

FINAL REPORT

Foundation Investigation and Design Highway 417 Overpass Structures at Preston Street Rapid Bridge Replacement Ottawa, Ontario

Site Nos. 3-55/1 and 3-55/2

G.W.P. 4173-15-00

W.P. 4069-13-01/W.P. 4070-13-01

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PART A

Foundation Investigation
Highway 417 Overpass Structures at Preston Street
Rapid Bridge Replacement
Ottawa, Ontario
Site Nos. 3-55/1 and 3-55/2

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the detailed design of numerous bridge replacements, overhead signs, noise barrier walls, temporary roadway protection systems, replacement of storm sewers (including trenchless crossings) and a high fill embankment on Highway 417 between Island Park Drive and Kent Street in Ottawa, Ontario (Assignment number 4016-E-0001).

This report presents the results of the foundation investigation carried out for the rapid bridge replacement (RBR) of the Highway 417 eastbound (Site 3-55/1) and westbound (Site 3-55/2) overpass structures at Preston Street (G.W.P. 4173-15-00 and W.P. 4069-13-01 and W.P. 4070-13-01). The replacement of the structures is to be carried out in accordance with the current version of the Canadian Highway Bridge Design Code, S6-14 (CHBDC).

The work described herein was not included in the original Terms of Reference for this assignment or the scope of work for Foundations Engineering outlined in the MTO's Request for Proposal, dated April 2016, subsequent addenda or included as part of Golder's original scope of work for Foundations Engineering services contained in WSP's Technical Proposal.

The scope of work for the foundation engineering services associated with the replacement of the Highway 417 Overpasses at Preston Street was outlined in Golder's Change Order #2 Technical Memorandum dated July 27, 2018. The investigation program was developed to meet the requirements of Table 17.8a of the RFP Terms of Reference (where applicable) as well as the structural requirements of WSP to complete the design. The work has been carried out in accordance with Golder's Quality Control Plan for foundation engineering services for the project dated August 29, 2016.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

Sites 3-55/1 and 3-55/2 are located at Station 27+056 approximately 130 m east of the O-Train Trillium Line, within the City of Ottawa. The location of the overpass structures is shown on the Key Plan on Drawings 1 through 5. Site photographs showing the general conditions at the site are presented in Appendix F.

At this location, Highway 417 is a divided highway with four travel lanes in each direction separated by a concrete barrier wall. The westbound structure includes the N/S-W onramp from Rochester Street while the eastbound structure includes the E-N/S offramp to Rochester Street. Concrete barriers are present along both the north and south sides the highway.

Each of the existing structures is a single-span concrete rigid frame bridge that is supported on shallow foundations founded directly on bedrock. Information provided in the RFP indicates that the structures were built in 1962. The eastbound structure and westbound structure have an average overall deck width of 22.2 m and 22.7 m respectively, measured perpendicular to the abutments and are separated from each other by a longitudinal joint. Two concrete cantilever retaining walls are located along the north and south sides of the highway for retaining the highway embankments. Noise barriers are present along the north side of Highway 417 and are carried through the entire length of the structures. There is an existing 1.2 m diameter watermain located just south of the eastbound structure which runs parallel to the highway.

The existing approach embankments are about 6 m to 7 m high relative to the elevation of Preston Street, with side slopes oriented at approximately 2 horizontal to 1 vertical (2H:1V).). Based on a visual observation at the time of the site investigation, no signs of foundation settlement were observed, and the existing embankment slopes appear to be performing satisfactorily.

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of Highway 417 lies within the minor physiographic region known as the Ottawa Valley Clay Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the former Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock².

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by igneous and metamorphic bedrock of the Precambrian Shield. Regional bedrock mapping indicates that the bedrock at this site is primarily limestone of the Verulam Formation³. The limestone is described as interbedded bioclastic, sublithographic to fine crystalline with very thin to medium bedded shale interbeds up to 8 cm thick. Bedrock outcrops are mapped north and south of the Highway 417 / Bronson Avenue Interchange.

The site lies between two faults striking southeast to northwest. The more prominent fault, the Gloucester fault, crosses Highway 417 at the approximate location of Preston Street.⁴ The second fault crosses Highway 417 some 300 metres east. Bedding which is normally sub-horizontal often dips steeply adjacent to and within fault zones.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes that have recently occurred in the WQ zone are the 1935 Témiscaming event, which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event, which had a magnitude of 5.6.

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. Ontario Ministry of Natural Resources.

² Belanger, J.R. "Urban Geology of Canada's National Capital Area", in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

³ Williams, D.A. Rae, A.M., and Wolf, R.R. 1984: Paleozoic Geology of the Ottawa Area, Southern Ontario, Ontario Geological Survey, Map P.2716. Geological Series-Preliminary Map, scale 1:50,000. Geology 1982.

⁴ MacDonald, G. and Harrison, J.E. 1976: Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, Map 1508A, scale 1:125,000. Geology 1967.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigations

The field work for the 2017 investigation was carried out between August 9 and August 14, 2017 and included advancing four boreholes, numbered 17-211 to 17-214 located along the highway approach embankments behind the existing abutments.

A supplemental investigation was carried out between November 5 and November 15, 2018 that included advancing a total of 24 coreholes/drillholes at the existing abutments, numbered 18-D01 to 18-D24 and four boreholes located within the Preston Street right-of-way numbered 18-2101 to 18-2104.

A further four boreholes, that also included coring of the existing concrete footings, were advanced within the highway embankments. These boreholes (numbered 18-2105 to 18-2108) were advanced on December 4 and December 5, 2018, and again between April 24 to April 30, 2019.

Four additional boreholes numbered 18-2109 to 18-2112, located along the highway approach embankments behind the existing abutments, were advanced between October 2, and October 18, 2018.

Three additional boreholes were also advanced as part of the investigation for the proposed staging area for this project. These boreholes (numbered 18-1113 to 18-1115) were advanced between November 19 and November 20, 2018.

Tables 1 and 2 further outline the location of the testholes with respect to the existing structures and staging area.

The 24 coreholes (12 per abutment) were drilled at approximately 3 m spacing along Preston Street through the existing sidewalks using portable drilling equipment and were then subsequently hydro-excavated to expose the top of the existing footings. Eight of the coreholes (four per abutment) were advanced through the existing footings and into the underlying bedrock to form Drillholes 18-D01D, 18-D04D, 18-D09D, 18-D12D, 18-D13D, 18-D16D, 18-D20D, and 18-D24D. Following vertical hydro-excavation, the drillholes advanced along the west abutment footing (18-D13D, 18-D16D, 18-D20D, and 18-D24D) were drilled on an incline due to the proximity of the corehole locations to existing buried utilities. The angle of inclination is indicated on the Record of Drillholes and is relative to the horizontal, with an azimuth perpendicular to the abutments.

Boreholes 18-2101 to 18-2104 were advanced using a combination of truck-mounted drilling and hydro-excavation equipment. The drilling equipment was supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. (CCC) of Ottawa, Ontario.

Borehole 18-2108 was advanced using portable rotary drilling equipment employing a third weight hammer lifted manually and dropped from the SPT height. Where a third weight hammer was used, the N values presented on the Record of Borehole are “uncorrected” and should be interpreted in consideration of their reduced penetration energy. This drilling equipment was also supplied and operated by CCC.

Boreholes 18-2105, to 18-2107 were advanced with portable rotary drilling equipment using HW sized casing due to the proximity of the borehole locations to the adjacent abutment retaining walls and embankment slopes. The drilling equipment used a full weight hammer, but the hammer was dropped from a reduced height of 0.61 m. Where the reduced hammer drop height was used, the N values presented on the Record of Boreholes are “uncorrected” and should be interpreted in consideration of their reduced penetration energy. This equipment was supplied and operated by Marathon Underground Constructors Corporation of Greely, Ontario.

All highway approach embankments boreholes were advanced using a truck mounted drill rig supplied and operated by George Downing Estate Drilling Limited of Hawkesbury, Ontario.

The boreholes advanced within the staging area were advanced with a track mounted drill rig. This equipment was supplied and operated by Marathon Underground Constructors Corporation of Greely, Ontario.

Hydro-excavation at all the coreholes and boreholes where it was required was carried out using equipment supplied and operated by CCC.

Traffic control required to close either the driving lanes of Highway 417 or Preston Street while carrying out field operations was provided by Beacon Lite Ltd. of Ottawa, Ontario.

Grab samples of the overburden were recovered from within the hydro-excavations carried out at the coreholes and Boreholes 18-2101 to 18-2104. Soil samples in Boreholes 17-211 to 17-214 and 18-2109 to 18-2112 were obtained at vertical sampling intervals of about 0.76 m, using a 50 mm outer diameter split-spoon sampler in general accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples from boreholes advanced with portable equipment were obtained at vertical intervals of either about 0.6 m, (Boreholes 18-2105 and 18-2108) or 1.0 m (Boreholes 18-1206 to 18-2107) also in accordance with ASTM D1586.

Concrete and bedrock core samples were obtained in the drillholes using BQ sized equipment. Concrete and bedrock core samples were obtained in Boreholes 18-2105 to 18-2108 and bedrock core samples were obtained in Boreholes 18-2101 to 18-2104 using a combination of NQ and HQ sized equipment.

Monitoring wells were installed in Boreholes 17-211, 18-2102 and 18-2111, to observe the stabilised groundwater level across the site. The monitoring wells consist of 32 mm outside diameter PVC tubing with a 1.5 m long slotted tip. The final groundwater levels were measured in the wells on October 27, 2017 (Borehole 17-211), April 25, 2019 (Borehole 18-2102) and December 6, 2018 (Borehole 18-2111). The wells were subsequently decommissioned according to Ontario MOE Regulation 903 (O.Reg 903) by a licenced well technician.

Where cored, the holes advanced through the existing footings and bedrock were grouted following completion of the work. The coreholes/drillholes were then backfilled with granular material above the existing footing level to the underside of the existing sidewalk and then capped with concrete.

The boreholes were backfilled with bentonite within the bedrock, and bentonite mixed with soil cuttings within the overburden. The boreholes were then capped with either concrete sidewalk patch or asphaltic concrete cold patch, depending on the surrounding surface cover. The boreholes were backfilled in general accordance with the intent of O.Reg 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of Golder's staff who located the testholes in the field, directed the drilling, sampling, and in-situ testing operations, logged the testholes and examined and cared for the samples. The soil and bedrock samples were identified in the field, placed in labelled containers, and transported to Golder's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses, Atterberg Limits and organic content testing were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength testing was carried out on select samples of the concrete footings and the limestone bedrock at Golder's Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

One soil sample from Borehole 17-214 was submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

In addition to the borehole investigations, Vertical Seismic Profiling (VSP) was also completed at this site. A 60 mm inside diameter solid rigid PVC casing was grouted for the full advancement depth (i.e. through the overburden and into the bedrock) at Borehole 18-2101 to allow for the VSP testing to be carried out.

The testhole locations and elevations were surveyed by Golder using a Trimble R8 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 9 geodetic datum. The testhole locations, including northing and easting coordinates, ground surface and top of existing abutment footing elevations, and drilled/cored depths are summarized in Tables 1 and 2 below.

Table 1: Summary of Corehole/Drillhole Locations

Corehole/ Drillhole ¹	Location	NAD83 CSRS CBNv6 2010.0 MTM Zone 9		Ground Surface Elevation (m)	Testhole Inclination ² (°)	Top of Existing Footing Elevation ³ (m)	Footing Thickness (m)	Corehole/ Drillhole Depth ⁴ (m)
		Northing (m)	Easting (m)					
18-D01/D	Sidewalk on Preston Street at east abutment	5029546.0	366572.9	59.9	Vertical	58.4	1.2	3.4
18-D02		5029542.3	366574.5	60.0	Vertical	58.4	-	1.6
18-D03		5029538.7	366576.1	60.1	Vertical	58.4	-	1.7
18-D04/D		5029535.0	366577.7	60.1	Vertical	58.4	1.3	3.7
18-D05		5029531.3	366579.2	60.2	Vertical	58.7	-	1.5
18-D06		5029527.7	366580.8	60.2	Vertical	58.4	-	1.8
18-D07		5029524.0	366582.4	60.3	Vertical	58.4	-	1.9
18-D08		5029520.4	366584.0	60.3	Vertical	59.3 ⁵	-	1.1
18-D09/D		5029516.7	366585.6	60.4	Vertical	58.4	1.1	4.0
18-D10		5029513.0	366587.2	60.4	Vertical	58.4	-	2.0
18-D11		5029509.4	366588.8	60.5	Vertical	58.4	-	2.1
18-D12/D		5029505.7	366590.4	60.5	Vertical	58.4	1.0	3.8
18-D13/D	Sidewalk on Preston Street at west abutment	5029500.9	366573.0	60.4	70	58.7	1.3	3.8
18-D14		5029504.6	366571.4	60.4	Vertical	59.6	-	0.8
18-D15		5029508.3	366569.8	60.3	Vertical	59.5 ⁶	-	0.8
18-D16/D		5029511.9	366568.2	60.3	65	58.6	1.0	3.9
18-D17		5029515.6	366566.6	60.3	Vertical	59.6 ⁶	-	0.7
18-D18		5029519.3	366565.0	60.2	Vertical	59.5 ⁶	-	0.7
18-D19		5029522.9	366563.4	60.2	Vertical	59.6 ⁶	-	0.6
18-D20/D		5029526.6	366561.8	60.1	70	58.7	1.1	3.4

Corehole/ Drillhole ¹	Location	NAD83 CSRS CBNv6 2010.0 MTM Zone 9		Ground Surface Elevation (m)	Testhole Inclination ² (°)	Top of Existing Footing Elevation ³ (m)	Footing Thickness (m)	Corehole/ Drillhole Depth ⁴ (m)
		Northing (m)	Easting (m)					
18-D21		5029530.2	366560.2	60.0	Vertical	59.4 ⁶	-	0.6
18-D22		5029533.9	366558.6	60.0	Vertical	59.4 ⁶	-	0.6
18-D23		5029537.5	366557.1	59.9	Vertical	59.3 ⁶	-	0.6
18-D24/D		5029541.2	366555.5	59.9	65	58.5	1.2	3.4

Notes: ¹ D = Corehole only; D/D = Combination Corehole and Drillhole

² Testhole inclination is measured clockwise from horizontal

³ Top of footing elevation shown is measured vertically from the ground surface

⁴ Depth indicated is measured along the drill path

⁵ Refusal to hydro-excavation on cobbles/boulders

⁶ Refusal to hydro-excavation on buried utility duct bank

Table 2: Summary of Borehole Locations

Borehole ¹	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Footing Thickness (m)	Drilled Length (m)
		Northing (m)	Easting (m)				
17-211	417 Eastbound E-N/S Off-ramp	5029498.4	366553.9	66.7	N/A	N/A	7.6
17-212	417 Westbound N/S-W On-ramp	5029536.7	366549.0	67.2			8.6
17-213	417 Eastbound E-N/S Off-ramp	5029508.7	366595.8	66.2			7.9
17-214	417 Westbound N/S-W On-ramp	5029551.0	366590.8	66.6			8.7
18-2101	Preston Street North of west abutment	5029545.7	366555.9	59.7			7.1
18-2102	Preston Street South of west abutment	5029498.6	366576.6	60.3			4.5
18-2103	Preston Street East Sidewalk North of east abutment	5029549.3	366568.8	59.8			2.1

Borehole ¹	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Top of Existing Footing Elevation (m)	Footing Thickness (m)	Drilled Length (m)
		Northing (m)	Easting (m)				
18-2104	Preston Street East Sidewalk South of east abutment	5029501.3	366590.0	60.4			6.6
18-2105	Highway 417 Embankment Northwest of west abutment	5029540.3	366549.8	61.8	58.5	1.3	6.2
18-2106	Highway 417 Embankment Southwest of west abutment	5029498.4	366566.9	62.9	58.5	1.1	6.7
18-2107	Highway 417 Embankment Northeast of east abutment	5029550.2	366578.0	62.6	58.5	1.5	6.9
18-2108	Highway 417 Embankment Southeast of east abutment	5029505.3	366597.8	62.9	58.4	1.1	7.3
18-2109	Highway 417 Westbound west of west abutment	5029531.4	366549.2	67.3	N/A	N/A	9.1
18-2110	Highway 417 Eastbound west of west abutment	5029515.0	366553.2	67.0			8.4
18-2111	Highway 417 Westbound east of east abutment	5029531.0	366589.5	66.7			8.6
18-2112	Highway 417 Eastbound east of east abutment	5029515.4	366596.7	66.4			6.9
18-1113	Staging Area 301 Preston Street	5029656.7	366528.9	59.1	N/A	N/A	3.3
18-1114		5029639.5	366600.0	59.6			4.6
18-1115		5029594.6	366557.5	59.3			3.4

Note: ¹ All boreholes were drilled vertically with an inclination of 90°

3.2 Previous Investigations (1959)

A previous investigation was carried out for the design of the existing structures in 1959. The subsurface information and results of the original investigation are contained in the report titled:

- *“Foundation Investigation Site of Bridge No. 15, Preston Street, Ottawa Queensway, McRostie & Associates Consulting Engineers and Surveyors Report No. 59-F-219C”, dated 1959 (GEOCRE No. 31G05-032).*

As part of the current assignment, previously collected subsurface information pertinent to the site was reviewed and compiled.

A total of six boreholes were advanced at the site as part of the original investigation along the then proposed bridge alignment over Preston Street. The Soil Profile and Laboratory Test Sheets and Borehole Location Plan from the previous investigation are provided for reference in Appendix C. The approximate borehole locations and ground surface elevations are shown on Drawings 1 and 2.

The locations of the previous boreholes should be considered approximate since the locations were referenced to an imperial borehole location plan rather than metric MTM coordinates. Further, the boreholes from the previous investigation were advanced prior to construction of the bridge and the ground surface conditions shown may not be representative of the post-construction subsurface conditions, particularly with respect to the composition and thickness of overburden and fill. It is also unknown if the surface of the bedrock as encountered in the 1959 investigation was altered during construction of the overpass structure. Therefore, the stratigraphy encountered in the 1959 boreholes was not included in the stratigraphic profiles shown on Drawings 1 and 2 but the depths to the encountered bedrock surface from the previous investigation have been included in Section 4.7 below.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the testholes and the results of in-situ testing from the current investigation are given on the Record of Borehole, Corehole, and Drillhole sheets presented in Appendix A. The results of the laboratory testing carried out during the current investigation are presented on the Record of Borehole sheets as well as on Figures B1 to B9 in Appendix B. The borehole locations and the interpreted stratigraphic profile projected along each abutment and staging area are provided on Drawings 1 to 5.

Photographs of the core recovered from the concrete footings and underlying bedrock are shown on Figures A1 to A30 provided in Appendix A. An assessment of the condition of the Portland Cement Concrete (PCC) footing cores is provided in Table A1 of Appendix A. The results of basic chemical analysis completed on select soil samples are provided in Appendix D.

The VSP test results and report carried out as part of the current investigation are presented in Appendix E and include the calculated shear wave velocity profile measured from the field testing and a graphical representation of the shear wave velocity profile with depth for that test.

The stratigraphic boundaries shown on the testhole sheets and on the interpreted stratigraphic sections from Drawings 1 to 5, are inferred from observations of drilling progress and noncontinuous sampling and therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

4.2 Site Stratigraphy Overview

In general, the subsurface conditions at the testhole locations advanced along Preston Street consist of PCC sidewalk or asphaltic concrete at surface, overlying granular fill overlying PCC footings and/or limestone bedrock.

At the approach boreholes the subsurface conditions consist of asphaltic concrete/PCC surface cover, overlying fill materials, overlying native glacial till all underlain PCC footings and/or limestone bedrock. Due to the age of the structures, it is possible that remnants of temporary works abandoned after construction of the existing structure may be buried in the fill. The results of utility locates carried out as part of the field investigation for this project indicate that there are buried utilities within the vicinity of the PCC footing of the existing west abutment.

At the embankment boreholes, the subsurface conditions consist of topsoil surface cover, overlying fill materials, overlying granular fill overlying PCC footing all underlain by limestone bedrock.

At the staging area boreholes, the subsurface conditions consist of topsoil surface cover, overlying fill materials, all underlain by limestone bedrock. Marl was encountered in Borehole 18-1114 directly above the bedrock surface.

The groundwater levels were measured at the site at depths ranging from 2.9 to 3.8 m, corresponding to Elevations 57.4 to 62.9 m.

A more detailed description of the overburden soil deposits, concrete footings, bedrock geology and groundwater conditions encountered during the field investigation is provided in the following sections.

4.3 Highway 417 Approach Embankments

4.3.1 Surface Cover / Surficial Materials

Boreholes 17-211 to 17-214 and 18-2109 to 18-2112 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete at the borehole locations ranges from 100 to 300 mm.

PCC was encountered below the asphaltic concrete in Boreholes 17-211 to 17-214, 18-2109 and 18-2112. The thickness of the concrete at the borehole locations ranges from 100 to 300 mm.

4.3.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete in Boreholes 18-2110 and 18-2111 and below the PCC at Boreholes 17-211 to 17-214, 18-2109 and 18-2112. The top of this layer was encountered at elevations ranging from 65.7 to 66.9 m. The thickness of the fill ranges from 200 to 500 mm.

Fill consisting predominantly of sand with varying amounts of silt was encountered at the ground surface at embankment Boreholes 18-2105 to 18-2108 and below the pavement structure at approach Boreholes 17-211 to 17-214 and 18-2109 to 18-2112. The top of this layer was encountered at elevations ranging from 61.8 to 66.5 m. The thickness of the fill ranges from 2.6 to 7.7 m. The SPT N values ranged from 8 to 80 blows per 0.3 metres of penetration but more typically were 10 to 44 blows, indicating a compact to dense state of packing. The measured moisture content of the samples tested ranged from 2 to 11 percent. The results of grain size analysis testing carried out on 13 samples of this material are provided on Figures B1 and B2 in Appendix B.

Silty clay to sandy clay fill was encountered in Boreholes 17-211 and 18-2110 at elevations of 60.8 and 65.6 m respectively. The thickness of the clayey fill at these locations was 1.7 and 0.7 m. The SPT N values ranged from

7 to 63, indicating a stiff to hard state of packing. The measured moisture content of two samples of the clayey fill was 24 and 17 percent. The results of an Atterberg Limits test completed on a single sample of this material indicated a liquid limit of 41, a plastic limit of 17, and a plasticity index of 25. Atterberg Limits analysis results are illustrated on Figure B3 in Appendix B and indicate a silty clay (CI).

Fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the sand fill in Boreholes 17-214, 18-2105 to 18-2109, and 18-2111. Cobbles were noted in this layer. The top of this fill layer was encountered at elevations ranging from 58.4 to 60.4 m. The thickness of the fill ranges from 0.5 to 1.5 m. The SPT N values ranged from 10 to 59 blows per 0.3 metres of penetration but more typically were 10 to 28 blows, indicating a compact state of packing. The measured moisture content of the samples tested ranged from 8 to 16 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B4 in Appendix B.

A silty sand fill with varying amounts of gravel and containing cobbles as well as debris including concrete, ash and wood was encountered in Boreholes 18-2109 and 18-2111. Silty sand fill was also encountered Borehole 18-2110 without any debris within the matrix. This layer was encountered at Elevation 61.1 m and is about 2.5 m in thickness. The SPT N values ranged from 10 to 64 blows per 0.3 metres of penetration, indicating a compact to very dense state of packing. The measured moisture content of the two samples tested ranged from 13 to 29 percent. The results of organic content testing on a single sample indicate an organic content of 7.5%. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B5 in Appendix B.

4.3.3 Glacial Till

Glacial till was encountered below the fill in Boreholes 18-2109 and 18-2111. The glacial till generally consists of a heterogeneous mixture of cobbles within a soil matrix of sand and gravel. The till is classified as a silty sandy gravel. This layer was encountered at elevations 58.9 and 58.5 m respectively and is about 400 mm in thickness in both boreholes.

The higher blow count (i.e., greater than 100) noted on the Record of Borehole may have been influenced by the underlying bedrock surface or the presence of cobbles or boulders within the till, rather than the state of packing of the soil matrix.

4.4 Preston Street

Boreholes 18-2101 to 18-2104 and the coreholes/drillholes 18-D01 to 18-D24 were advanced within the Preston Street right-of-way along the existing abutments.

4.4.1 Surface Cover

Boreholes 18-2101 and 18-2102 were advanced through the Preston Street pavement structure. The thickness of the asphaltic concrete at the borehole locations ranges from 100 to 200 mm.

A PCC sidewalk was encountered at the ground surface at Boreholes 18-2103 and 18-2104 and the coreholes/drillholes advanced along Preston Street. The thickness of the concrete ranges from 100 to 200 mm at the testhole locations.

4.4.2 Pavement Structure and Roadway Fills

Pavement structure fill consisting predominantly of sand and gravel was encountered below the asphaltic concrete in Boreholes 18-2101 and 18-2102 and below the PCC at Boreholes 18-2103 and 18-2104 and the

coreholes. The top of this layer was encountered at elevations ranging from 59.6 to 60.4 m. The thickness of the fill ranges from 0.1 to 1.5 m. The measured moisture content of the samples tested ranged from 2 to 9 percent. The results of grain size analysis testing carried out on three samples of this material are provided on Figure B6 in Appendix B.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the pavement structure at Boreholes 18-2102 and 18-2103 and the coreholes. The top of this layer was encountered at elevations ranging from 59.4 to 60.2 m. The thickness of the fill ranges from 0.3 to 1.8 m. The measured moisture content of the samples tested ranged from 7 to 9 percent.

4.5 Staging Area

The proposed staging area for this project is the sports field at 301 Preston Street, northeast of the site. The location of the staging area is shown in the plan view on Drawing 5. Boreholes 18-1113 to 18-1115 were advanced within the staging area.

4.5.1 Surface Cover

Topsoil with a thickness of 200 mm was encountered at the ground surface of all the boreholes advanced within the staging area.

4.5.2 Fill

Fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the topsoil at all boreholes advanced in the staging area. The top of this layer was encountered at elevations ranging from 58.9 to 59.4 m. The thickness of the fill layer ranges from 3.1 to 3.5 m. The measured SPT N values ranged from 4 to 32 blows per 0.3 metres of penetration but more typically 7 to 15, indicating a loose to compact state of packing.

The measured moisture content of the five samples tested ranged from 2 to 9 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B7 in Appendix B.

Clayey silt fill, with varying amounts of sand and gravel, was encountered in Borehole 18-1113 at Elevation 58.3 m and is about 600 mm in thickness. One SPT N value of 8 blows per 0.3 meters of penetration was recorded in the clayey silt, which indicates a loose state of packing. The measured moisture content of one sample of the clayey silt fill was 21 percent.

4.5.3 Marl

Marl, which is considered a highly compressible material, was encountered below the fill material in Borehole 18-1114 at Elevation 55.9 m and is about 0.8 m in thickness. The measured moisture content of a single sample of the marl was 180 percent. The results of laboratory testing indicate that the marl has an organic content of 10 percent.

4.6 Concrete Footings

The existing concrete footings were encountered in coreholes/drillholes 18-D01 to 18-D24 and embankment Boreholes 18-2105 to 18-2108.

The hydro-excavation was terminated at the top of the buried utility that was present along the entire length of the west abutment (Coreholes 18-D13 to 18-D24) and therefore the depth to the top of footing could not be assessed in the coreholes where additional diamond drilling was not undertaken along the west abutment.

The top of the concrete footing was encountered at elevations ranging from 58.4 to 58.7 m. The thickness of the footings ranges from 1.0 to 1.5 m, as indicated by coring through the existing footing to the underlying bedrock. Tables 1 and 2 in Section 3.1 provide the top of footing elevation and footing thickness at each of the drillhole locations and at Boreholes 18-2105 to 18-2108. An assessment of the condition of the PCC footing cores is provided in Table A1 of Appendix A.

Results of unconfined compressive strength (UCS) testing carried out on six concrete core samples are presented on Figure B8 provided in Appendix B. The samples tested had UCS values ranging from 19 to 30 MPa.

4.7 Bedrock

The overburden materials and concrete footings are underlain by limestone bedrock with shale partings and interbeds. Regional bedrock mapping indicates that the bedrock at this site is primarily limestone of the Verulam Formation.

Bedrock was proven by coring using a combination of NQ and HQ sized equipment in Boreholes 18-2101, 18-2102, and 18-2104 to 18-2107. Bedrock was proven by coring using BQ sized equipment in Drillholes 18-D01/D, 18-D04/D, 18-D09/D, 18-D12/D, 18-D13/D, 18-D16/D, 18-D20/D, and 18-D24/D. Photographs of the bedrock core are provided in Appendix A.

Table 3 summarizes the depths and the elevations of the bedrock surface as encountered at the testhole locations from the current and previous investigations.

Table 3: Summary of Bedrock Surface Depths and Elevations

Drillhole / Borehole	Drillhole / Borehole Location	Existing Ground Surface Elevation (m)	Testhole Inclination ¹ (°)	Depth to Bedrock Surface ² (m)	Bedrock Surface Elevation ³ (m)
18-D01D	Sidewalk along Preston Street at east abutment	59.9	Vertical	2.7	57.2
18-D04D		60.1	Vertical	3.0	57.1
18-D09D		60.4	Vertical	3.1	57.3
18-D12D		60.5	Vertical	3.1	57.4
18-D13D	Sidewalk along Preston Street at west abutment	60.4	70	3.2	57.4
18-D16D		60.3	65	3.0	57.5
18-D20D		60.1	70	2.6	57.6
18-D24D		59.9	65	2.7	57.4
18-2101	Preston Street North of west abutment	59.7	Vertical	1.8	57.9
18-2102	Preston Street South of west abutment	60.3	Vertical	1.6	58.6
18-2104	Preston Street East Sidewalk South of east abutment	60.4	Vertical	3.1	57.3
18-2105	Highway 417 Embankment Northwest of west abutment	61.8	Vertical	4.6	57.2

Drillhole / Borehole	Drillhole / Borehole Location	Existing Ground Surface Elevation (m)	Testhole Inclination ¹ (°)	Depth to Bedrock Surface ² (m)	Bedrock Surface Elevation ³ (m)
18-2106	Highway 417 Embankment Southwest of west abutment	62.9	Vertical	5.5	57.5
18-2107	Highway 417 Embankment Northeast of east abutment	62.6	Vertical	5.6	57.1
18-2108	Highway 417 Embankment Southeast of east abutment	62.9	Vertical	5.6	57.3
1	West abutment	67.3	Vertical	8.4	58.9
3	West abutment	59.5	Vertical	1.3	58.2
4	East abutment	59.6	Vertical	3.0	56.6
6	East abutment	65.1	Vertical	7.4	57.7

Notes: ¹ Testhole inclination is measured clockwise from the horizontal

² Depth indicated is measured along the drill path

³ Top of bedrock surface elevation shown is measured vertically from the ground surface

The bedrock encountered was slightly weathered to fresh and thinly to medium bedded. Thin shale interbeds were present in the bedrock core. Rock Quality Designation (RQD) values measured on recovered bedrock core samples typically ranged from about 55 to 100 percent, indicating a fair to excellent rock quality.

Results of unconfined compressive strength (UCS) testing carried out on six bedrock core samples are presented on Figure B9 provided in Appendix B. The samples tested had UCS values ranging from 37 to 69 MPa, indicating a medium strong to strong bedrock.

4.8 Groundwater Conditions

Monitoring wells were installed in Boreholes 17-211, 18-2102 and 18-2111 to allow for measurement of the groundwater levels across the site.

Table 4 summarizes the depths and the elevations of the groundwater levels measured in the monitoring wells installed at the site.

Table 4: Summary of Groundwater Conditions

Borehole	Location	Screened Interval	Depth (m)	Elevation (m)	Date
17-211	West Approach Eastbound	Sand Fill and Silty Clay Fill	3.8	62.9	October 27, 2017
18-2102	Preston Street South of west abutment	Bedrock	2.9	57.4	April 25, 2019
18-2111	Highway 417 Westbound east of east abutment	Fill and till	Monitoring well dry Elevation of the bottom of well = 58.1 m		December 6, 2018

It is expected that the groundwater levels will be subject to fluctuations both seasonally and as a result of precipitation events.

4.9 Steel Corrosion and Sulphate Attack, Chemical Analysis

One soil sample from Borehole 17-214 was submitted to Eurofins Environmental Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in Table 5.


