GOLDER

FINAL REPORT

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

Site Nos. 3-57/1 and 3-57/2
G.W.P. 4173-15-00
W.P. 4126-11-01 & 4215-15-01

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PART A

Foundation Investigation
Highway 417 Overpass Structures at Booth Street
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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) and widening of the Highway 417 eastbound (Site 3-57/1) and westbound (Site 3-57/2) overpass structures at Booth Street (G.W.P. 4173-15-00 and W.P. 4126-11-01 and W.P. 4215-15-01). 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 terms of reference and scope of work for the foundation investigation are outlined in the MTO's Request for Proposal, dated April 2016, and subsequent addenda. Golder's scope of work for foundation engineering services associated with the Highway 417 Overpasses at Booth Street is contained in Table 17.8.3 of WSP's Technical Proposal for this assignment dated June 28, 2016. 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 3-57/1 and 3-57/2 are located at Station 27+370, approximately 460 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 speed change lane of the Highway 417 / Bronson Avenue Interchange ends approximately 15 m east of Site 3-57/2.

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 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 of each structure, measured perpendicular to the centerline of the highway, is approximately 20.6 m. Each abutment has two retaining walls located along the north and south sides of the highway embankment for retaining the embankment fill. Noise barriers are installed on concrete barriers on the north side of Highway 417 and carried through the entire length of the structures. There is a 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 Booth 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. There is an existing retaining wall located at the toe of the northeast highway embankment that runs parallel to Raymond Street.

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 is 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 bedrock[2].

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 Formation.[3] 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 northeast. 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 m 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.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigations (2017 and 2018)

The field work for the 2017 investigation was carried out between March 20 and April 10, 2017 and included advancing a total of 24 coreholes, designated as 17-B01 to 17-B24, and four boreholes, designated as 17-121 to 17-124, located along Booth Street.

A supplemental investigation was carried out between October 2 and 11, 2018 and April 10 and 15, 2019, that included advancing eight additional boreholes located along the approach and highway embankments, designated as 18-1201 to 18-1208.

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[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.

Five additional boreholes were also advanced as part of the investigation for the proposed staging areas for this project. These included Boreholes 18-1212 and 18-1213, which were advanced on November 19, 2018, and Boreholes 18-1209 to 18-1211, which were advanced on January 27, 2019.

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

The 24 coreholes (12 per abutment) were drilled at approximately 3 m spacing along Booth 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 further advanced into the underlying bedrock to form Drillholes 17-B01D, 17-B04D, 17-B08D, 17-B12D, 17-B13D, 17-B16D, 17-B20D, and 17-B24D. Following the vertical hydro-excavation all drillholes except for 17-B04 were drilled on an incline due to the proximity of their location to the adjacent abutment and existing 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 17-121 to 17-124 were located on Booth Street to the north and south of the existing abutments, while Boreholes 18-1201 to 18-1204 were advanced through the existing Highway 417 embankments. Boreholes 18-1205 to 18-1208 were located within the highway approach embankments behind the existing abutments. Boreholes 18-1209 to 18-1213 were advanced at the proposed staging areas located in the existing parking lots south of Orangeville Street, to the east and west of Booth Street.

Boreholes 17-121 to 17-124 and Boreholes 18-1205 to 18-1213 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. of Ottawa, Ontario.

Boreholes 18-1201 to 18-1204 were advanced with portable rotary drilling equipment using NW and HW sized casing due to the proximity of the borehole locations to the adjacent abutment wingwalls and embankment slopes. The drilling equipment used a full weight hammer, but was dropped from a reduced height of 0.61 m. Where the reduced 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.

Traffic control, required to close either the driving lanes of Highway 417 or Booth 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 17-123 and 17-124. Soil samples in Boreholes 17-121 and 17-122 and Boreholes 18-1201 to 18-1204 were obtained at vertical sampling intervals of about 0.6 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 truck-mounted drilling equipment (Boreholes 18-1205 to 18-1213) were obtained at vertical intervals of about 0.76 m, 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 18-1201 to 18-1204 using a combination of NQ and HQ sized equipment.

Monitoring wells were installed in Boreholes 17-121, 17-124, and 18-1207, to observe the stabilised groundwater 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 (Boreholes 17-121 and 17-124) and December 6, 2018 (Borehole 18-1207) and then the wells were 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, 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 and grain size distribution analyses were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength testing was carried out on select samples of the 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 17-122 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 at the current sites, shear wave velocity profiling was completed at the nearby Highway 417 Overpass Structures at Rochester Street (Sites 3-56/1 and 3-56/2), located approximately 130 m west of Booth Street. Due to the close proximity and similar nature of the surficial and bedrock geology of the sites, the profiles developed at Rochester Street (Sites 3-56/1 and 3-56/2) are considered relevant to the current structures.

The shear wave velocity profiling was carried out in the grassy area next to the eastbound E-N/S off-ramp of the Highway 417 / Rochester Street Interchange, just west of Rochester Street, using the Multichannel Analysis of Surface Waves (MASW) technique. The MASW profiling was carried out on October 18, 2017, by personnel from Golder's Mississauga and Ottawa offices. A series of low frequency (4.5 Hz) geophones were laid out at 2 m intervals. A 9.9 kg sledgehammer and 34 kg drop weight were used as the seismic source. The source locations were offset at various distances beyond the end and collinear with the geophone array.

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.

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)					
17-B01/D	Sidewalk on Booth Street at east abutment	5029629.0	366875.9	66.4	88	65.7	0.9	2.4
17-B02		5029624.8	366877.7	66.4	Vertical	65.7	-	0.7
17-B03		5029622.2	366879.0	66.4	Vertical	65.7	-	0.7
17-B04/D		5029619.4	366880.2	66.4	Vertical	65.7	1.0	2.5
17-B05		5029616.6	366881.4	66.4	Vertical	65.7	-	0.7
17-B06		5029613.8	366882.6	66.4	Vertical	65.7	-	0.7
17-B07		5029611.1	366883.8	66.5	Vertical	65.9	-	0.6
17-B08/D		5029608.5	366884.9	66.5	84	65.9	1.0	2.2
17-B09		5029605.6	366886.2	66.5	Vertical	65.9	-	0.6
17-B10		5029602.8	366887.4	66.5	Vertical	65.9	-	0.6
17-B11		5029600.1	366888.6	66.6	Vertical	65.9	-	0.7
17-B12/D		5029597.1	366889.9	66.6	Vertical	65.9	0.9	2.6
17-B13/D	Sidewalk on Booth Street at west abutment	5029591.2	366873.2	66.6	77	65.8	1.0	2.5
17-B14		5029594.3	366871.9	66.6	Vertical	65.8	-	0.8
17-B15		5029597.4	366870.5	66.6	Vertical	65.8	-	0.8
17-B16/D		5029600.5	366869.2	66.5	77	65.8	1.1	2.3
17-B17		5029603.4	366867.9	66.5	Vertical	65.8	-	0.7
17-B18		5029606.6	366866.5	66.4	Vertical	65.8	-	0.6
17-B19		5029609.9	366865.1	66.4	Vertical	65.7	-	0.7
17-B20/D		5029612.6	366863.9	66.4	78	65.7	1.1	2.4
17-B21		5029615.6	366862.6	66.4	Vertical	65.7	-	0.7
17-B22		5029618.7	366861.3	66.3	Vertical	65.7	-	0.6
17-B23		5029621.8	366859.9	66.3	Vertical	65.7	-	0.6
17-B24/D		5029624.3	366858.8	66.3	69	65.7	0.9	2.3

Notes: [1] B = Corehole only; B/D = Combination Corehole and Drillhole
[2] Testhole inclination is measured counter-clockwise from the vertical
[3] Top of footing elevation shown is measured vertically from the ground surface
[4] Depth indicated is measured along the drill path

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)				
17-121	Booth Street West Sidewalk South of west abutment	5029588.1	366875.8	66.6	N/A	N/A	4.1
17-122	Booth Street East Sidewalk South of east abutment	5029591.2	366891.0	66.7			4.2
17-123	Booth Street West Sidewalk North of west abutment	5029627.2	366858.8	66.3			4.8
17-124	Booth Street East Sidewalk North of east abutment	5029631.8	366873.5	66.4			4.4
18-1201	Highway 417 Embankment Northwest of west abutment	5029623.2	366850.6	68.4	65.5	0.9	5.6
18-1202	Highway 417 Embankment Southwest of west abutment	5029588.0	366868.8	69.5	66.7	1.0	5.7
18-1203	Highway 417 Embankment Northeast of east abutment	5029632.6	366880.7	68.7	66.1	1.1	5.5
18-1204	Highway 417 Embankment Southeast of east abutment	5029597.6	366900.1	70.5	66.2	1.0	7.1
18-1205	Highway 417 Westbound west of west abutment	5029618.3	366850.1	71.9	N/A	N/A	6.9
18-1206	Highway 417 Eastbound west of west abutment	5029601.2	366853.7	72.1			6.9

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)				
18-1207	Highway 417 Westbound East of east abutment	5029618.2	366891.1	72.6	N/A	N/A	6.9
18-1208	Highway 417 Eastbound East of east abutment	5029602.4	366898.5	72.9			7.6
18-1209	Staging Area 1 Southwest of eastbound structure South of Orangeville Street	5029514.3	366806.2	65.3			1.0
18-1210	Staging Area 1 Southwest of eastbound structure South of Orangeville Street	5029529.9	366838.3	66.0			1.0
18-1211	Staging Area 1 Southwest of eastbound structure South of Orangeville Street	5029545.2	366884.1	66.8			1.6
18-1212	Staging Area 2 Southeast of eastbound structure South of Orangeville Street	5029556.0	366916.4	67.2	N/A	N/A	1.6
18-1213	Staging Area 2 Southeast of eastbound structure South of Orangeville Street	5029572.0	366933.6	67.8			1.4

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

3.2 Previous Investigation (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:

- "*Report of Soil Investigation Site of Bridge No. 17, at Booth Street, the Queensway, For De Leuw, Cather & Company of Canada, Limited, Consulting Engineers, Report No. S-108-59, W.P. 941-59*", dated December 9, 1959 (GEOCRES No. 31G05-030).

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

A total of seven boreholes were advanced at the site as part of the original investigation along the then proposed bridge alignment over Booth Street. The Soil Profile and Laboratory Test Sheets 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.

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 B6 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 A31 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 MASW test results and report from Sites 3-56/1 and 3-56/2 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 those sites.

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 Booth Street consist of PCC sidewalk at surface, overlying granular fill overlying PCC footings and/or limestone bedrock.

At the approach boreholes the subsurface conditions consist of asphaltic concrete/Portland cement concrete surface cover, overlying fill materials, overlying native glacial till all underlain by 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.

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 asphaltic concrete surface cover, overlying fill materials, overlying native glacial till, all underlain by limestone bedrock.

The groundwater levels measured at the site at depths range from 2.2 to 6.9 m in depth, corresponding to Elevations 64.1 to 65.7 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 18-1205 to 18-1208 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete at the borehole locations ranges from 200 to 300 mm.

PCC was encountered below the asphaltic concrete in Boreholes 18-1205 and 18-1208 and is 300 mm in thickness.

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 18-1206 and 18-1207 and below the PCC at Boreholes 18-1205 and 18-1208. The top of this layer was encountered at elevations ranging from 71.4 to 72.5 m. The thickness of the fill ranges from 300 to 600 mm.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered at the ground surface at embankment Boreholes 18-1201 to 18-1204 and below the pavement structure at approach Boreholes 18-1205 to 18-1208. The top of this layer was encountered at elevations ranging from 68.4 to 72.1 m. The thickness of the fill ranges from 2.6 to 6.8 m. The SPT N values ranged from 4 to 91, indicating a loose to very dense state of packing, but more typically dense to very dense. The measured moisture content of the samples tested ranged from 5 to 10 percent. The results of grain size analysis testing carried out on nine samples of this material are provided on Figures B1 and B2 in Appendix B.

A sandy clayey silt fill was encountered in Boreholes 18-1206 and 18-1208 at elevations of 70.9 and 67.6 m respectively. The clayey silt fill at Borehole 18-1206 contains ash, asphalt debris and organic matter. The thickness of the silt fill at these locations was 0.2 and 0.6 m. One SPT N value of 2 was recorded in the clayey silt at Borehole 12-1208, indicating a firm state of packing. The measured moisture content of the two samples tested

of the clayey silt fill was 17 and 20 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B3 in Appendix B.

4.3.3 Glacial Till

Glacial till was encountered below the fill in Borehole 18-1207. 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 gravelly sand some silt trace clay. This layer was encountered at Elevation 66.5 m and is about 800 mm in thickness.

One SPT N value of 6 was recorded in the till, indicating a loose state of packing. The higher blow count (i.e., 60) 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.

The measured moisture content of a single sample of the glacial till was 29 percent. The results of grain size distribution testing carried out on a single sample of the glacial till are provided on Figures B4 Appendix B.

4.4 Booth Street

Boreholes 17-121 to 17-124 and the coreholes/drillholes 17-B01 to 17-B24 were advanced within the Booth Street right-of-way along the existing abutments.

4.4.1 Surface Cover

A PCC sidewalk was encountered at the ground surface at Boreholes 17-121 to 17-124 and the coreholes/drillholes advanced along Booth Street. The thickness of the concrete ranges from 100 to 200 mm at the testhole locations.

4.4.2 Sand, Gravely Sand, and Sand and Gravel Fill

A fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the PCC sidewalk at all testhole locations. The top of this layer was encountered at elevations ranging from 66.1 to 66.6 m. The thickness of the layer ranges from 0.4 to 1.0 m. The SPT N values ranged from 11 to 13, indicating a compact state of packing.

The moisture content of the samples tested ranged from 9 to 13 percent. The results of grain size analysis tests carried out on six samples of this material are provided on Figure B5 in Appendix B.

4.5 Staging Areas

Boreholes 18-1209 to 18-1211 were advanced within Staging Area 1 and Boreholes 18-1212 and 18-1213 were advanced within Staging Area 2. The locations of the staging areas are shown on the plan view on Drawing 5.

4.5.1 Surface Cover

Asphaltic concrete was encountered at the ground surface of all boreholes advanced within the staging areas.

The thickness of the asphaltic concrete at the borehole locations in Staging Area 1 ranges from 40 to 50 mm, while in Staging Area 2 the thickness ranges from 70 to 80 mm.

4.5.2 Fill

A fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the asphaltic concrete at all boreholes advanced in the staging areas. The top of this layer was encountered at

elevations ranging from 65.2 to 67.7 m. The thickness of the layer ranges from 0.95 to 1.6 m. The measured SPT N values ranged from 31 to 36, indicating a dense state of packing.

The measured moisture content of the five samples tested ranged from 3 to 8 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B6 in Appendix B.

4.6 Concrete Footings

The existing concrete footings were encountered in coreholes/drillholes 17-B01 to 17-B24 and embankment Boreholes 18-1201 to 18-1204. The top of the concrete footing was encountered at elevations ranging from 66.7 to 65.5 m. The thickness of the footings ranges from 0.9 to 1.1 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 18-1201 to 18-1204. An assessment of the condition of the PCC footing cores is provided in Table A1 of Appendix A.

4.7 Bedrock

The overburden 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 NQ sized equipment in Boreholes 17-121 to 17-124 and NQ and HQ sized equipment in Boreholes 18-1201 to 18-1204. Bedrock was proven by coring using BQ sized equipment in Drillholes 17-B01/D, 17-B04/D, 17-B08/D, 17-B12/D, 17-B13/D, 17-B16/D, 17-B20/D, and 17-B24/D. Photographs of the bedrock core are provided in Appendix A. Bedrock was also proven by coring using BX sized coring equipment in Boreholes 1 to 7 during the 1959 investigation.

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)
17-B01D	Sidewalk along Booth Street at east abutment	66.4	88	1.5	64.8
17-B04D		66.4	Vertical	1.7	64.7
17-B08D		66.5	84	1.7	64.9
17-B12D		66.6	79	1.7	65.0
17-B13D	Sidewalk along Booth Street at west abutment	66.6	77	1.8	64.9
17-B16D		66.5	77	1.8	64.8
17-B20D		66.4	78	1.9	64.6
17-B24D		66.3	69	1.6	64.9
17-121	Booth Street Southwest of west abutment	66.6	Vertical	0.9	65.7

Drillhole / Borehole	Drillhole / Borehole Location	Existing Ground Surface Elevation (m)	Testhole Inclination[1] (°)	Depth to Bedrock Surface[2] (m)	Bedrock Surface Elevation[3] (m)
17-122	Booth Street Southeast of east abutment	66.7	Vertical	1.0	65.7
17-123	Booth Street Northwest of west abutment	66.3	Vertical	1.2	65.1
17-124	Booth Street Northeast of east abutment	66.4	Vertical	0.9	65.5
18-1201	Highway 417 Embankment Northwest of west abutment	68.4	Vertical	3.9	64.5
18-1202	Highway 417 Embankment Southwest of west abutment	69.5	Vertical	3.8	65.7
18-1203	Highway 417 Embankment Northeast of east abutment	68.7	Vertical	3.7	65.0
18-1204	Highway 417 Embankment Southeast of east abutment	70.5	Vertical	5.3	65.2
1	West abutment	66.5	Vertical	1.1	65.4
2	West abutment	66.2	Vertical	1.0	65.2
3	East abutment	66.7	Vertical	0.9	65.8
4	East abutment	66.3	Vertical	0.8	65.5
5	West abutment	66.4	Vertical	0.8	65.6
6	East abutment	66.9	Vertical	1.0	65.9
7	East abutment	66.8	Vertical	0.7	66.1

Notes: [1] Testhole inclination is measured counter clockwise from the vertical
[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 also present in the bedrock core. Rock Quality Designation (RQD) values measured on recovered bedrock core samples typically ranged from about 0 to 100 percent, but more generally ranged from about 53 to 100 percent indicating fair to excellent quality rock.

Results of unconfined compressive strength (UCS) testing carried out on four bedrock core samples are presented on Figure B7 provided in Appendix B. The samples tested had UCS values ranging from 36 to 74 MPa, indicating a medium strong to strong bedrock.

4.8 Groundwater Conditions

Monitoring wells were installed in Boreholes 17-121, 17-124, and 18-1207 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	Borehole Location	Screened Interval	Depth (m)	Elevation (m)	Date
17-121	West Abutment	Bedrock	2.5	64.1	October 27, 2017
17-124	East Abutment	Bedrock	2.0 2.2	64.4 64.2	April 26, 2017 October 27, 2017
18-1207	East Abutment	Fill and Bedrock	6.9	65.7	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 17-122 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)
17-122	SS1	0.3 – 0.9	Fill	0.028	<0.01	0.63	8.8	1590

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, and Mr. Matt Kennedy, P.Eng., Senior Geotechnical Engineer. 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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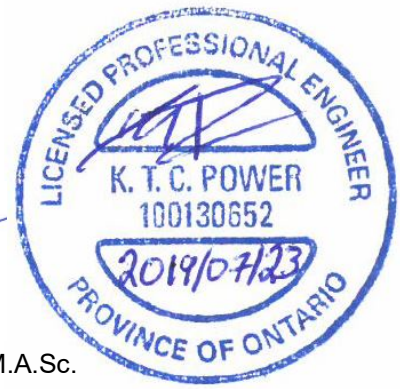

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PART B

Foundation Design
Highway 417 Overpass Structures at Booth Street
Rapid Bridge Replacement
Site Nos. 3-57/1 & 3-52/2

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 3-57/1) and westbound (Site 3-57/2) overpass structures at Booth Street, (G.W.P. 4173-15-00, W.P. 4126-11-01 & 4215-15-01). 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 GEOCRES 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 that are 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 of each structure, measured perpendicular to the centerline of the highway, is approximately 20.6 m. The existing abutments are supported on shallow foundations bearing directly on the bedrock. Each abutment has two retaining walls located along the north and south sides of the highway embankment for retaining the embankment fill. Noise barriers are installed on concrete barriers on the north side of Highway 417 and carried through the entire length of the Booth Street Overpass structures.

At this location, Highway 417 is a divided highway with four travel lanes in each direction separated by a concrete barrier wall. The westbound speed change lane of the Highway 417 / Bronson Avenue Interchange ends approximately 15 m east of Site 3-57/2.

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 71.9 to 72.1 m at the west abutment, and from 72.6 to 72.9 m at the east abutment in the westbound and eastbound directions respectively. The top of sidewalk elevations of Booth Street ranges from about Elevation 66.3 to 66.7 m.

The existing approach embankments are about 6 to 7 m high relative to the elevation of Booth 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 northeast highway embankment that runs parallel to Raymond Street.

6.3 Proposed Structures

Based on the May 2019 Preliminary General Arrangement (GA) Drawing provided by WSP, Highway 417 will be widened approximately 3.5 m to the north and south at this location for the addition of a new speed change lane in each direction. 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 areas 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 at the current sites, shear wave velocity profiling was completed at the nearby Highway 417 Overpass Structures at Rochester Street (Sites 3-56/1 and 3-56/2), located approximately 130 m west of Booth Street. Due to the close proximity and similar nature of the surficial and bedrock geology of the sites, the profiles developed for the Sites 3-56/1 and 3-56/2 are considered relevant to the current structures.

The shear wave velocity profiling was carried out in the grassy area next to the eastbound E-N/S off-ramp of the Highway 417 / Rochester Street Interchange, just west of Rochester Street, using the Multichannel Analysis of Surface Waves (MASW) technique. Profiling was carried out on October 18, 2017, by personnel from the Golder’s Mississauga and Ottawa offices. The shear wave velocities measured at that site are presented in the technical memorandum in Appendix E

Based on the results of the MASW testing at the Rochester Street site, an average shear wave velocity of 1,530 m/s was calculated for 30 m of rock underlying the footings at the Booth Street site (3-57/1 and 3-57/2), corresponding to Site Class A 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 A 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 <= 0.2 s	0.438
T = 0.5 s	0.237
T = 1.0 s	0.118
T = 2.0 s	0.056
T = 5.0 s	0.015
T => 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 A) 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 A seismic hazard values given in Table 7 can be used for design.

Table 7: Site Class A Spectral Values for Subject Site

Parameter	2% Probability of Exceedance in 50 Years (2,475-year) (g)
PGA	0.252
T <= 0.2 s	0.302
T = 0.5 s	0.135
T = 1.0 s	0.067
T = 2.0 s	0.032
T = 5.0 s	0.009
T => 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-4523-2) indicates that the footings were to bear directly on the bedrock, with a design top of footing elevations ranging from 65.7 m in the westbound direction to 65.8 m in the eastbound direction. 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 Booth 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	64.5 to 65.7
East Abutment	64.7 to 65.7

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 Footing Elevations

Footing Location	Reference Corehole/Drillhole	Elevation of Top of Footing (m)
West Abutment	17-B13 to 17-B24	65.7 to 65.8
East Abutment	17-B01 to 17-B12	65.7 to 65.9

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 ϕ' = 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 end of the excavation) 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 ($\phi°$)	Soil Unit Weight (γ, kN/m^3)	Coefficients of Earth Pressure		
			Active, Ka	At-Rest, Ko	Passive, Kp
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 ($\phi°$)	Soil Unit Weight (γ, kN/m^3)	Coefficients of Earth Pressure		
			Active, Ka	At-Rest, Ko	Passive, Kp
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. 0.25g for Site Class A 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. 0.13g for Site Class A).

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	Clear Stone	SSM
Yielding Wall	2,475-year	0.252	0.44	0.44	0.52	0.56
Non-Yielding Wall			0.34	0.34	0.42	0.45

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 be widened approximately 3.5 m to the north and south at this location for the addition of a new speed change lane in each direction using conventional 2H:1V side slopes. 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 0.126g, equal to ½ of the site adjusted PGA value (0.252g) was used for seismic analysis, (see Section 6.4.3).
- Groundwater level of 65.7 m.

Table 13: Geotechnical Design Parameters for Stability Analysis

Material	Bulk Unit Weight (kN/m^3)	Internal Angle of Friction ($\phi°$)
New Earth or Granular Embankment Fill	20	33
Existing 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. 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 Booth 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.

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.

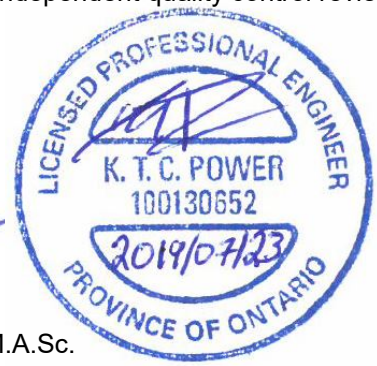
The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results in Table 5 were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and 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 of Golder and Mr. Matt Kennedy, P.Eng., Senior Geotechnical Engineer. 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.

Golder Associates Ltd.



Kenton C. Power, P.Eng, M.A.Sc.
Geotechnical Engineer

Matt Kennedy, P.Eng
Senior Geotechnical Engineer

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

KCP/WC/MJK/FJH/hdw
https://golderassociates-my.sharepoint.com/personal/hweima_golder_com/documents/desktop/booth street/1662565-1120-001-reva-final booth st bridge-2019-07-24.docx

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	■ Feasible for support of the bridge replacement and rapid bridge replacement (RBR) technique ■ Preferred option from a foundation perspective	■ 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	■ 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	■ Low cost ■ Less expensive than deep foundations	■ 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	■ Feasible for support of the of the bridge replacement and rapid bridge replacement (RBR) technique	■ Conventional excavation and construction ■ Also compatible with RBR techniques	■ 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	■ Moderate cost ■ Less expensive than deep foundations	■ Low risk of settlement; existing overpass structures have performed satisfactorily
Deep foundations	■ Feasible but not required or practical	■ High bearing resistance ■ Negligible settlement	■ Shallow bedrock depth would result lengths of less than 2 m which would likely require socketing into the strong limestone bedrock for a stable pile/caisson configuration	■ High cost, compared to other viable alternatives	■ Rock socketing would be required

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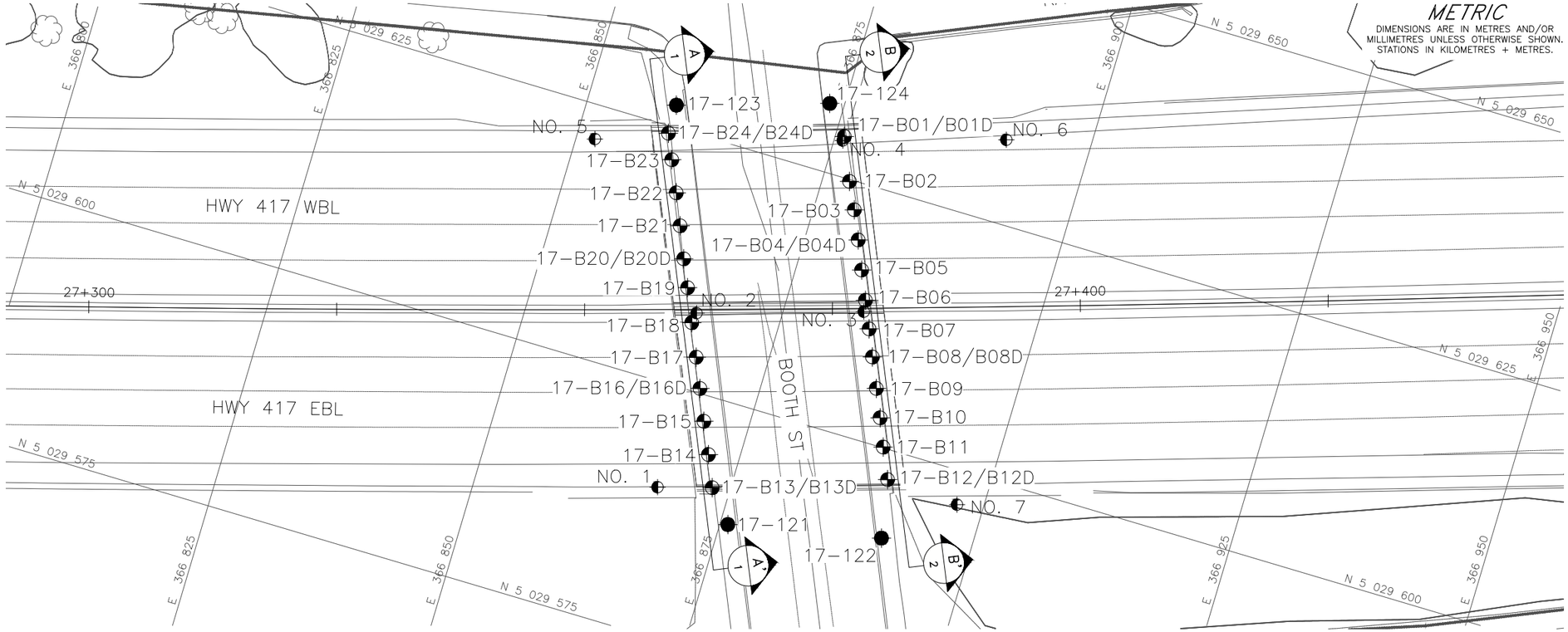

