RETAINING WALLS
SOIL STRATA

SHEET



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer, measured on November, 27, 2010
- WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

| No. | ELEVATION | NORTHING | EASTING |
|-------|-----------|-----------|----------|
| BC-1 | 218.0 | 4797350.6 | 270543.7 |
| BC-3A | 216.7 | 4797364.8 | 270517.8 |
| BC-4 | 220.7 | 4797371.1 | 270573.8 |
| BC-5 | 218.0 | 4797387.0 | 270578.4 |
| BC-6A | 218.5 | 4797415.3 | 270555.1 |
| OS-4 | 220.6 | 4797370.8 | 270547.7 |

NOTES

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REFERENCE

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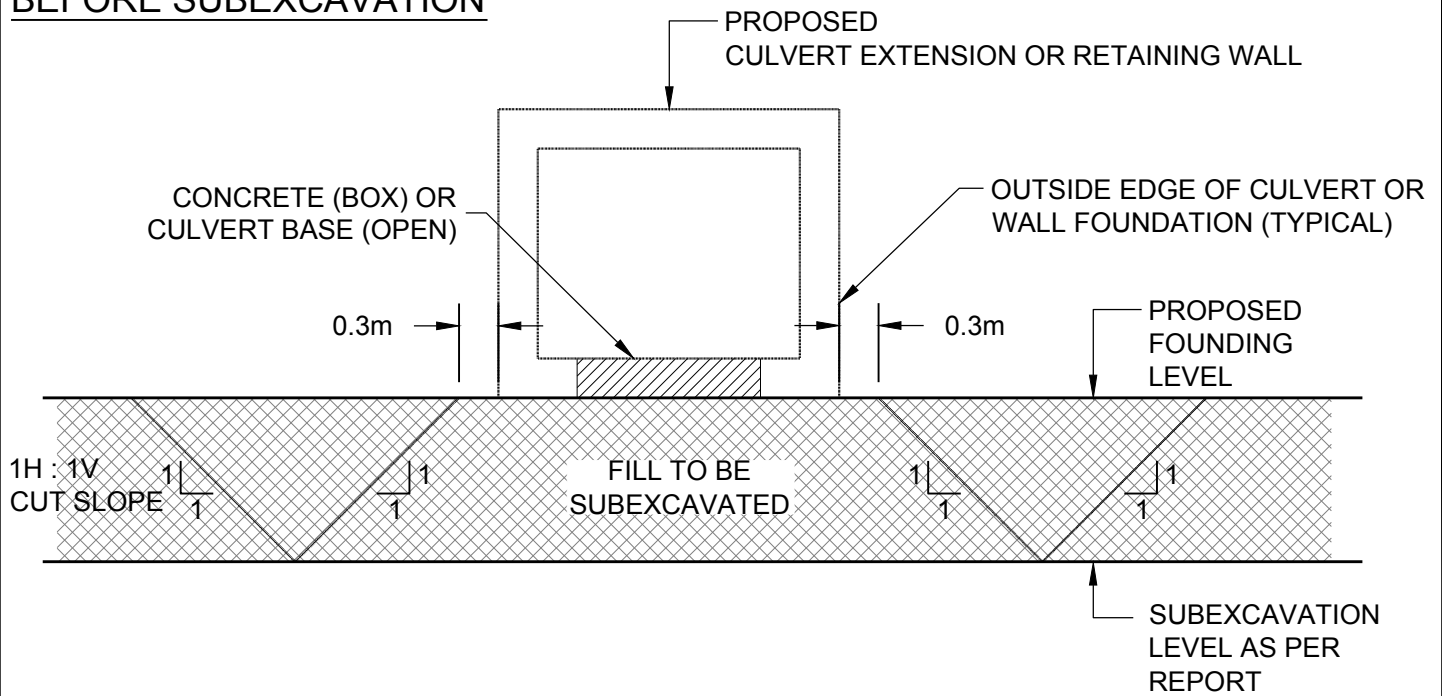


| NO. | DATE | BY | REVISION |
|-----|-----------|-----|--------------------------|
| 1 | 1/27/2015 | JFC | PROJECT NO. 10-1184-0016 |
| 2 | 1/27/2015 | JFC | DATE: 1/27/2015 |
| 3 | 1/27/2015 | JFC | APPD. LCC |
| 4 | 1/27/2015 | JFC | DWG. 2 |

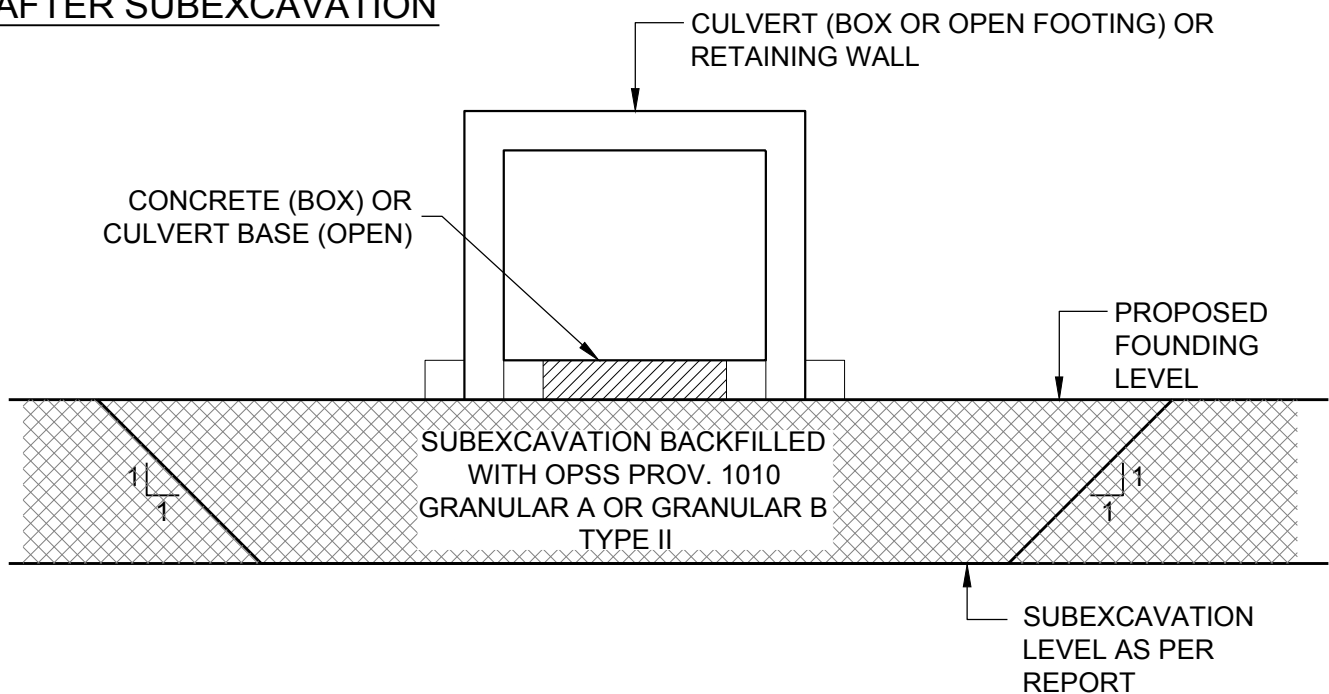


FIGURES

BEFORE SUBEXCAVATION



AFTER SUBEXCAVATION



CLIENT
IBI GROUP

CONSULTANT



| | |
|------------|------------|
| YYYY-MM-DD | 2015-02-25 |
| PREPARED | JFC |
| DESIGN | SMM |
| REVIEW | SMM |
| APPROVED | LCC |