Table 5: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample	Sample Depth (m)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
17-214	SS12	7.6 – 8.2	Fill	0.275	0.07	<0.05	10.4	20,000

5.0 CLOSURE

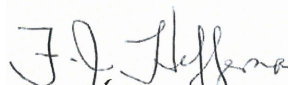
This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior Geotechnical Engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

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KCP/WC/FJH/hdw

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PART B

Foundation Design
Highway 417 Overpass Structures at Preston Street
Rapid Bridge Replacement
Ottawa, Ontario
Site Nos. 3-55/1 and 3-55/2

6.0 FOUNDATION ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical input for the rapid bridge replacement (RBR) and widening of the Highway 417 eastbound (Site 3-55/1) and westbound (Site 3-55/2) overpass structures at Preston Street, (G.W.P. 4173-15-00, W.P. 4069-13-01 & 4070-13-01). The input provided herein is based on interpretation of the factual data obtained from the testholes advanced during the current subsurface investigation, as well as the available GEOCRETS information for the site, and in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-S6-14 (CHBDC).

The foundation investigation report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on aspects of construction must 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 Existing Conditions

Each of the existing structures is a single-span concrete rigid frame bridge supported on shallow foundations founded directly on bedrock. Information provided in the RFP indicates that the structures were built in 1962. The structures have a clear span of 18.3 m measured perpendicular to the abutments and are separated from each other by a longitudinal joint. The average overall deck width measured perpendicular to the centerline of the highway, is approximately 22.2 m and 22.7 m, for the EBL and WBL structures respectively. The existing abutments are supported on shallow foundations bearing directly on the bedrock. The west and east abutments have two retaining walls, located along the north and south sides of the highway embankment, for retaining the embankment fill. Noise barriers are supported on the concrete barriers on the north side of Highway 417 and extend along and beyond the entire length of the Preston Street Overpass structure.

At this location, Highway 417 is a divided highway with four travel lanes in each direction and the E-N/S offramp to Preston and the N/S-W onramp from Preston Street. The two structures are separated by a concrete barrier wall.

Based on the base plan mapping provided for this project and the ground surface elevations at the borehole locations surveyed during the field investigation, the top of pavement elevation of Highway 417 ranges from 67.3 to 66.7 m at the west abutment, and from 66.7 to 66.2 m at the east abutment in the westbound and eastbound directions respectively. The top of pavement elevation of Preston Street ranges from about Elevation 60.3 to 59.7 m.

The existing approach embankments are about 6 to 7 m high relative to the elevation of Preston Street with side slopes oriented at approximately 2H:1V. Based on a visual observation at the time of the site investigation, no signs of foundation settlement were observed, and the existing embankment slopes appear to be performing satisfactorily. There is an existing retaining wall located at the toe of the northwest highway embankment that runs parallel to St Anthony Street.

6.3 Proposed Structures

Based on the May 2019 Preliminary General Arrangement (GA) Drawing provided by WSP, the existing structures are to be replaced and no widening is anticipated at this location. It is understood that the preferred replacement alternative involves the use of RBR techniques. The existing bridge structures will be demolished in place with removal of the superstructure down to the existing footing level. The new structures will be pre-assembled in the staging area and transported using specialized heavy-lift equipment to their final locations. Consideration is also being given to incorporating the existing spread footings into the new overpass structures.

6.4 Seismic Design

6.4.1 Seismic Hazard and Importance Category

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

In accordance with Section 4.4.2 of the CHBDC, and as specified in the RFP by the MTO, the bridge structures have been given an importance category of “Major Route” bridge.

6.4.2 Seismic Site Classification

In addition to the borehole investigations, Vertical Seismic Profiling (VSP) geophysical testing was carried out at the existing bridge location to evaluate the average shear wave velocity of the upper 30 m of soil/bedrock at this site. The shear wave velocity profiling was carried out in Borehole 18-2101 on June 4, 2019, by personnel from Golder’s Montreal and Ottawa offices.

The shear wave velocities measured are presented in the technical memorandum provided in Appendix E and indicate that the average shear wave velocity of the upper 30 m of the subsurface soil/bedrock stratigraphy, measured from the existing ground surface of Borehole 18-2101, is 1081 m/s.

It has been confirmed by testholes advanced through the existing abutment footings that the footings are founded directly on bedrock. Based on the results of the VSP testing at the Rochester Street site, an average shear wave velocity of 1,275 m/s was calculated for 30 m of rock underlying the footings, which corresponds to Site Class B in accordance with Table 4.1 of the CHBDC. It should be noted that, as indicated in the notes for Table 4.1 of the CHBDC, a Site Class B is only assigned for structures founded directly on bedrock.

6.4.3 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.1 of the CHBDC and based on the location of the bridge (latitude 45.40 N longitude 75.71 W), the values provided in Table 6 are the reference Site Class C (reference) peak seismic hazard values based on data obtained from Earthquakes Canada (www.earthquakescanada.nrcan.gc.ca).

Table 6: Site Class C Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.280
$T \leq 0.2$ s	0.438
$T = 0.5$ s	0.236
$T = 1.0$ s	0.118
$T = 2.0$ s	0.056
$T = 5.0$ s	0.015
$T \Rightarrow 10.0$ s	0.005

The values given above are for the reference ground condition Site Class C and must be modified to the site-specific seismic site classification given in Section 6.4.2 (Site Class B) in accordance with Section 4.4.3 of the CHBDC. As indicated in Section 4.4.3.3 of the CHBDC, the value of PGA_{ref} for use with Tables 4.2 to 4.9 shall be taken as 80 percent of the PGA for Site Class C where $Sa(0.2)/PGA$ is less than 2.0. Based on this requirement a PGA_{ref} value of 0.224 was used for the 2,475-year return period. The corresponding site-specific Site Class B seismic hazard values given in Table 7 can be used for design.

Table 7: Site Class B Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.244
$T \leq 0.2$ s	0.337
$T = 0.5$ s	0.153
$T = 1.0$ s	0.074
$T = 2.0$ s	0.035
$T = 5.0$ s	0.010
$T \Rightarrow 10.0$ s	0.003

The fundamental period of the replacement structures has yet to be confirmed and may depend on the final design of the superstructure. In consideration of the structure's "Major Route" importance category and the site specific seismic hazard values given in Table 7, the bridges would fall in Seismic Performance Category 1, if the fundamental period of the structure is greater than or equal to 0.5 s, or Seismic Performance Category 2, if the fundamental period of the structure is less than 0.5 s, in accordance with Table 4.10 of the CHBDC.

Based on the regular geometry of the bridge (since its skew angle is less than 20°), it is understood that the structure will be designed using a "force-based approach" as defined in the CHBDC, depending on the Seismic Performance Category.

6.5 Foundation Options

6.5.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the CHBDC and its Commentary, the existing overpass structures and foundation systems may be classified as having large traffic volumes and its performance as having potential impacts on other transportation corridors, hence having a “typical” consequence level associated with exceeding limits states design. Given the level of foundation investigation completed to date as presented in Sections 3.0 and 4.0, in comparison to the degree of site understanding in Section 6.5 of CHBDC, the level of confidence for design is considered to be a “typical degree of site and prediction model understanding” for these sites. Accordingly, the appropriate corresponding ULS and SLS consequence factor, ψ of 1.0, and geotechnical resistance factors from Tables 6.1 and 6.2 of the CHBDC have been used for design, as indicated in the following sections.

For seismic design, the consequence factor, Ψ , and resistance factor, ϕ_{gu} , should be taken as unity, as per Section 4.6.3 of the CHBDC.

6.5.2 Existing Conditions

The original 1961 GA drawing (Drawing No. D-4445-2) indicates that the footings were to bear directly on the bedrock, with design top of footing elevations ranging from 58.7 m at the west abutment to 58.4 m at the east abutment. The coreholes/drillholes advanced through the existing abutment footings into the underlying bedrock as part of the current foundation investigation confirms that the abutment footings are founded directly on the limestone bedrock.

6.5.3 Foundation Design Alternatives

Based on the results of the current investigation, shallow foundations are considered the preferred alternative from a foundations perspective for the replacement of the overpass structures and the associated retaining walls. Shallow foundations are more cost-effective than deep foundations (discussed below) for both conventional and rapid bridge replacement of the structure, whether by incorporating the existing foundations, or removing the existing foundations and constructing new footings directly on the bedrock. For the RBR option, the re-use of the existing foundations is considered a significant advantage.

Deep foundations, including steel H-piles, steel tube piles or caissons, are not considered warranted or practical at this site in comparison to shallow foundations, since the bedrock surface is located at shallow depth (i.e., less than 1.8 m) below the top of pavement elevation of Preston Street.

A comparison of foundation alternatives, including advantages, disadvantages, risks and relative costs is provided in Table 14 following the text of this report.

6.6 Shallow Foundations

6.6.1 Founding Level

Table 8 provides the founding elevations recommended for design of new abutment footings founded directly on the bedrock surface. The founding elevations were selected based on the bedrock quality as well as to match the founding elevations of the existing structures.

Table 8: Design Footing Founding Elevations

Foundation Element	Footing Founding Elevations (m)
West Abutment	58.6 to 57.2
East Abutment	57.4 to 57.1

Subexcavation may be required to remove any weathered, loose, or fractured bedrock before construction of the abutment and wingwall footings. For the shallow excavation depths expected (i.e., of less than about 2 m) the bedrock can likely be removed using mechanical methods such as hoe ramming.

Alternatively, the existing foundations may be left in place and new cast-in-place footings constructed or precast footings may be placed on top of the existing concrete footings. Table 9 outlines the elevation of the top surface of the existing west and east abutment footings.

Table 9: Summary of Top of Footing Elevations

Footing Location	Reference Corehole/Drillhole	Elevation of Top of Footing (m)
West Abutment	18-D13 to 18-D24	58.7 to 58.5
East Abutment	18-D01 to 18-D12	58.4

6.6.2 Geotechnical Resistance

6.6.2.1 New Footings Supported on Bedrock Surface

The overpass replacement structures can be supported on cast-in-place strip or spread footings founded at or below the elevations provided in Section 6.6.1. The design should be based on a factored geotechnical resistance of 2 MPa at Ultimate Limit States (ULS). For footings founded on/in the bedrock, settlement is considered to be negligible under the anticipated loadings and therefore the SLS condition will not govern the design.

The factored geotechnical resistances provided above are given for loads that will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the footing, inclination of the load should be taken into account in accordance with Sections 6.10.3 and 6.10.4 of the CHBDC.

6.6.2.2 New Footings Supported on Existing Footings

If the existing footings are left in place and new footings (cast-in-place or precast) are constructed on top, the geotechnical resistances provided above are also applicable. Table A1 provided in Appendix A summarizes the condition of the cores taken from the existing footings at the site.

6.6.3 Resistance to Lateral Forces/Sliding Resistance

6.6.3.1 Footings on Bedrock

Resistance to lateral forces/sliding resistance between new or existing cast-in-place or precast (formed) concrete footings and the bedrock surface should be calculated in accordance with Section 6.10.5 of the CHBDC.

An unfactored coefficient of friction, $\tan \phi' = 0.70$ can be used for the interface between the cast-in-place concrete footing and bedrock. For the assessment of sliding resistance between precast concrete footings placed on bedrock it is recommended that a coefficient of friction of 0.6 be used.

If necessary, sliding resistance can be supplemented by doweling the footings into the bedrock. The horizontal resistance of the dowels will be dependent on the strength of the bedrock, grout and steel. For this site, where the rock mass is essentially as strong as or is stronger than concrete, the design of the dowels in the rock may be handled in the same way as the dowel embedment into the concrete. The dowels should have a minimum embedded length within sound bedrock of 1 m, and the structural strength of the dowel and compressive strength of the grout should not be exceeded.

For uplift of the dowels, a factored value of 1 MPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given and it should therefore be verified in the field by pull-out testing. In this case, a Special Provision will have to be included in the Contract Documents to cover this testing.

6.6.3.2 New Footings Supported on Existing Footings

Cast-in-place or precast footings could be constructed on top of the existing footings for a rapid bridge replacement. It is recommended that consideration be given to roughening the surface of the existing footings prior to constructing cast-in-place footings. In the case of new precast footings, it is anticipated that it would be necessary to place a concrete levelling pad on top of the existing foundations, to ensure a level and even surface on which to place the new footings.

For the assessment of sliding resistance between precast (formed) concrete footings on screened concrete, and assuming the use of post-grouting, it is recommended that a coefficient of friction of 0.6 be used.

To supplement the sliding resistance and provide additional resistance to lateral forces, mechanical attachments such as dowels may be used to secure the new footings to the existing footings; the dowels should be designed by the structural engineer. Lightweight fill could also be used behind the abutment walls to reduce the active thrust on the walls.

6.6.4 Foundation Compliance Springs

Once the preferred foundation design alternative has been confirmed and the footing configurations and dimensions are known, foundation compliance springs for dynamic analysis for the bridge abutments can be provided.

6.6.5 Frost Protection

For spread footings placed on fresh limestone bedrock, existing footings or mass concrete, frost protection cover is not required.

6.7 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment walls and any associated wing walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the walls:

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (Aggregates) Granular A or Granular B Type II, should be used as backfill behind the walls. Alternatively, 19 mm clear crushed stone can be used as a backfill material provided a Class II nonwoven geotextile having a Filtration Opening Size (FOS) not exceeding 100 microns in accordance with OPSS 1860 is placed over the existing embankment fill and native soil, with overlaps of at least 0.5 m between rolls, prior to placement of the clear stone. If clear stone backfill is used it should only be placed once the wing walls are in place, otherwise some type of restraint (e.g., gabion baskets) would need to be provided perpendicular to the abutments (i.e., at the ends of the excavations) prior to placement of the clear stone. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting). Other aspects of the granular backfill requirements with respect to sub drains and frost taper should be in accordance with OPSD 3101.150 (Walls, Abutment, Backfill, Minimum Granular Requirement), OPSD 3121.150 (Walls, Retaining, Backfill, Minimum Granular Requirement), and 3190.100 (Walls, Retaining and Abutment, Wall Drain).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC Section 6.12.3 and Figure 6.6. Care must be taken during the compaction operation not to overstress the wall. Heavy construction equipment should be maintained at a distance of at least 1 m away from the walls while the backfill soils are being placed. Hand operated compaction equipment should be used to compact the backfill soils within a 1 m wide zone adjacent to the walls. Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.8 m behind the back of the wall (Case (a) on Figure C6.20 of the Commentary to the CHBDC). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (Case (b) on Figure C6.20 of the Commentary to the CHBDC).

6.7.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated.

For Case (a), the pressures are based on the proposed embankment fill and the following parameters (unfactored) may be used assuming the use of earth fill or Select Subgrade Material (SSM):

Table 10: Static Lateral Earth Pressure Coefficients, Earth Fill or SSM

Soil Type	Internal Angle of Friction (ϕ°)	Soil Unit Weight (γ , kN/m ³)	Coefficients of Earth Pressure		
			Active, K_a	At-Rest, K_o	Passive, K_p
Earth Fill or SSM	30	20	0.33	0.50	3.0

For Case (b), the pressures are based on using engineered granular fill or clear stone and the following parameters (unfactored) may be used:

Table 11: Static Lateral Earth Pressure Coefficients, Earth Granular A, B Type II and Clear Stone

Soil Type	Internal Angle of Friction (ϕ°)	Soil Unit Weight (γ , kN/m ³)	Coefficients of Earth Pressure		
			Active, K_a	At-Rest, K_o	Passive, K_p
Granular A	35	22	0.27	0.43	3.7
Granular B Type II	35	21	0.27	0.43	3.7
Clear Stone	28	17	0.36	0.53	2.8

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

Where the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the Commentary to the CHBDC.

6.7.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must be taken into account in the design in accordance with Section 4.6 of the CHBDC. In this regard, the following should be included in the assessment of lateral earth pressures:

Seismic loading will result in increased lateral earth pressures acting on the wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 6.7.1 above, plus the earthquake-induced dynamic earth pressure.

In accordance with Sections 4.6.5 and C.4.6.5 of the 2014 CHBDC and its Commentary, for structures which do not allow lateral yielding, the horizontal seismic coefficient (k_h) used in the calculation of the seismic active pressure coefficient is taken as equal to the site adjusted PGA estimated at the ground surface (i.e. 0.24g for Site Class B for this site; see Section 6.4.3). For structures which allow lateral yielding, k_h is taken as 0.5 times the site adjusted PGA estimated at the ground surface (i.e. 0.12g for Site Class B).

The seismic active pressure coefficients (K_{AE}) provided in Table 12 for the two backfill cases (Case (a) and Case (b)) may be used in design. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

In accordance with Section C4.6.5 of the Commentary to the CHBDC the K_{AE} value for a yielding wall is applicable provided that the wall can move up to $250k_h$ mm, where k_h is the site-specific PGA as given in Table 12. This corresponds to displacements of about 60 mm for the 2,475-year design earthquake at this site.

Table 12: Seismic Active Pressure Coefficients, K_{AE} for Various Materials

Structure Type	Design Earthquake	Site Specific PGA (g)	Granular A	Granular B Type II	SSM	Clear Stone
Non-Yielding Wall	2,475-year	0.24	0.43	0.43	0.51	0.55
Yielding Wall			0.34	0.34	0.41	0.44

The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_a \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ yielding walls}$$

$$\sigma_h(d) = K_o \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ non-yielding walls}$$

Where: $\sigma_h(d)$ is the (static plus seismic) lateral earth pressure at depth, d , (kPa);

K_a is the static active earth pressure coefficient;

K_o is the static at-rest earth pressure coefficient;

K_{AE} is the seismic active earth pressure coefficient;

γ is the unit weight of the backfill soil (kN/m^3), as given previously;

d is the depth below the top of the wall (m); and,

H is the total height of the wall (m).

6.8 Embankment Design and Construction

Based on the May 2019 General Arrangement (GA) Drawing provided by WSP, Highway 417 will not be widened at this location and the bridge structures are to be replaced in kind. It is also understood that the existing retaining wall along the northeast embankment slope will be removed and replaced as part of the overall construction plan for the bridge replacement.

6.8.1 Subgrade Preparation

Any surficial topsoil, organic matter, and softened/loosened soils or fill containing deleterious material should be stripped from within the limits of the footprint of the new embankment, including from the any existing embankment side slopes. All subgrade soils should be proof rolled prior to fill placement.

Any new embankment fill for the approach embankments should be placed and compacted in accordance with OPSS.PROV 206 (*Grading*) and OPSS.PROV 501 (*Compacting*). Benching of the existing embankment side slopes should be carried out to “key in” the new fill materials in areas where the embankment is widened, in accordance with OPSD 208.010 (*Benching of Earth Slopes*).

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

6.8.2 Assessment of Global Stability

The global stability for the proposed widening constructed using conventional granular fill with 2H:1V side slopes as outlined in WPS's May 2019 GA, was evaluated using GeoStudio 2018 Slope/W software for limit equilibrium analysis. Input parameters for the analysis provided in Table 13 are based on the in-situ SPT N values and the results of laboratory testing. It has been assumed the site preparation activities as outlined above will occur prior to construction of the embankment.

The following additional parameters were used in the analysis.

- The embankment is to be constructed with a horizontal backslope.
- A seismic horizontal loading of 0.12g, equal to ½ of the site adjusted PGA value (0.24g) was used for seismic analysis, (see Section 6.4.3).
- Groundwater level of 60.0 m.

Table 13: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m ³)	Internal Angle of Friction (φ°)
New Earth or Granular Embankment Fill	20	33
Existing Highway Embankment Fill	20	33
Existing Grade Fill	19	30

With appropriate subgrade preparation and proper placement of earth or granular soils, the 6 to 7 m high embankment, with a 2H:1V side slope, will have a factor of safety greater than 1.54 against deep seated slope instability and a factor of safety greater than 1.1 for seismic instability. The results do however indicate that some shallow sloughing (with factors of safety less than 1.1) could occur of the embankment side slopes during seismic loading. That sloughing would not however impair the embankment in the short-term and is mainly a maintenance/repair issue. The potential for sloughing could be reduced by providing well vegetated side slopes, as mentioned above in Section 6.8.1. The results of the slope stability analysis are provided in Figures G1 and G2 in Appendix G.

6.8.3 Settlement

Based on the subsurface conditions encountered at the site (and in the absence of any compressible soil layers), only minimal settlement (i.e., less than 25 mm) is anticipated due to the compression of the existing embankment fill, which is expected to take place during the construction of the widening. The magnitude of settlement of the new embankment fill will depend on the type of fill placed, on the method and sequence of placement and compaction, but is expected to range from about 0.5 to 1.0 percent of the thickness of the embankment fill.

6.9 Other Design Considerations

It has been confirmed by testholes advanced through the abutment footings that these footings are founded on the bedrock. It is likely that the existing footings for the retaining walls (up to the expansion joints) are founded on the bedrock, however, confirmation of the founding conditions in these areas is outside of the current scope of work.

6.10 Construction Considerations

6.10.1 Open-Cut Excavations

Excavations 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.

Excavations to depths of up to about 6 to 7 m below the existing Highway 417 grade through the existing fill are anticipated. The groundwater levels at the abutments are indicated to be at about Elevation 65.7 m within the overburden, just above the bedrock surface (i.e., at or just above the founding level of the existing foundations).

The soils at this site would be generally classified as Type 3 soils (compact to loose fill material above groundwater level) in accordance with the OHSA. Accordingly, excavations should be made with side slopes no steeper than 1H:1V. Any fill which extends below the water table would be classified as Type 4 soil and excavations in these materials should be sloped no steeper than 3H:1V. As indicated in OHSA, if an excavation contains more than one type of soil, the soil type for the excavation shall be classified as the type with the highest number among the soil types present within the excavation.

6.10.2 Temporary Protection Systems

If the required safe side slopes for the open cut excavations cannot be accommodated, then temporary roadway protection (i.e., excavation shoring) will be required to facilitate excavation to the foundation level for the RBR. Temporary excavation support may also be required along Preston Street for construction of the abutment footings due to space restrictions and existing utilities.

The design of the shoring will be entirely the responsibility of the contractor. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems), and the lateral movement should meet Performance Level 2 provided that any existing adjacent utilities can tolerate this magnitude of deformation. Traffic loading should be included as a surcharge. Traffic loading above the shoring and does not account for construction equipment loadings which may be higher; the contractor's shoring designer should confirm those load requirements.

6.10.3 Groundwater and Surface Water Control

The groundwater level at the site is typically near or below the bedrock surface. Excavations to expose the bedrock surface for founding of spread footings will likely involve minimal groundwater and surface water control. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

However, the selection and design of temporary unwatering/dewatering system is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with Special Provision (SP) FOUN0003 (*Dewatering Structure Excavations*) which amends OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*).

In accordance with SP FOUN0003, the temporary dewatering system shall be designed and carried out in accordance with OPSS.PROV 517 (*Dewatering*) with amendments as per SP 517F01 (*Dewatering System*). Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, and it is therefore not a requirement to carry out a preconstruction survey or to require a dewatering design engineer for the dewatering system as per Table A of SP 517F01.

6.11 Corrosion and Cement Type

One soil sample was submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results in Table 5 were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, GU cement could be specified for concrete in below grade applications.


The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. Generally, the test results provided in Table 5 indicate a high potential for corrosion of exposed ferrous metal at the site which should be considered in the design.

7.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior Geotechnical Engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

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William Cavers, P.Eng.
Associate, Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

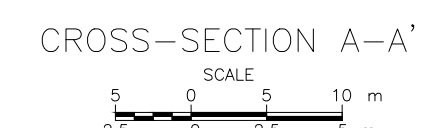
KCP/WC/FJH/hdw

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Table 14 – Comparison of Foundation Alternatives

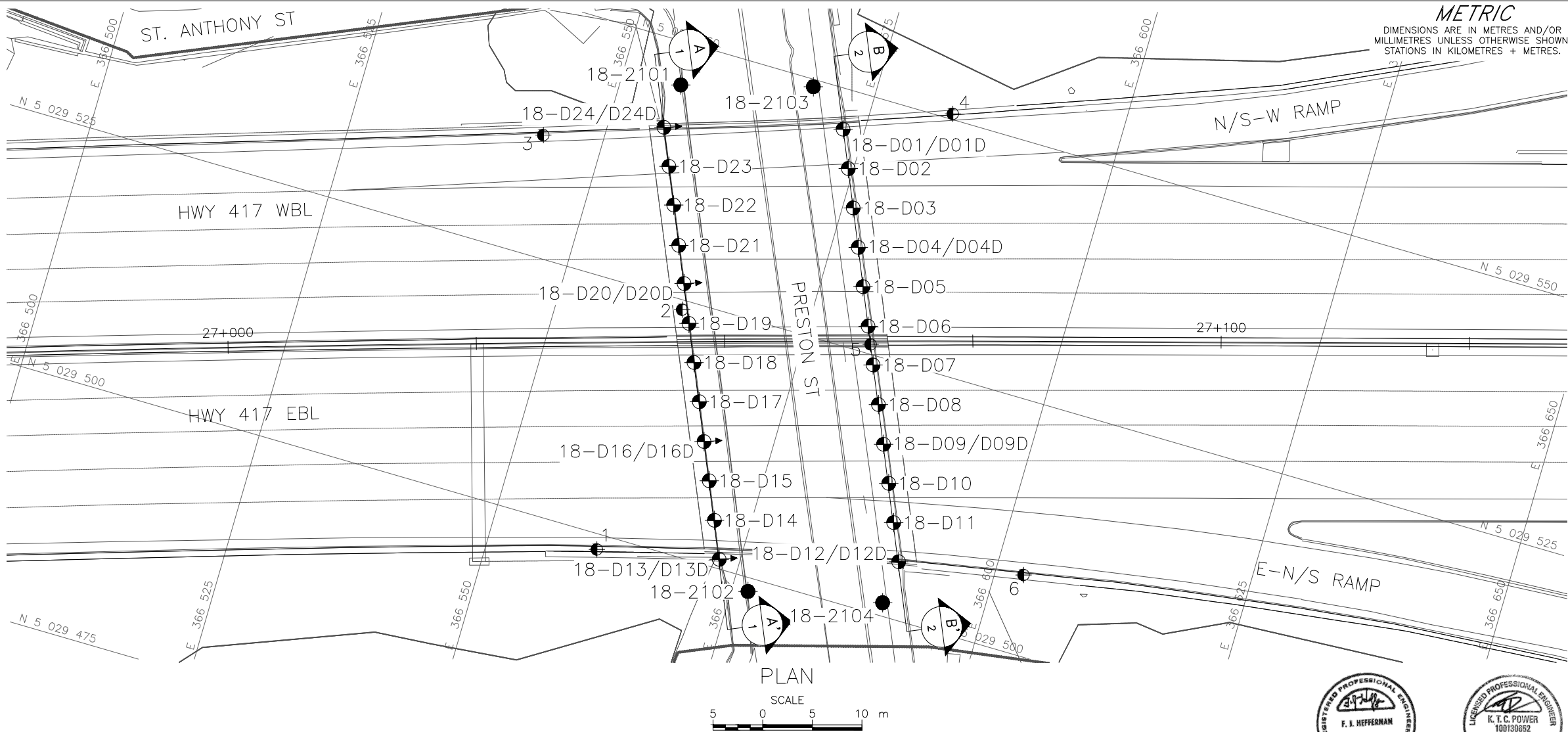
Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/Risks
New cast-in-place or precast spread footings supported on existing spread footings	<ul style="list-style-type: none">■ Feasible for support of the bridge replacement and rapid bridge replacement (RBR) technique■ Preferred option from a foundation perspective	<ul style="list-style-type: none">■ Avoids demolition and removal of existing foundations allowing reduced excavation support■ Compatible with rapid bridge replacement (RBR) techniques■ Facilitates shorter construction time compared to casting new footings	<ul style="list-style-type: none">■ Structural design must counteract sliding of new footings on existing foundations■ A levelling layer of grout will likely be required between the new and existing footings if precast footings are used	<ul style="list-style-type: none">■ Low cost■ Less expensive than deep foundations	<ul style="list-style-type: none">■ Low risk of settlement; existing overpass structures have performed satisfactorily■ Low to moderate risk of variation in elevation of top surface of existing footings and can be addressed through the use of a concrete levelling layer on top of footing
New cast-in-place or precast spread footings supported on bedrock	<ul style="list-style-type: none">■ Feasible for support of the of the bridge replacement and rapid bridge replacement (RBR) technique	<ul style="list-style-type: none">■ Conventional excavation and construction■ Also compatible with RBR techniques	<ul style="list-style-type: none">■ Would require demolition and removal of existing footings, unless new footings are located behind existing with a longer bridge span length (which would increase structure costs) and would increase construction time■ Deeper temporary protection required■ Results in increased time for construction compared to incorporating existing foundations due to excavation, demolition/ removal, forming, reinforcing and casting stages	<ul style="list-style-type: none">■ Moderate cost■ Less expensive than deep foundations	<ul style="list-style-type: none">■ Low risk of settlement; existing overpass structures have performed satisfactorily
Deep foundations	<ul style="list-style-type: none">■ Feasible but not required or practical	<ul style="list-style-type: none">■ High bearing resistance■ Negligible settlement	<ul style="list-style-type: none">■ Shallow bedrock depth would likely require socketing into the strong limestone bedrock for a stable pile/caisson configuration	<ul style="list-style-type: none">■ High cost, compared to other viable alternatives	<ul style="list-style-type: none">■ Rock socketing would be required



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

Base plans provided in digital format by WSP Canada Group Limited,
drawing file nos. MIDTOWN-XB1.dwg and 3416024-XA1-MEDIAN.dwg,
received APR. 19, 2017.

