FINAL REPORT

Foundation Investigation and Design
Highway 417 Overhead Sign Replacements
Ottawa, Ontario

G.W.P. 4173-15-00

Sites: 417-0120.6, 417-0120.0, 417-0119.3, 417-0119.4, 417-0119.5

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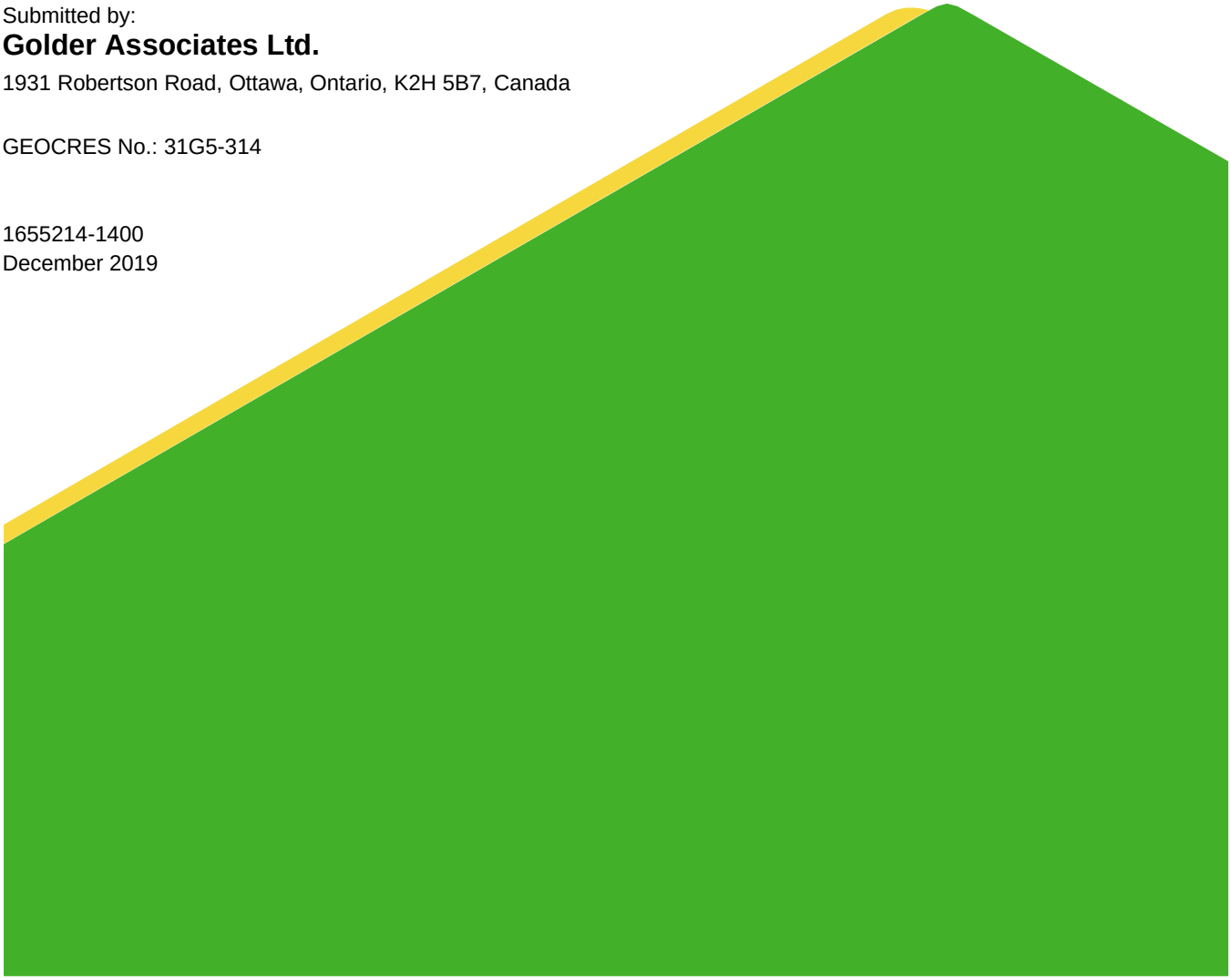

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PART A

Foundation Investigation
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Ottawa, Ontario

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 replacement of existing overhead signs and bridge mounted signs along Highway 417 between the CPR/O-Train overpass to the Kent Street overpass (Sites 417-0120.6, 417-0120.0, 417-0119.3, 417-0119.4 and 417-0119.5). The replacement of the signs is to be carried out in accordance with the current MTO Sign Support Manual, dated February 2019, and in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-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 overhead sign replacement project 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

The overhead signs are located along Highway 417 between the CPR/O-Train overpass and Kent Street in the City of Ottawa. The locations of the overhead sign structures are shown on the Key Plan on Drawings 1 through 5 and are detailed below.

The description and stationing for the proposed overhead signs (OHS) is based on information provided on the revised Sheet 316 of the 60% Contract Drawings provided by WSP on October 18, 2019. A copy of the revised Sheet 316 has been provided after the text of this report.

- Site 417-0120.6, the Bronson Avenue/Rochester Street overhead sign, is located at Station 27+021 in the eastbound lanes just west of Preston Street; see Drawing 1,
- Site 417-0120.0, the Bronson Avenue overhead sign, is located at Station 27+603 in the eastbound lanes about 180 m west of Bronson Avenue; see Drawing 2,
- Site 417-0119.3, the Bronson Avenue overhead sign, is located at Station 28+105 in the westbound lanes just east of Percy Street; see Drawing 3,
- Site 417-0119.4, the Kent Street overhead sign, is located at Station 28+269 in the eastbound lanes about 125 m west of Lyon Street; see Drawing 4, and
- Site 417-0119.5, the Bronson Avenue overhead sign, is located at Station 28+478 in the westbound direction just west of Kent Street; see Drawing 5.

At these locations, Highway 417 is a divided highway with three or four travel lanes in each direction separated by a concrete barrier wall.

2.2 Regional Geology

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

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

Highway 417 crosses two main faults striking southeast to northwest. The more prominent fault, the Gloucester fault, crosses Highway 417 at the approximate location of Preston Street[4]. The second fault crosses Highway 417 at the approximate location of Kent Street. Bedding which is normally sub-horizontal often dips steeply adjacent to and within fault zones.

The sites fall 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

The field work for this investigation was carried out on May 13, 2019 and between June 16 and July 25, 2019. The field investigation included advancing a total of ten boreholes, numbered 19-401 to 19-410, inclusive.

Two boreholes, one at each sign pedestal, were advanced at the proposed location of each overhead sign listed in Section 2. All boreholes were advanced within Highway 417, except for Borehole 19-405 which was advanced to the north of Highway 417 at the base of the highway embankment within the City of Ottawa Yard at 380 Catherine Street.

[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.

The boreholes were advanced using a truck-mounted drill rig supplied and operated by George Downing Estate Drilling of Grenville-sur-la-rouge, Québec.

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

The boreholes were advanced to depths within the overburden ranging from 4.3 to 10.4 m below the existing ground surface. Soil samples in the boreholes were obtained at vertical intervals of about 0.76 m, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedure (ASTM D1586).

Boreholes 19-401 to 19-405 were further extended into the underlying bedrock using rotary diamond drilling techniques while retrieving NQ sized bedrock cores. Within these boreholes, the drilled length into the bedrock ranged from 3.1 to 4.9 m (i.e., total borehole depths ranging from about 7.7 to 13.2 m).

Monitoring wells were installed in Boreholes 19-402, 19-403, 19-405, 19-408 and 19-410 to observe the stabilised groundwater level at the sites. The monitoring wells consisted of 32 mm outside diameter PVC tubing with 1.5 to 3.0 m long screens. Table 3 summarizes the depths and the elevations of the groundwater levels measured in the monitoring wells installed at the sites. After taking the final water level readings the wells were subsequently decommissioned according to Ontario MOE Regulation 903 (O.Reg 903) by a licenced well technician.

The boreholes were backfilled with bentonite within the bedrock and bentonite mixed with soil cuttings within the overburden and capped with asphaltic concrete cold patch. The boreholes were backfilled in general accordance with the intent of Ontario MOE Regulation 903, as amended. The site conditions were restored following completion of the field work.

In addition to the borehole investigations, groundwater sampling was carried out in Borehole 19-405 by WSP for environmental testing. Further details with regards to material handling, reuse and/or disposal are provided in WSP's 2018 Phase II ESA and Earth Management Plan Reports, which are provided under separate cover.

The field work was supervised on a full-time basis by members of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, logged the boreholes 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 moisture content determinations, Atterberg Limits, grain size distribution analyses and organic content testing were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength testing was carried out on five samples of the bedrock core at Golder's Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

A total of six soil samples were 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 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 borehole locations, including northing and easting coordinates, ground surface elevations, and borehole depths are summarized in Table 1.

Table 1: Summary of Borehole Locations

Borehole	Overhead Sign	Site (Highway 417 Direction)	NAD83 CSRS CBNv6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Borehole Depth (m)
			Northing (m)	Easting (m)		
19-401	OHS-1	Site 417-0120.6 (Eastbound)	5029510.2	366538.0	67.3	13.2
19-402			5029495.3	366541.9	67.0	10.8
19-403	OHS-2	Site 417-0120.0 (Eastbound)	5029679.4	367097.4	74.5	10.8
19-404			5029663.3	367103.3	74.6	7.7
19-405	OHS-3	417-0119.3 (Westbound)	5029901.7	367548.3	66.9	10.1
19-406			5029881.3	367556.4	73.6	10.4
19-407	OHS-4	Site 417-0119.4 (Eastbound)	5029955.2	367704.2	72.3	10.1
19-408			5029939.2	367712.7	72.3	10.1
19-409	OHS-5	417-0119.5 (Westbound)	5030080.3	367872.5	72.1	8.2
19-410			5030068.5	367878.7	72.4	9.8

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the current investigation are given on the Record of Borehole 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 B20 in Appendix B. The borehole locations and ground surface elevations at each overhead sign are provided on Drawings 1 to 5.

Photographs of the core recovered from the bedrock are shown on Figures A1 to A10 provided in Appendix A. The results of basic chemical analysis completed on select soil samples are provided in Appendix C.

The stratigraphic boundaries shown on the Record of Borehole sheets 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 Overburden

In general, the subsurface conditions at the borehole locations advanced at the proposed overhead sign locations consist of asphaltic concrete pavement overlying PCC concrete, overlying fill materials, overlying native silt, silty sand to sand and gravel overlying glacial till all underlain by limestone bedrock.

The groundwater level was measured at the sites at depths ranging from 2.8 to 10.0 m, corresponding to Elevations 69.1 to 57.0 m.

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

4.3 Site 417-0120.6: OHS-1

Boreholes 19-401 and 19-402 were advanced at the proposed location of the OHS-1. A detailed description of the subsurface conditions encountered in these boreholes is provided in the following sections.

4.3.1 Pavement

Boreholes 19-401 and 19-402 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete pavement at the borehole locations was 0.3 and 0.2 m respectively.

Portland Cement Concrete (PCC) was encountered below the asphaltic concrete in Borehole 19-402 and is about 0.3 m in thickness.

4.3.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting of gravelly sand to sand was encountered below the pavement and extends to depths of about 0.6 and 0.9 m at Boreholes 19-401 and 19-402, respectively.

Fill consisting predominantly of sand with varying amounts of silt and gravel was encountered below the pavement structure in both boreholes. The top of this layer was encountered at elevations 66.7 and 66.1 m and the layer extends to depths of about 3.1 and 2.1 m, respectively. Standard Penetration Tests (SPT) carried out within the fill material gave SPT N values ranging from 13 to 72, indicating a compact to very dense state of packing. The results of grain size distribution testing carried out on a selected sample of the fill are provided on Figure B1 in Appendix B. The measured moisture content of two samples of the fill were about 8 and 11 percent.

A sandy clayey silt fill was encountered below the sand fill in Boreholes 19-401 and 19-402 at elevations of 64.3 and 64.9 m, respectively. The clayey silt fill contains cobbles and boulders, ash, wood and organic matter. The clayey silt fill extends to depths below the existing ground surface of about 6.1 and 5.3 m. The SPT N values ranged from 2 to 16, indicating a firm to very stiff consistency. The measured moisture content of three samples of the fill ranged from about 20 to 29 percent. Results of grain size distribution testing carried out on three samples of this material are provided on Figure B2 in Appendix B. The results of Atterberg Limits testing carried out on two samples of this material indicates liquid limits of 29 and 30, plastic limits of 13 and 14, and plasticity indices of 16. The Atterberg Limits test results are provided on Figure B3 in Appendix B and indicate a clayey silt (CL) of low plasticity.

Fill consisting of gravel and sand with varying amounts of silt was encountered below the clayey silt fill in Borehole 19-401. This layer was encountered at Elevation 61.2 m and is about 2.2 m in thickness. Cobbles, ash and organic matter were encountered in this layer. The SPT N values ranged from 15 to greater than 50 but more typically 15 to 22, indicating a compact state of packing.

4.3.3 Clayey Silt

Clayey silt was encountered below the fill material in Borehole 19-402. This deposit was encountered at Elevation 61.7 m and is about 1.2 m in thickness. The SPT N values were 4 and 3 indicating a stiff consistency. The measured moisture content of a single sample of the clayey silt was 25 percent. Results of grain size distribution testing carried out a single sample of this material are provided on Figure B4 in Appendix B. The results of Atterberg Limits testing completed on a single sample of this material indicates a liquid limit of 34, a plastic limit of 16, and a plasticity index of 18. The Atterberg Limits test results are illustrated on Figure B5 in Appendix B and indicate a clayey silt of low plasticity (CL).

4.3.4 Gravel and Sand

Gravel and sand was encountered beneath the clayey silt in Borehole 19-402. The top of this deposit was encountered at Elevation 60.5 m with a thickness of about 1.2 m. One SPT N value of 52 was recorded, indicating a very dense condition.

The moisture content of one sample tested was 9 percent. The results of grain size analysis tests carried out on a single sample of this material are provided on Figure B6 in Appendix B.

4.4 Site 417-0120.0: OHS-2

Boreholes 19-403 and 19-404 were advanced at the proposed location of the OHS-2. A detailed description of the subsurface conditions encountered in these boreholes is provided in the following sections.

4.4.1 Pavement

Boreholes 19-403 and 19-404 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete pavement at the borehole locations ranges was 0.3 and 0.2 m.

Portland Cement Concrete (PCC) was encountered below the asphaltic concrete pavement in Borehole 19-404 and is about 0.3 m in thickness.

4.4.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting of gravelly sand was encountered below pavement that extends to depths of about 0.7 m and 0.5 m in Boreholes 19-403 and 19-404, respectively.

Fill consisting predominantly of sand with varying amounts of silt was encountered below the pavement structure fill in both borehole locations. The sand fill extends to depths of about 3.8 and 2.1 m below the existing ground surface (at about Elevations 70.7 and 72.5 m), respectively. The SPT N values ranged from 3 to 54, but more typically 14 to 36, indicating a compact to dense state of packing. The measured moisture content of two samples of the fill were about 4 and 5 percent. The results of grain size distribution testing carried out on two selected samples of the sand fill are provided on Figure B7 in Appendix B.

Gravel and sand fill with varying amounts of silt was encountered below the sand fill in both boreholes that extends to depths below the existing ground surface of about 6.3 and 4.3 m (Elevations about 68.3 m and 70.3 m) respectively. Debris including brick, concrete, glass, wood and organic matter was encountered gravel and sand fill in Borehole 19-404 and organic matter was encountered in Borehole 19-403. The SPT N values ranged from 8 to greater than 50, indicating a loose to very dense state of packing. The moisture content of one sample of this material was measured at 9 percent. The results of grain size analysis tests carried out on a single sample of the sand and gravel fill are provided on Figure B8 in Appendix B.

4.4.3 Sand

Sand was encountered below the fill materials in Borehole 19-403. This deposit was encountered at Elevation 68.3 m and is about 0.6 m in thickness. One SPT N value of 45 was recorded, indicating a dense state of packing.

4.5 Site 417-0119.3: OHS-3

Boreholes 19-405 and 19-406 were advanced at the proposed location of OHS-3. Borehole 19-405 was advanced to the north of Highway 417 at the base of the highway embankment within the City of Ottawa Yard at 380 Catherine Street, while Borehole 19-406 was advanced through the Highway 417 pavement structure.

In addition to the borehole investigations groundwater sampling was carried out in Borehole 19-405 by WSP for environmental testing. Further details with regards to material handling, reuse and/or disposal are provided in WSP's 2018 Phase II ESA and Earth Management Plan Reports, which are provided under separate cover.

A detailed description of the subsurface conditions encountered in these boreholes is provided in the following sections.

4.5.1 Pavement

Asphaltic concrete pavement was encountered at the ground surface at both borehole locations. The thickness of the asphaltic concrete pavement at Borehole 19-405 was 0.1 m (City Yard) and 0.3 m at Borehole 19-406 (Highway 417).

4.5.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting predominantly of gravel and sand was encountered below the asphaltic concrete pavement in both boreholes. The thickness of the pavement structure fill was 0.3 and 0.4 in Boreholes 19-405 and 19-406 respectively.

Embankment fill consisting of sand with varying amounts of silt and gravel, was encountered below the pavement structure fill in Borehole 19-406. This layer was encountered at Elevation 72.9 m and is about 7.7 m in thickness. The SPT N values ranged from 1 to 52, but were more typically 7 to 35, indicating a loose to dense state of packing. The measured moisture content of the samples tested ranged from 4 to 12 percent. The results of grain size analysis testing carried out on three samples of this material are provided on Figure B9 in Appendix B.

Sand fill was encountered below the pavement structure fill in Borehole 19-405. This layer was encountered at Elevation 66.5 m and is about 2.5 m in thickness. The SPT N values ranged from 6 to 36, but were more typically 6 to 7, indicating a loose state of packing.

4.5.3 Buried Topsoil

Buried topsoil was encountered below the embankment fill in Borehole 19-406. This layer was encountered at Elevation 65.2 m and is about 0.3 m in thickness.

4.5.4 Organic Silt and Sand

Organic silt was encountered below the fill materials in Borehole 19-405. This layer was encountered at Elevation 64.0 m and is about 0.6 m in thickness. The SPT N value was 4 indicating a loose state of packing. The measured moisture content of the sample tested was 47 percent. The results of organic content testing on a single sample indicated an organic content of 4%.

4.5.5 Sand and Gravel

Sand and gravel was encountered below the organic silt and sand in Borehole 19-405. This deposit was encountered at Elevation 63.4 m and is about 0.6 m in thickness.

4.5.6 Silt

Silt was encountered below the sand and gravel in Borehole 19-405. This deposit was encountered at Elevation 62.8 m and is about 2.0 m in thickness. The SPT N values were 16 and 17, indicating a compact state of packing. The measured moisture content of one sample tested was 20 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B10 in Appendix B.

4.5.7 Silty Sand

Silty sand was encountered below the buried topsoil in Borehole 19-406. This deposit was encountered at Elevation 64.9 m and is about 1.4 m in thickness. An SPT N value of 4 indicates a loose state of packing. The measured moisture content of one sample tested was 34 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B11 in Appendix B.

4.5.8 Glacial Till

Glacial till was encountered below the silt in Borehole 19-405 and the silty sand in Borehole 19-406 The glacial till generally consists of a heterogeneous mixture of cobbles within a soil matrix of silt, sand and gravel. The till is classified as sand and gravel to sandy silt with some gravel and clay. The thickness of the till layer at these locations was 0.9 and 0.3 m in Boreholes 19-405 and 19-406, respectively.

One SPT N value in the till of 7 indicates a loose state of packing. The moisture content of the two samples of till tested were 10 and 13 percent. The results of grain size analysis tests carried out on two samples of this material are provided on Figure B12 in Appendix B.

4.6 Site 417-0119.4: OHS-4

Boreholes 19-407 and 19-408 were advanced at the proposed location of OHS-4. A detailed description of the subsurface conditions encountered in these boreholes is provided in the following sections.

4.6.1 Pavement

Boreholes 19-407 and 19-408 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete pavement at the borehole locations was 0.3 and 0.1 m.

PCC was encountered below the asphaltic concrete pavement in Borehole 19-408 and is about 0.3 m in thickness.

4.6.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting of sand and gravel with varying amounts of silt was encountered below the pavement and extends to depths of about 0.8 and 0.9 m. The measured moisture content of the sample tested was 2 percent. The results of grain size distribution testing carried out on a single sample of the pavement structure fill are provided on Figure B13 in Appendix B.

Sand fill with varying amounts of silt and gravel was encountered below the pavement structure fill in both boreholes locations. The thickness of the sand fill layer ranges from 6.7 to 7.5 m in Boreholes 19-407 and 19-408 respectively. The SPT N values in the sand fill layer ranged from 2 to 57, but were more typically 10 to 34, indicating a compact to dense state of packing. The measured moisture content of three samples of the sand fill ranged from about 5 to 7 percent. The results of grain size distribution testing carried out on three samples of the fill are provided on Figure B14 in Appendix B.

Silty clay fill was encountered below the sand fill in Borehole 19-407. This layer was encountered at Elevation 64.8 m and is about 0.7 m in thickness. The SPT N value was 7, indicating a stiff consistency.

4.6.3 Sandy Silt

Sandy silt was encountered below the fill material in Borehole 19-407. The top of this deposit was encountered at elevation 64.1 m and the deposit is about 0.8 m in thickness. One SPT N of 40 indicates a dense state of packing.

The moisture content of one sample tested was 19 percent. The results of a grain size analysis test carried out on a single sample of this material are provided on Figure B15 in Appendix B.

4.6.4 Glacial Till

A non-cohesive glacial till deposit consisting of a heterogeneous mixture of silt and sand with varying amounts of gravel, cobbles and boulders was encountered beneath the sandy silt in Borehole 19-407 and below the fill materials in Borehole 19-408. This deposit was encountered at elevations of 63.3 and 63.9 m respectively. The till was not fully penetrated but was proven to extend to depths of 10.1 m below pavement surface.

The SPT N values ranged from 13 to 88, indicating a compact to very dense state of packing. The higher blow counts (i.e., greater than 50) noted on the Record of Boreholes in the till 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 moisture content of the two samples tested were 8 and 24 percent. The results of grain size analysis tests carried out on two samples of the till are provided on Figure B16 in Appendix B.

4.7 Site 417-0119.5: OHS-5

Boreholes 19-409 and 19-410 were advanced at the proposed location of OHS-5. A detailed description of the subsurface conditions encountered in these boreholes is provided in the following sections.

4.7.1 Pavement

Boreholes 19-409 and 19-410 were advanced through the Highway 417 pavement structure. The thickness of the asphaltic concrete pavement at both borehole locations was 0.3 m.

4.7.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting of sand and gravel with varying amounts of silt was encountered below the pavement at both borehole locations extending to depths of about 2.0 and 2.1 m. The SPT N values ranged from 51 to 88, indicating a very dense state of packing. The measured moisture content of one sample of the pavement structure fill was 4 percent. The results of grain size distribution testing carried out on a single sample of this material are provided on Figure B17 in Appendix B.

Sand fill with varying amounts silt and gravel was encountered below the pavement structure fill at both borehole locations. This layer was encountered at Elevations 70.1 and 70.3 m and is about 3.2 m in thickness in Boreholes 19-409 and 19-410, respectively. The SPT N values ranged from 9 to 44, indicating a loose to dense state of packing. The measured moisture content of two samples of the fill was 7 percent. The results of grain size distribution testing carried out on two samples of the sand fill are provided on Figure B18 in Appendix B.

4.7.3 Silt and Sand

Silt and sand was encountered below the fill in both boreholes. The top of this deposit was encountered at Elevations 66.9 and 67.1 m and the thickness of the deposit is 0.7 and 1.1 m in Boreholes 19-409 and 19-410, respectively. The SPT N values were 12 and 28, indicating a compact state of packing.

The moisture content of the two samples tested were 22 and 23 percent. The results of grain size analysis tests carried out on two samples of the silt and sand are provided on Figure B19 in Appendix B.

4.7.4 Clay

Clay, grey in colour, was encountered below the silt and sand layer in both boreholes at Elevations 66.2 and 66.0 m respectively. The layer was not fully penetrated but was proven to extend to depths of about 8.2 and 9.8 m below the ground surface. The SPT N values in the clay layer ranged from 1 to 8. The results of in-situ vane testing in the clay layer gave undrained shear strength values ranging from about 42 to 85 kilopascals, indicating a firm to stiff consistency. Based on the ratio of the measured in-situ natural shear strength to the remolded shear strength ranging from 6 to 7, the clay is classified as sensitive.

The results of grain size distribution testing carried out on three samples of the clay are provided on Figure B20 in Appendix B. The results of Atterberg Limits testing completed on three samples of this material indicated indicates liquid limits ranging from 66 to 88, plastic limits ranging from 22 to 27, and plasticity indexes ranging from 43 and to 66. Atterberg Limits analysis results are illustrated on Figure B21 in Appendix B and indicate a clay (CH) of high plasticity. The moisture content of the samples tested ranged from 58 to 71 percent and is generally below the liquid limit.

4.8 Bedrock

The overburden materials are underlain by limestone bedrock with shale partings and interbeds.

Bedrock core samples were obtained in Boreholes 19-401 to 19-405 using NQ sized equipment. Photographs of the bedrock core are provided on Figures A1 to A10 in Appendix A.

Table 2 summarizes the depth to and the elevation of the bedrock surface as encountered at the borehole locations from the current investigation.

Table 2: Summary of Bedrock Surface Depths and Elevations

Borehole	Overhead Sign	Ground Surface Elevation (m)	Depth to the Bedrock Surface (m)	Bedrock Surface Elevation (m)
19-401	OHS-1	67.3	8.3	59.0
19-402		67.0	7.7	59.3
19-403	OHS-2	74.5	6.9	67.6
19-404		74.6	4.3	70.3
19-405	OHS-3	66.9	7.0	59.9

In general, the bedrock encountered was slightly weathered to fresh and thin to medium bedded. A thin layer of weathered bedrock was encountered within Borehole 19-403. Thin shale interbeds were also present in the bedrock cores. Rock Quality Designation (RQD) values measured on recovered bedrock core samples typically ranged from about 8 to 100 percent, but more generally ranged from about 65 to 100 percent indicating fair to excellent rock quality.

Results of unconfined compressive strength (UCS) testing carried out on five bedrock core samples are summarized on Figure B22 in Appendix B. The samples tested had UCS values ranging from 65 to 81 MPa, indicating a strong bedrock.

4.9 Groundwater Conditions

Monitoring wells were installed in Boreholes 19-402, 19-403, 19-405, 19-408 and 19-410 (one at each OHS location) to observe the stabilized groundwater level at the sites.

Table 3 summarizes the depths and the elevations of the groundwater levels measured in the monitoring wells installed at the site.

Table 3: Summary of Groundwater Conditions

Borehole	Overhead Sign	Screened Interval	Depth (m)	Elevation (m)	Date of Reading
19-402	OHS-1	Bedrock	10.0	57.0	July 31, 2019
19-403	OHS-2	Bedrock	5.4	69.1	August 20, 2019
19-405	OHS-3	Fill/ Sand and Gravel/Silt	2.8	64.1	June 19, 2019
19-408	OHS-4	Glacial Till	6.4	65.9	July 23, 2019
19-410	OHS-5	Clay	Monitoring well dry at the bottom of well at Elevation 63.0 m		August 19, 2019

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

4.10 Steel Corrosion and Sulphate Attack, Chemical Analysis

Six soil samples were submitted to Eurofins Environment Testing for chemical analysis related to the 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 C and are summarized in Table 4.