PROJECT
BORER'S CREEK CULVERT EXTENSION AND RETAINING WALL
HIGHWAY 5 & 6 WIDENING

TITLE
PROPOSED CULVERT EXTENSION AND RETAINING WALL
SUBEXCAVATION GEOMETRY

PROJECT No.
10-1184-0016

CONTROL
0001

Rev.
A

FIGURE
1

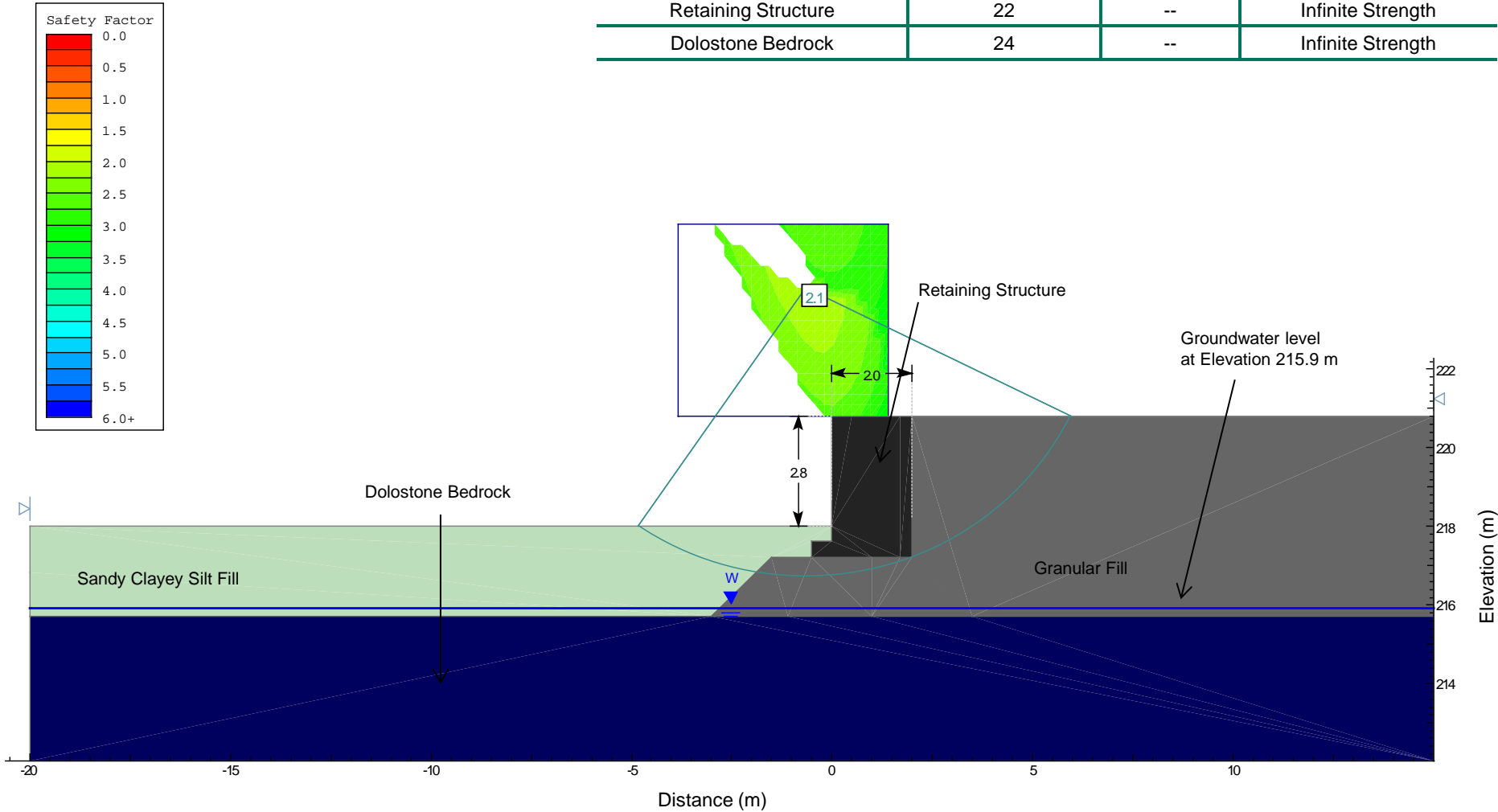


Retaining Structure - South of Single Cell Culvert, West side of Highway 6 - Global Stability Analysis

Figure 2

NOTE:
1. All dimensions are in metres.

| Material Name | Unit Weight (kN/m ³) | Cohesion (kPa) | Friction Angle (degrees) |
|------------------------|----------------------------------|----------------|--------------------------|
| Granular Fill | 20 | 0 | 30 |
| Sandy Clayey Silt Fill | 20 | 0 | 28 |
| Retaining Structure | 22 | -- | Infinite Strength |
| Dolostone Bedrock | 24 | -- | Infinite Strength |





APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

| | |
|-------------|---|
| C_c | compression index (normally consolidated range) |
| C_r | recompression index (over-consolidated range) |
| C_s | swelling index |
| C_α | secondary compression index |
| m_v | coefficient of volume change |
| C_v | coefficient of consolidation (vertical direction) |
| C_h | coefficient of consolidation (horizontal direction) |
| T_v | time factor (vertical direction) |
| U | degree of consolidation |
| σ'_p | pre-consolidation stress |
| OCR | over-consolidation ratio = σ'_p / σ'_{vo} |

(d) Shear Strength

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

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

| Per cent by Weight | Modifier | Example |
|--------------------|--|---|
| 0 to 5 | Trace | Trace sand |
| 5 to 12 | Trace to Some (or Little) | Trace to some sand |
| 12 to 20 | Some | Some sand |
| 20 to 30 | (ey) or (y) | Sandy |
| over 30 | And (non-cohesive (cohesionless)) or With (cohesive) | Sand and Gravel Silty Clay with sand / Clayey Silt with sand |



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No BC-1 | | SHEET 1 OF 1 | | METRIC | | | | | | | | | |
|--------------|---|-------------------|---------|----------------------------|------------|---|-----------------|--|----|----|----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|-------------------|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797350.6 ; E 270543.7 | | ORIGINATED BY | | | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 102 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | | | | | | | | |
| DATUM | | Geodetic | | DATE | | October 8, 2014 | | CHECKED BY | | | | | | | | | |
| | | | | | | | | SMM | | | | | | | | | |
| 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) | |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | WATER CONTENT (%) |
| 218.0 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.2 | Sandy clayey silt trace to some gravel, cobbles between 0.0 m and 0.6 m depth (FILL) Stiff to hard Brown Moist - Augers grinding between 0.0 m and 2.3 m | | 1A | SS | 30 | | | | | | | | | | | | |
| | | | 1B | SS | 30 | | | | | | | | | | | | |
| | | | 2 | SS | 33 | | | | | | | | | | | | |
| | | | 3 | SS | 9 | | | | | | | | | | | | |
| 215.7 | DOLOSTONE (BEDROCK) | | 4 | SS | 100/0.0 | | | | | | | | | | | | |
| 2.3 | Bedrock cored from depths of 2.6 m to 6.0 m For bedrock coring details, refer to Record of Drillhole BC-1. | | 1 | RC | REC 100% | | | | | | | | | | | | |
| | | | 2 | RC | REC 100% | | | | | | | | | | | | |
| | | | 3 | RC | REC 85% | | | | | | | | | | | | |
| 212.0 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| 6.0 | NOTE: 1. Spoon bouncing and auger refusal at a depth of 2.3 m below ground surface (Elev. 215.7 m). 2. Water level in open borehole measured at a depth of 2.1 m below ground surface (Elev. 215.9 m) upon completion of drilling and prior to rock coring. | | | | | | | | | | | | | | | | |