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NO.	DATE	BY	REVISION
Geocres No. 31G5-310			
HWY. 417		PROJECT NO. 1655214-1210	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 9/25/2019	SITE: 3-55/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

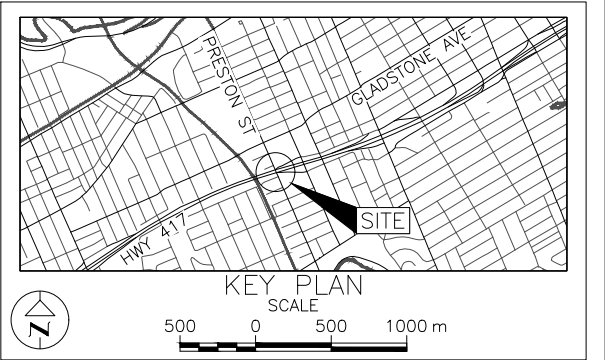


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173-15-00

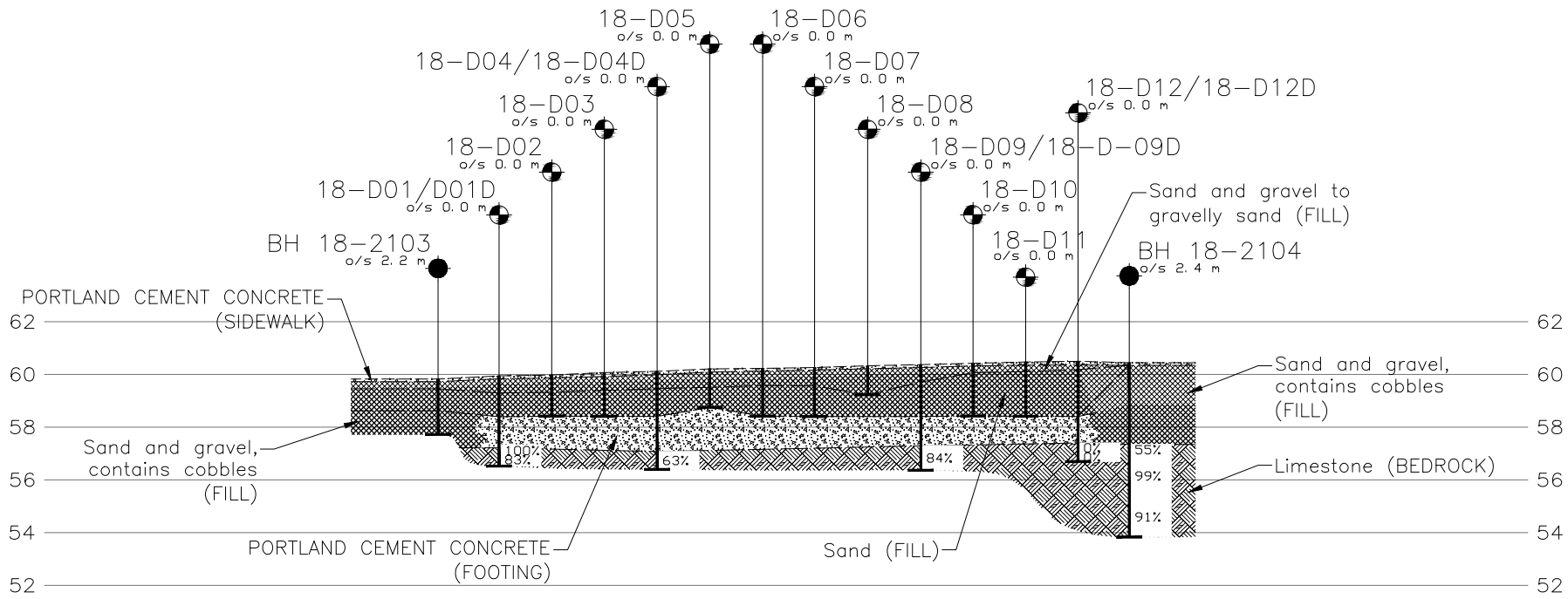
HIGHWAY 417 OVERPASS
STRUCTURES AT PRESTON STREET
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.402932 LONG. -75.710928

SHEET



LEGEND

- Borehole - Current Investigation
- Corehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31G05-032)
- Inclined Borehole Orientation
- 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)

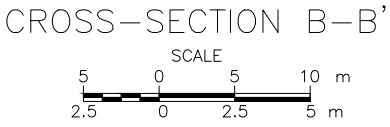


BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
18-D01/D01D	59.9	5029546.0	366572.9
18-D02	60.0	5029542.3	366574.5
18-D03	60.1	5029538.7	366576.1
18-D04/D04D	60.1	5029535.0	366577.7
18-D05	60.2	5029531.3	366579.2
18-D06	60.2	5029527.7	366580.8
18-D07	60.3	5029524.0	366582.4
18-D08	60.3	5029520.4	366584.0
18-D09/D09D	60.4	5029516.7	366585.6
18-D10	60.4	5029513.0	366587.2
18-D11	60.5	5029509.4	366588.8
18-D12/D12D	60.5	5029505.7	366590.4
18-D13/D13D	60.4	5029500.9	366573.0
18-D14	60.4	5029504.6	366571.4
18-D15	60.3	5029508.3	366569.8
18-D16/D16D	60.3	5029511.9	366568.2
18-D17	60.3	5029515.6	366566.6
18-D18	60.2	5029519.3	366565.0
18-D19	60.2	5029522.9	366563.4
18-D20/D20D	60.1	5029526.6	366561.8
18-D21	60.0	5029530.2	366560.2
18-D22	60.0	5029533.9	366558.6
18-D23	59.9	5029537.5	366557.1
18-D24/D24D	59.9	5029541.2	366555.5
18-D21	60.0	5029530.2	366560.2
18-D22	60.0	5029533.9	366558.6
18-D23	59.9	5029537.5	366557.1
18-D24	59.9	5029541.2	366555.5
18-2101	59.7	5029545.7	366555.9
18-2102	60.3	5029498.6	366576.6
18-2103	59.8	5029549.3	366568.8
18-2104	60.4	5029501.3	366590.0
BH 1	67.3	5029498.4	366560.8
BH 2	60.1	5029524.0	366562.4
BH 3	59.5	5029537.0	366544.0
BH 4	59.6	5029550.5	366583.0
BH 5	60.0	5029526.0	366581.6
BH 6	65.1	5029507.9	366602.8

NOTES

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

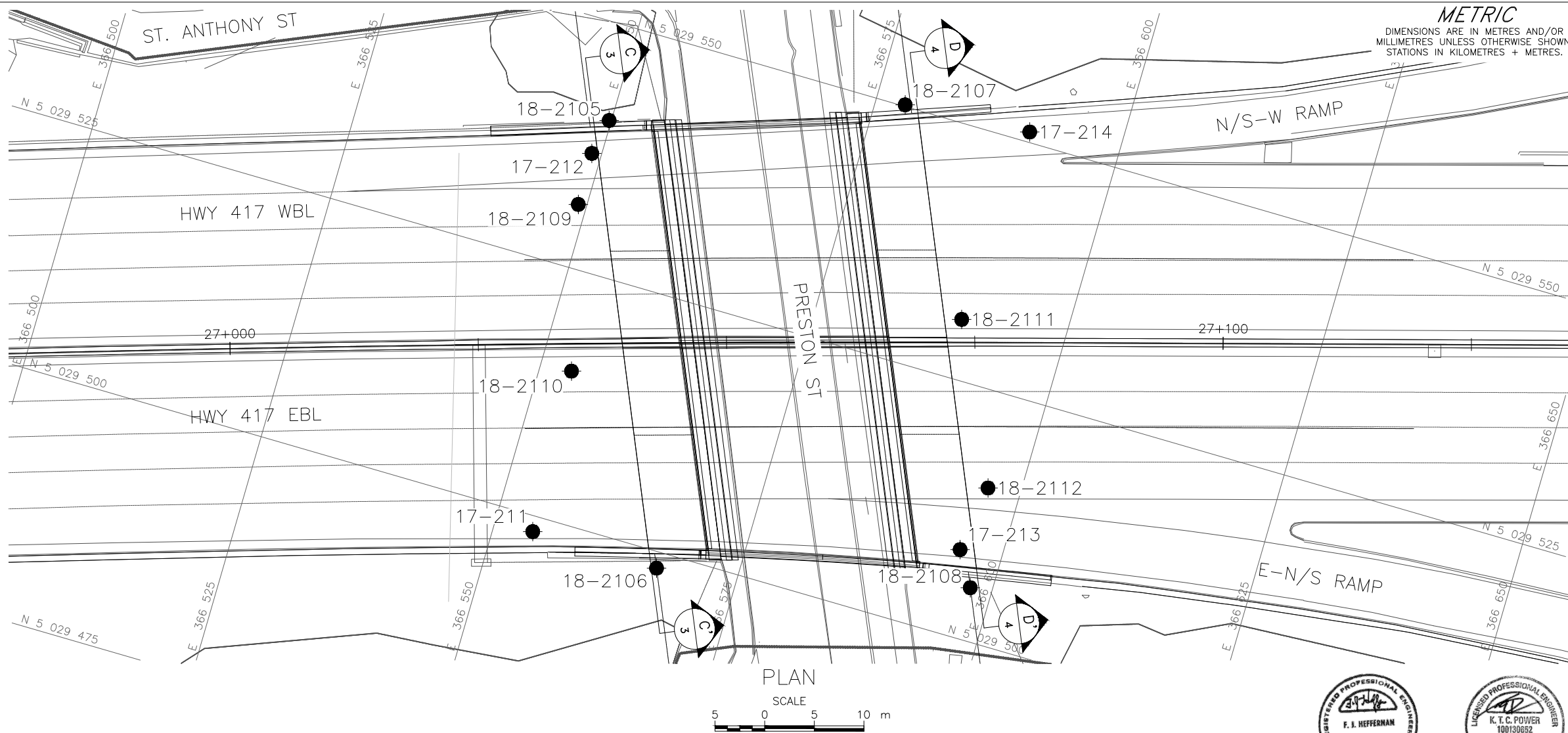
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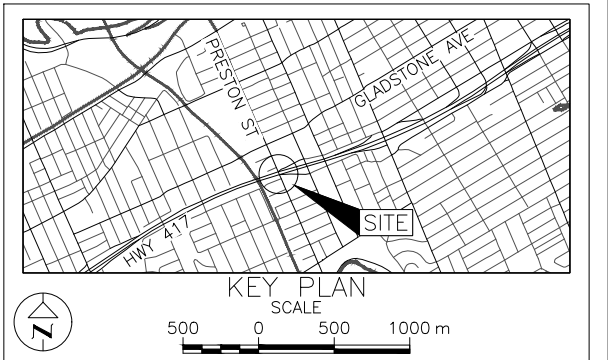
NO.	DATE	BY	REVISION
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DRAWN: JM		CHKD. FJH	APPD. FJH
		DIST. EASTERN	
		SITE: 3-55/1&2	
		DWG. 2	



CONT No.
GWP No. 4173-15-00

HIGHWAY 417 OVERPASS
STRUCTURES AT PRESTON STREET
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.402932 LONG. -75.710928

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 OCT 27, 2017

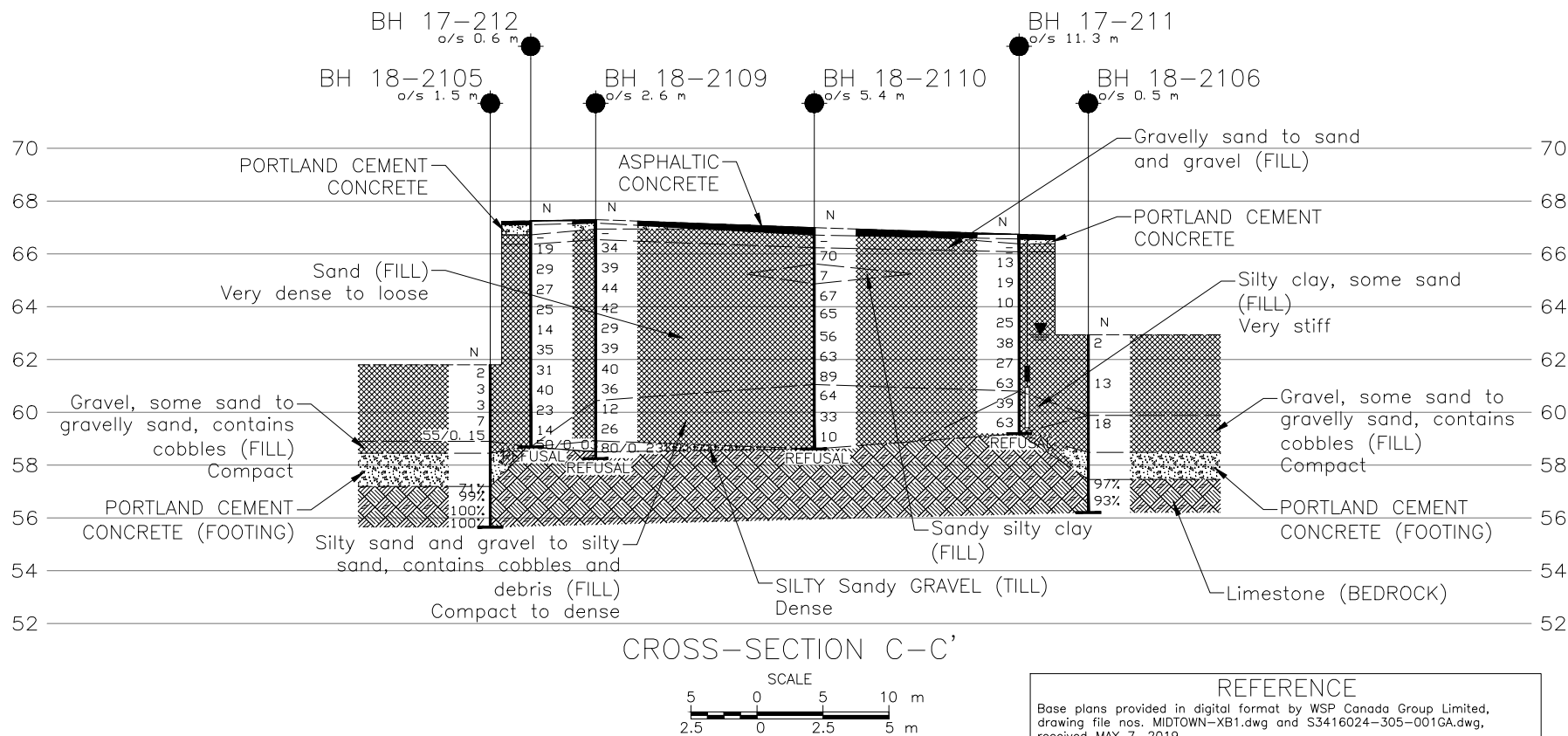
BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
17-211	66.7	5029498.4	366553.9
17-212	67.2	5029536.7	366549.0
17-213	66.2	5029508.7	366595.8
17-214	66.6	5029551.0	366590.8
18-2105	61.8	5029540.3	366549.8
18-2106	62.9	5029498.4	366566.9
18-2107	62.6	5029550.2	366578.0
18-2108	62.9	5029505.3	366597.8
18-2109	67.3	5029531.4	366549.2
18-2110	67.0	5029515.0	366553.2
18-2111	66.7	5029531.0	366589.5
18-2112	66.4	5029515.4	366596.7

NOTES

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

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



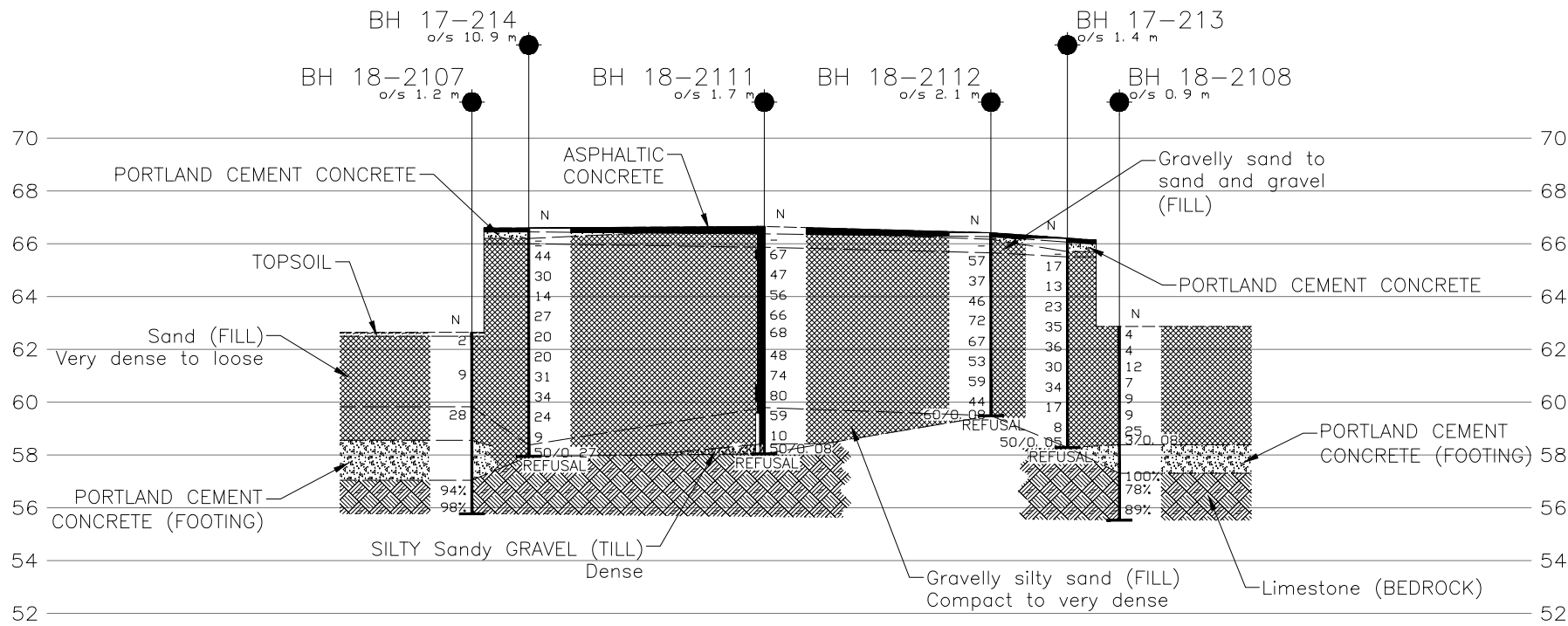
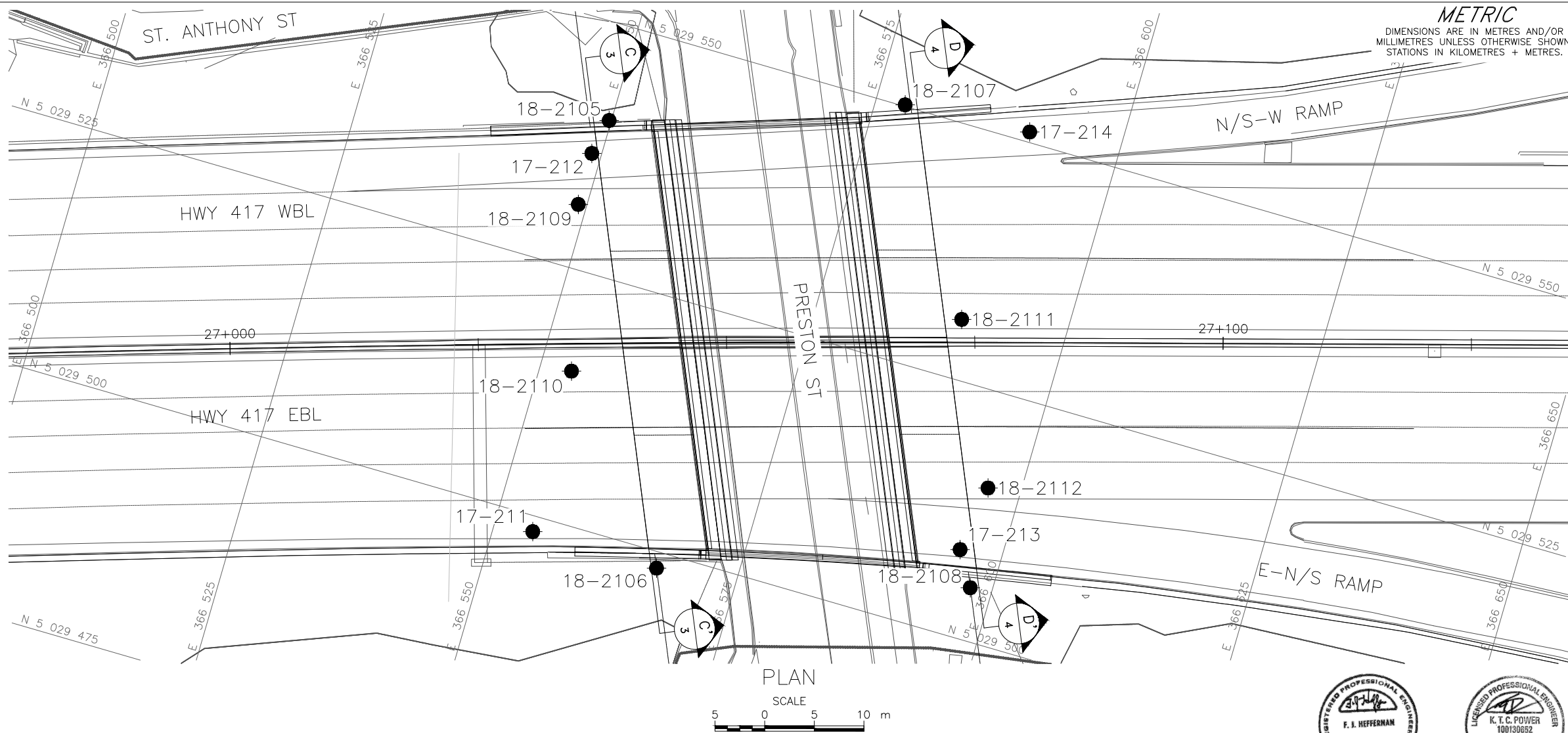
REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file nos. MIDTOWN-XB1.dwg and S3416024-305-001GA.dwg, received MAY 7, 2019.

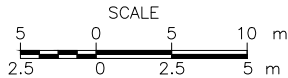
NO.	DATE	BY	REVISION
1	9/25/2019	JM	1
2	10/1/2019	FJH	2
3	10/1/2019	FJH	3

Geocres No. 31G5-310

HWY. 417	PROJECT NO. 1655214-1210	DIST. EASTERN
SUBM'D. KCP	CHKD. KCP	DATE: 9/25/2019
DRAWN: JM	CHKD. FJH	APPD. FJH
		DWG. 3



CROSS-SECTION D-D'



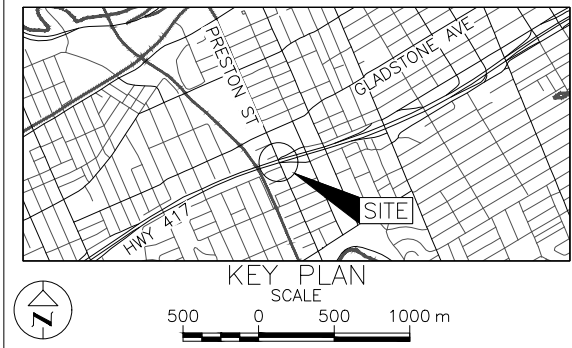
REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file nos. MIDTOWN-XB1.dwg and S3416024-305-001GA.dwg, received MAY 7, 2019.

CONT No.
GWP No. 4173-15-00

HIGHWAY 417 OVERPASS
STRUCTURES AT PRESTON STREET
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.402932 LONG. -75.710928

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)

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9

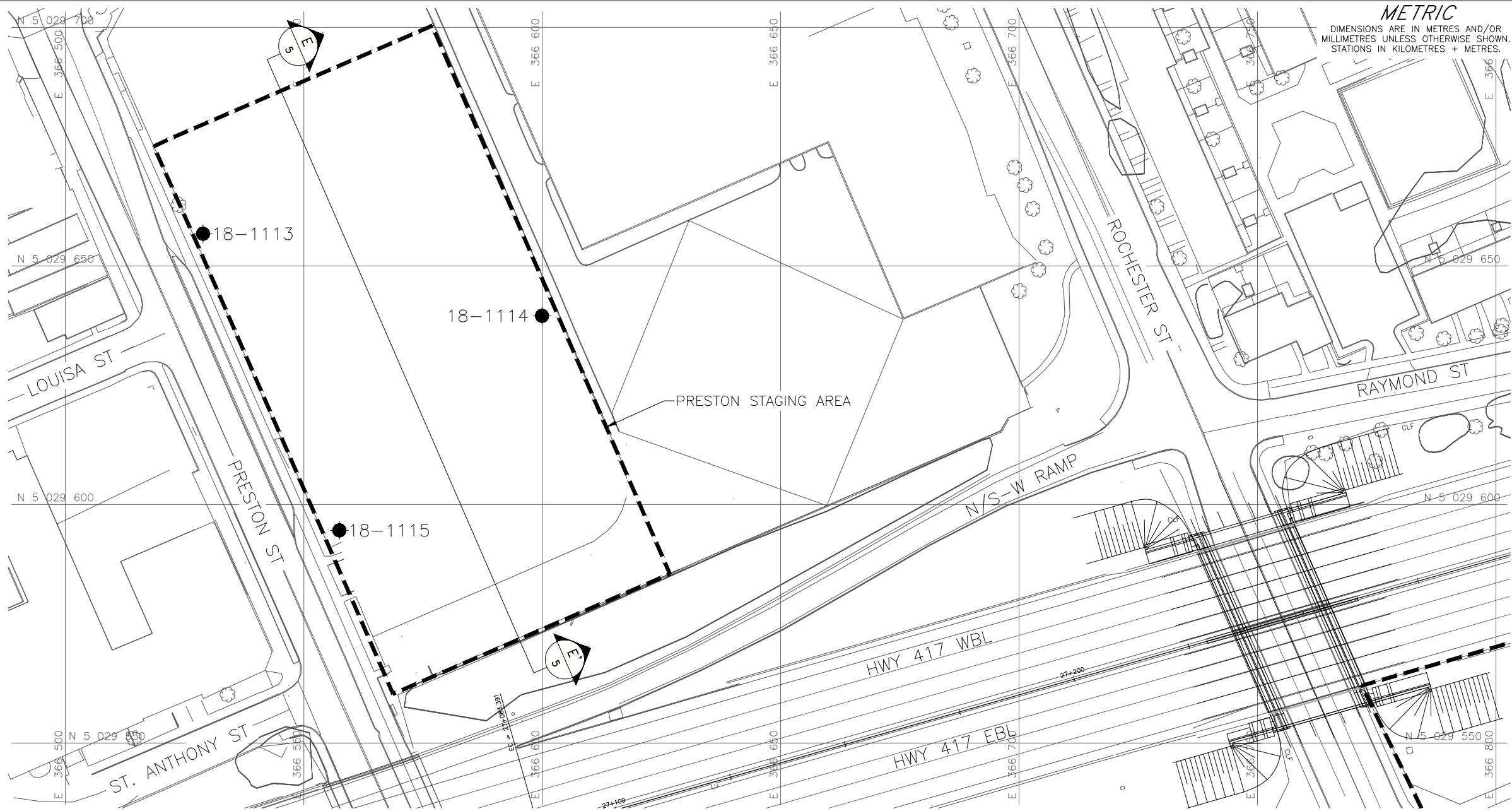
No.	ELEVATION	NORTHING	EASTING
17-211	66.7	5029498.4	366553.9
17-212	67.2	5029536.7	366549.0
17-213	66.2	5029508.7	366595.8
17-214	66.6	5029551.0	366590.8
18-2105	61.8	5029540.3	366549.8
18-2106	62.9	5029498.4	366566.9
18-2107	62.6	5029550.2	366578.0
18-2108	62.9	5029505.3	366597.8
18-2109	67.3	5029531.4	366549.2
18-2110	67.0	5029515.0	366553.2
18-2111	66.7	5029531.0	366589.5
18-2112	66.4	5029515.4	366596.7

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.

NO.	DATE	BY	REVISION
1	9/25/2019	JM	1
Geocres No. 31G5-310			
HWY. 417		PROJECT NO. 1655214-1210	
SUBM'D. KCP		DATE: 9/25/2019	
DRAWN: JM		SITE: 3-55/1&2	
CHKD. KCP		APPD. FYI	
CHKD. FYI		DWG. 4	



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

CONT No.
GWP No. 4173-15-00

HIGHWAY 417 OVERPASS
STRUCTURES AT PRESTON STREET
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404099 LONG. -75.711066

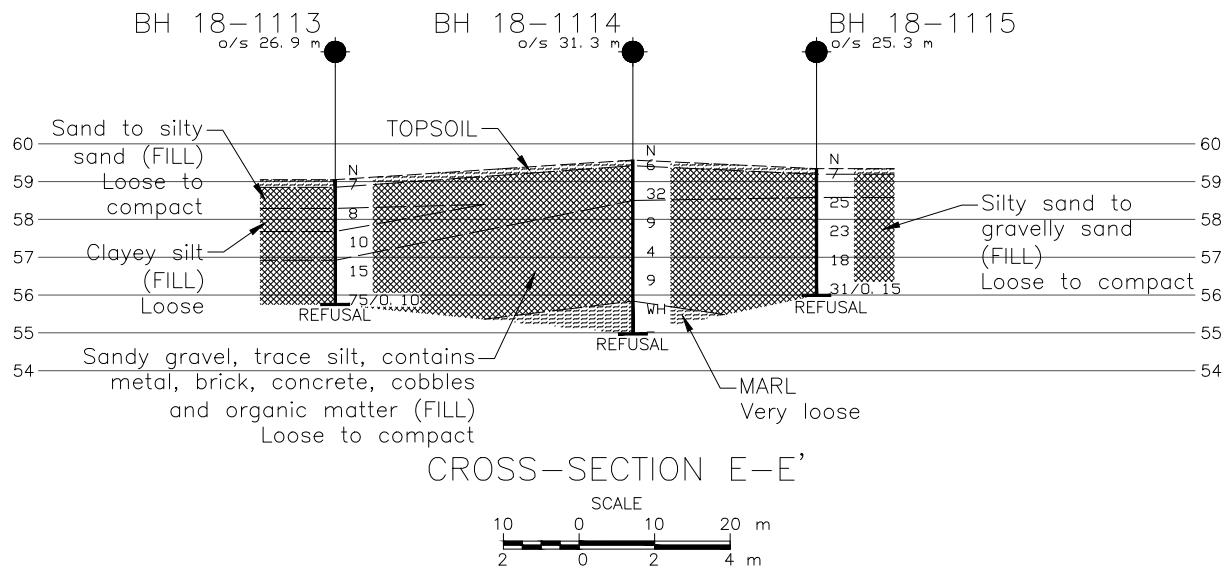
SHEET



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
18-1113	59.1	5029656.7	366528.9
18-1114	59.6	5029639.5	366600.0
18-1115	59.3	5029594.6	366557.5



NOTES

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

REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file no. 3416024-XSTAGING AREA.dwg, received MARCH 22, 2019.



NO.	DATE	BY	REVISION
Geocres No. 31G5-310			
HWY. 417	PROJECT NO. 1655214-1210		DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/09/2019	SITE: 3-55/1&2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 5

APPENDIX A

Borehole Record and Laboratory Test Results (Current Investigation)

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Record of Coreholes/Drillholes 18-D01 to 18-D24

Records of Boreholes 17-211 to 17-214

Record of Boreholes 18-2101 to 18-2112

Record of Boreholes 18-1113 to 18-1115

Bedrock Core Photographs, Figures A1 to A30

Table A1 - Concrete Core Condition Assessment

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, 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	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

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

(b) Cohesive Soils

Consistency	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 10	Trace	Trace sand
10 to 20	Some	Some sand
20 to 35	(ey) or (y)	Sandy
over 35	And	Sand and Gravel

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° 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 1655214-1210		RECORD OF COREHOLE No 18-D01		SHEET 1 OF 1		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029546.0; E 366572.9 NAD 83 MTM ZONE 9 (LAT. 45.403130; LONG. -75.710910)		ORIGINATED BY PAH			
DIST Eastern HWY 417		BOREHOLE TYPE Portable Drill/Hydro-excavation		COMPILED BY ZS			
DATUM Geodetic		DATE November 6, 2018		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED											
59.9	GROUND SURFACE																			
0.0	PORTLAND CEMENT																			
59.8	CONCRETE (SIDEWALK)																			
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-															
59.6	(SP) Sand, some gravel (FILL) Brown Moist		2	GS	-															
0.3																				
59.3	(SP) Sand (FILL) Brown																			
0.7																				
58.4																				
1.6	END OF COREHOLE AT TOP OF FOOTING NOTES: 1. Corehole continued on Record of Drillhole 18-D01D																			

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PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-D01D

SHEET 1 OF 1

LOCATION: N 5029546.0 ; E 366572.9

DRILLING DATE: November 7, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS S.D.C.	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	10 ⁻⁹	10 ⁻⁸	10 ⁻⁷	10 ⁻⁶		W1	W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
		TOP OF FOOTING		58.39																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

DEPTH SCALE

1 : 25



LOGGED: PAH

CHECKED: KCP

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D02		SHEET 1 OF 1		METRIC							
G.W.P.		4173-15-00		LOCATION		N 5029542.3; E 366574.5 NAD 83 MTM ZONE 9 (LAT. 45.403090; LONG. -75.710890)		ORIGINATED BY PAH							
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY ZS							
DATUM		Geodetic		DATE		November 6, 2018		CHECKED BY KCP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p	W	W _L			
60.0	GROUND SURFACE							20	40	60	80	100			
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)														
59.9	(GP) Sandy gravel (FILL)														
0.1	Grey														
59.7	(SP) Gravelly sand (FILL)														
0.3															
59.4	(SP) Sand (FILL)														
0.7	Brown Moist														
58.4	END OF COREHOLE AT TOP OF FOOTING														
1.6															

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D03				SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029538.7; E 366576.1 NAD 83 MTM ZONE 9 (LAT. 45.403060; LONG. -75.710870)		ORIGINATED BY		PAH								
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY		ZS								
DATUM		Geodetic		DATE		November 6, 2018		CHECKED BY		KCP								
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 (%)
60.1	GROUND SURFACE							20	40	60	80	100						
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)						60											
60.0																		
0.2	(GP) Sandy gravel (FILL) Grey Moist																	
59.7																		
0.4	(SP) Gravelly sand (FILL) Grey brown Moist																	
59.4																		
0.7	(SP) Sand (FILL) Brown Moist																	
58.4																		
1.7	END OF COREHOLE AT TOP OF FOOTING																	

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D04		SHEET 1 OF 1		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029535.0; E 366577.7 NAD 83 MTM ZONE 9 (LAT. 45.403030; LONG. -75.710850)		ORIGINATED BY PAH									
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY ZS									
DATUM		Geodetic		DATE		November 6, 2018		CHECKED BY KCP									
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									
60.1	GROUND SURFACE							20	40	60	80	100					
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-												
59.8																	
0.4	(SP) Gravelly sand (FILL) Grey brown Moist		2	GS	-												
59.4																	
0.7	(SP) Sand, contains metal wire (FILL) Brown Moist																
58.4			3	GS	-												
1.7	END OF COREHOLE AT TOP OF FOOTING																
NOTES:																	
1. Corehole continued on Record of Drillhole 18-D04D																	

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-D04D

SHEET 1 OF 1

LOCATION: N 5029535.0 ;E 366577.7

DRILLING DATE: November 6, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
							TOTAL CORE % 000000 000000	SOLID CORE % 000000 000000				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 ⁻⁹ 10 ⁻⁸ 10 ⁻⁷ 10 ⁻⁶	10 ⁻⁹ 10 ⁻⁸ 10 ⁻⁷ 10 ⁻⁶	W1 W2 W3 W4 W5 W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		TOP OF FOOTING		58.41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

DEPTH SCALE

1 : 25



LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT		1655214-1210				RECORD OF COREHOLE No 18-D05				SHEET 1 OF 1				METRIC					
G.W.P.		4173-15-00		LOCATION		N 5029531.3; E 366579.2 NAD 83 MTM ZONE 9 (LAT. 45.402990; LONG. -75.710840)				ORIGINATED BY				PAH					
DIST		Eastern		HWY		417		BOREHOLE TYPE		Portable Drill/Hydro-excavation				COMPILED BY		ZS			
DATUM		Geodetic		DATE		November 5-6, 2018				CHECKED BY		KCP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L						
60.2	GROUND SURFACE																		
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																		
0.1	(GP) Sandy gravel (FILL) Grey Moist																		
59.8	(SP) Gravelly sand Grey brown Moist																		
0.4																			
59.5	(SP) Sand Brown Moist																		
0.7																			
58.7	END OF COREHOLE AT TOP OF FOOTING																		
1.5																			

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D06		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029527.7; E 366580.8 NAD 83 MTM ZONE 9 (LAT. 45.402960; LONG. -75.710820)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 5-6, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W _p	W	W _L		GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
								20	40	60	80	100	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
60.2	GROUND SURFACE					1	GS	-	60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

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

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D07		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029524.0; E 366582.4 NAD 83 MTM ZONE 9 (LAT. 45.402930; LONG. -75.710800)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 5, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								20	40	60	80	100	W _p	W	W _L					
60.3	GROUND SURFACE																			
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																			
0.1	(GP) Sandy gravel (FILL) Grey Moist																			
60.0							60													
0.4	(SP/GP) Sand and gravel, contains cobbles (FILL) Brown Moist																			
59.6																				
0.7	(SP) Sand (FILL) Brown Moist																			
58.4							59													
1.9	END OF COREHOLE AT TOP OF FOOTING																			

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D08		SHEET 1 OF 1		METRIC										
G.W.P.		4173-15-00		LOCATION		N 5029520.4; E 366584.0 NAD 83 MTM ZONE 9 (LAT. 45.402890; LONG. -75.710780)		ORIGINATED BY PAH										
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY ZS										
DATUM		Geodetic		DATE		November 5, 2018		CHECKED BY KCP										
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 (%)
60.3	GROUND SURFACE							20	40	60	80	100						
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																	
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-													
60.0																		
0.4	(SP) Sand, some gravel, contains cobbles/boulder (FILL) Brown		2	GS	-													
59.2																		
1.1	END OF COREHOLE																	
NOTES:																		
1. Hydro-excavation refusal on cobble/boulder.																		