PLAN

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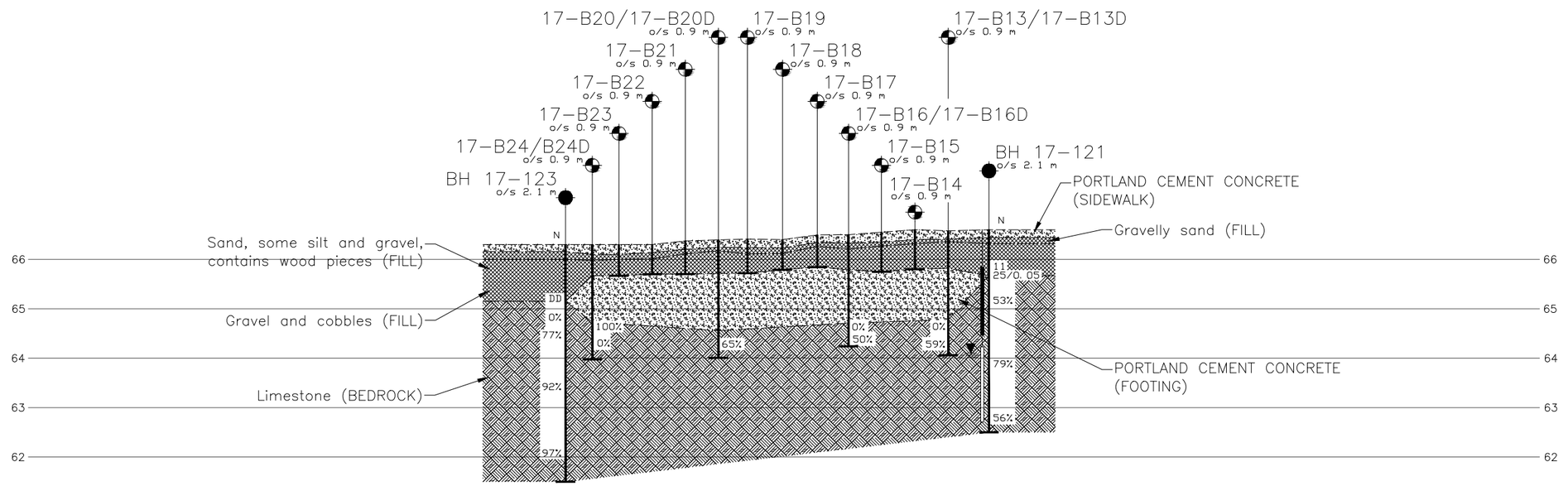

CROSS-SECTION A-A'

SCALE 5 0 5 10 m
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NOTES

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REFERENCE

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

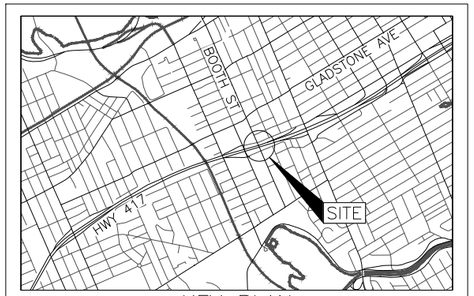
CONT No.
GWP No. 4173-15-00

HIGHWAY 417 OVERPASS STRUCTURES AT BOOTH STREET

BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.403689 LONG. -75.707079

SHEET

GOLDER



KEY PLAN
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LEGEND

- Borehole – Current Investigation
- Corehole – Current Investigation
- Borehole – Previous Investigation (Geocres No. 31G05-030)
- 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)
- WL in piezometer, measured on OCTOBER 27, 2017

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

No.	ELEVATION	NORTHING	EASTING
17-121	66.6	5029588.1	366875.8
17-122	66.7	5029591.2	366891.0
17-123	66.3	5029627.2	366858.8
17-124	66.4	5029631.8	366873.5
17-B01/B01D	66.4	5029629.0	366875.9
17-B02	66.4	5029624.8	366877.7
17-B03	66.4	5029622.2	366879.0
17-B04/B04D	66.4	5029619.4	366880.2
17-B05	66.4	5029616.6	366881.4
17-B06	66.4	5029613.8	366882.6
17-B07	66.5	5029611.1	366883.8
17-B08/B08D	66.5	5029608.5	366884.9
17-B09	66.5	5029605.6	366886.2
17-B10	66.5	5029602.8	366887.4
17-B11	66.6	5029600.1	366888.6
17-B12/B12D	66.6	5029597.1	366889.9
17-B13/B13D	66.6	5029591.2	366873.2
17-B14	66.6	5029594.3	366871.9
17-B15	66.6	5029597.4	366870.5
17-B16/B16D	66.5	5029600.5	366869.2
17-B17	66.5	5029603.4	366867.9
17-B18	66.4	5029606.6	366866.5
17-B19	66.4	5029609.9	366865.1
17-B20/B20D	66.4	5029612.6	366863.9
17-B21	66.4	5029615.6	366862.6
17-B22	66.3	5029618.7	366861.3
17-B23	66.3	5029621.8	366859.9
17-B24/B24D	66.3	5029624.3	366858.8
NO. 1	66.4	5029589.7	366867.9
NO. 2	66.2	5029607.6	366866.6
NO. 3	66.7	5029612.6	366882.8
NO .4	66.3	5029628.5	366875.8
NO. 5	66.4	5029621.5	366851.8
NO. 6	66.9	5029633.3	366891.6
NO. 7	66.8	5029596.6	366897.3

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31G5-308

HWY. 417	PROJECT NO. 1655214-1120		DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/07/2019	SITE: 3-57.1 & 3-57.2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

K. K. C. POWER 100130592 LICENSED PROFESSIONAL ENGINEER 2019/07/23 PROVINCE OF ONTARIO

F. J. HEFFERNAN REGISTERED PROFESSIONAL ENGINEER 2019/07/25 PROVINCE OF ONTARIO

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MINISTRY OF TRANSPORTATION, ONTARIO

CONT No.
GWP No. 4173-15-00

SHEET

HIGHWAY 417 OVERPASS STRUCTURES AT BOOTH STREET

BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.403689 LONG. -75.707079

GOLDER

METRIC
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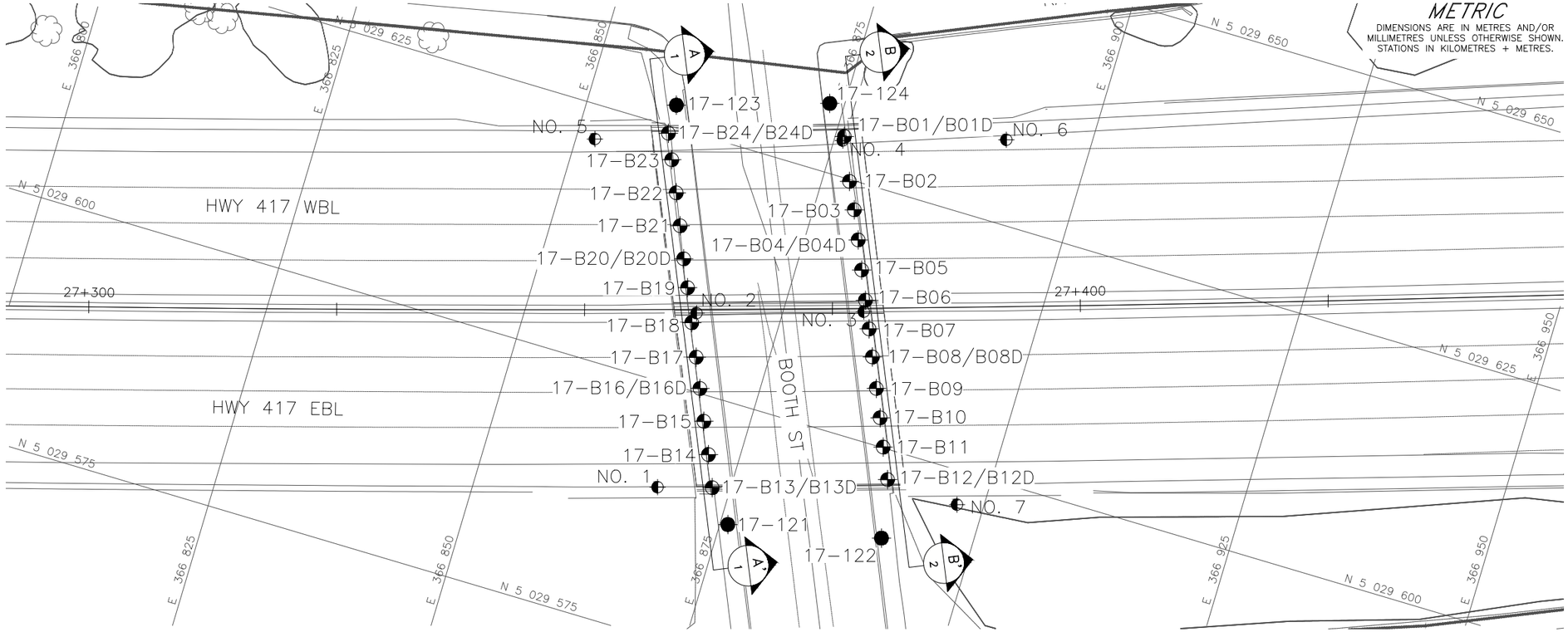

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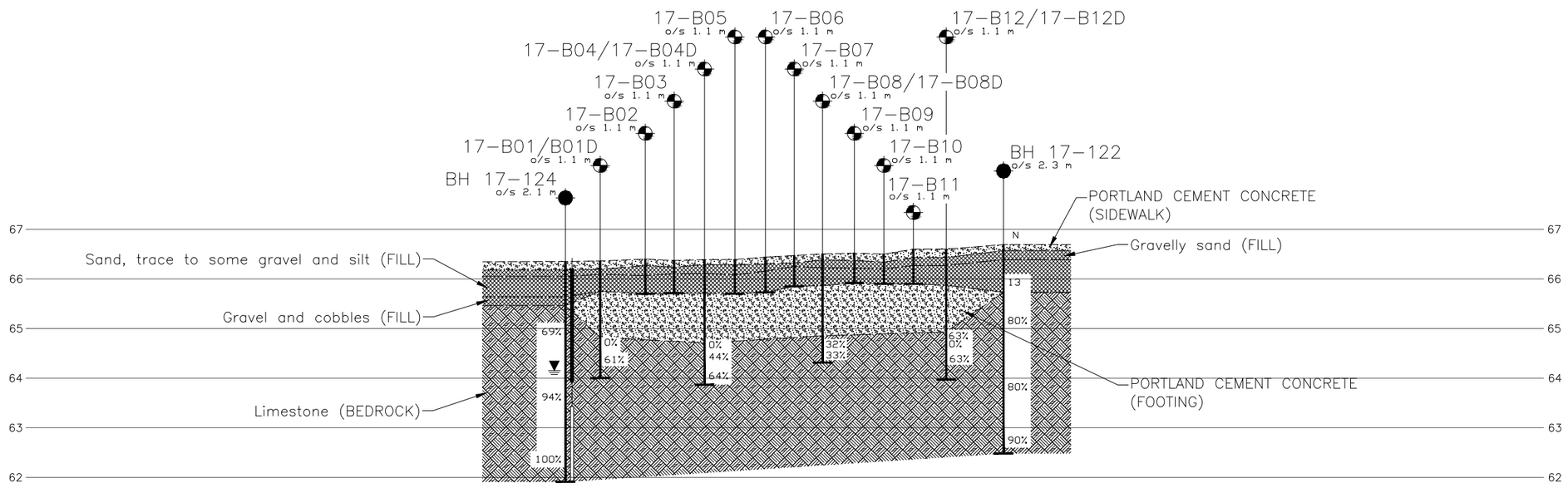

CROSS-SECTION B-B'
SCALE
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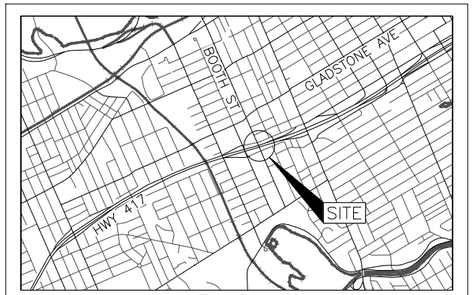

KEY PLAN
SCALE
500 0 500 1000 m

LEGEND

- Borehole – Current Investigation
- Corehole – Current Investigation
- Borehole – Previous Investigation (Geocres No. 31G05-030)
- 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)
- WL in piezometer, measured on OCTOBER 27, 2017

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

No.	ELEVATION	NORTHING	EASTING
17-121	66.6	5029588.1	366875.8
17-122	66.7	5029591.2	366891.0
17-123	66.3	5029627.2	366858.8
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17-B11	66.6	5029600.1	366888.6
17-B12/B12D	66.6	5029597.1	366889.9
17-B13/B13D	66.6	5029591.2	366873.2
17-B14	66.6	5029594.3	366871.9
17-B15	66.6	5029597.4	366870.5
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17-B17	66.5	5029603.4	366867.9
17-B18	66.4	5029606.6	366866.5
17-B19	66.4	5029609.9	366865.1
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17-B21	66.4	5029615.6	366862.6
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NO. 1	66.4	5029589.7	366867.9
NO. 2	66.2	5029607.6	366866.6
NO. 3	66.7	5029612.6	366882.8
NO .4	66.3	5029628.5	366875.8
NO. 5	66.4	5029621.5	366851.8
NO. 6	66.9	5029633.3	366891.6
NO. 7	66.8	5029596.6	366897.3

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REFERENCE

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K. C. POWER 100130592 LICENSED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 2019/07/23

F. J. HEFFERNAN REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 2019/07/23

NO.	DATE	BY	REVISION
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Geocres No. 31G5-308

HWY. 417		PROJECT NO. 1655214-1120	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/07/2019	SITE: 3-57.1 & 3-57.2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 2

PLOT DATE: July 25, 2019
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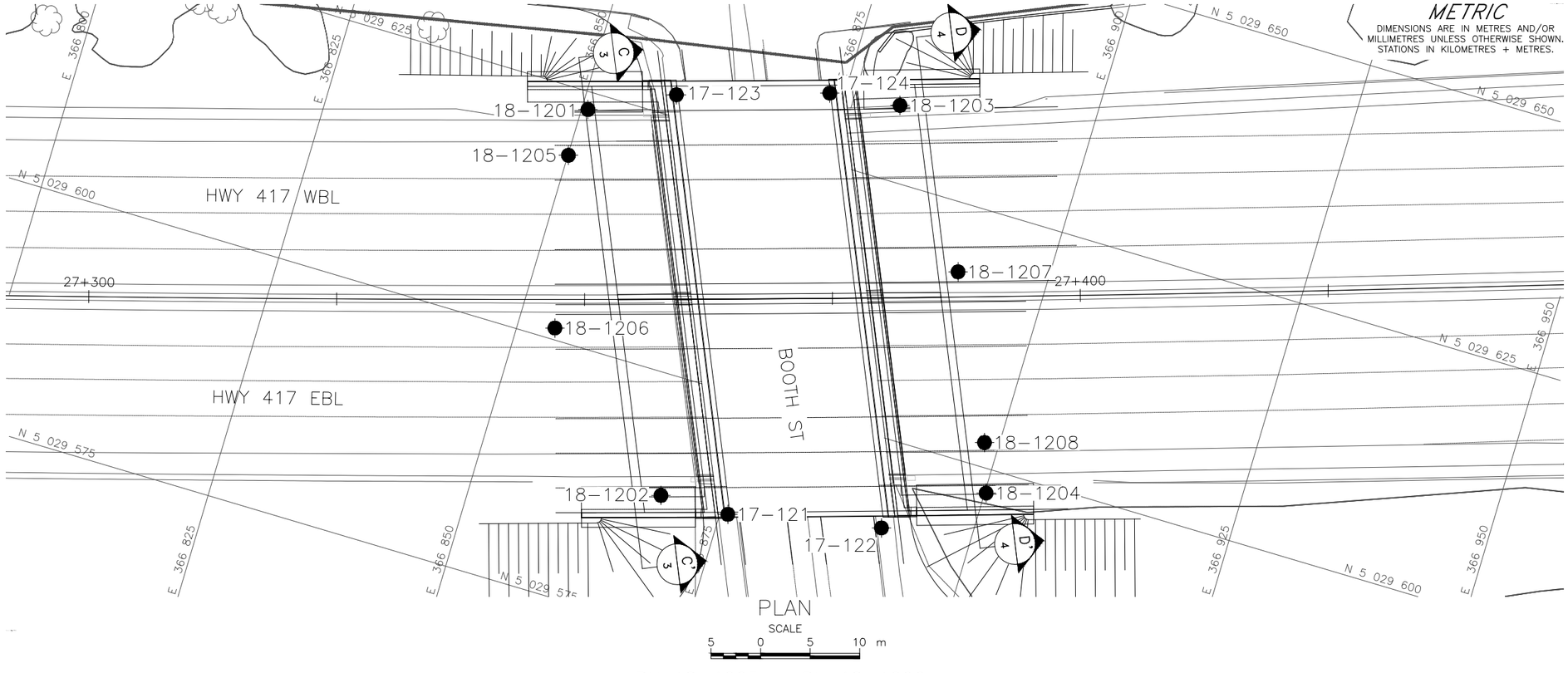
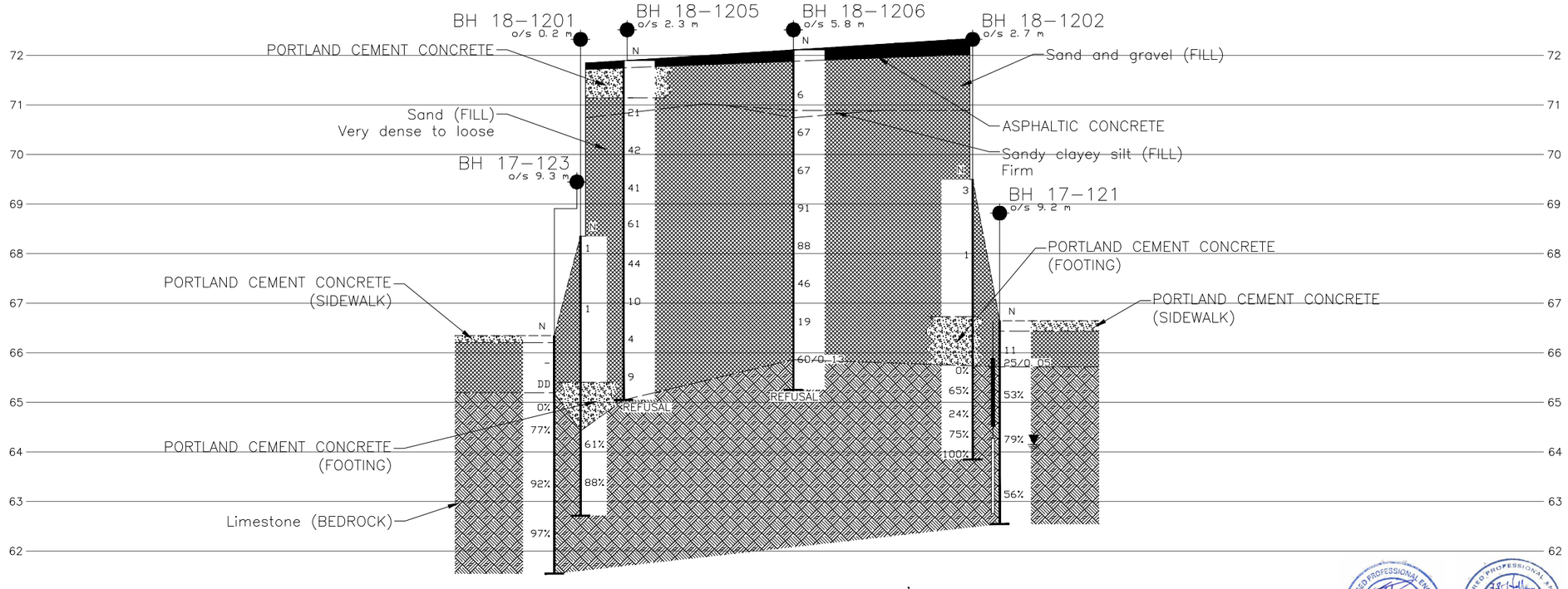
MINISTRY OF TRANSPORTATION, ONTARIO





CONT No.
GWP No. 4173-15-00

HIGHWAY 417 OVERPASS STRUCTURES AT BOOTH STREET
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.403689 LONG. -75.707079

SHEET

GOLDER

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 OCTOBER 27, 2017

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

No.	ELEVATION	NORTHING	EASTING
17-121	66.6	5029588.1	366875.8
17-122	67.0	5029591.2	366891.0
17-123	66.3	5029627.2	366858.8
17-124	66.4	5029631.8	366873.5
18-1201	68.4	5029623.2	366850.6
18-1202	69.5	5029588.0	366868.8
18-1203	68.7	5029632.6	366880.7
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18-1212	67.2	5029556.0	366916.4
18-1213	67.8	5029572.0	366933.6

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REFERENCE

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NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31G5-308

HWY. 417	PROJECT NO. 1655214-1120		DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/07/2019	SITE: 3-57.1 & 3-57.2
DRAWN: KM	CHKD. FJH	APPD. FJH	DWG. 3

K.K.C. POWER 100130052 LICENSED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 2019/07/23

F. J. HEFFERNAN REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 2019/07/23

PLOT DATE: July 25, 2019
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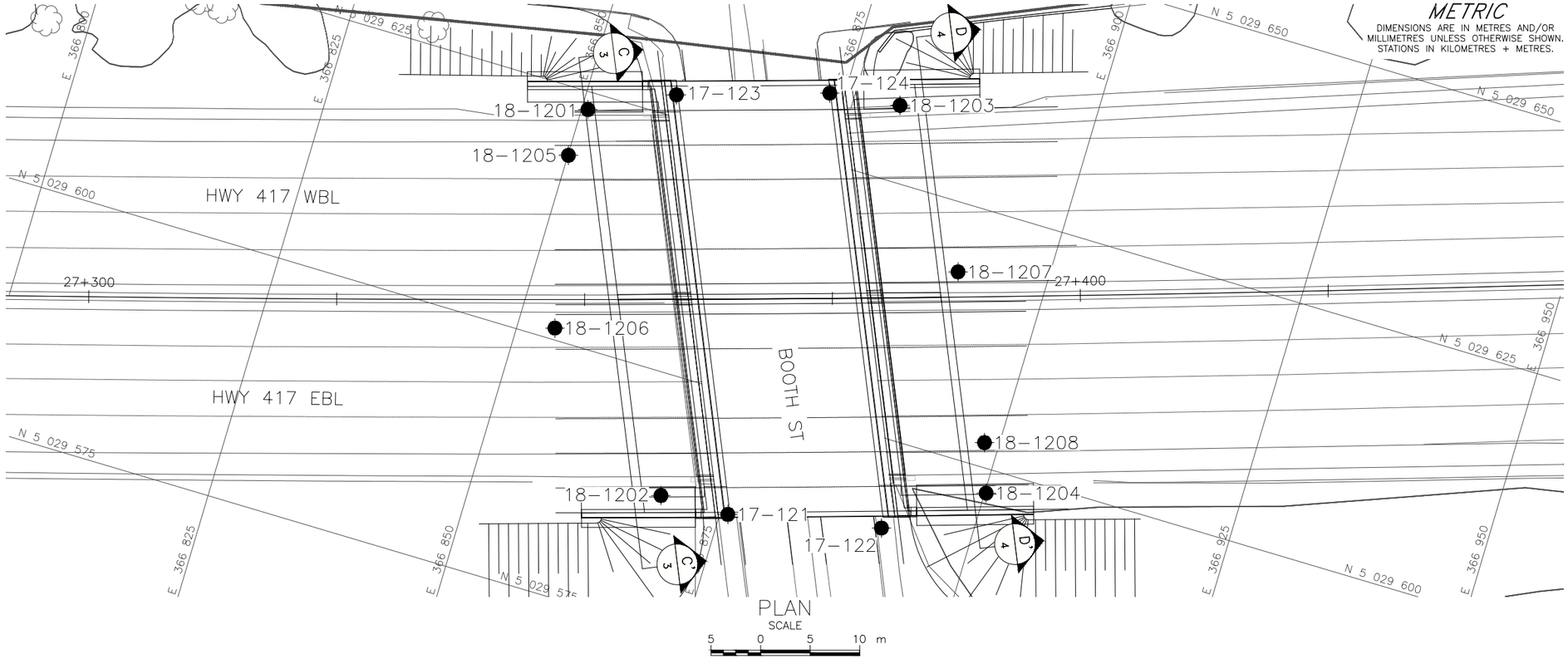
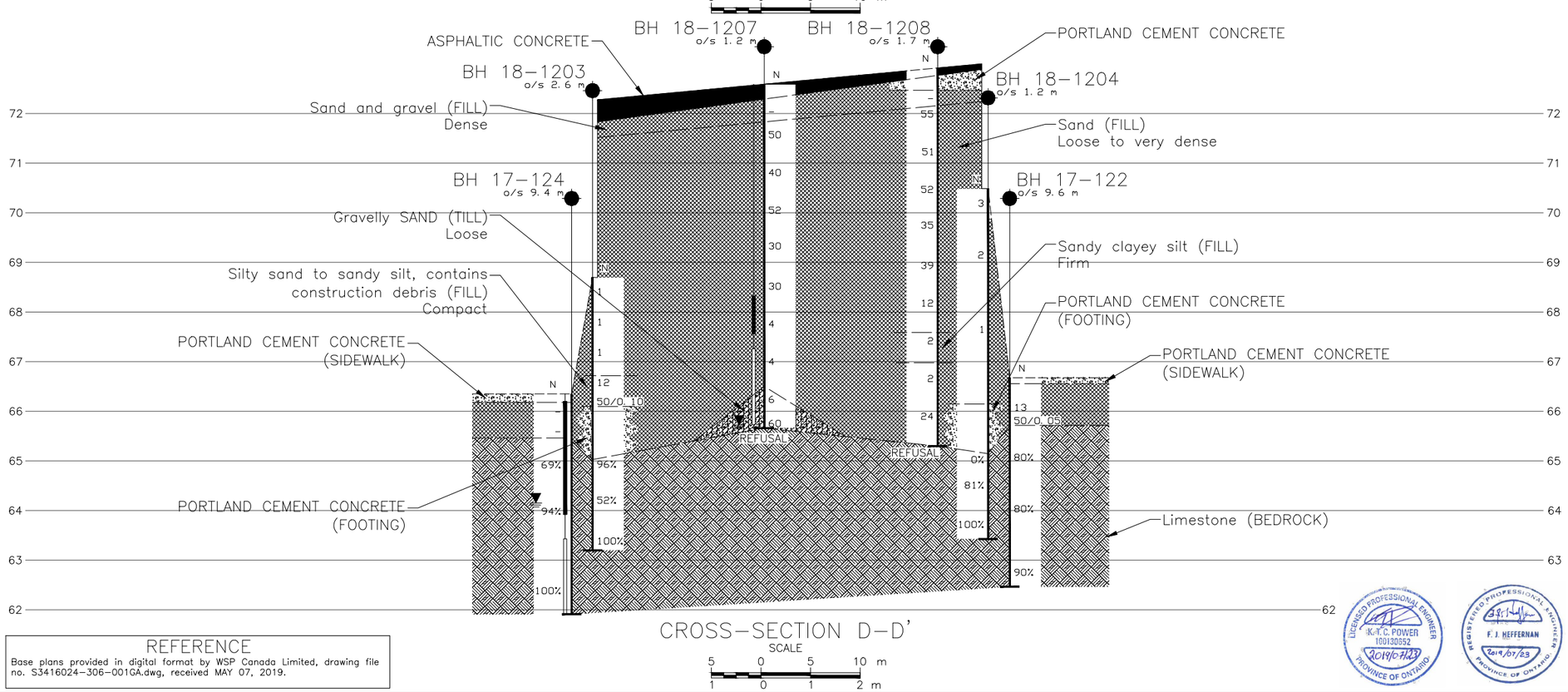
MINISTRY OF TRANSPORTATION, ONTARIO





REFERENCE

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CONT No.
GWP No. 4173–15–00

HIGHWAY 417 OVERPASS STRUCTURES AT BOOTH STREET

BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.403689 LONG. –75.707079

SHEET

GOLDER

LEGEND

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- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on OCTOBER 27, 2017 and DECEMBER 6, 2018

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

No.	ELEVATION	NORTHING	EASTING
17–121	66.6	5029588.1	366875.8
17–122	67.0	5029591.2	366891.0
17–123	66.3	5029627.2	366858.8
17–124	66.4	5029631.8	366873.5
18–1201	68.4	5029623.2	366850.6
18–1202	69.5	5029588.0	366868.8
18–1203	68.7	5029632.6	366880.7
18–1204	70.5	5029597.6	366900.1
18–1205	71.9	5029618.3	366850.1
18–1206	72.1	5029601.2	366853.7
18–1207	72.6	5029618.2	366891.1
18–1208	72.9	5029602.4	366898.5
18–1209	65.3	5029514.3	366806.2
18–1210	66.0	5029529.9	366838.3
18–1211	66.8	5029545.2	366884.1
18–1212	67.2	5029556.0	366916.4
18–1213	67.8	5029572.0	366933.6

NOTES

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

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
.	.	.	.