Table 4: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample	Sample Depth (m)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
19-401	SS5	3.8 – 4.4	Fill	0.114	0.02	0.35	8.3	2,860
19-404	SS3	1.5 – 2.1	Fill	0.037	0.02	0.18	9.2	5,560
19-405	SS8	5.3 – 5.9	Silt	0.032	< 0.01	0.56	8.3	1,790
19-406	SS6	2.3 – 2.9	Fill	0.058	< 0.01	0.15	8.5	6,670
19-407	SS3	1.5 – 2.1	Till	0.022	0.01	0.18	9.1	5,560
19-410	SS5	3.8 – 4.4	Fill	0.038	< 0.01	0.17	8.5	5,880

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 of Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

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PART B

Foundation Design Report
Highway 417 Overhead Sign Replacements
Sites: 417-0120.6, 417-0120.0, 417-0119.3, 417-0119.4 and 417-0119.5
Ottawa, Ontario

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical parameters and recommendations for the design of the proposed overhead sign (OHS) foundations. The input provided herein is based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation, and in accordance with the current MTO Sign Support Manual, dated February 2019, 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

In general, the subsurface conditions at the borehole locations advanced at the proposed overhead sign locations consist of asphaltic concrete pavement overlying PCC concrete, overlying fill materials, overlying native silt, silty sand to sand and gravel overlying glacial till all in turn underlain by limestone bedrock.

Limestone bedrock was encountered and cored in Boreholes 19-401 to 19-405. The groundwater level was measured at the site at depths ranging from 2.8 to 10.0 m, corresponding to Elevations 64.1 to 57.0 m.

The locations of the proposed OHS signs, overburden thickness, cored length of bedrock and the borehole depth at each overhead sign location are summarized Table 5.

Table 5: OHS Locations, Summary of Soil and Bedrock Stratigraphy

Site (Designation)	Highway 417 Stationing Direction	Borehole	Overburden Thickness (m)	Bedrock Encountered (Cored Length - m)	Total Borehole Depth (m)
Site 417-0120.6 (OHS-1)	27+021 Eastbound	19-401	8.3	Yes (4.9)	13.2
		19-402	7.7	Yes (3.1)	10.8
417-0120.0 (OHS-2)	27+603 Eastbound	19-403	6.9	Yes (3.6)	10.8
		19-404	4.3	Yes (3.4)	7.7
417-0119.3 (OHS-3)	28+105 Westbound	19-405	7.0	Yes (3.1)	10.1
		19-406	10.4	No	10.4
417-0119.4 (OHS-4)	28+269 Eastbound	19-407	10.1	No	10.1
		19-408	10.1	No	10.1
417-0119.5 (OHS-5)	28+478 Westbound	19-409	8.2	No	8.2
		19-410	9.8	No	9.8

6.3 Proposed Construction

Based on information provided in 60% Contract Drawing Sheet number 316 and information detailed in the MTO Sign Support Manual, the new overhead signs will consist of either a Tri-Chord Type I or II structure. A copy of Sheet 316 has been provided after the text of this report.

6.4 Design of Sign Support Foundations

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*), the design frost penetration depth at these sites is 1.8 m below the existing ground surface.

Caisson foundations for sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual* (February 2019). The *Sign Support Manual* includes standard caisson foundation designs for both Type I or II structures as follows:

- **Trichord Overhead Signs:** Section 4: Tri-Chord Static Sign Supports, and Standard Drawings SS118-3, SS118-4 and SS118-5, SS118-26 and SS118-28.

In the standard caisson foundation design, as outlined in the tables on the Standard Drawings, and depending on the type and class of the sign, the caisson is extended 5 m to 6.4 m below the design frost penetration depth of 1.8 m resulting in a total caisson length of 6.8 m to 8.2 m below the final grade. It is understood that all five signs are being designed as Type I structures. The standard sign foundation designs presented in MTO's Sign Support Manual have been developed based on the minimum soil conditions given in Section 4.5.4 *Foundations* of the Sign Support Manual and are summarized below.

- **Case 1 (Non-Cohesive Soils):** Sand with a friction angle of 28° surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30° surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials looser or softer than those of Case 1 or Case 2 are present. The standard foundation design is also not applicable where rock fill or bedrock is encountered within the standard foundation depth. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the subsurface conditions at the proposed sign locations have been compared to the standard design requirements and it has been assessed that eight out of the ten foundations elements can be designed based on the Standard Foundation Design Drawings as outlined in the Sign Support Manual. Table 6 outlines foundation design approach required at each site.

Table 6: Summary of Foundation Design Approach

Borehole	Overhead Sign	Foundation Design Approach
19-401	OHS-1	Standard
19-402		
19-403	OHS-2	Standard
19-404		Site-Specific Bedrock Foundation
19-405	OHS-3	Site-Specific Founded on Existing Retaining Wall
19-406		Standard
19-407	OHS-4	Standard
19-408		
19-409	OHS-5	Standard
19-410		

6.4.1 Site-Specific Caisson Foundation Design in Soil

A site-specific caisson foundation design may be carried out by the structural engineer to optimize the standard foundation design. In the design of the sign foundations, the passive resistance within the upper 1.8 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this unfactored lateral resistance to obtain the factored ultimate lateral geotechnical resistance.

Table 7, following the text of this report, summarizes geotechnical parameters for the soils and bedrock encountered at the borehole locations that can be used for site-specific design. The parameters presented in Table 7 are based on field and laboratory test data as well as accepted correlations (NAVFAC 1986, Bowles, 1984 and Kulhawy and Mayne, 1990) and the analysis was tempered by engineering judgment based on experience in similar soils.

Based on site observations, the OHS foundations will be constructed in areas of relatively flat ground; however, in the event that the OHS foundations are located on the highway embankment slope or within about 2 diameters of the crest of the slope in the direction of loading, there would be unbalanced earth pressures around the foundation due to it being located within sloping ground (assumed 2H:1V embankment). For this case, the passive earth pressure coefficient ($K_{p2:1}$), in accordance with Figure C6.18 of the CHDBC and its Commentary to be used in the foundation design is also included in Table 7.

The resistance to lateral loading of caissons may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction (k_h in kPa/m) is determined based on the equations given below:

For cohesionless soils:

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

where n_h is the constant of horizontal subgrade reaction (kPa/m);
z is the depth (m); and
B is the caisson diameter (m)

For cohesive soils:

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

where S_u is the undrained shear strength of the soil (kPa); and
B is the caisson diameter (m)

Table 7 outlines the range for the values of n_h and S_u that may be used in the preliminary structural analysis for the site. The ranges in values reflect the variability in the subsurface conditions, the soil properties and the approximate nature of the analysis and the non-linear nature of the soil behaviour (such that k_h is a function of deflection).

The spring constant, *K*, for structural analysis may be obtained by the expression:

$$K = k_h \times L \times B \text{ (kN/m)},$$

Where k_h = coefficient of horizontal subgrade reaction (kPa/m);
B = buried caisson diameter, (m); and
L = length of the caisson segment used in the analysis (m).

Construction Sheet 316 indicates that that the caisson foundations for the OHS will be in close proximity to the caisson foundations for the proposed noise walls for this project with an edge to edge separation of approximately 0.3 m, in essence acting as a caisson group. For caissons arranged in closely spaced groups, the caisson-soil-caisson interaction causes the individual caisson in a group to be less effective than a single caisson in lateral resistance.

It is understood that the design location of the noise wall caissons can be adjusted so that caissons of the two structures do not align. Therefore, in order to reduce the possibility of group effects the noise wall foundations should be located so that the OHS foundations are located in the middle of a noise wall panel, maximizing the lateral separation between the foundations.

These “group effects” can be incorporated into the design using a method that modifies the single caisson lateral resistance using a reduction factor. The use of the reduction factor is highly dependent on the direction of loading. There are two limiting cases that may be considered: loading along the centerline of both caissons (i.e., the loading acts on both caissons along a line drawn through their centres) and loading perpendicular to a line drawn through the centres of both caissons.

Where the caissons are loaded along a line through the caisson centres, the reduction factor should be estimated based on Figures C6.11.3(s) and C6.11.3(t), provided in Section C6.11.3.4 of CHBDC, for the leading and trailing caisson, respectively.

For loading perpendicular to a line drawn through the caisson centres, the reduction factor should be estimated based on Figure C6.11.3(r) provided in Section C6.11.3.4 of CHBDC for side by side caissons.

Pile spacing to diameter ratio for use with the code figures above should be calculated based on the diameter of the largest pile.

6.4.2 Caisson Foundations Embedded or Socketed into Bedrock

In accordance with MTO's *Sign Support Manual*, and with MTO approval, where bedrock is encountered at a depth, Y, less than the minimum of 5 m below the bottom of the frost penetration depth, a reduced caisson length, $L_{caisson}$, may be calculated as follows:

$$L_{caisson} = Y + [(L - Y) / 2]$$

Where $L_{caisson}$ = length of caisson below frost penetration depth (m),
Y = the overburden thickness below the depth of frost penetration (m); and
L = required length of caisson below frost depth where bedrock is not present (m).
(See Standard Drawings SS118-3, SS118-4 and SS118-5 Design Information Tables)

Based on the results of the foundation investigation, bedrock coring will be required to meet the minimum caisson length below the frost penetration depth for the foundation element at OHS-2 at the location of Borehole 19-404. At this location a shorter caisson length may be designed as per the above formula. However, if MTO does not approve this approach, then the bedrock socket should be extended to meet the minimum required length.

From a geotechnical perspective, the rock sockets could have a diameter less than the "standard" caisson diameter of 1,200 mm; in this case, the actual rock socket diameter should be determined based on site-specific design by the structural engineers, using the passive lateral resistance (f_{horiz}, in kPa) for the rock mass as provided in Table 7.

6.5 Construction Considerations

6.5.1 Groundwater and Surface Water Control

The water-bearing cohesionless soils at this site should be expected to run or flow into the caisson hole during or after drilling of the caisson foundations for the OHS supports. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement, such as by using temporary or permanent caisson liners, and/or using drilling mud. Foundations for the OHS supports should be constructed consistent with OPSS.PROV 915 (*Sign Support Structures*) and OPSS 903 (*Construction Specification for Deep Foundations*), respectively. Suggested wording for a Non-Standard Special Provision (NSSP) to alert the Contractor of this condition has been provided in Appendix D.

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

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

6.5.2 Obstructions in Overburden

Increased difficulty with the installation of caissons at the location of some of the OHS should be anticipated due to the presence of cobbles and boulders within the fill materials and till materials and the relatively shallow depth to the bedrock surface. Recommended wording for an NSSP alerting the Contractor to this condition and the requirement to use appropriate equipment and installation techniques is provided in Appendix D.

6.5.3 Cement Type and Steel Corrosion Potential

Six soil samples were submitted to Eurofins Environment Testing for chemical analysis related to the 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 C and are summarized in Table 4

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 4 of this report, 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 results provided in Table 4 indicate a moderate to 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. 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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Table 7: Geotechnical Design Parameters for Overhead Sign Foundations–Site No. 417-0120.6, 417-0120.0, 417-0119.3, 417-0119.4 and 417-0119.5

Site (Overhead Sign)	Highway 417 Stationing Direction[1]	Borehole	Foundation Design Approach	Bottom of Caisson Elevation[6] (m)	Deposit Description	Approximate Deposit Elevation[2] (m)	Soil Design Parameters[3,4]								Design Groundwater Elevation (m)	Auger Refusal Elevation (m)
							S_u (kPa)	ϕ_e (°)	K_p[5]	$K_{p,2:1}$[5]	n_h (kPa/m)	f_{horz} (kPa)	γ (kN/m^3)	γ_e (kN/m^3)		
417-0120.6 (OHS-1)	27+021 Eastbound	19-401	Standard	60.5	FILL - Sand	65.5 to 64.3	-	28	2.8	1.1	2,000 to 4,000	-	19	-	57.0	59.0
					FILL – Sandy clayey silt	64.3 to 61.2	60	-	-	-	-	-	18	-		
					FILL - Gravel and sand	61.2 to 59.0	-	32	3.3	1.3	6,000 to 8,000	-	20	-		
					Limestone Bedrock	< 59.0	-	-	-	-	-	2,000	-	-		
		19-402		60.2	FILL - Gravel and sand	65.2 to 64.9	-	32	3.3	1.3	6,000 to 8,000	-	19	-		59.3
					FILL – Sandy clayey silt	64.9 to 61.7	60	-	-	-	-	-	18	-		
					Clayey silt	61.7 to 60.5	60	-	-	-	-	-	18	-		
					Gravel and sand	60.5 to 59.3	-	32	3.3	1.3	8,000 to 10,000	-	20	-		
					Limestone Bedrock	< 59.3	-	-	-	-	-	2,000	-	-		
417-0120.0 (OHS-2)	27+603 Eastbound	19-403	Standard	67.7	FILL – Sand	72.7 to 70.7	-	32	3.3	1.3	6,000 to 8,000	-	19	-	69.0	67.6
					FILL - Gravel and sand	70.7 to 69.0	-	32	3.3	1.3	4,000 to 6,000	-	20	-		
					FILL – Gravel and sand	69.0 to 68.3	-	30	2.8	1.1	3,000 to 4,000	-	19	9.2		
					Sand	68.3 to 67.6	-	32	3.3	1.3	4,000 to 6,000	-	20	10.2		
					Limestone Bedrock	< 67.6	-	-	-	-	-	2,000	-	-		
		19-404	Site-Specific Bedrock foundation	69.1	FILL – Sand	72.8 to 72.5	-	28	2.8	1.1	2,000 to 4,000	-	19	-		70.3
					FILL – Gravelly sand	72.5 to 70.3	-	32	3.3	1.3	6,000 to 8,000	-	20	-		
					Limestone Bedrock	< 70.3	-	-	-	-	-	2,000	-	-		
417-0119.3 (OHS-3)	28+105 Westbound	19-405	Site-Specific Founded on Retaining Wall	N/A	FILL – Sand	65.1 to 64.0	-	28	2.8	1.1	2,000 to 4,000	-	19	-	64.0	59.9
					Organic Silt	64.0 to 63.4	-	26	2.6	1.0	1,000 to 2,000	-	18	8.2		
					Sand and gravel	63.4 to 62.8	-	30	3.0	1.2	3,000 to 4,000	-	19	9.2		
					Silt	62.8 to 60.8	-	28	2.8	1.1	1,000 to 2,000	-	19	9.2		
					TILL – Sandy silt	60.8 to 59.9	-	34	3.5	1.4	4,000 to 6,000	-	21	11.2		
					Limestone Bedrock	< 59.9	-	-	-	-	-	2,000	-	-		
		19-406	Standard	66.8	FILL – Sand	71.8 to 69.0	-	28	2.8	1.1	2,000 to 4,000	-	19	-	64.0	59.9
					FILL – Sand	69.0 to 65.2	-	32	3.3	1.3	6,000 to 8,000	-	19	-		
					Silty Clay	65.2 to 64.9	80	-	-	-	-	-	18	-		
					Silty Sand	64.9 to 63.5	-	30	3.0	1.2	3,000 to 4,000	-	19	9.2		
					TILL – sand and gravel	63.5 to 59.9	-	34	3.5	1.4	6,000 to 8,000	-	21	11.2		
					Limestone Bedrock	< 59.9	-	-	-	-	-	2,000	-	-		

Table 7: Geotechnical Design Parameters for Overhead Sign Foundations–Site No. 417-0120.6, 417-0120.0, 417-0119.3, 417-0119.4 and 417-0119.5 ctd.

Site (Overhead Sign)[1]	Highway 417 Stationing Direction[1]	Borehole	Foundation Design Approach	Bottom of Caisson Elevation[6] (m)	Deposit Description	Approximate Deposit Elevation[2] (m)	Soil Design Parameters[3,4]								Design Groundwater Elevation (m)	Auger Refusal Elevation (m)
							S_u (kPa)	ϕ' (°)	K_p[5]	$K_{p,2:1}$[5]	n_h (kPa/m)	f_{horz} (kPa)	γ (kN/m^3)	γ_E (kN/m^3)		
417-0119.4 (OHS-4)	28+269 Eastbound	19-407	Standard	65.5	FILL – Sand	70.5 to 67.9	-	32	3.3	1.3	6,000 to 8,000	-	19	-	65.0	NA
					FILL – Sand to silty sand	67.9 to 64.8	-	30	3.0	1.2	4,000 to 6,000	-	19	9.2		
					Fill – Silty clay	64.8 to 64.1	60	-	-	-	-	-	18	8.2		
					Sandy silt or TILL – Sand and silt	64.1 to 62.2	-	34	3.5	1.4	6,000 to 8,000	-	21	11.2		
		19-408		65.5	FILL – Sand	70.5 to 65.4	-	32	3.3	1.3	6,000 to 8,000	-	19	-		
					FILL – Sand and silt	65.4 to 63.9	-	30	3.0	1.2	1,000 to 2,000	-	19	9.2		
					TILL – Sand and silt	63.9 to 62.2	-	34	3.5	1.4	6,000 to 8,000	-	21	11.2		
417-0119.5 (OHS-5)	28+478 Westbound	19-409	Standard	65.3	FILL - Gravelly sand to sand	70.6 to 66.9	-	32	2.8	1.3	6,000 to 8,000	-	20	-	65.0	NA
		19-410		65.6	Silt and sand	66.9 to 66.2	-	30	3.0	1.2	4,000 to 6,000	-	20	-		
					Clay	66.2 to 62.7	60	-	-	-	-	-	17	7.2		

NOTES:

*Deposit thickness for design to be considered ½ of the fill thickness presented.

1. Approximate stationing and overhead sign support numbering as per the revised Sheet 316 from the 60% Contract Package provided by WSP on October 18, 2019.
2. Approximate deposit elevations are provided starting from the frost depth elevation (1.8 m below the existing ground surface elevations at the proposed sign support location).
3. Design parameters:
   - s_u = undrained shear strength (kPa)
   - ϕ' = effective (drained) friction angle (degrees)
   - K_p = passive earth pressure coefficient
   - $K_{p,2:1}$ = passive earth pressure coefficient for 2 H:1V sloping ground surface
   - n_h = constant of horizontal subgrade reaction (kPa/m)
   - γ = bulk unit weight (kN/m^3)
   - γ' = effective unit weight (below the groundwater level) (kN/m^3)
4. The resistance in the upper 1.8 m below ground surface should be neglected to account for frost action.
5. The passive earth pressure coefficients provided assume a vertical foundation element, zero interface friction between the soil and the foundation element, and a horizontal backslope.
6. Bottom of caisson elevations provided by WSP on October 25, 2019.

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ASTM International:

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

Ontario Provisional Standard Drawing:

- OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specification:

- OPSS 903 Construction Specification for Deep Foundations
- OPSS 915 Construction Specification for Sign Support Structures

Ontario Water Resources Act:

- Ontario Regulation 903 Wells

Ministry of Transportation, Ontario

- Ministry of Transportation Ontario. Sign Support Manual. Provincial Highways Management Division, Highway Standards Branch, Bridge Office. February 2019.

METRIC

PLATE No

CONT No

WP No 4173-15-00

OVERHEAD SIGN SECTIONS

SHEET 316

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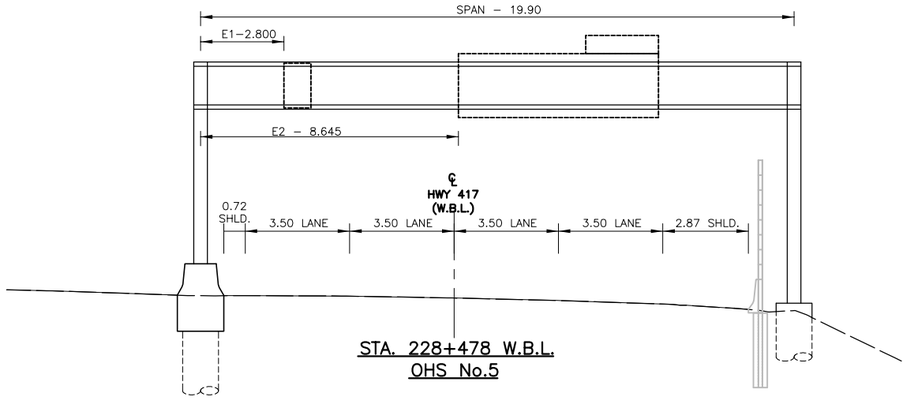

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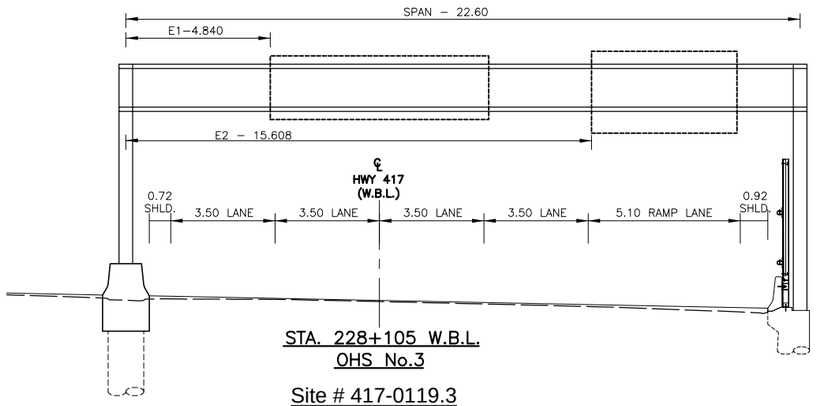
Site # 417-0119.5



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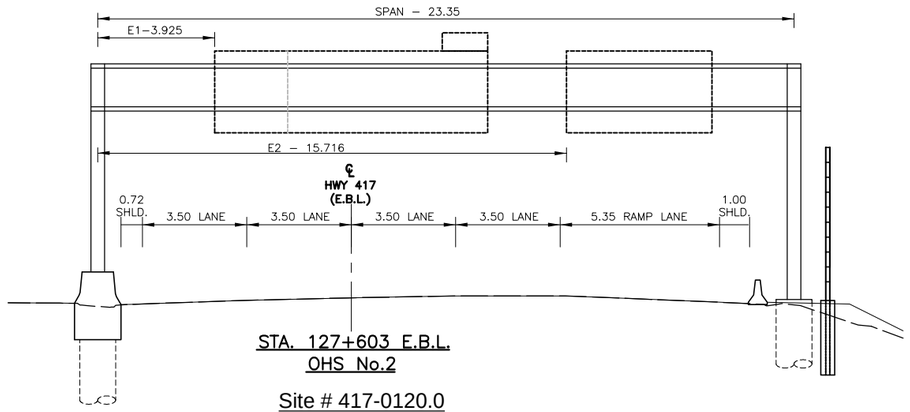

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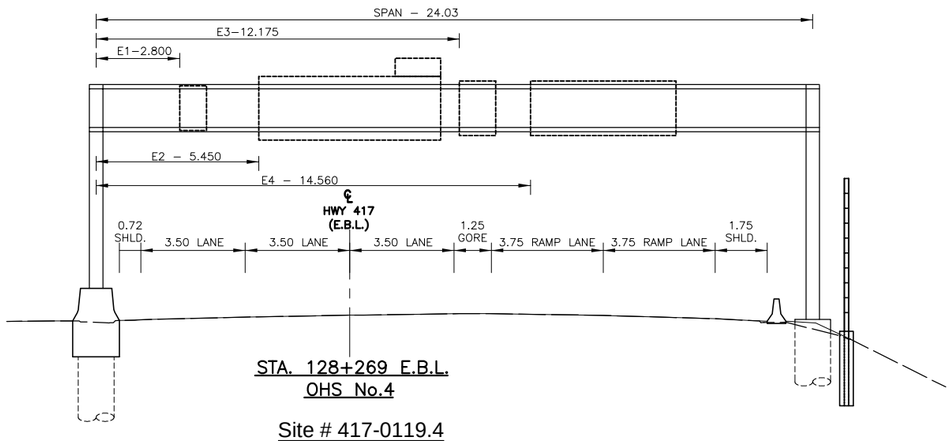

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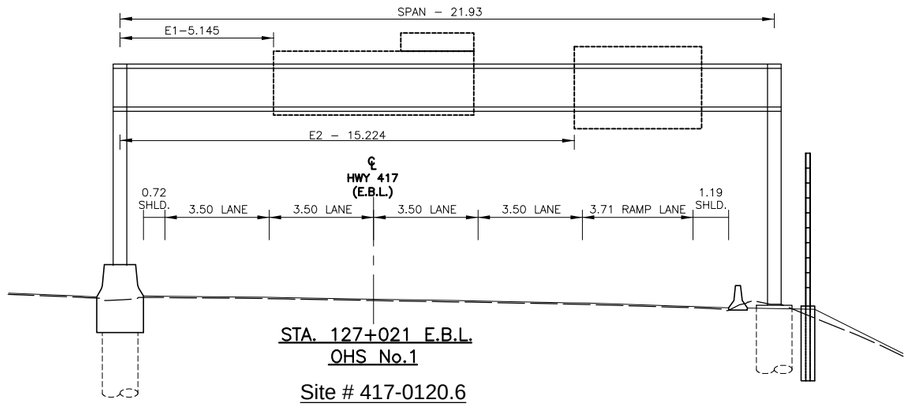

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Site # 417-0120.6

MINISTRY OF TRANSPORTATION, ONTARIO PR-S-707 88-05

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MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No.
GWP No. 4173-15-00

SHEET

HIGHWAY 417
BRONSON AVE./ROCHESTER ST.
OVERHEAD SIGN - SITE No. 417-0120.6
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.402816 LONG. -75.711366

GOLDER

PLAN
SCALE
10 0 10 20 m

KEY PLAN
SCALE
500 0 500 1000 m

BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
19-401	67.3	5029510.2	366538.0
19-402	67.0	5029495.3	366541.9
19-403	74.5	5029679.4	367097.4
19-404	74.6	5029663.3	367103.3
19-405	66.9	5029901.7	367548.3
19-406	73.6	5029881.3	367556.4
19-407	72.3	5029955.2	367704.2
19-408	72.3	5029939.2	367712.7
19-409	72.1	5030080.3	367872.5
19-410	72.4	5030068.5	367878.7

LICENSED PROFESSIONAL ENGINEER K.T.C. POWER 100130652 2019/12/04 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL GEOSCIENTIST F. J. HEFFERNAN PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
0			

Georcres No. 31G5-314

HWY. 417	PROJECT NO. 1655214-1400	DIST. EASTERN
SUBM'D. SS	CHKD. KCP	DATE: 12/11/2019	SITE: 417-0120.6
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

REFERENCE
Base plans provided in digital format by WSP Canada Group Limited, drawing file no. MIDTOWN-XB1.dwg, received OCT. 25, 2017.