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA GDT 4/20/15 DD

[illegible]

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No BC-3A | | SHEET 1 OF 1 | | METRIC | | | | | | | | | |
|---------------|---|-------------------|---------|-----------------------------|------------|---|-----------------|---|----|----|----|-----|------------------------------------|-------------------------------------|-----------------------------------|---|--|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797364.8 ; E 270517.8 | | ORIGINATED BY | | | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 102 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | | | | | | | | |
| DATUM | | Geodetic | | DATE | | October 14, 2014 | | CHECKED BY | | | | | | | | | |
| | | | | | | | | SMM | | | | | | | | | |
| 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 | | | | | | | | | |
| 216.7 | GROUND SURFACE | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | TOPSOIL | | 1 | - | REC | | | | | | | | | | | | |
| 216.4 | | | 1 | RC | REC 100% | | | | | | | | | | | | |
| 0.3 | DOLOSTONE (BEDROCK) | | | | | | | | | | | | | | | | |
| | Bedrock cored from depths of 0.3 m to 3.5 m | | | | | | | | | | | | | | | | |
| | For bedrock coring details, refer to Record of Drillhole BC-3A. | | | | | | | | | | | | | | | | |
| | | | 2 | RC | REC 97% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 3 | RC | REC 92% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 213.2 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| 3.5 | NOTE: 1. Open borehole dry upon completion of drilling and prior to rock coring. | | | | | | | | | | | | | | | | |

PROJECT: 10-1184-0016

RECORD OF DRILLHOLE: BC-3A

SHEET 1 OF 1

LOCATION: N 4797364.81 ;E 270517.76

DRILLING DATE: October 14, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY | | | | | | | | | | | | | | | | FEATURES | PIEZOMETER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | TOTAL CORE % | SOLID CORE % | | | | TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | Continued from Record of Borehole BC-3A | | 216.43 0.25 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50



LOGGED: SP

CHECKED: SMM

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No BC-4 | | SHEET 1 OF 1 | | METRIC | | | | | | | | |
|--|--|-------------------|--------|----------------------------|-------------------------|---|--|--------------------|----|----|-----|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797371.1 ; E 270573.8 | | ORIGINATED BY | | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 102 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | | | | | | | |
| DATUM | | Geodetic | | DATE | | October 28, 2014 | | CHECKED BY | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV. DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | | | "N" VALUES | SHEAR STRENGTH kPa | | | | | | | | |
| 220.7 | GROUND SURFACE | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | Silty sand and gravel (FILL) Compact Brown Moist | | 1 | SS | 26 | | | | | | | | | | | |
| 219.5 | | | 2A | SS | 14 | | | | | | | | | | | |
| 1.2 | Sandy clayey silt, trace gravel (FILL) Stiff Grey-brown Moist | | 2B | | | | | | | | | | | | | |
| | | | 3 | SS | 8 | | | | | | | | | | | |
| | | | 4A | SS | 8 | | | | | | | | | | | |
| 217.8 | | | 4B | | | | | | | | | | | | | |
| 2.9 | CLAYEY SILT, trace to some sand, trace gravel (TILL) Very stiff Brown Moist | | 5 | SS | 21 | | | | | | | | | | | |
| 216.8 | | | 6A | SS | 100/0 | | | | | | | | | | | |
| 3.9 | END OF BOREHOLE AUGER AND SPOON REFUSAL INFERRED BEDROCK | | 6B | | | | | | | | | | | | | |
| NOTE: 1. Open borehole dry upon completion of drilling. 2. Water level readings in piezometer: Date Depth (m) Elev. (m) 11/02/14 3.7 217.0 | | | | | | | | | | | | | | | | |

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 4/20/15 DD

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No BC-5 | | SHEET 1 OF 1 | | METRIC | | | | | | | | | |
|--------------|---|-------------------|---------|----------------------------|------------|---|-----------------|--|--|-----|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797387.0 ; E 270578.4 | | ORIGINATED BY | | AJS | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 102 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | PKS | | | | | | | |
| DATUM | | Geodetic | | DATE | | October 10, 2014 | | CHECKED BY | | SMM | | | | | | | |
| 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | |
| 218.0 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.2 | Sand and gravel (FILL) | | 1 | SS | 19 | | | | | | | | | | | | |
| 217.3 | Compact Grey-brown Dry | | | | | | | | | | | | | | | | |
| 0.7 | | | 2A | SS | 106 | | | | | | | | | | | | |
| 216.8 | CLAYEY SILT, trace sand, trace gravel (TILL) | | | | | | | | | | | | | | | | |
| 1.2 | Hard Brown Moist | | 3 | SS | 100/0.15 | | | | | | | | | | | | |
| | DOLOSTONE (BEDROCK) | | 1 | RC | REC 100% | | | | | | | | | | | | RQD = 50% |
| | Bedrock cored from depths of 1.5 m to 4.8 m | | | | | | | | | | | | | | | | |
| | For bedrock coring details, refer to Record of Drillhole BC-5. | | 2 | RC | REC 85% | | | | | | | | | | | | RQD = 67% |
| | | | | | | | | | | | | | | | | | |
| | | | 3 | RC | REC 100% | | | | | | | | | | | | RQD = 100% |
| 213.2 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| 4.8 | NOTE: 1. Spoon bouncing and auger refusal at a depth of 1.4 m below ground surface (Elev. 216.6 m) 2. Open borehole dry upon completion of drilling and prior to rock coring. | | | | | | | | | | | | | | | | |

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 4/20/15 DD

PROJECT: 10-1184-0016

RECORD OF DRILLHOLE: BC-5

SHEET 1 OF 1

LOCATION: N 4797387.01 ;E 270578.44

DRILLING DATE: October 10, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY | | | | | | | | | | | | | | | | FEATURES | PIEZOMETER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | TOTAL CORE % | SOLID CORE % | | | | TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | W1 | W2 | | W3 | W4 | W5 | W6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 2 | NQRC NW Casing Rock Coring | Continued from Record of Borehole BC-5 | | 216.50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50