LICENSED PROFESSIONAL ENGINEER K.A.C. POWER 100130052 2019/07/23 PROVINCE OF ONTARIO

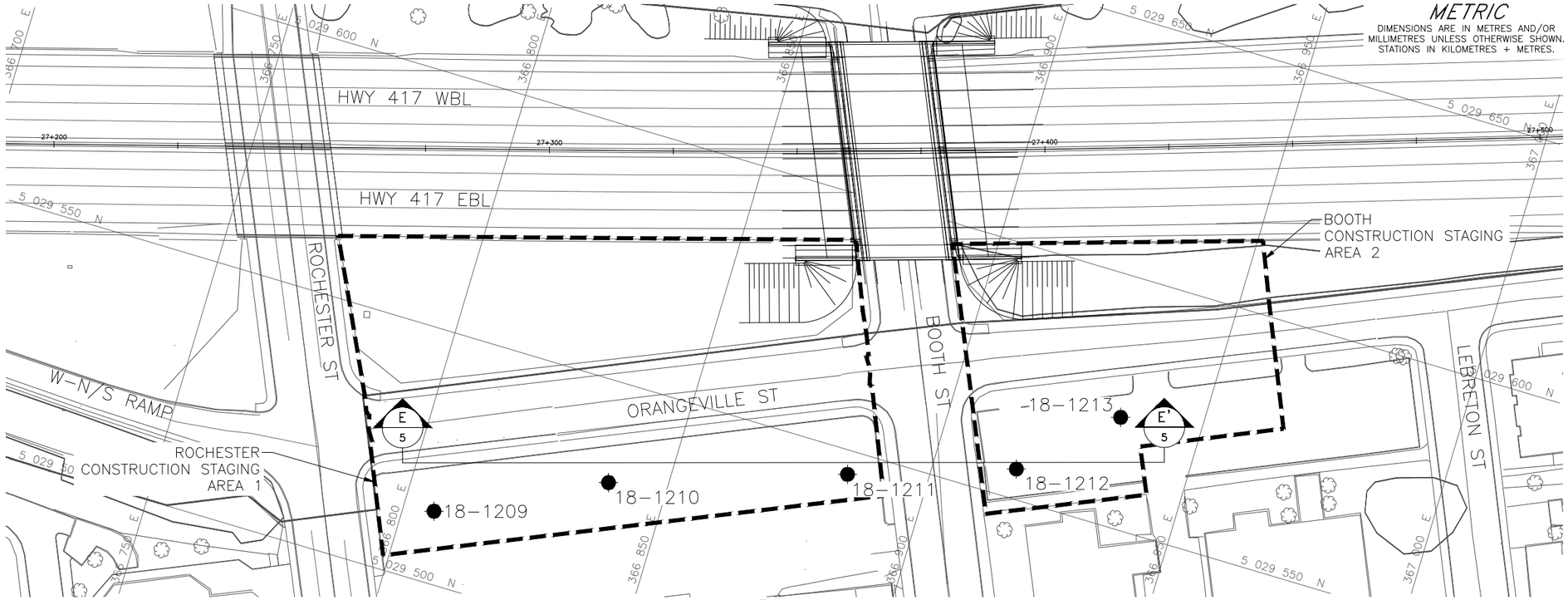
REGISTERED PROFESSIONAL ENGINEER F. J. HEFFERNAN 2019/07/23 PROVINCE OF ONTARIO

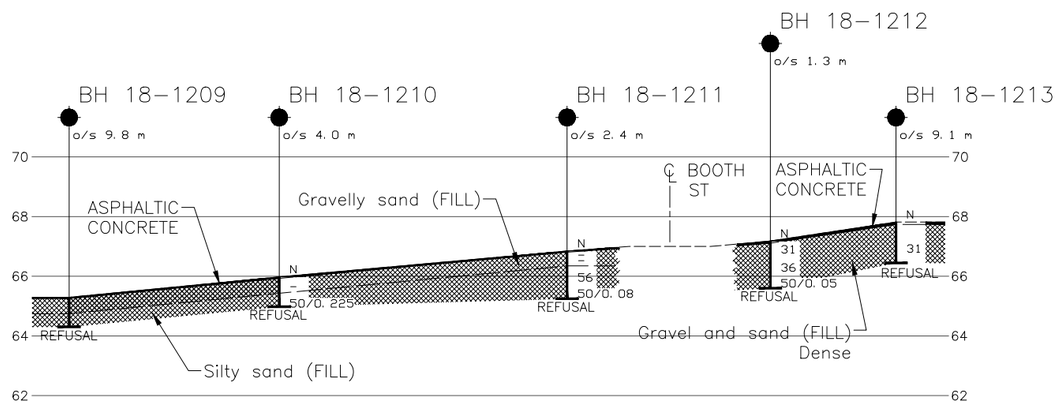
Geocres No. 31G5–308

HWY. 417		PROJECT NO. 1655214–1120	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/07/2019	SITE: 3-57.1 & 3-57.2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 4

PLOT DATE: July 25, 2019
FILENAME: N:\Active\Spatial_LM\MTO\Hwy417Rehab&Widening\99_PROJ\1655214_MTO_Hwy417BridgeReplacement\40_PROD\Phase1120_Booth\S\1655214-1120-BD-0001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO





CROSS-SECTION E-E'
SCALE
10 0 10 20 m
2 0 2 4 m

CONT No.
GWP No. 4173-15-00

SHEET

HIGHWAY 417 OVERPASS
STRUCTURES AT BOOTH STREET
STAGING AREAS
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.403170 LONG. -75.706753

GOLDER

KEY PLAN
SCALE
500 0 500 1000 m

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
18-1209	65.3	5029514.3	366806.2
18-1210	66.0	5029529.9	366838.3
18-1211	66.8	5029545.2	366884.1
18-1212	67.2	5029556.0	366916.4
18-1213	67.8	5029572.0	366933.6

NOTES

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

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 Limited, drawing file no. 3416024-XSTAGING AREA.dwg, received MARCH 22, 2019.

REFERENCE

LICENSED PROFESSIONAL ENGINEER K.A.T.C. POWER 100130552 2019/07/23 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER F. J. HEFFERNAN 2019/07/23 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31G5-308

HWY. 417		PROJECT NO. 1655214-1120	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 25/07/2019	SITE: 3-57.1 & 3-57.2
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 5

PLOT DATE: July 25, 2019
FILENAME: N:\Active\Spatial_MX\MTO\Hwy417\Rehab&Widening\09_PROJ\1655214_MTO_Hwy417BridgeReplacement\05_PROD\Phase1120_Booth01\1655214-1120-BR-D001.dwg

APPENDIX A

Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Record of Coreholes/Drillholes 17-B01 to 17-B24
Record of Boreholes 17-121 to 17-124
Record of Boreholes 18-1201 to 18-1213
Bedrock Core Photographs, Figures A1 to A31
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
υ	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

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
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 δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

2 shear strength = (compressive strength)/2

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, 60º 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 cm^2 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

Compactness 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	100 to 200	1,000 to 2,000
Very stiff	over 200	over 4,000
Hard		

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

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, 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 90º 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
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

GOLDER

RECORD OF COREHOLE No 17-B01

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00

LOCATION N 5029629.0; E 366875.9 NAD 83 MTM ZONE 9 (LAT. 45.403855; LONG. -75.707036)

ORIGINATED BY DWM

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE March 20, 2017

CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.4	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.1	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.8	(SP) Gravelly sand, trace silt, contains cobbles (FILL) Brown						66				
0.6	END OF COREHOLE										

NOTES:

1. Corehole continued on Record of Drillhole 17-B01D.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B01D

SHEET 1 OF 1

LOCATION: N 5029629.0 ;E 366875.9

DRILLING DATE: March 27, 2017

DATUM: Geodetic

INCLINATION: -88° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WEATHERING INDEX (W1 W2 W3 W4 W5 W6)	FEATURES
		TOP OF FOOTING		65.75													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.61	C1												
				64.82													
2		Limestone (BEDROCK), with black shale partings Weathered to fresh Thinly to medium bedded Grey Fined grained Non-Porous Medium strong to strong		1.54	C1												
					C2												
				64.00													
		END OF DRILLHOLE		2.36													
3																	
4																	
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B02

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00

LOCATION N 5029624.8; E 366877.7 NAD 83 MTM ZONE 9 (LAT. 45.403817; LONG. -75.707014)

ORIGINATED BY DWM

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE March 20, 2017

CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.4	GROUND SURFACE										
0.0 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 65.7	(SP) Gravelly sand (FILL) Grey-brown						66				
0.7	END OF COREHOLE										

+ 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B03

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029622.2; E 366879.0 NAD 83 MTM ZONE 9 (LAT. 45.403794; LONG. -75.706997) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.4	GROUND SURFACE										
0.0 / 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.1	(SP) Gravelly sand (FILL) Grey										
0.3	(SP) Sand, trace silt and gravel (FILL) Brown						66				
65.7											
0.7	END OF COREHOLE										

$+^3, \times^3$: 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B04

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029619.4; E 366880.2 NAD 83 MTM ZONE 9 (LAT. 45.403768; LONG. -75.706982) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.4	GROUND SURFACE										
0.0 / 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 / 66.1	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.7	(SP) Sand, trace silt and gravel, contains cobbles (FILL) Brown						66				
0.7	END OF COREHOLE										

NOTES:

1. Corehole continued on Record of Drillhole 17-B04D.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B04D

SHEET 1 OF 1

LOCATION: N 5029619.4 ;E 366880.2

DRILLING DATE: March 27, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		TOP OF FOOTING		65.71													
1	Portable Drill, B/Q Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.68	C1												
				64.71													
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.68	C1												
					C2												
					C3												
				63.87													
		END OF DRILLHOLE		2.52													
3																	
4																	
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B05

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029616.6; E 366881.4 NAD 83 MTM ZONE 9 (LAT. 45.403743; LONG. -75.706967) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.4	GROUND SURFACE										
0.0 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 66.1	(SP) Gravelly sand (FILL) Grey										
0.3 65.7	(SM) Silty sand, some gravel, contains cobbles (FILL) Brown		1	GRAB	-		66				17 62 (21)
0.7	END OF COREHOLE										

+ ³, × ³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B06

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029613.8; E 366882.6 NAD 83 MTM ZONE 9 (LAT. 45.403717; LONG. -75.706952) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.4	GROUND SURFACE										
0.0 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 66.1	(SP) Gravelly sand (FILL) Grey										
0.3 65.7	(SP) Sand, trace silt, some gravel, contains cobbles (FILL) Brown						66				
0.7	END OF COREHOLE										

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

GOLDER

RECORD OF COREHOLE No 17-B07

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029611.1; E 366883.8 NAD 83 MTM ZONE 9 (LAT. 45.403693; LONG. -75.706937) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.5	GROUND SURFACE										
0.0 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
	(SP) Gravelly sand (FILL) Grey										
0.2	(SP-SM) Sand, some silt and gravel (FILL) Brown Moist		1	GRAB	-		66				
65.9											
0.6	END OF COREHOLE										

$+^3$, $\times^3$: 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B08

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029608.5; E 366884.9 NAD 83 MTM ZONE 9 (LAT. 45.403670; LONG. -75.706923) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.5	GROUND SURFACE									
0.0 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)									
0.1 66.2	(SP) Gravelly sand, contains cobbles (FILL) Grey		1	GRAB	-					
0.3 65.9	(SP-SM) Sand, some silt and gravel (FILL) Brown						66			
0.6	END OF COREHOLE NOTES: 1. Corehole continued on Record of Drillhole 17-B08D.									

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B08D

SHEET 1 OF 1

LOCATION: N 5029608.5 ;E 366884.9

DRILLING DATE: March 23, 2017

DATUM: Geodetic

INCLINATION: -84° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.87													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.64	C1	0											
				64.86													
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.65	C2	0											
					C3	0											
				64.32													
		END OF DRILLHOLE		2.19													
3																	
4																	
5																	

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B09

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029605.6; E 366886.2 NAD 83 MTM ZONE 9 (LAT. 45.403643; LONG. -75.706907) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.5	GROUND SURFACE										
0.0 / 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 / 66.2	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.9	(SP-SM) Sand, some silt and gravel (FILL) Brown						66				
0.6	END OF COREHOLE										

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B10

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029602.8; E 366887.4 NAD 83 MTM ZONE 9 (LAT. 45.403619; LONG. -75.706892) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.5	GROUND SURFACE										
0.0 / 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.2 / 66.2	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.9	(SP-SM) Sand, some silt and gravel (FILL) Brown Moist		1	GRAB	-		66				
0.6	END OF COREHOLE										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B11

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029600.1; E 366888.6 NAD 83 MTM ZONE 9 (LAT. 45.403594; LONG. -75.706877) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.6	GROUND SURFACE										
0.0 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.2 66.3	(SP) Gravelly sand (FILL) Grey		1	GRAB	-						
0.3 65.9	(SP-SM) Sand some silt and gravel, contains bedrock fragments (FILL) Brown Moist		2	GRAB	-		66				
0.7	END OF COREHOLE										

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

GOLDER

RECORD OF COREHOLE No 17-B12

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029597.1; E 366889.9 NAD 83 MTM ZONE 9 (LAT. 45.403566; LONG. -75.706860) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 20, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					kN/m³	GR SA SI CL
66.6	GROUND SURFACE										
0.0 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.2 66.3	(SM/GM) Sand and gravel, some silt (FILL) Grey		1	GRAB	-						35 54 (11)
0.3 65.9	(SP-SM) Sand, some silt and gravel (FILL) Brown Moist		2	GRAB	-		66				
0.7	END OF COREHOLE										

NOTES:

1. Corehole continued on Record of Drillhole 17-B12D.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B12D

SHEET 1 OF 1

LOCATION: N 5029597.1 ;E 366889.9

DRILLING DATE: March 23, 2017

DATUM: Geodetic

INCLINATION: -79° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.88													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.73	C1	100											
				64.96													
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.67	C1	100	100	100	100	5							
					C1	100											
					C2	100											
				64.02													
		END OF DRILLHOLE		2.63													
3																	
4																	
5																	

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

RECOVERY: 80 60 40 20 | R.Q.D.: 80 60 40 20 | FRACT. INDEX PER: 5 10 15 20 | DIP w.r.t. CORE AXIS: 0 30 60 90 | HYDRAULIC CONDUCTIVITY K, cm/sec: 10^{-6} 10^{-5} 10^{-4} 10^{-3} | WEATHERING INDEX: W1 W2 W3 W4 W5 W6

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B13

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029591.2; E 366873.2 NAD 83 MTM ZONE 9 (LAT. 45.403516; LONG. -75.707075) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.6	GROUND SURFACE										
0.0 / 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
	(SP) Gravelly sand (FILL) Grey		1	GRAB	-						
0.2	(SM) Sand, some silt (FILL) Brown Moist		2	GRAB	-		66				3 83 (14)
65.8 / 0.8	END OF COREHOLE										

NOTES:

1. Corehole continued on Record of Drillhole 17-B13D.

$+^3, \times^3$: 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 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B13D

SHEET 1 OF 1

LOCATION: N 5029591.2 ;E 366873.2

DRILLING DATE: March 30, 2017

DATUM: Geodetic

INCLINATION: -77° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.87													
1	Portable Drill BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.75	C1	0-100											
					C2	0-100											
				64.86													
2		Limestone (BEDROCK), with shale partings Slightly weathered Thinly bedded Grey Fine grained Non-porous Medium strong to strong		1.79	C2	0											
					C3	0											
				64.16													
		END OF DRILLHOLE		2.51													
3																	
4																	
5																	

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B14

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029594.3; E 366871.9 NAD 83 MTM ZONE 9 (LAT. 45.403544; LONG. -75.707091) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.6	GROUND SURFACE										
0.0	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.4											
	(SP) Gravelly sand (FILL) Grey										
0.3	(SP-SM) Sand, some silt and gravel, contains cobbles (FILL) Brown						66				
65.8											
0.8	END OF COREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B15

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029597.4; E 366870.5 NAD 83 MTM ZONE 9 (LAT. 45.403571; LONG. -75.707109) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.6	GROUND SURFACE										
0.0 / 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.3	(SP) Gravelly sand (FILL) Grey										
	(SP-SM) Sand some silt and gravel, contains cobbles (FILL) Brown		1	GRAB	-		66				
65.8											
0.8	END OF COREHOLE										

$+^3$, $\times^3$: 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B16

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029600.5; E 366869.2 NAD 83 MTM ZONE 9 (LAT. 45.403599; LONG. -75.707125) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
66.5	GROUND SURFACE					
0.0 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)					
66.2	(SP) Gravelly sand (FILL) Grey Moist		1	GRAB	-	
0.3	(SP-SM) Sand some silt and gravel (FILL) Brown Moist					
65.8						
0.7	END OF COREHOLE					

NOTES:

1. Corehole continued on Record of Drillhole 17-B16D.

ELEVATION SCALE: 66

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 25 50 75

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B16D

SHEET 1 OF 1

LOCATION: N 5029600.5 ;E 366869.2

DRILLING DATE: March 30, 2017

DATUM: Geodetic

INCLINATION: -77° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.84													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.71	C1	100-0											
					C2	0											
				64.79													
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.79	C2	0											
					C3	0											
				64.33													
		END OF DRILLHOLE		2.26													
3																	
4																	
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B17

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00

LOCATION N 5029603.4; E 366867.9 NAD 83 MTM ZONE 9 (LAT. 45.403625; LONG. -75.707141)

ORIGINATED BY DWM

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill/Hydro-excavation

COMPILED BY ZS

DATUM Geodetic

DATE March 28, 2017

CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.5	GROUND SURFACE										
0.0 / 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
	(SP) Gravelly sand (FILL) Grey										
0.2	(SP-SM) Sand, some silt and gravel, contains cobbles (FILL) Brown Moist		1	GRAB	-		66				
65.8											
0.7	END OF COREHOLE										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B18

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029606.6; E 366866.5 NAD 83 MTM ZONE 9 (LAT. 45.403654; LONG. -75.707159) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.4	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.1	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.8	(SP-SM) Sand, some silt and gravel (FILL) Brown Moist		1	GRAB	-		66				
0.6	END OF COREHOLE										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B19

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029609.9; E 366865.1 NAD 83 MTM ZONE 9 (LAT. 45.403684; LONG. -75.707176) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED		kN/m³	GR SA SI CL
66.4	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.1	(SM/GM) Sand and gravel, some silt (FILL) Grey Moist		1	GRAB	-						38 50 (12)
0.3	(SP-SM) Sand, some silt, trace gravel (FILL) Brown Moist						66				
65.7											
0.7	END OF COREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B20

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029612.6; E 366863.9 NAD 83 MTM ZONE 9 (LAT. 45.403708; LONG. -75.707191) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
66.4	GROUND SURFACE										
0.0 / 66.3	PORTLAND CEMENT CONCRETE (SIDEWALK)										
	(SM/GM) Sand and gravel, some silt (FILL) Grey										
0.2	(SP-SM) Sand, some silt, trace gravel (FILL) Brown Moist		1	GRAB	-		66				
65.7											
0.7	END OF COREHOLE										
	NOTES: 1. Corehole continued on Record of Drillhole 17-B20D.										

$+^3$, $\times^3$: 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 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B20D

SHEET 1 OF 1

LOCATION: N 5029612.6 ;E 366863.9

DRILLING DATE: March 29, 2017

DATUM: Geodetic

INCLINATION: -78° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.72													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.69	C1	100-0											
					C2	100-0											
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		64.59 1.85	C2	0											
		END OF DRILLHOLE		64.05 2.40													
3																	
4																	
5																	

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B21

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029615.6; E 366862.6 NAD 83 MTM ZONE 9 (LAT. 45.403736; LONG. -75.707207) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.4	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.1 / 0.3	(SP) Gravelly sand (FILL) Grey										
	(SP-SM) Sand, some silt, trace gravel (FILL) Brown						66				
65.7 / 0.7	END OF COREHOLE										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF COREHOLE No 17-B22

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029618.7; E 366861.3 NAD 83 MTM ZONE 9 (LAT. 45.403764; LONG. -75.707224) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.3	GROUND SURFACE										
0.0 / 66.1	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.0	(SP) Gravelly sand (FILL) Grey						66				
0.3 / 65.7	(SP-SM) Sand, some silt, trace gravel (FILL) Brown Moist		1	GRAB	-						
0.6	END OF COREHOLE										

+ 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 6/12/19 JM

GOLDER

RECORD OF COREHOLE No 17-B23

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029621.8; E 366859.9 NAD 83 MTM ZONE 9 (LAT. 45.403792; LONG. -75.707241) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.3	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 / 66.0	(SP) Gravelly sand (FILL) Grey						66				
0.3 / 65.7	(SP-SM) Sand, some silt, trace gravel (FILL) Brown Moist		1	GRAB	-						
0.6	END OF COREHOLE										

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

GOLDER

RECORD OF COREHOLE No 17-B24

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029624.3; E 366858.8 NAD 83 MTM ZONE 9 (LAT. 45.403814; LONG. -75.707255) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable Drill/Hydro-excavation COMPILED BY ZS

DATUM Geodetic DATE March 28, 2017 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
66.3	GROUND SURFACE										
0.0 66.1	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.0	(SP) Gravelly sand (FILL) Grey		1	GRAB	-						
0.3	Moist						66				
65.7	(SP-SM) Sand, some silt, trace gravel (FILL) Brown Moist		2	GRAB	-						
0.6	END OF COREHOLE										
	NOTES: 1. Corehole continued on Record of Drillhole 17-B24D.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-B24D

SHEET 1 OF 1

LOCATION: N 5029624.3 ;E 366858.8

DRILLING DATE: March 29, 2017

DATUM: Geodetic

INCLINATION: -69° AZIMUTH:

DRILL RIG: Portable Drill

DRILLING CONTRACTOR: CCC

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		TOP OF FOOTING		65.73													
1	Portable Drill / BQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		0.63	C1	100											
				64.85													
2		Limestone (BEDROCK), with black shale partings Slightly weathered Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.57	C1	0											
					C2	0											
				64.14													
		END OF DRILLHOLE		2.33													

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF BOREHOLE No 17-121

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029588.1; E 366875.8 NAD 83 MTM ZONE 9 (LAT. 45.403487; LONG. -75.707042) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Continuous 50 mm Diam. Split Spoon/NQ Core COMPILED BY ZS

DATUM Geodetic DATE March 31, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.6	GROUND SURFACE										
0.0 / 66.4	PORTLAND CEMENT CONCRETE (SIDEWALK)										
66.3	(SP) Gravelly sand (FILL) Grey										
0.3	(SP-SM) Sand, trace gravel and silt, contains organic matter (FILL) Compact Brown Dry		1	SS	11		66		○		9 81 8 2
65.7			2	SS	25/0.05						
0.9	Limestone (BEDROCK) Bedrock cored from depths of 0.9 m to 4.1 m. For bedrock coring details refer to Record of Drillhole 17-121		C1	RC	REC 86%		65			UCS = 70 MPa	RQD = 53%
			C2	RC	REC 98%		64				RQD = 79%
			C3	RC	REC 92%		63				RQD = 56%
62.5											
4.1	END OF BOREHOLE										

NOTES:

1. Water level in well screen at a depth of 2.5 m below ground surface (Elev. 64.1 m), measured on October 27, 2017.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-121

SHEET 2 OF 2

LOCATION: N 5029588.1 ;E 366875.8

DRILLING DATE: March 31, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		Continued from Record of Borehole 17-121		65.72													
1	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Slightly weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		0.93	C1	100-25											
2																	
					C2	25											
3																	
					C3	25											
4				62.55													
		END OF DRILLHOLE		4.10													
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GOLDER

RECORD OF BOREHOLE No 17-122

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029591.2; E 366891.0 NAD 83 MTM ZONE 9 (LAT. 45.403514; LONG. -75.706847) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Continuous 50 mm Diam. Split Spoon/NQ Core COMPILED BY ZS

DATUM Geodetic DATE April 3, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.7	GROUND SURFACE										
0.0 66.6	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 66.4	(SP) Gravelly sand (FILL) Grey										
0.3	(SP) Sand, some gravel, trace silt (FILL) Compact Grey brown Dry		1	SS	13		66				
65.7			2	SS	50/0.05						
1.0	Limestone (BEDROCK) Bedrock cored from depths of 1.0 m to 4.2 m For bedrock coring details refer to Record of Drillhole 17-122		C1	RC	REC 96%		65				RQD = 80%
			C2	RC	REC 99%		64				RQD = 80%
			C3	RC	REC 100%		63				RQD = 90%
62.5											
4.2	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-122

SHEET 2 OF 2

LOCATION: N 5029591.2 ;E 366891.0

DRILLING DATE: April 3, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		Continued from Record of Borehole 17-122		65.72													
1	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Slightly weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		0.96	C1	0											
2																	
3					C2	0											
4					C3	0											
				62.47													
		END OF DRILLHOLE		4.21													
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GOLDER

RECORD OF BOREHOLE No 17-123

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029627.2; E 366858.8 NAD 83 MTM ZONE 9 (LAT. 45.403840; LONG. -75.707255) ORIGINATED BY KM

DIST Eastern HWY 417 BOREHOLE TYPE Hydro-excavation/NQ Core COMPILED BY ZS

DATUM Geodetic DATE April 6/10, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.3	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE (SIDEWALK)										
0.1 / 66.0	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.5	(SP) Sand, trace gravel and silt, contains organic matter (FILL) Brown Moist		1	GRAB	-		66				
0.8 / 65.2	(GP) Gravel and cobbles (FILL)		2	RC	DD						
1.2	Limestone (BEDROCK) Bedrock cored from depths of 1.2 m to 4.8 m For bedrock coring details refer to Record of Drillhole 17-123		C1	RC	REC 65%		65				RQD = 0%
			C2	RC	REC 95%						RQD = 77%
			C3	RC	REC 99%		64				RQD = 92%
			C4	RC	REC 97%		63				RQD = 97%
61.5							62				
4.8	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-123

SHEET 2 OF 2

LOCATION: N 5029627.2 ;E 366858.8

DRILLING DATE: April 6/10, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WEATHERING INDEX (W1 W2 W3 W4 W5 W6)	FEATURES
		Continued from Record of Borehole 17-123		65.19													
2	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Slighlty weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		1.15	C1	70											
					C2	95											
3					C3	100											
4					C4	100											
				61.54													
		END OF DRILLHOLE		4.80													
5																	
6																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: KM
CHECKED: KCP

GOLDER

RECORD OF BOREHOLE No 17-124

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029631.8; E 366873.5 NAD 83 MTM ZONE 9 (LAT. 45.403880; LONG. -75.707066) ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Hydro-excavation/NQ Core COMPILED BY ZS

DATUM Geodetic DATE April 6/10, 2017 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.4	GROUND SURFACE										
0.0 / 66.2	PORTLAND CEMENT CONCRETE										
66.1	(SP) Gravelly sand (FILL) Grey										
0.3 / 65.7	(SP-SM) Sand, some gravel, trace silt (FILL) Moist		1	GRAB	-		66		○		11 78 9 2
0.7 / 65.5	(GP) Gravel and cobbles (FILL)		2	GRAB	-						
0.9	Limestone (BEDROCK) Bedrock cored from depths 0.9 m to 4.4 m. For bedrock coring details refer to Record of Drillhole 17-124		C1	RC	REC 96%	▼	65			UCS = 36 MPa	RQD = 69%
			C2	RC	REC 96%		64				RQD = 94%
			C3	RC	REC 100%		63				RQD = 100%
62.0							62				
4.4	END OF BOREHOLE										

NOTES:

1. Water level in well screen at a depth of 2.2 m below ground surface (Elev. 64.2 m), measured on October 27, 2017.

+ 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 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 17-124

SHEET 2 OF 2

LOCATION: N 5029631.8 ;E 366873.5

DRILLING DATE: April 6/10, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: CCC

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		Continued from Record of Borehole 17-124		65.46													
1	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Slighlty weathered to fresh Thinly to medium bedded Grey Fine grained Non-porous Medium strong to strong		0.89	C1	85											
2																	
3					C2	100											
4					C3	100											
				61.91													
		END OF DRILLHOLE		4.44													
5																	

DEPTH SCALE
1 : 25

GOLDER

LOGGED: DWM
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF BOREHOLE No 18-1201

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029623.2; E 366850.6 NAD 83 MTM ZONE 9 (LAT. 45.403800; LONG. -75.707360) ORIGINATED BY RI

DIST Eastern HWY 417 BOREHOLE TYPE Rotary Drill/Wash Boring, HW Casing/HQ Core COMPILED BY ZS

DATUM Geodetic DATE April 12, 2019 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
68.4	GROUND SURFACE										
0.0	(SW-SM) Sand, trace silt (FILL) Brown Moist to wet		1	SS	1		68		○		2 93 (5)
			2	SS	1		67				
65.5											
3.0	PORTLAND CEMENT CONCRETE (FOOTING)		1	RC	-		66				
			2A	RC	-						
64.5							65				
3.9	Limestone (BEDROCK) Bedrock cored from depths 3.9 m to 5.6 m For bedrock coring details refer to Record of Drillhole 18-1201		2B	RC	REC 100%						RQD = 61%
			3	RC	REC 97%		64				RQD = 88%
62.8							63				
5.6	END OF BOREHOLE										

NOTE:

1. A reduced SPT hammer drop of 0.61 m was used for all split spoon samples "N" values are not representative of ASTM D1586 SPTN and should be interpreted in consideration of this reduced energy.