PLOT DATE: December 11, 2019

MINISTRY OF TRANSPORTATION, ONTARIO

PLAN

SCALE 10 0 10 20 m

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

CONT No.
GWP No. 4173-15-00

SHEET

HIGHWAY 417
BRONSON AVE. OVERHEAD SIGN
SITE NO. 417-0120.0
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.404289 LONG. -75.704201

GOLDER

KEY PLAN
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19-402	67.0	5029495.3	366541.9
19-403	74.5	5029679.4	367097.4
19-404	74.6	5029663.3	367103.3
19-405	66.9	5029901.7	367548.3
19-406	73.6	5029881.3	367556.4
19-407	72.3	5029955.2	367704.2
19-408	72.3	5029939.2	367712.7
19-409	72.1	5030080.3	367872.5
19-410	72.4	5030068.5	367878.7

LICENSED PROFESSIONAL ENGINEER K.T.C. POWER 100130652 2019/12/09 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER F. J. HEFFERNAN DEC 9, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
0			

Geocres No. 31G5-314

HWY. 417		PROJECT NO. 1655214-1400	DIST. EASTERN
SUBM'D. SS	CHKD. KCP	DATE: 12/11/2019	SITE: 417-0120.0
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 2

REFERENCE
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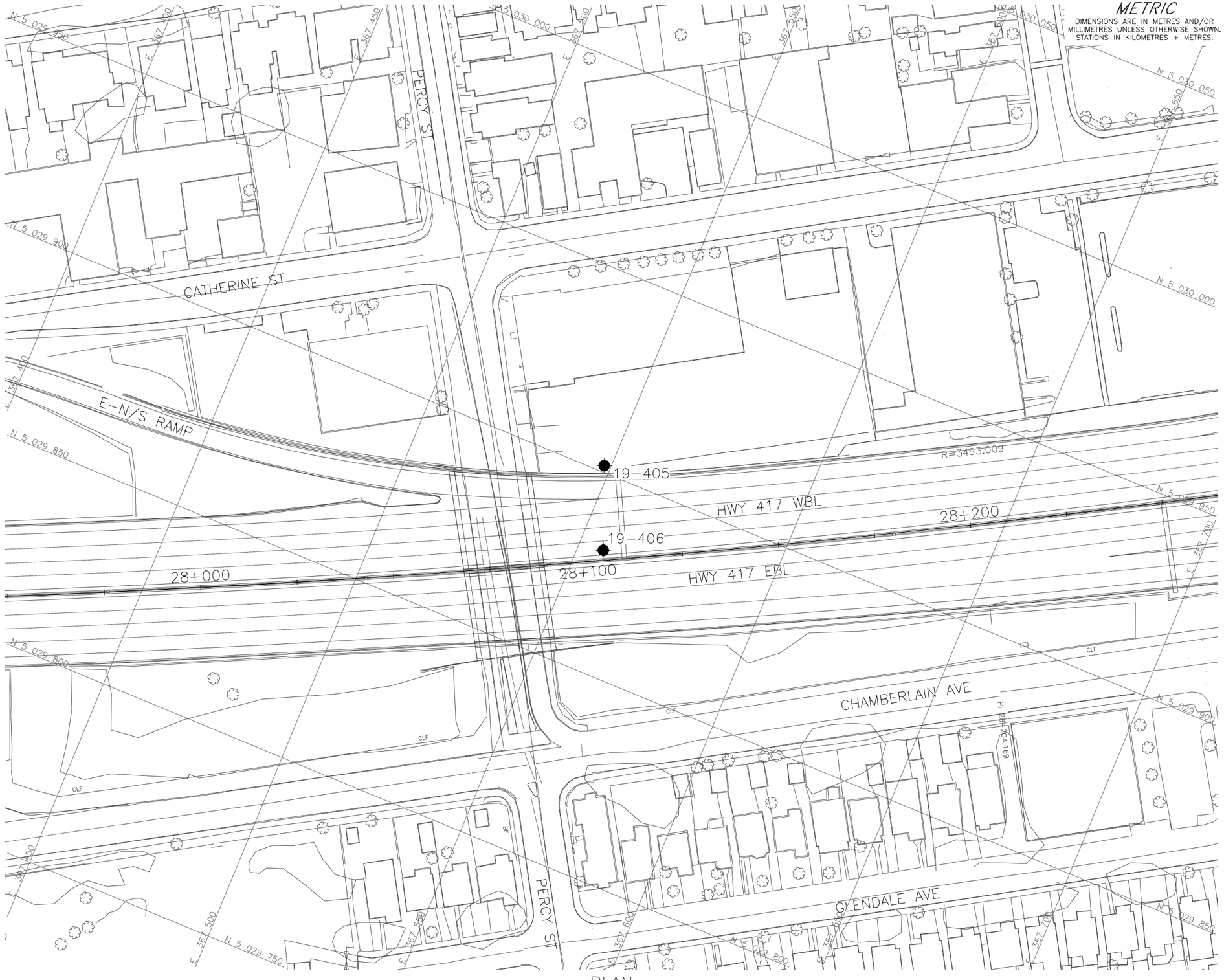
MINISTRY OF TRANSPORTATION, ONTARIO



METRIC

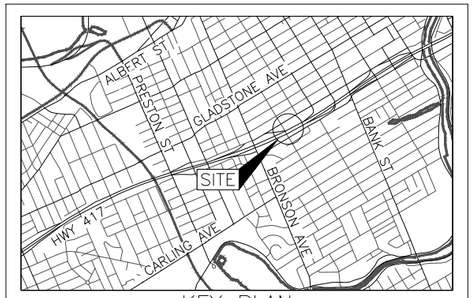
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173-15-00

HIGHWAY 417
BRONSON AVE. OVERHEAD SIGN
SITE NO. 417-0119.3
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.406249 LONG. -75.698413

SHEET

GOLDER



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BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9			
No.	ELEVATION	NORTHING	EASTING
19-401	67.3	5029510.2	366538.0
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19-407	72.3	5029955.2	367704.2
19-408	72.3	5029939.2	367712.7
19-409	72.1	5030080.3	367872.5
19-410	72.4	5030068.5	367878.7

PLAN
SCALE
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REFERENCE

Base plans provided in digital format by WSP Canada Group Limited, drawing file no. MIDTOWN-XB1.dwg, received OCT. 25, 2017.

NO.	DATE	BY	REVISION
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Geocres No. 31G5-314

HWY. 417	PROJECT NO. 1655214		DIST. EASTERN
SUBM'D. SS	CHKD. KCP	DATE: 12/11/2019	SITE: 417-0119.3
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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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

CONT No.
GWP No. 4173-15-00

SHEET

HIGHWAY 417
KENT ST. OVERHEAD SIGN
SITE NO. 417-0119.4
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.406716 LONG. -75.696414

GOLDER

KEY PLAN
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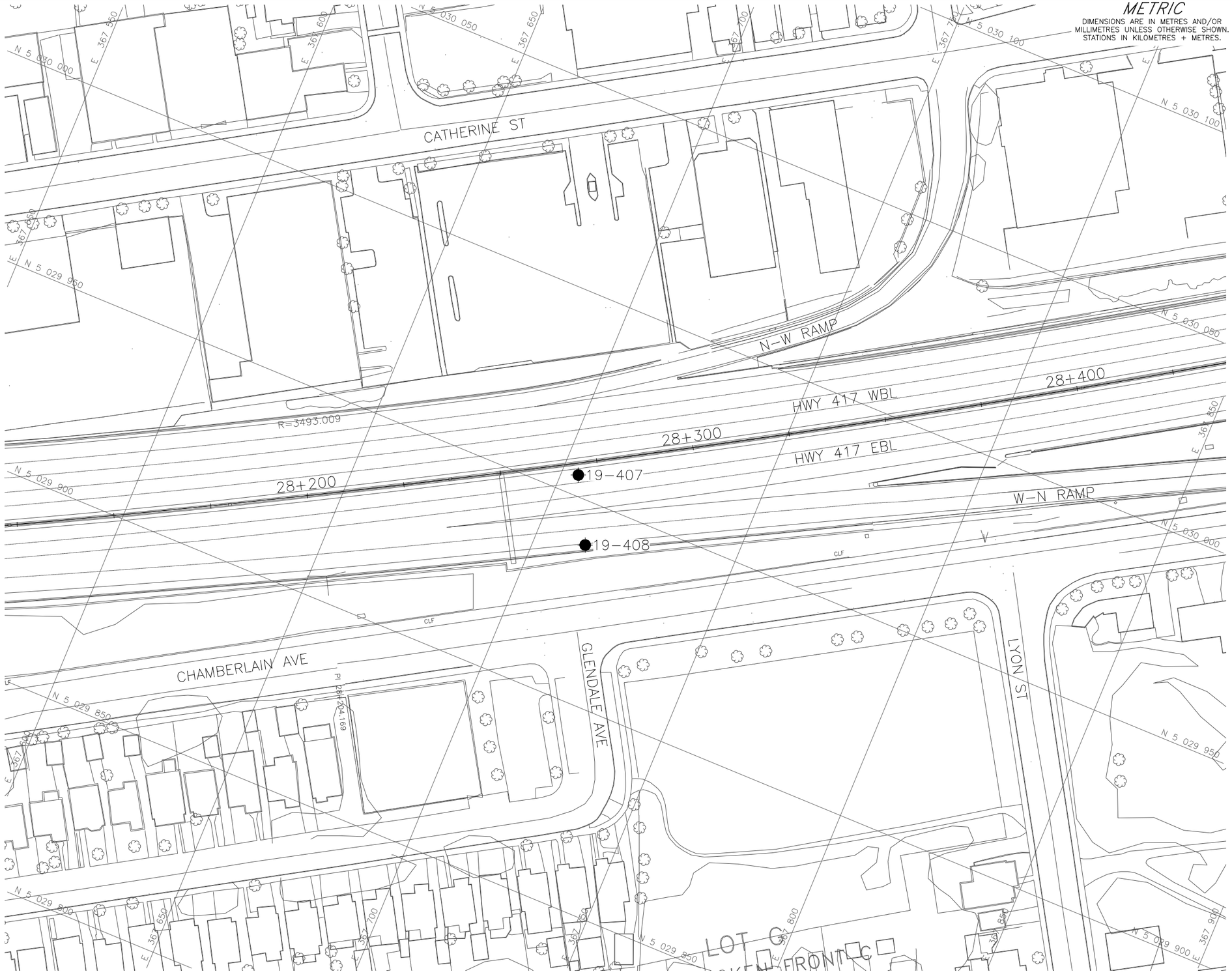

PLAN
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BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9

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19-406	73.6	5029881.3	367556.4
19-407	72.3	5029955.2	367704.2
19-408	72.3	5029939.2	367712.7
19-409	72.1	5030080.3	367872.5
19-410	72.4	5030068.5	367878.7

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DEC 5, 2019
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PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
0	.	.	.

Geocres No. 31G5-314

HWY. 417		PROJECT NO. 1655214	DIST. EASTERN
SUBM'D. SS	CHKD. KCP	DATE: 12/11/2019	SITE: 417-0119.4
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MINISTRY OF TRANSPORTATION, ONTARIO

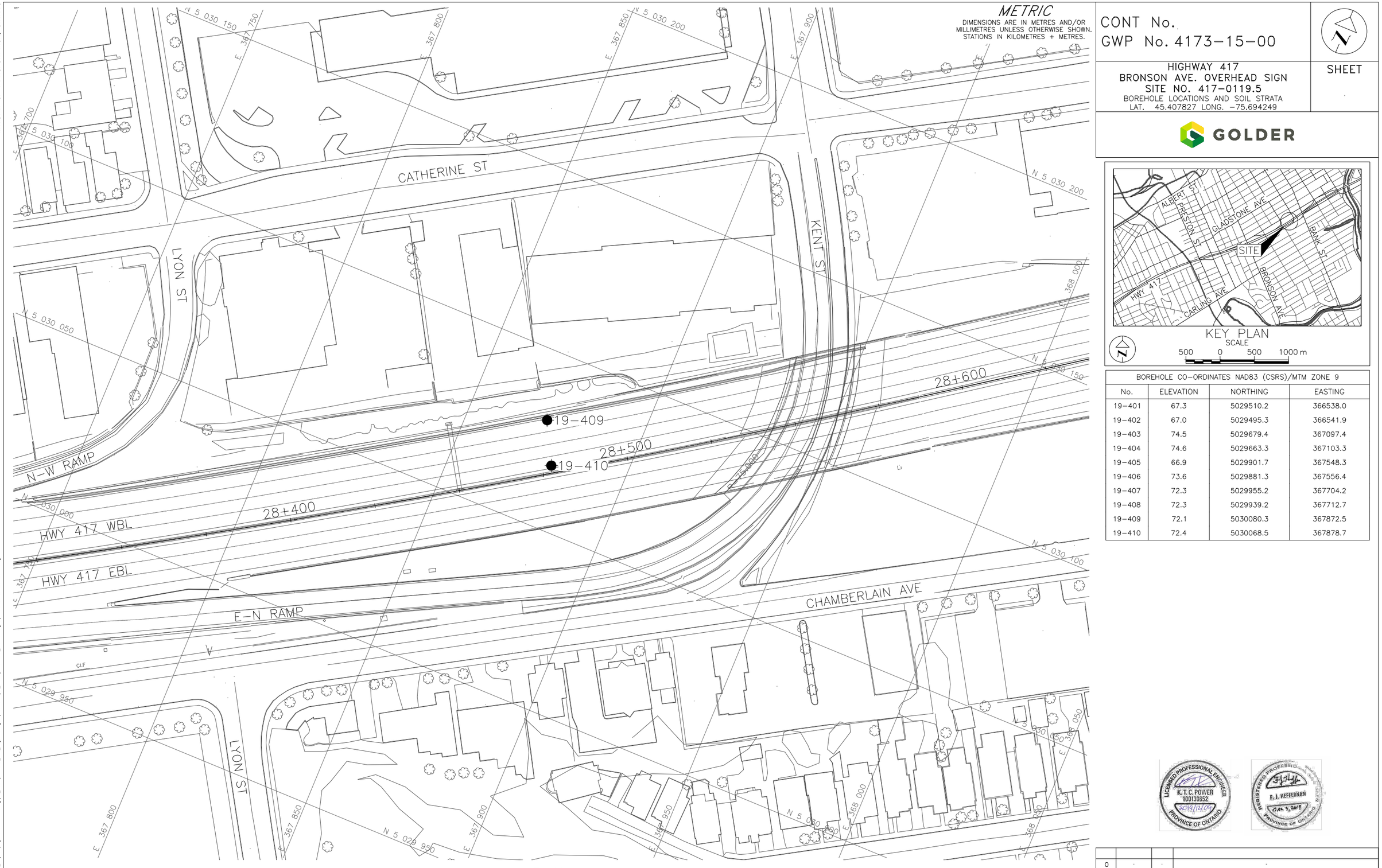
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4173-15-00

HIGHWAY 417
BRONSON AVE. OVERHEAD SIGN
SITE NO. 417-0119.5
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.407827 LONG. -75.694249

SHEET

GOLDER



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KEY PLAN
SCALE
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BOREHOLE CO-ORDINATES NAD83 (CSRS)/MTM ZONE 9

No.	ELEVATION	NORTHING	EASTING
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19-406	73.6	5029881.3	367556.4
19-407	72.3	5029955.2	367704.2
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19-409	72.1	5030080.3	367872.5
19-410	72.4	5030068.5	367878.7

REFERENCE
Base plans provided in digital format by WSP Canada Group Limited, drawing file no. MIDTOWN-XB1.dwg, received OCT. 25, 2017.

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REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
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Geocres No. 31G5-314

HWY. 417	PROJECT NO. 1655214		DIST. EASTERN
SUBM'D. SS	CHKD. KCP	DATE: 12/11/2019	SITE: 417-0119.5
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APPENDIX A

Lists of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Records of Boreholes and Drillholes 19-401 to 19-410
Bedrock Core Photographs, Figures A1 to A10

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 10	Trace	Trace sand
10 to 20	Some	Some sand
20 to 35	(ey) or (y)	Sandy
over 35	And	Sand and Gravel

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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 BOREHOLE No 19-401

SHEET 1 OF 3

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029510.2; E 366538.0 NAD 83 MTM ZONE 9 (LAT. 45.402816; LONG. -75.711366)

ORIGINATED BY KM

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 16-17, 2019

CHECKED BY SS/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
67.3	GROUND SURFACE										
0.0 / 67.0	ASPHALTIC CONCRETE										
0.3 / 66.7	(SW) Gravelly sand (FILL) Brown Moist										
0.6	(SP/SW) Sand, some gravel, contains cobbles (FILL) Very dense to dense Brown Moist		1	SS	72						
			2	SS	46						
65.0											
2.3 / 64.3	(SM/ML) Silty sand, some gravel (FILL) Compact Grey Moist		3	SS	13				○		
3.1	(CL) Sandy clayey silt, contains wood fibers, organic matter, ash, cobbles and boulders (FILL) Stiff to very stiff Brown, mottled		4	SS	5				⊢○⊣		2 31 42 26
			5	SS	10						
			6	SS	16						
			7	SS	50/0.20				○		3 38 33 26
61.2											
6.1 / 60.6	(GP/SP) Gravel and sand (FILL) Compact Grey Moist		8	SS	15						
6.7	(GM/SM) Gravelly silty sand, contains cobbles, organic matter and ash (FILL) Compact Grey brown Moist		9	SS	22						
			10	SS	50/0.20						
59.0											
8.3	Limestone (BEDROCK) Bedrock cored from depths 8.3 m to 13.2 m For bedrock coring details refer to Record of Drillhole 19-401		1	RC	REC 100%						RQD = 65%
			2	RC	REC 100%						RQD = 61%

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-401

SHEET 2 OF 3

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029510.2; E 366538.0 NAD 83 MTM ZONE 9 (LAT. 45.402816; LONG. -75.711366)

ORIGINATED BY KM

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 16-17, 2019

CHECKED BY SS/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
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Limestone (BEDROCK)		2	RC							RQD = 61%
	Bedrock cored from depths 8.3 m to 13.2 m For bedrock coring details refer to Record of Drillhole 19-401		3	RC	REC 47%		57				RQD = 18%
							56				
			4	RC	REC 100%		55				RQD = 93%
54.1											
13.2	END OF BOREHOLE										

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

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

PROJECT: 1655214-1400

RECORD OF DRILLHOLE: 19-401

SHEET 3 OF 3

LOCATION: N 5029510.2 ;E 366538.0

DRILLING DATE: June 16-17, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing 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 19-401		58.98														
9	Rotary Drill NQ Core	Limestone (BEDROCK), with thin black shale partings Fresh to slightly weathered Thinly to medium bedded Grey to brown Fine to medium grained Non-porous Strong		8.33	1													
10					2													UCS = 80.3 MPa
11		- Core lost during drilling from 10.8 m to 11.6 m			3													
12					4													
13				54.13														
		END OF DRILLHOLE		13.18														
14																		
15																		
16																		
17																		
18																		

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

RECOVERY: TOTAL CORE % (80 60 40 20); 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); 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)

DEPTH SCALE
1 : 50

GOLDER

LOGGED: KM

CHECKED: SS/KCP

GOLDER

RECORD OF BOREHOLE No 19-402

SHEET 1 OF 3

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029495.3; E 366541.9 NAD 83 MTM ZONE 9 (LAT. 45.402682; LONG. -75.711319)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 18-19, 2019

CHECKED BY SS/KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
67.0	GROUND SURFACE								
0.0	ASPHALTIC CONCRETE								
0.2	PORTLAND CEMENT CONCRETE								
66.5	(SW) Gravelly sand (FILL) Grey brown		1	GS	-				
0.5	(SP) Sand, trace gravel (FILL) Brown Moist		2	SS	14		66		
66.1	(GP/SP) Gravel and sand, some silt (FILL) Compact to dense Dark brown Moist		3	SS	36		65		42 40 (18)
0.9									
64.9	(CL) Sandy clayey silt, contains organic matter, moderately fissured (FILL) Firm to stiff Grey brown		4	SS	4		64		2 23 41 34
2.1			5	SS	2				
			6	SS	5		63		
			7	SS	4		62		
61.7	(CL) CLAYEY SILT, some sand Stiff Dark brown		8	SS	4				0 19 53 28
5.3			9	SS	3		61		
60.5	(GW/SW) GRAVEL and SAND, some silt Very dense Dark brown Moist		10	SS	52		60		47 34 (19)
6.5			11	SS	50/0.08				
59.3	Limestone (BEDROCK) Bedrock cored from depths 7.7 m to 10.8 m For bedrock coring details refer to Record of Drillhole 19-402		1	RC	REC 100%		59		RQD = 95%
7.7			2	RC	REC 100%		58		RQD = 98%

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

Continued Next Page

+ 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 12/3/19 JM

RECORD OF BOREHOLE No 19-402

SHEET 2 OF 3

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029495.3; E 366541.9 NAD 83 MTM ZONE 9 (LAT. 45.402682; LONG. -75.711319)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 18-19, 2019

CHECKED BY SS/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
	--- CONTINUED FROM PREVIOUS PAGE ---		2	RC							RQD = 98%
56.3			3	RC	REC 100%						RQD = 100%
10.8	END OF BOREHOLE										

NOTES:

1. Water level in well screen at a depth of 10.0 m below ground surface (Elev. 57.0 m), measured on July 31, 2019.

+^{3}, ×^{3}: Numbers refer to Sensitivity

○$^{3\%}$ STRAIN AT FAILURE

PROJECT: 1655214-1400

RECORD OF DRILLHOLE: 19-402

SHEET 3 OF 3

LOCATION: N 5029495.3 ;E 366541.9

DRILLING DATE: June 18-19, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing 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	WEATH-ERING INDEX	FEATURES
		Continued from Record of Borehole 19-402		59.34													
8	Rotary Drill, 200 mm Diam. (Hollow Stem)	Limestone (BEDROCK) with thin black shale partings Fresh Thinly to medium bedded Grey to dark grey Fine to medium grained Non-porous Strong		7.69	1												
9					2												UCS = 68.5 MPa
10					3												
				56.28													
11		END OF DRILLHOLE		10.75													
12																	
13																	
14																	
15																	
16																	
17																	

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: SS/KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 12/3/19 JM

GOLDER

RECORD OF BOREHOLE No 19-403

SHEET 1 OF 3

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029679.4; E 367097.4 NAD 83 MTM ZONE 9 (LAT. 45.404289; LONG. -75.704201)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 16-17, 2019

CHECKED BY SS/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
74.5	GROUND SURFACE										
0.0 / 74.2	ASPHALTIC CONCRETE										
0.3 / 73.8	(SW) Gravelly sand (FILL) Grey		1	GS	-		74				
0.7	(SM) Sand, some silt, trace gravel, contains clayey silt seams (FILL) Dense to very dense Brown Moist		2	SS	42				○		3 82 (15)
			3	SS	36		73				
			4	SS	54		72				
			5	SS	36		71				
70.7											
3.8	(GW/SW) Gravel and sand, some silt, trace clay, contains organic matter (rootlets) (FILL) Compact to loose Dark brown to black		6	SS	15						
			7	SS	9		70				
			8	SS	8	▼	69		○		46 36 13 5
68.3											
6.3	(SP) SAND, trace silt Grey		9	SS	45		68				
67.6											
6.9	(BEDROCK) Weathered		10	SS	100/0.05						
67.3											
7.2	Limestone (BEDROCK) Bedrock cored from depths 7.2 m to 10.8 m For bedrock coring details refer to Record of Drillhole 19-403		1	RC	REC 100%		67				RQD = 98%
			2	RC	REC 100%		66				RQD = 99%
							65				

Continued Next Page

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

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

GOLDER

PROJECT 1655214-1400

RECORD OF BOREHOLE No 19-403

SHEET 2 OF 3

METRIC

G.W.P. 4173-15-00 LOCATION N 5029679.4; E 367097.4 NAD 83 MTM ZONE 9 (LAT. 45.404289; LONG. -75.704201) ORIGINATED BY RI

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

DATUM Geodetic DATE June 16-17, 2019 CHECKED BY SS/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
	--- CONTINUED FROM PREVIOUS PAGE ---		2	RC							RQD = 99%
63.7			3	RC	REC 100%		64				RQD = 100%
10.8	END OF BOREHOLE										

NOTES:

1. Water level in well screen at a depth of 5.4 m below ground surface (Elev. 69.1 m), measured on August 20, 2019.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: 20 40 60 80 100

WATER CONTENT (%): 25 50 75

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

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

PROJECT: 1655214-1400

RECORD OF DRILLHOLE: 19-403

SHEET 3 OF 3

LOCATION: N 5029679.4 ;E 367097.4

DRILLING DATE: June 16-17, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing 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 19-403		67.33														
8	Rotary Drill NQ Core	Limestone (BEDROCK), with black shale partings Fresh Thinly to medium bedded Grey to brown Fine to medium grained Non-porous Strong		7.19	1													UCS = 72.5 MPa
9					2													
10					3													
				63.74														
11		END OF DRILLHOLE		10.78														
12																		
13																		
14																		
15																		
16																		
17																		

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED: SS/KCP

GOLDER

RECORD OF BOREHOLE No 19-404

SHEET 1 OF 2

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029663.3; E 367103.3 NAD 83 MTM ZONE 9 (LAT. 45.404144; LONG. -75.704126)

ORIGINATED BY RI

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core

COMPILED BY ZS

DATUM Geodetic

DATE June 19-20, 2019

CHECKED BY SS/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
74.6	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
0.2	PORTLAND CEMENT CONCRETE										
74.1	(SW) Gravelly sand (FILL) Grey		1	GS	-		74				
0.5	(SM) Sand, some silt, trace gravel (FILL) Compact to very loose Brown Moist		2	SS	14			○			6 81 (13)
72.5			3	SS	3		73				
2.1	(SM) Gravelly silty sand, contains brick, mortar, wood, concrete, organic matter and glass (FILL) Compact to very dense Brown Moist		4	SS	17		72				
			5	SS	56		71				
70.3			6	SS	53/0.15						
4.3	Limestone (BEDROCK) Bedrock cored from depths 4.3 m to 7.7 m For bedrock coring details refer to Record of Drillhole 19-404		1	RC	REC 100%		70				RQD = 99%
			2	RC	REC 100%		69				RQD = 99%
			3	RC	REC 100%		68				RQD = 100%
66.9							67				
7.7	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 12/3/19 JM

PROJECT: 1655214-1400

RECORD OF DRILLHOLE: 19-404

SHEET 2 OF 2

LOCATION: N 5029663.3 ;E 367103.3

DRILLING DATE: June 19-20, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing 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 19-404		70.31														
5	Rotary Drill / NQ Core	Limestone (BEDROCK), with thin black shale partings Fresh Thin to medium bedded Grey to brown Fine to medium grained Non-porous Strong		4.29	1													UCS = 81.2 MPa
6					2													
7				66.90	3													
		END OF DRILLHOLE		7.70														
8																		
9																		
10																		
11																		
12																		
13																		
14																		

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: SS/KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 12/3/19 JM

GOLDER

PROJECT 1655214-1400

RECORD OF BOREHOLE No 19-405

SHEET 1 OF 3

METRIC

G.W.P. 4173-15-00 LOCATION N 5029901.7; E 367548.3 NAD 83 MTM ZONE 9 (LAT. 45.406249; LONG. -75.698413) ORIGINATED BY PAH

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

DATUM Geodetic DATE May 13, 2019 CHECKED BY SS/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
66.9	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
0.1	(SW) Gravelly sand (FILL) Grey		1	GRAB	-						
66.5							66				
0.4	(SP) Sand, some gravel, contains wood pieces (FILL) Loose to dense Moist		2	SS	6						
			3	SS	36		65				
			4	SS	7						
64.0							64				
2.9	(OM,SP) Organic SILT and SAND Brown and grey Moist		5	SS	4				○		OC = 4.2%
63.4							63				
3.5	(SW/GW) SAND and GRAVEL Grey Wet		6	SS	25						
62.8							62				
4.1	(ML) SILT, some sand, trace clay, contains clayey silt seams Compact Grey Wet		7	SS	17				○		0 15 80 5
			8	SS	16						
60.8							61				
6.1	(ML) Sandy SILT, some clay, trace gravel, contains cobbles (TILL) Loose Grey Wet		9	SS	7				○		9 32 46 12
59.9			10	SS	11/0.15		60				
7.0	Limestone (BEDROCK) Bedrock cored from depths 7.0 m to 10.1 m For bedrock coring details refer to Record of Drillhole 19-405		1	RC	REC 97%						RQD = 40%
			2	RC	REC 99%		59				RQD = 91%
			3	RC	REC 100%		58				RQD = 100%
							57				

Continued Next Page

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

GOLDER

PROJECT 1655214-1400

RECORD OF BOREHOLE No 19-405

SHEET 2 OF 3

METRIC

G.W.P. 4173-15-00 LOCATION N 5029901.7; E 367548.3 NAD 83 MTM ZONE 9 (LAT. 45.406249; LONG. -75.698413) ORIGINATED BY PAH

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

DATUM Geodetic DATE May 13, 2019 CHECKED BY SS/KCP

SOIL PROFILE			SAMPLES			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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
56.8			3	RC							RQD = 100%
10.1	END OF BOREHOLE										
	NOTES:										
	1. Water level in well screen at a depth of 2.8 m below ground surface (Elev. 64.1 m), measured on June 19, 2019.										