PROJECT		RECORD OF COREHOLE No 18-D09				SHEET 1 OF 1		METRIC									
1655214-1210		G.W.P. 4173-15-00		LOCATION N 5029516.7; E 366585.6 NAD 83 MTM ZONE 9 (LAT. 45.402860; LONG. -75.710760)		ORIGINATED BY PAH											
DIST Eastern HWY 417		BOREHOLE TYPE Portable Drill/Hydro-excavation		COMPILED BY ZS													
DATUM Geodetic		DATE November 5, 2018		CHECKED BY KCP													
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
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	25 50 75	kN/m ³				
60.4	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
60.3	(GP) Sandy gravel (FILL)																
0.1	Grey Moist																
60.1	(SP) Gravelly sand (FILL)																
0.4	Grey brown Moist																
59.7	(SP) Sand (FILL)																
0.7	Brown Moist																
58.4	END OF COREHOLE AT TOP OF FOOTING																
2.0	NOTES: 1. Corehole continued on Record of Drillhole 18-D09D																

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-D09D

SHEET 1 OF 1

LOCATION: N 5029516.7 ;E 366585.6

DRILLING DATE: November 5, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Js	10 ⁻⁵	10 ⁻⁴	10 ⁻³	10 ⁻²	W1		W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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2	Rotary Drill 48 mm Diam.	TOP OF FOOTING		58.40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

DEPTH SCALE

1 : 25



LOGGED: PAH

CHECKED: KCP

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PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D10		SHEET 1 OF 1		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029513.0; E 366587.2 NAD 83 MTM ZONE 9 (LAT. 45.402830; LONG. -75.710740)		ORIGINATED BY PAH									
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY ZS									
DATUM		Geodetic		DATE		November 5, 2018		CHECKED BY KCP									
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									
60.4	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-												
60.0	(SP) Sand, contains brick/asphaltic concrete pieces (FILL) Brown Moist																
0.4			2	GS	-												
58.4	END OF COREHOLE AT TOP OF FOOTING																
2.0																	

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D11				SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029509.4; E 366588.8 NAD 83 MTM ZONE 9 (LAT. 45.402800; LONG. -75.710720)		ORIGINATED BY		PAH								
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY		ZS								
DATUM		Geodetic		DATE		November 5, 2018		CHECKED BY		KCP								
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 (%)
60.5	GROUND SURFACE							20	40	60	80	100						
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																	
60.4	(GP) Sandy gravel (FILL)																	
0.1	Grey Moist																	
60.1	(SP) Sand (FILL)																	
0.4	Brown Moist																	
58.4	END OF COREHOLE AT TOP OF FOOTING																	
2.1																		

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

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: CCC

[illegible]

DEPTH SCALE

1 : 25



GOLDER

LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL IM\IMTO\HWY417\REHAB&WIDENING\02 DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D13		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029500.9; E 366573.0 NAD 83 MTM ZONE 9 (LAT. 45.402720; LONG. -75.710920)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	REMOULDED	WATER CONTENT (%)						
60.4	GROUND SURFACE						20	40	60	80	100									
0.0	PORTLAND CEMENT CONCRETE																			
0.1	(GP) Sandy Gravel (FILL) Grey Moist		1	GS	-															
60.1	(SP) Sand, some gravel (FILL) Brown Moist		2	GS	-															
0.3																				
59.7	END OF COREHOLE AT CONCRETE DUCT BANK																			
0.7																				

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: CCC

[illegible]

DEPTH SCALE

1 : 25



GOLDER

LOGGED: PAH

CHECKED: KCP

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D14		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029504.6; E 366571.4 NAD 83 MTM ZONE 9 (LAT. 45.402750; LONG. -75.710940)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	REMOULDED	w _p	w		w _L			
60.4	GROUND SURFACE						20	40	60	80	100									
0.0	PORTLAND CEMENT																			
60.3	CONCRETE (SIDEWALK)																			
0.1	(GP) Sandy gravel (FILL)																			
60.1	Grey																			
0.3	Moist																			
	(SP) Sand, some gravel, contains																			
	pieces of transite pipe (FILL)																			
	Brown																			
59.6																				
0.8	END OF COREHOLE AT																			
	CONCRETE DUCT BANK																			

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF COREHOLE No 18-D15		SHEET 1 OF 1		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029508.3; E 366569.8 NAD 83 MTM ZONE 9 (LAT. 45.402790; LONG. -75.710960)		ORIGINATED BY PAH									
DIST		Eastern HWY 417		BOREHOLE TYPE		Portable Drill/Hydro-excavation		COMPILED BY ZS									
DATUM		Geodetic		DATE		November 8, 2018		CHECKED BY KCP									
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									
60.3	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
0.1	(GP) Sandy gravel (FILL) Grey Moist																
60.0																	
0.3	(SP) Sand, some gravel (FILL) Brown Moist																
59.5																	
0.8	END OF COREHOLE AT CONCRETE DUCT BANK																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D16		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029511.9; E 366568.2 NAD 83 MTM ZONE 9 (LAT. 45.402820; LONG. -75.710980)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W _p	W	W _L		GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE	20	40	60	80	100	● QUICK TRIAXIAL × REMOULDED	WATER CONTENT (%)						
60.3	GROUND SURFACE																				
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																				
60.2																					
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-																
60.0																					
0.3	(SP) Sand, some gravel (FILL) Brown Moist		2	GS	-																
59.5																					
0.8	END OF COREHOLE AT CONCRETE DUCT BANK																				

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-D16D

SHEET 1 OF 1

LOCATION: N 5029511.9 ; E 366568.2

DRILLING DATE: November 12, 2018

DATUM: Geodetic

INCLINATION: -65° AZIMUTH: 100°

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Js	10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³	W1 W2 W3 W4 W5 W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
0		GROUND SURFACE		60.30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											</

UCS = 52 MPa

DEPTH SCALE

1 : 25



LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D17		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029515.6; E 366566.6 NAD 83 MTM ZONE 9 (LAT. 45.402850; LONG. -75.711000)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
60.3	GROUND SURFACE																			
0.0	PORTLAND CEMENT																			
60.2	CONCRETE (SIDEWALK)																			
0.1	(GP) Sandy gravel (FILL)																			
60.0	Grey																			
	Moist																			
0.3	(SP) Sand, some gravel (FILL)																			
	Brown																			
	Moist																			
59.6																				
0.7	END OF COREHOLE AT CONCRETE DUCT BANK																			

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PROJECT 1655214-1210			RECORD OF COREHOLE No 18-D18			SHEET 1 OF 1			METRIC								
G.W.P. 4173-15-00			LOCATION N 5029519.3; E 366565.0 NAD 83 MTM ZONE 9 (LAT. 45.402890; LONG. -75.711020)			ORIGINATED BY PAH											
DIST Eastern HWY 417			BOREHOLE TYPE Portable Drill/Hydro-excavation			COMPILED BY ZS											
DATUM Geodetic			DATE November 8, 2018			CHECKED BY KCP											
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									
60.2	GROUND SURFACE							20	40	60	80	100					
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
0.1	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-		60										
59.9																	
0.3	(SP) Sand, some gravel (FILL) Moist		2	GS	-												
59.5																	
0.7	END OF COREHOLE AT CONCRETE DUCT BANK																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D19		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029522.9; E 366563.4 NAD 83 MTM ZONE 9 (LAT. 45.402920; LONG. -75.711040)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W _p	W	W _L		GR	SA	SI	CL	
60.2	GROUND SURFACE																		
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																		
60.1	(GP) Sandy gravel (FILL) Grey Moist																		
59.9	(SP) Sand, some gravel (FILL) Brown Moist																		
0.3																			
59.6																			
0.6	END OF COREHOLE AT CONCRETE DUCT BANK																		

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PROJECT		RECORD OF COREHOLE No 18-D20				SHEET 1 OF 1		METRIC									
G.W.P. 1655214-1210		LOCATION N 5029526.6; E 366561.8 NAD 83 MTM ZONE 9 (LAT. 45.402950; LONG. -75.711060)				ORIGINATED BY PAH											
DIST Eastern HWY 417		BOREHOLE TYPE Portable Drill/Hydro-excavation				COMPILED BY ZS											
DATUM Geodetic		DATE November 8, 2018				CHECKED BY KCP											
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									
60.1	GROUND SURFACE							20	40	60	80	100					
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)						60										
0.1	(SP) Gravelly sand (FILL)																
59.8	Grey Moist																
0.3	(SP) Sand, some gravel, contains pieces of transite pipe (FILL)																
59.5	Brown Moist																
0.6	END OF COREHOLE AT CONCRETE DUCT BANK																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-D20D

SHEET 1 OF 1

LOCATION: N 5029526.6 ;E 366561.8

DRILLING DATE: November 8, 2018

DATUM: Geodetic

INCLINATION: -70° AZIMUTH: 100°

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Js	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1			W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
0		GROUND SURFACE		60.08																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

UCS = 19 MPa

DEPTH SCALE

1 : 25






LOGGED: PAH

CHECKED: KCP

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PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D21		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029530.2; E 366560.2 NAD 83 MTM ZONE 9 (LAT. 45.402980; LONG. -75.711080)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	REMOULDED	W _p	W		W _L			
60.0	GROUND SURFACE																			
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																			
59.9	(GP) Sandy gravel (FILL) Grey Moist		1	GS	-															
59.7	(SP) Sand, some gravel (FILL) Brown Moist		2	GS	-															
59.4	END OF COREHOLE AT CONCRETE DUCT BANK																			
0.6																				

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D22		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029533.9; E 366558.6 NAD 83 MTM ZONE 9 (LAT. 45.403020; LONG. -75.711100)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _p	W	W _L					
60.0	GROUND SURFACE																			
0.0	PORTLAND CEMENT																			
59.9	CONCRETE (SIDEWALK)																			
0.1	(GP) Sandy gravel (FILL)																			
59.7	Grey Moist																			
0.3	(SP) Sand, some gravel (FILL)																			
59.4	Brown Moist																			
0.6	END OF COREHOLE AT CONCRETE DUCT BANK																			

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF COREHOLE No 18-D23		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029537.5; E 366557.1 NAD 83 MTM ZONE 9 (LAT. 45.403050; LONG. -75.711120)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill/Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 8, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)							
59.9	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
59.8																	
0.1	(GP) Sandy gravel (FILL)																
59.6	Grey Moist																
0.3	(SP) Sand, some gravel (FILL)																
	Brown Moist																
59.3																	
0.6	END OF COREHOLE AT CONCRETE DUCT BANK																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITOHWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT 1655214-1210				RECORD OF COREHOLE No 18-D24				SHEET 1 OF 1				METRIC					
G.W.P. 4173-15-00				LOCATION N 5029541.2; E 366555.5 NAD 83 MTM ZONE 9 (LAT. 45.403080; LONG. -75.711140)				ORIGINATED BY PAH									
DIST Eastern HWY 417				BOREHOLE TYPE Portable Drill/Hydro-excavation				COMPILED BY ZS									
DATUM Geodetic				DATE November 8, 2018				CHECKED BY KCP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
59.9	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																
59.8	(GP) Sandy gravel (FILL)		1	GS	-												
59.7	Grey Moist																
0.2	(SP) Sand, some gravel (FILL)																
	Brown Moist																
59.3	END OF COREHOLE AT CONCRETE DUCT BANK																
0.6																	

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITOHWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: CCC

[illegible]

DEPTH SCALE

1 : 25



GOLDER

LOGGED: PAH

CHECKED: KCP

PROJECT		1655214-1210		RECORD OF BOREHOLE No 17-211		SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029498.4; E 366553.9 NAD 83 MTM ZONE 9 (LAT. 45.402709; LONG. -75.711165)		ORIGINATED BY								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY								
DATUM		Geodetic		DATE		August 9, 2017		CHECKED BY								
								KCP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W _p	W	W _L		
66.7	GROUND SURFACE															
0.0	ASPHALTIC CONCRETE															
66.3	PORTLAND CEMENT CONCRETE															
0.4	(SP) Gravelly sand (FILL)		1	GRAB	-											
66.0	Grey		2	GRAB	-											
0.7	Dry															
	(SP) Sand, trace silt (FILL)		3	SS	13											
	Compact to very dense															
	Brown		4	SS	19											
	Moist															
			5	SS	10											
			6	SS	25											
			7	SS	38											
			8	SS	27											
			9	SS	63											
60.8	(Cl) Silty clay, some sand (FILL)															
5.9	Very stiff		10	SS	39											
	Grey brown															
	Moist		11	SS	63											
59.2	END OF BOREHOLE															
7.6	AUGER REFUSAL															
NOTES:																
1. Water level in well screen at a depth of 3.8 m below ground surface (Elev. 62.9 m), measured on October 27, 2017.																

PROJECT		1655214-1210		RECORD OF BOREHOLE No 17-212		SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029536.7; E 366549.0 NAD 83 MTM ZONE 9 (LAT. 45.403053; LONG. -75.711222)		ORIGINATED BY								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY								
DATUM		Geodetic		DATE		August 14, 2017		CHECKED BY								
KCP																
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								
67.2	GROUND SURFACE															
0.0	ASPHALTIC CONCRETE															
0.2	PORTLAND CEMENT CONCRETE															
66.7																
0.5	(SP) Gravelly sand (FILL) Grey Dry		1	GRAB	-											
66.3																
0.9	(SP) Sand, trace silt (FILL) Compact to dense Brown Moist		2	SS	19											
			3	SS	29											
			4	SS	27											
			5	SS	25											
			6	SS	14											
			7	SS	35											
			8	SS	31											
			9	SS	40											
			10	SS	23											
			11	SS	14											
			12	SS	50/0.03											
58.6																
8.6	END OF BOREHOLE AUGER REFUSAL															

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITOHWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT 1655214-1210		RECORD OF BOREHOLE No 17-213		SHEET 1 OF 1		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029508.7; E 366595.8 NAD 83 MTM ZONE 9 (LAT. 45.402797; LONG. -75.710629)		ORIGINATED BY RI			
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY ZS			
DATUM Geodetic		DATE August 9, 2017		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE	20	40	60	80	100								
								● QUICK TRIAXIAL × REMOULDED	20	40	60	80	100								
66.2	GROUND SURFACE																				
0.0	ASPHALTIC CONCRETE																				
0.2	PORTLAND CEMENT CONCRETE																				
65.7																					
65.5	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-																
0.7	(SP) Sand, trace silt (FILL) Loose Grey brown Moist		2	SS	17																
			3	SS	13																
			4	SS	23																
			5	SS	35																
			6	SS	36																
			7	SS	30																
			8	SS	34																
			9	SS	17																
			10	SS	8																
			11	SS	50/0.05																
58.3	END OF BOREHOLE AUGER REFUSAL																				
7.9																					

PROJECT 1655214-1210		RECORD OF BOREHOLE No 17-214		SHEET 1 OF 1		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029551.0; E 366590.8 NAD 83 MTM ZONE 9 (LAT. 45.403179; LONG. -75.710687)		ORIGINATED BY DG			
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY ZS			
DATUM Geodetic		DATE August 14, 2017		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	w _p	w	w _L					
66.6	GROUND SURFACE																			
0.0	ASPHALTIC CONCRETE																			
66.2	PORTLAND CEMENT CONCRETE																			
66.0	(SP) Gravelly sand (FILL) Grey Dry		1	GRAB	-															
0.6	(SP/SM) Sand, trace silt (FILL) Dense to loose Brown Moist		2	GRAB	-															
			3	SS	44															
			4	SS	30															
			5	SS	14															
			6	SS	27															
			7	SS	20															
			8	SS	20															
			9	SS	31															
			10	SS	34															
			11	SS	24															
			12	SS	9															
58.4	(SM) Gravelly sand, some silt, trace clay, contains brick fragments (FILL) Dark grey brown Moist		13	SS	50/0.27															
8.2																				
58.0	END OF BOREHOLE AUGER REFUSAL																			
8.7																				

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMT\Hwy417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT 1655214-1210		RECORD OF BOREHOLE No 18-2101		SHEET 1 OF 2		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029545.7; E 366555.9 NAD 83 MTM ZONE 9 (LAT. 45.403130; LONG. -75.711130)		ORIGINATED BY PAH			
DIST Eastern HWY 417		BOREHOLE TYPE Hydro-excavation, Rotary Drill, HW Casing/HQ Core		COMPILED BY ZS			
DATUM Geodetic		DATE November 8, 2018		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p W W _L						
59.7	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.2	(GW) Sand and gravel, some silt Grey to brown		1	GS	-												
			2	GS	-												
			3	GS	-												
58.0																	
1.8	Limestone (BEDROCK) Bedrock cored from depths 1.8 m to 7.1 m For bedrock coring details refer to Record of Drillhole 18-2101		1	RC	REC 100%												
			2	RC	REC 99%												
			3	RC	REC 100%												
			4	RC	REC 100%												
52.6																	
7.1	END OF BOREHOLE																

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

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTD\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2101

SHEET 2 OF 2

LOCATION: N 5029545.7 ; E 366555.9

DRILLING DATE: November 8, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 ⁻⁹	10 ⁻⁸	10 ⁻⁷	10 ⁻⁶	W1	W2		W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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UCS = 39 MPa

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF BOREHOLE No 18-2102		SHEET 1 OF 2		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029498.6; E 366576.6 NAD 83 MTM ZONE 9 (LAT. 45.402700; LONG. -75.710870)		ORIGINATED BY PAH									
DIST		Eastern HWY 417		BOREHOLE TYPE		Hydro-excavation, Rotary Drill, NW Casing/NQ Core		COMPILED BY ZS									
DATUM		Geodetic		DATE		November 8, 2018		CHECKED BY KCP									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p W W _L				
60.3	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALTIC CONCRETE																
0.2	(GP) Gravel, some sand, trace silt (FILL) Grey		1	GS	-												81 14 (5)
59.4			2	GS	-												
1.0	(SP) Sand, contains cobbles (FILL) Brown Moist		3	GS	-												
58.7																	
1.6	Limestone (BEDROCK) Bedrock cored from depths 1.6 m to 4.5 m For bedrock coring details refer to Record of Drillhole 18-2102		1	RC	REC 95%												RQD = 87%
			2	RC	REC 100%												RQD = 100%
55.8																	
4.5	END OF BOREHOLE																
NOTES:																	
1. Water level in well screen at a depth of 2.9 m below ground surface (Elev. 57.4 m), measured on April 25, 2019.																	

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2102

SHEET 2 OF 2

LOCATION: N 5029498.6 ;E 366576.6

DRILLING DATE: November 8, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCC

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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	w1	w2	w3	w4	w5		w6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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		Continued from Record of Borehole 18-2102		58.66																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT <u>1655214-1210</u>		RECORD OF BOREHOLE No 18-2103		SHEET 1 OF 1		METRIC	
G.W.P. <u>4173-15-00</u>		LOCATION <u>N 5029549.3; E 366568.8 NAD 83 MTM ZONE 9 (LAT. 45.403160; LONG. -75.710970)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Hydro-excavation</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>November 15, 2018</u>		CHECKED BY <u>KCP</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		WATER CONTENT (%)			
								20	40	60	80	100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED							
59.8	GROUND SURFACE																			
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)																			
59.4	(SW) Gravelly sand, angular (FILL) Grey		1	GS	-															
0.4	(SW) Sand, some gravel, contains cobbles (FILL) Brown		2	GS	-															
58.6																				
1.2	Sand and gravel, contains cobbles (FILL) Grey brown		3	GS	-															
57.7																				
2.1	END OF BOREHOLE																			
	NOTES: 1. Hydro-excavation was terminated due to proximity to vital gas main.																			

PROJECT 1655214-1210		RECORD OF BOREHOLE No 18-2104		SHEET 1 OF 2		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029501.3; E 366590.0 NAD 83 MTM ZONE 9 (LAT. 45.402720; LONG. -75.710700)		ORIGINATED BY PAH			
DIST Eastern HWY 417		BOREHOLE TYPE Hydro-excavation, Rotary Drill, HW Casing/HQ Core		COMPILED BY ZS			
DATUM Geodetic		DATE November 15, 2018		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) w _p w w _L				
60.4	GROUND SURFACE																
0.0	PORTLAND CEMENT CONCRETE																
0.1	(GW/SW) Gravel and sand, trace silt, contains asphalt and brick (FILL) Grey to brown Moist		1	GS	-												
			2	GS	-												
			3	GS	-												
58.8																	
1.6	(SW/GW) Sand and gravel, contains concrete and brick (FILL) Grey brown																
57.3																	
3.1	Limestone (BEDROCK) Bedrock cored from depths 3.1 m to 6.6 m For bedrock coring details refer to Record of Drillhole 18-2104		1	RC	REC 100%												
			2	RC	REC 100%												
			3	RC	REC 100%												
53.8																	
6.6	END OF BOREHOLE																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2104

SHEET 2 OF 2

LOCATION: N 5029501.3 ; E 366590.0

DRILLING DATE: November 15, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: CCCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec			WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Js	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1		W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
		Continued from Record of Borehole 18-2104		57.34 3.10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

UCS = 38 MPa

DEPTH SCALE

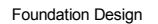
1 : 50



LOGGED: PAH

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM



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

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2105

SHEET 2 OF 2

LOCATION: N 5029540.3 ;E 366549.8

DRILLING DATE: April 25, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: Marathon 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Js	10 ⁻⁵	10 ⁻⁴	10 ⁻³	10 ⁻²	W1		W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT		RECORD OF BOREHOLE				No 18-2106		SHEET 1 OF 2		METRIC							
G.W.P. 1655214-1210		LOCATION		N 5029498.4; E 366566.9 NAD 83 MTM ZONE 9 (LAT. 45.402707; LONG. -75.710999)				ORIGINATED BY		KM							
DIST Eastern HWY 417		BOREHOLE TYPE		Rotary Drill, HW Casing/HQ Core				COMPILED BY		ZS							
DATUM Geodetic		DATE		April 24, 2019				CHECKED BY		KCP							
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									
62.9	GROUND SURFACE							20	40	60	80	100					
0.0	(SP) Sand, trace silt (FILL) Brown Moist		1	SS	2												
			2	SS	13												
59.9																	
3.1	(GP) Gravel, some sand, contains cobbles, shale and concrete fragments (FILL) Brown Moist		3	SS	18												
			1	RC	-												
			2	RC	-												
58.5																	
4.5	PORTLAND CEMENT CONCRETE (FOOTING)		3	RC	-												
			4A	RC	-												
57.4																	
5.5	Limestone (BEDROCK)		4B	RC	REC 100%												
	Bedrock cored from depths 5.5 m to 6.7 m																
	For bedrock coring details refer to Record of Drillhole 18-2106		5	RC	REC 100%												
56.2																	
6.7	END OF BOREHOLE																
	NOTES: 1. A reduced hammer drop of 0.61 m was used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of this reduced energy.																

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2106

SHEET 2 OF 2

LOCATION: N 5029498.4 ;E 366566.9

DRILLING DATE: April 24, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
					DEPTH (m)	RECOVERY			SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
												DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Js	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1	W2	W3			W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KM

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT		RECORD OF BOREHOLE				No 18-2107		SHEET 1 OF 2		METRIC							
G.W.P. 1655214-1210		LOCATION		N 5029550.2; E 366578.0 NAD 83 MTM ZONE 9 (LAT. 45.403172; LONG. -75.710851)				ORIGINATED BY		RI							
DIST Eastern HWY 417		BOREHOLE TYPE		Rotary Drill, HW Casing/HQ Core				COMPILED BY		ZS							
DATUM Geodetic		DATE		April 30, 2019				CHECKED BY		KCP							
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									
62.6	GROUND SURFACE																
0.0	(SM) Silty sand, contains organic matter (rootlets) (TOPSOIL)																
0.2	Dark brown Moist		1	SS	2												1 83 (16)
	(SP/SM) Sand, some silt (FILL)																
	Brown Moist to wet																
59.8																	
2.8	(SM/ML) Gravely silty sand to sandy silt, contains organic matter and wood (FILL)		3	SS	28												
	Dark brown Moist to wet																
58.9																	
3.8	(GP) Gravel and cobbles (FILL)																
58.5	Dark brown Moist to wet																
4.1	PORTLAND CEMENT CONCRETE (FOOTING)		1	RC	-												
57.0			2A	RC	-												
5.6	Limestone (BEDROCK)																
	Bedrock cored from depths 5.6 m to 6.9 m		2B	RC	REC 100%												RQD = 94%
	For bedrock coring details refer to Record of Drillhole 18-2107																
			3	RC	REC 100%												RQD = 98%
55.7																	
6.9	END OF BOREHOLE																
	NOTES:																
	1. A reduced hammer drop of 0.61 m was used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of this reduced energy.																

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2107

SHEET 2 OF 2

LOCATION: N 5029550.2 ; E 366578.0

DRILLING DATE: April 30, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: Marathon 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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
								RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
								TOTAL CORE %	SOLID CORE %				Jr	Js		W1	W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: RI

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT 1655214-1210		RECORD OF BOREHOLE No 18-2108				SHEET 1 OF 2		METRIC									
G.W.P. 4173-15-00		LOCATION N 5029505.3; E 366597.8 NAD 83 MTM ZONE 9 (LAT. 45.402760; LONG. -75.710600)				ORIGINATED BY PAH											
DIST Eastern HWY 417		BOREHOLE TYPE Rotary Drill, HW Casing/HQ Core				COMPILED BY ZS											
DATUM Geodetic		DATE December 4-5, 2018				CHECKED BY KCP											
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									
62.9	GROUND SURFACE							20	40	60	80	100					
0.0	(SP) Sand, some silt, contains silty sand seams (FILL) Brown Moist		1	SS	4												
			2	SS	4		62										1 87 (12)
			3	SS	12												
			4	SS	7		61										
			5	SS	9												
			6	SS	9		60										1 93 (6)
59.1	(SP) Sand, contains wood and cobbles (FILL) Brown Very moist		7	SS	25		59										
58.4			8	SS	3/0.08												
4.5	PORTLAND CEMENT CONCRETE (FOOTING)		1	RC	-												
			2	RC	-												
			3A	RC	-		58										
57.3	Limestone (BEDROCK)		3B	RC	REC 100%												
5.6	Bedrock cored from depths 5.6 m to 7.3 m For bedrock coring details refer to Record of Drillhole 18-2108		4	RC	REC 100%		57										RQD = 100%
			5	RC	REC 100%												RQD = 78%
55.6	END OF BOREHOLE						56										RQD = 89%
7.3	NOTES: 1. Manual third-weight hammer was used for all split spoon samples. "N" values are not representative of ASTM D1586 SPT N values and should be interpreted in consideration of this reduced energy.																

PROJECT: 1655214-1210

RECORD OF DRILLHOLE: 18-2108

SHEET 2 OF 2

LOCATION: N 5029505.3 ; E 366597.8

DRILLING DATE: December 4-5, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

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	
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX							
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	W1	W2	W3	W4	W5		W6
							88 88															

UCS = 20 MPa

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

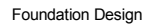
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 9/16/19 JM

PROJECT		1655214-1210		RECORD OF BOREHOLE No 18-2109		SHEET 1 OF 1		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029531.4; E 366549.2 NAD 83 MTM ZONE 9 (LAT. 45.403000; LONG. -75.711220)		ORIGINATED BY									
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY									
DATUM		Geodetic		DATE		October 17-18, 2018		CHECKED BY									
KCP																	
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									
67.3	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
66.9	PORTLAND CEMENT CONCRETE																
0.4	(SP) Sand and gravel (FILL) Grey		1	GS	-												
66.5	(SP) Sand, trace silt (FILL) Dense to compact Brown to dark brown Moist		2	SS	34												
0.8																	
			3	SS	39												
			4	SS	44												
			5	SS	42												
			6	SS	29												
			7	SS	39												
			8	SS	40												
			9	SS	36												
60.4	(SM/GM) Silty sand and gravel, contains organic matter, wood, brick and cobbles (FILL) Compact Dark brown to black Moist		10	SS	12												
6.9			11	SS	26												
58.9	(GM) Silty Sandy GRAVEL (TILL) Dense Grey Wet		12	SS	80/0.23												
58.5	Weathered BEDROCK																
58.3																	
9.1	END OF BOREHOLE AUGER REFUSAL																
NOTES: 1. Borehole dry upon completion of drilling.																	

PROJECT 1655214-1210			RECORD OF BOREHOLE No 18-2110			SHEET 1 OF 1			METRIC								
G.W.P. 4173-15-00			LOCATION N 5029515.0; E 366553.2 NAD 83 MTM ZONE 9 (LAT. 45.402850; LONG. -75.711170)			ORIGINATED BY DJG											
DIST Eastern HWY 417			BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)			COMPILED BY ZS											
DATUM Geodetic			DATE October 2, 2018			CHECKED BY KCP											
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									
67.0	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALTIC CONCRETE																
66.7																	
0.3	(SW) Sand and gravel (FILL) Grey Moist		1	GS	-												
66.2																	
0.8	(SP/SW) SAND (FILL) Very dense Brown Dry		2	SS	70												
65.6																	
1.4	(CI) Sandy silty clay, trace gravel (FILL) Stiff Grey brown Moist		3	SS	7												
64.9																	
2.1	(SM/SP) Sand, trace silt (FILL) Very dense Brown Dry to moist		4	SS	67												
			5	SS	65												
			6	SS	56												
			7	SS	63												
			8	SS	89												
61.1																	
5.9	(SP/SM) Silty sand, contains cobbles (FILL) Very dense to dense Grey Moist		9	SS	64												
			10	SS	33												
59.5																	
7.5	(SM) Silty sand, contains organic matter, cobbles, brick and wood (FILL) Compact Grey to dark brown Moist		11	SS	10												
58.6																	
8.4	END OF BOREHOLE AUGER REFUSAL																
	NOTES: 1. Borehole dry upon completion of drilling.																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITO\HWY417\REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM



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

PROJECT		1655214-1210		RECORD OF BOREHOLE No 18-2112		SHEET 1 OF 1		METRIC									
G.W.P.		4173-15-00		LOCATION		N 5029515.4; E 366596.7 NAD 83 MTM ZONE 9 (LAT. 45.402850; LONG. -75.710610)		ORIGINATED BY									
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY									
DATUM		Geodetic		DATE		October 12, 2018		CHECKED BY									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	W _p W W _L	25 50 75						
66.4	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
0.3	PORTLAND CEMENT CONCRETE																
65.6	(SP) Gravelly sand (FILL) Grey		1	GS	-		66										
0.8	(SP) Sand, trace silt (FILL) Very dense to dense Brown Moist		2	SS	57		65										
			3	SS	37												
			4	SS	46		64										
			5	SS	72		63										
			6	SS	67		62										
			7	SS	53		61										1 91 (8)
			8	SS	59												
			9	SS	44		60										0 91 (9)
59.5	END OF BOREHOLE AUGER REFUSAL		10	SS	60/0.08												
6.9	NOTES: 1. Borehole dry upon completion of drilling.																