$+^3, \times^3$: 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 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 18-1201

SHEET 2 OF 2

LOCATION: N 5029623.2 ;E 366850.6

DRILLING DATE: April 12, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: EXPLO 220

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		Continued from Record of Borehole 18-1201		65.40													
3	Rotary Drill, HQ Core	PORTLAND CEMENT CONCRETE (FOOTING)		2.95	1												
					2A												
				64.42													
4		Limestone (BEDROCK), with fine shale partings Fresh Thinly to medium bedded Grey Fine to medium grained Non-porous Medium strong		3.93	2B	100											
5					3	100											
				62.71													
		END OF DRILLHOLE		5.64													
6																	
7																	
8																	
9																	
10																	
11																	
12																	

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF BOREHOLE No 18-1202

SHEET 1 OF 2 **METRIC**

PROJECT 1655214-1120
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic

LOCATION N 5029588.0; E 366868.8 NAD 83 MTM ZONE 9 (LAT. 45.403480; LONG. -75.707130)
BOREHOLE TYPE Rotary Drill/Wash Boring, HW Casing/HQ Core
DATE April 11, 2019

ORIGINATED BY RI/RK
COMPILED BY ZS
CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
69.5	GROUND SURFACE										
0.0	(SW) Sand (FILL) Brown Moist to wet		1	SS	3		69				
			2	SS	1		68				
66.9							67				
2.8	(SW) Sand, some gravel, contains cobbles (FILL) Brown Moist		1	RC	-						
	PORTLAND CEMENT CONCRETE (FOOTING)		2	RC	-						
65.7			3A 3B	RC RC	-		66				
3.8	Limestone (BEDROCK) Bedrock cored from depths 3.8 m to 5.7 m For bedrock coring details refer to Record of Drillhole 18-1202		4	RC	REC 88%						RQD = 65%
			5	RC	REC 100%		65				RQD = 24%
			6	RC	REC 100%						RQD = 75%
63.9			7	RC	REC 100%		64				RQD = 100%
5.7	END OF BOREHOLE NOTE: 1. A reduced SPT hammer drop of 0.61 m was used for all split spoon samples "N" values are not representative of ASTM D1586 SPTN and should be interpreted in consideration of this reduced energy.										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 18-1202

SHEET 2 OF 2

LOCATION: N 5029588.0 ;E 366868.8

DRILLING DATE: April 11, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: EXPLO 220

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		Continued from Record of Borehole 18-1202		66.73													
3		PORTLAND CEMENT CONCRETE (FOOTING)		2.77	1												
					2												
				65.74	3A												
					3B												
4	Rotary Drill HQ Core	Limestone (BEDROCK), with black, fine grained shale partings Fresh Thinly to medium bedded Grey to brown Fine to medium grained Non-porous Medium strong		3.76	4	100											
5					5	100											
					6	25											
				63.85	7	25											
		END OF DRILLHOLE		5.65													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI/RK

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF BOREHOLE No 18-1203

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00

LOCATION N 5029632.6; E 366880.7 NAD 83 MTM ZONE 9 (LAT. 45.403880; LONG. -75.706970)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Rotary Drill/Wash Boring, HW Casing/HQ Core

COMPILED BY ZS

DATUM Geodetic

DATE April 15, 2019

CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
68.7	GROUND SURFACE										
0.0	(SW) Sand (FILL) Brown Moist		1	SS	1						
			2	SS	1		68		○		1 96 (3)
			3	SS	1						
66.7							67				
2.0	(SM/ML) Silty sand to sandy silt, some gravel, contains wood, mortar, organic matter, brick and cobbles (FILL) Compact		4	SS	12						
66.1			5	SS	50/0.10						
2.6	Black to dark brown Moist to wet		1	RC	-		66				
	PORTLAND CEMENT CONCRETE (FOOTING)		2A	RC	-						
65.0							65				
3.7	Limestone (BEDROCK)		2B	RC	REC 100%						RQD = 96%
	Bedrock cored from depths 3.7 m to 5.5 m For bedrock coring details refer to Record of Drillhole 18-1203		3	RC	REC 74%		64				RQD = 52%
63.2			4	RC	REC 100%					UCS = 74 MPa	RQD = 100%
5.5	END OF BOREHOLE NOTE: 1. A reduced SPT hammer drop of 0.61 m was used for all split spoon samples "N" values are not representative of ASTM D1586 SPTN and should be interpreted in consideration of this reduced energy.										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-GTA.GDT 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 18-1203

SHEET 2 OF 2

LOCATION: N 5029632.6 ;E 366880.7

DRILLING DATE: April 15, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: EXPLO 220

DRILLING CONTRACTOR: Marathon Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH-ERING INDEX	FEATURES
		Continued from Record of Borehole 18-1203		66.10													
3	Rotary Drill / HQ Rod	PORTLAND CEMENT CONCRETE (FOOTING)		2.60	1												
					2A												
				65.03													
4	Rotary Drill / NQ Core	Limestone (BEDROCK), with fresh, thin laminations to thin beds, black, fine grained shale partings Fresh Thinly to medium bedded Grey to brown Fine to medium grained Non-porous Medium strong		3.67	2B	100											
					3	100											
5					4	100											
				63.20													
		END OF DRILLHOLE		5.50													
6																	
7																	
8																	
9																	
10																	
11																	
12																	

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 6/12/19 JM

GOLDER

RECORD OF BOREHOLE No 18-1204

SHEET 1 OF 2

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029597.6; E 366900.1 NAD 83 MTM ZONE 9 (LAT. 45.403560; LONG. -75.706730) ORIGINATED BY RI/RK

DIST Eastern HWY 417 BOREHOLE TYPE Rotary Drill/Wash Boring, NW Casing/NQ Core COMPILED BY ZS

DATUM Geodetic DATE April 10, 2019 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
70.5	GROUND SURFACE										
0.0 / 69.9	(SM) Silty sand, contains organic matter (FILL) Brown to dark brown Moist		1	SS	3		70				
0.6	(SW) Sand (FILL) Brown Moist to wet		2	SS	2		69				
67.3			3	SS	1		68		○		3 94 (3)
3.2 / 66.7	BOULDER						67				
3.8 / 66.2	(SW) Sand, contains cobbles (FILL) Brown Moist to wet		1	RC	-						
4.3 / 65.2	PORTLAND CEMENT CONCRETE (FOOTING)		2A	RC	-		66				
5.3	Limestone (BEDROCK)		2B	RC	REC 100%		65				RQD = 0%
	Bedrock cored from depths 5.3 m to 7.1 m For bedrock coring details refer to Record of Drillhole 18-1204		3	RC	REC 93%					UCS = 70 MPa	RQD = 81%
63.4			4	RC	REC 100%		64				RQD = 100%
7.1	END OF BOREHOLE NOTE: 1. A reduced SPT hammer drop of 0.61 m was used for all split spoon samples "N" values are not representative of ASTM D1586 SPTN and should be interpreted in consideration of this reduced energy.										

+ ^{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 6/12/19 JM

PROJECT: 1655214-1120

RECORD OF DRILLHOLE: 18-1204

SHEET 2 OF 2

LOCATION: N 5029597.6 ;E 366900.1

DRILLING DATE: April 10, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: EXPLO 220

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	WEATHERING INDEX	FEATURES
		Continued from Record of Borehole 18-1204		66.15													
		PORTLAND CEMENT CONCRETE (FOOTING)		4.34	1												
5					2A												
				65.15													
	Rotary Drill NQ Core	Limestone (BEDROCK), with black, fine grained shale partings Fresh Thinly to medium bedded Grey to brown Fine to medium grained Non-porous Medium strong		5.34	2B	0											
6					3	0											
					4	0											
7				63.43													
		END OF DRILLHOLE		7.06													
8																	
9																	
10																	
11																	
12																	
13																	
14																	

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

RECOVERY: 80 60 40 20 | R.Q.D.: 80 60 40 20 | FRACT. INDEX PER: 5 10 15 20 | DIP w.r.t. CORE AXIS: 0 30 60 90 | HYDRAULIC CONDUCTIVITY K, cm/sec: 10^{-6} 10^{-5} 10^{-4} 10^{-3} | WEATHERING INDEX: W1 W2 W3 W4 W5 W6

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI/RK
CHECKED: KCP

GOLDER

RECORD OF BOREHOLE No 18-1205

SHEET 1 OF 1 **METRIC**

PROJECT 1655214-1120
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic

LOCATION N 5029618.3; E 366850.1 NAD 83 MTM ZONE 9 (LAT. 45.403750; LONG. -75.707360)
BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)
DATE October 11, 2018

ORIGINATED BY DJG
COMPILED BY ZS
CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
71.9	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
0.2 / 71.4	PORTLAND CEMENT CONCRETE, with rebar										
0.5 / 71.1	(SP/GP) Sand and gravel (FILL) Grey Moist		1	GS	-						
0.8	(SP/SM) Sand, trace silt and gravel Loose to very dense Brown Moist		2	SS	21		71				
			3	SS	42		70		○		
			4	SS	41		69				
			5	SS	61				○		
			6	SS	44		68				
			7	SS	10		67		○		3 89 (8)
			8	SS	4		66				
			9	SS	9				○		
65.0							65				
6.9	END OF BOREHOLE AUGER REFUSAL										

NOTES:

1. Borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

PROJECT 1655214-1120

RECORD OF BOREHOLE No 18-1206

SHEET 1 OF 1

METRIC

G.W.P. 4173-15-00 LOCATION N 5029601.2; E 366853.7 NAD 83 MTM ZONE 9 (LAT. 45.403600; LONG. -75.707320) ORIGINATED BY RI

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS

DATUM Geodetic DATE October 2 and 3, 2018 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
72.1	GROUND SURFACE										
0.0 / 71.9	ASPHALTIC CONCRETE						72				
0.2 / 71.3	(SP/GP) Sand and gravel (FILL) Grey Moist										
0.8 / 70.9	(SP) Sand, some gravel (FILL) Loose Brown Moist		1	SS	6		71		○		
1.4	(CL/CI) Sandy clayey silt, contains ash/asphalt debris and organic matter (FILL) Firm Grey brown Moist		2	SS	67						
	(SM) Sand, some silt and gravel (FILL) Very dense Brown Moist		3	SS	67		70		○		
			4	SS	91		69				
			5	SS	88				○		
			6	SS	46		68		○		14 73 (13)
66.8											
5.3	(SP) Sand (FILL) Compact Brown Moist		7	SS	19		67		○		0 97 (3)
65.8			8	SS	60/0.13		66				
6.3 / 65.2	Weathered Shale (BEDROCK)										
6.9	END OF BOREHOLE AUGER REFUSAL										

NOTES:

1. Borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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GOLDER

RECORD OF BOREHOLE No 18-1207

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00

LOCATION N 5029618.2; E 366891.1 NAD 83 MTM ZONE 9 (LAT. 45.403750; LONG. -75.706840)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)

COMPILED BY ZS

DATUM Geodetic

DATE October 4, 2018

CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
72.6	GROUND SURFACE										
0.0 / 72.3	ASPHALTIC CONCRETE										
0.3 / 71.8	(SP/GP) Sand and gravel (FILL) Grey Moist		1	GS	-		72				
0.8	(SP-SM) Sand, trace silt (FILL) Very dense to loose Brown Moist		2	SS	50				○		
			3	SS	40		71				
			4	SS	52		70		○		2 92 (6)
			5	SS	30		69				
			6	SS	30						
			7	SS	4		68		○		1 96 (3)
			8	SS	4		67				
66.5											
6.1	(SM) Gravelly SAND, some silt, trace clay, contains shale bedrock fragments and organic matter (TILL) Loose Grey brown Wet		9	SS	6				○		25 55 14 6
65.7			10	SS	60		66				
6.9	END OF BOREHOLE AUGER REFUSAL										

NOTES:

1. Water level in well screen at a depth of 6.9 m below ground surface (Elev. 65.7 m), measured on Dec. 6, 2018.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

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GOLDER

RECORD OF BOREHOLE No 18-1208

SHEET 1 OF 1 **METRIC**

PROJECT 1655214-1120
G.W.P. 4173-15-00
LOCATION N 5029602.4; E 366898.5 NAD 83 MTM ZONE 9 (LAT. 45.403610; LONG. -75.706750)
ORIGINATED BY DJG
DIST Eastern HWY 417
BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)
COMPILED BY ZS
DATUM Geodetic
DATE October 9, 2018
CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
72.9	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
72.5	PORTLAND CEMENT CONCRETE, with rebar										
0.4	(SP/GP) Sand and gravel (FILL) Grey		1	GS	-						
72.1	Moist										
0.8	(SP) Sand, trace silt and gravel (FILL) Very dense to compact Brown Dry		2	SS	55		72		○		
			3	SS	51		71				
			4	SS	52				○		
			5	SS	35		70				
			6	SS	39		69				
			7	SS	12		68		○		2 96 (2)
67.6											
5.3	(CL) Sandy clayey silt (FILL) Firm Brown Moist		8	SS	2				○		2 45 32 21
67.0							67				
5.9	(SP) Sand, trace silt (FILL) Very loose to compact Brown Moist		9	SS	2						
			10	SS	24		66		○		
65.3											
7.6	END OF BOREHOLE AUGER REFUSAL										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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GOLDER

RECORD OF BOREHOLE No 18-1209

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029514.3; E 366806.2 NAD 83 MTM ZONE 9 (LAT. 45.402820; LONG. -75.707940) ORIGINATED BY PAH

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS

DATUM Geodetic DATE January 27, 2019 CHECKED BY KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
65.3	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE *(40 mm)*		1	GS	-		65				
0.0	(SP) Gravelly sand, angular (FILL) Grey		2	GS	-				○		
64.7											
0.6	(SM) Silty sand, trace gravel, angular (FILL) Grey brown		3	GS	-						
64.3											
1.0	END OF BOREHOLE AUGER REFUSAL										
	NOTE: 1. Borehole dry upon completion of drilling										

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

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GOLDER

RECORD OF BOREHOLE No 18-1210

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029529.9; E 366838.3 NAD 83 MTM ZONE 9 (LAT. 45.402960; LONG. -75.707530) ORIGINATED BY PAH

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS

DATUM Geodetic DATE January 27, 2019 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.0	GROUND SURFACE										
0.0 / 0.1	ASPHALTIC CONCRETE *(50 mm)*										
	(SP) Gravelly sand, angular (FILL) Grey		1	GS	-						
65.4											
0.6	(SM) Silty sand, angular (FILL) Grey brown										
65.0			2	SS	50/0.225		65		○		
1.0	END OF BOREHOLE AUGER REFUSAL										

NOTE:

1. Borehole dry upon completion of drilling

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No 18-1211

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029545.2; E 366884.1 NAD 83 MTM ZONE 9 (LAT. 45.403090; LONG. -75.706940) ORIGINATED BY PAH

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS

DATUM Geodetic DATE January 27, 2019 CHECKED BY KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.8	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE *(40 mm)*		1	GS	-						
0.0	(SW) Gravelly sand (FILL) Grey		2	GS	-				○		
66.3											
0.5	(SM) Silty sand, angular (FILL) Very dense Grey brown										
			3	SS	56		66		○		
65.2			4	SS	50/0.08						
1.6	END OF BOREHOLE AUGER REFUSAL										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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GOLDER

RECORD OF BOREHOLE No 18-1212

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029556.0; E 366916.4 NAD 83 MTM ZONE 9 (LAT. 45.403190; LONG. -75.706520) ORIGINATED BY KM

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
67.2	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE *(70 mm)*										
0.1	(GM/SM) Gravel and sand, contains cobbles and boulders (FILL) Dense Brown Moist		1	SS	31		67				
			2	SS	36		66		○		45 37 18 18
65.6			3	SS	50/0.05						
1.6	END OF BOREHOLE AUGER REFUSAL										

NOTE:

1. Borehole dry upon completion of drilling

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No 18-1213

SHEET 1 OF 1

METRIC

PROJECT 1655214-1120

G.W.P. 4173-15-00 LOCATION N 5029572.0; E 366933.6 NAD 83 MTM ZONE 9 (LAT. 45.403330; LONG. -75.706300) ORIGINATED BY IAN

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
67.8	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE *(80 mm)*										
0.1	(GM/SM) Gravel and sand, some silt, contains cobbles (FILL) Dense Brown Moist										
			1	SS	31		67				
66.4											
1.4	END OF BOREHOLE AUGER REFUSAL										
	NOTE: 1. Borehole dry upon completion										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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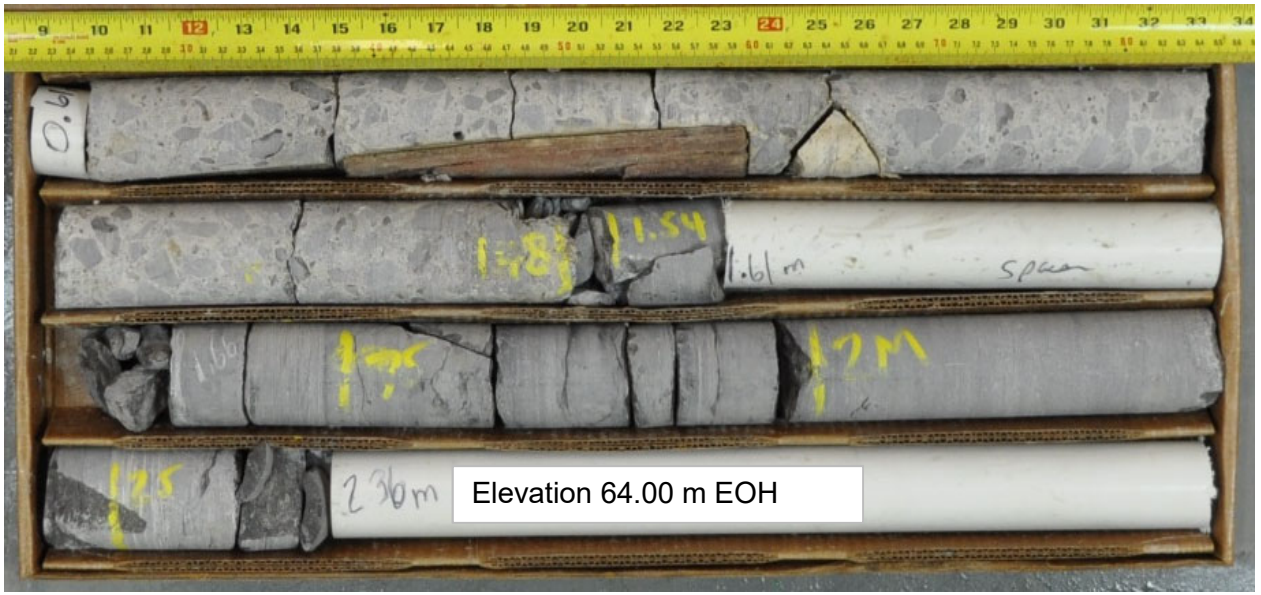
CH 17B-01 (Dry)

Core Box 1 of 1

Elevation 65.75 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

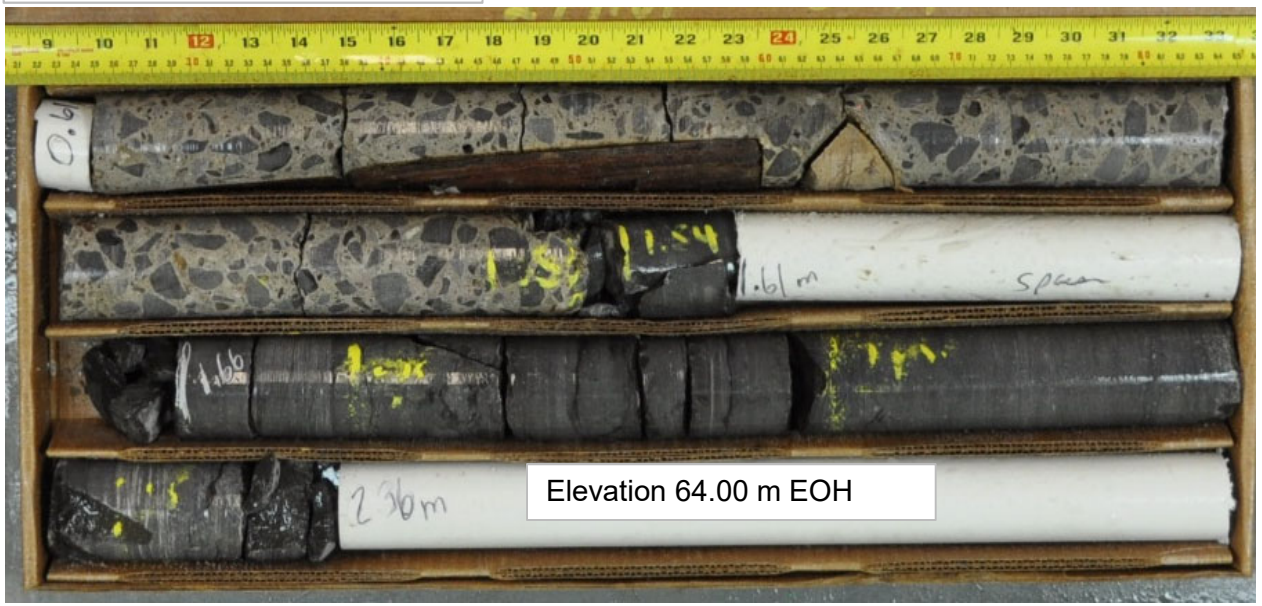
Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A1

CH 17B-01 (Wet)
Core Box 1 of 1

Elevation 65.75 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
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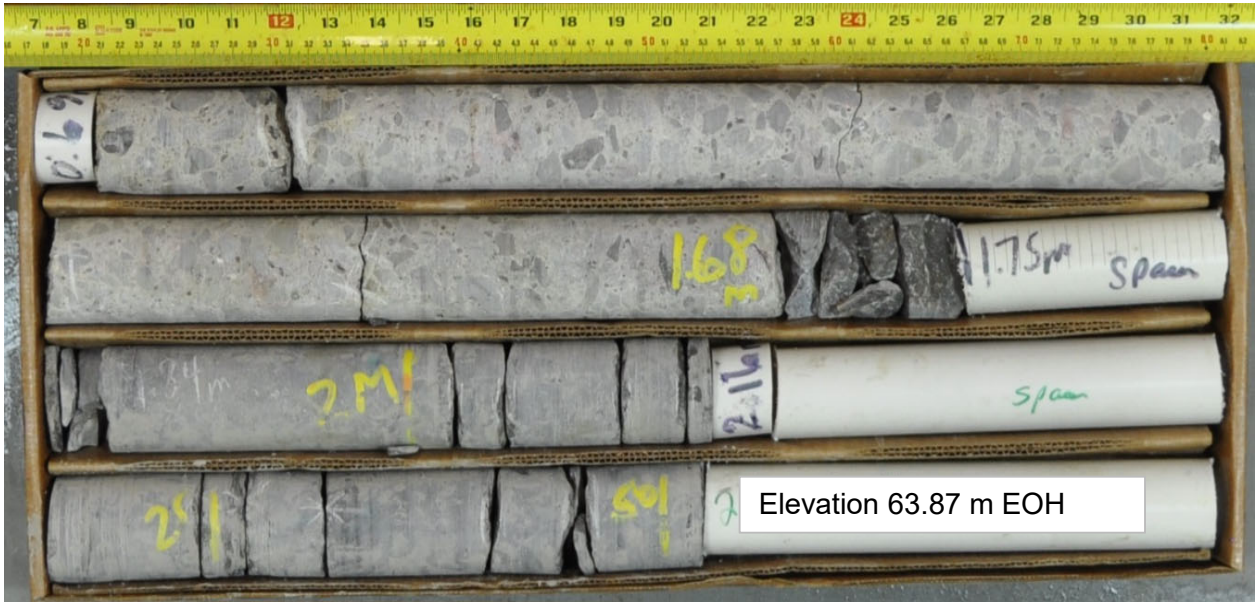
Figure A2

CH 17B-04 (Dry)

Core Box 1 of 1

Elevation 65.71 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
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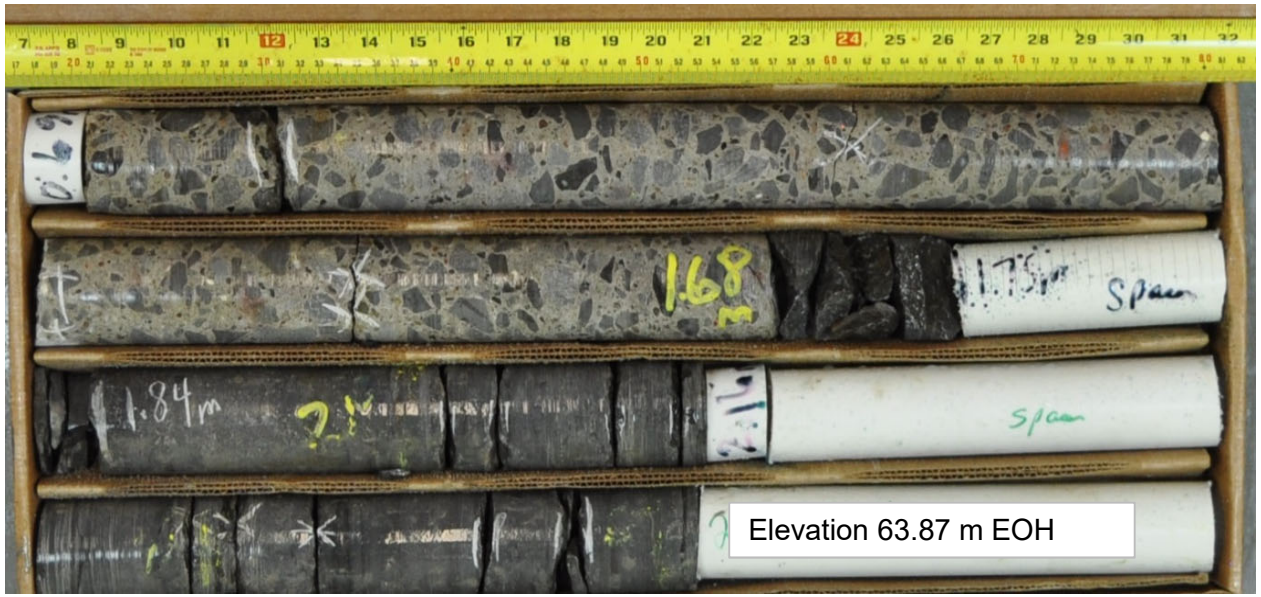
Figure A3

CH 17B-04 (Wet)

Core Box 1 of 1

Elevation 65.71 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
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Figure A4

CH 17-B08 (Dry)

Core Box 1 of 1

Elevation 65.87 m Top Footing

Elevation 64.32 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A5**

CH 17-B08 (Wet)

Core Box 1 of 1

Elevation 65.86 m Top Footing

Elevation 64.32 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
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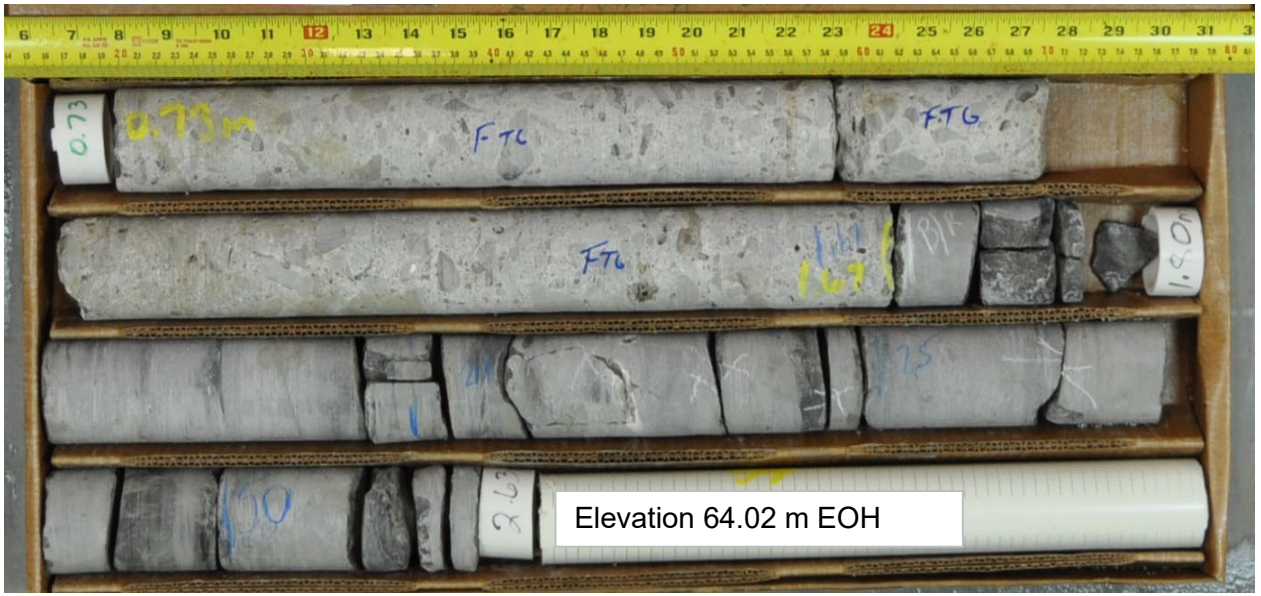
Figure A6

CH 17-B12 (Dry)