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

PROJECT: 1655214-1400

RECORD OF DRILLHOLE: 19-405

SHEET 3 OF 3

LOCATION: N 5029901.7 ;E 367548.3

DRILLING DATE: May 13, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing 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	
		NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**																
		Continued from Record of Borehole 19-405		59.90														
8	Rotary Drill / NQ Core	Limestone (BEDROCK), with thin black shale partings Fresh Thinly to medium bedded Grey Non-porous Strong		7.01	1	100												UCS = 65.1 MPa
9					2	100												
10				56.77	3	100												
		END OF DRILLHOLE		10.14														
11																		
12																		
13																		
14																		
15																		
16																		
17																		

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: SS/KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417REHAB&WIDENING\02_DATA\GINT\1655214.GPJ GAL-MISS.GDT 12/3/19 JM

GOLDER

RECORD OF BOREHOLE No 19-406

SHEET 1 OF 2

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029881.3; E 367556.4 NAD 83 MTM ZONE 9 (LAT. 45.406065; LONG. -75.698311)

ORIGINATED BY RI

DIST Eastern HWY 417

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

COMPILED BY ZS

DATUM Geodetic

DATE June 20-21, 2019

CHECKED BY SS/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
73.6	GROUND SURFACE										
0.0	ASPHALTIC CONCRETE										
73.3											
73.1	(SW) Gravelly sand (FILL) Grey		1	GS	-						
	(SP) Sand (FILL) Brown Moist		2	GS	-						
0.7	(SW) Gravelly sand (FILL) Grey		3	GS	-						
	(SM) Sand, contains silty sand seams (FILL) Very loose to very dense Brown Moist		4	SS	32		73		○		0 83 (17)
			5	SS	8		72				
			6	SS	7		71				
			7	SS	3		70				
			8	SS	1		69		○		0 88 (2)
			9	SS	35		68				
			10	SS	29		67				
			11	SS	39		66				
			12	SS	52		65		○		5 81 (16)
			13	SS	16		64				
65.2											
8.4	(CI) Silty clay, trace sand, contains organic matter (rootlets) (TOPSOIL) Dark brown\		14	SS	4	▽					
64.9	(SM) SILTY SAND, contains silty clay seams Loose Grey Wet		15	SS	4				○		0 62 30 8
8.7											

Continued Next Page

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

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

GOLDER

RECORD OF BOREHOLE No 19-406

SHEET 2 OF 2 **METRIC**

PROJECT 1655214-1400
G.W.P. 4173-15-00 LOCATION N 5029881.3; E 367556.4 NAD 83 MTM ZONE 9 (LAT. 45.406065; LONG. -75.698311) ORIGINATED BY RI
DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS
DATUM Geodetic DATE June 20-21, 2019 CHECKED BY SS/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
	--- CONTINUED FROM PREVIOUS PAGE ---										
63.5 / 10.1	(GP/SP) GRAVEL and SAND, some silt (TILL) Grey brown Wet		16	SS	28				○		45 42 (13)
63.2 / 10.4	END OF BOREHOLE										
	NOTES: 1. Water level in open borehole at a depth of 8.6 m below ground surface (Elev. 73.6 m), upon completion of drilling.										

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

GOLDER

RECORD OF BOREHOLE No 19-407

SHEET 1 OF 2

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00 LOCATION N 5029955.2; E 367704.2 NAD 83 MTM ZONE 9 (LAT. 45.406716; LONG. -75.696414) ORIGINATED BY DJG

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

DATUM Geodetic DATE June 17, 2019 CHECKED BY SS/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
72.3	GROUND SURFACE										
0.0 / 72.0	ASPHALTIC CONCRETE						72				
0.3 / 71.5	(SW/GW) Sand and gravel, some silt (FILL) Grey Dry		1	AS	-				○		40 48 (12)
0.8	(SP) Sand, trace silt (FILL) Compact to dense Brown Moist		2	SS	28		71				
			3	SS	46						
			4	SS	34		70		○		2 90 (8)
			5	SS	44		69				
67.9			6	SS	37						
4.4	(SP) Sand, some gravel, contains crushed asphalt (FILL) Compact to loose Brown to dark brown Moist		7	SS	10		68				
			8	SS	4		67				
66.2											
6.1	(SM) Silty sand, trace gravel, contains wood, brick, asphalt and construction debris (FILL) Very loose to compact Brown to dark brown moist		9	SS	2		66				
			10	SS	16		65				
64.8											
7.5	(CI) Silty clay, trace gravel (FILL) Stiff Grey brown		11	SS	7	▽					
64.1											
8.2	(ML) Sandy SILT Dense Grey Wet		12	SS	40		64		○		0 31 67 2
63.3											
9.0	(SM/ML) SAND and SILT, some gravel (TILL) Very dense Grey brown Moist		13	SS	88		63		○		13 41 (46)

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 19-407

SHEET 2 OF 2 **METRIC**

PROJECT 1655214-1400
G.W.P. 4173-15-00 LOCATION N 5029955.2; E 367704.2 NAD 83 MTM ZONE 9 (LAT. 45.406716; LONG. -75.696414) ORIGINATED BY DJG
DIST Eastern HWY 417 BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem) COMPILED BY ZS
DATUM Geodetic DATE June 17, 2019 CHECKED BY SS/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						
	--- CONTINUED FROM PREVIOUS PAGE ---										
63.3 / 10.1	END OF BOREHOLE	XXXX									
	NOTES:										
	1. Water level in open borehole at depth of 7.8 m below ground surface (Elev. 64.5 m), upon completion of drilling.										

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

GOLDER

RECORD OF BOREHOLE No 19-408

SHEET 1 OF 2

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5029939.2; E 367712.7 NAD 83 MTM ZONE 9 (LAT. 45.406572; LONG. -75.696307)

ORIGINATED BY KM

DIST Eastern HWY 417

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

COMPILED BY ZS

DATUM Geodetic

DATE June 19, 2019

CHECKED BY SS/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
72.3	GROUND SURFACE										
0.0	ASPHALT										
71.9	PORTLAND CEMENT CONCRETE										
0.4	(SW/GW) Sand and gravel (FILL) Grey Moist										
71.4			1	SS	42						
0.9	(SM) Sand, some silt (FILL) Very dense to loose Brown		2	SS	54				○		1 83 (16)
			3	SS	57						
			4	SS	34						
			5	SS	45						
			6	SS	9						
			7	SS	25				○		2 90 (8)
66.2											
6.1	(SM) Gravelly silty sand, contains ash and brick (FILL) Compact Brown-black Moist		8	SS	28	▼					
65.4											
6.9	(SM/ML) Sand and silt, contains organic matter, wood, ceramic, plastic and glass (FILL) Loose to compact Dark brown to black		9	SS	5						
			10	SS	12						
63.9											
8.4	(SP/ML) SAND and SILT, some gravel, contains cobbles and boulders (TILL) Compact Grey		11	SS	13				○		12 46 (42)
			12	SS	50/0.03						
			13	SS	50/0.03						

Continued Next Page

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

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

GOLDER

RECORD OF BOREHOLE No 19-408

SHEET 2 OF 2 **METRIC**

PROJECT 1655214-1400
G.W.P. 4173-15-00
LOCATION N 5029939.2; E 367712.7 NAD 83 MTM ZONE 9 (LAT. 45.406572; LONG. -75.696307)
ORIGINATED BY KM
DIST Eastern HWY 417
BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)
COMPILED BY ZS
DATUM Geodetic
DATE June 19, 2019
CHECKED BY SS/KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L 25 50 75	γ kN/m^3	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			
62.2 / 10.1	END OF BOREHOLE										
	NOTES:										
	1. Water level in well screen at a depth of 6.4 m below ground surface (Elev. 65.9 m), measured on July 23, 2019.										

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

GOLDER

RECORD OF BOREHOLE No 19-409

SHEET 1 OF 1 **METRIC**

PROJECT 1655214-1400
G.W.P. 4173-15-00
DIST Eastern HWY 417
DATUM Geodetic

LOCATION N 5030080.3; E 367872.5 NAD 83 MTM ZONE 9 (LAT. 45.407827; LONG. -75.694249)
BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)
DATE July 25, 2019

ORIGINATED BY DJG
COMPILED BY ZS
CHECKED BY SS/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 / 71.8	ASPHALTIC CONCRETE						72				
0.3	(SW/GW) Gravelly sand (FILL) Very dense Grey		1	GS	-						
			2	SS	81		71				
70.1			3	SS	55						
2.0	(SM) Sand, some silt, trace gravel (FILL) Compact Brown Dry to moist		4	SS	15		70		○		3 83 (14)
			5	SS	22		69				
			6	SS	27		68				
66.9			7	SS	16	▽					
5.2 / 66.2	(ML/SM) SILT and SAND Compact Grey brown		8	SS	12		67		○		0 43 (57)
5.9	(CH) CLAY Firm to stiff Grey		9	SS	4		66				
			10	SS	2		65		○		0 0 30 70
63.9							64	× + × +			
8.2	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 4.9 m below ground surface (Elev. 67.2 m), upon completion of drilling.

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

GOLDER

PROJECT 1655214-1400

RECORD OF BOREHOLE No 19-410

SHEET 1 OF 2

METRIC

G.W.P. 4173-15-00 LOCATION N 5030068.5; E 367878.7 NAD 83 MTM ZONE 9 (LAT. 45.407720; LONG. -75.694171) ORIGINATED BY KM

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

DATUM Geodetic DATE June 20, 2029 CHECKED BY SS/KCP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
72.4	GROUND SURFACE						
0.0 / 72.1	ASPHALTIC CONCRETE						
71.9 / 0.5	(SW/GW) Gravelly sand (FILL) Grey Moist						
71.2	(SM) Silty sand, trace gravel (FILL) Grey Moist		1	SS	88		
1.2 / 70.3	(SM/GW) Gravelly sand, some silt (FILL) Very dense Grey		2	SS	51		
2.1 / 68.6	(SM) Sand, some silt, contains ash (FILL) Dense Brown		3	SS	43		
			4	SS	33		
3.8 / 67.1	(ML/SM) Silt and sand (FILL) Dense to loose Brown Moist		5	SS	44		
			6	SS	9		
5.3 / 66.0	(SM/ML) SAND and SILT Compact Grey brown		7	SS	28		
6.4	(CH) CLAY Stiff Grey		8	SS	8		
			9	SS	2		
			10	SS	1		
62.7			11	SS	2		
9.8							

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
	3	74		(23)
	2	83		(15)
	0	62		(38)
	0	0	22	78
	0	0	52	48

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 19-410

SHEET 2 OF 2

METRIC

PROJECT 1655214-1400

G.W.P. 4173-15-00

LOCATION N 5030068.5; E 367878.7 NAD 83 MTM ZONE 9 (LAT. 45.407720; LONG. -75.694171)

ORIGINATED BY KM

DIST Eastern HWY 417

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

COMPILED BY ZS

DATUM Geodetic

DATE June 20, 2029

CHECKED BY SS/KCP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	w_P w w_L 25 50 75	γ kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										
	NOTES: 1. Monitoring well dry at bottom of well (Elev. 63.0 m) on August 19, 2019.										

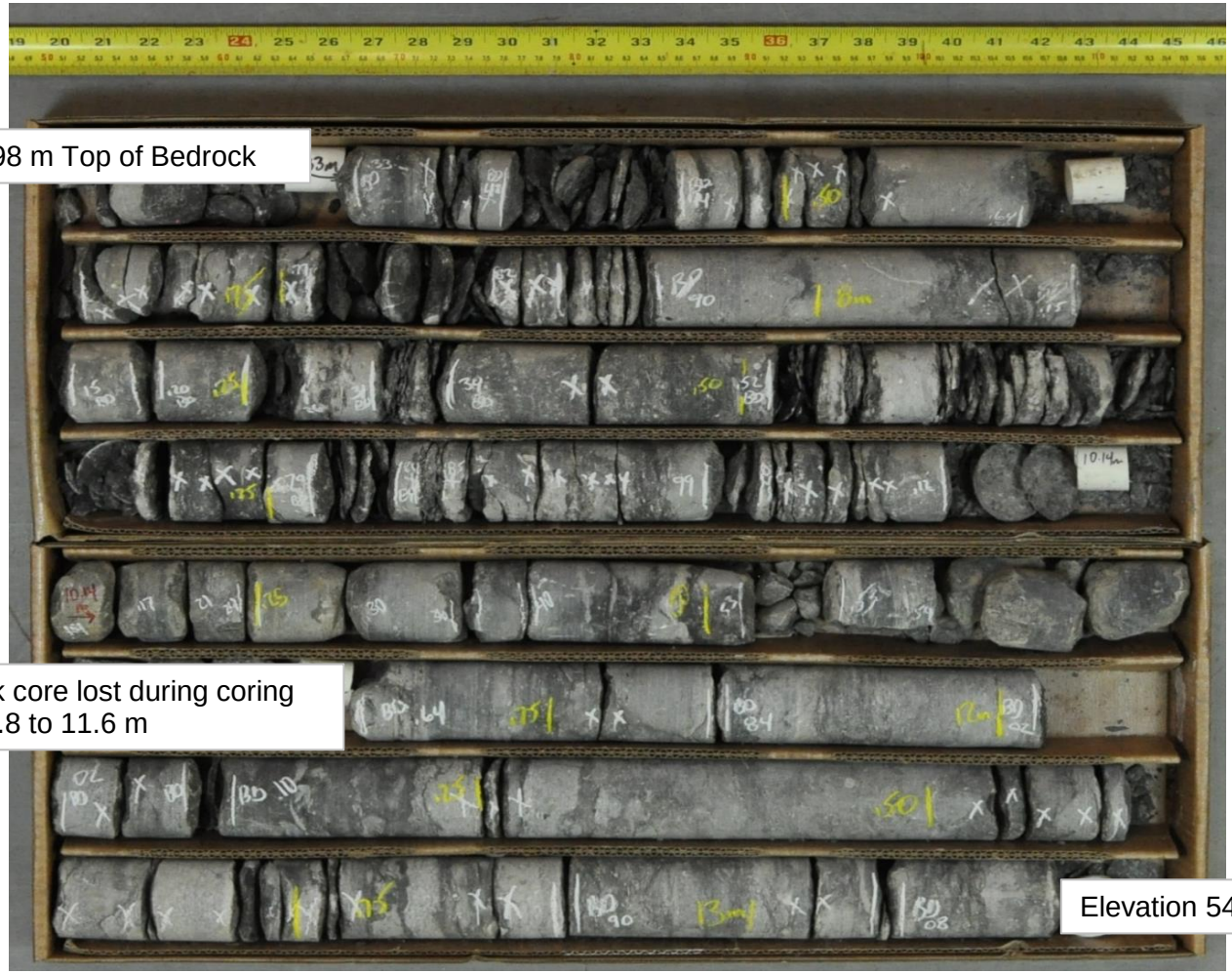
$+^3, \times^3$: Numbers refer to Sensitivity

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

BH 19-401 (Dry)

Cored Length : 8.3 to 13.2 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

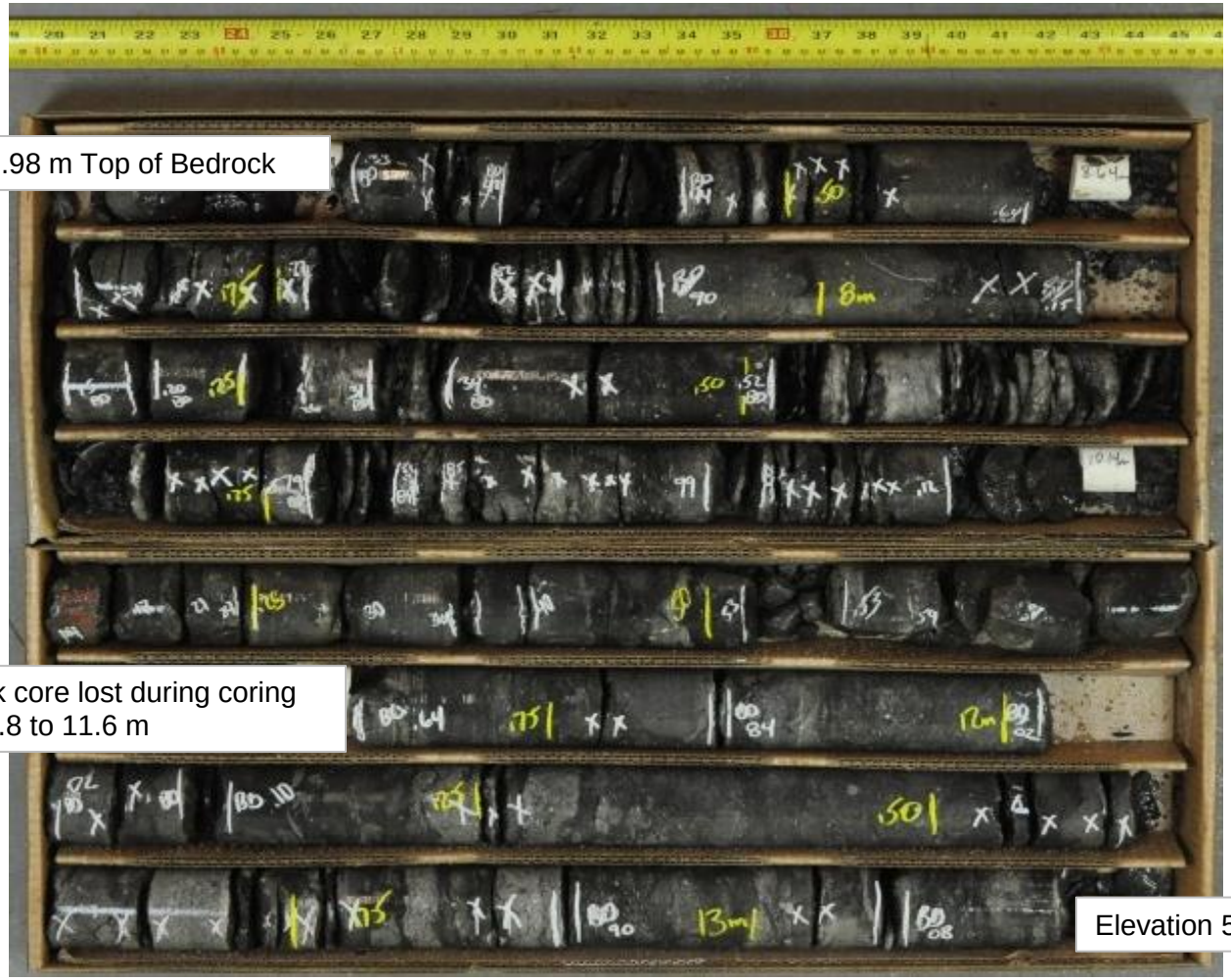
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A1

BH 19-401 (Wet)

Cored Length : 8.3 to 13.2 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

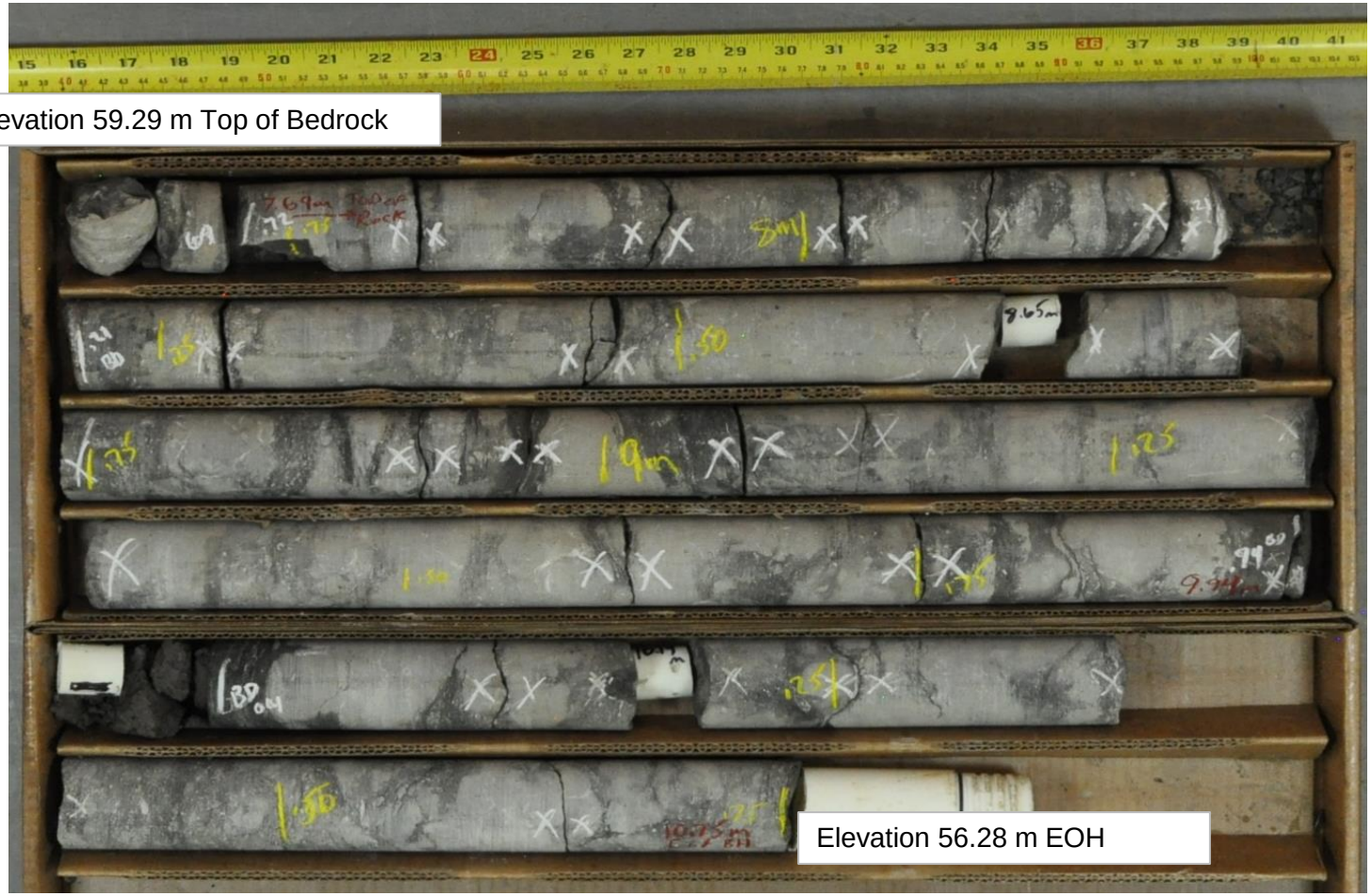
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-08-13
Checked:	SS
Review:	KCP

Figure A2

BH 19-402 (Dry)

Cored Length : 7.7 to 10.8 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

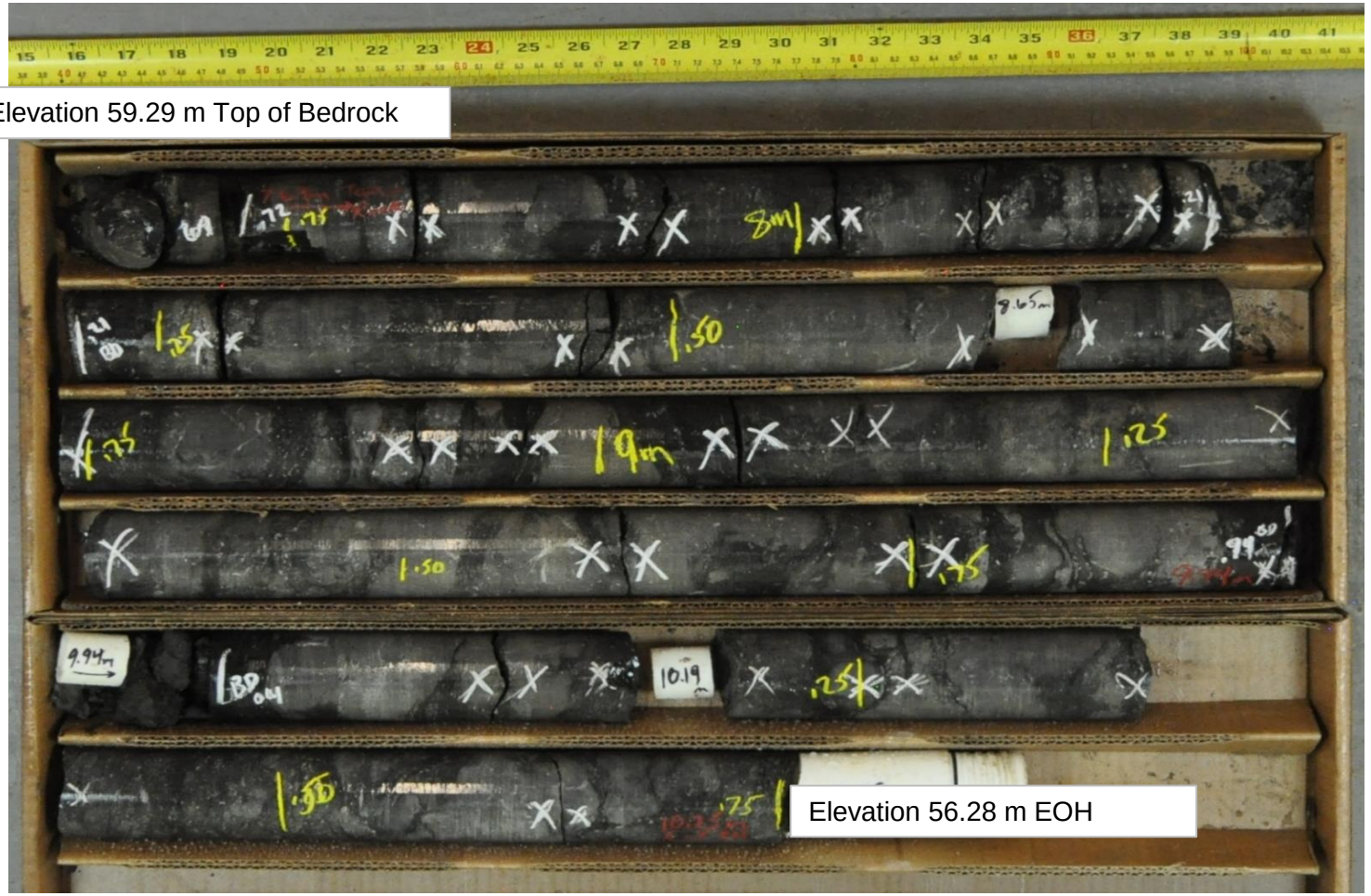
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A3

BH 19-402 (Wet)