LOGGED: SP

CHECKED: SMM

GTA-RCK 046 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 4/20/15 DD

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No BC-6A | | SHEET 1 OF 1 | | METRIC | | | | | | | | | |
|--------------|--|-------------------|---------|-----------------------------|------------|---|-----------------|--|--|--|--|--|---------------------------------|-------------------------------|--------------------------------|------------------|---------------------------------------|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797415.3 ; E 270555.1 | | ORIGINATED BY | | | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 102 mm O.D. Continuous Flight Solid Stem Augers | | COMPILED BY | | | | | | | | | |
| DATUM | | Geodetic | | DATE | | October 9, 2014 | | CHECKED BY | | | | | | | | | |
| | | | | | | | | SMM | | | | | | | | | |
| 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | |
| 218.5 | GROUND SURFACE | | | | | | | | | | | | | | | | |
| 0.0 | TOPSOIL | | | | | | | | | | | | | | | | |
| 0.1 | Silty clay, some sand, trace gravel, containing rootlets (FILL) | | 1 | SS | 6 | | | | | | | | | | | | |
| 217.8 | Firm | | | | | | | | | | | | | | | | |
| 0.7 | Brown Moist | | 2 | SS | 22 | | | | | | | | | | | | |
| | SILTY CLAY, trace to some sand, trace gravel (TILL) | | | | | | | | | | | | | | | | |
| | Very stiff to hard | | | | | | | | | | | | | | | | |
| 216.6 | Brown Moist | | 3A | SS | 34 | | | | | | | | | | | | |
| 1.9 | DOLOSTONE (BEDROCK) | | 3B | | | | | | | | | | | | | | |
| | Bedrock cored from depths of 2.1 m to 5.5 m. | | 4 | SS | 100/0 | | | | | | | | | | | | |
| | For bedrock coring details, refer to Record of Drillhole BC-6A. | | 1 | RC | REC 100% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 2 | RC | REC 100% | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | 3 | RC | REC 100% | | | | | | | | | | | | |
| 213.0 | END OF BOREHOLE | | | | | | | | | | | | | | | | |
| 5.5 | NOTE: | | | | | | | | | | | | | | | | |
| | 1. Spoon bouncing and auger refusal at a depth of 2.3 m below ground surface (Elev. 216.2 m) | | | | | | | | | | | | | | | | |
| | 2. Open borehole dry upon completion of drilling. | | | | | | | | | | | | | | | | |

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 4/20/15 DD

PROJECT: 10-1184-0016

RECORD OF DRILLHOLE: BC-6A

SHEET 1 OF 1

LOCATION: N 4797415.29 ;E 270555.14

DRILLING DATE: October 9, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-55 Track

DRILLING CONTRACTOR: DBW Drilling

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | FLUSH RETURN | NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY | | | | | | | | | | | | | | FEATURES | PIEZOMETER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | RECOVERY | | R.Q.D. % | FRACT. INDEX PER 25 | DISCONTINUITY DATA | | | | | WEATH- ERING INDEX | | | | | | | Diametral Point Load Index (MPa) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | TOTAL CORE % | SOLID CORE % | | | TYPE AND SURFACE DESCRIPTION | Jr | Ja | Jn | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | Continued from Record of Borehole BC-6A | | 216.45 2.10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50



LOGGED: SP

CHECKED: SMM

GTA-RCK 046 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-MISS.GDT 4/20/15 DD

| PROJECT | | 10-1184-0016 | | RECORD OF BOREHOLE No OS-4 | | SHEET 1 OF 1 | | METRIC | | | | | | | | | | | | | |
|---------------|---|-------------------|---------|----------------------------|------------|---|-----------------|--|---|--|--|-------------|---|--|---------------------------------------|-------------------|--|--|-------------|--|--|
| G.W.P. | | 2112-05-00 | | LOCATION | | N 4797368.3 ; E 270547.7 | | ORIGINATED BY | | | | | | | | | | | | | |
| DIST | | Central HWY 5 & 6 | | BOREHOLE TYPE | | 150 mm O.D. Continuous Flight Solid Stem Augers and NQ Casing | | COMPILED BY | | | | | | | | | | | | | |
| DATUM | | Geodetic | | DATE | | September 3, 2013 | | CHECKED BY | | | | | | | | | | | | | |
| | | | | | | | | SMM | | | | | | | | | | | | | |
| 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 | | | GR SA SI CL | | |
| 220.5 | GROUND SURFACE | | | | | | | 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED | | | | | W _p W W _L 10 20 30 | | | kN/m ³ | | | | | |
| 0.0 | ASPHALT (150 mm) | | | | | | | | | | | | | | | | | | | | |
| 0.2 | Sand, trace to some gravel, trace silt (FILL) | | 1 | SS | 33 | | 220 | | | | | | | | | | | | | | |
| 219.7 | Dense Brown Moist | | 2 | SS | 16 | | | | | | | | | | | | | | 36 51 10 3 | | |
| 0.8 | Sand and gravel, trace to some silt, trace clay (FILL) | | | | | | | | | | | | | | | | | | | | |
| 219.1 | Compact Brown Moist | | 3 | SS | 8 | | 219 | | | | | | | | | | | | | | |
| 1.4 | Clayey silt, trace to some sand, trace gravel, trace organics, containing rootlets (FILL) | | | | | | | | | | | | | | | | | | | | |
| | Firm Mottled brown and grey Wet | | 4 | SS | 7 | | 218 | | | | | | | | | | | | | | |
| 217.3 | DOLOSTONE fragments Grey | | 5A | SS | 50/0.05 | | | | | | | | | | | | | | | | |
| | DOLOSTONE (BEDROCK) | | | | | | | | | | | | | | | | | | | | |
| 3.4 | Bedrock cored from depths of 3.4 m to 6.4 m. | | 1 | RC | REC 94% | | 217 | | | | | | | | | | | | RQD = 66% | | |
| | For bedrock coring details, refer to Record of Drillhole OS-4. | | | | | | | | | | | | | | | | | | | | |
| | | | 2 | RC | REC 100% | | 216 | | | | | | | | | | | | | | |
| | | | | | | | 215 | | | | | | | | | | | | RQD = 84% | | |
| 214.1 | END OF BOREHOLE | | | | | | | | | | | | | | | | | | | | |
| 6.4 | NOTES: | | | | | | | | | | | | | | | | | | | | |
| | 1. Split spoon bouncing and auger grinding at a depth of 3.2 m (Elev. 214.3 m). | | | | | | | | | | | | | | | | | | | | |
| | 2. Water level in open borehole not recorded as water was introduced for bedrock coring. | | | | | | | | | | | | | | | | | | | | |

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 4/20/15 DD

PROJECT: 10-1184-0016

RECORD OF DRILLHOLE: OS-4

SHEET 1 OF 1

LOCATION: N 4797368.33 ;E 270547.68

DRILLING DATE: September 3, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME-75 Truck-mounted

DRILLING CONTRACTOR: DBW Drilling

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY | | | | | | | | | | | | | | | | | | FEATURES | PIEZOMETER | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | TOTAL CORE % | SOLID CORE % | | | | TYPE AND SURFACE DESCRIPTION | | | Jr | Ja | Jn | W1 | W2 | W3 | W4 | W5 | W6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| | | Continued from Record of Borehole OS-4 | | 217.15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

DEPTH SCALE

1 : 50



LOGGED: JG/AV

CHECKED: SMM



APPENDIX B

Laboratory Test Results (Soil and Rock) and Bedrock Core Photographs

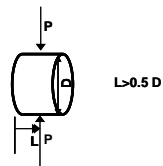
TABLE B1
POINT LOAD TEST RESULTS ON ROCK SAMPLES

| Borehole Number | Run Number | Sample Depth (m) | Sample Elevation (m) | Bedrock Description | Test Type | Is (50mm) (MPa) | Approx. UCS Value ⁽¹⁾ (MPa) |
|-----------------|------------|------------------|----------------------|---------------------|-----------|-----------------|--|
| BC-1 | 1 | 3.0 | 215.0 | Dolostone | Axial | 1.78 | 17.8 |
| BC-1 | 1 | 3.3 | 214.7 | Dolostone | Diametral | 4.91 | 49.1 |
| BC-5 | 2 | 2.7 | 215.3 | Dolostone | Diametral | 10.67 | 106.7 |
| BC-5 | 2 | 2.8 | 215.2 | Dolostone | Axial | 8.20 | 82.0 |
| OS-4 | 1 | 3.85 | 216.8 | Dolostone | Diametral | 17.30 | 173.0 |
| OS-4 | 1 | 3.93 | 216.7 | Dolostone | Axial | 16.04 | 160.4 |
| OS-4 | 2 | 4.98 | 215.6 | Dolostone | Axial | 3.46 | 34.6 |
| OS-4 | 2 | 5.33 | 215.3 | Dolostone | Diametral | 18.32 | 183.2 |

⁽¹⁾ $Is_{50} \times K$ (actual value could be confirmed by UCS testing) from ISRM. This range has been given based on $K = 10$, calculated from Is_{50} Average of 8 tests on Axial Orientations and UCS Average of 2 tests conducted from core samples obtained from the boreholes advanced at the Borer's Creek. Refer to "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int.J.Rock. Mech. Min.Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, PP 51-60.