Core Box 1 of 1

Elevation 65.88 m Top Footing

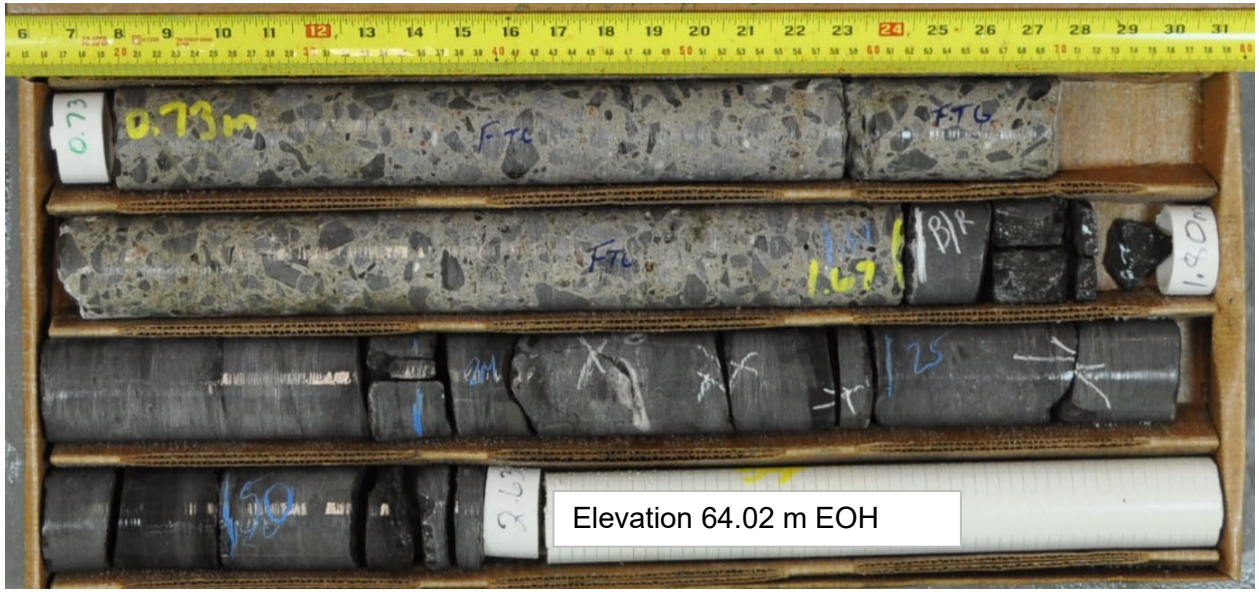


GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A7**

CH 17-B12 (Wet)

Core Box 1 of 1

Elevation 65.88 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
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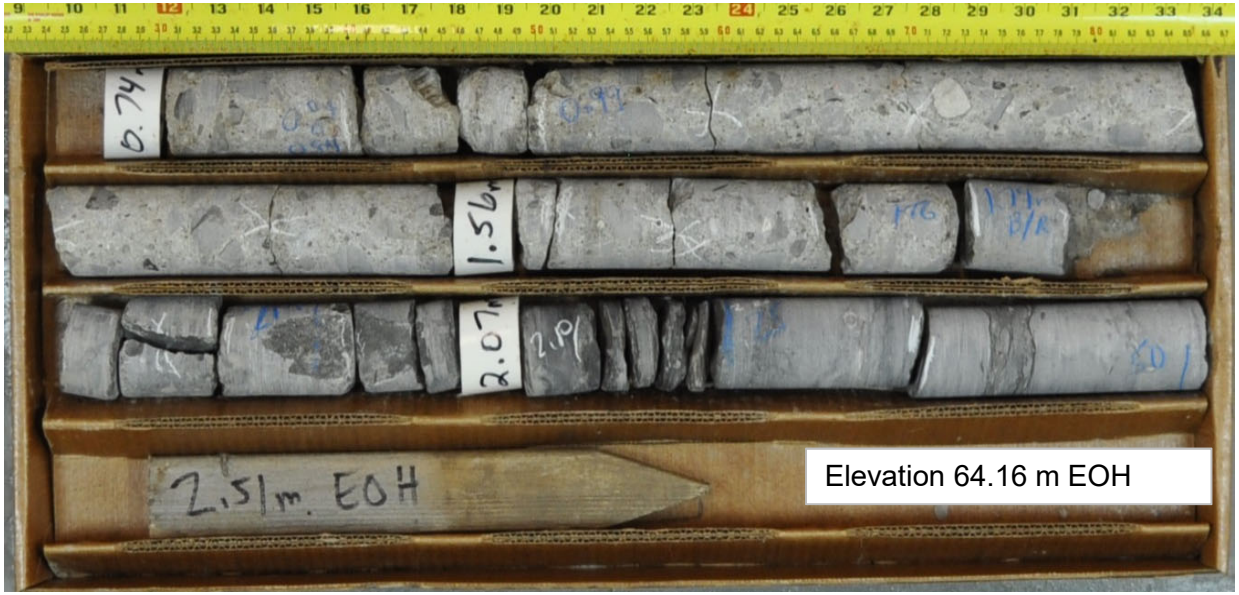
Figure A8

CH 17-B13 (Dry)

Core Box 1 of 1

Elevation 65.87 m Top Footing



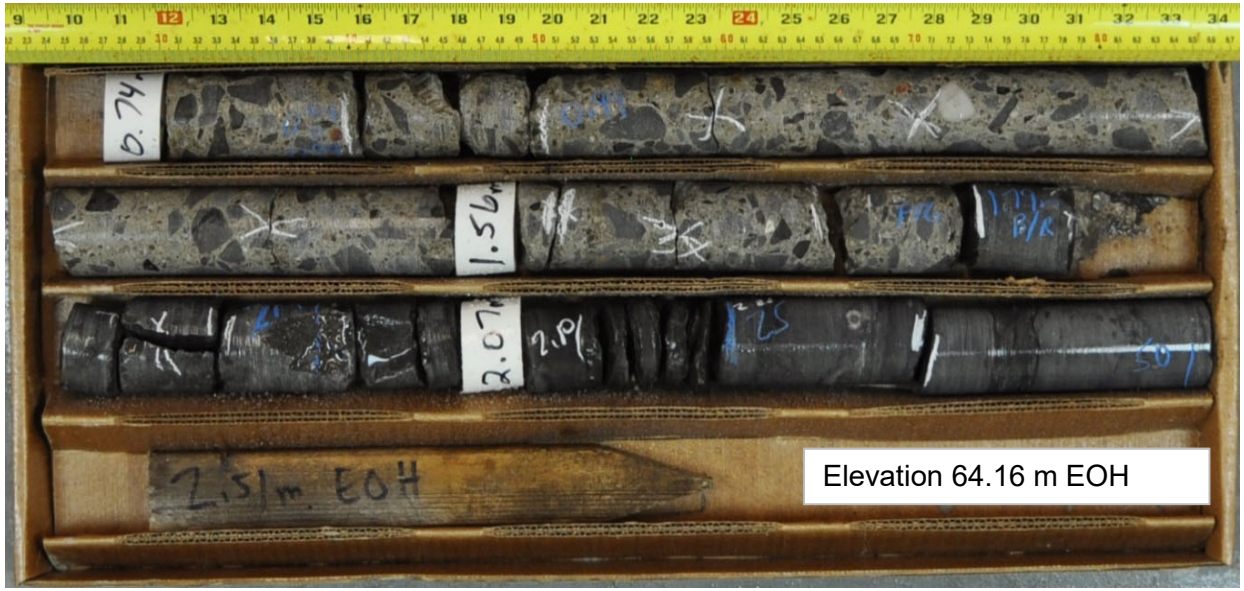
Elevation 64.16 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A9**

CH 17-B13 (Wet)

Core Box 1 of 1

Elevation 65.87 m Top Footing



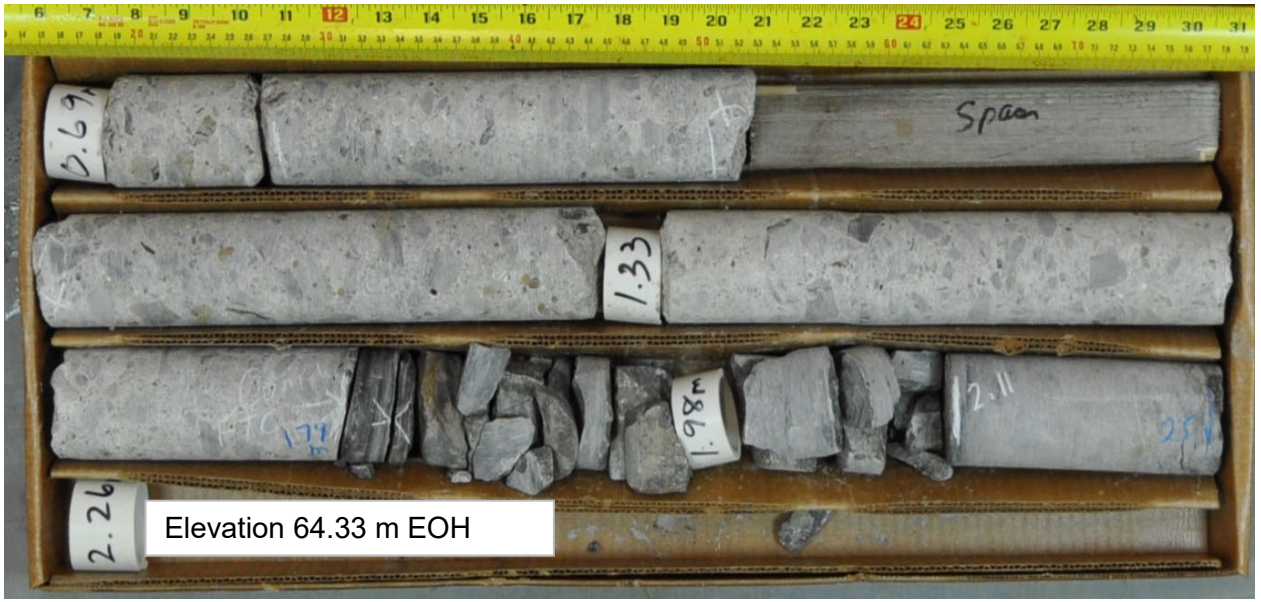
Elevation 64.16 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A10**

CH 17-B16 (Dry)

Core Box 1 of 1

Elevation 65.84 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
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Figure A11

CH 17-B16 (Wet)

Core Box 1 of 1

Elevation 65.84 m Top Footing

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
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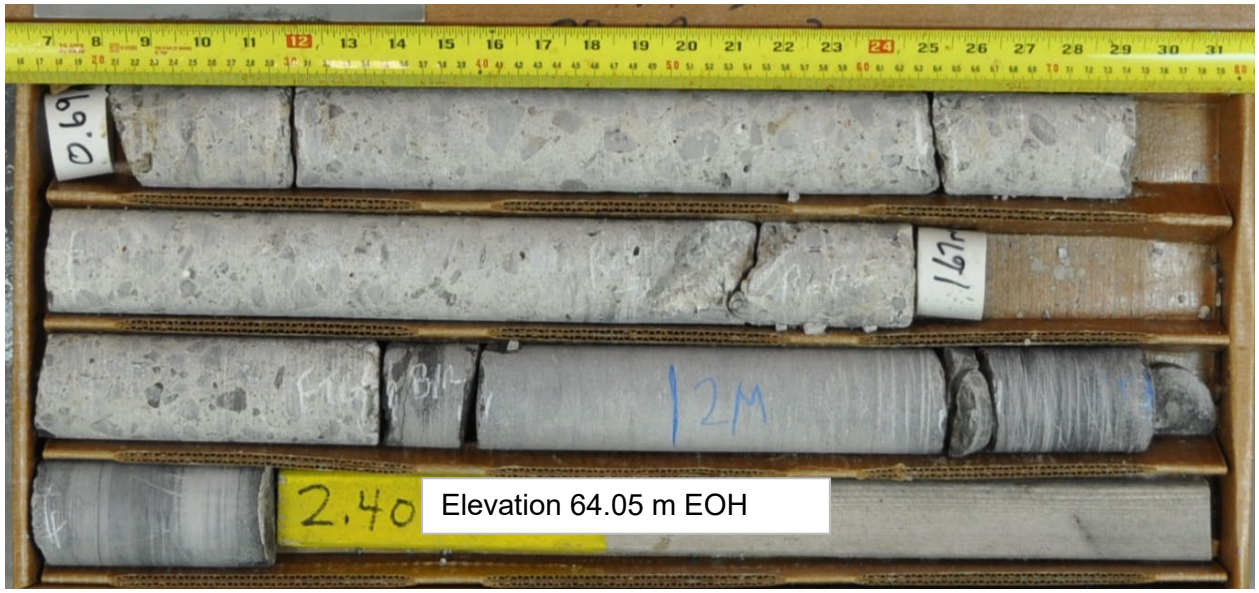
Review:	FJH

Figure A12

CH 17-B20 (Dry)

Core Box 1 of 1

Elevation 65.72 m Top Footing



Elevation 64.05 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
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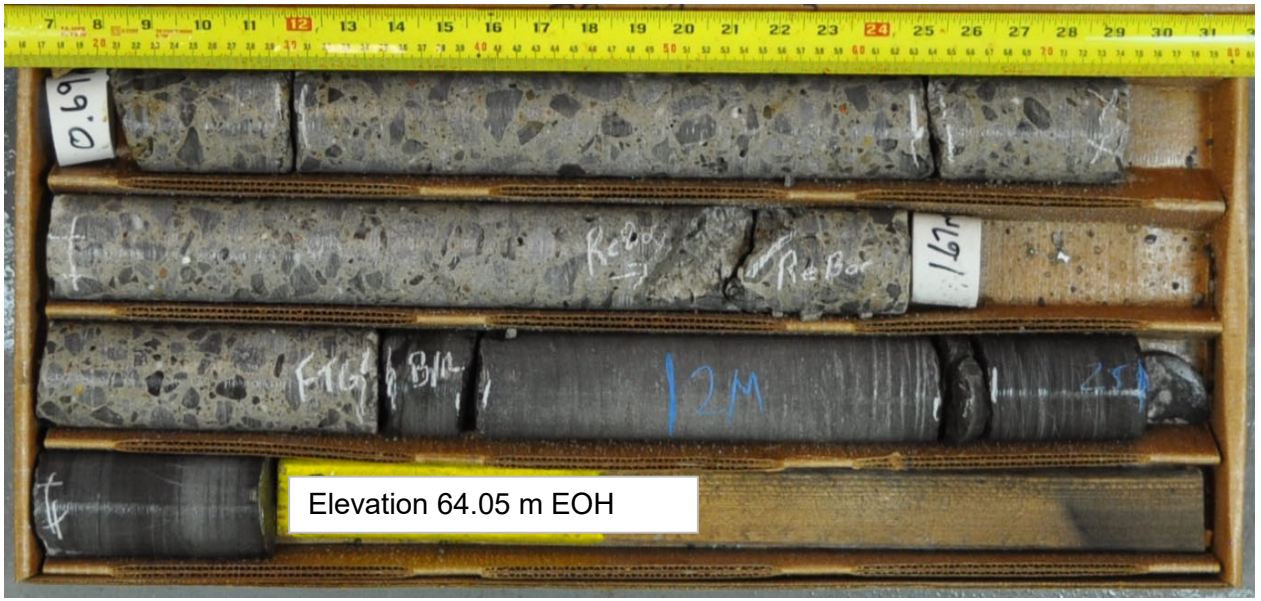
Review:	FJH

Figure A13

CH 17-B20 (Wet)

Core Box 1 of 1

Elevation 65.72 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
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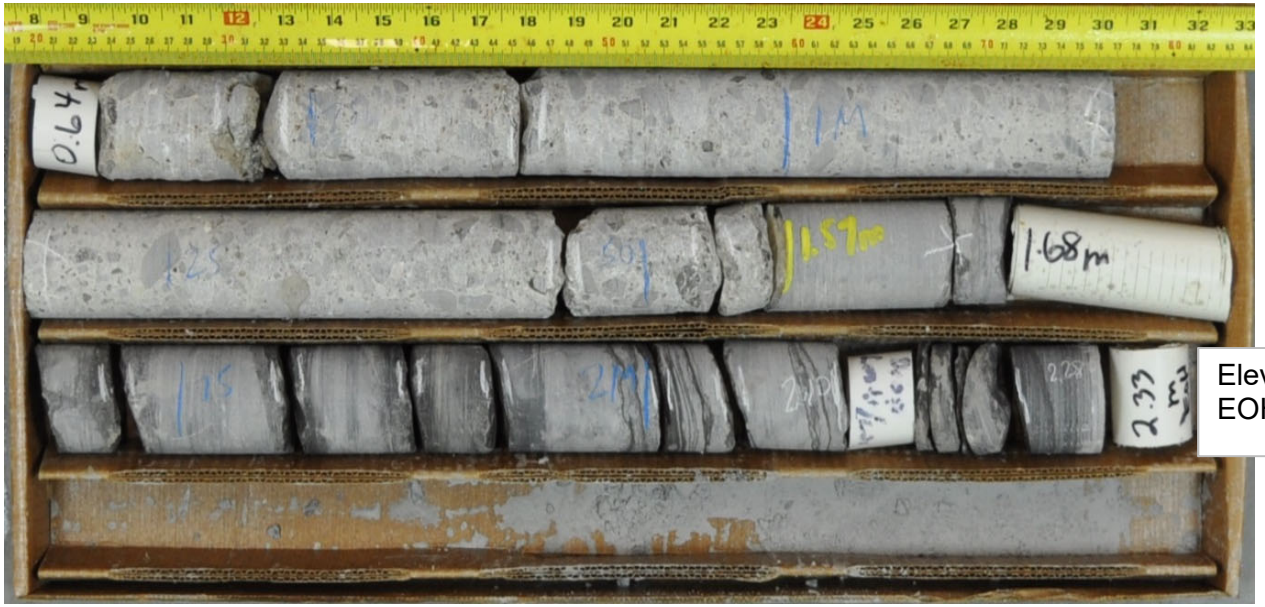
Figure A14

CH 17-B24 (Dry)

Core Box 1 of 1

Elevation 65.73 m Top Footing



Elevation 64.14 m
EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

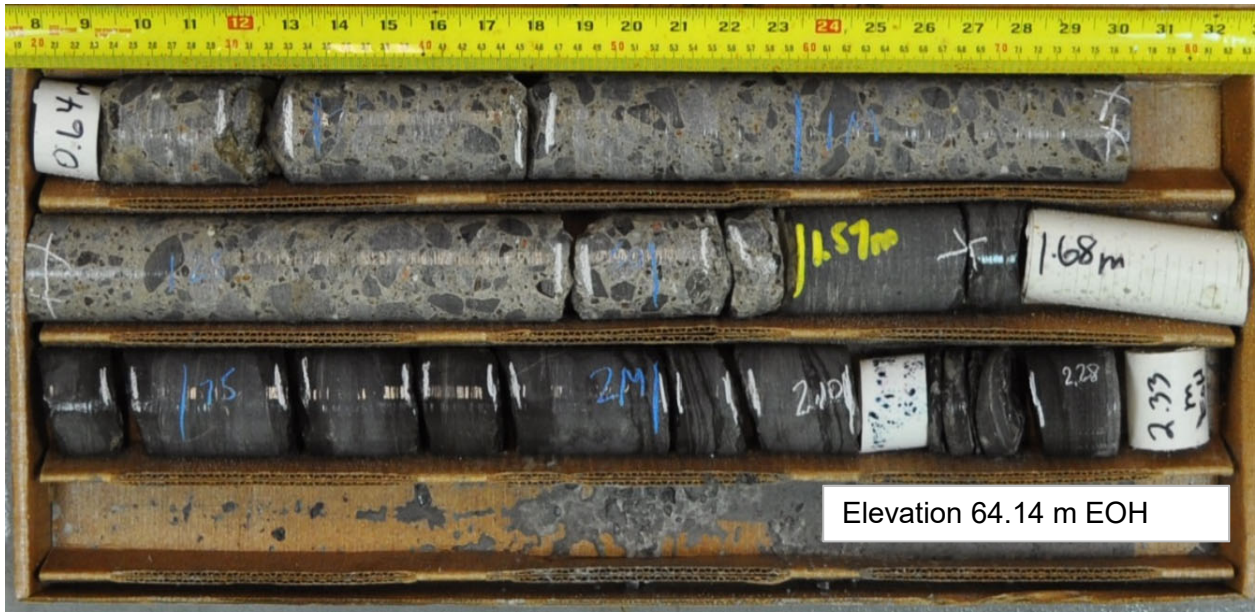
Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A15

CH 17-B24 (Wet)

Core Box 1 of 1

Elevation 65.73 m Top Footing



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
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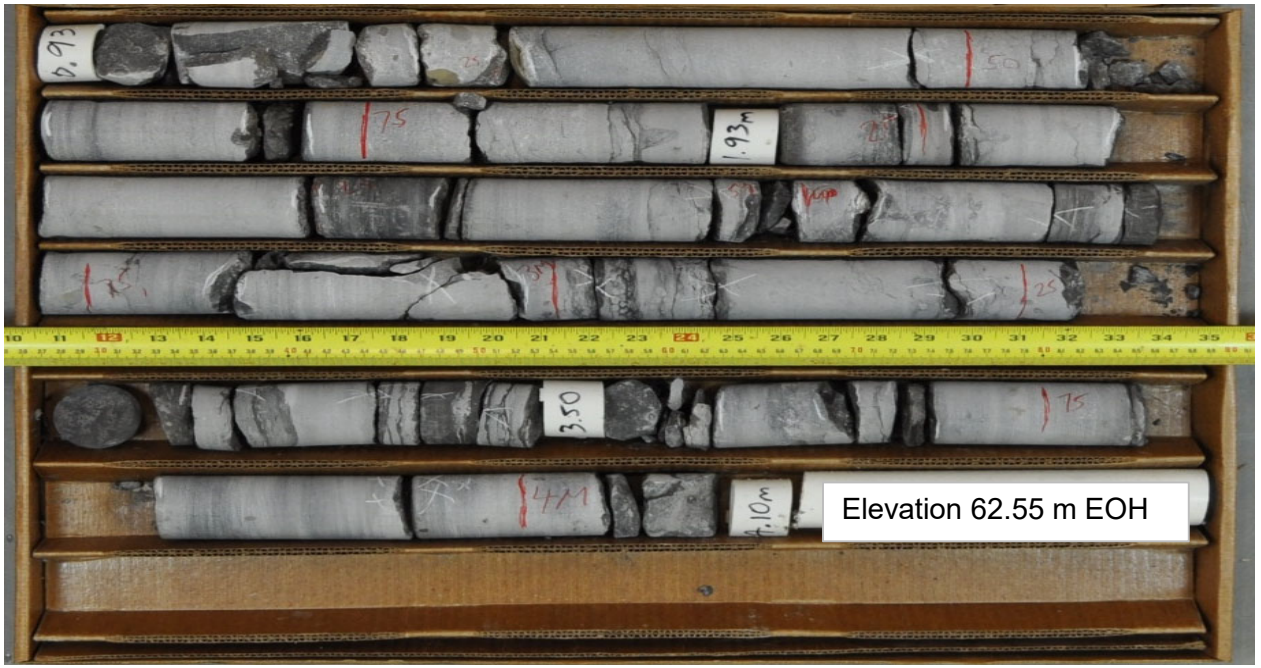
Review:	FJH

Figure A16

BH 17-121 (Dry)

Core Box 1 and 2 of 2

Elevation 65.72 m Top of Bedrock



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

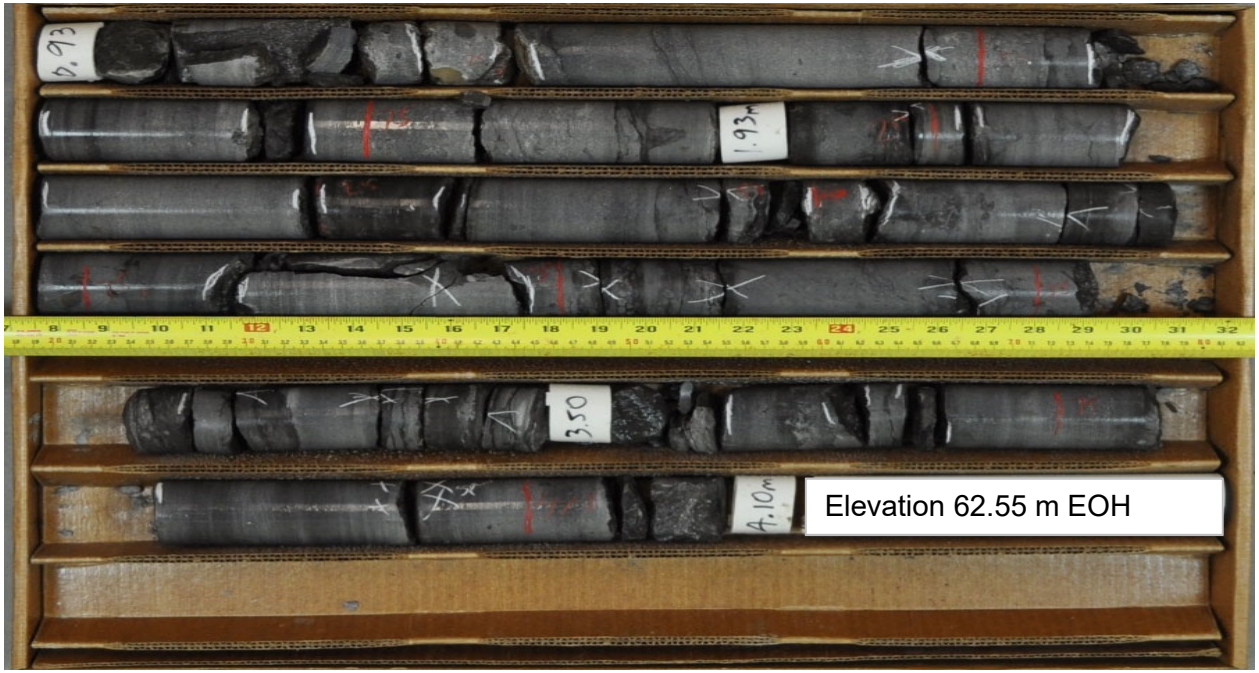
Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A17

BH 17-121 (Wet)

Core Box 1 and 2 of 2

Elevation 65.72 m Top of Bedrock



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

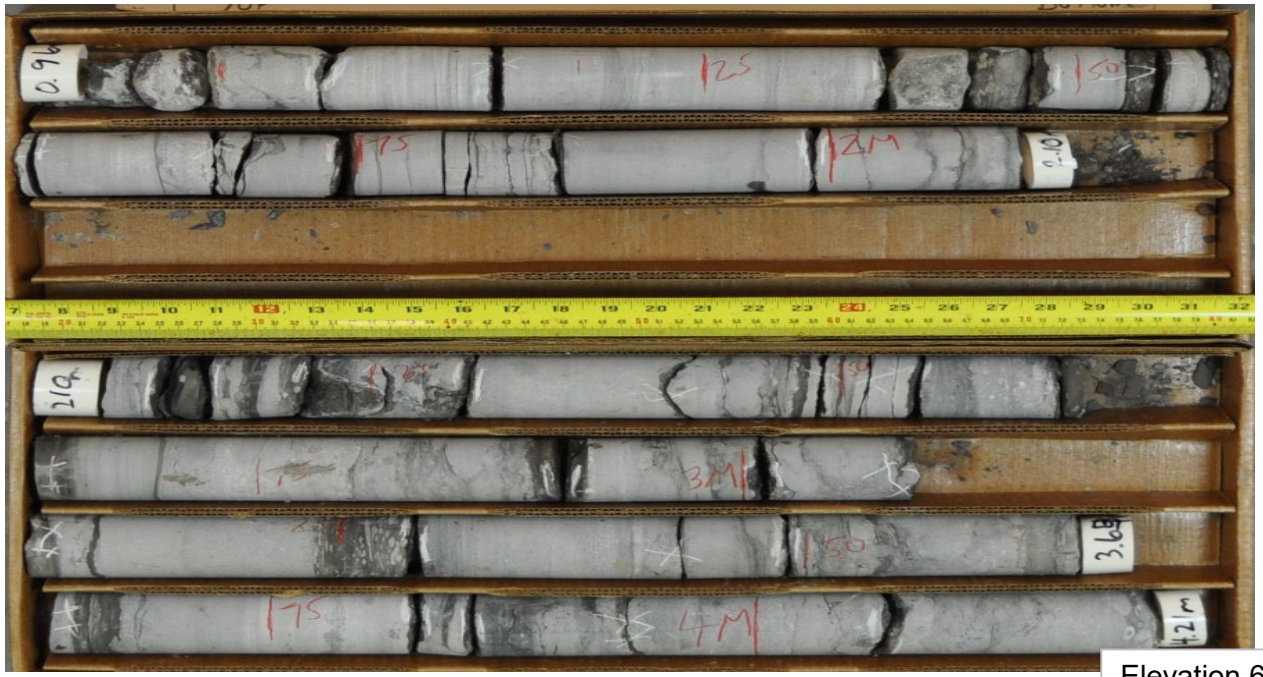
Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A18

BH 17-122 (Dry)