PROJECT 1655214-1110		RECORD OF BOREHOLE No 18-1113		SHEET 1 OF 1		METRIC	
G.W.P. 4173-15-00		LOCATION N 5029656.7; E 366528.9 NAD 83 MTM ZONE 9 (LAT. 45.404130; LONG. -75.711460)		ORIGINATED BY PAH			
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY ZS			
DATUM Geodetic		DATE November 20, 2018		CHECKED BY KCP			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L				GR SA SI CL			
								20 40 60 80 100						25 50 75						
59.1	GROUND SURFACE						59													
0.0 58.9	TOPSOIL																			
0.2	(SP) Sand (FILL) Loose Brown to red-brown Moist		1	SS	7															
58.3																				
0.8	(CL-ML) Clayey silt, trace gravel, occasional sand seams (FILL) Loose Brown Moist		2	SS	8		58						o							
57.7																				
1.4	(SM) Silty sand (FILL) Compact Brown Moist		3	SS	10															
57.0							57													
2.1	(GP) Sand and gravel, trace silt (FILL) Compact Brown Moist		4	SS	15								o							
55.8							56													
3.3	END OF BOREHOLE AUGER REFUSAL		5	SS	75/0.10															

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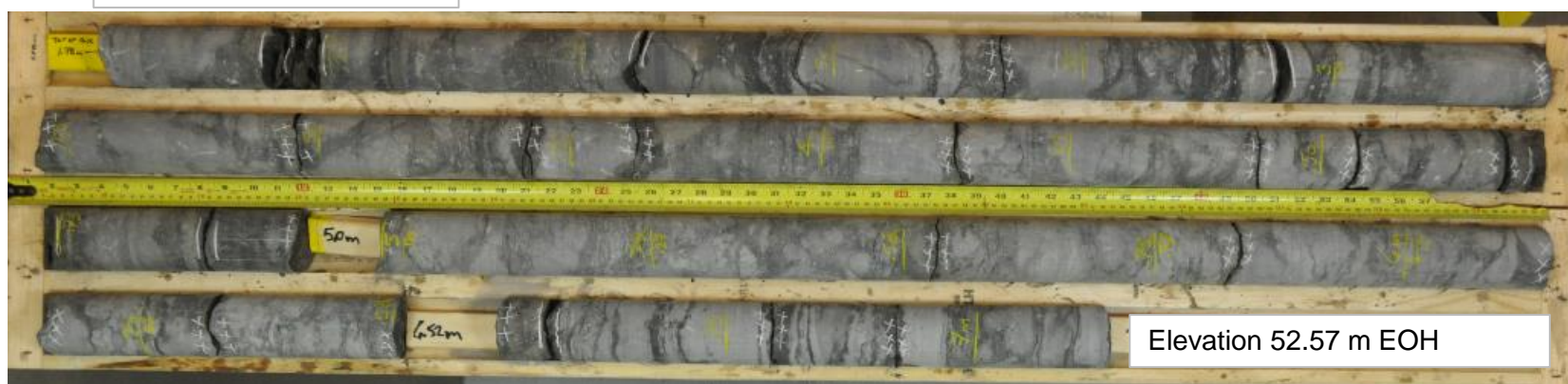
PROJECT		1655214-1110		RECORD OF BOREHOLE No 18-1114		SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029639.5; E 366600.0 NAD 83 MTM ZONE 9 (LAT. 45.403970; LONG. -75.710560)		ORIGINATED BY PAH								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY ZS								
DATUM		Geodetic		DATE		November 19, 2018		CHECKED BY KCP								
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								
59.6	GROUND SURFACE															
0.0	TOPSOIL															
0.2	(SM) Silty sand, contains organic matter (FILL)		1	SS	6											
59.2	Loose Dark brown moist															
0.5	(SP) Sand, trace gravel (FILL)															
58.5	Compact Brown Moist		2	SS	32											
1.1	(GP) Sandy gravel, trace silt, contains cobbles (FILL)															
			3	SS	9											
57.5	(GP/SP) Gravel and sand, mixed with concrete, brick debris and organic matter (FILL)															
2.1			4	SS	4											
			5	SS	9											
55.9	MARL, contains shells Light brown to grey Very loose		6	SS	WH											
3.7																
55.1	Limestone (BEDROCK)		7	SS	-											
4.6	END OF BOREHOLE AUGER REFUSAL															

PROJECT		1655214-1110		RECORD OF BOREHOLE No 18-1115		SHEET 1 OF 1		METRIC								
G.W.P.		4173-15-00		LOCATION		N 5029594.6; E 366557.5 NAD 83 MTM ZONE 9 (LAT. 45.403560; LONG. -75.711110)		ORIGINATED BY PAH								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY ZS								
DATUM		Geodetic		DATE		November 19, 2018		CHECKED BY KCP								
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								
59.3	GROUND SURFACE															
0.0	TOPSOIL															
0.2	(SP) Sand (FILL) Loose Brown to red-brown Moist		1	SS	7		59									
58.5																
0.8	(GP) Sandy gravel (FILL) Compact Brown Moist		2	SS	25		58									
			3	SS	23											
			4	SS	18		57									
56.0			5	SS	31/0.15		56									
3.4	END OF BOREHOLE AUGER REFUSAL															

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 9/16/19 JM

BH 18-2101 (Dry)
Core Box 1 of 1

Top of Bedrock 57.92 m



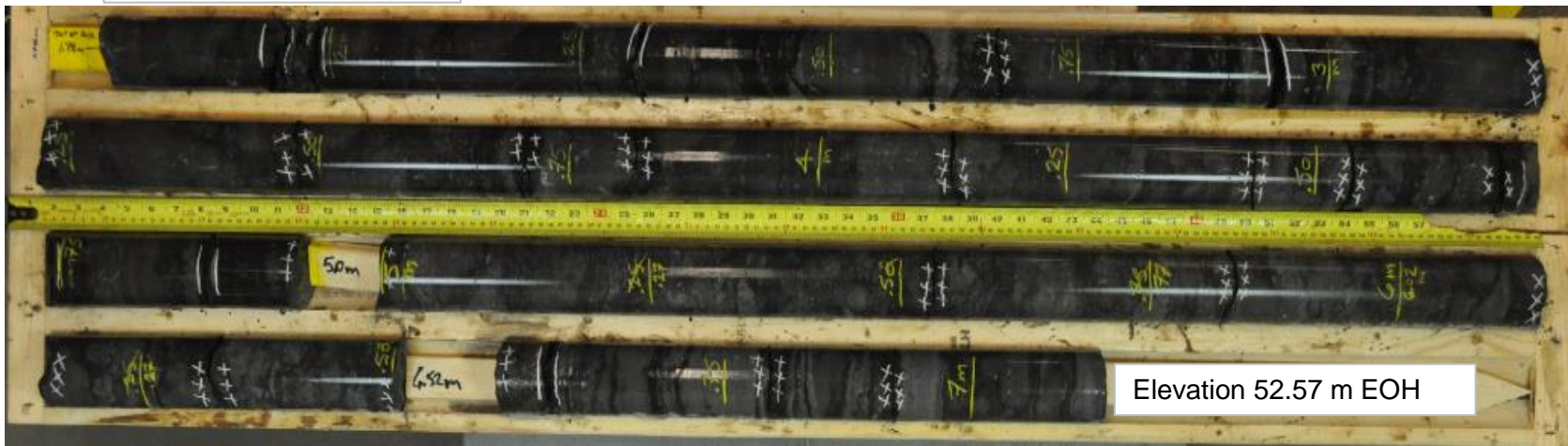
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Figure A1

BH 18-2101 (Wet)
Core Box 1 of 1

Top of Bedrock 57.92 m



Elevation 52.57 m EOH

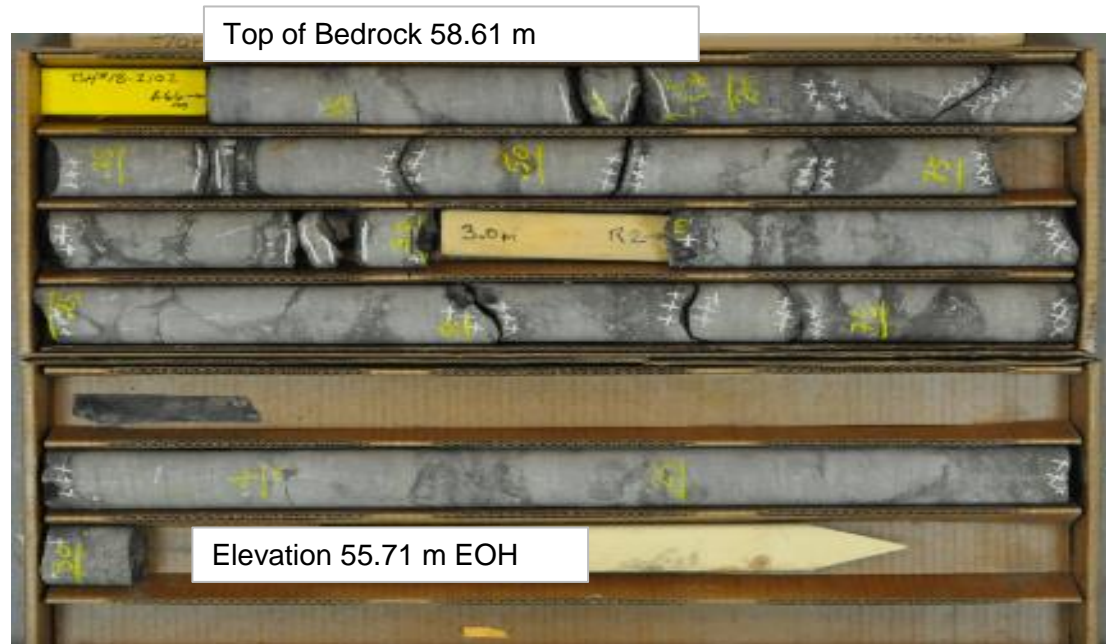


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Figure A2

BH 18-2102 (Dry)
Core Box 1 of 1



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Figure A3

BH 18-2102 (Wet)
Core Box 1 of 1



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Figure A4

BH 18-2104 (Dry)
Core Box 1 and 2 of 2

Top of Bedrock Elevation 57.34 m



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Figure A5

BH 18-2104 (Wet)
Core Box 1 and 2 of 2

Top of Footing Elevation 57.34 m



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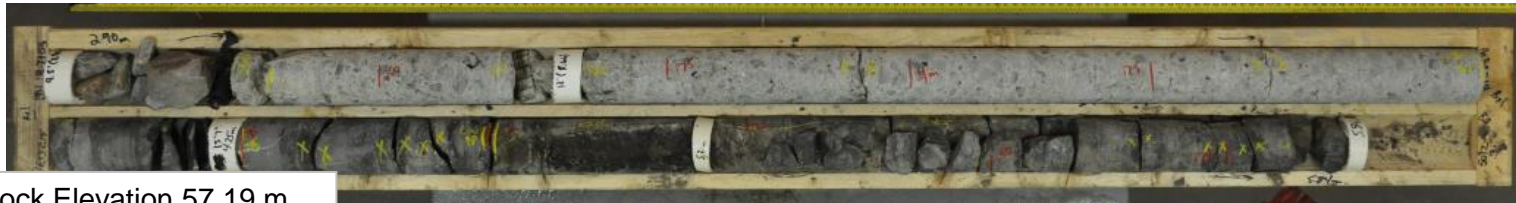
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Figure A6

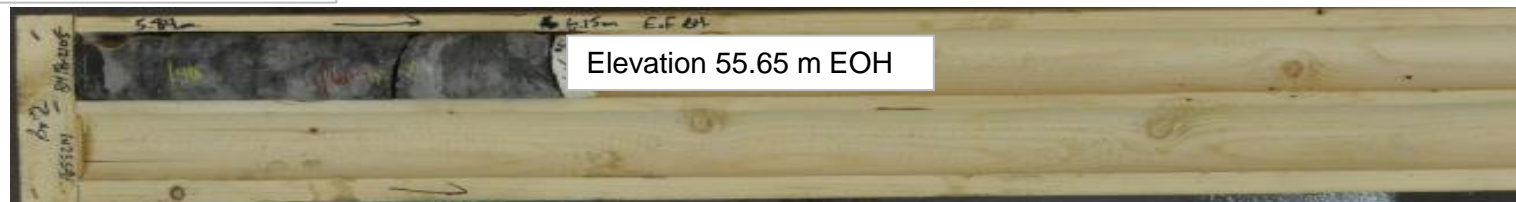
BH 18-2105 (Dry)
Core Box 1 and 2 of 2

Cobbles

Top of Footing Elevation 58.45 m



Top of Bedrock Elevation 57.19 m



Elevation 55.65 m EOH



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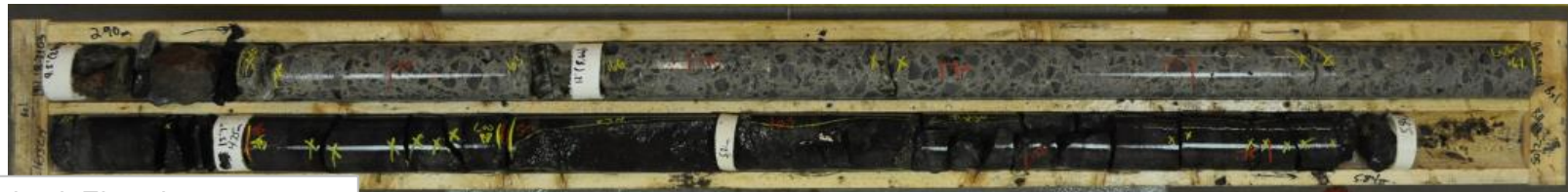
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Figure A7

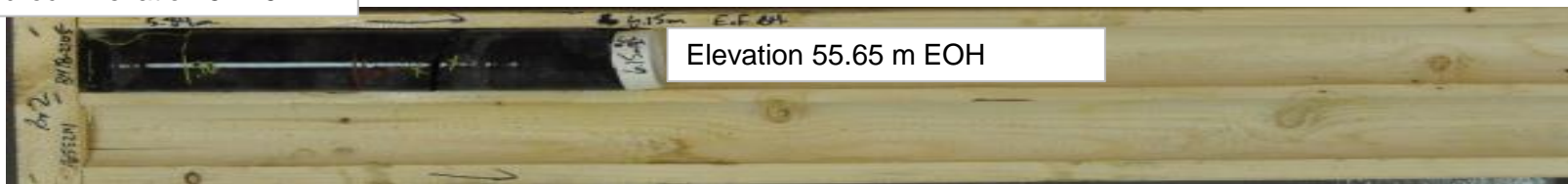
**BH 18-2105 (Wet)
Core Box 1 and 2 of 2**

Cobbles

Top of Footing Elevation 58.45 m



Top of Bedrock Elevation 57.19 m



Elevation 55.65 m EOH

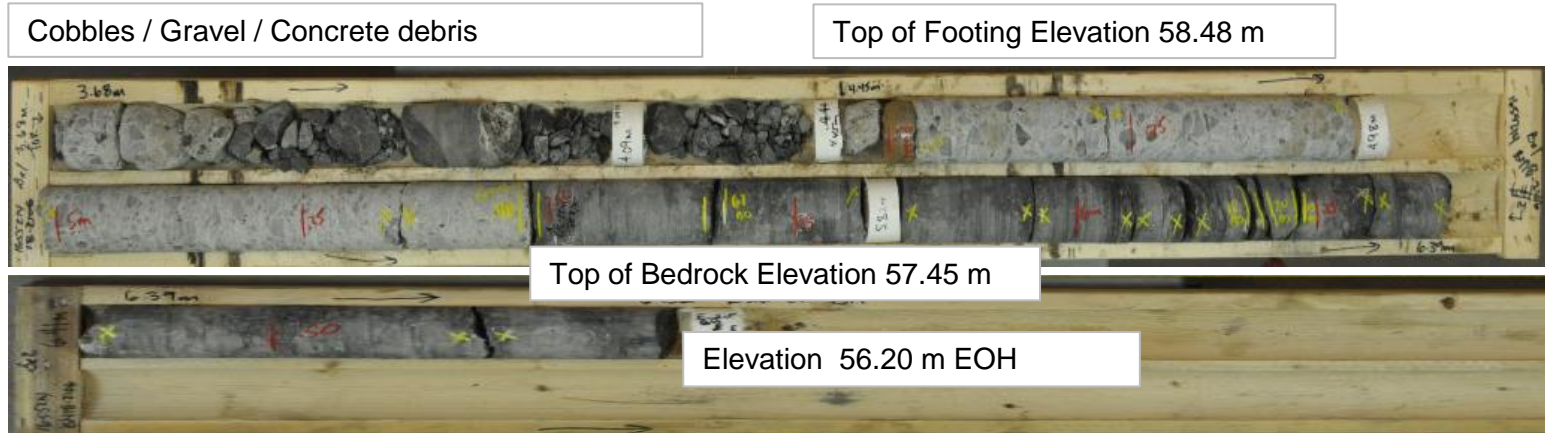


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Figure A8

BH 18-2106 (Dry)
Core Box 1 and 2 of 2

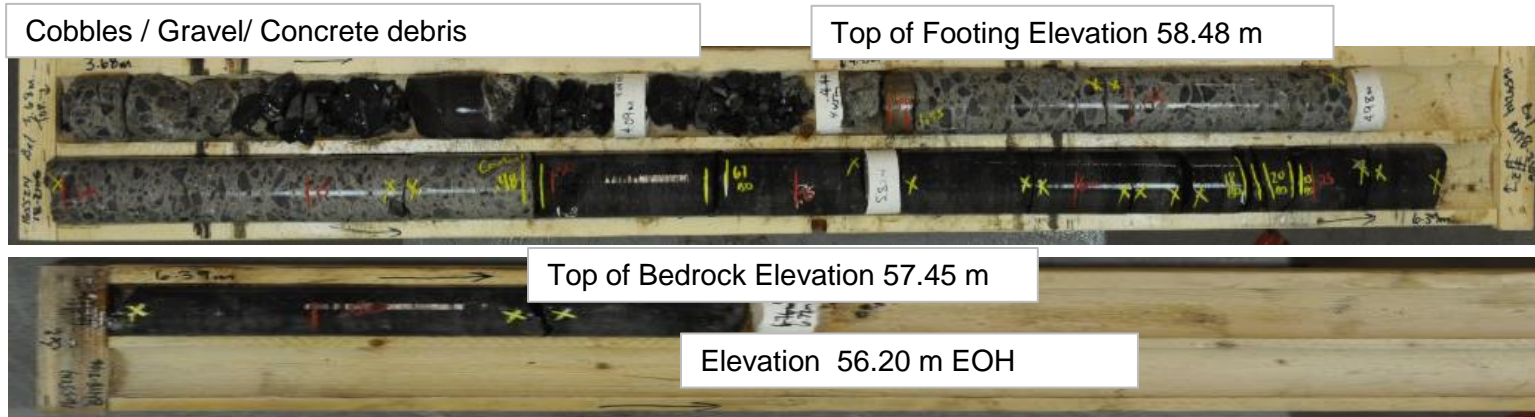


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Figure A9

BH 18-2106 (Wet)
Core Box 1 and 2 of 2



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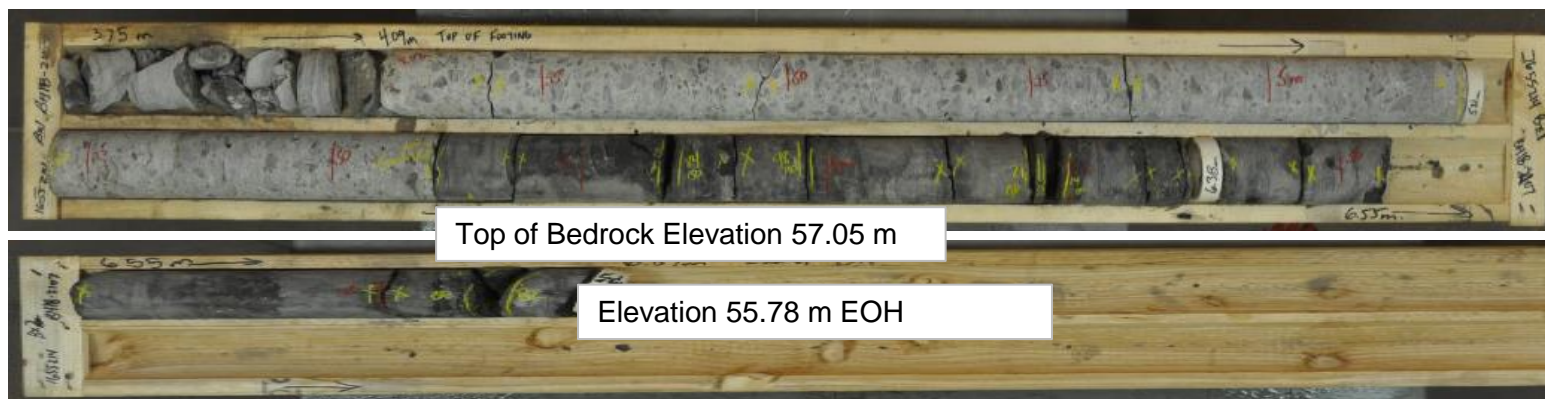
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Figure A10

BH 18-2107 (Dry)
Core Box 1 and 2 of 2

Cobbles / Gravel

Top of Footing Elevation 58.56 m



Geotechnical Investigation

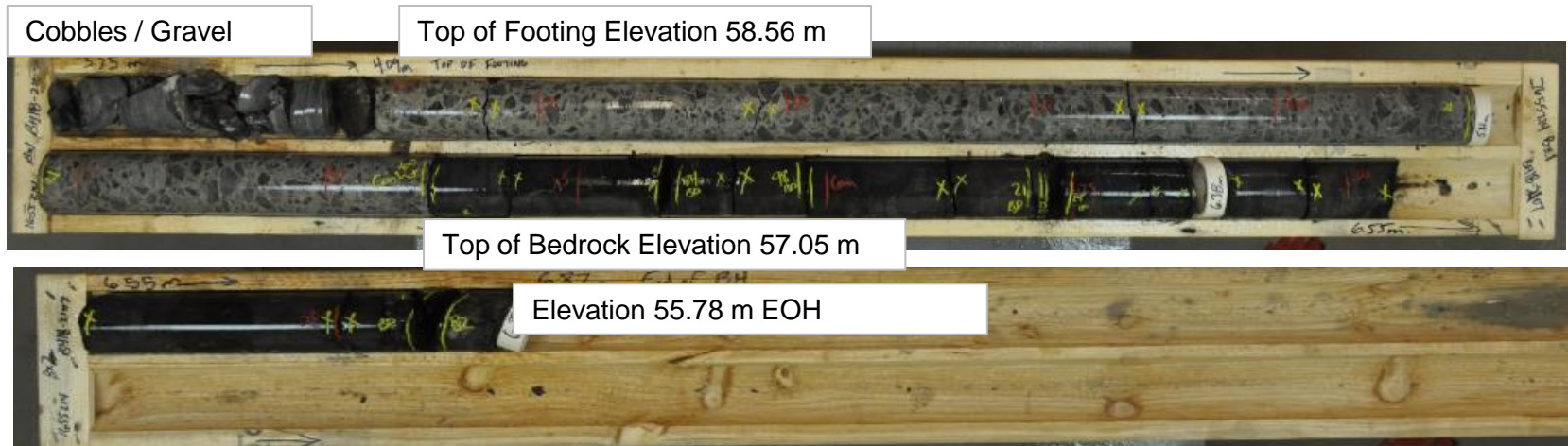
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Figure A11