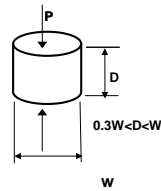
DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis (planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis



Compiled By: AJS
Checked By: SMM
Reviewed By: JMAC

TABLE B2
SUMMARY OF UNIAXIAL COMPRESSIVE STRENGTH TEST RESULTS
BORER'S CREEK CULVERT EXTENSIONS AND RETAINING WALLS
HIGHWAY 6, HAMILTON, ONTARIO

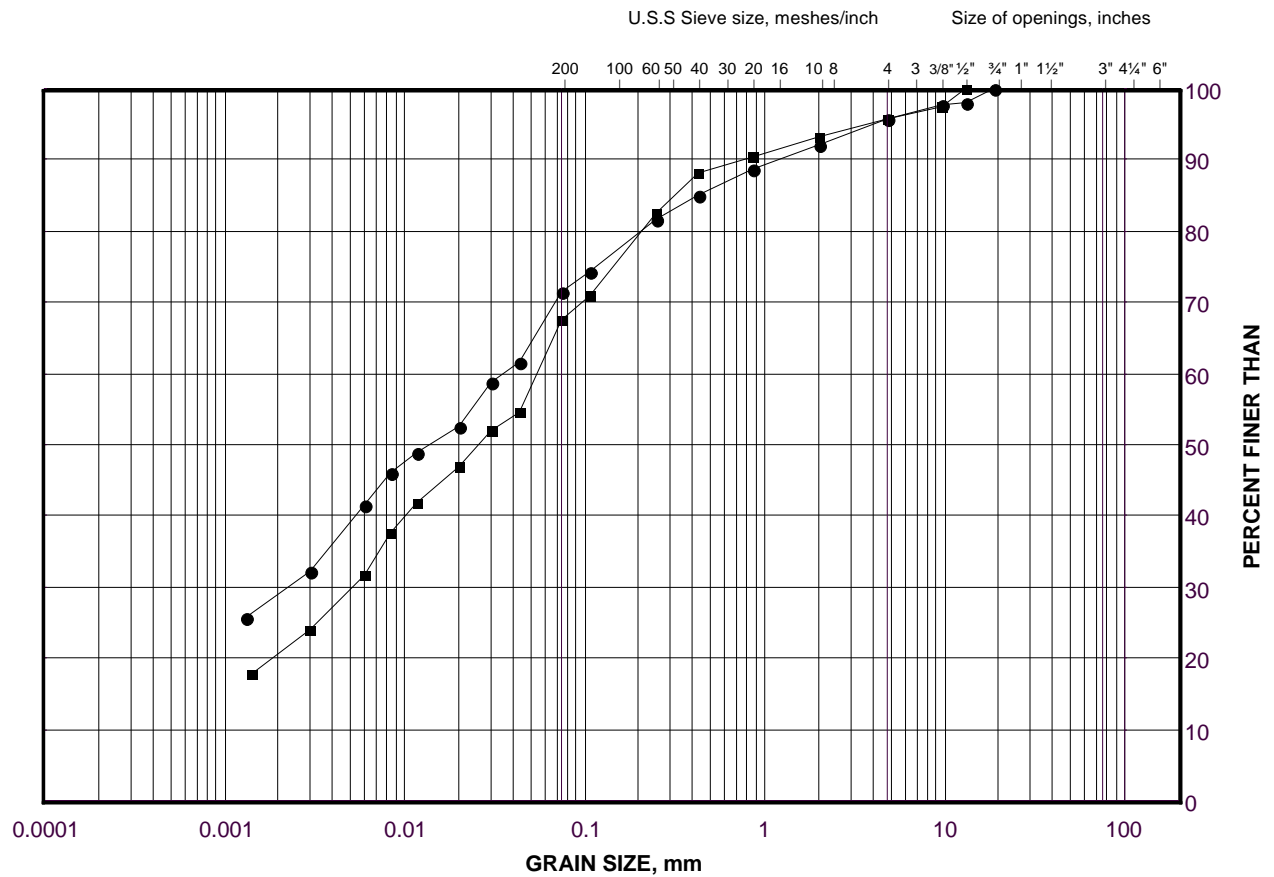
| Borehole Number (Core Run) | Sample Depth (m) | Sample Elevation (m) | Rock Type | Core Diameter (mm) | Uniaxial Compressive Strength (MPa) |
|---|---------------------------------|-------------------------------------|------------------|-----------------------------------|--|
| BC-6A (1) | 2.8 | 215.7 | Dolostone | 4.74 | 119 |
| OS-4 (2) | 5.2 | 215.4 | Dolostone | 4.73 | 96 |

Compiled By: AJSReviewed By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt (Fill)