Core Box 1 and 2 of 2

Elevation 65.72 m Top of Bedrock



Elevation 62.47 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

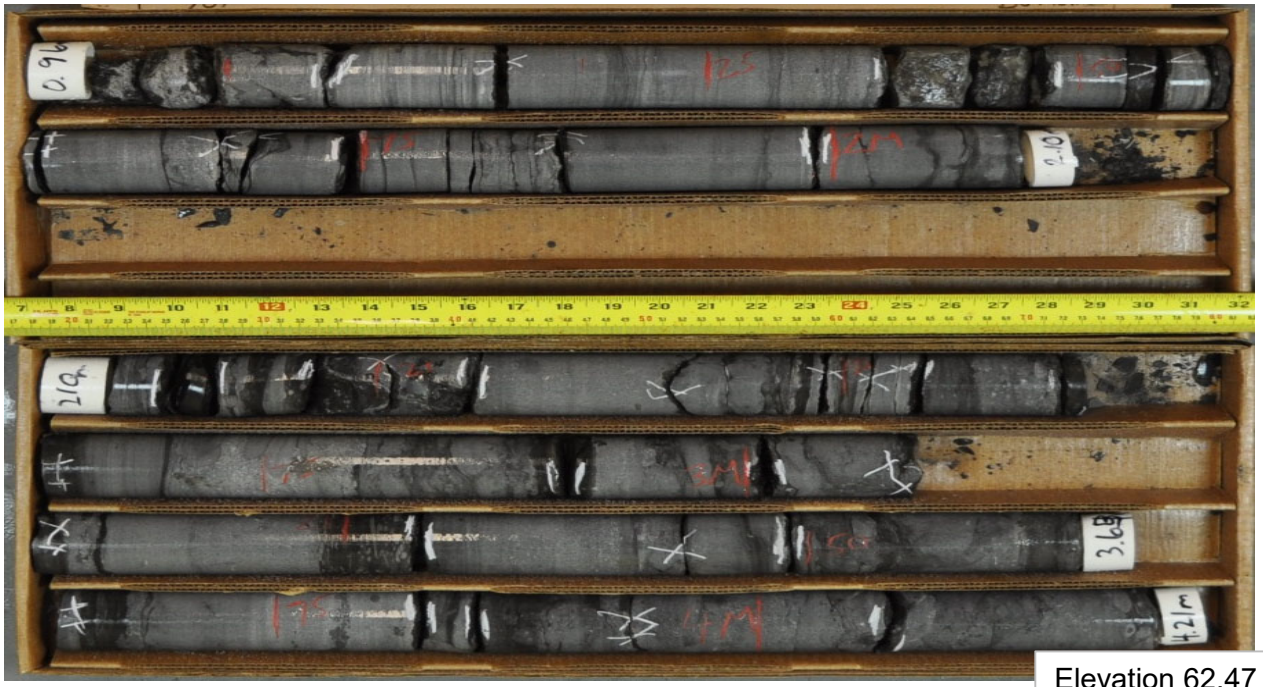
Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A19

BH 17-122 (Wet)

Core Box 1 and 2 of 2

Elevation 65.72 m Top of Bedrock



Elevation 62.47 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

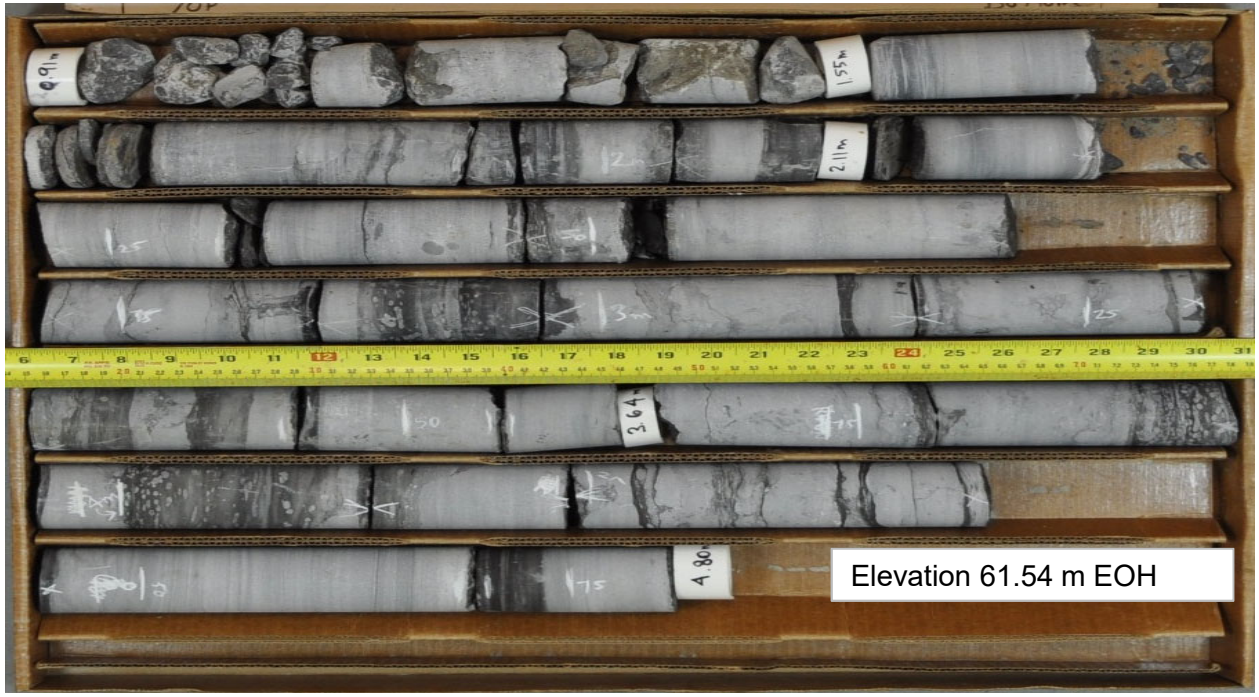
Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A20

BH 17-123 (Dry)

Core Box 1 and 2 of 2

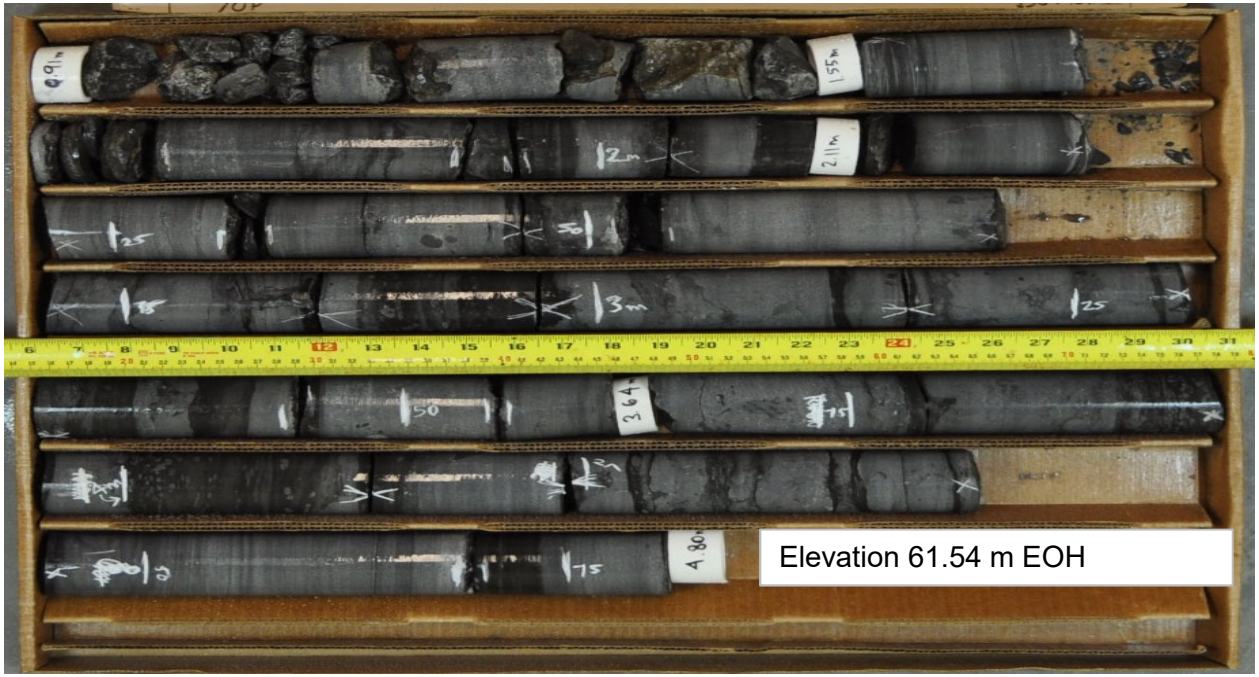


GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A21**

BH 17-123 (Wet)

Core Box 1 and 2 of 2

Elevation 65.19 m Top of Bedrock



GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A22

BH 17-124 (Dry)

Core Box 1 and 2 of 2

Elevation 65.46 m Top of Bedrock

Elevation 61.91 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A23**

BH 17-124 (Wet)

Core Box 1 and 2 of 2

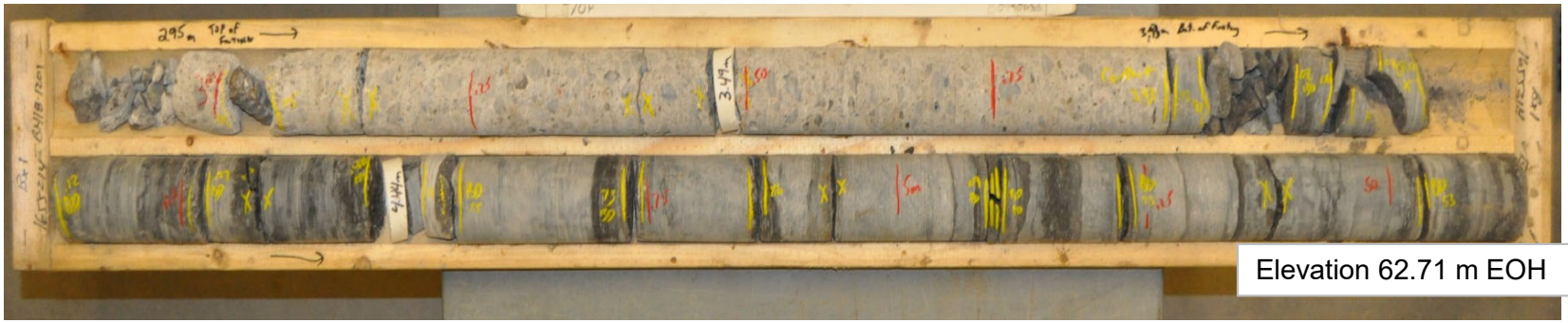
Elevation 65.46 m Top of Bedrock

Elevation 61.91 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A24**

CH 18-1201 (Dry)
Core Box 1 of 1

Elevation 65.40 m Top of Footing



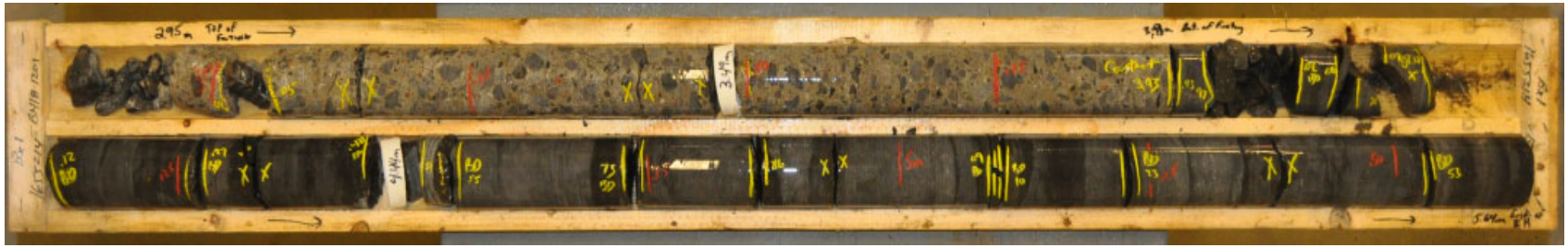
Elevation 62.71 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A25**

CH 18-1201 (Wet)

Core Box 1 of 1

Elevation 65.40 m Top of Footing



Elevation 62.71 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A26**

CH 18-1202 (Dry)
Core Box 1 and 2 of 2

Elevation 66.73 m Top of Bedrock

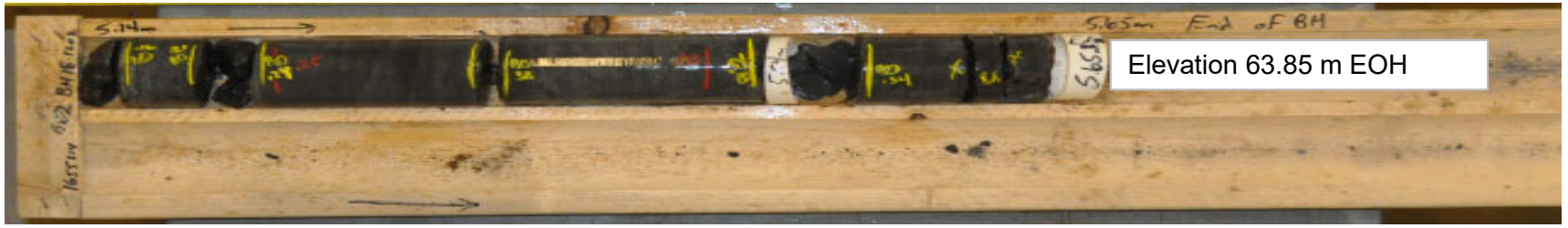
Elevation 63.85 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A27**

CH 18-1202 (Wet)

Core Box 1 and 2 of 2

Elevation 66.73 m Top of Footing



Elevation 63.85 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

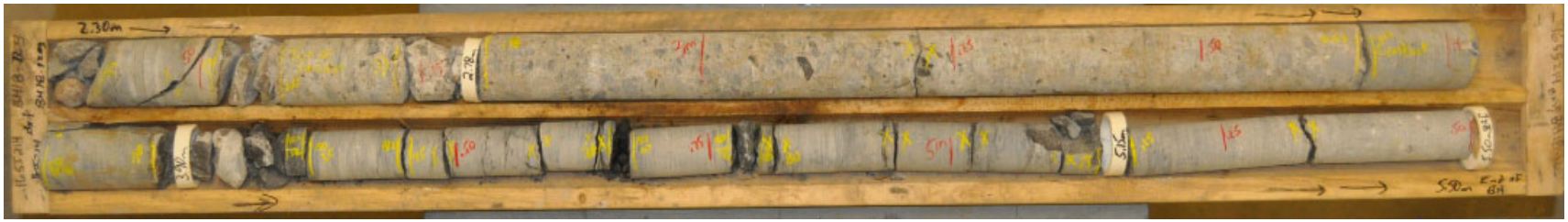
Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A27

CH 18-1203 (Dry)
Core Box 1 of 1

Elevation 66.10 m Top of Footing

Boulder above Footing



Elevation 63.20 m EOH

GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A28**

CH 18-1203 (Wet)

Core Box 1 of 1

Elevation 66.10 m Top of Footing

Boulder above Footing

Elevation 63.20 m EOH

GOLDER

Foundation Investigation

Highway 417 Overpass Structructures at Booth Street

Ottawa, Ontario

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

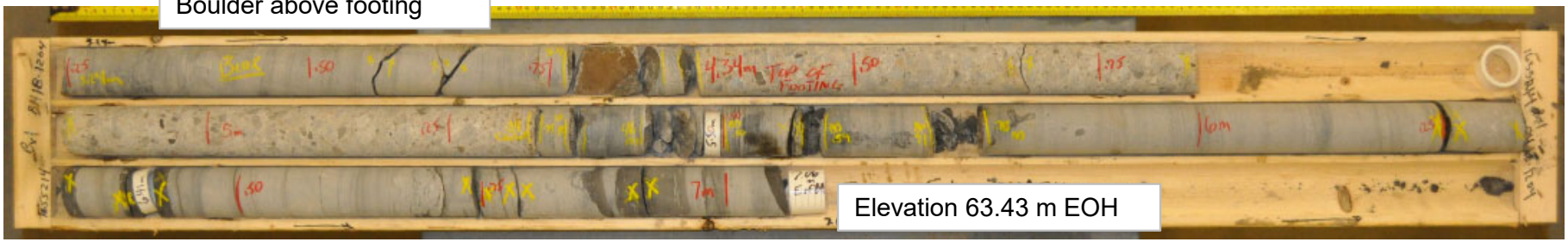
Figure A29

CH 18-1204 (Dry)

Core Box 1 of 1

Elevation 66.15 m Top of Footing

Boulder above footing



Elevation 63.43 m EOH

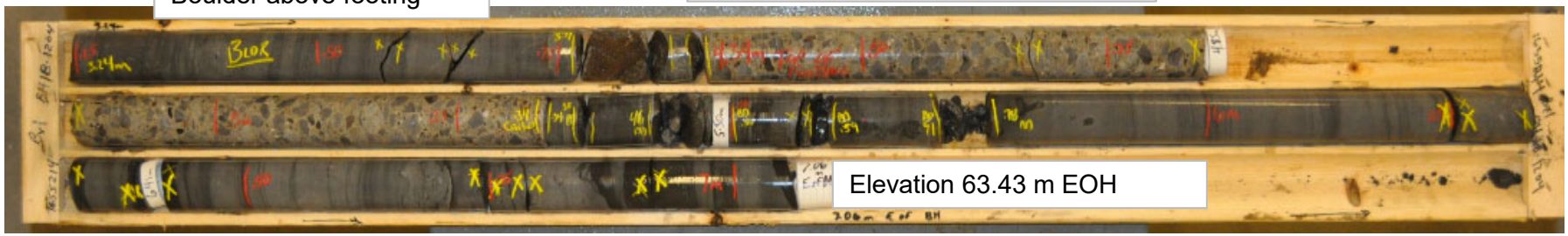
GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**

Project No.	1655214 / 1120
Drawn:	KS
Date:	2019-05-03
Checked:	KCP
Review:	FJH

Figure A30

CH 18-1204 (Wet)

Core Box 1 of 1



GOLDER	**Foundation Investigation** **Highway 417 Overpass Structructures at Booth Street** **Ottawa, Ontario**	Project No. 1655214 / 1120 Drawn: KS Date: 2019-05-03 Checked: KCP Review: FJH	**Figure A31**

TABLE A1: Concrete Core Condition Assessment
Existing Concrete Footing - Booth Street

Project No. 1655214 - 1120 **2017-10-20 / 2019-05-30** **CNM / KM**

Booth Street

17-B01 : 0.61 - 1.54
- Top surface ± intact.
- Wood (formwork?) along edge from 0.61 to 1.03m.
- Good condition, with only mechanical breaks to 1.47m.
- 1.47-1.54 : Washed-out muddy appearance. Loose aggregate pieces. Likely poured in water.
- No bond to rock.

17-B04 : - 0.69 - 1.68
- Top surface ± intact.
- Good condition, with only mechanical breaks only.
- Partial bond to rock (rock surface broken up in coring).

17-B08 : 0.64 - 1.54
- Top surface ± intact.
- Drilled through 2 vertical re-bars (splice) and 2 horizontal bar.
- Concrete paste in good condition, but many voids present, including at aggregate interfaces; Likely insufficiently vibrated during placement.
- Mechanical breaks only.
- 1.53-1.55 : Heavily voided at rock interface; Voids heavily rust-stained. No bond to rock; rock surface broken up in coring.

17-B12 : - 0.73 - 1.67
- Top surface broken up.
- Open cold joint at 1.23m with signs of dirt between lifts.
- Otherwise good condition, with only mechanical breaks only.
- Formed to rock surface at bottom, but not bonded (some of shaley rock surface lost in coring).

17-B13 : - 0.74 - 1.79
- Top surface ± intact.
- Small diameter core; much mechanical breakage.
- Otherwise good condition.
- No bond to rock. Bottom surface missing/lost in coring. Lower 1cm shows signs of being placed in water.

17-B16 : - 0.69 - 1.79
- Top surface ± intact.
- Possible cold joint at 1.33m, but too much drilling damage (spun) to confirm.
- Otherwise good condition, with only mechanical breaks only.
- Formed to rock surface at bottom, but not bonded.

17-B20 : - 0.69 - 1.85
- Top surface ± intact, but very rough.
- Cold joint at 1.67m.
- Otherwise good condition, with only mechanical breaks only.
- Shaley rock surface lost in coring. Bottom of concrete partially formed to rock.

17-B24: - 0.64 - 1.57
- Top surface broken up, missing.
- 0.70-0.73 : Heavily voided break.
- Otherwise good condition, with only mechanical breaks only.
- Formed to rock surface at bottom, but not bonded.

18-1201 2.95 to 3.93
Top of surface of concrete broken up, possibly due to coring (approx 3" of cover)
Rebar at 3.03, 32 m of Ø bar
Well consolidated, mechanical breaks only
Good bond to rock, broken during coring

18-1202 2.77 to 3.75
Plastic at surface
Good condition, mechnical breaks
Core broken at shallow depth/Top of surface broken
Core broken at 3.55 due to rebar
Well formed but unbonded to rock

18-1203 2.60 to 3.67
Rebar at 2.74 - 2.75 m (~ 140 mm cover)
Broken at 2.73 to 2.78 m (due to rebar and spinning during coring)
Occasional air entrainment
Well consolidated, mechnical breaks only
Good bond to rock

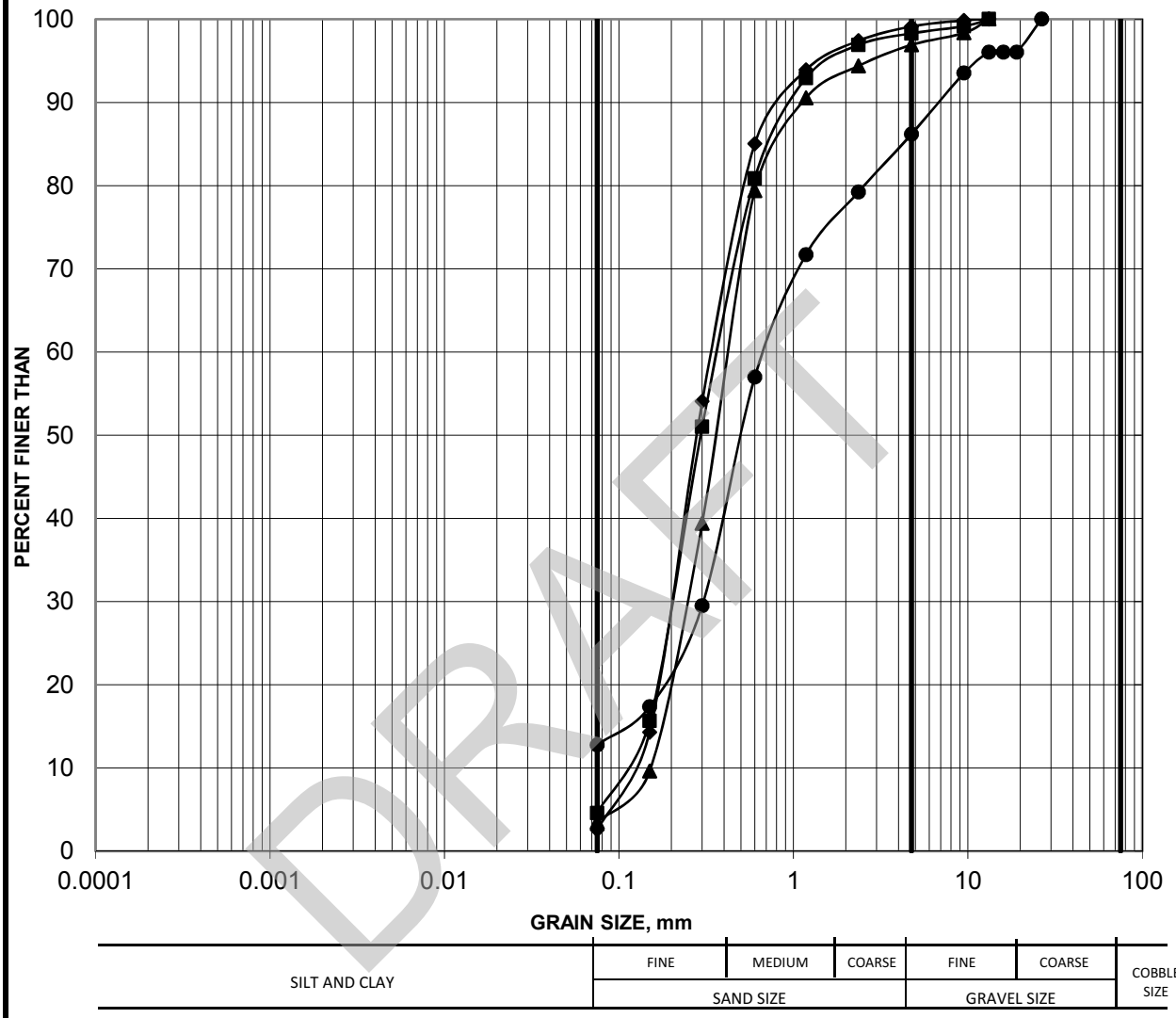
18-1204 4.34 to 5.34
Well consolidated, occasional air void entrainment
Good condition, mechnical breaks only
Unboded to rock, presence of "fibrous", "paperlike" material between the concrete and rock

APPENDIX B

Laboratory Test Results, Current Investigation

GRAIN SIZE DISTRIBUTION	FIGURE B1

SAND TO SILTY SAND (FILL)



Borehole	Sample	Depth (m)
18-1201	1	0.00-0.61
18-1203	2	0.61-1.22
18-1204	3	2.59-3.20
18-1206	5B	3.81-4.37

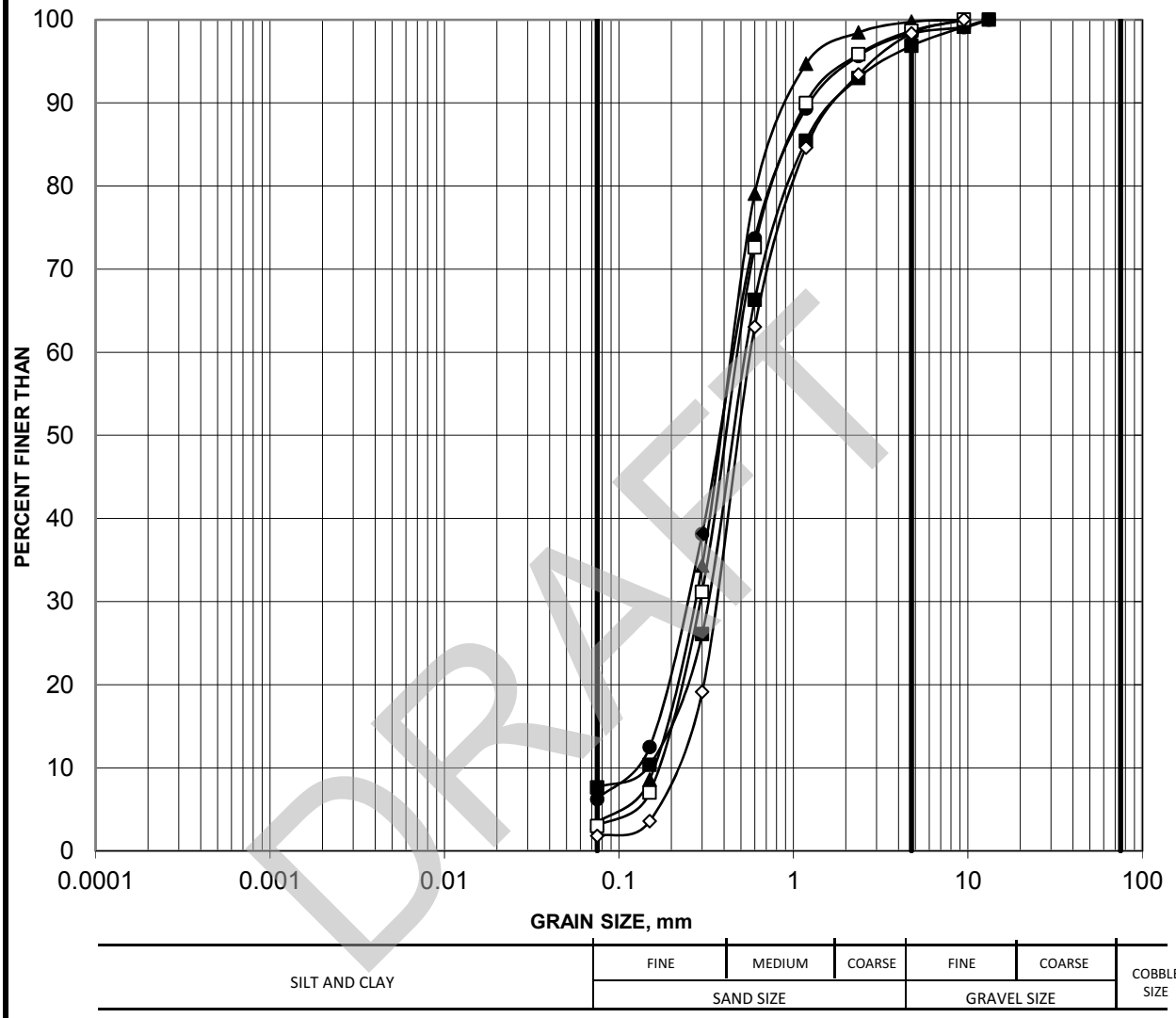
Project: 1655214 /1120

Golder Associates

Created by: MI
Checked by: GM

GRAIN SIZE DISTRIBUTION	FIGURE B2

SAND (FILL)



Borehole	Sample	Depth (m)
18-1205	7	4.57-5.18
18-1206	7	5.34-5.95
18-1207	4	2.28-2.89
18-1207	7	4.57-5.18
18-1208	7	4.57-5.18