**BH 18-2107 (Wet)
Core Box 1 and 2 of 2**

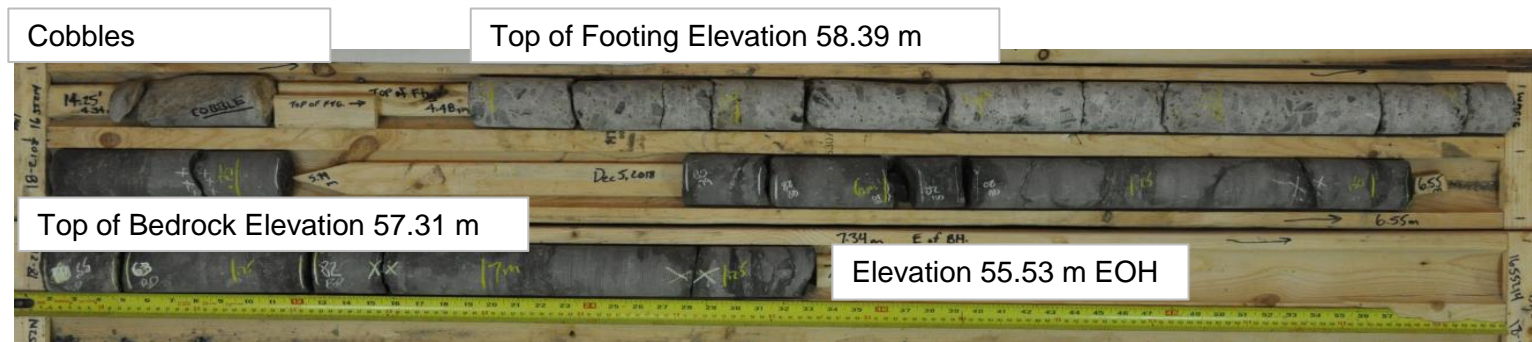


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Figure A12

BH 18-2108 (Dry)
Core Box 1 and 2 of 2

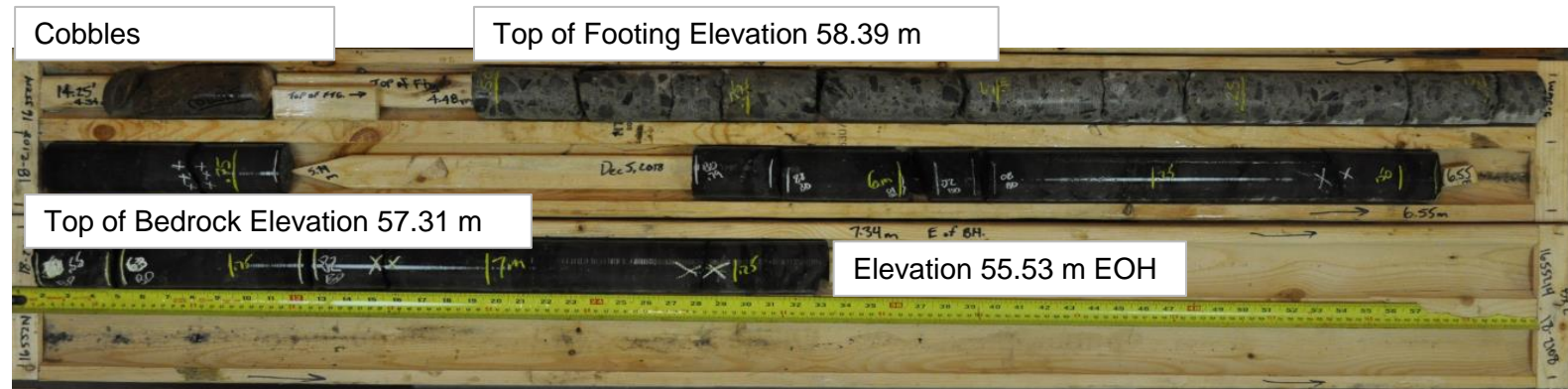


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Figure A13

BH 18-2108 (Wet)
Core Box 1 and 2 of 2

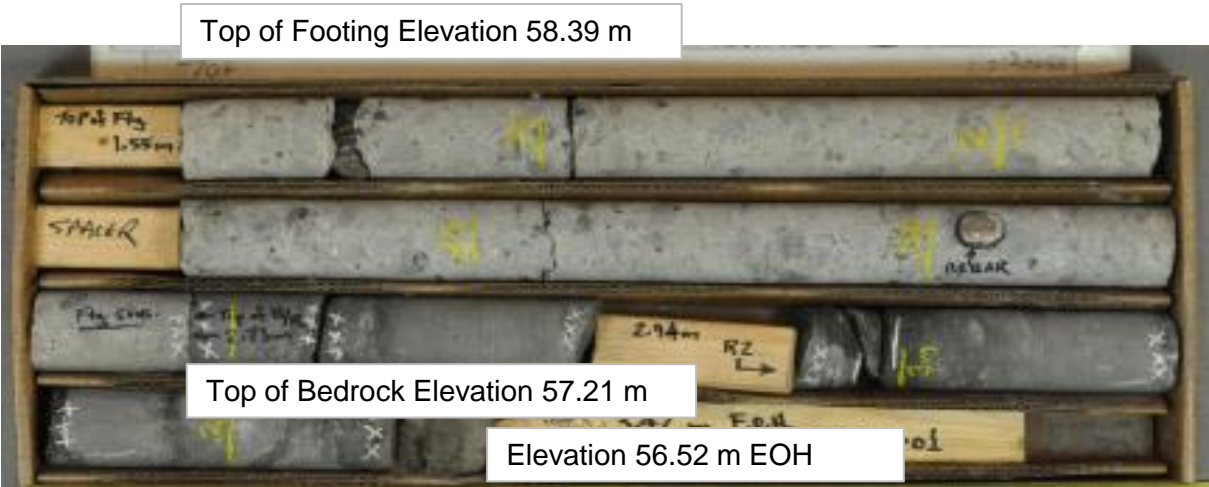


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Figure A14

Corehole 18-D01 (Dry)
Core Box 1 of 1

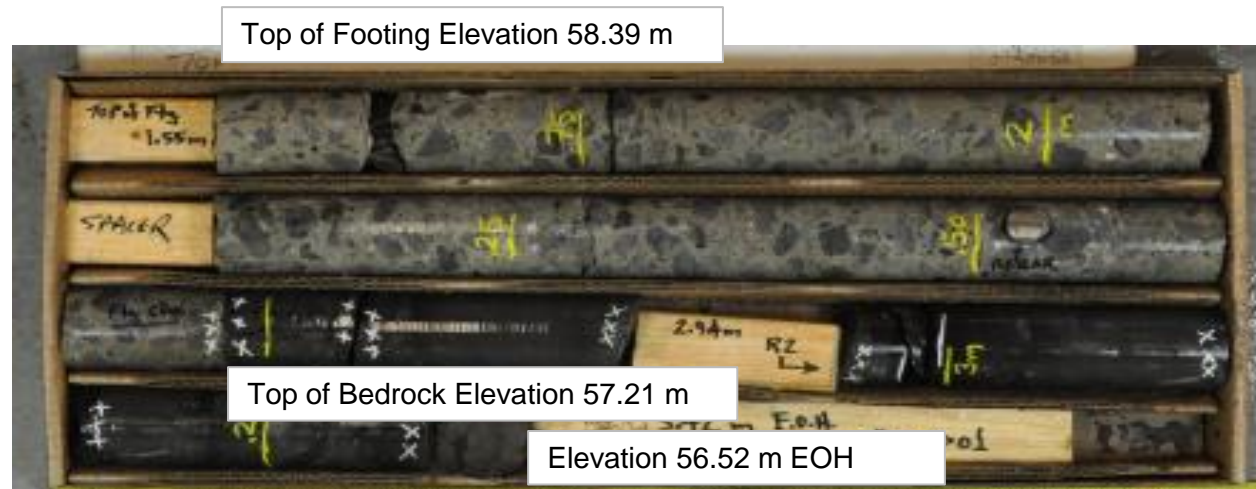


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Figure A15

Corehole 18-D01 (Wet)
Core Box 1 of 1

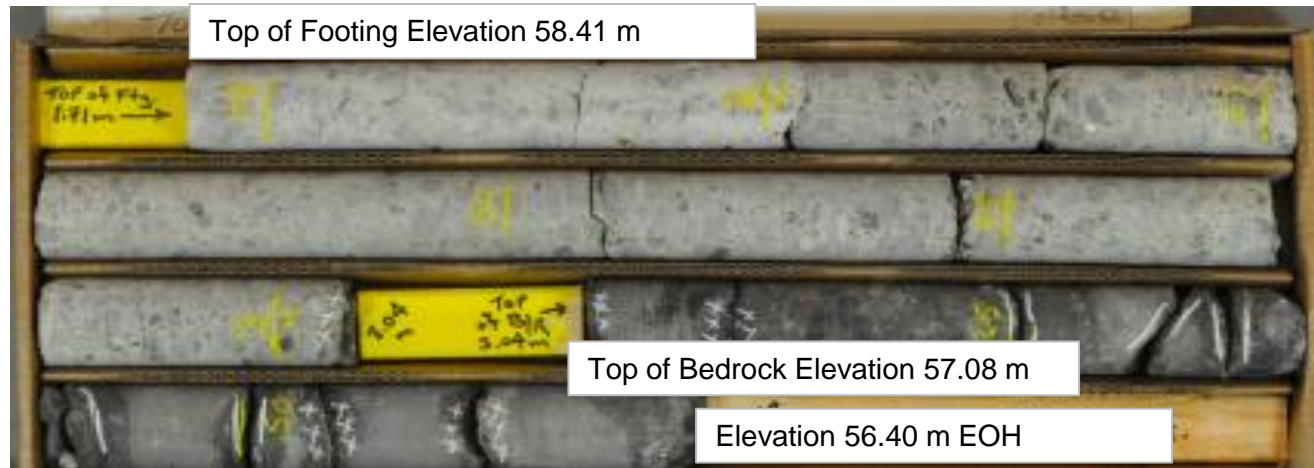


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Figure A16

Corehole 18-D04 (Dry)
Core Box 1 of 1

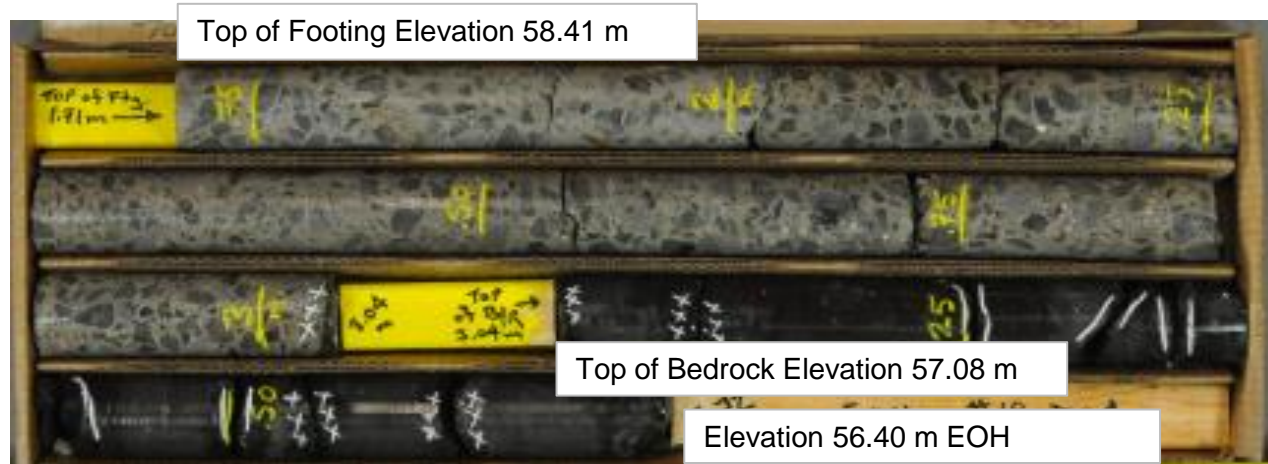


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Figure A17

Corehole 18-D04 (Wet)
Core Box 1 of 1

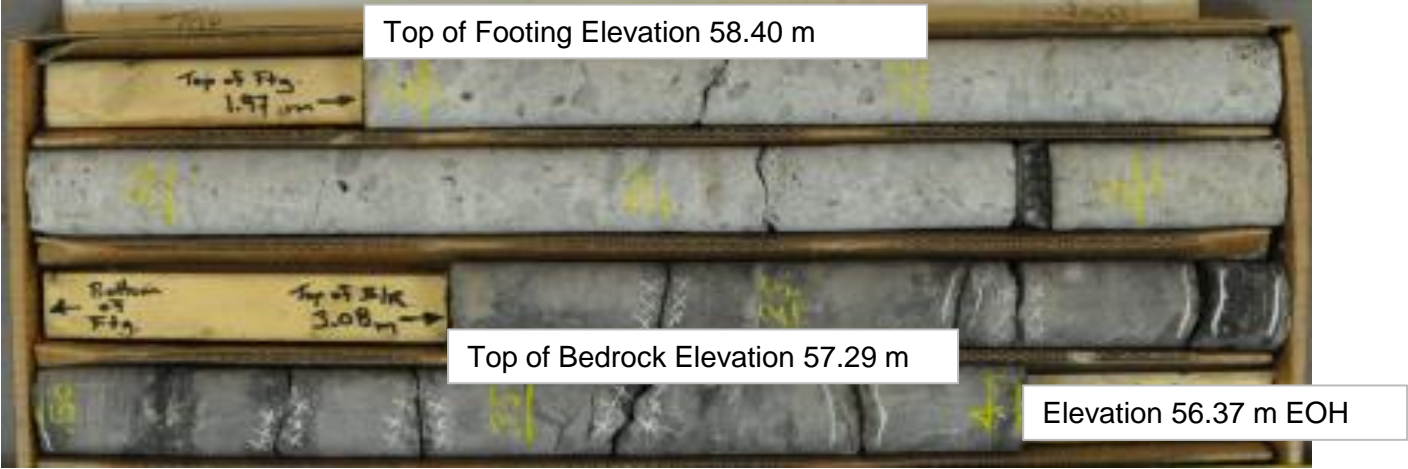


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Figure A18

Corehole 18-D09 (Dry)
Core Box 1 of 1

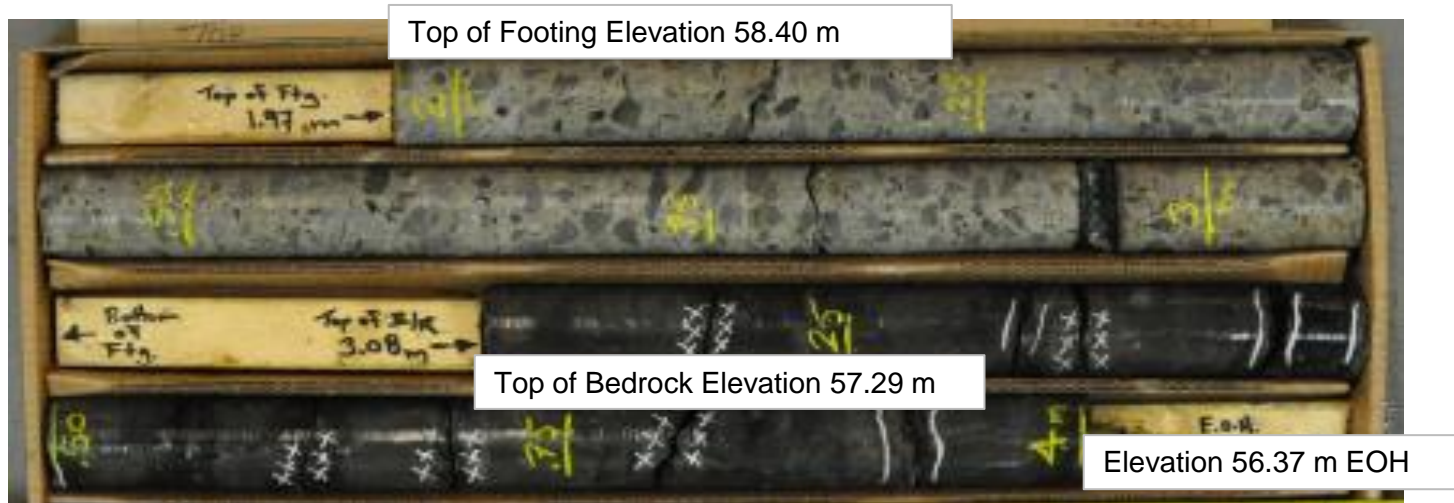


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Figure A19

Corehole 18-D09 (Wet)
Core Box 1 of 1

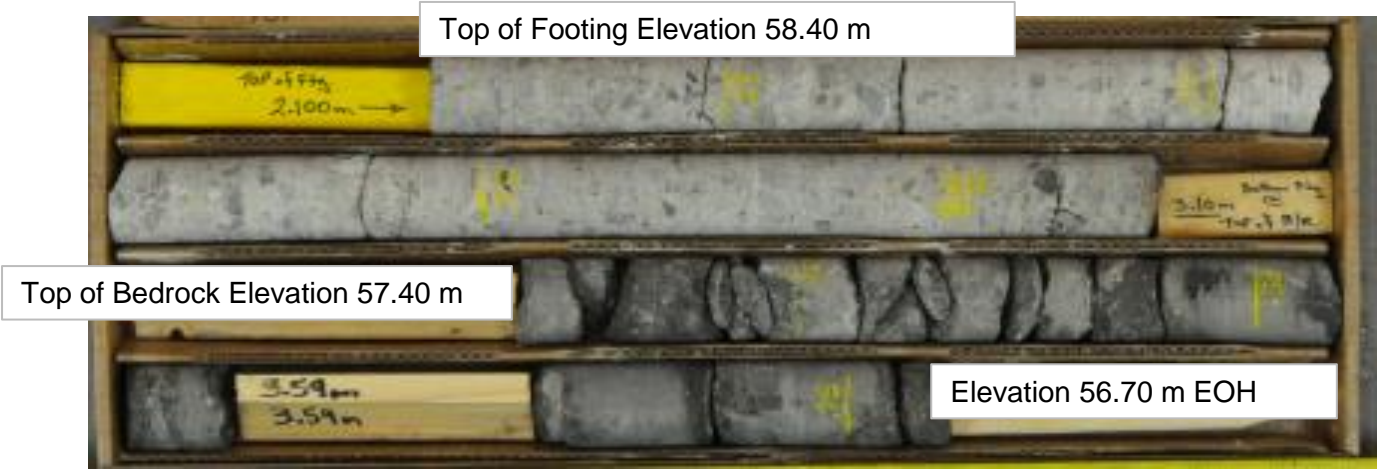


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Figure A20

Corehole 18-D12 (Dry)
Core Box 1 of 1

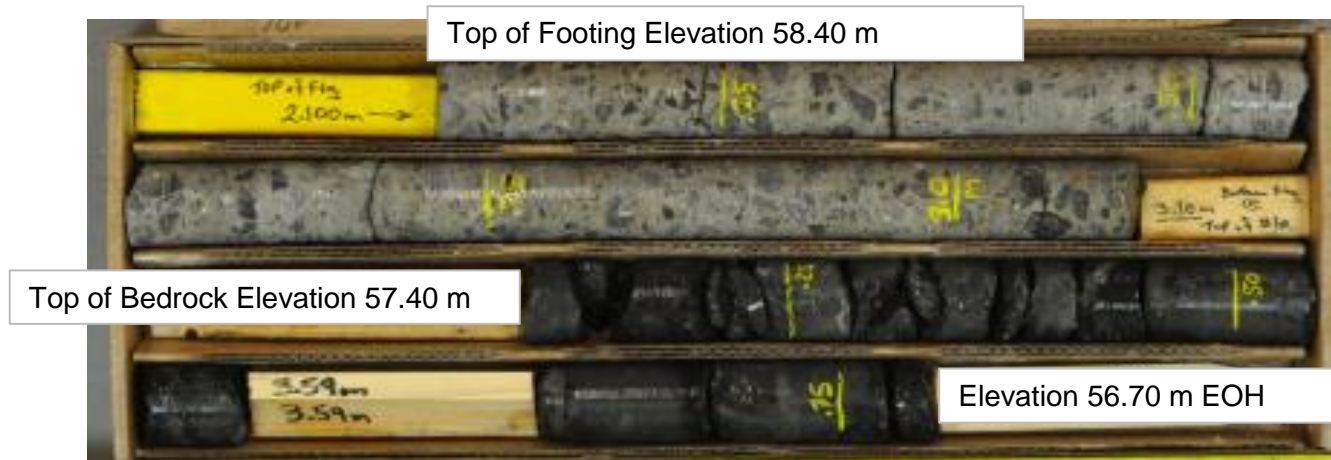


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Figure A21

Corehole 18-D12 (Wet)
Core Box 1 of 1



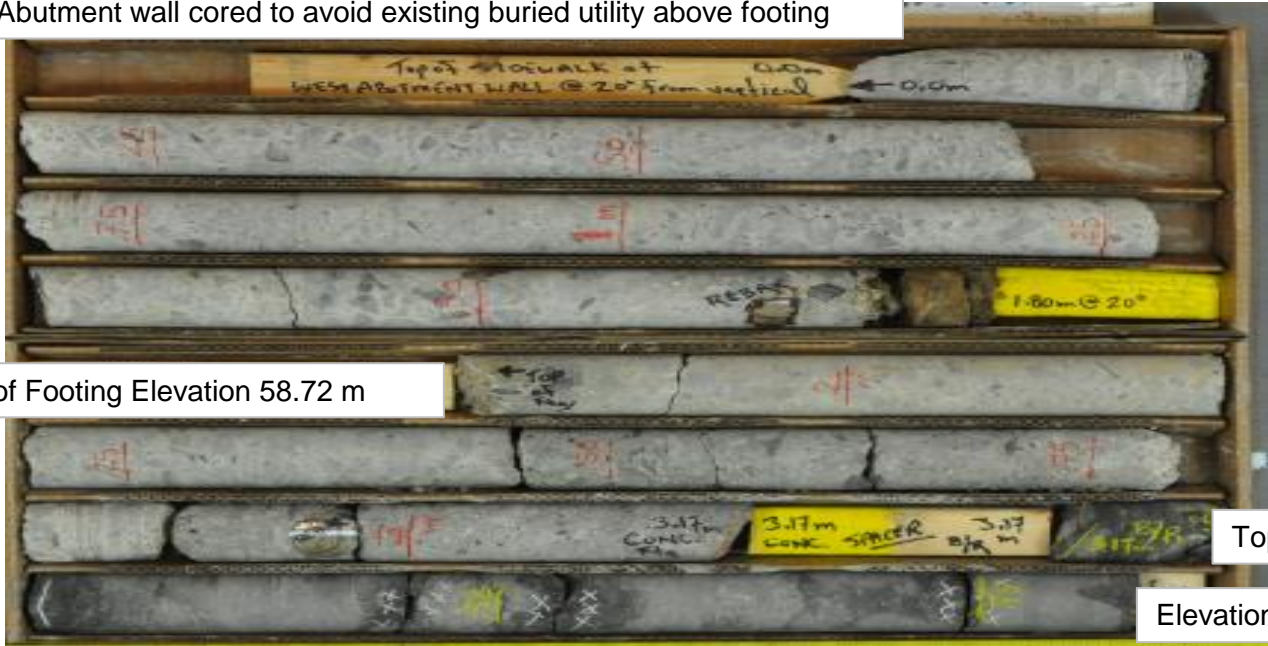
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Figure A22

Corehole 18-D13 (Dry)
Core Box 1 of 1

Ground Surface Elevation 60.41 m
Abutment wall cored to avoid existing buried utility above footing



Top of Footing Elevation 58.72 m

Top of Bedrock Elevation 57.43 m

Elevation 56.80 m EOH



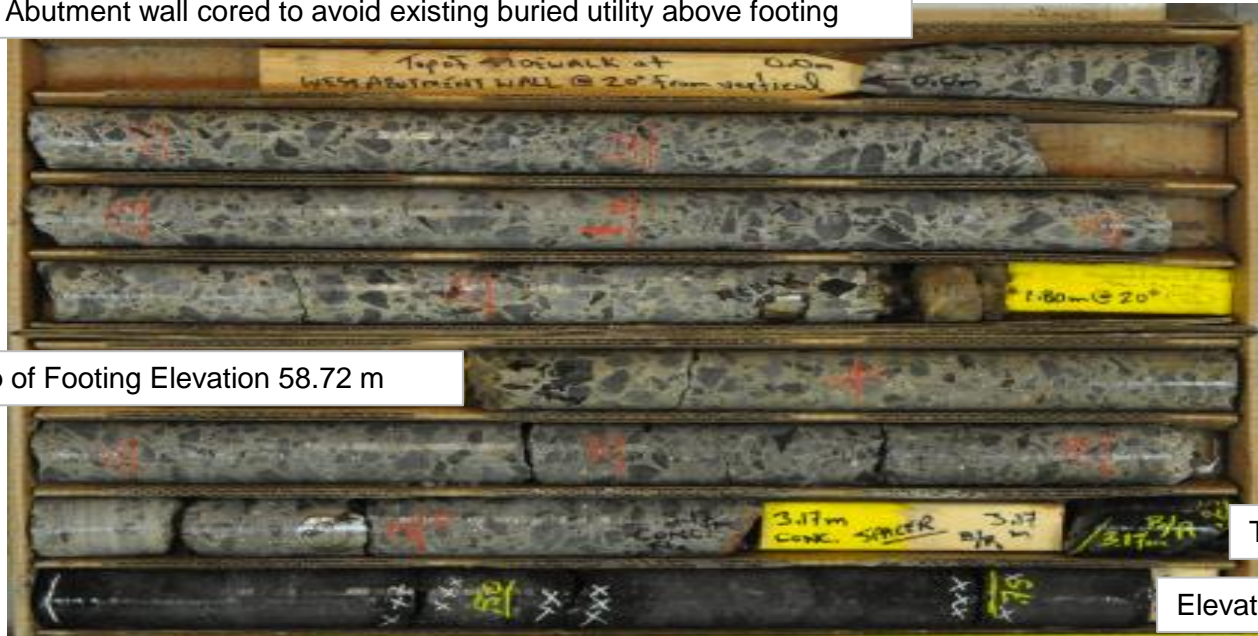
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Figure A23

Corehole 18-D13 (Wet)
Core Box 1 of 1

Ground Surface Elevation 60.41 m
 Abutment wall cored to avoid existing buried utility above footing



Top of Footing Elevation 58.72 m

Top of Bedrock Elevation 57.43 m

Elevation 56.80 m EOH



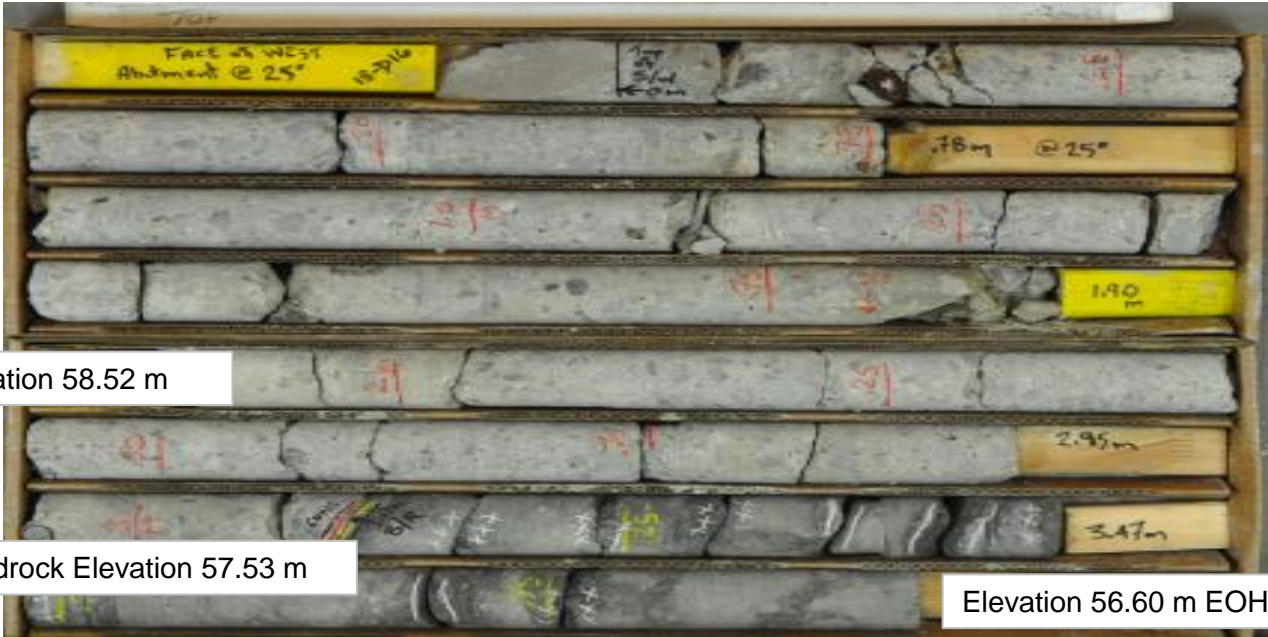
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Figure A24

Corehole 18-D16 (Dry)
Core Box 1 of 1

Ground Surface Elevation 60.30 m
Abutment wall cored to avoid existing buried utility above footing



Top of Footing Elevation 58.52 m

Top of Bedrock Elevation 57.53 m

Elevation 56.60 m EOH



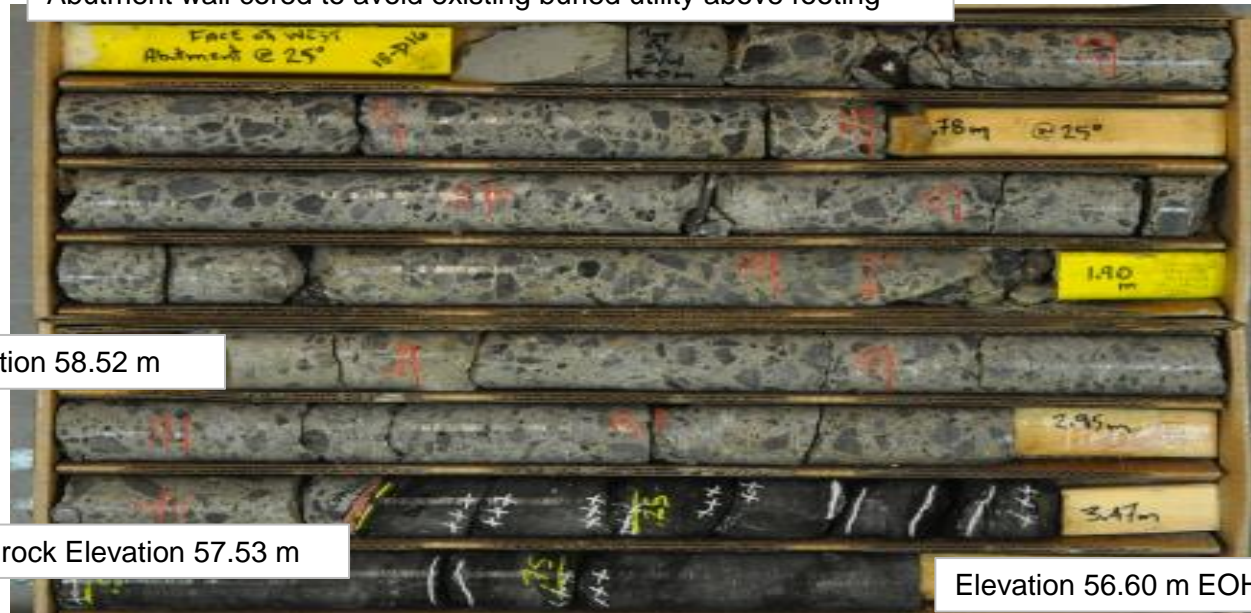
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Figure A25

Corehole 18-D16 (Wet)
Core Box 1 of 1

Ground Surface Elevation 60.30 m
 Abutment wall cored to avoid existing buried utility above footing



Top of Footing Elevation 58.52 m

Top of Bedrock Elevation 57.53 m

Elevation 56.60 m EOH



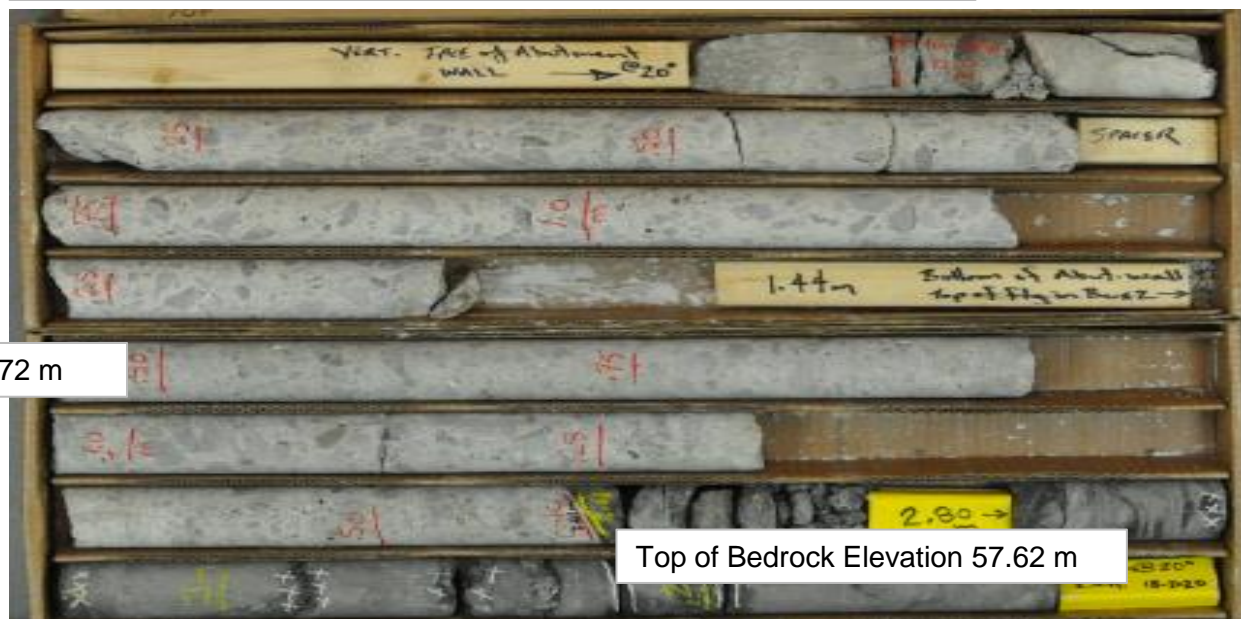
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Figure A26

Corehole 18-D20 (Dry)
Core Box 1 of 1

Ground Surface Elevation 60.08 m
 Abutment wall cored to avoid existing buried utility



Top of Footing Elevation 58.72 m

Top of Bedrock Elevation 57.62 m

Elevation 56.84 m EOH



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Figure A27

Corehole 18-D20 (Wet)
Core Box 1 of 1

Ground Surface Elevation 60.08 m
 Abutment wall cored to avoid existing buried utility



Top of Footing Elevation 58.72 m

Top of Bedrock Elevation 57.62 m

Elevation 56.84 m EOH



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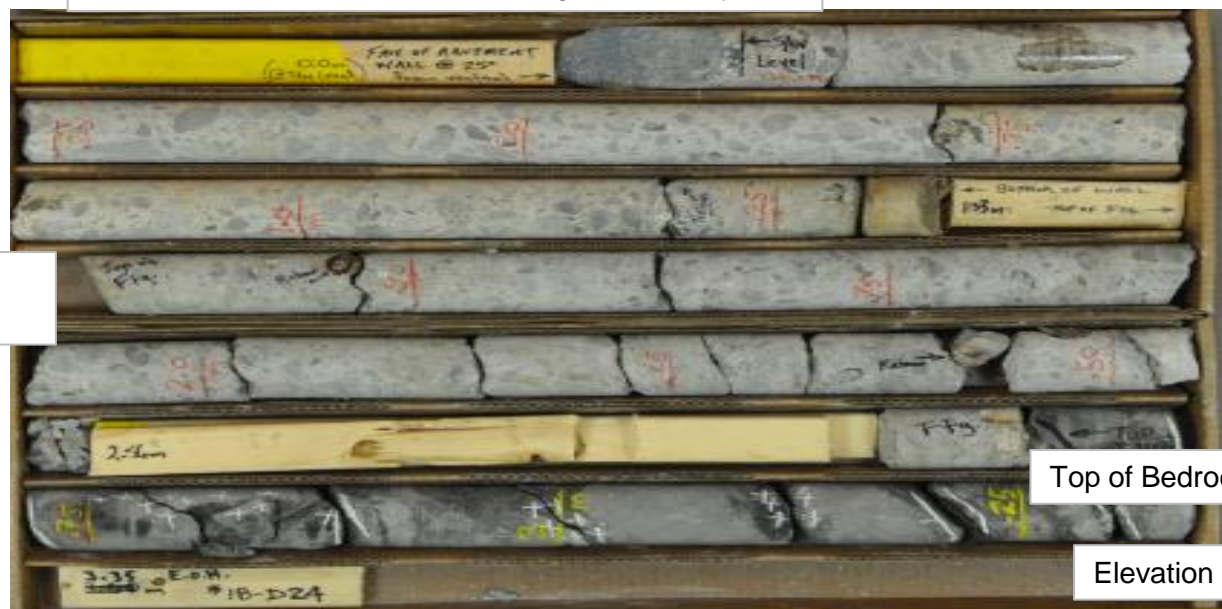
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Figure A28

Corehole 18-D24 (Dry)
Core Box 1 of 1

Ground Surface Elevation 59.88 m
 Abutment wall cored to avoid existing buried utility

Top of Footing
 Elevation 58.56 m



Top of Bedrock Elevation 57.39 m

Elevation 56.74 m EOH



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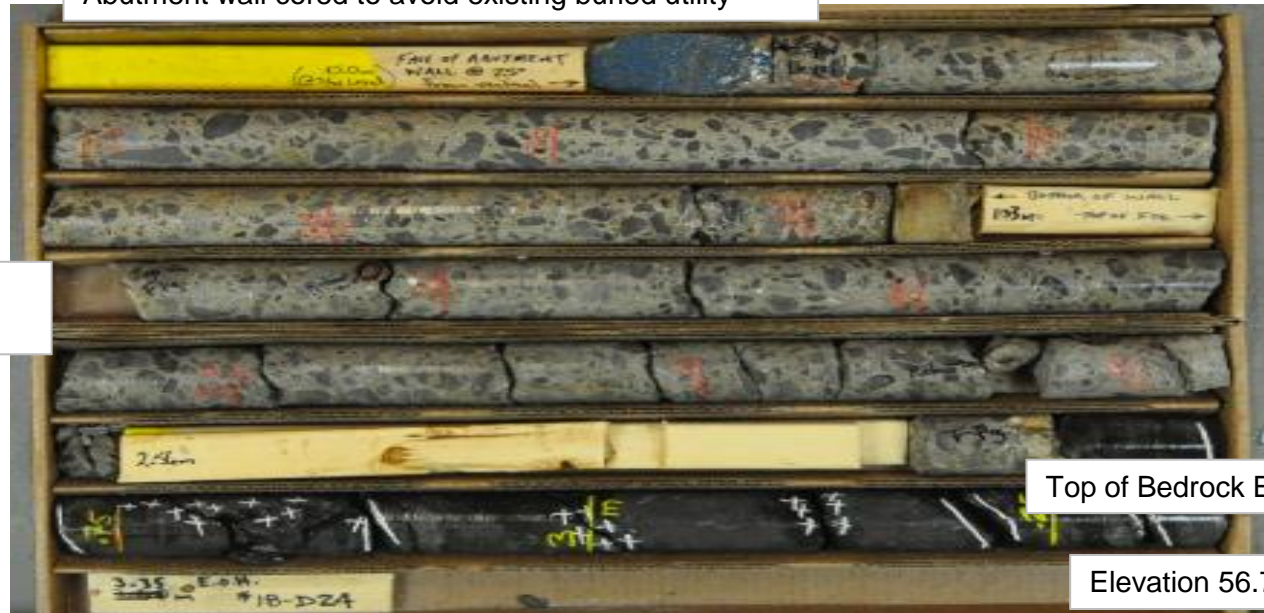
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Figure A29

Corehole 18-D24 (Wet)
Core Box 1 of 1

Ground Surface Elevation 59.88 m
 Abutment wall cored to avoid existing buried utility

Top of Footing
 Elevation 58.56 m



Top of Bedrock Elevation 57.39 m

Elevation 56.74 m EOH



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Figure A30

Preston Street**18-2105:** 3.35 to 4.61

Geotextile at surface
Top broken up and some damage due to core spinning during drilling
Occasional air entrainment, well consolidated
32m diameter rebar at 3.64 m (~290 mm of cover)
Broken at 3.63 to 3.66 m due to drilling through rebar
Poor bond to rock