FIGURE B1



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

LEGEND

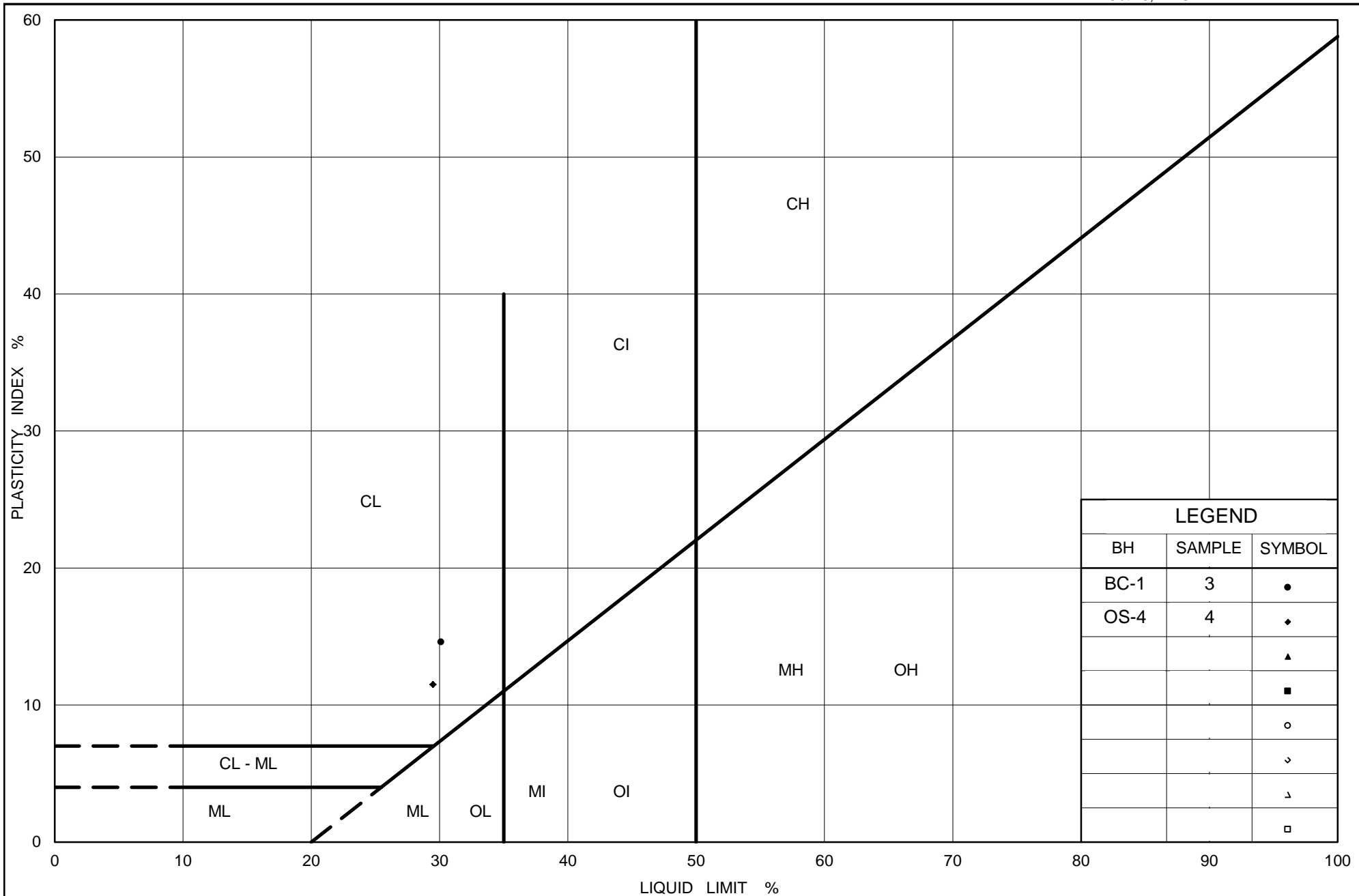
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | BC-4 | 3 | 218.8 |
| ■ | BC-1 | 3 | 216.2 |

Project Number: 10-1184-0016

Checked By: SMM

Golder Associates

Date: 04-Feb-15



Ministry of Transportation

Ontario

PLASTICITY CHART

Sandy Clayey Silt (Fill)

Figure No. B2

Project No. 10-1184-0016

Checked By: SMM

Sand and Gravel (Fill)

U.S.S Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

| Grain Size (mm) | Percent Finer (%) |
|-----------------|-------------------|
| 0.075 | 100 |
| 0.15 | 90 |
| 0.3 | 80 |
| 0.6 | 70 |
| 1.18 | 60 |
| 2.5 | 50 |
| 5.0 | 40 |
| 10.0 | 30 |
| 20.0 | 20 |
| 40.0 | 15 |
| 60.0 | 10 |
| 100.0 | 5 |
| 200.0 | 2 |
| 400.0 | 1 |
| 600.0 | 0.5 |
| 1000.0 | 0.2 |
| 2000.0 | 0.1 |
| 4000.0 | 0.05 |
| 6000.0 | 0.02 |
| 10000.0 | 0.01 |
| 20000.0 | 0.005 |
| 40000.0 | 0.002 |
| 60000.0 | 0.001 |
| 100000.0 | 0.0005 |
| 200000.0 | 0.0002 |
| 400000.0 | 0.0001 |

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

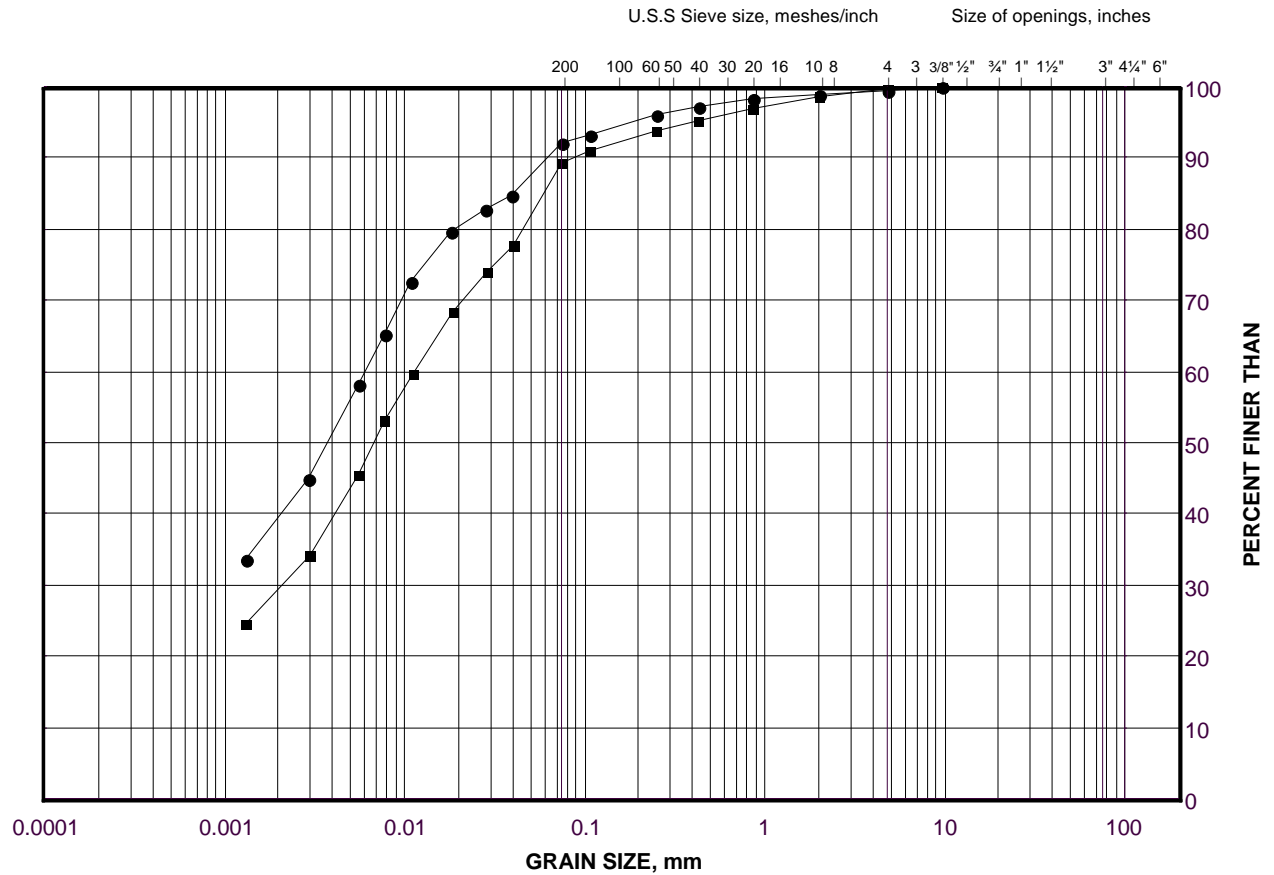
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | OS-4 | 2 | 219.6 |

Date: 31-Mar-14

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay (Till)