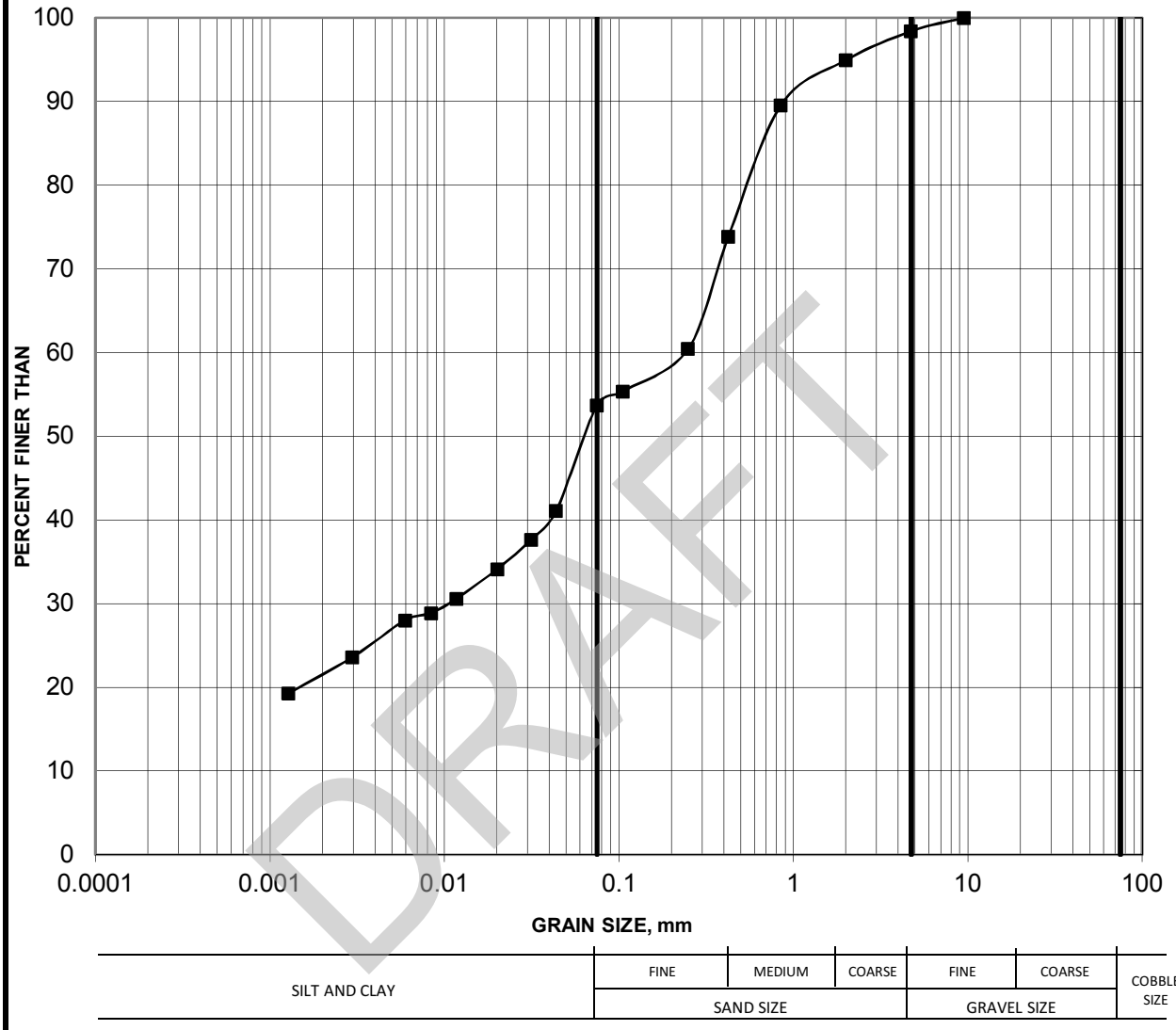
Project: 1655214/1120

Golder Associates

Created by: MI
Checked by: GM

GRAIN SIZE DISTRIBUTION	FIGURE B3

SANDY CLAYEY SILT (FILL)



Borehole	Sample	Depth (m)
18-1208	8	5.33-5.94

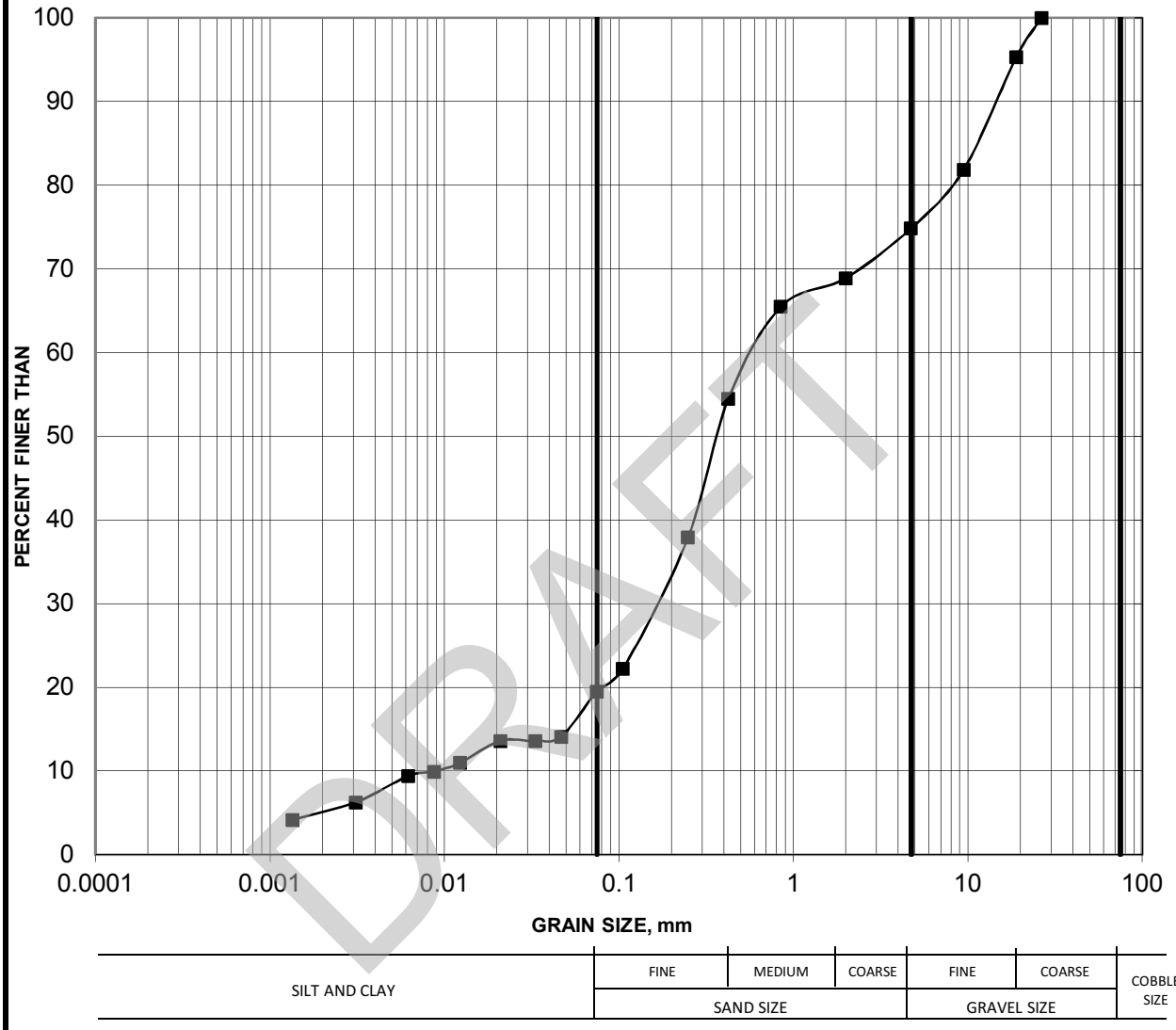
Project: 1655214/1120

Golder Associates

Created by: MI
Checked by: GM

GRAIN SIZE DISTRIBUTION	FIGURE B4

GRAVELLY SILTY SAND TRACE CLAY (TILL)



Borehole	Sample	Depth (m)
18-1207	9	6.09-6.70

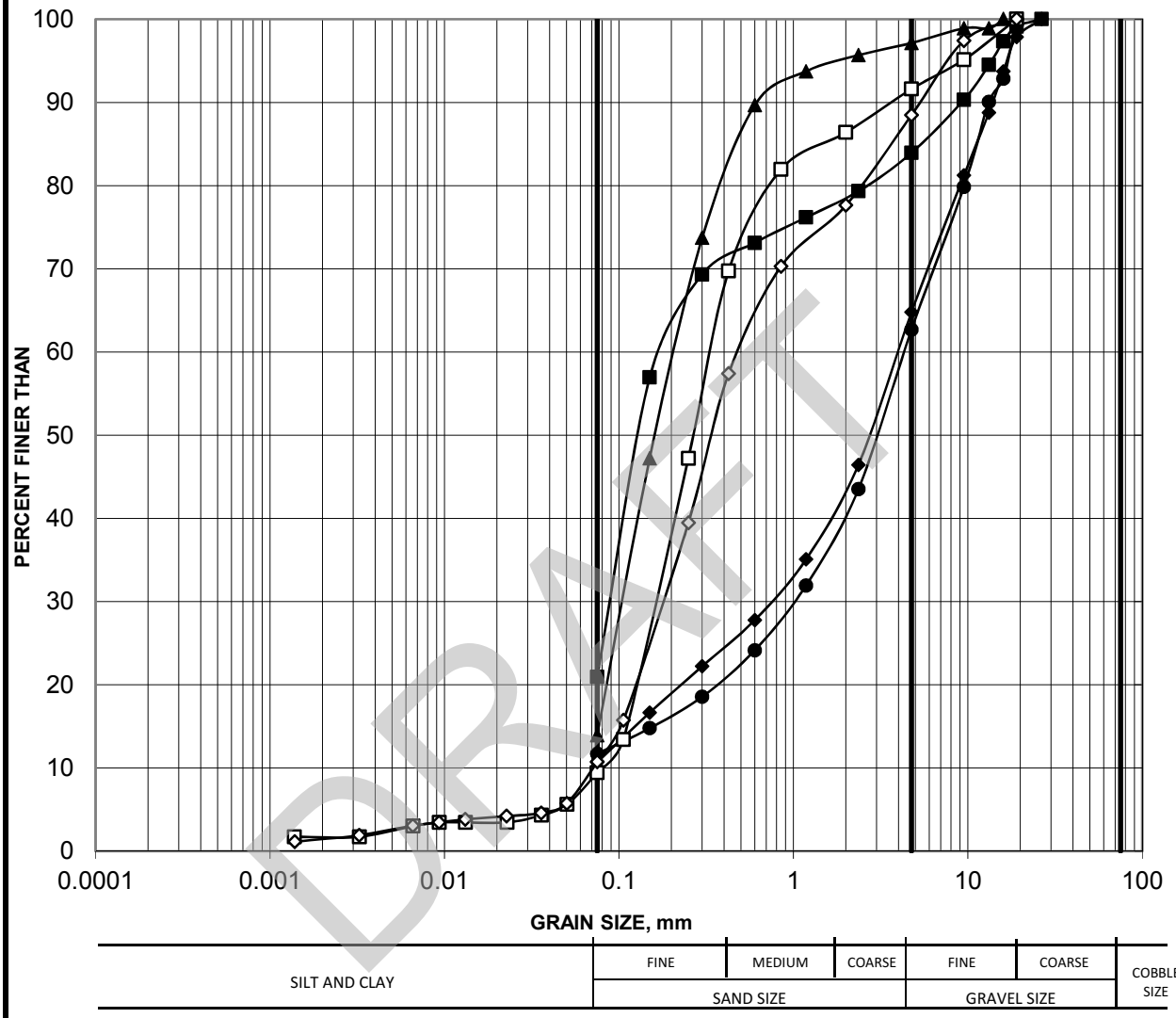
Project: 1655214/1120

Golder Associates

Created by: MI
Checked by: GM

GRAIN SIZE DISTRIBUTION	FIGURE B5

SAND, GRAVELLY SAND, AND SAND AND GRAVEL (FILL)



Borehole	Sample	Depth (m)
17-B05	1	0.31-0.69
17-B12	1	0.17-0.30
17-B13	2	0.22-0.60
17-B19	1	0.17-0.30
17-121	1	0.27-0.88
17-124	1	0.30-0.71

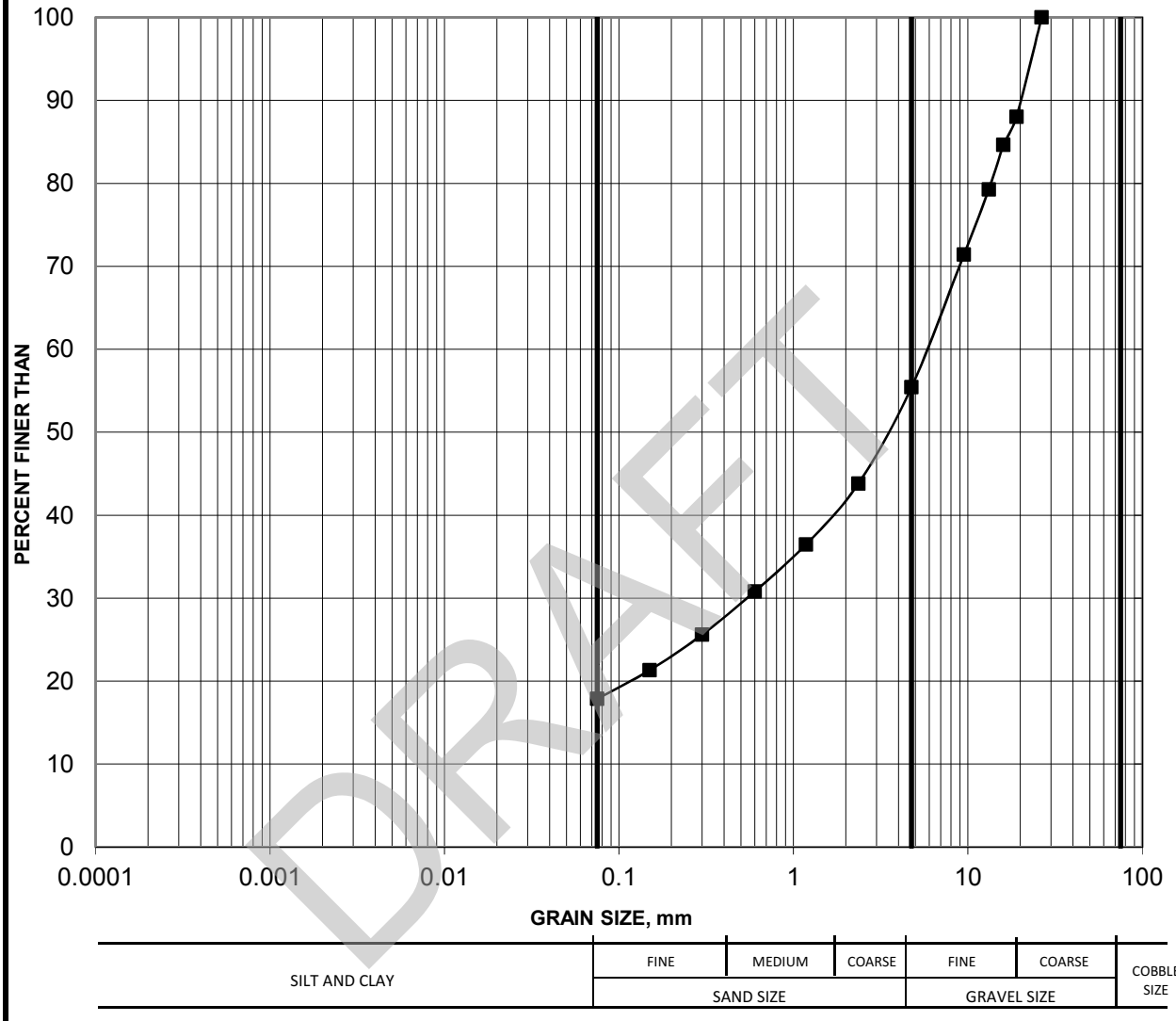
Project: 1655214 /1120

Golder Associates

Created by: MI
Checked by: GM

GRAIN SIZE DISTRIBUTION	FIGURE B6

GRAVEL AND SAND (FILL)



Borehole	Sample	Depth (m)
18-1212	2	0.76-1.37

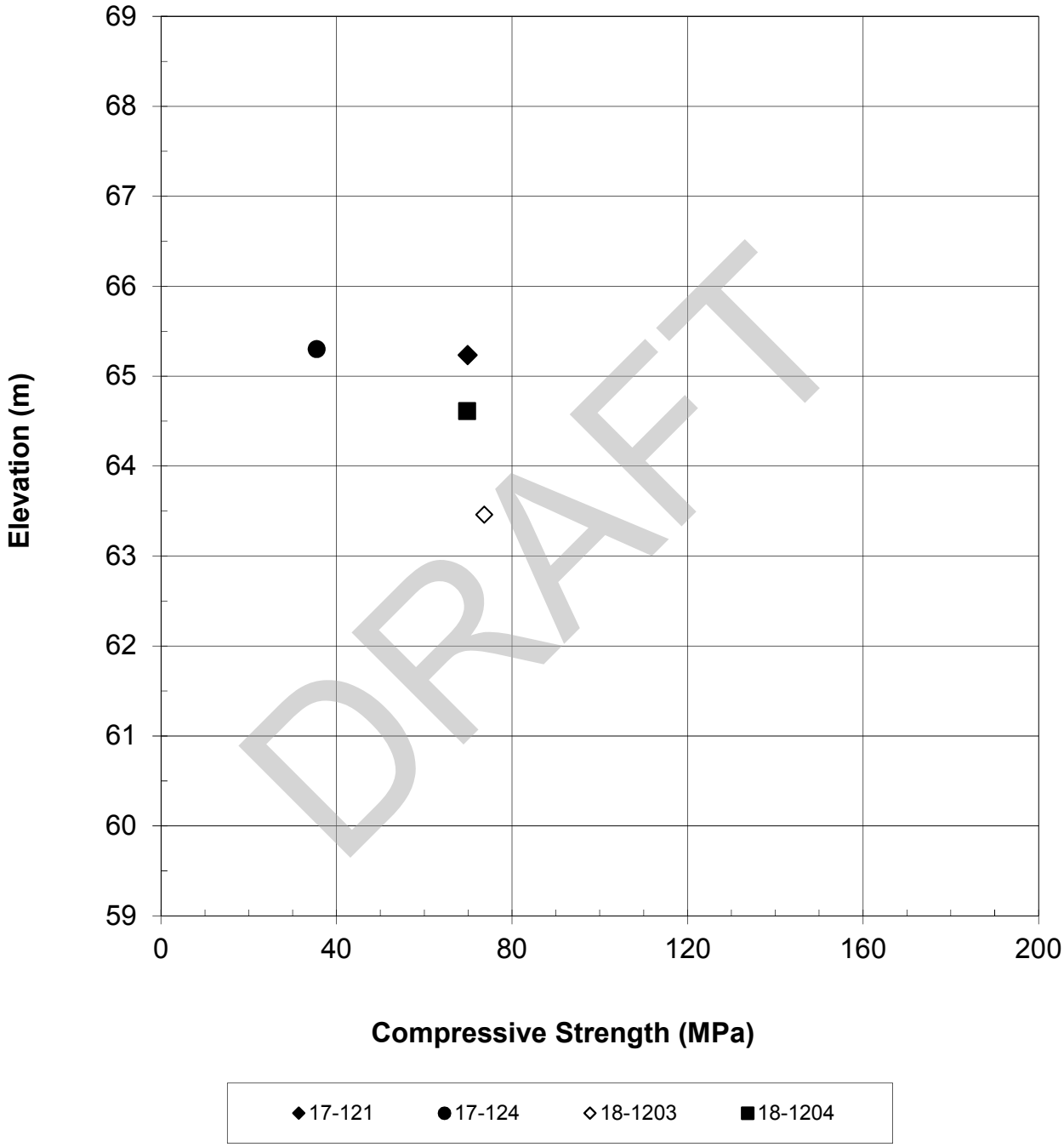
Project: 1655214/1120

Golder Associates

Created by: MI
Checked by: GM

SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
UNCONFINED COMPRESSION TESTS

FIGURE B7



Project: 1655214 /1120

GOLDER

Created by: MI
Checked by: GM

APPENDIX C

Previous Investigations, GEOCRES 31G05-030 (1959)

Soil Profile & Laboratory Tests Sheets

No. 1 to 7

Test Boring Plan

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 218.0
Remarks: Test Boring

Sheet No. 1 of 7
Hole No. 1

Borings by: F.E.Johnston Drilling Co.,Ltd. Date: Nov. 23, 1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unsm.Comp. Strength Tons/Sq Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface 0				0	218.0	
	Boulder Till				1		
					2		
					3	215.0	
	3'6"					214.5	(Rock) Plugged and dr at 3'6".
	Bedrock				4		
					5		
	Limestone with thin bands of interbedded shale up to 2 inches thick. Minor carbonate replacement and slight evidence of mineralization.	Core		94% Recovery	6		
					7		
					8	210.0	Footing Elevation
					9		
					10		
					11		
					12		
					13	205.0	
	13'6"				14		
					15		

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

Location: Bridge No. 17 - Booth St., The Queensway.

ELEVATION (Zero Depth): 217.3
Remarks: Test Borings

Sheet No. 2 of 7

Hole No. 2

Borings by: F. E. Johnston Drilling Co., Ltd. Date: Nov. 23,1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq.Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface 0				0	217.3	
	Fill Material - Clay and Angular Cobbles				1		
					2	215.3	
						215.0	Footing Elevation
	3'3"				3	214.0	(Rock)
	Bedrock				4	212.8	Ground Water Level 4'5".
	Limestone with inter-banded shale layers up to 3 inches thick. Minor carbonate and mineralization replacement.	Core		92% Recovery	5		
					6		
					7	210.0	
	8'2"				8		
					9		
					10		

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE & LABORATORY TESTS

Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 218.7
Remarks: Test Borings

Sheet No. 3 of 7

Hole No. 3

Borings by: F.E.Johnston Drilling Co., Ltd. Date: Nov. 25, 1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq.Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface 0				0	218.7	
	Black Top Soil 1				1		
	Fill - Boulders & Clay 2'10"				2	216.2	Ground Water Level 2'8"
						215.8	(Rock)
	Bedrock Limestone with minor shale. One band 1 inch thick. Minor carbonate replacement and mineralization.	Core		96% Recovery	3 4	215	Footing Elevation
		Core		97% Recovery	5 6		
	8'5½"				7 8	210	
					9		

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 217.5
Remarks: Test Borings

Sheet No. 4 of 7
Hole No. 4.

Borings by: F. E. Johnston Drilling Co.,Ltd. Date: Nov.24,1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface 0				0	217.5	
	Black Clayey Top Soil 1'				1		
	Fill Material (Clayey-Sand) 2' 6"				2	215.0	(Rock)
					3		
						214.0	Ground Water Level 3'6"
	Bedrock	Core		96% Recovery	4		
	Limestone to 7 feet followed by limestone interbedded with shale layers up to 2 inches thick. Minor carbonate and minor mineralization.				5		
					6		
					7		
					8	210.0	Footing Elevation
					9		
		Core		98% Recovery	10		
					11		
					12	205.0	
	13' 1"				13		
					14		
					15		

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 217.7
Remarks: Test Borings

Sheet No. 5 of 7
Hole No. 5.

Borings by: F.E.Johnston Drilling Co.,Ltd. Date: Nov. 24 & 25/59.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq.Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface				0	217.7	
	Fill Material				1		
	Clay and Cobbles				2		Ground Water Level 2' 1".
	2'6"						
	Bedrock	Core		71% Recovery	3	215.2	(Rock)
	Limestone interbanded with shale. A 4-inch band of shale at 7'6". Minor carbonate and mineralization.	Core		88% Recovery	4		
					5		
					6		
					7		
					8	210.0	Footing Elevation
		Core		95% Recovery	9		
					10		
					11		
					12		
		Core		100% Recovery	13	205.0	
	13'2"				14		
					15		

JOHN D. PATTERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 219.4
Remarks: Test Borings

Sheet No. 6 of 7

Hole No 6

Borings by: F.E.Johnston Drilling Co., Ltd. Date: Nov. 25, 1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface				0	219.4	
	Ashes and Crushed Stone Fill				1		
	Fill - Boulders and Clay				2		
	3'4"				3	216.1 (Rock)	Ground Water Level 4'5".
	Bedrock	Core		91% Recovery	4		
	Limestone with minor shale bands. Thickest band 1 inch. Minor carbonate and mineralization.				5		
					6		
					7		
					8		
					9	210.0	Footing Elevation
		Core		99% Recovery	10		
					11		
					12		
					13		
		Core		95% Recovery	14	205	
	14' 7"				15		

JOHN D. PATERSON
CONSULTING ENGINEER
OTTAWA CANADA

SOIL PROFILE
&
LABORATORY TESTS

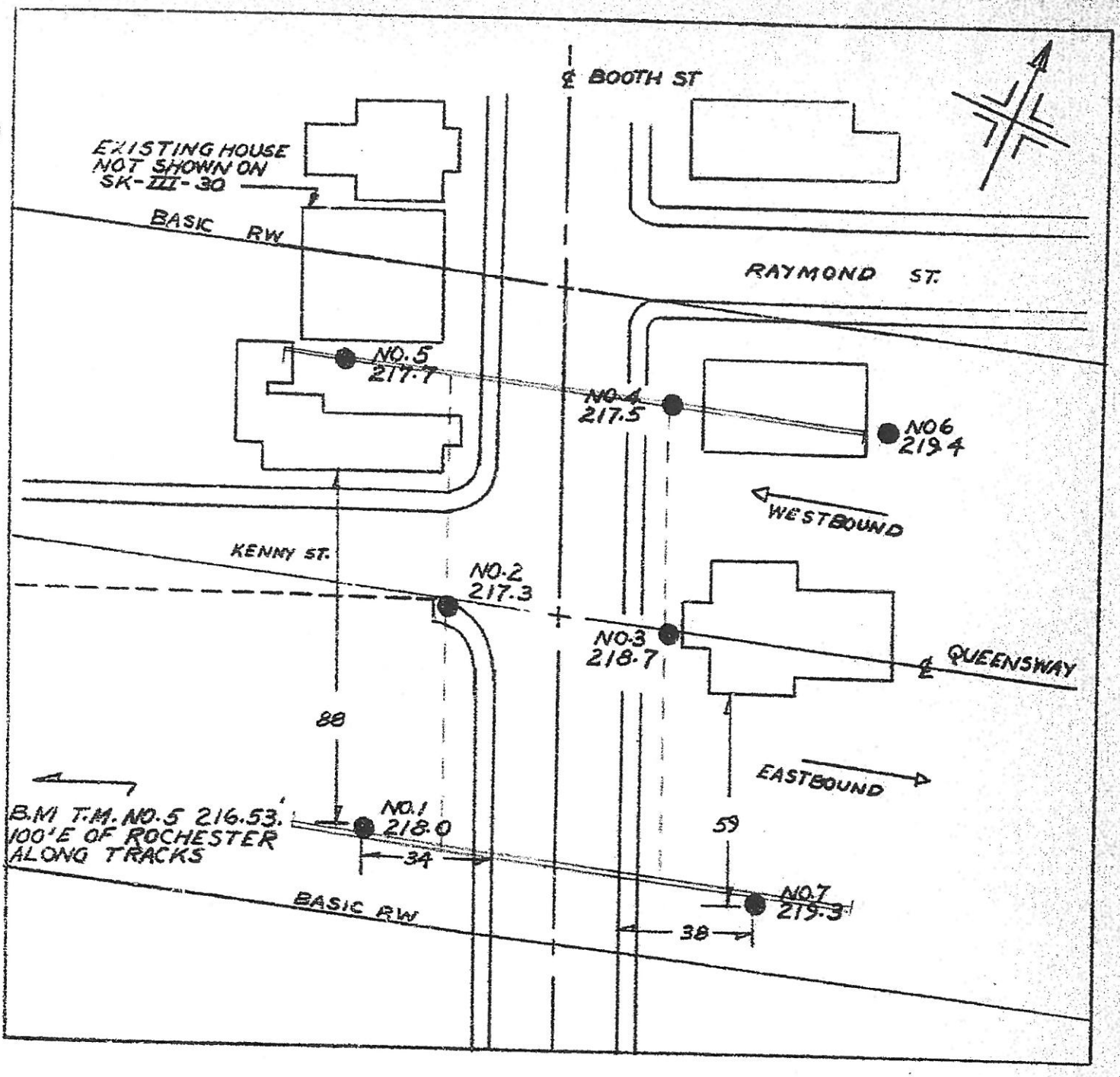
Location: Bridge No. 17 - Booth Street, The Queensway.

ELEVATION (Zero Depth): 219.3
Remarks: Test Borings

Sheet No. 7 of 7.
Hole No. 7.

Borings by: F.S.Johnston Drilling Co., Ltd. Date: Nov. 26,1959.