Cored Length : 7.7 to 10.8 metres

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

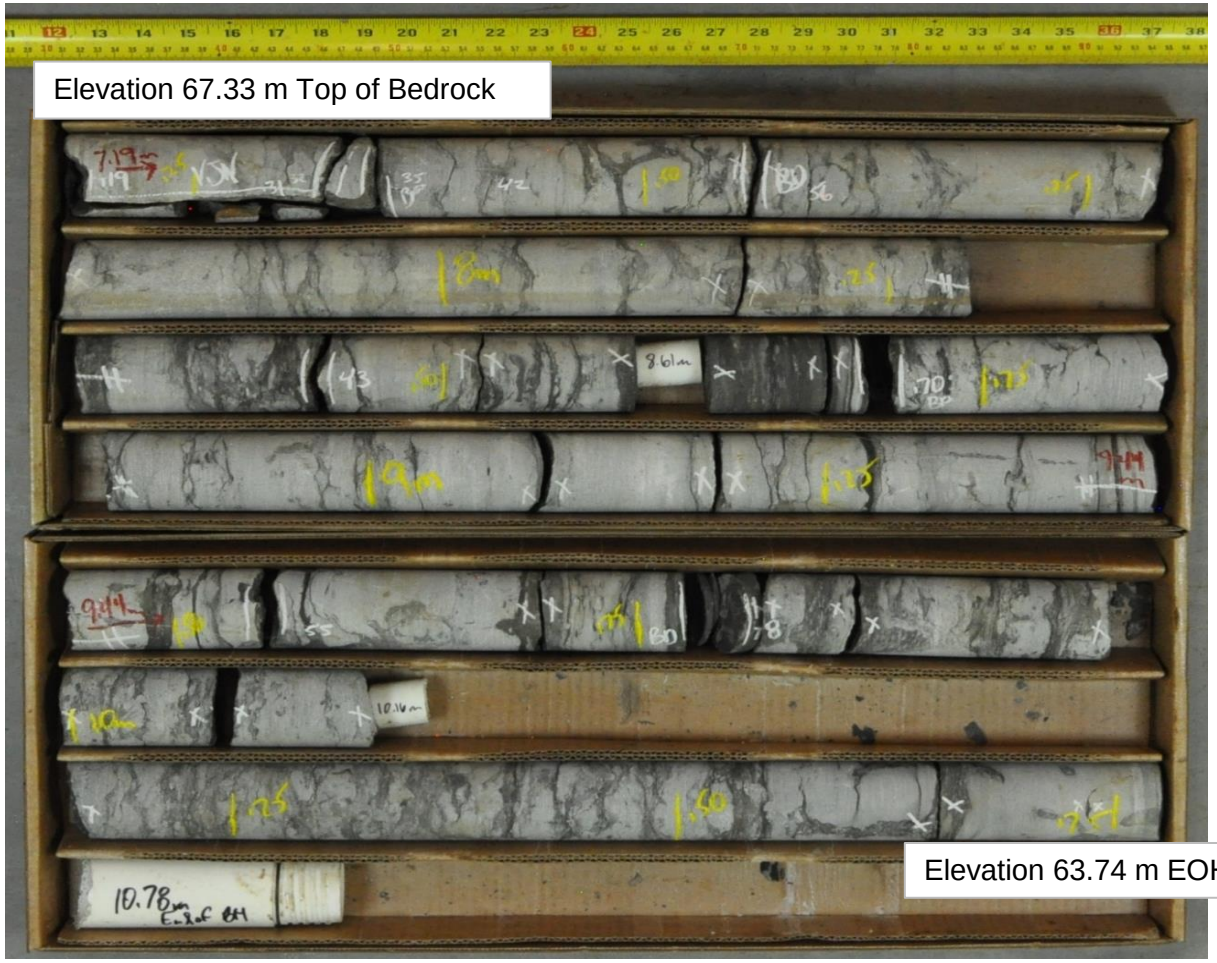
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A4

BH 19-403 (Dry)

Cored Length : 7.2 to 10.8 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

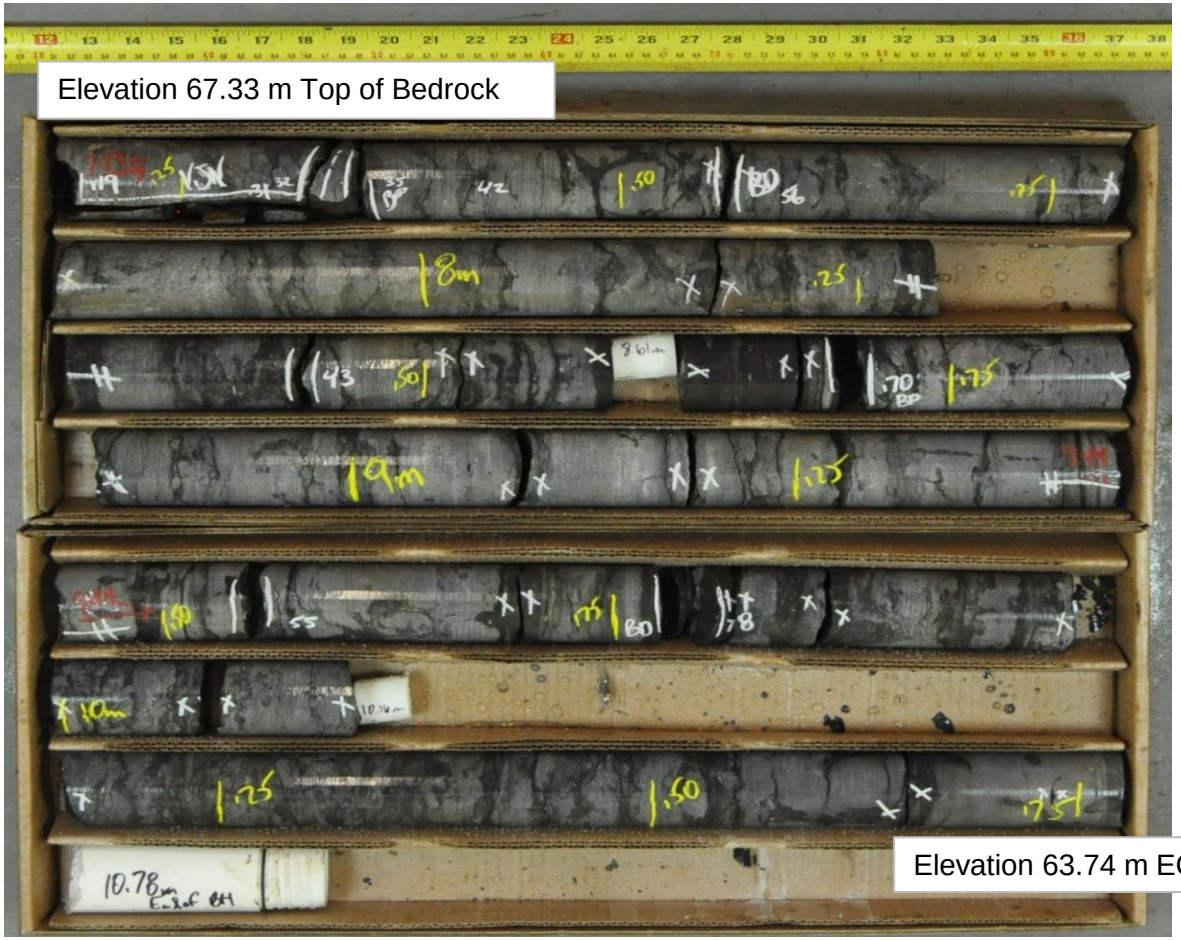
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A5

BH 19-403 (Wet)

Cored Length : 7.2 to 10.8 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

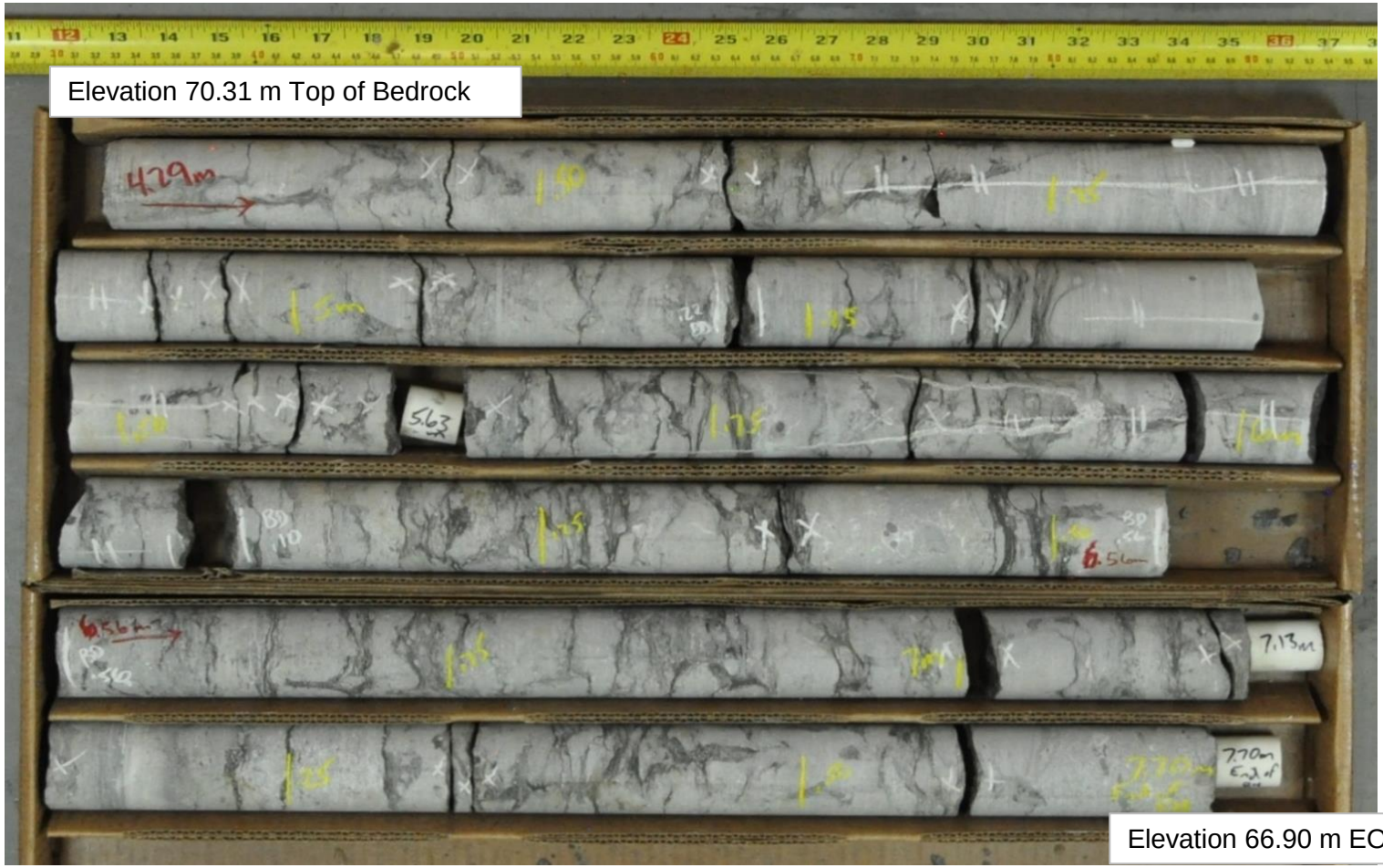
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A6

BH 19-404 (Dry)

Cored Length : 4.3 to 7.7 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

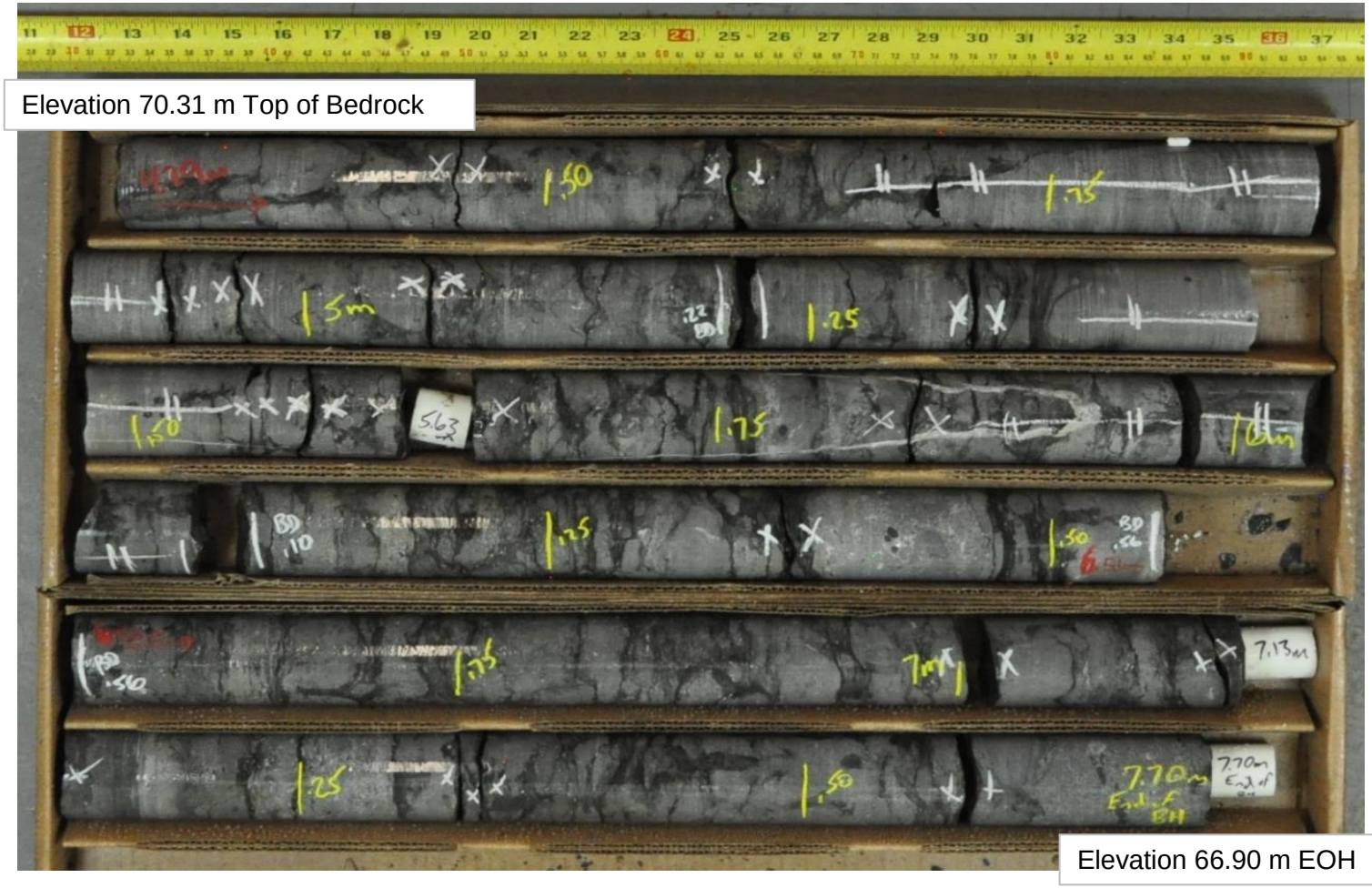
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A7

BH 19-404 (Wet)

Cored Length : 4.3 to 7.7 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

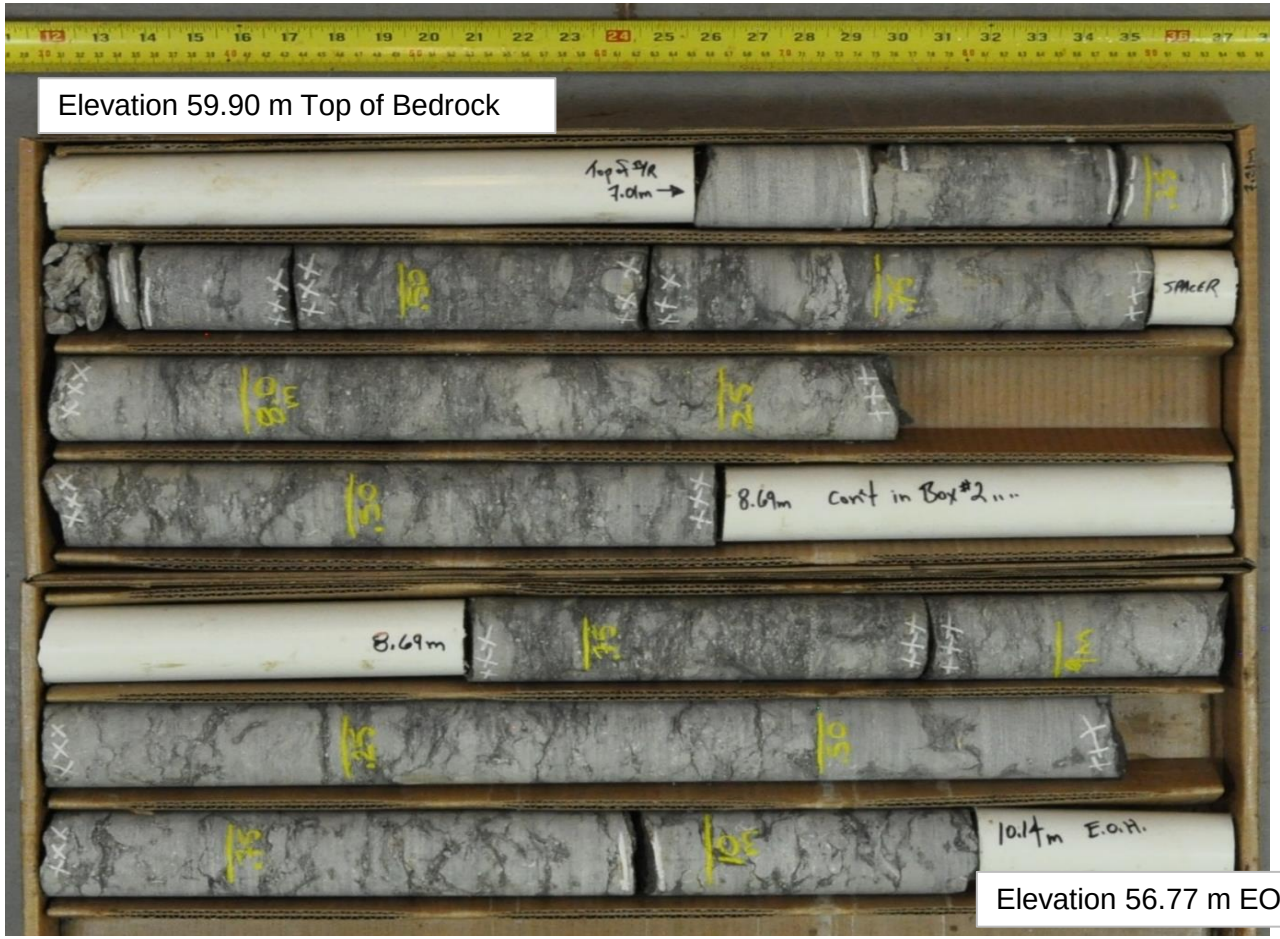
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A8

BH 19-405 (Dry)

Cored Length : 7.0 to 10.1 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

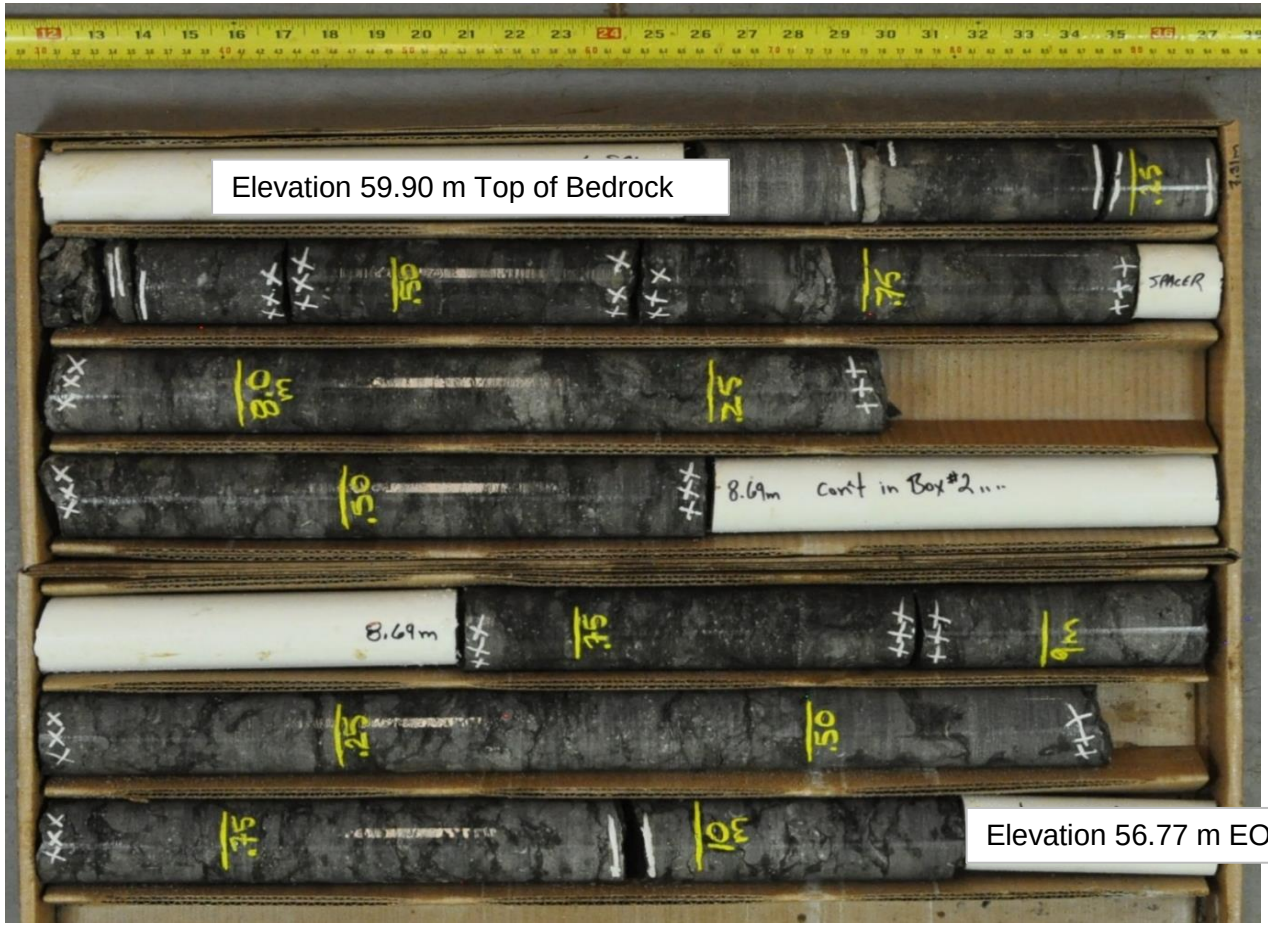
Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

Figure A9

BH 19-405 (Wet)

Cored Length : 7.0 to 10.1 m

Core Box 1 and 2 of 2



GOLDER

Foundation Investigation

Highway 417 Overhead Sign Replacements

Ottawa, Ontario

Project No.	1655214 / 1400
Drawn:	AK
Date:	2019-07-19
Checked:	SS
Review:	KCP

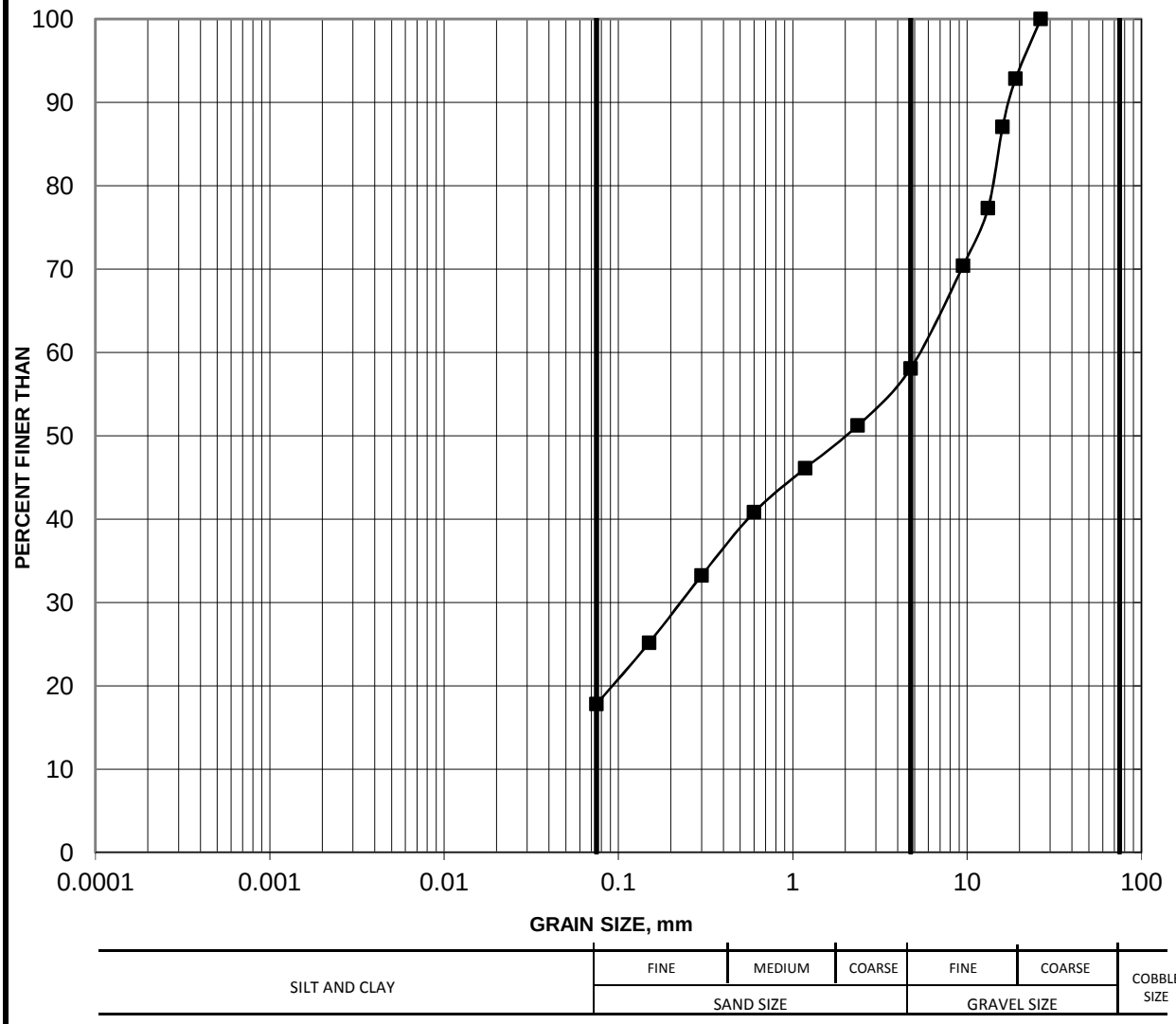
Figure A10

APPENDIX B

Laboratory Test Results, Current Investigation

GRAIN SIZE DISTRIBUTION	FIGURE B1

GRAVEL AND SAND (FILL)