FIGURE B4



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

LEGEND

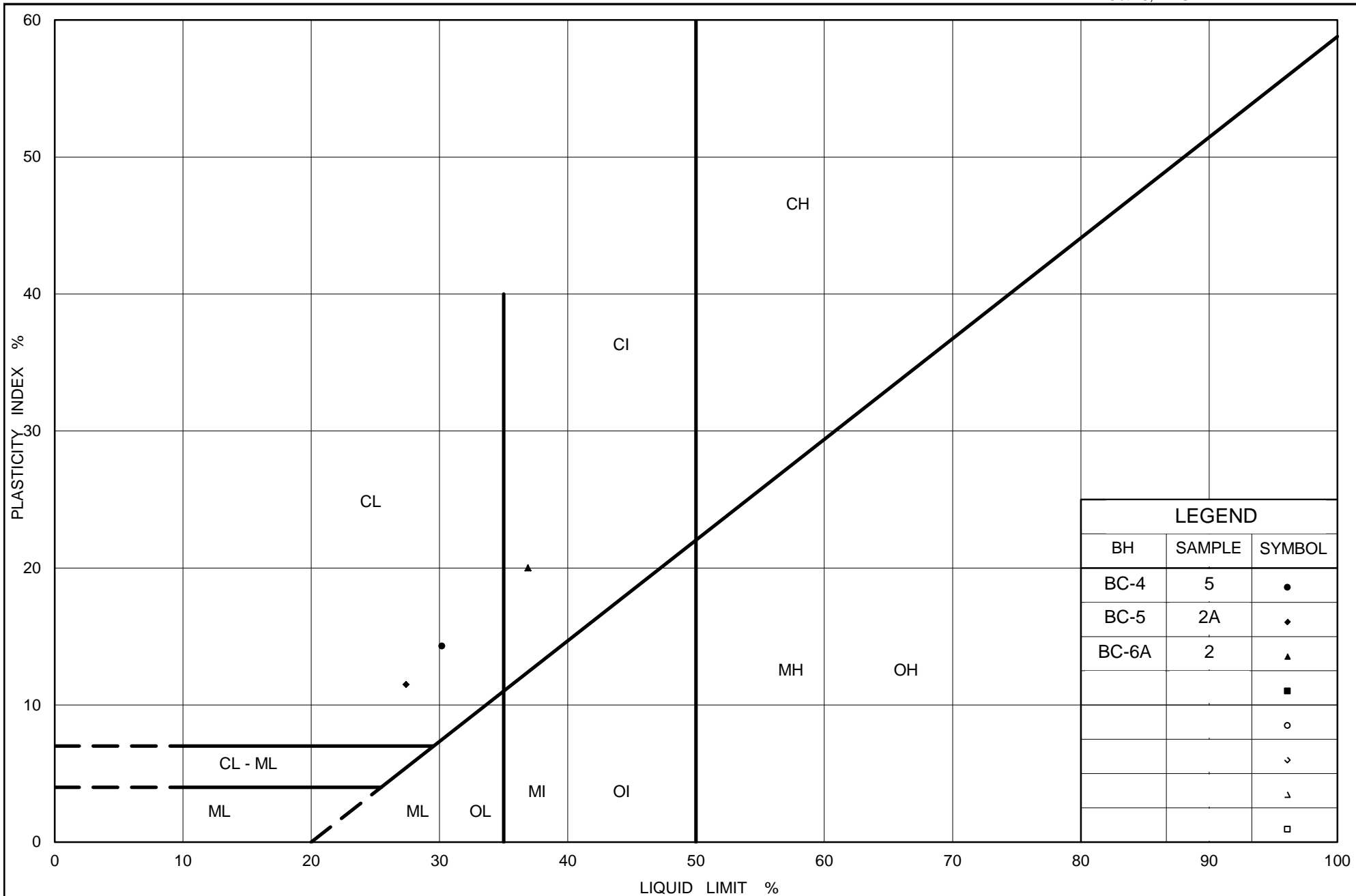
| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|--------|----------|--------|--------------|
| ● | BC-6A | 2 | 217.4 |
| ■ | BC-4 | 5 | 217.4 |

Project Number: 10-1184-0016

Checked By: SMM

Golder Associates

Date: 04-Feb-15



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt to Silty Clay (Till)

Figure No. B5

Project No. 10-1184-0016

Checked By: SMM




BH BC-1: Box 1 of 1: 2.6 m to 6.0 m depth



BH BC-3A: Box 1 of 1: 0.25 m to 3.50 m depth



BH BC-5: Box 1 of 1: 1.47m to 4.80 m depth

| | | | | |
|---|---|--------------|------------|----------|
| PROJECT | BORER'S CREEK CULVERT AND RETAINING WALL CITY OF HAMILTON, MINISTRY OF TRANSPORTATION, ONTARIO GWP 2112-05-00 | | | |
| TITLE | Bedrock Core Photograph – Borehole BC-1, BC-3A and BC-5 | | | |
|  | PROJECT No.: | 10-1184-0016 | FILE No. | ---- |
| | DESIGN | | SCALE | AS SHOWN |
| | CADD | -- | | REV. |
| | CHECK | SMM | APRIL 2015 | |
| | REVIEW | LCC | | |
| FIGURE B6 | | | | |

UNCONFINED COMPRESSION TEST (UC)**Figure B8****ASTM D 7012-07****Sheet 1 of 2****SAMPLE IDENTIFICATION**

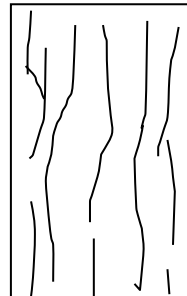
| | | | |
|-----------------|--------------|-----------------|---------|
| PROJECT NUMBER | 10-1184-0016 | SAMPLE NUMBER | - |
| BOREHOLE NUMBER | BC-6A | SAMPLE DEPTH, m | 2.7-2.9 |

TEST CONDITIONS

| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST,min | >2 <15 | L/D | 2.24 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 10.63 | WATER CONTENT, (specimen) % | 0.12 |
| SAMPLE DIAMETER, cm | 4.74 | UNIT WEIGHT, kN/m ³ | 25.99 |
| SAMPLE AREA, cm ² | 17.62 | DRY UNIT WT., kN/m ³ | 25.96 |
| SAMPLE VOLUME, cm ³ | 187.26 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 496.50 | VOID RATIO | - |
| DRY WEIGHT, g | 495.90 | | |

VISUAL INSPECTION**FAILURE SKETCH****TEST RESULTS**

| | | | |
|----------------------|---|-------------------------|-------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 118.7 |
|----------------------|---|-------------------------|-------|

REMARKS:

DATE:

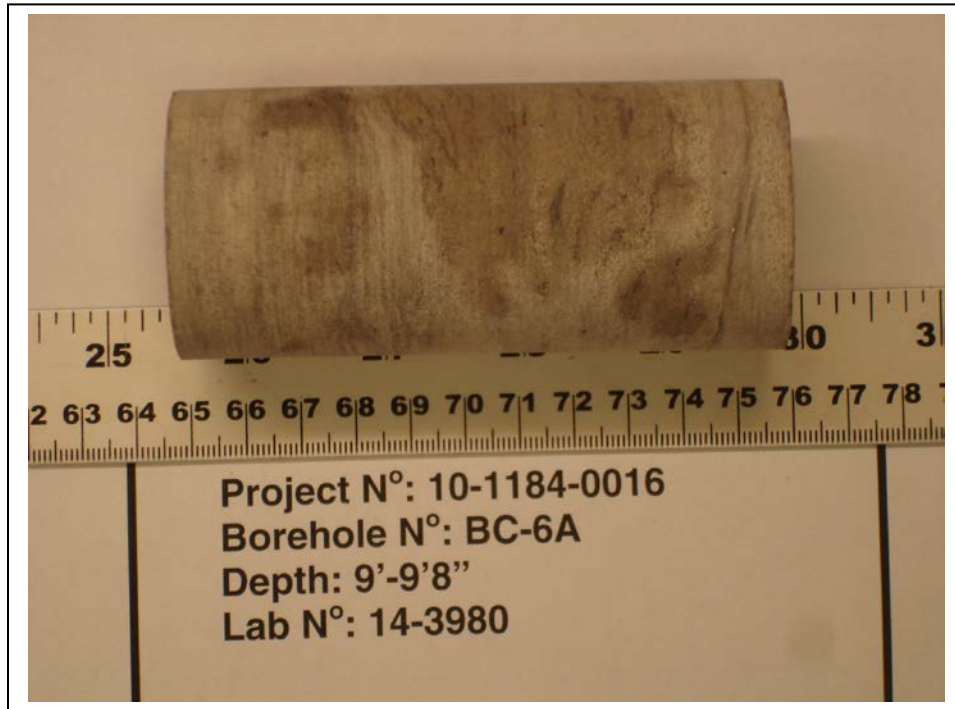
11/26/2014

Checked By:

Golder Associates

UNCONFINED COMPRESSION TEST
ASTM D7012-07

FIGURE B8
Sheet 2 of 2



BEFORE COMPRESSION



AFTER COMPRESSION

Date Nov. 25, 2014
Project 10-1184-0016

Golder Associates

Drawn Frank
Chkd. SMM

UNCONFINED COMPRESSION TEST (UC)**Figure B9****ASTM D 7012-07****Sheet 1 of 2****SAMPLE IDENTIFICATION**

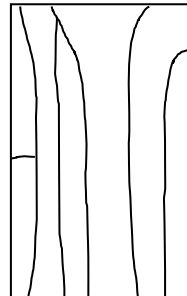
| | | | |
|-----------------|--------------|-----------------|-----------|
| PROJECT NUMBER | 10-1184-0016 | SAMPLE NUMBER | 2 |
| BOREHOLE NUMBER | OS-4 | SAMPLE DEPTH, m | 5.19-5.30 |

TEST CONDITIONS

| | | | |
|-----------------------|--------|------------------|-----------|
| MACHINE SPEED, mm/min | - | TYPE OF SPECIMEN | Rock Core |
| DURATION OF TEST,min | >2 <15 | L/D | 2.03 |

SPECIMEN INFORMATION

| | | | |
|--------------------------------|--------|---------------------------------|-------|
| SAMPLE HEIGHT, cm | 9.59 | WATER CONTENT, (specimen) % | 0.08 |
| SAMPLE DIAMETER, cm | 4.73 | UNIT WEIGHT, kN/m ³ | 26.41 |
| SAMPLE AREA, cm ² | 17.54 | DRY UNIT WT., kN/m ³ | 26.39 |
| SAMPLE VOLUME, cm ³ | 168.23 | SPECIFIC GRAVITY | - |
| WET WEIGHT, g | 453.15 | VOID RATIO | - |
| DRY WEIGHT, g | 452.79 | | |

VISUAL INSPECTION**FAILURE SKETCH****TEST RESULTS**

| | | | |
|----------------------|---|-------------------------|------|
| STRAIN AT FAILURE, % | - | COMPRESSIVE STRESS, MPa | 96.4 |
|----------------------|---|-------------------------|------|

REMARKS:

DATE:

10/23/2013

Checked By:

Golder Associates

UNCONFINED COMPRESSION TEST

ASTM D7012-07

FIGURE B9

Sheet 2 of 2



BEFORE COMPRESSION



AFTER COMPRESSION

Date 11/4/2013
Project 10-1184-0016

Golder Associates

Drawn Frank
Chkd. SMM



APPENDIX C

Non-Standard Special Provisions



WORKING SLAB - Item No.

Non-Standard Special Provision

1.0 Scope

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

2.0 References

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

Ontario Provincial Standard Specifications, Construction

OPSS 902 Excavating and Backfilling - Structures

3.0 Definitions - Not Used

4.0 Design and Submission Requirements - Not Used

5.0 Materials

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

6.0 EQUIPMENT - Not Used

7.0 CONSTRUCTION

7.01 Excavation

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

7.02 Protection of Founding Soil

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

7.03 Protection of Founding Bedrock

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

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



7.04 Dewatering

Dewatering shall be carried out according to OPSS 902.

8.0 Quality Assurance - Not Used

9.0 Measurement for Payment - Not Used

10.0 Basis of Payment

10.01 Working Slab - Item

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

END OF SECTION



OBSTRUCTIONS - Item No.

Non-Standard Special Provision

The existing fill and the native cohesive till contain cobbles and/or shale fragments as indicated in the Record of Borehole sheets. Although not encountered in the boreholes advanced at this site, the cohesive (clayey silt to clayey silt with sand) till deposit should be expected to contain boulders. Appropriate equipment and construction procedures shall be selected to address the presence of such obstructions for installation of temporary protection systems, excavation for structure foundations and retaining walls, as applicable.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



VIBRATION MONITORING - Item No.

Non-Standard Special Provision

Scope

This special provision describes requirements for vibration monitoring during advancement of the drilled holes to allow for placement of the soldier piles into bedrock for soldier pile and concrete panel walls or temporary protection systems.

References

The subsurface conditions at the site are described in the following Foundation Investigation Report for GWP 2112-05-00:

Foundation Investigation Report, Borer's Creek Culvert Extensions and Retaining Walls, Future Highway 5 / Highway 6 Interchange, City of Hamilton, Ministry of Transportation, Ontario, GWP 2112-05-00

Definitions

Quality Verification Engineer (QVE): An Engineer with a minimum of five (5) years experience in the field of installation of piling and vibration monitoring or, alternatively, with expertise demonstrated by providing satisfactory quality verification services for a minimum of two (2) projects of similar scope to the contract. The QVE shall be retained by the Contractor to ensure general conformance with the contract documents and issue certificates of conformance.

Submission Requirements

The Contractor/QVE shall submit details of the vibration monitoring plan to the Contract Administrator for review. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- Qualifications of vibration monitoring specialist.
- Details regarding proposed instrumentation.
- Proposed location of instruments.
- Proposed frequency of readings.
- Proposed methods for adjusting piling methods if readings show vibrations exceeding tolerable levels.

Monitoring

The Contractor/QVE shall take readings on the existing adjacent residential and commercial buildings during drilling of the holes through bedrock.

The vibrations measured at the existing adjacent residential and commercial buildings shall not exceed 50 mm/s (peak particle velocity).



The results shall be submitted to the Contract Administrator after each hole for placement of the soldier piles has been drilled. As a minimum, the pile number, location, and drilling log must be submitted with vibration monitoring results.

If the vibration monitoring results are acceptable, the Contractor may continue with the next pile(s) with readings taken during drilling of each hole. The results of subsequent piles should be submitted to the Contract Administrator after each pile has been driven.

If the readings are not within the limits stated above, the Contractor must alter the drilling procedures until the vibrations at the existing adjacent residential and commercial buildings are within acceptable levels. The above process must be repeated for each pile.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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