BLOWS PER FOOT	SOIL DESCRIPTION	Samples Type	Samples No.	Unconf. Comp. Strength Tons/Sq Ft.	Depth in Feet	ELEV.	MOISTURE CONTENT PER CENT. 30 40 50 60 70
	Ground Surface 0				0	219.3	
	Black Top Soil 1				1		
	Boulder Till				2		
	2'4"					217.0	(Rock)
	Bedrock Limestone with thin layers of interbedded shale with decreasing shale content with depth. Minor carbonate replacement and very minor mineralization.	Core		100% Recovery	3		
					4	215.	
		Core		99% Recovery	5		
					6		
		Core		100% Recovery	7		
					8		
					9		
						210	Footing Elevation
		Core		94% Recovery	10		
					11		
					12		
					13		
		Core		95% Recovery	14		
						205	
	14'10½"				15		



TEST BORING PLAN
QUEENSWAY
BRIDGE NO.17 AT BOOTH ST.
OTTAWA, ONT.

SCALE 1"=40' NOV. 1959

JOB NO C-44-M STAGE III

PLAN TAKEN FROM SK-III-30

APPENDIX D

Results of Chemical Analysis

Eurofins Environment Testing Report No. 1706532

Certificate of Analysis

eurofins | Environment Testing

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: 1706532
Date Submitted: 2017-05-02
Date Reported: 2017-05-09
Project: 1655214.1120
COC #: 817720

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.
					1290760 / Soil / / 2017-04-26 / 17-122 SA1
Agri. - Soil	pH	2.0			8.8
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.63
	Resistivity	1	ohm-cm		1590
	SO4	0.01	%		<0.01
Subcontract	Cl	0.002	%		0.028

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.

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

MASW Test Results and Report

Sites 3-56/1 and 3-56/2 Highway 417 Overpass at Rochester Street

TECHNICAL MEMORANDUM

DATE December 8, 2017 **PROJECT No.** 1655214/1500

TO Susan Trickey
Golder Associates Ltd.

FROM Stephane Sol
Christopher Phillips **EMAIL** ssol@golder.com
cphillips@golder.com

CHBDC SEISMIC SITE CLASS TESTING RESULTS – HWY417 (ROCHESTER ST EXIT) OTTAWA, ONTARIO

This technical memorandum presents the results of one Multichannel Analysis of Surface Waves (MASW) test performed for the purpose of the Canadian Highway Bridge Design Code (CHBDC 2014) Seismic Site Classification for a site located near the HWY417 off ramp to Rochester Street just east of Preston Street in Ottawa, Ontario (Figure 1). The MASW line was located on a grassy area on north of the off ramp. The geophysical testing was performed by Golder personnel on October 18, 2017.

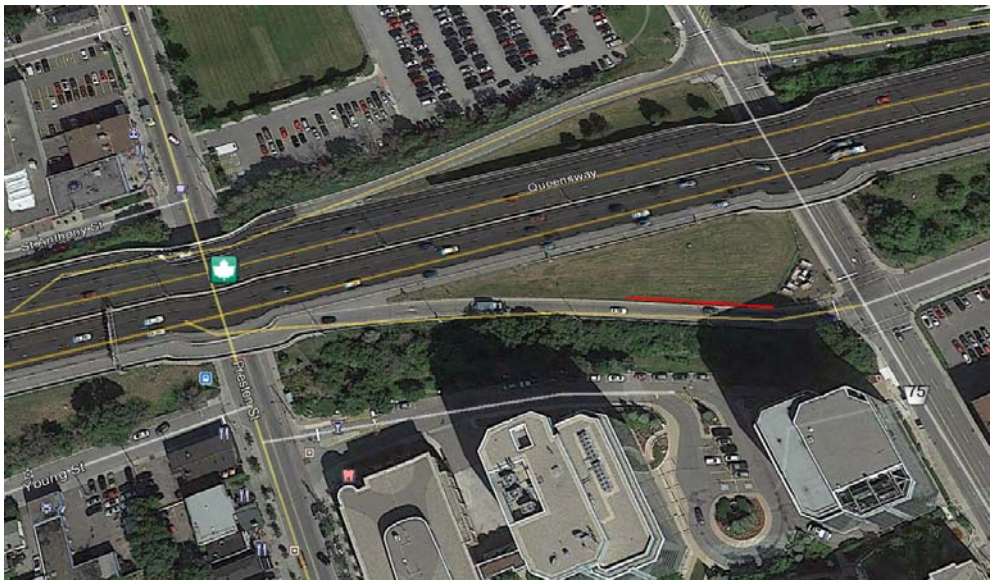


Figure 1: MASW Location Site Map (MASW Line in red)

Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium, surface waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that particular wavelength of surface wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledge hammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors, and water-wave action (in near-shore environments).

The geophone receivers measure the wave-train associated with the surface wave travelling from a seismic source at different distances from the source.

The participation of surface waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the ‘dispersion curve’) is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear-modulus of the medium as a function of depth.

Field Work

The MASW field work was conducted on October 18, 2017, by personnel from the Golder Mississauga and Ottawa offices. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at 2 metre intervals. Both active and passive readings were recorded along the MASW line. For the active investigation, a seismic drop of 34 kg and a 9.9 kg sledge hammer were used as seismic sources. Active seismic records were collected with seismic sources located 5, 10, 15, and 20 metres from and collinear to the geophone array. An example of active seismic records collected is shown in Figure 2 below.

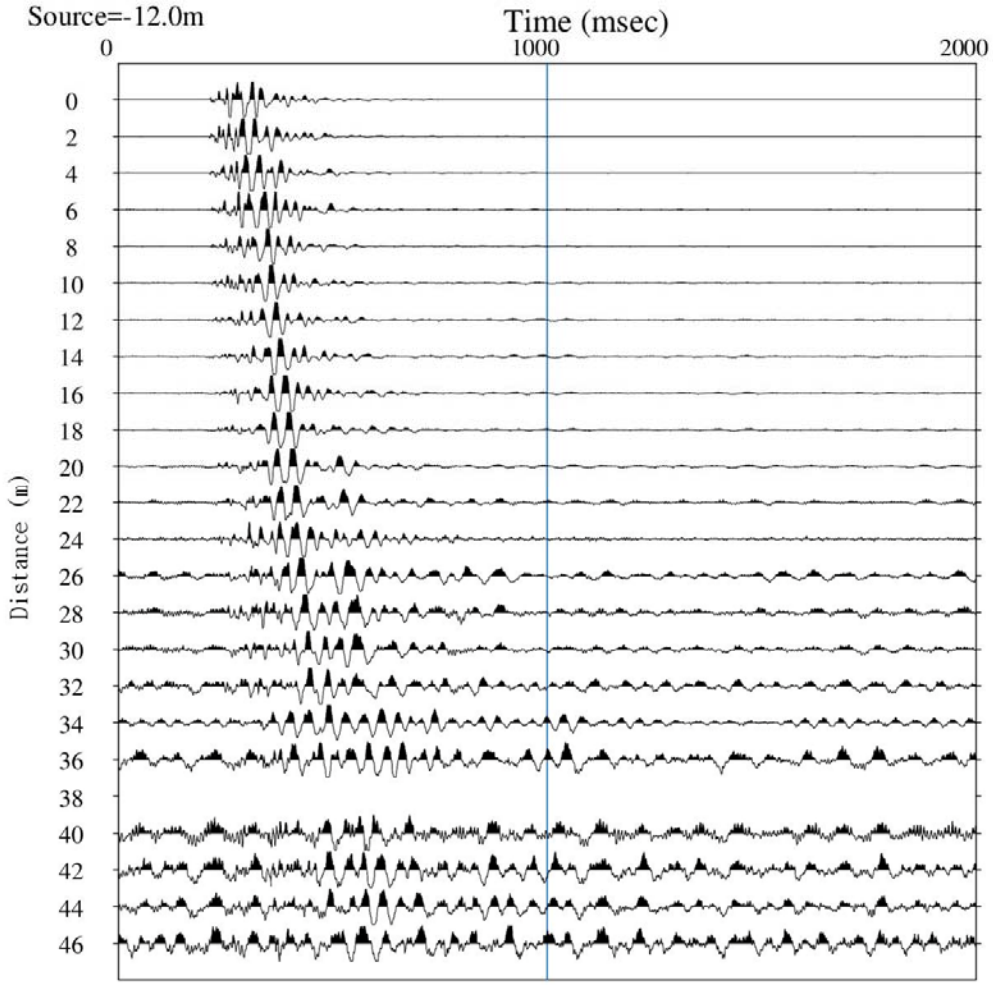


Figure 2: Typical seismic record collected along MASW Line 1

Data Processing

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

1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;

2) Calculation of the phase for each frequency component;

3) Linear regression to calculate phase velocity for each frequency component;

4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient (r2) between the data and the linear regression best fit line used to calculate phase velocity;

5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and,

6) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figure 3 and 4. Shear wave velocity profiles were generated through inverse modelling to best fit the calculated dispersion curves. The active survey provided a dispersion curve with a suitable frequency range (14 -33 Hz). The minimum measured surface wave frequency with sufficient signal-to-noise ratio to accurately measure phase velocity was approximately 14 Hz.

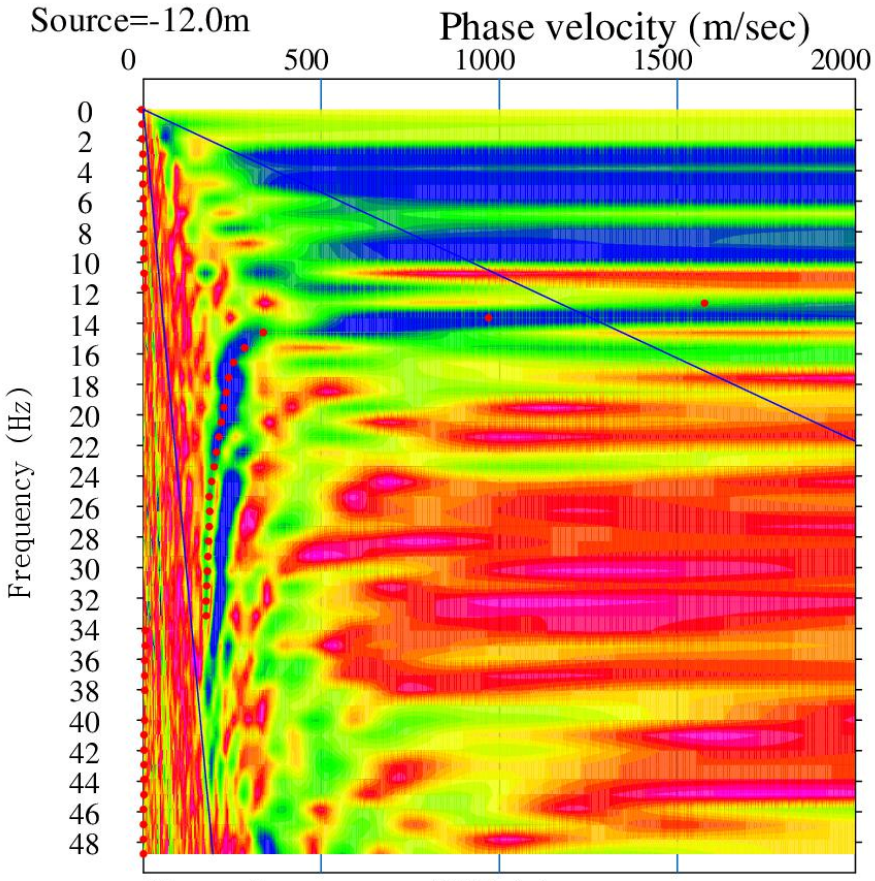


Figure 3: Active MASW Dispersion Curve Picks (red dots) along MASW Line 1

Results

The MASW test results are presented in Figure 4, which presents the calculated shear wave velocity profile derived from the field testing. The results along MASW Line 1 have been calculated using a weight-drop located at 15 m from the last geophone. The field collected dispersion curves are compared with the model generated dispersion curves on Figure 5. There is a satisfactory correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 11%.

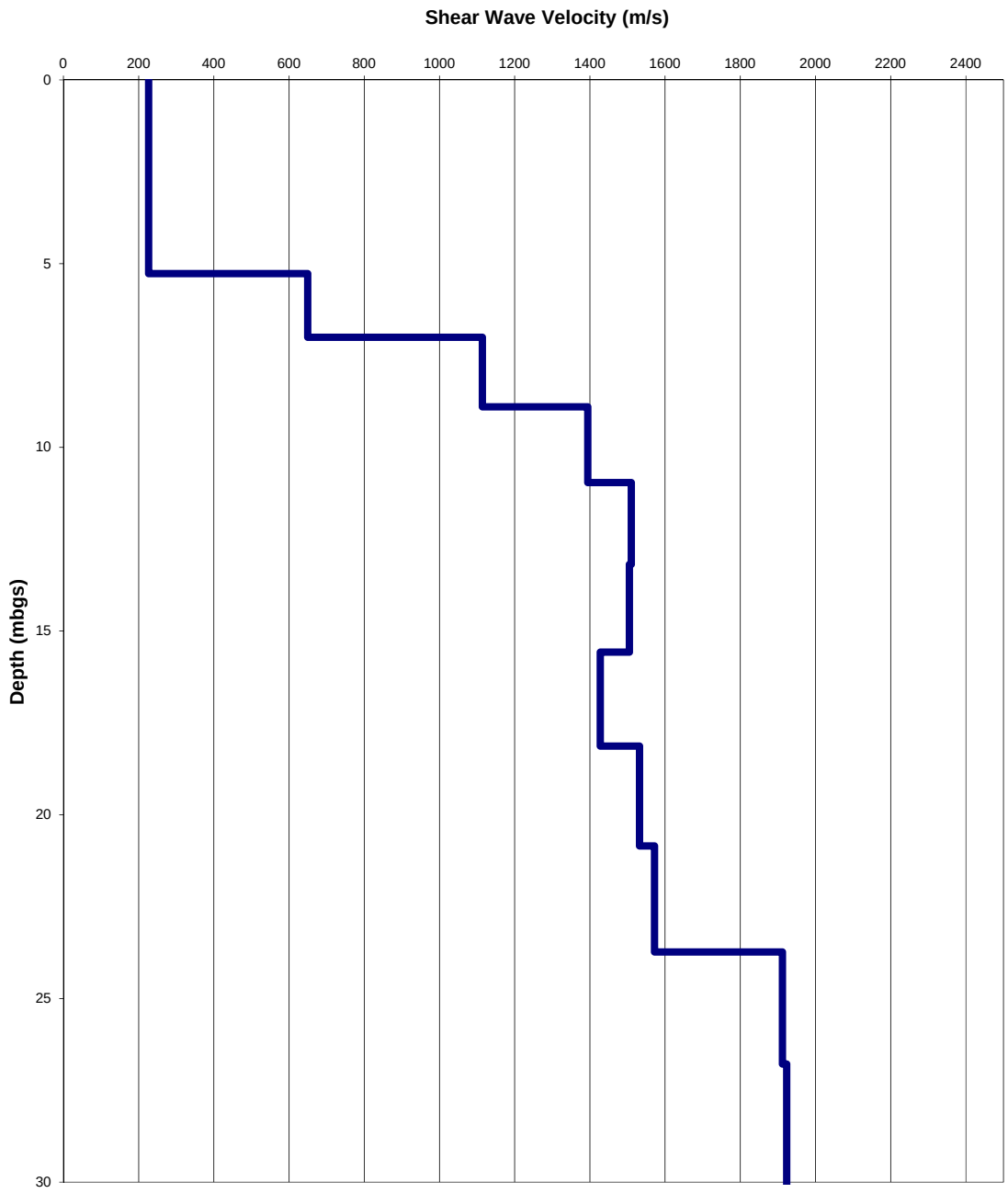


Figure 4: MASW Modelled Shear-Wave Velocity Depth profile along MASW Line 1

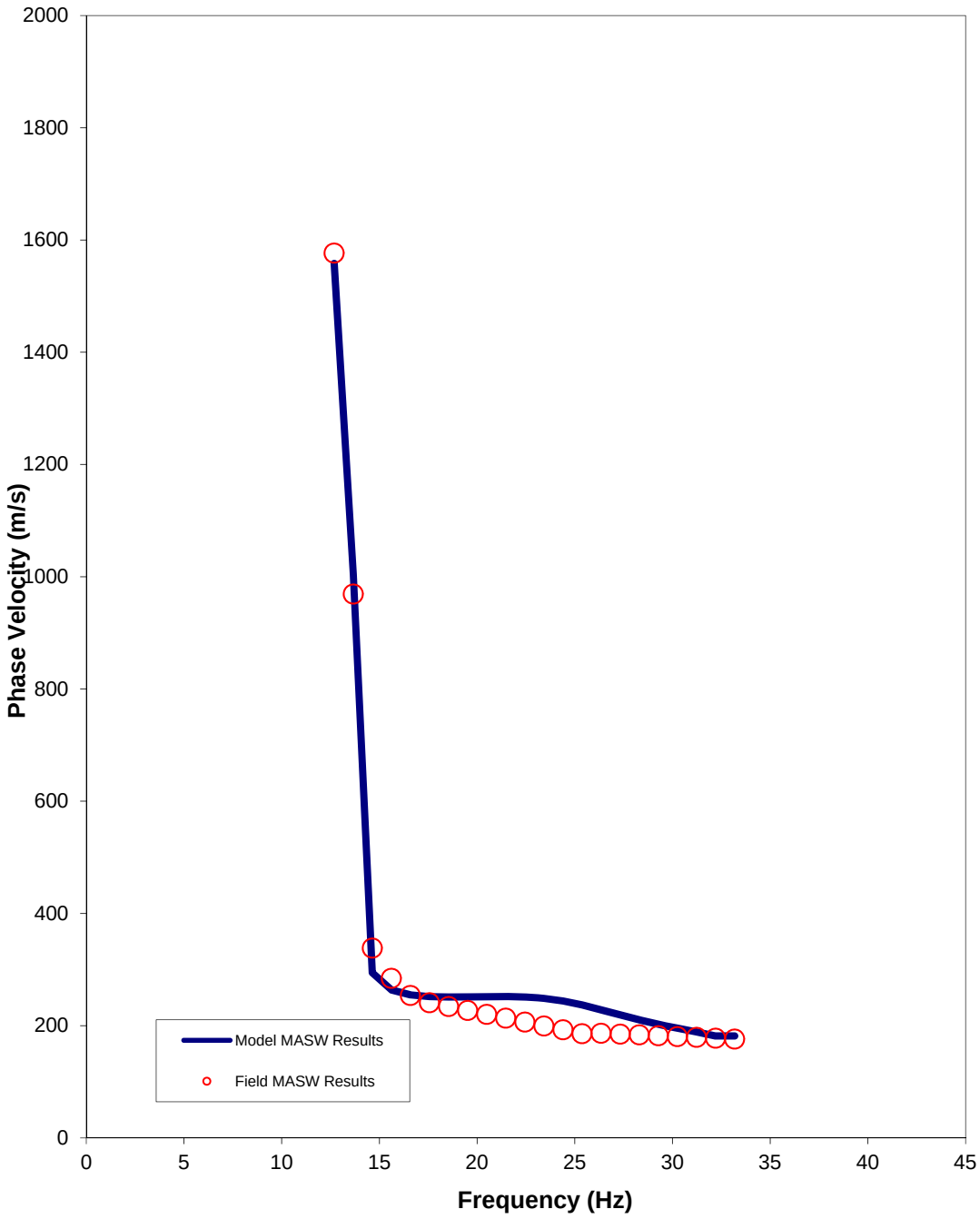


Figure 5: Comparison of Field (red dots) vs. Modelled Data (blue line) along MASW Line 1

To calculate the average shear-wave velocity as required by the Canadian Highway Bridge Design Code (CHBDC, 2014), the results were modelled to 30 metres below ground surface. The average shear-wave velocity along MASW Line 1 was found to be 734 m/s (Table 1).

The Canadian Highway Bridge Design Code (CHBDC, 2014) requires special site-specific evaluation if certain soil types are encountered on the site, so the site classification stated here should be reviewed, and modified if necessary, according to borehole stratigraphy, standard penetration resistance results, and undrained shear strength measurements, if available for this site.

Table 1: Shear-Wave Velocity Profile along MASW Line 1

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	226	0.004732
1.07	2.31	1.24	226	0.005460
2.31	3.71	1.40	226	0.006188
3.71	5.27	1.57	226	0.006916
5.27	7.01	1.73	650	0.002664
7.01	8.90	1.90	1114	0.001701
8.90	10.96	2.06	1395	0.001478
10.96	13.19	2.23	1510	0.001473
13.19	15.58	2.39	1505	0.001588
15.58	18.13	2.55	1428	0.001789
18.13	20.85	2.72	1532	0.001775
20.85	23.74	2.88	1572	0.001835
23.74	26.79	3.05	1912	0.001595
26.79	30.00	3.21	1924	0.001671
Vs Average to 30 mbgs (m/s)				**734**

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.

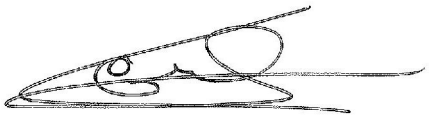
Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on 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 this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.



Stephane Sol, Ph.D, P. Geo.
Senior Geophysicist

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

SS/CRP/mvrd
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APPENDIX F

Site Photographs

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

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

Photograph 3: Looking southeast towards the northeast embankment; 2019-03-13

Photograph 4: Looking southwest towards the northwest embankment; 2019-03-13

Photograph 5: Looking northeast towards the southeast embankment; 2019-03-13

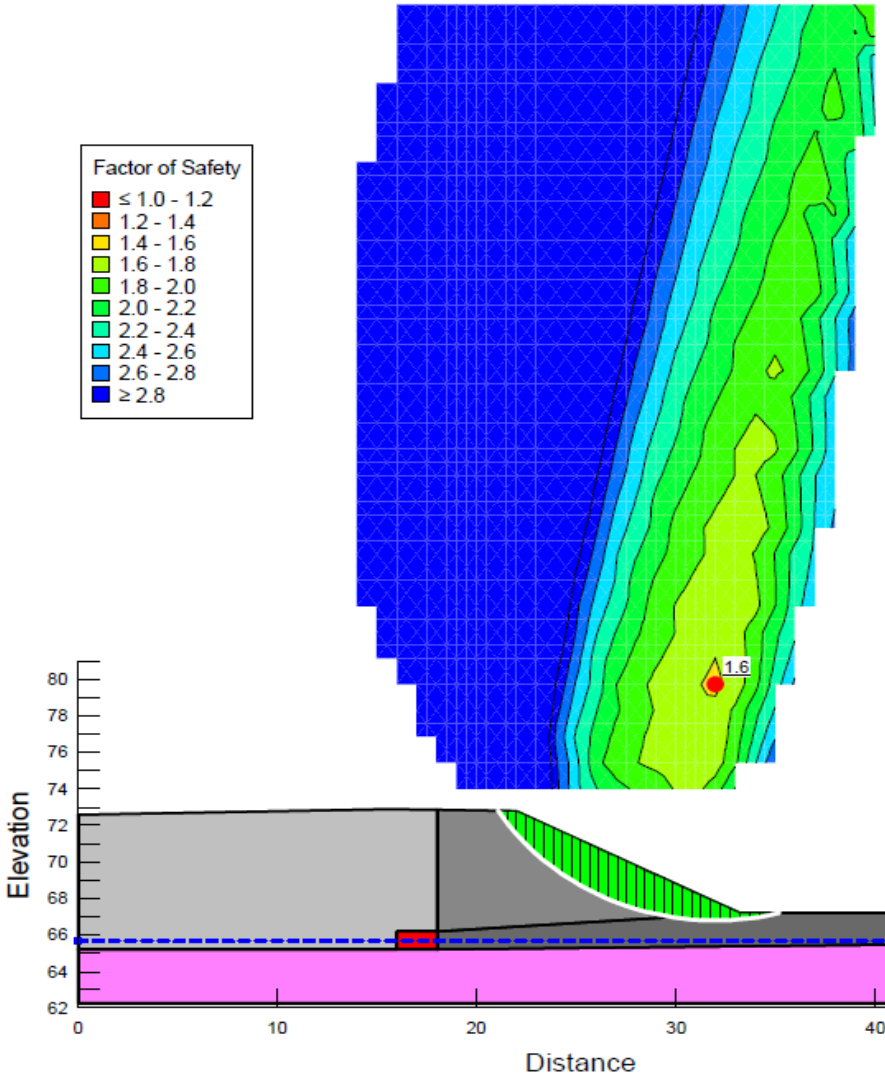
Photograph 6: Looking northwest towards the southwest embankment; 2019-03-13

APPENDIX G

Results of Slope Stability Analysis

Figure G1 – Static Analysis

Figure G2 – Seismic Analysis



File Name: 1655214-1120 Booth Street Overpass Global Failures _ RKJune_2019.gsz
Title: Booth Street Overpass - South Section
Name: 1.1 Static Drained
Method: Morgenstern-Price
Direction of movement: Left to Right
Horz Seismic Load: 0

Groundwater Elevation of 65.7 Metres
Minimum Slip Surface Depth of 2.5 Metres

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Embankment Fill	Mohr-Coulomb	20	0	33
	Existing Grade Fill	Mohr-Coulomb	19	0	30
	Footing	Bedrock (Impenetrable)			
	Widening Embankment Fill	Mohr-Coulomb	20	0	33

GOLDER

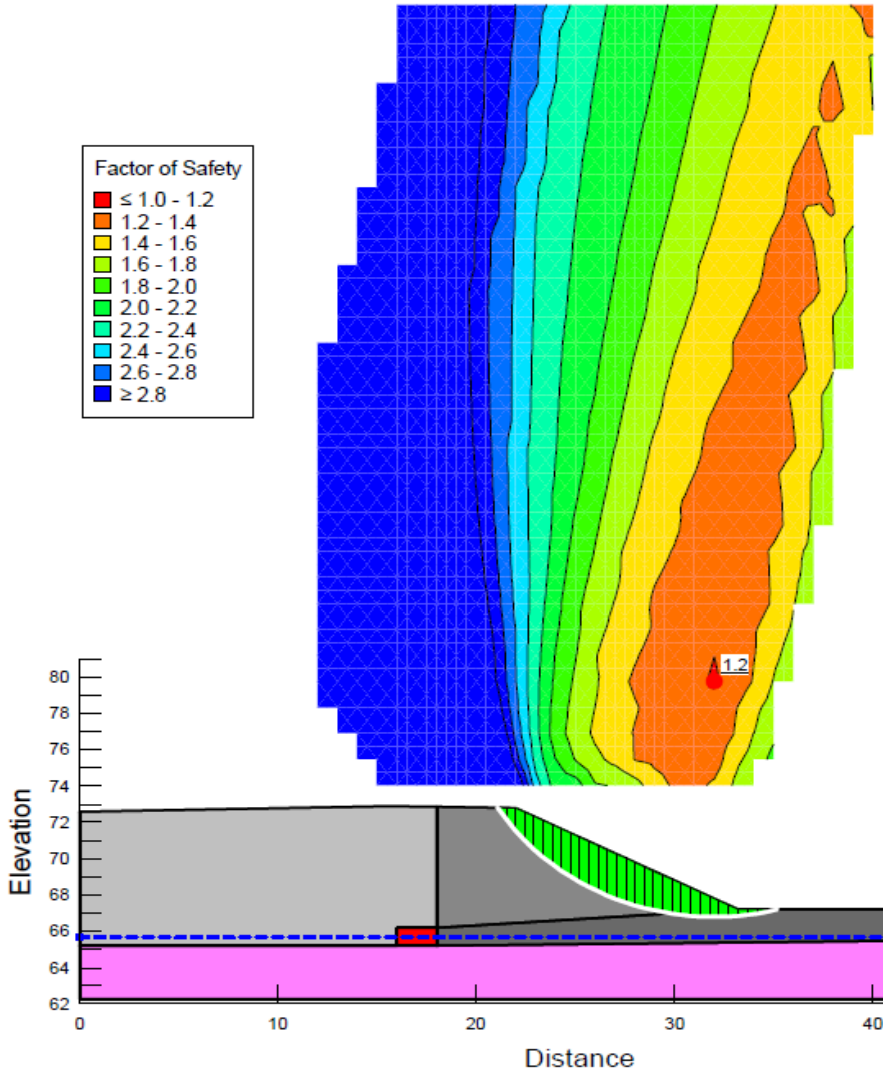
Foundation Investigation

Highway 417 Overpass Structures at Booth Street
Slope Stability - Static Analysis

Ottawa, Ontario

Project No.	1655214-1120
Drawn:	RK
Date:	2019-06-24
Checked:	KP
Review:	

Figure G1



File Name: 1655214-1120 Booth Street Overpass Global Failures _ RKJune_2019.gsz
Title: Booth Street Overpass - South Section
Name: 1.2 Seismic Load
Method: Morgenstern-Price
Direction of movement: Left to Right
Horz Seismic Load: 0.126

Groundwater Elevation of 65.7 Metres
Minimum Slip Surface Depth of 2.5 Metres

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Embankment Fill	Mohr-Coulomb	20	0	33
	Existing Grade Fill	Mohr-Coulomb	19	0	30
	Footing	Bedrock (Impenetrable)			
	Widening Embankment Fill	Mohr-Coulomb	20	0	33

GOLDER

Foundation Investigation

Highway 417 Overpass Structures at Booth Street
Slope Stability - Seismic Analysis

Ottawa, Ontario

Project No.	1655214-1120
Drawn:	RK
Date:	2019-06-24
Checked:	KP
Review:	

Figure G2

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