Borehole	Sample	Depth (m)
19-402	3	1.52-2.13

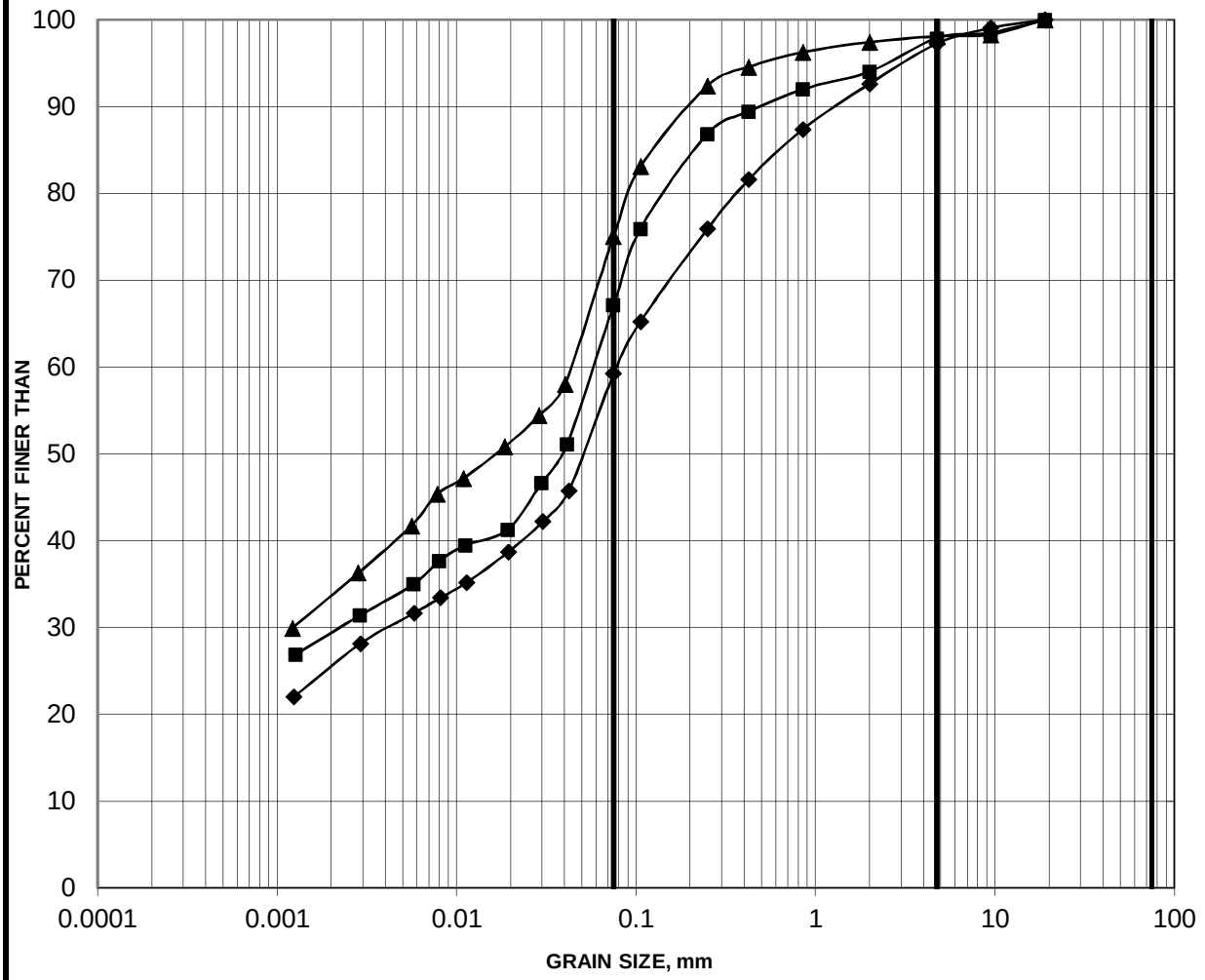
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B2

SANDY CLAYEY SILT (FILL)



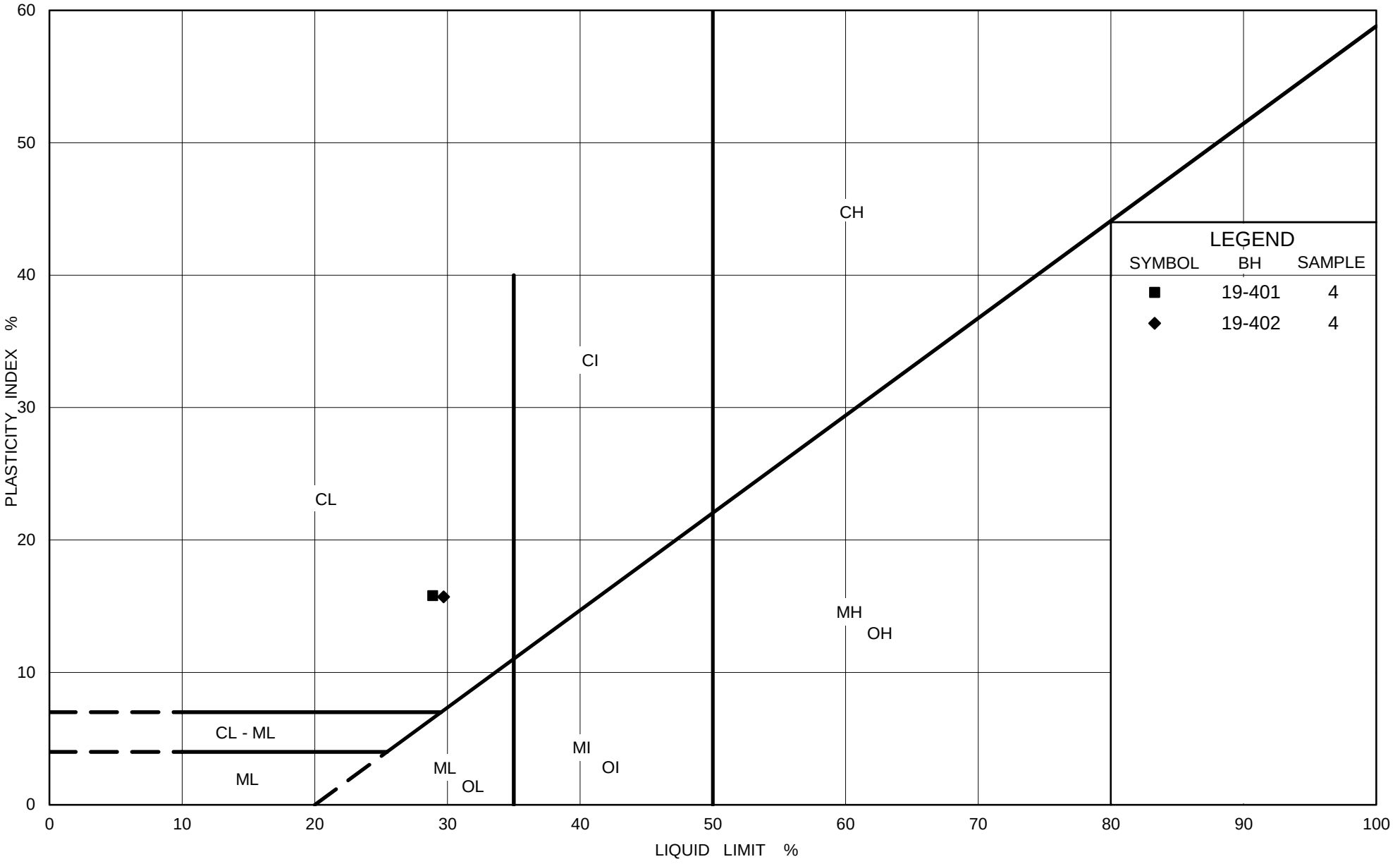
Borehole	Sample	Depth (m)
19-401	4	3.05-3.66
19-401	7	5.33-5.94
19-402	4	2.29-2.90

Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

Oct 75, FF-S-21



Ministry of Transportation

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PLASTICITY CHART
SANDY CLAYEY SILT (FILL)

FIG No. B3

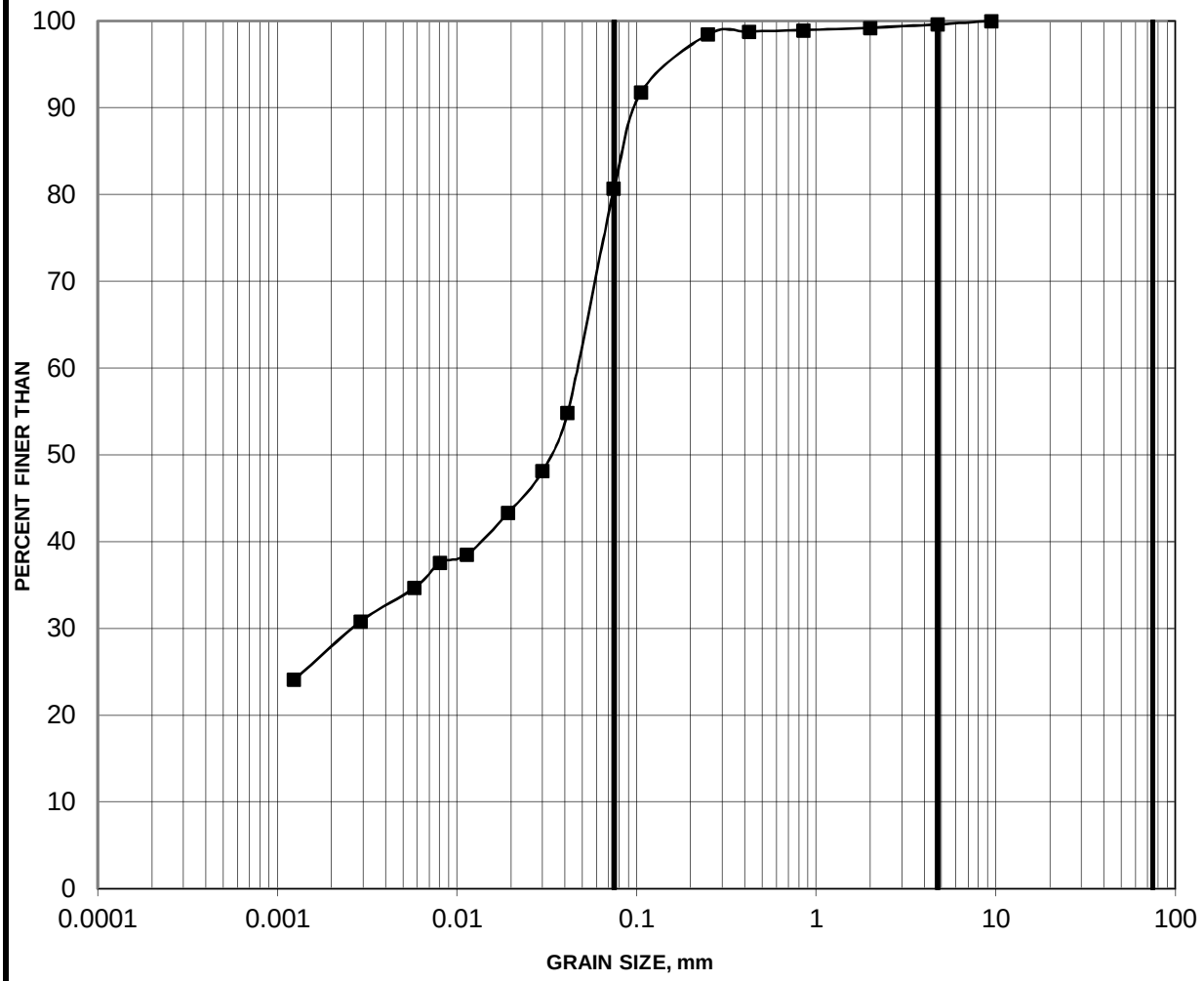
Project No. 1655214/1400

Compiled By : CW Checked By : MI

GRAIN SIZE DISTRIBUTION

FIGURE B4

CLAYEY SILT



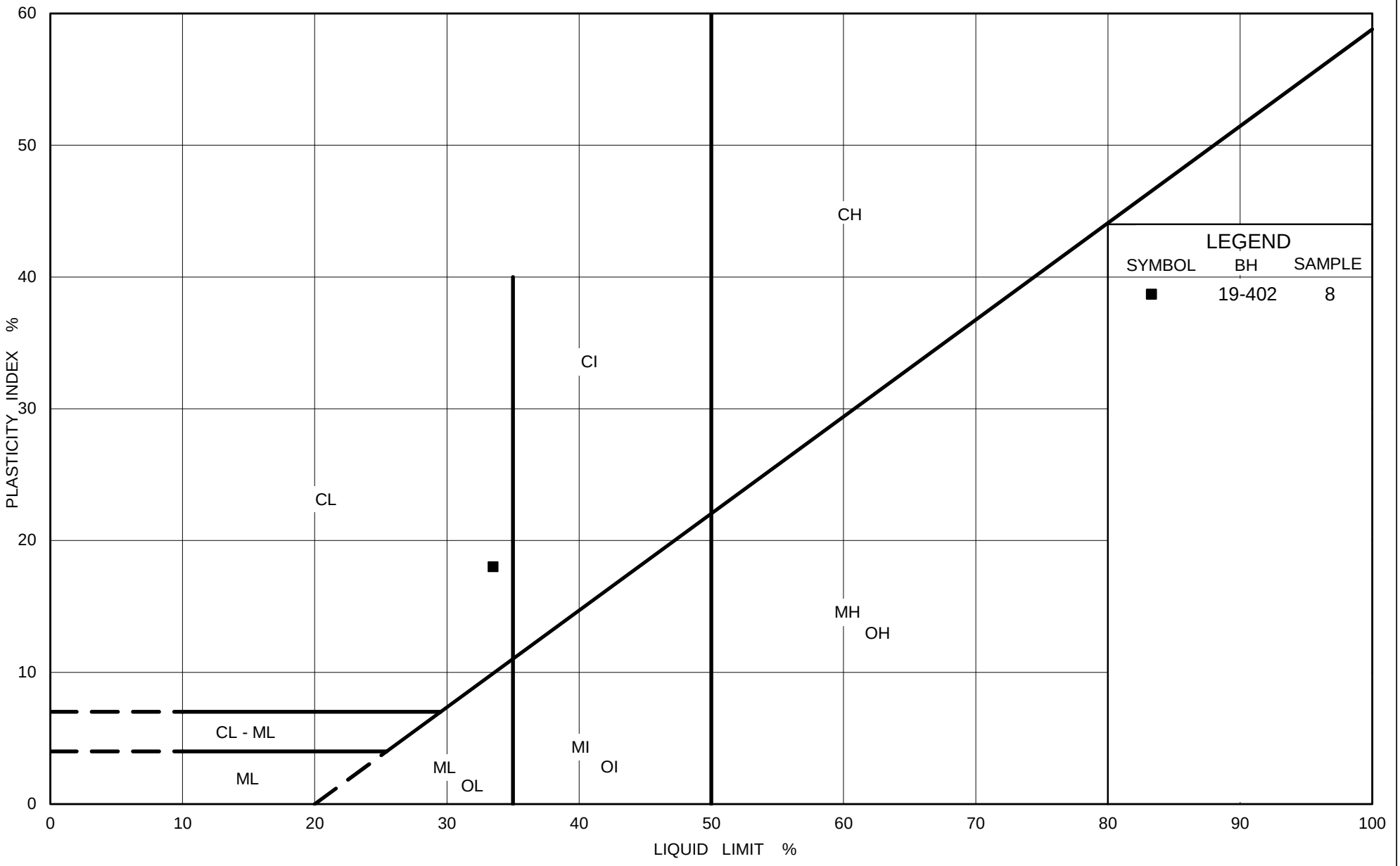
Borehole	Sample	Depth (m)
19-402	8	5.33-5.94

Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
CLAYEY SILT

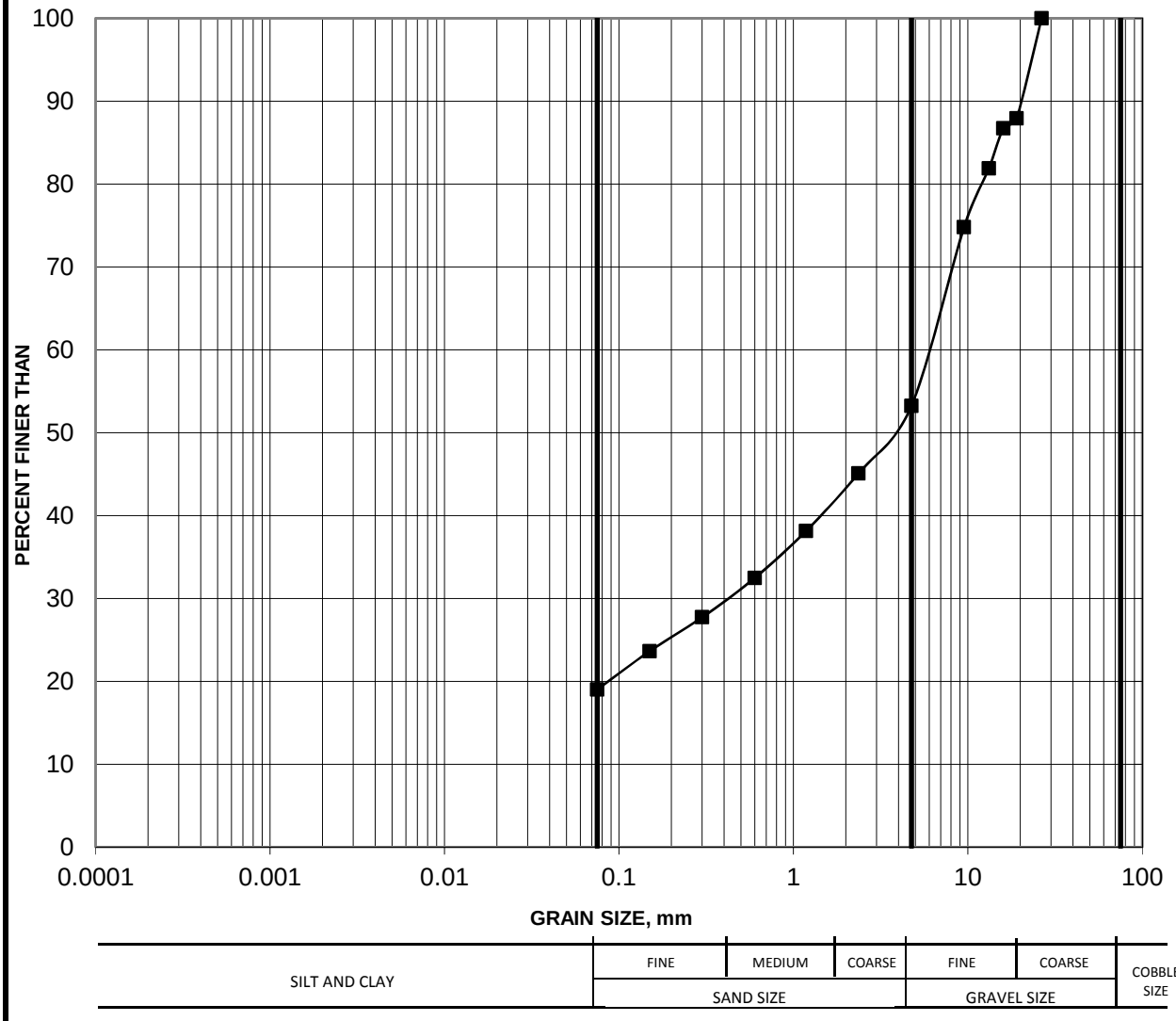
FIG No. B5

Project No. 1655214/1400

Compiled By : CW Checked By : MI

GRAIN SIZE DISTRIBUTION	FIGURE B6

SAND AND GRAVEL



Borehole	Sample	Depth (m)
19-402	10	6.86-7.47

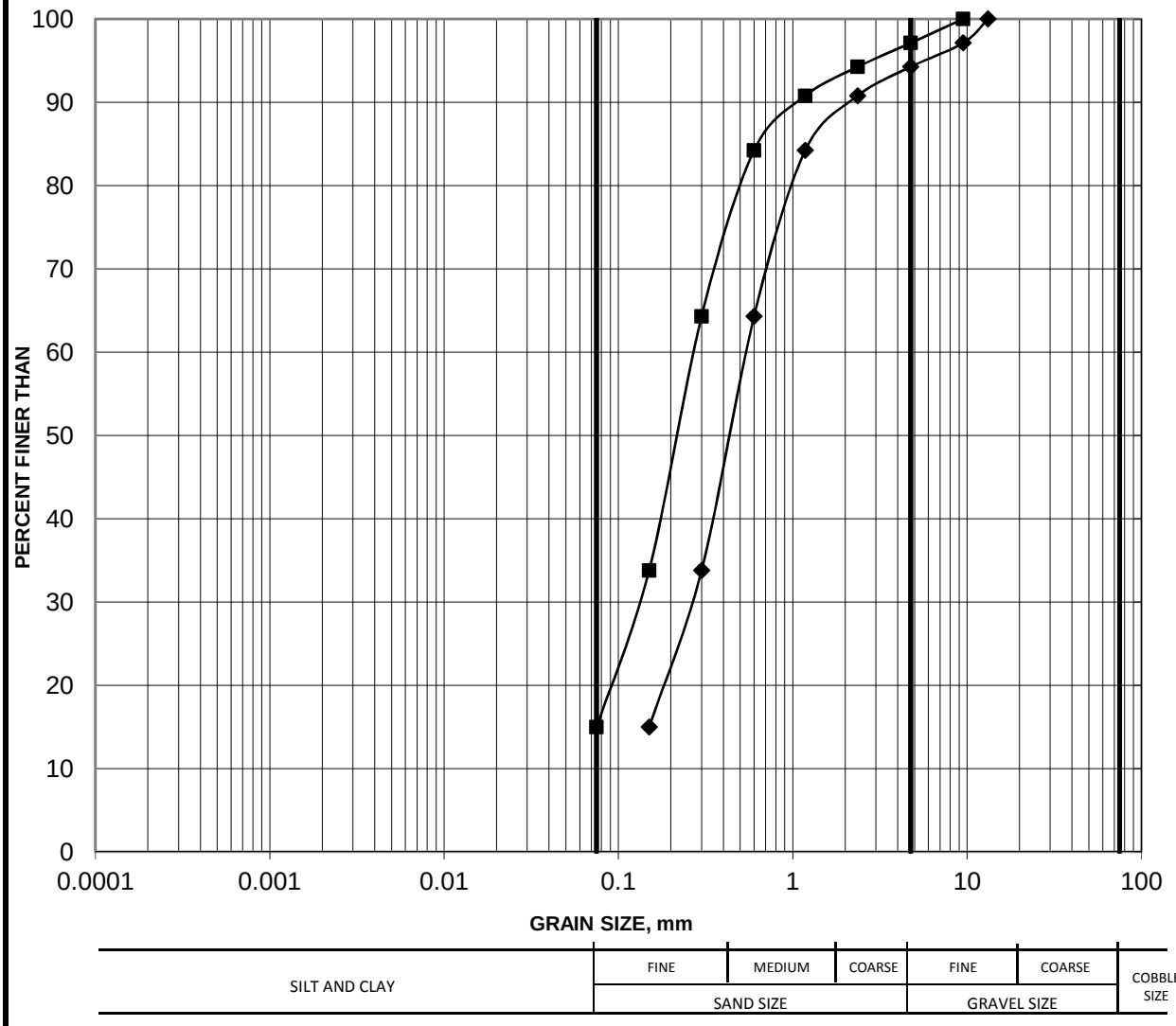
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B7

SAND (FILL)



Borehole	Sample	Depth (m)
19-403	2	0.76-1.37
19-404	2	0.76-1.37

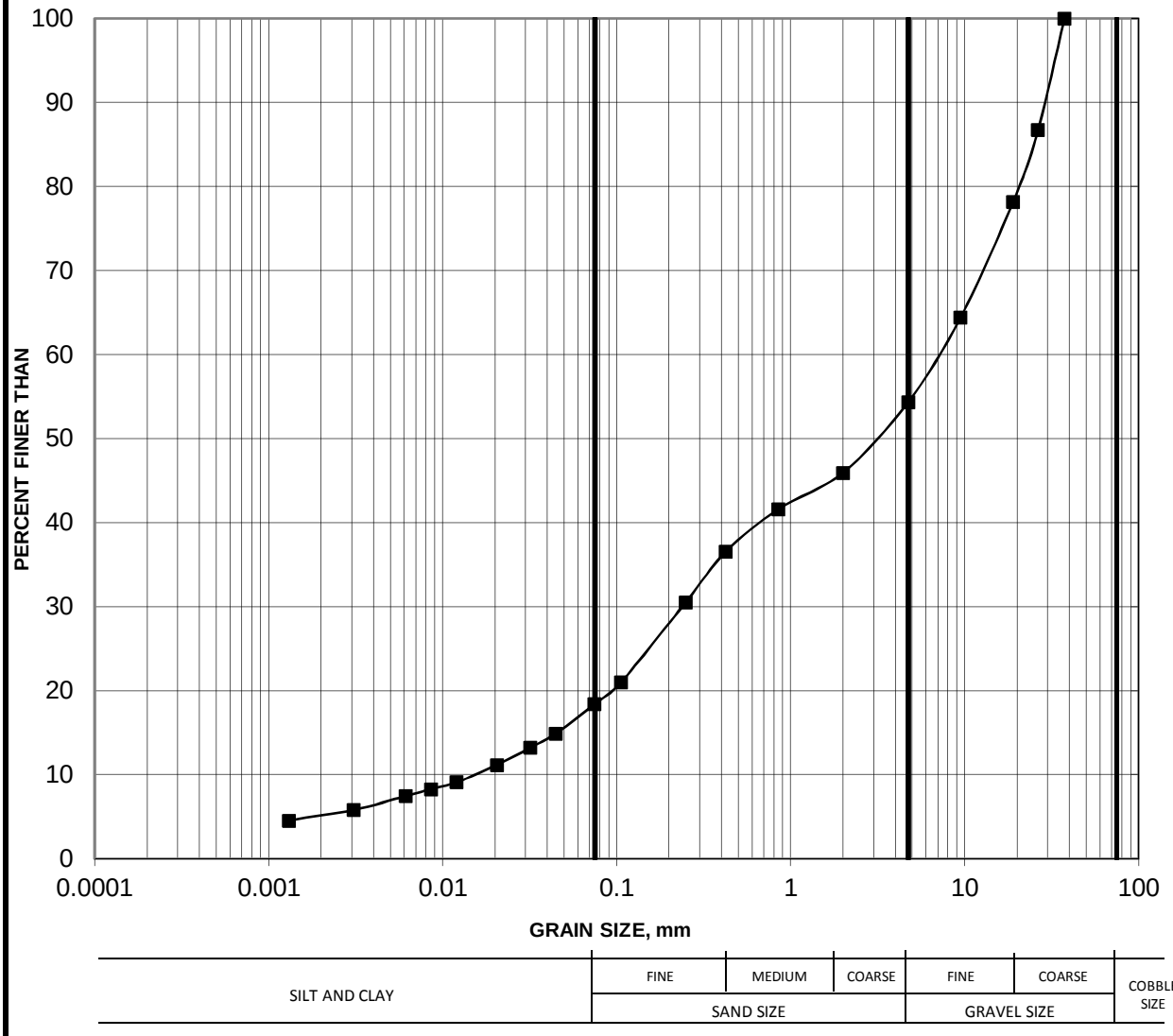
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B8

GRAVEL AND SAND (FILL)