18-2106: 4.45 to 5.48

32 mm diameter bar at 4.50, not 75 mm cover, not enough cover,
possibly deteriorated during coring
Good bond to rock, broken during coring
Well consolidated, occasional air void entrainment
Mechanical breaks

18-2107: 4.09 to 5.60

Well consolidated, occasional mechanical breaks
Good condition, good bond to rock
Top surface damaged slightly due to core spinning
Occasional air entrainment

18-2108 4.84 - 5.60

Well consolidated, occasional air entrainment
Mechanical breaks only
Broken at 4.82 m to 4.97 m due to core spinning during drilling
Poor bond to rock

18-D20: 1.44 - 2.61

Well consolidated, occasional air void entrainment
Excellent Bond to rock
Underlying Bedrock broken @ surface (2.61 m)
Mechanical Breaks only

18-D13: 1.80 - 3.17

Well consolidated, occasional air void entrainment
Mechanical Breaks mostly
Broken @ 2.79 m , 2.87 m, Possibly due to core spinning during drilling
36-38 mm diameter Bar @ 2.96 m

18-D04: 1.71 - 3.04

Well consolidated, occasional air entrainment
Mechanical Breaks only
Damaged @ 2.73 m due to core spinning during drilling
Good Bond to rock, rock in poor condition @ surface

18-D12: 2.10 - 3.10

Well consolidated
Core broken at 2.71 m likely due to spinning during coring
Poor bond to rock

Preston Street

- 18-D24:** 1.33 - 2.65
Well consolidated, occasional air entrainment
Mechanical breaks only
18 mm diameter @ 1.47 m depth
18 mm diameter @ 2.44 m depth
2.50 to 2.56 m broken due to core spinning during drilling
concrete broken @ 2.65 m possibly due to core spinning during drilling
Poor / Unbonded to rock
- 18-D16** 1.90 - 2.95
Well consolidated, occasional air entrainment
Mechanical breaks only
18 mm diameter rebar @ 2.95 m
- 18-D01** From 1.55 - 2.73
Well consolidated, occasional air entrainment
18 mm dia. Rebar @ 1.64 m > 75 mm cover
18 mm dia. Rebar @ 2.53 m
Good condition, mechanical breaks only
Good bond to rock
- 18-D09** 1.97 - 3.08
Well consolidated, occasional air entrainment
18 mm diameter bar @ 2.95 m
Good condition, mechanical breaks only
Fair bond to rock

APPENDIX B

Laboratory Test Results, Current Investigation

Figure B1 – Grain Size Distribution Test Results – Sand - Fill

Figure B2 – Grain Size Distribution Test Results – Sand - Fill

Figure B3 – Plasticity Chart Sandy – Silty Clay - Fill

Figure B4 – Grain Size Distribution Test Results – Gravelly Sand - Fill

Figure B5 – Grain Size Distribution Test Results – Silty Sand - Fill

Figure B6 – Grain Size Distribution Test Results – Gravel Some Sand to Sand and Gravel – Fill

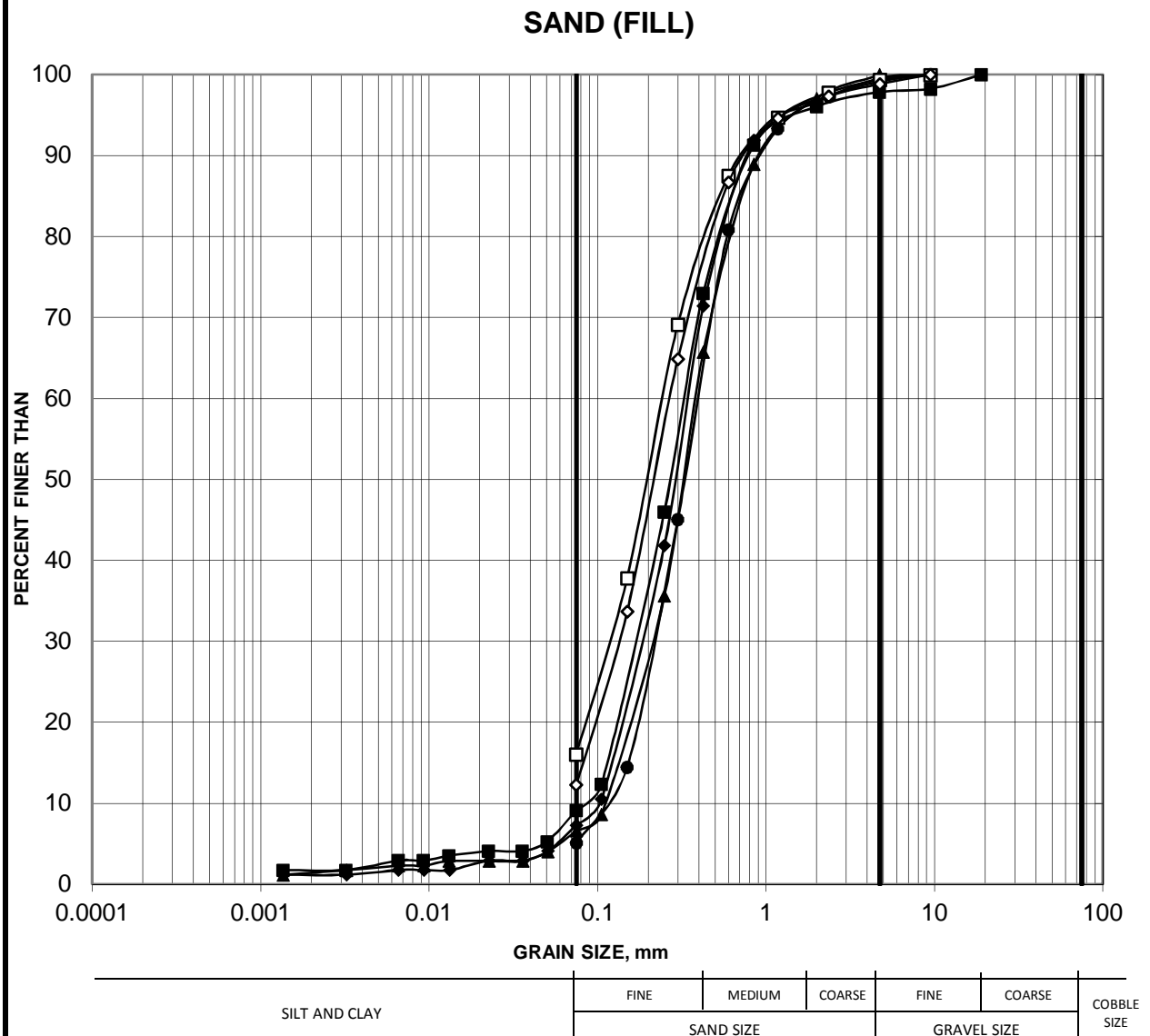
Figure B7 – Grain Size Distribution Test Results – Sandy Gravel – Fill

Figure B8 – Summary of Laboratory Compressive Strength Unconfined Compression Tests - Concrete

Figure B9 – Summary of Laboratory Compressive Strength Unconfined Compression Tests – Bedrock

GRAIN SIZE DISTRIBUTION

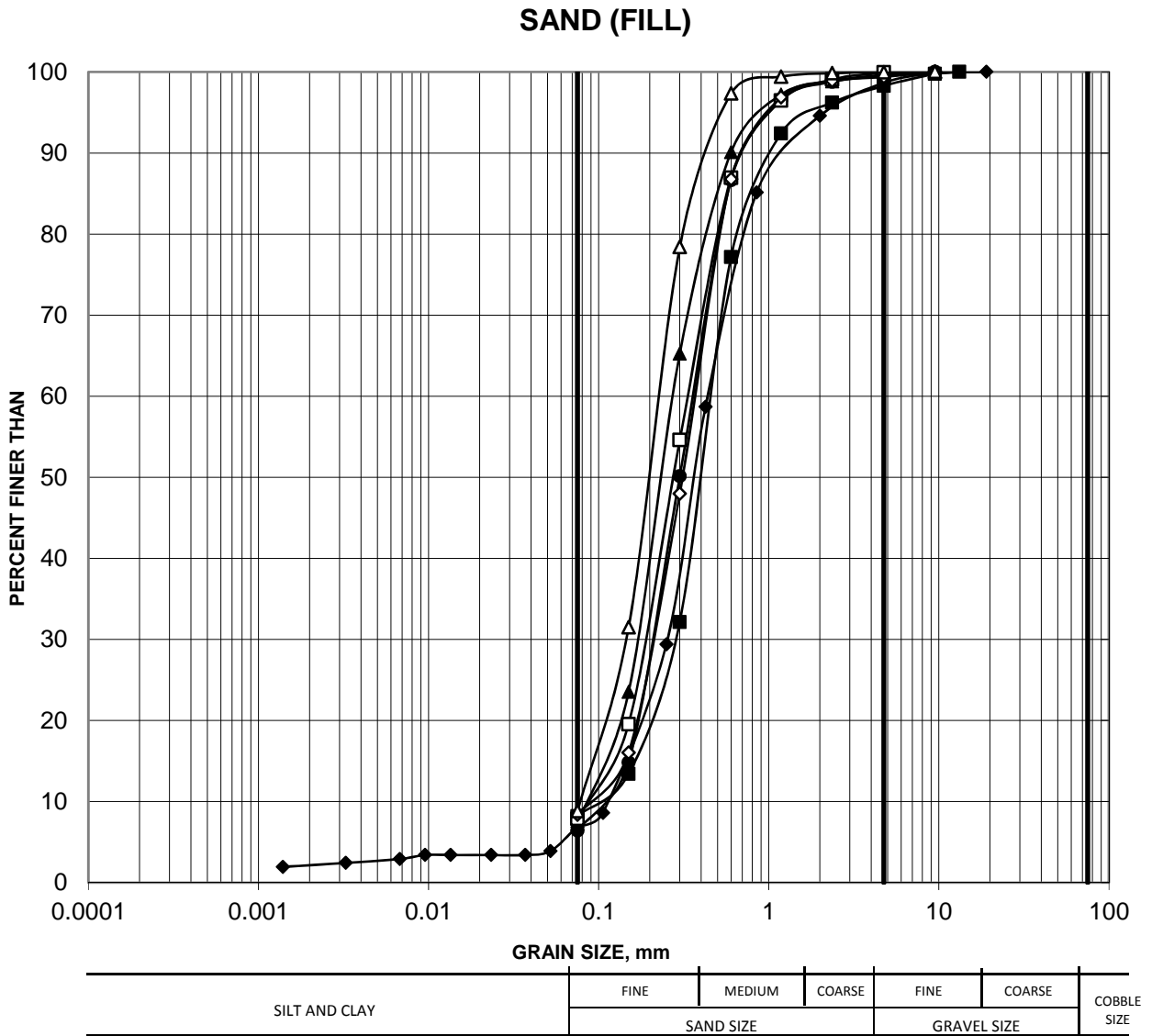
FIGURE B1



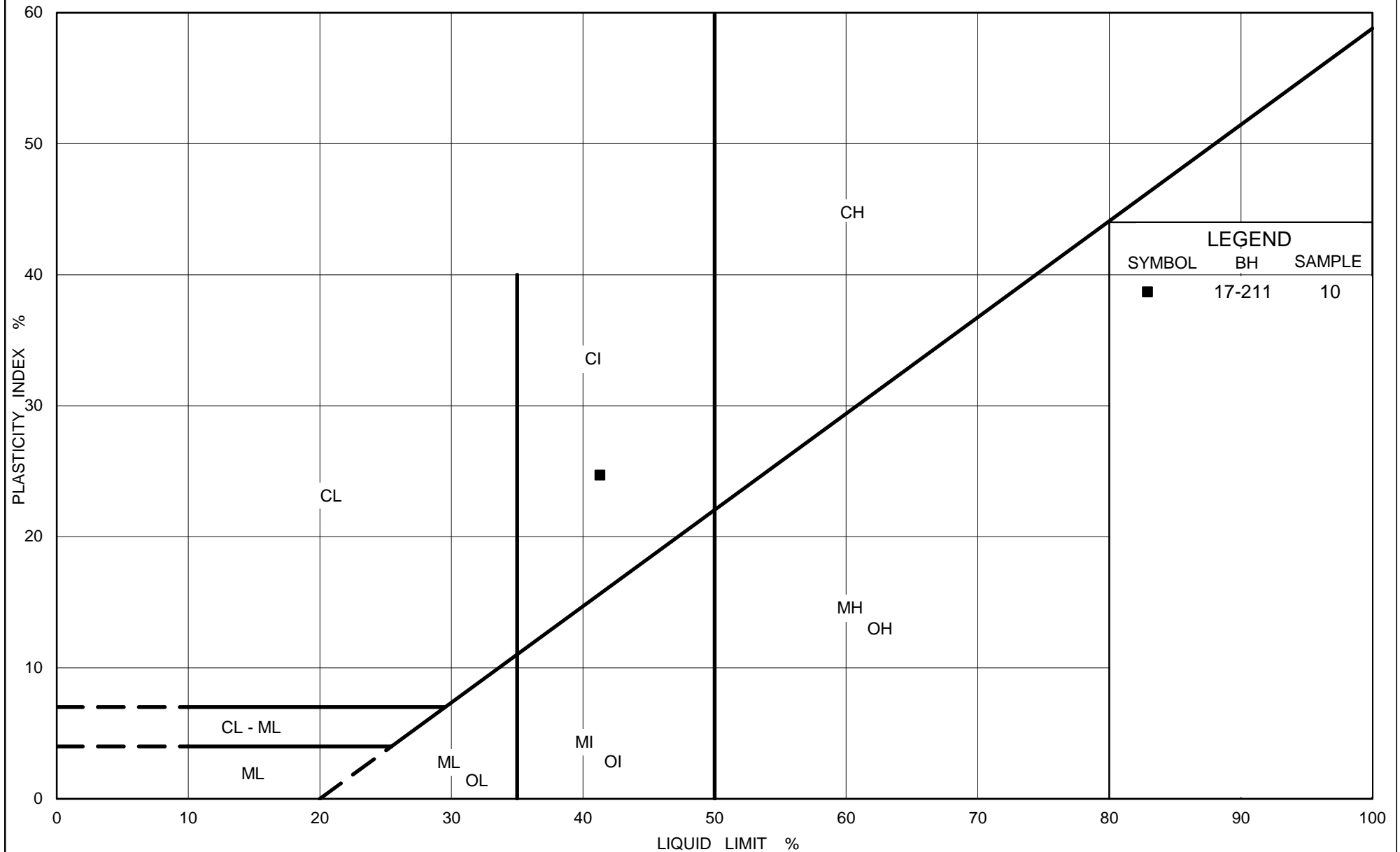
Borehole	Sample	Depth (m)
■ 17-211	7	3.81-4.42
◆ 17-212	8	5.33-5.94
▲ 17-214	7	3.81-4.42
● 18-2105	3	1.22-1.83
□ 18-2107	1	0.00-0.61
◇ 18-2108	2	0.61-1.22

GRAIN SIZE DISTRIBUTION

FIGURE B2



Borehole	Sample	Depth (m)
■ 18-2109	4	2.29-2.90
◆ 18-2109	7	4.57-5.18
▲ 18-2110	6	3.81-4.42
● 18-2111	6	3.81-4.22
□ 18-2111	8	5.34-5.95
◇ 18-2112	7	4.57-5.18
△ 18-2112	9	6.09-6.70



Ontario

Ministry of Transportation

PLASTICITY CHART SANDY SILTY CLAY (FILL)

FIG No. B3

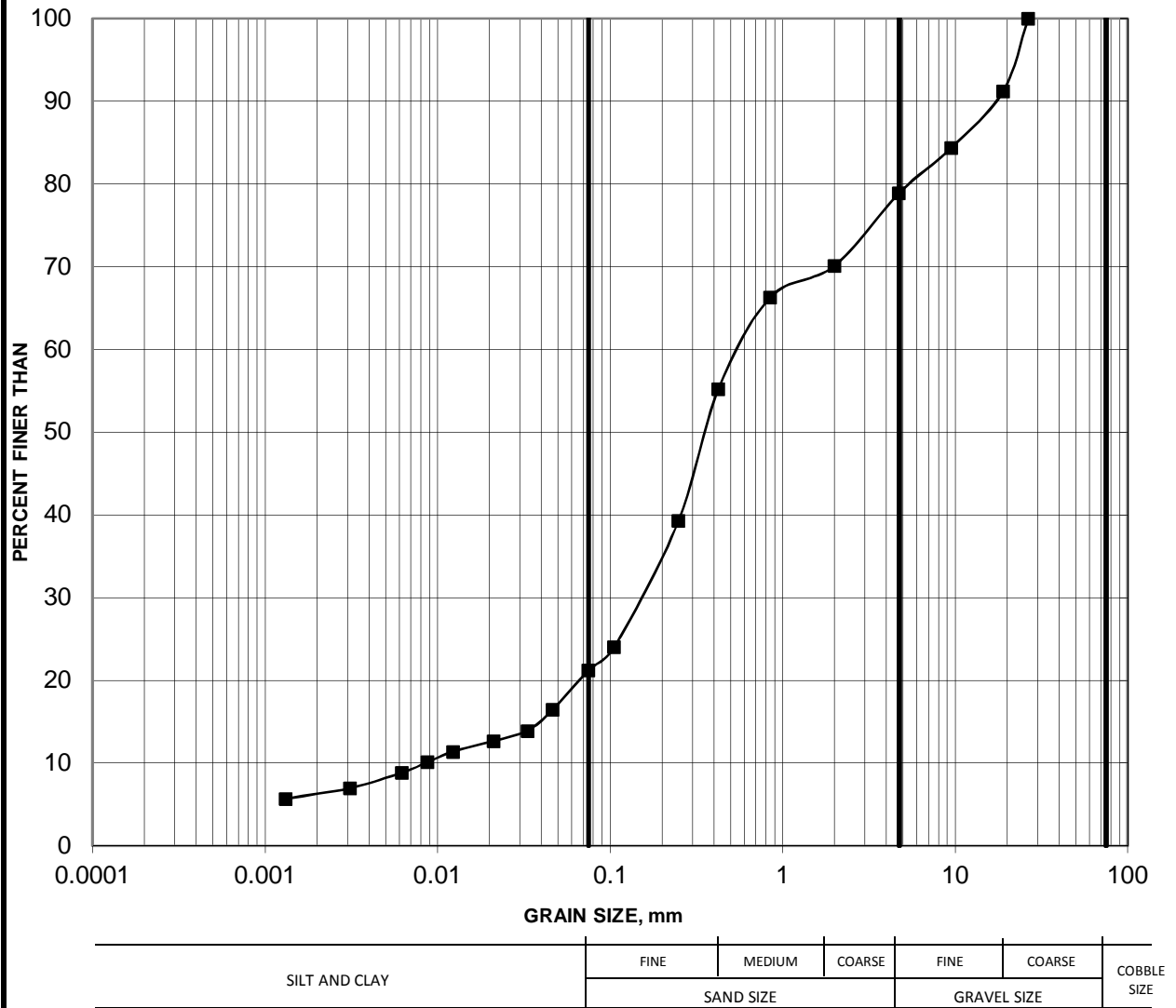
Project No. 1655214/1210

Compiled By : MI Checked By : CW

GRAIN SIZE DISTRIBUTION

FIGURE B4

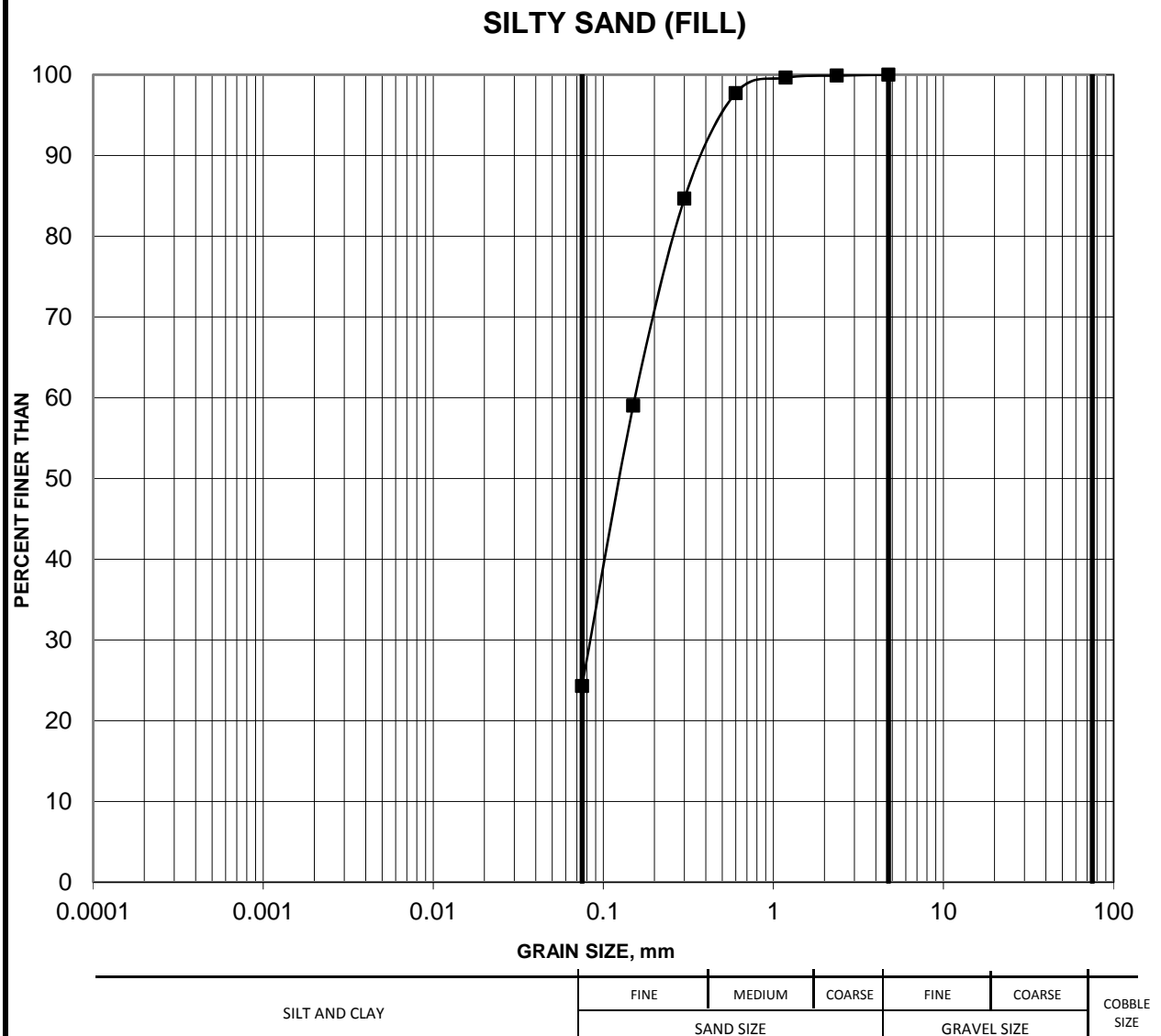
GRAVELLY SAND (FILL)



Borehole	Sample	Depth (m)
—■— 17-214	13	8.38-8.99

GRAIN SIZE DISTRIBUTION

FIGURE B5

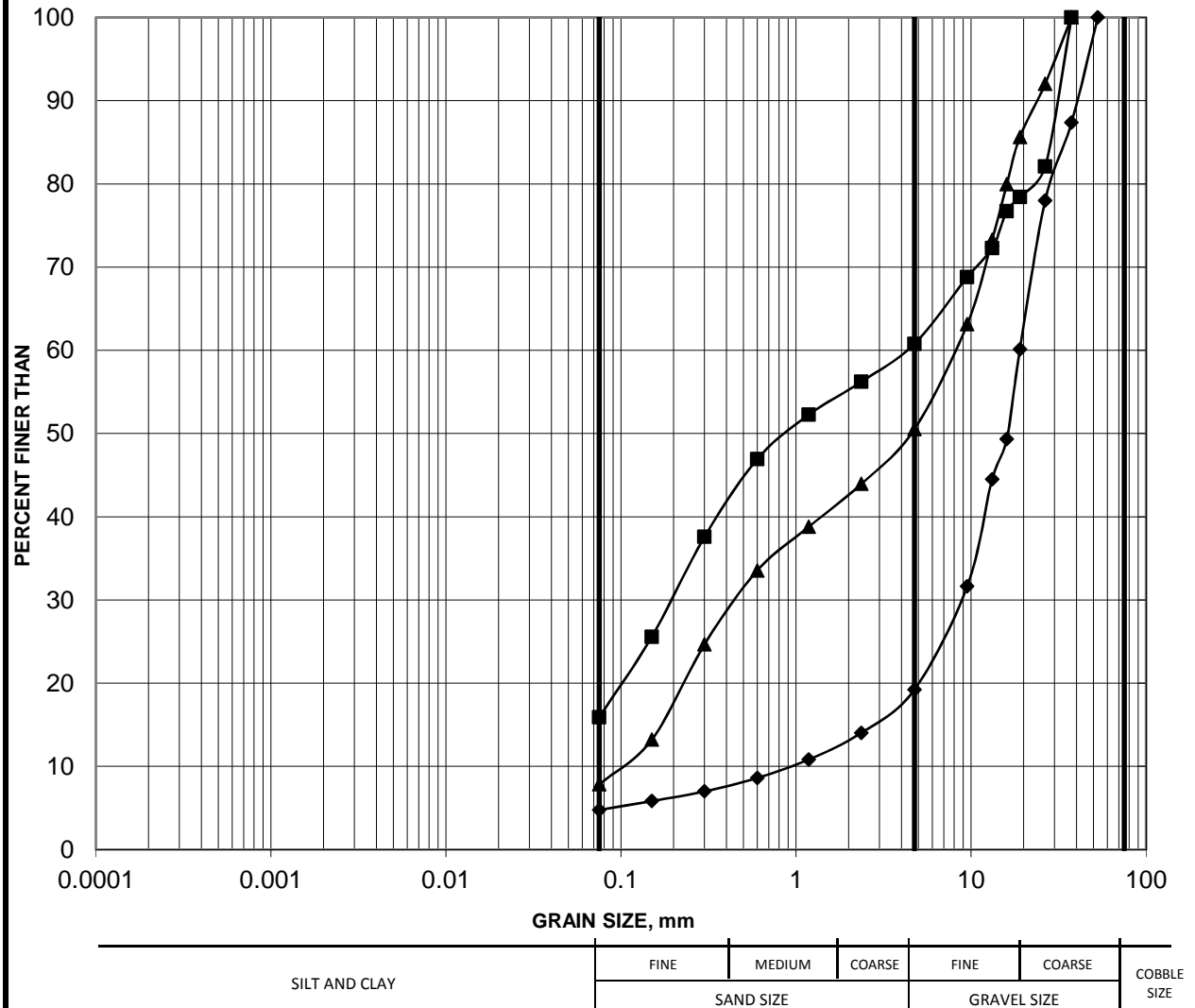


Borehole	Sample	Depth (m)
18-2110	9	6.00-6.70

GRAIN SIZE DISTRIBUTION

FIGURE B6

GRAVEL SOME SAND TO SAND AND GRAVEL (FILL)

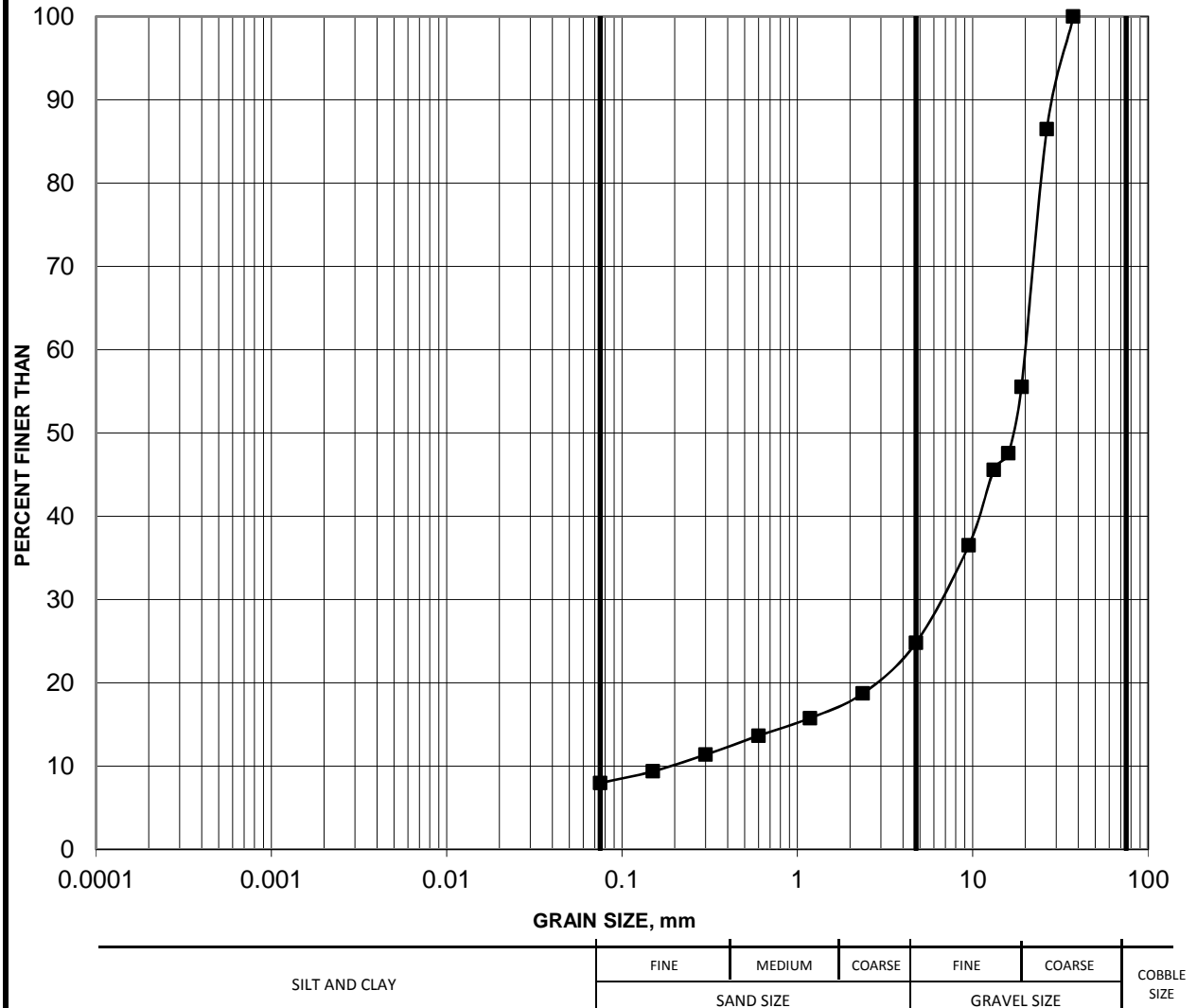


Borehole	Sample	Depth (m)
18-2101	3	1.22-1.67
18-2102	2	0.45-0.95
18-2104	3	1.22-1.60

GRAIN SIZE DISTRIBUTION

FIGURE B7

SANDY GRAVEL (FILL)

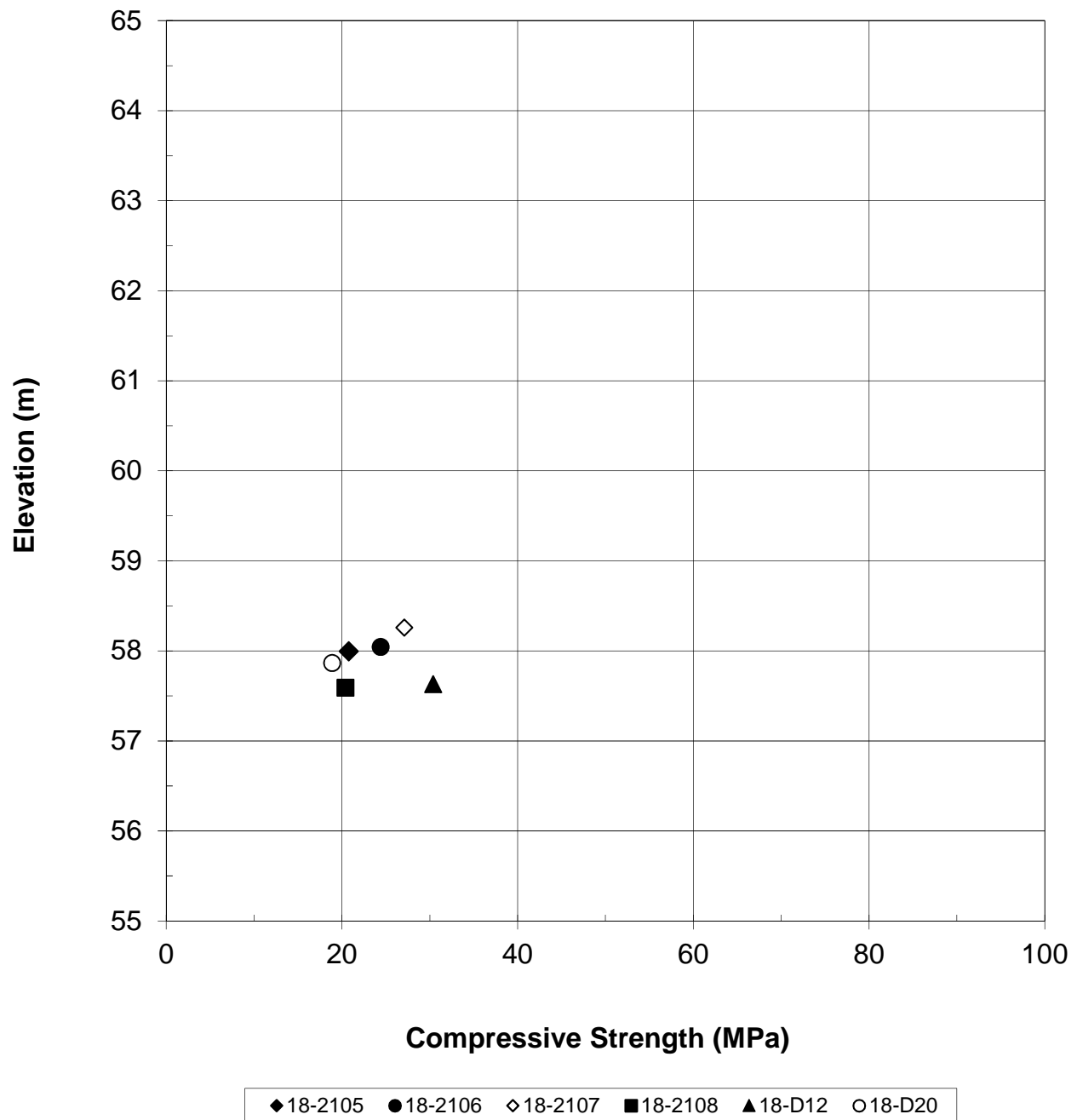


Borehole	Sample	Depth (m)
18-1114	3	1.52-2.13

**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
UNCONFINED COMPRESSION TESTS**

FIGURE B8

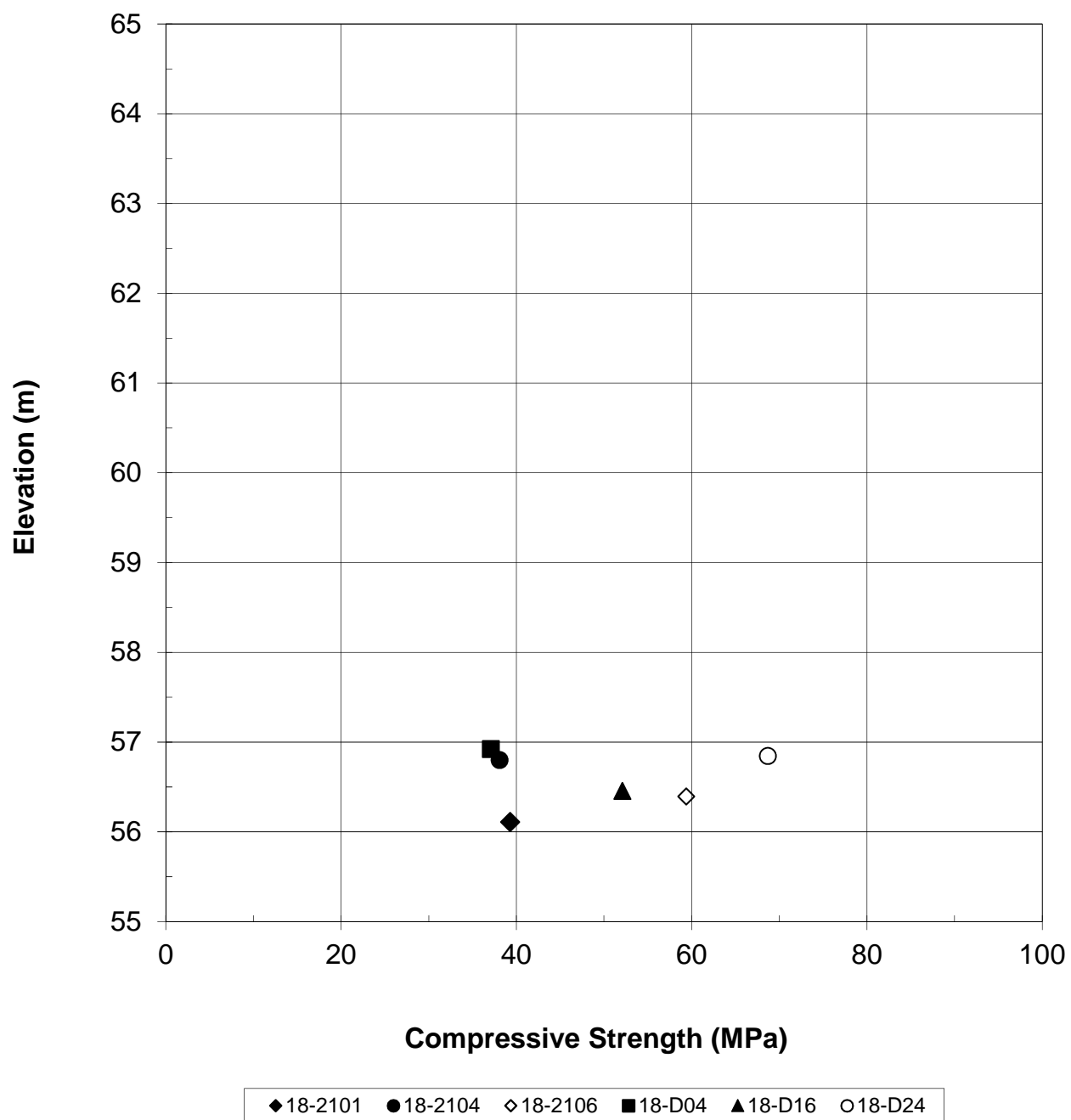
CONCRETE CORE SAMPLES



**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
UNCONFINED COMPRESSION TESTS**

FIGURE B9

BEDROCK CORE SAMPLES



APPENDIX C

Previous Investigation, GEOCRES 31G05-032 (1959)

Soil Profile & Summary of Field and Laboratory Tests Sheets No. 1 to 6

Borehole Locations Plate 1

McROSTIE & ASSOCIATES

CONSULTING ENGINEERS

OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

PRESTON / QUEENSWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 220.7 DATE July 13th 1959

HOLE NO.

REMARKS B.M. PEG UNDER C.N.R. BRIDGE AT PRESTONELEV. 197.9, GEODETIC DATUM

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT. ²	SMALL SCALE PENETROMETER KIPS/FT. ²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	PROBING OR VANE TEST	
							LB. HAMMER	NO CASING
							INCH DROP	INCH DIA. ROD
							BLOWS PER FOOT OR	SHEAR STRENGTH IN KIPS PER FT. ²
				GROUND SURFACE →	0.0	220.7		
		12	1-1	FILL				Overnight Water Level D-1
		4	1-2					
		6	1-3					
		2	1-4			200.0	210.7	
		2	1-5					
		2	1-6					
		5	1-7					
		4	1-8			200.0	200.7	
		13	1-9					
		54	1-10					
				LIMESTONE	27.7	193.0		
				CORE RECOVERY 91%		191.9		
				LIMESTONE				
				CORE RECOVERY 95%				
				BOTTOM OF HOLE →	38.7	192.0		

1" DROP →

0 10 20 30 40 50

% WATER CONTENT

NATURAL ○

LIQUID LIMIT □

PLASTIC LIMIT △

PLATE

2

McROSTIE & ASSOCIATES
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY
OF FIELD AND LABORATORY TESTS

PRESTON / QUEENSWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 213.5 DATE July 10th 1959

REMARKS See Plate #2

HOLE NO.

6

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT. ²	SMALL SCALE PENETROMETER KIPS/FT. ²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	• DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION	PROBING OR VANE TEST					
						LB. HAMMER	NO CASING				
						INCH DROPINCH DIA. ROD				
							BLOWS PER FOOT OR SHEAR STRENGTH IN KIPS PER FT. ²					
				GROUND SURFACE								
					0.0	213.5	HOLE DRY OVERNIGHT					
		6	6-1									
		12	6-2									
		7	6-3	FILL								
		9	6-4		1.0	202.5						
		8	6-5									
		103	6-6		6.1	197.4						
			6-7	BOULDERS IN FILL								
		72	6-8		21.5	192.0						
		82	6-9	DENSE SAND & GRAVEL	24.2	189.3						
				LIMESTONE								
				CORE RECOVERY 76%	29.0							
				LIMESTONE								
				CORE RECOVERY 87%								
				Bottom of Hole	34.7	178.8						
							0	10	20	30	40	50
							% WATER CONTENT				PLATE	
							NATURAL	○				7
							LIQUID LIMIT	□				
							PLASTIC LIMIT	△				

McROSTIE & ASSOCIATES
CONSULTING ENGINEERS
BOREHOLE LOCATIONS
BRIDGE No. 15 AT PRESTON ST.
SCALE 1" = 40' PLATE 1

APPENDIX D

**Results of Chemical Analysis
Eurofins Environment Testing Report No. 1717681**



Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Susan Trickey
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1717681
Date Submitted: 2017-09-13
Date Reported: 2017-09-18
Project: 1655214/1210
COC #: 823412

Lab I.D.
Sample Matrix
Sample Type
Sampling Date
Sample I.D.

1320349
Soil

2017-08-14
17-214 SA 12/25-27

Group	Analyte	MRL	Units	Guideline	
Agri. - Soil	pH	2.0			10.4
	SO4	0.01	%		0.07
General Chemistry	Cl	0.002	%		0.275
	Electrical Conductivity	0.05	mS/cm		<0.05
	Resistivity	1	ohm-cm		20000

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

146 Colonnade Rd. Unit 8, Ottawa, ON K2E 7Y1

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX E

Vertical Seismic Profiling (VSP) Test Results and Report

Sites 3-55/1 and 3-55/2 Highway 417 Overpass Structures at Preston Street

TECHNICAL MEMORANDUM

DATE July 10, 2019

N° de projet 1655214-1210-Rev B

TO Kenton Power
Golder Associates Ltd.

CC Chris Phillips

FROM Philippe Martin

EMAIL pmartin@golder.com

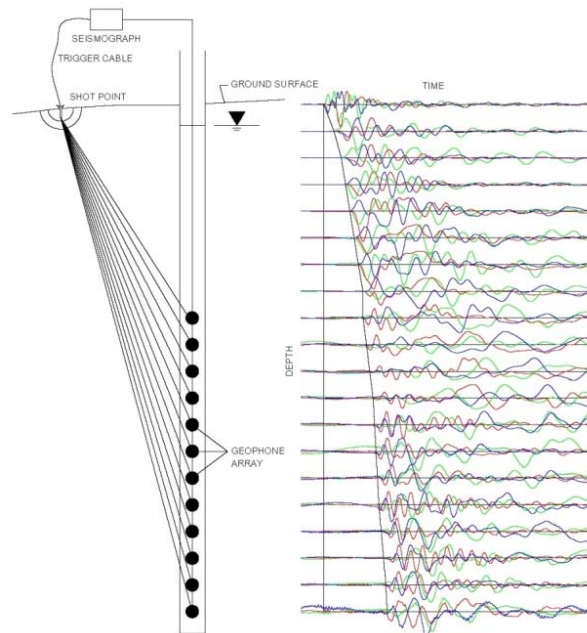
VERTICAL SEISMIC PROFILING TEST RESULTS - MIDTOWN BRIDGE AT PRESTON, OTTAWA, ONTARIO

This memorandum presents the results of the Vertical Seismic Profiling (VSP) testing carried out inside borehole BH-18-2101 at the Midtown Bridge on Preston avenue, Ottawa, Ontario on June 4th, 2019. Borehole BH-18-2101 was drilled to an approximate depth of 7.1 m below the existing ground surface and then cased with a 2.5 inch PVC pipe grouted in place.

Methodology

For the VSP method, seismic energy is generated at the ground surface by an active seismic source and recorded by a geophone located in a nearby borehole at a known depth. The active seismic source can be either compression or shear wave. The time required for the energy to travel from the source to the receiver (geophone) provides a measurement of the average compression or shear-wave seismic velocity of the medium between the source and the receiver. Data obtained from different geophone depths are used to calculate a detailed vertical seismic velocity profile of the subsurface in the immediate vicinity of the test borehole.

The high resolution results of a VSP survey are often used for earthquake engineering site classification, as per the 2015 National Building Code of Canada.



Example 1: Layout and resulting time traces from a VSP survey.

Fieldwork

The fieldwork was carried out on June 4, 2019, by personnel from the Golder Montreal office.

Both compression and shear-wave seismic sources were used. The compression and shear-wave sources were located 0.2 m and 0.3 m from the borehole respectively. The seismic source for the compression wave test consisted of an 8 kg sledge-hammer vertically impacted on a metal plate. The seismic source for the shear-wave test consisted of a 2.4 metre long, 150 millimetre by 150 millimetre wooden beam, anchored to the pavement with four (4) 10 inches-long nails and horizontally struck with a 8 kilogram sledge hammer on alternate ends of the beam to induce polarized shear waves. The shear source was coupled to the ground surface by having the operator standing on top of the beam. Test measurements were conducted from the bottom up to the surface. Measurements were recorded in the borehole with a 3-component receiver spaced mostly at 1-metre intervals.

The seismic records collected for each source location were stacked a minimum of nine (9) times to minimize the effects of ambient background seismic noise on the collected data. The data was sampled at 0.020833 millisecond intervals and a total time window of 0.341 seconds was collected for each seismic shot.

Data Processing

Processing of the VSP test results consisted of the following main steps:

- 1) Combination of seismic records to present seismic traces for all depth intervals on a single plot for each seismic source and for each component;
- 2) Low Pass Filtering of data to remove spurious high frequency noise;
- 3) First break picking of the compression and shear-wave arrivals; and,

- 4) Calculation of the average compression and shear-wave velocity to each tested depth interval.

Processing of the VSP data was completed using the SeisImager/SW software package (Geometrics Inc.). The seismic records are presented on the following two plots and show the first break picks of the compression wave (Figure 1) and shear wave arrivals (Figure 2) overlaid on the seismic waveform traces recorded at the different geophone depths for Borehole BH-18-2101. The arrivals were picked on the vertical component for the compression source and on the two horizontal components for the shear source.

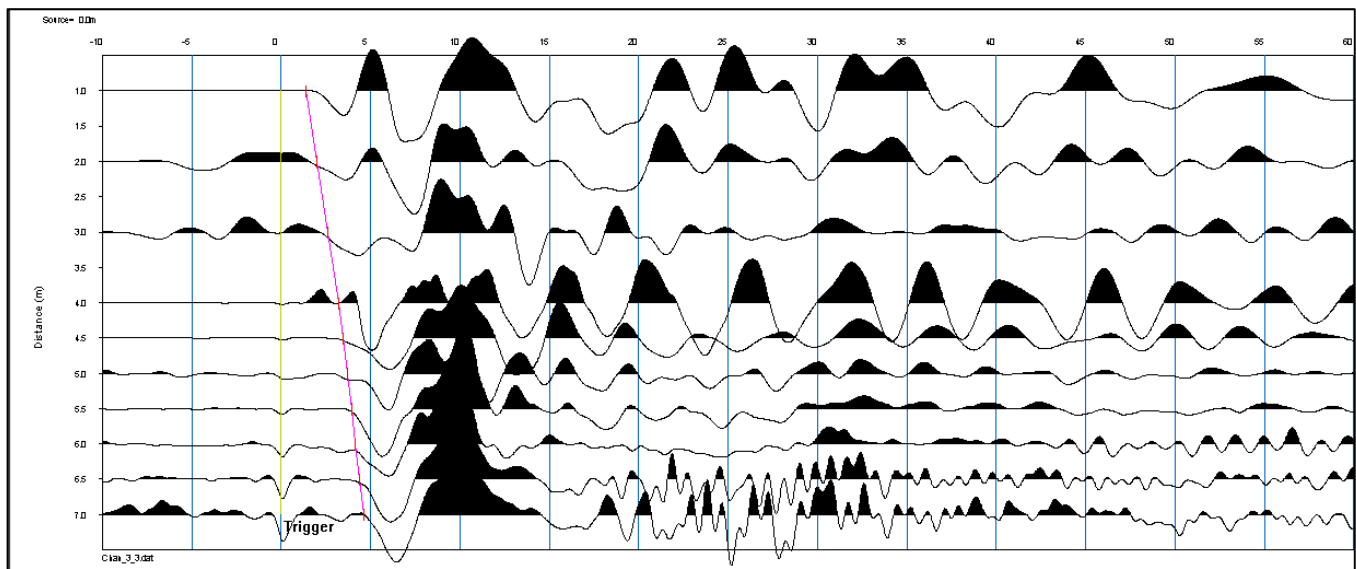


Figure 1: First break picking of compression wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole BH-18-2101.

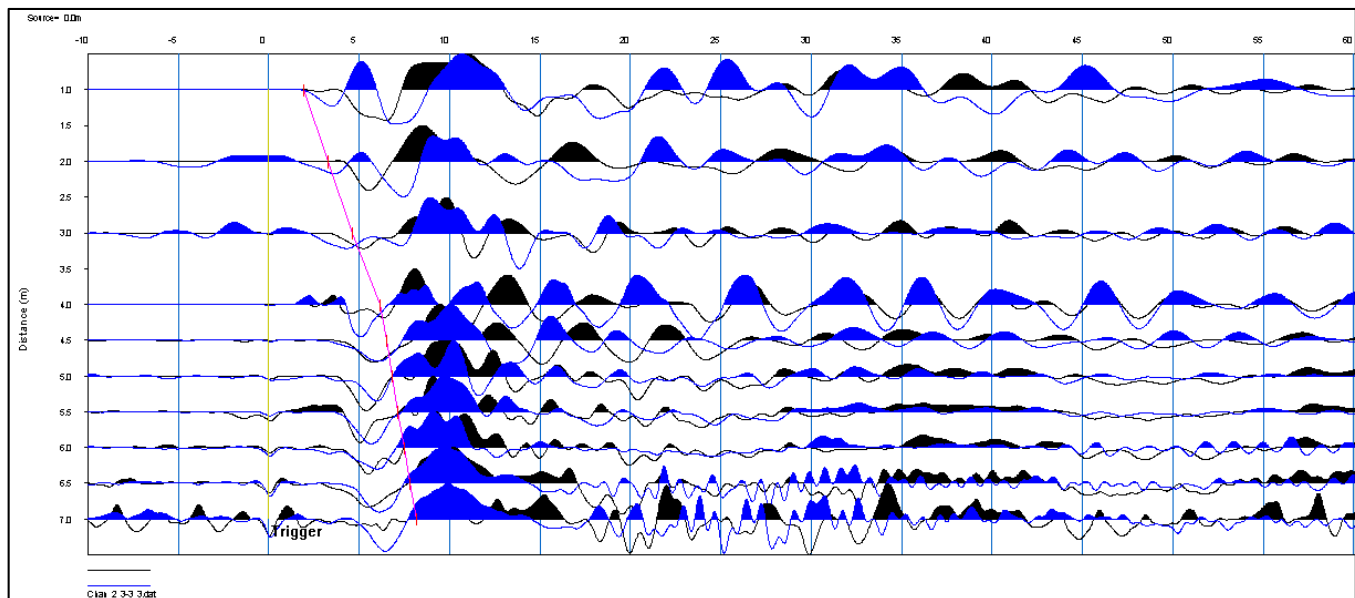


Figure 2: First break picking of shear wave arrivals (red) along the seismic traces recorded at each receiver depth of Borehole BH-18-2101.

Results

The VSP results are summarized in Table 1. The shear wave and compression wave layer velocities were calculated by best fitting a theoretical travel time model to the field data. The depths presented in the table are relative to ground surface.

The estimated dynamic engineering moduli, based on the calculated wave velocities, are also presented in Table 1. The engineering moduli were calculated using an estimated bulk density, based on the borehole log. At borehole BH-18-2101, an estimated bulk density of 1,900 kg/m³ and 2,100 kg/m³ were used for the fill and bedrock respectively.

The average shear wave velocity from ground surface to a depth of 30 metres was estimated to be 1081 metres per second. The average velocity was calculated assuming that the velocity from 7 metres to a depth of 30 metres was constant with an average shear-wave velocity value of 1350 m/s which is equal to the velocity of the bedrock at the bottom of the borehole.

Limitations

This technical memorandum, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

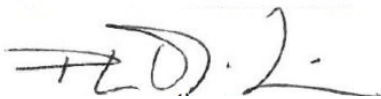
Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that these results meet your current needs. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.



Philippe Martin, P.Eng (QC)
Senior Geophysicist, Associate

PM/CP



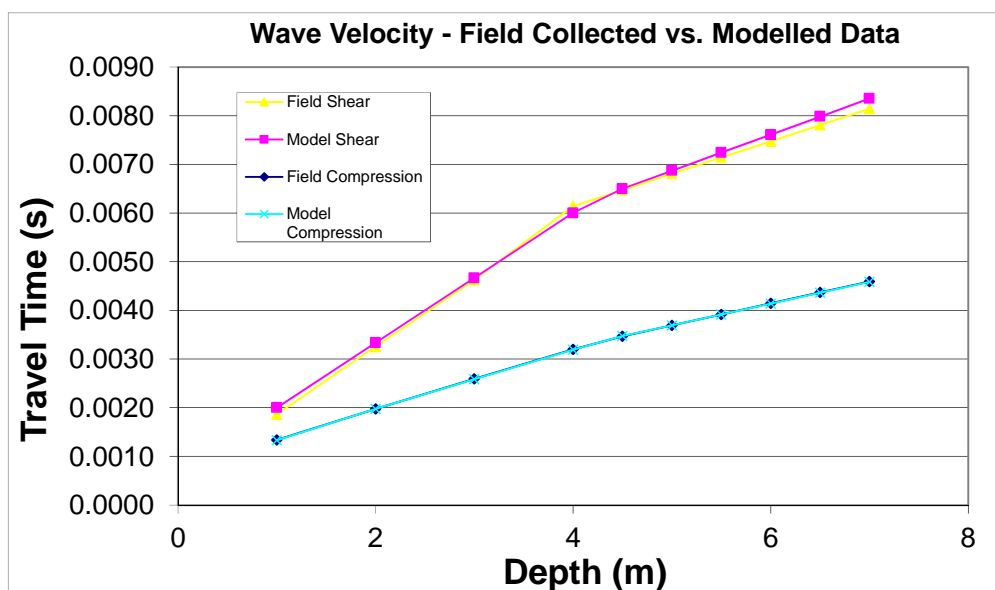
Christopher Phillips, M.Sc., P. Geo.
Senior Geophysicist, Principal

c:\users\pmartin\documents\1- projects gal\1655214 1210 midtown bridge vsp testing at preston\memo\1655214-1210 tech memovsp_midtown bridge at preston_july 10 2019 - revb.docx

Attachment: Table 1 – Compression and Shear Wave Velocity Profiles at Borehole BH-18-2101

TABLE 1
SHEAR WAVE VELOCITY PROFILE AT BOREHOLE BH-18-2101

Layer Depth (m)		Velocities (m/s)		Estimated Bulk Density (kg/m ³)	Dynamic Engineering Properties			
Top	Bottom	Compressional Wave	Shear Wave		Poissons Ratio	Shear Modulus (MPa)	Deformation Modulus (MPa)	Bulk Modulus (MPa)
0.0	1.0	750	500	1900	0.10	475	1045	435
1.0	2.0	1550	750	1900	0.35	1069	2880	3140
2.0	3.0	1645	750	2100	0.37	1181	3234	4108
3.0	4.0	1645	750	2100	0.37	1181	3234	4108
4.0	4.5	1800	1000	2100	0.28	2100	5363	4004
4.5	5.0	2250	1350	2100	0.22	3827	9329	5528
5.0	5.5	2250	1350	2100	0.22	3827	9329	5528
5.5	6.0	2250	1350	2100	0.22	3827	9329	5528
6.0	6.5	2250	1350	2100	0.22	3827	9329	5528
6.5	7.0	2250	1350	2100	0.22	3827	9329	5528

**Notes**

1. Depth Presented relative to ground surface.
2. This Table to be analyzed in conjunction with the accompanying report.

APPENDIX F

Site Photographs



Photograph 1: Looking north along Preston Street towards the Highway 417 Overpass at Preston Street; 2019-03-13



Photograph 2: Looking south along Preston Street towards the Highway 417 Overpass at Preston Street; 2019-03-13



Photograph 3: Looking northwest towards the southwest embankment; 2019-03-13



Photograph 4: : Looking east towards the southeast embankment; 2019-05-24



Photograph 5: Looking east towards the northeast embankment; 2019-05-24

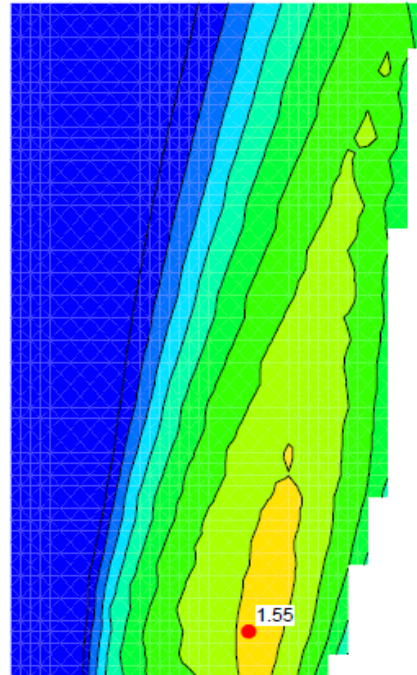
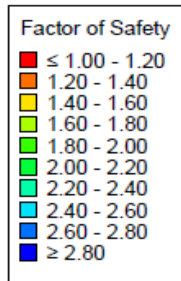


Photograph 6: Looking southwest towards the northwest embankment; 2019-03-13

APPENDIX G

Results of Slope Stability Analysis

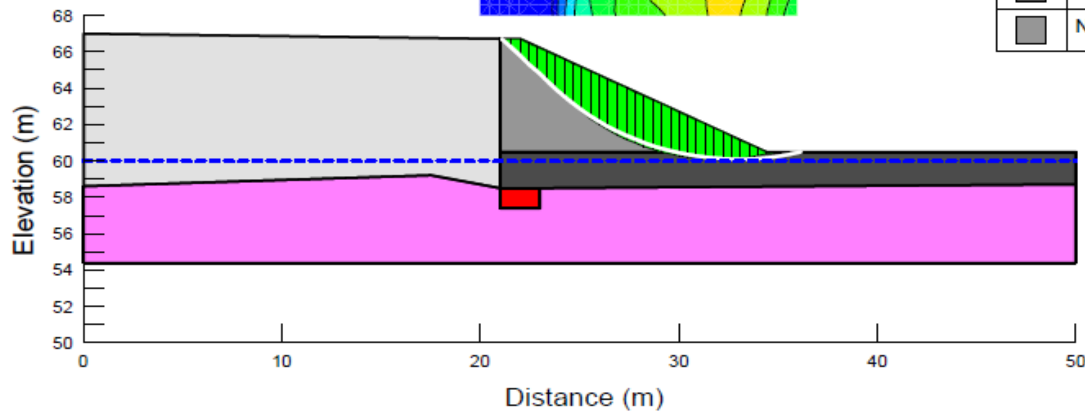
Figure G1 – Static Condition
Figure G2 – Seismic Condition



File Name: 2019_08_13_1655214-1210 Preston Street Overpass Global Failures _ RKJu
 Title: Preston Street Overpass - South Section
 Name: 1.1 Static Drained
 Method: Morgenstem-Price
 Direction of movement: Left to Right
 Horz Seismic Load: 0 g

Groundwater Elevation of 60.0 m
 Minimum Slip Surface Depth of 2.5 m

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion* (kPa)	Phi* (°)
	Bedrock	Bedrock (Impenetrable)			
	Concrete Footing	Bedrock (Impenetrable)			
	Existing Embankment Fill	Mohr-Coulomb	20	0	33
	Existing Grade Fill	Mohr-Coulomb	19	0	30
	New Embankment Fill	Mohr-Coulomb	20	0	33



Foundation Investigation

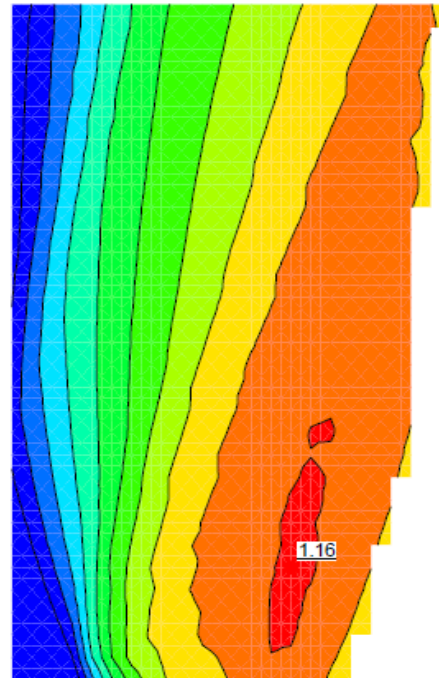
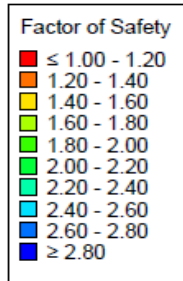
Highway 417 Overpass Structures at Preston Street

Slope Stability - Static Analysis

Ottawa, Ontario

Project No. 1655214-1210
 Drawn: RK
 Date: 2019-08-13
 Checked: KP
 Review: FJH

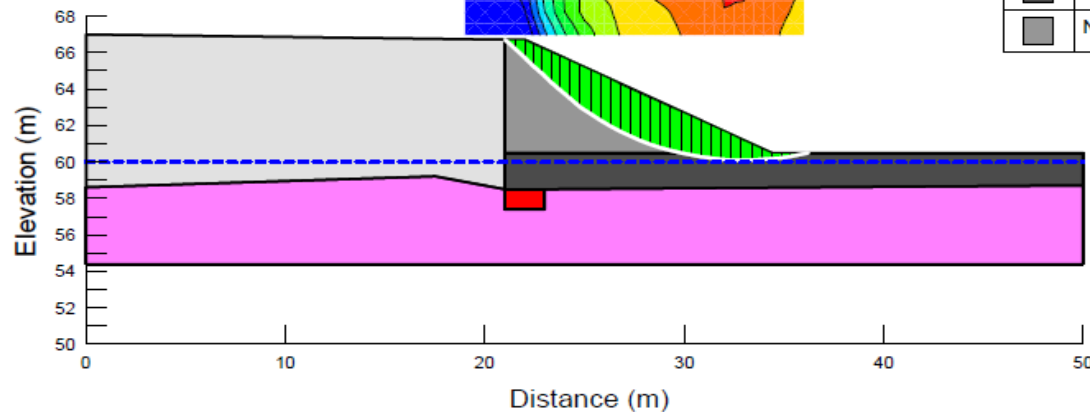
Figure G1



File Name: 2019_08_13_1655214-1210 Preston Street Overpass Global Failures _ RKJu
 Title: Preston Street Overpass - South Section
 Name: 1.2 Seismic Load
 Method: Morgenstern-Price
 Direction of movement: Left to Right
 Horz Seismic Load: 0.122 g

Groundwater Elevation of 60.0 m
 Minimum Slip Surface Depth of 2.5 m

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)			
	Concrete Footing	Bedrock (Impenetrable)			
	Existing Embankment Fill	Mohr-Coulomb	20	0	33
	Existing Grade Fill	Mohr-Coulomb	19	0	30
	New Embankment Fill	Mohr-Coulomb	20	0	33



Foundation Investigation

Highway 417 Overpass Structures at Preston Street

Slope Stability - Seismic Analysis

Ottawa, Ontario

Project No. 1655214-1210
 Drawn: RK
 Date: 2019-07-25
 Checked: KP
 Review: FJH

Figure G2



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