Borehole	Sample	Depth (m)
19-403	8	5.33-5.94

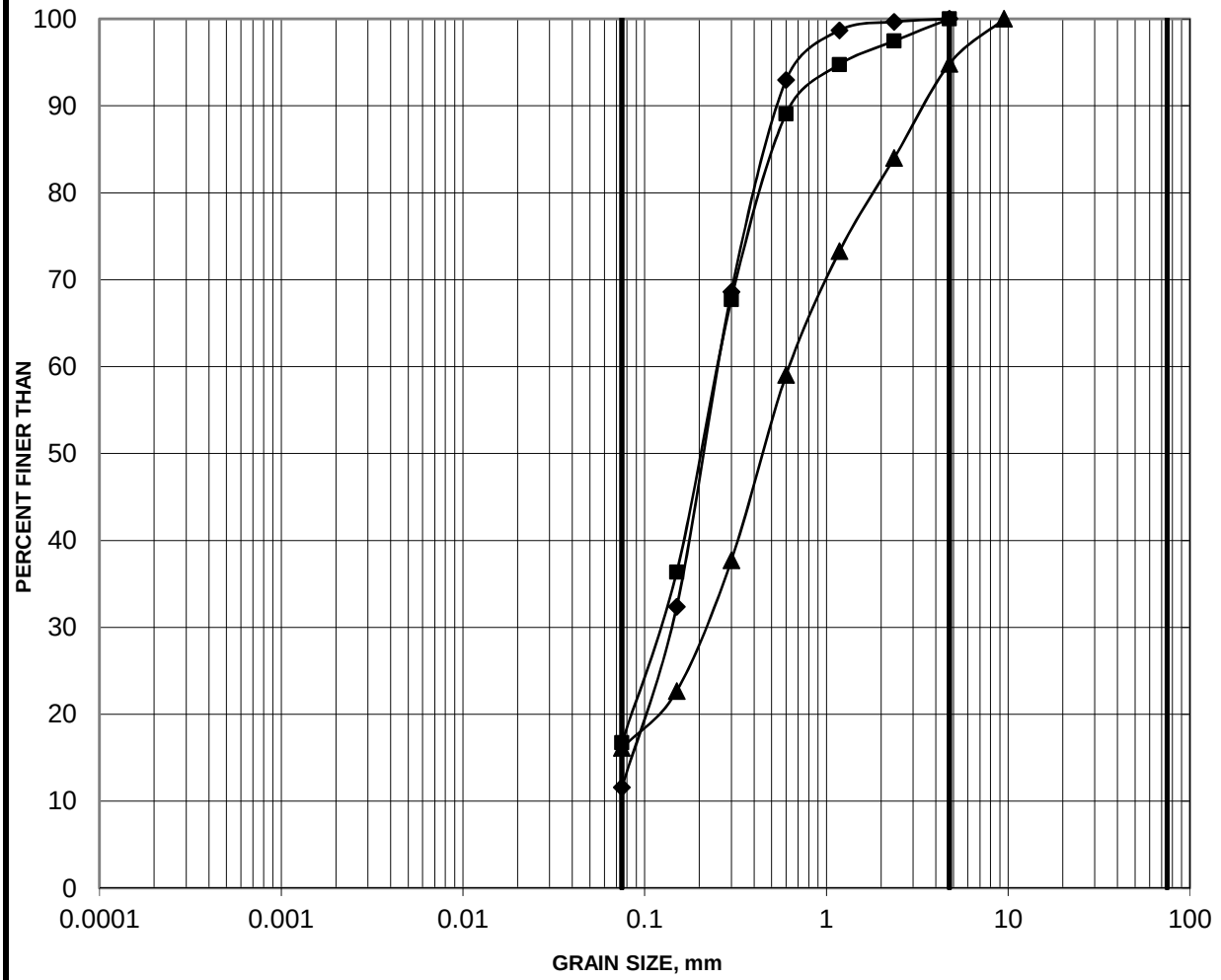
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B9

SAND (FILL)



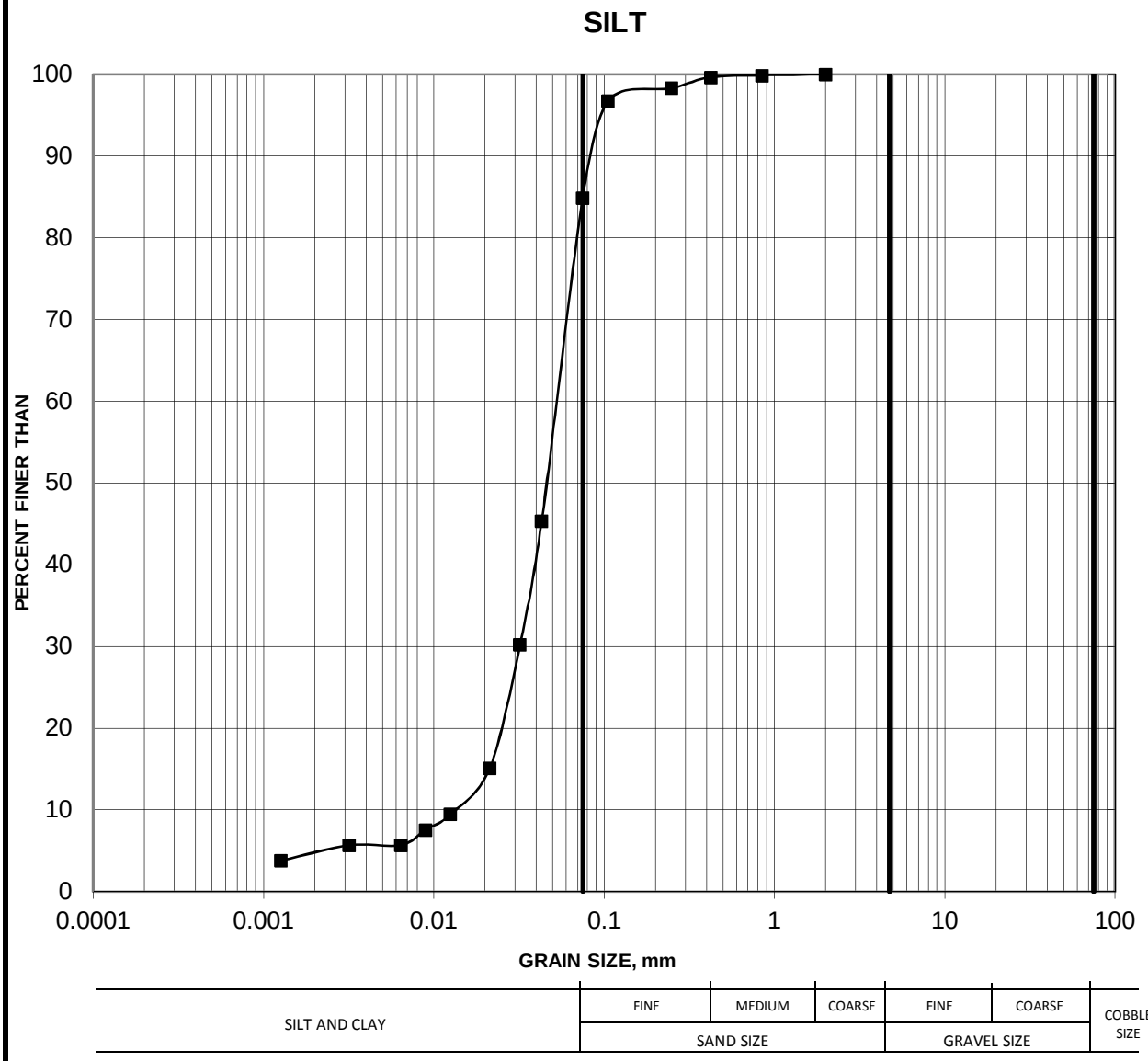
Borehole	Sample	Depth (m)
19-406	4	0.76-1.37
19-406	8	3.81-4.42
19-406	12	6.86-7.47

Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B10



Borehole	Sample	Depth (m)
19-405	7	4.57-5.18

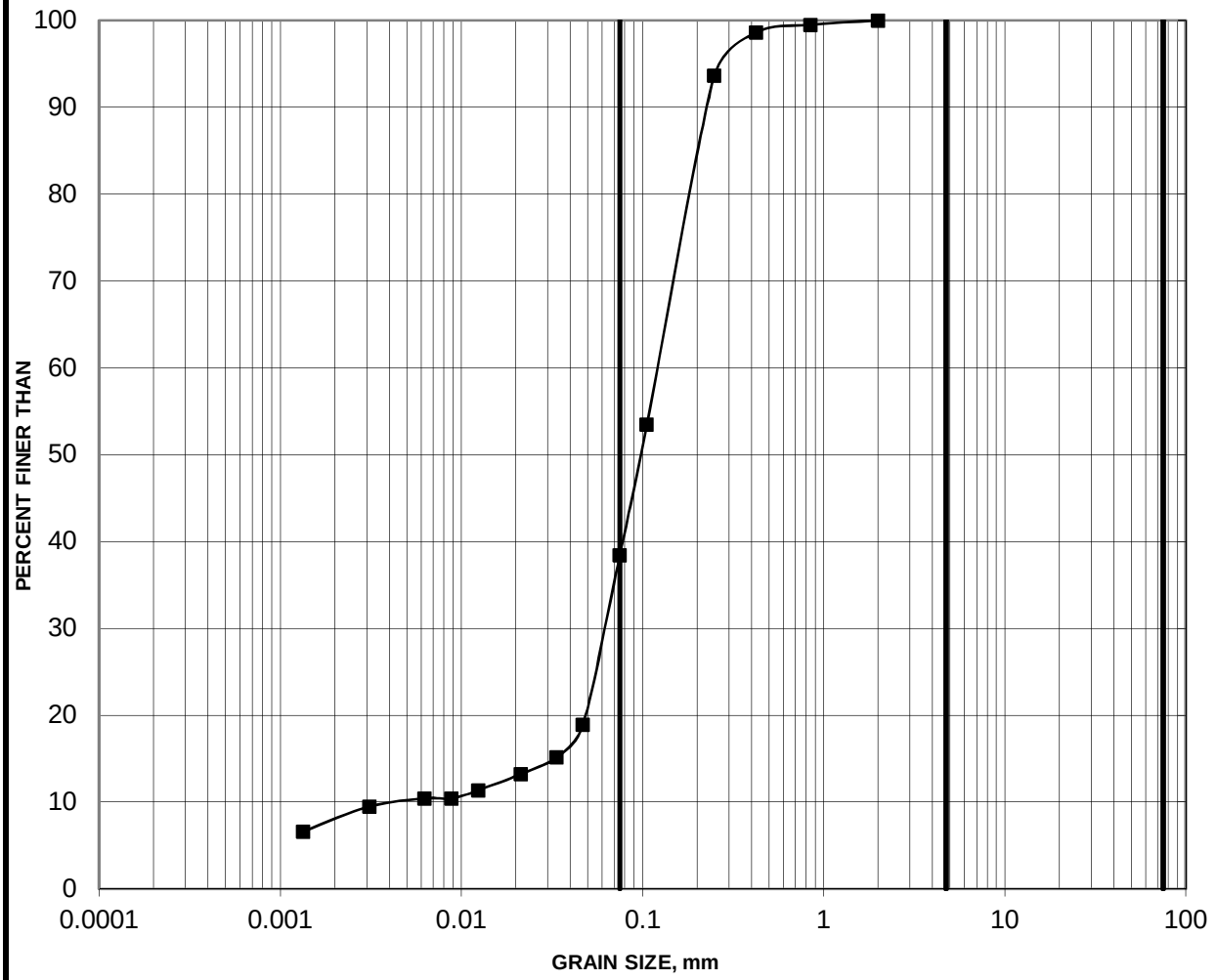
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B11

SILTY SAND



Borehole	Sample	Depth (m)
19-406	15	9.14-9.75

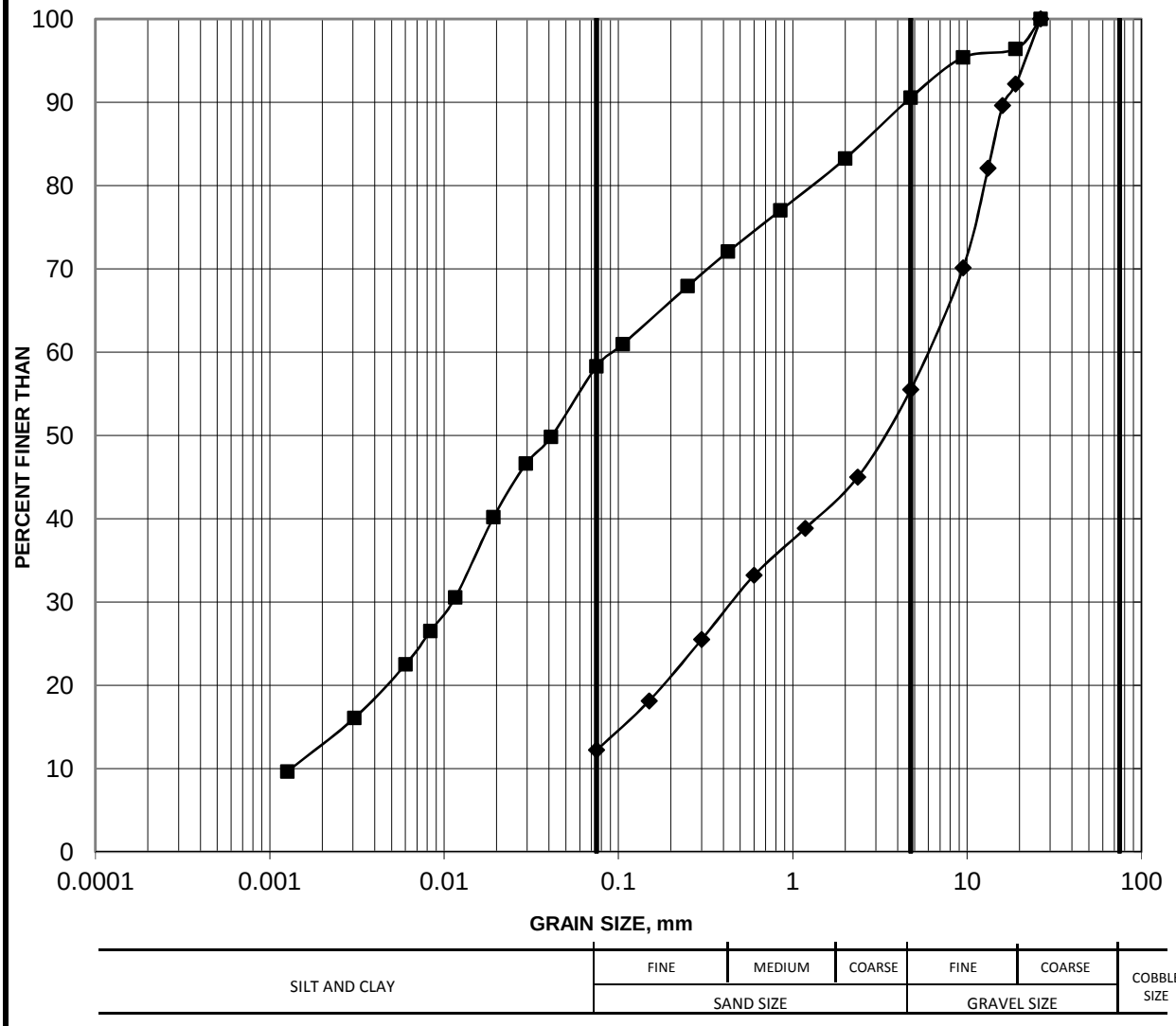
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B12

GLACIAL TILL



Borehole	Sample	Depth (m)
19-405	9	6.10-6.71
19-406	16B	10.06-10.36

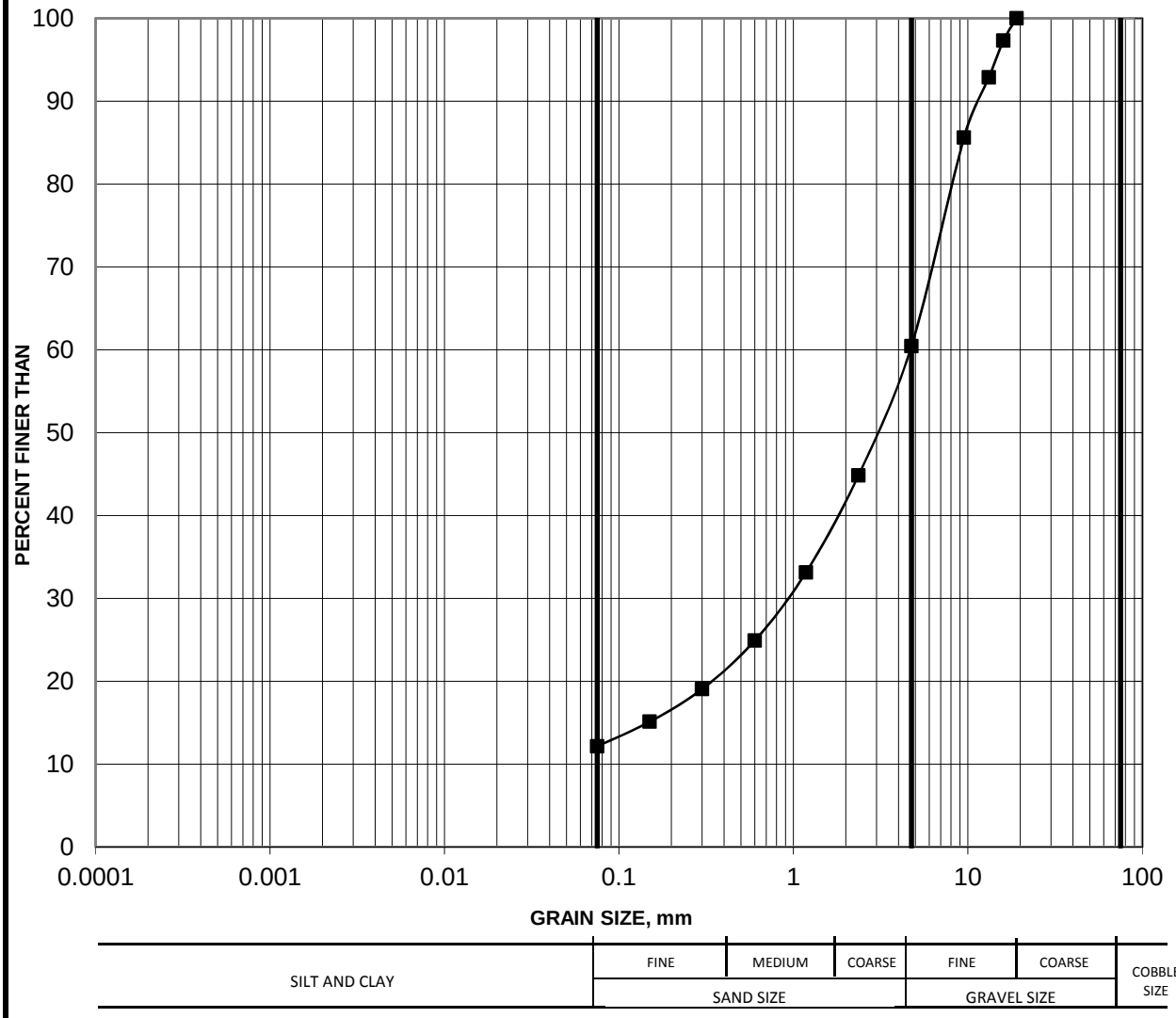
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B13

SAND AND GRAVEL (FILL)



Borehole	Sample	Depth (m)
19-407	1	0.30-0.76

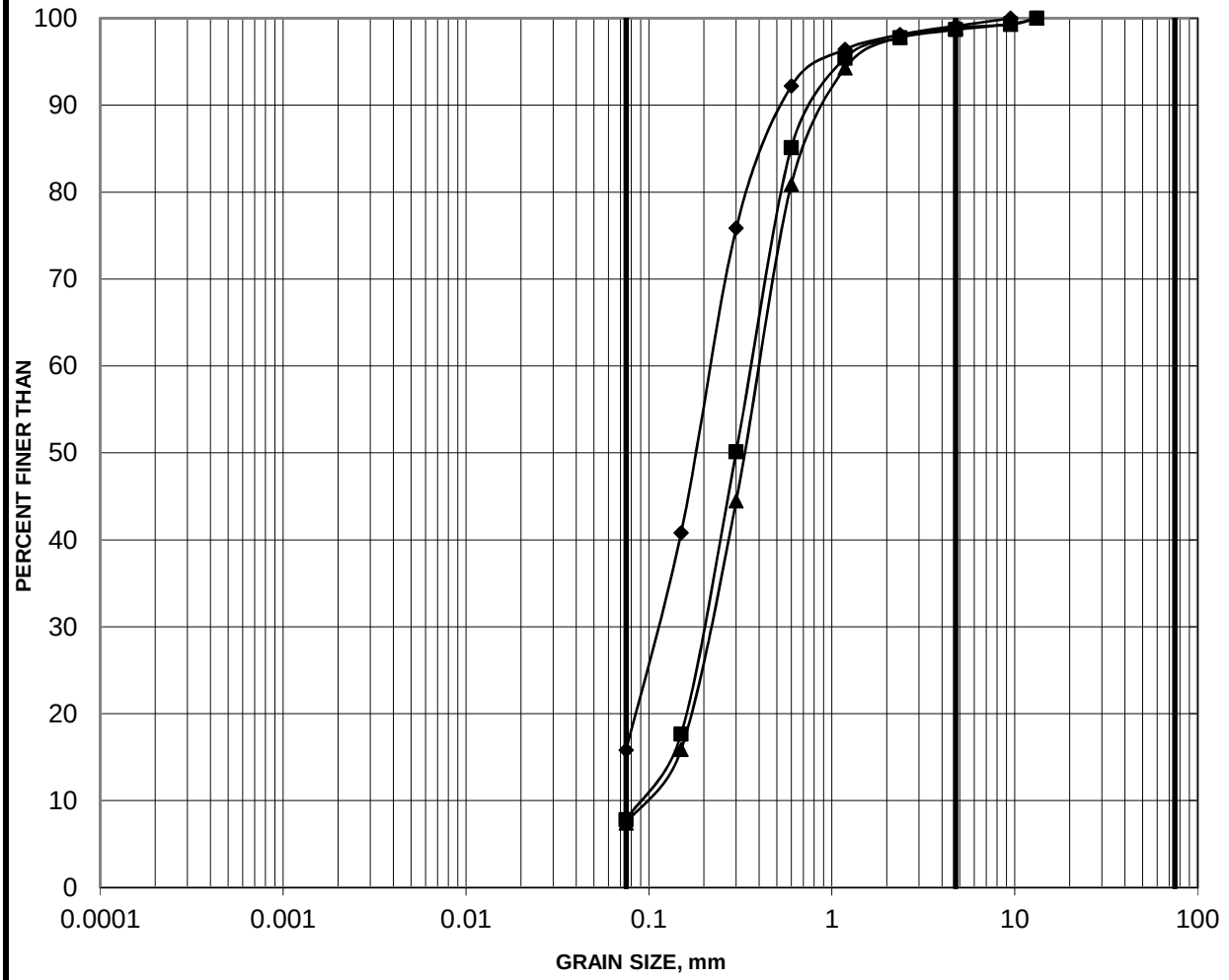
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B14

SAND (FILL)



Borehole	Sample	Depth (m)
19-407	4	2.29-2.90
19-408	2	1.52-2.13
19-408	7	5.33-5.94

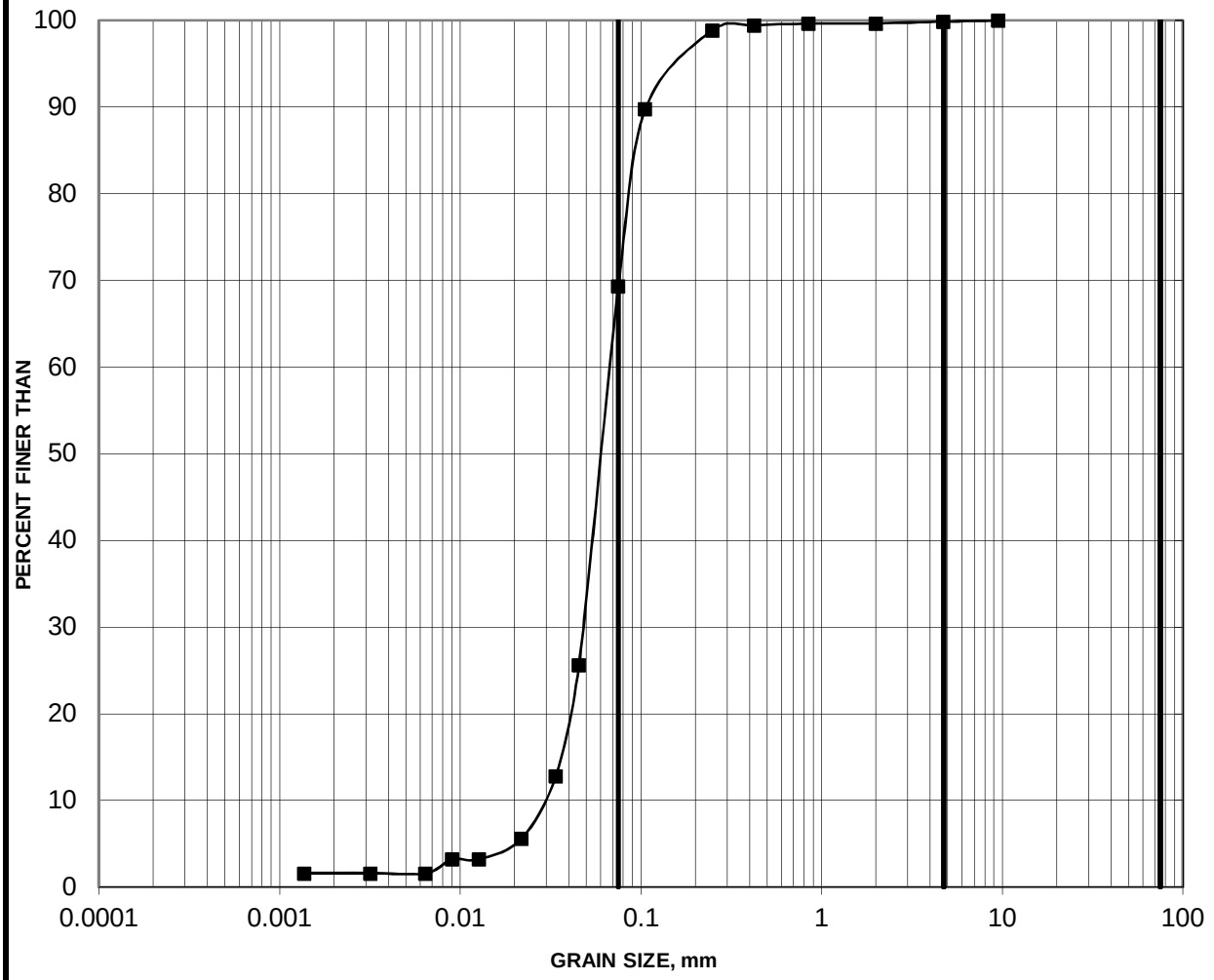
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B15

SANDY SILT



Borehole	Sample	Depth (m)
19-407	12	8.38-8.99

Project: 1655214/1400

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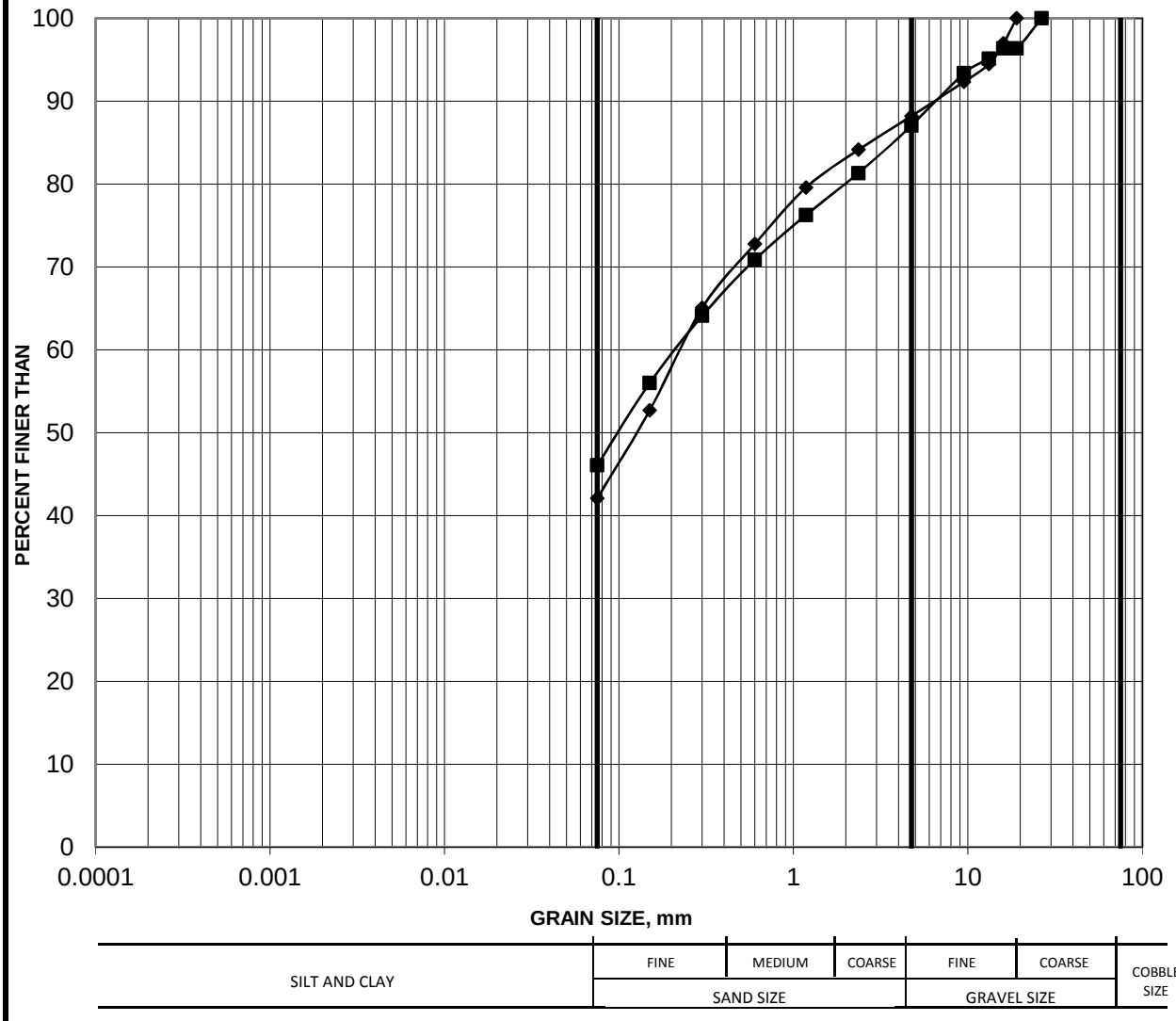
Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B16

GLACIAL TILL



Borehole	Sample	Depth (m)
19-407	13	9.14-9.75
19-408	11	8.38-8.99

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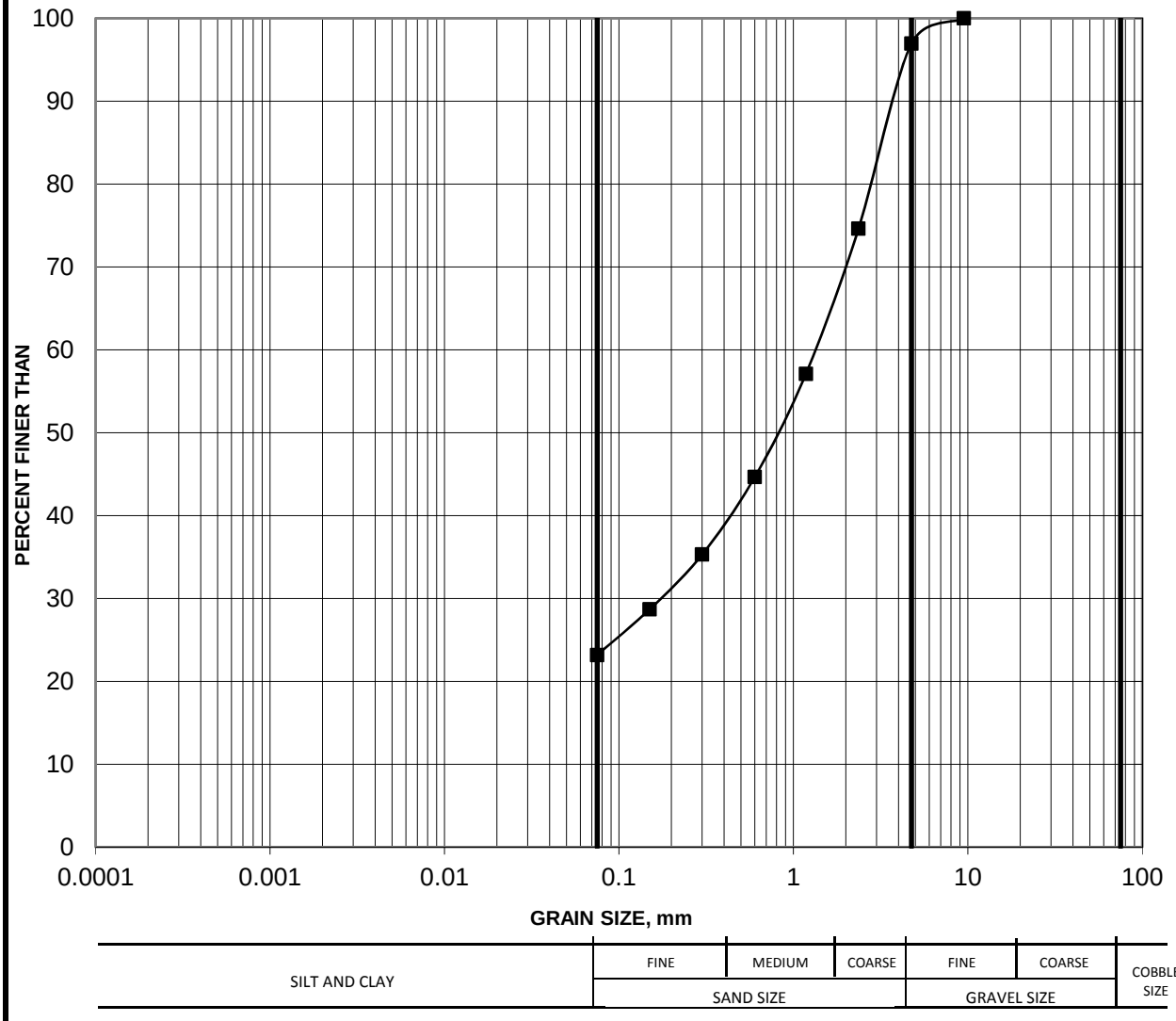
Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B17

SILTY SAND (FILL)



Borehole	Sample	Depth (m)
19-410	1	0.76-1.40

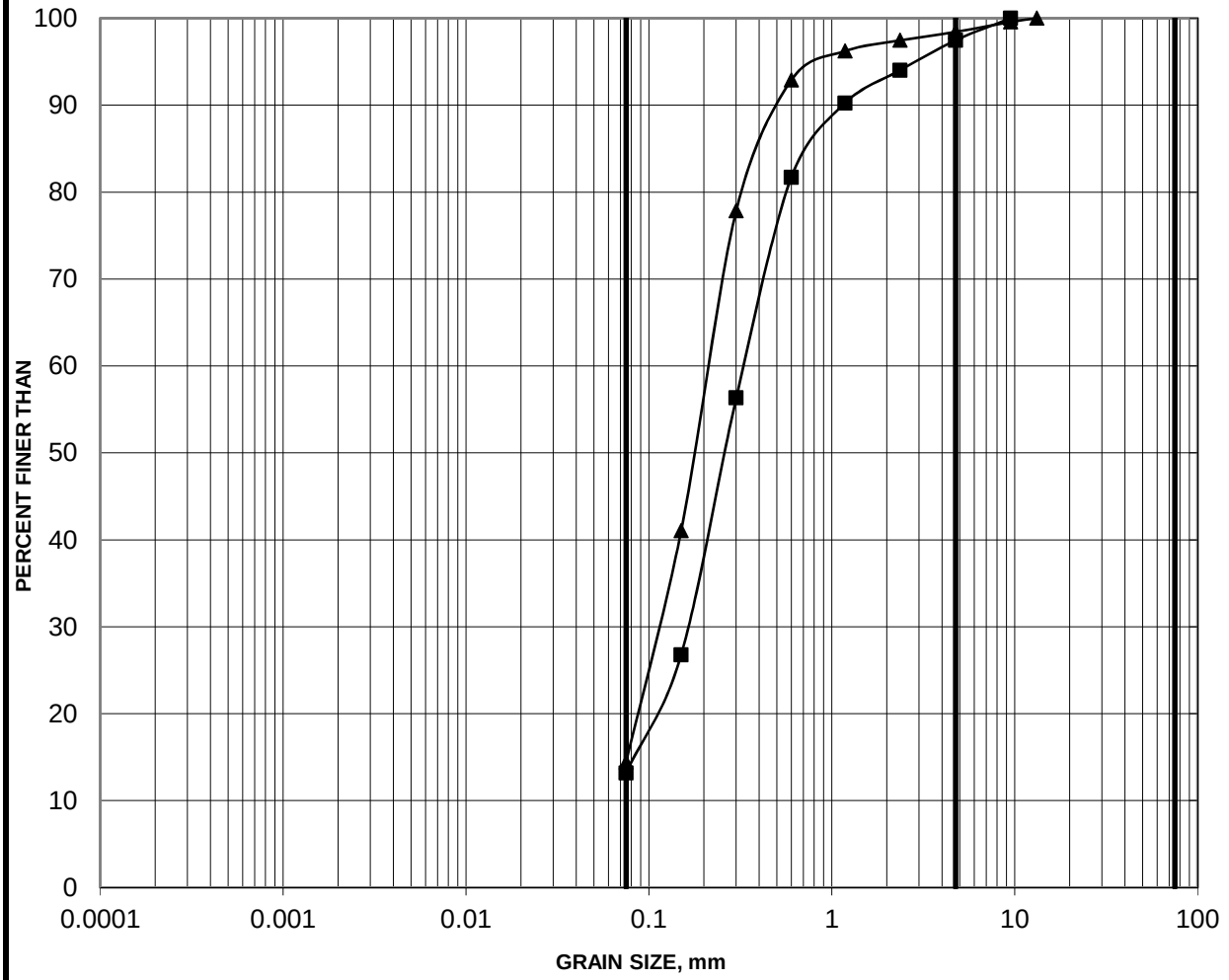
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B18

SAND (FILL)



Borehole	Sample	Depth (m)
19-409	4	2.29-2.90
19-410	3	2.29-2.90

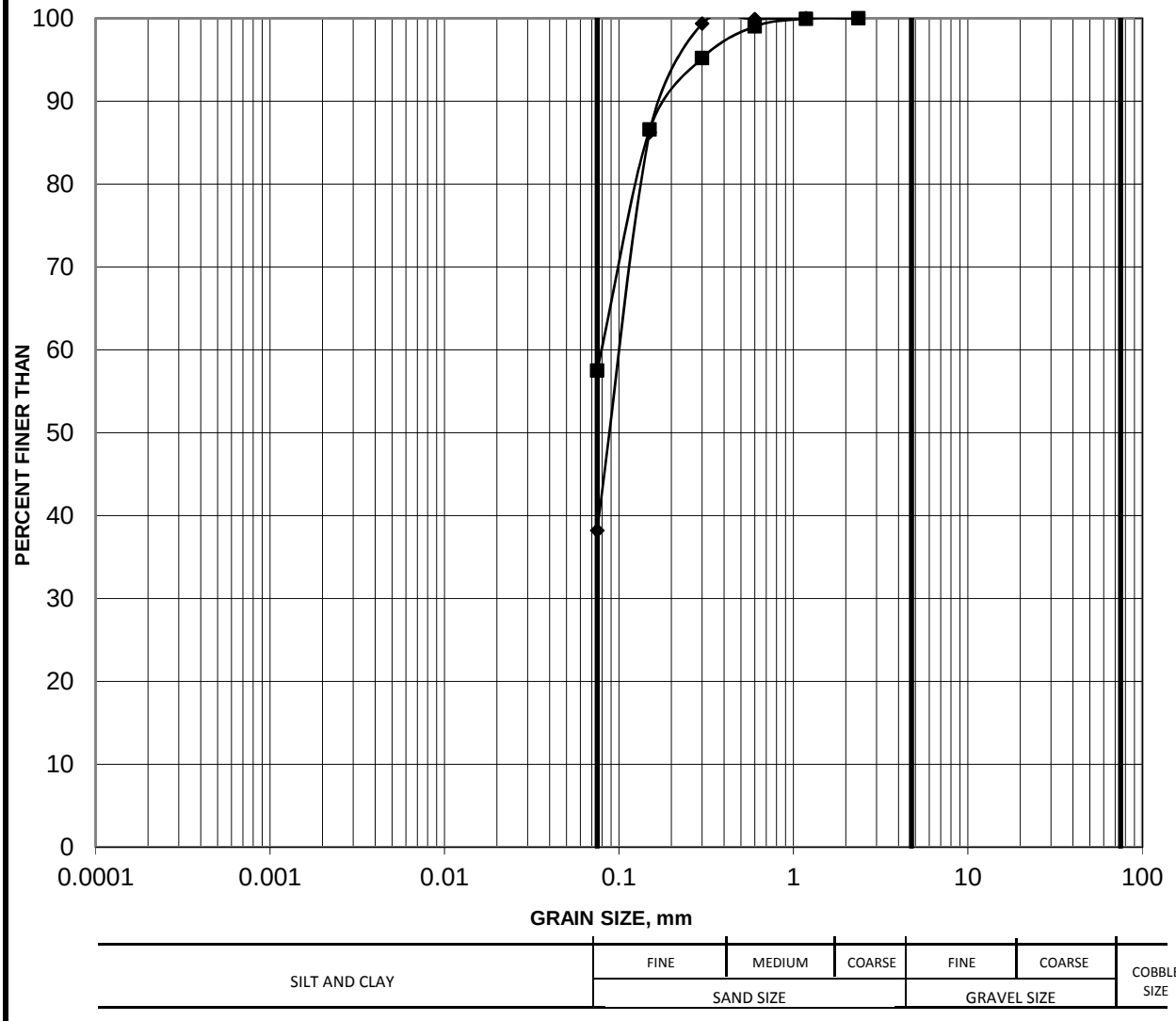
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION	FIGURE B19

SILT AND SAND



Borehole	Sample	Depth (m)
19-409	8	5.33-5.94
19-410	7	5.33-5.94

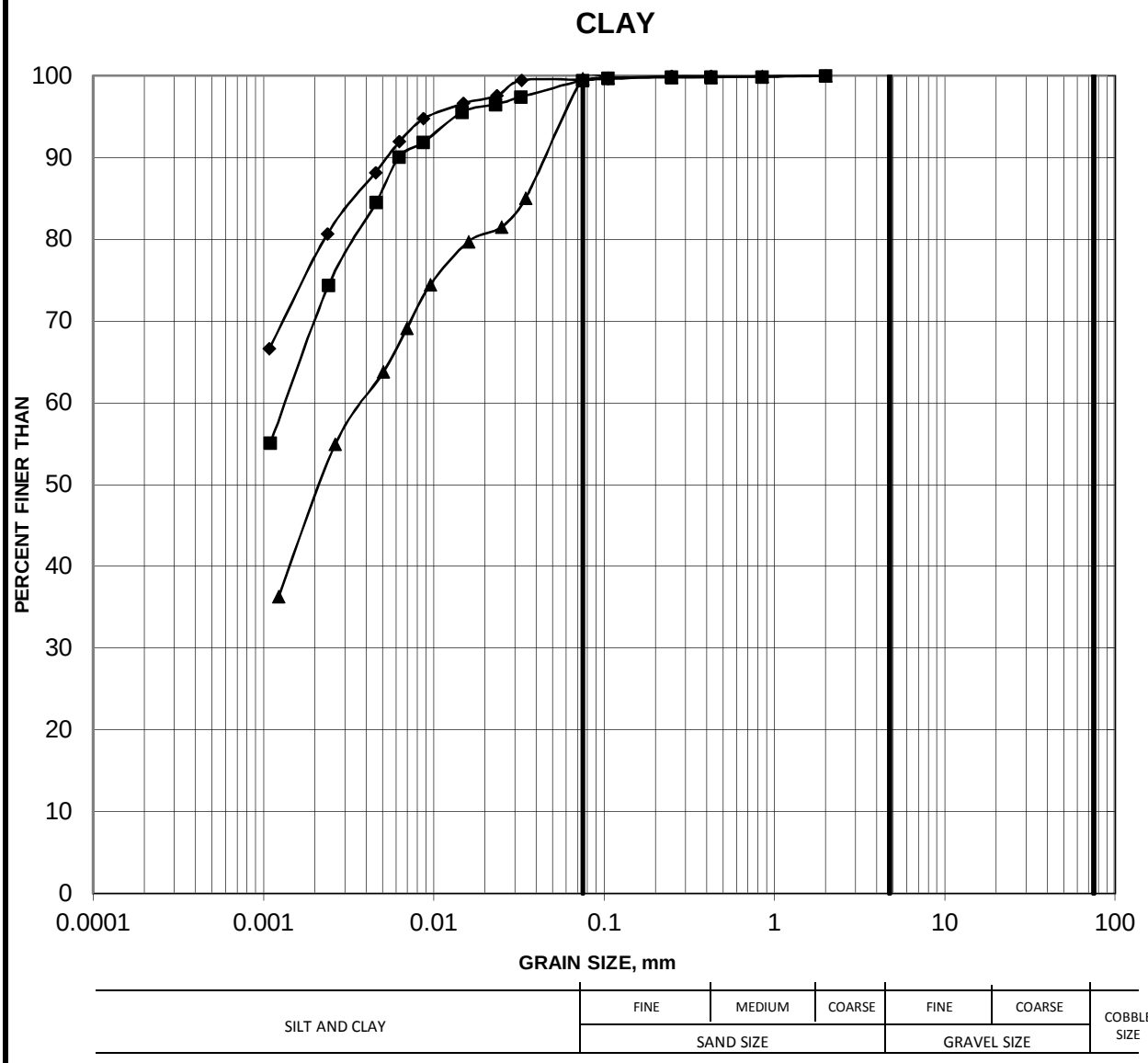
Project: 1655214/1400

Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION

FIGURE B20



Borehole	Sample	Depth (m)
19-409	10	6.86-7.47
19-410	9	6.86-7.47
19-410	11	9.14-9.75

Project: 1655214/1400

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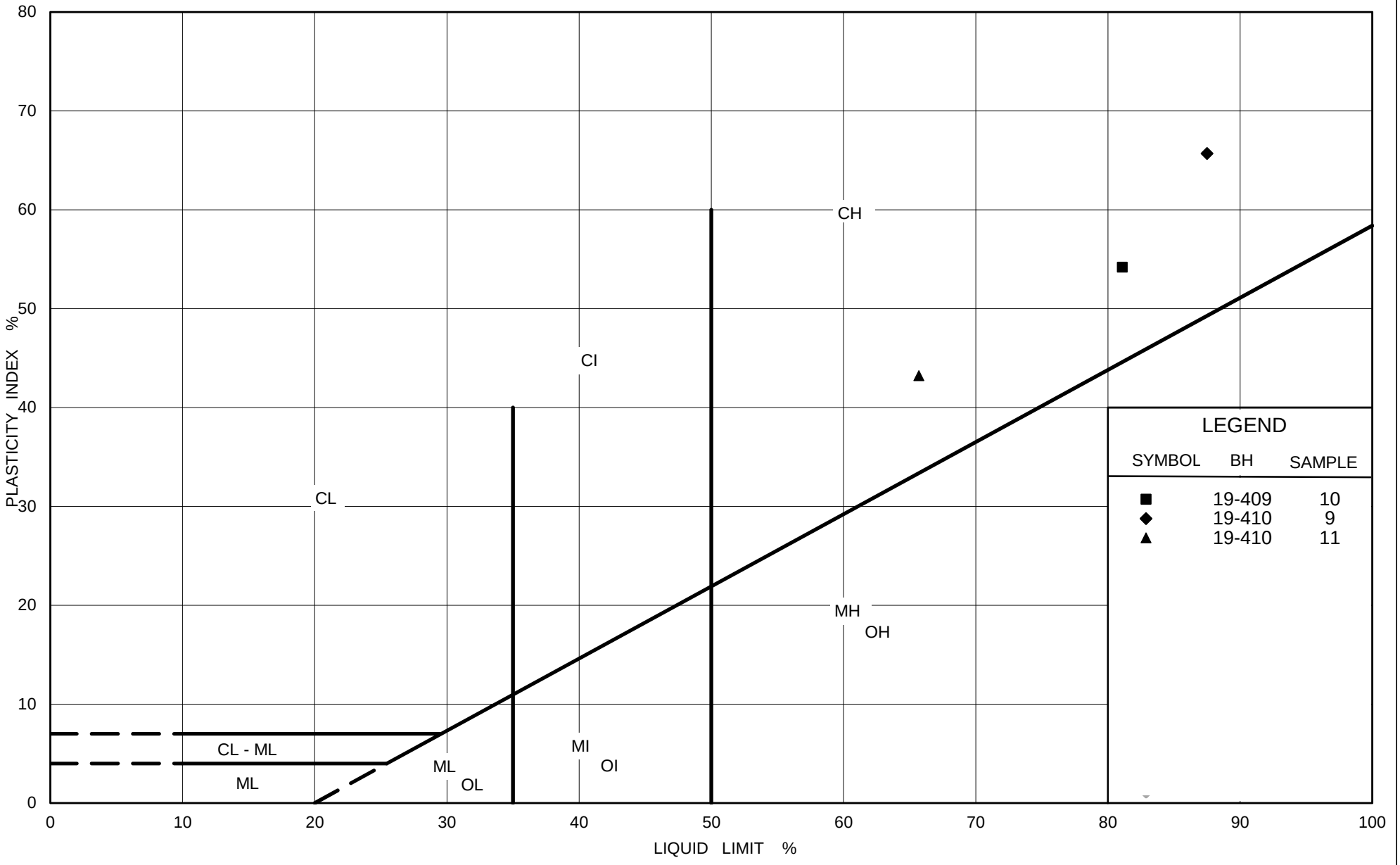

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PLASTICITY CHART
CLAY

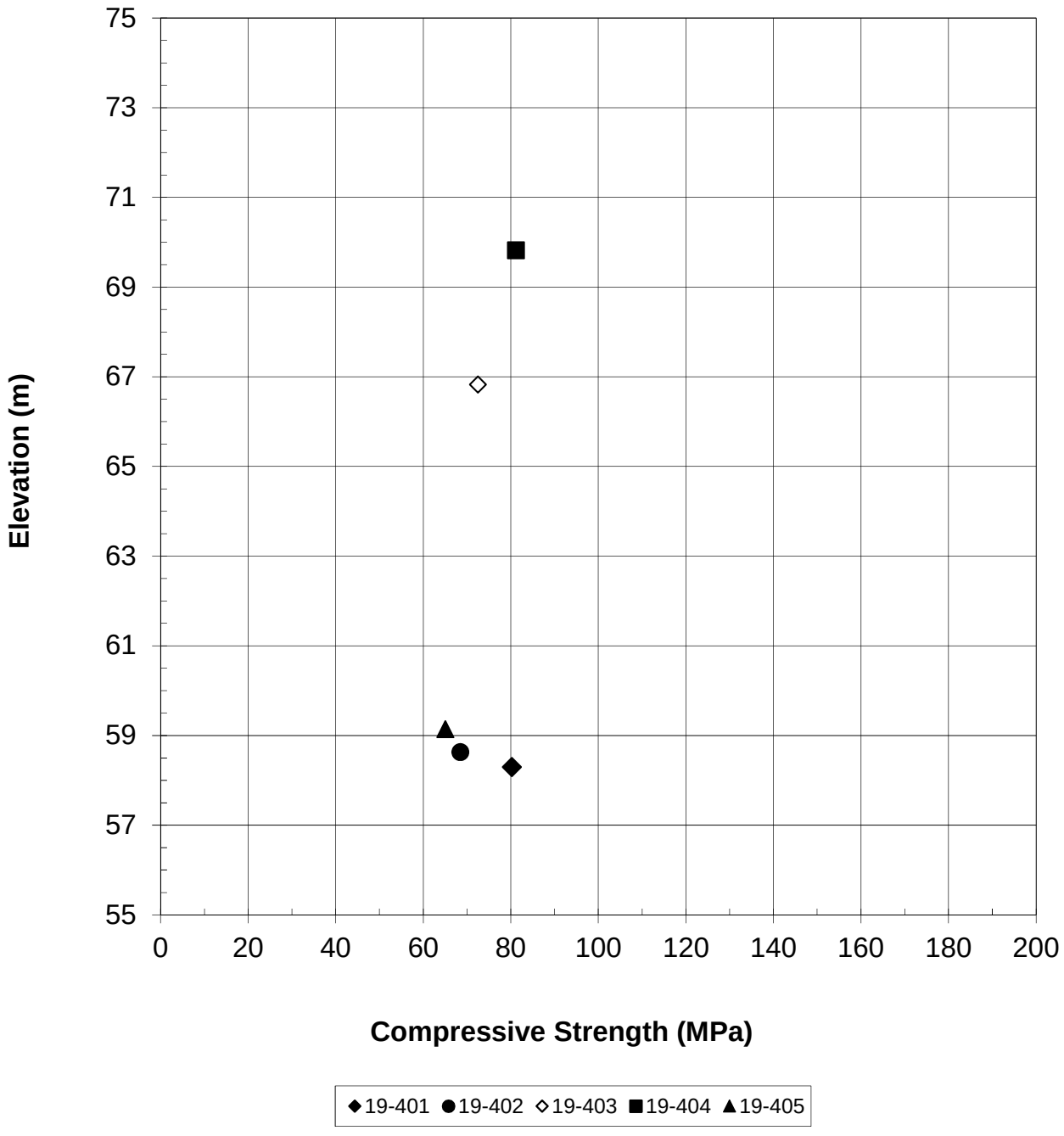
FIG No. B21

Project No. 1655214/1400

Compiled By : CW Checked By : MI

SUMMARY OF LABORATORY COMPRESSIVE STRENGTH
UNCONFINED COMPRESSION TESTS

FIGURE B22



Project: 1655214/1400

GOLDER

Created by: CW
Checked by: MI

APPENDIX C

Basic Chemical Analysis Results

Eurofins Report Numbers 1908450 and 1912180

Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1908450
Date Submitted: 2019-05-29
Date Reported: 2019-06-05
Project: 1655214/1400
COC #: 843943

				Lab I.D.	1429393
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2019-05-13
				Sample I.D.	14-405 sa8 17.5-19.5
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	SO4	0.01	%		<0.01
Cl in Concrete	Cl	0.002	%		0.032
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.56
	pH	2.00			8.31
	Resistivity	1	ohm-cm		1790

Guideline = *** = Guideline Exceedence**

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

Certificate of Analysis

eurofins | Environment Testing

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
.
Attention: Kenton Power
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1912180
Date Submitted: 2019-07-11
Date Reported: 2019-07-18
Project: 1655214/1400
COC #: 846092

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.			
					1440656 Soil 2019-06-16 19-401 sa 5	1440657 Soil 2019-06-19 19-404 sa 3	1440658 Soil 2019-06-20 19-406 sa 6	1440659 Soil 2019-06-17 19-407 sa 3
Anions	Cl	0.002	%		0.114	0.037	0.058	0.022
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.35	0.18	0.15	0.18
	pH	2.00			8.29	9.22	8.46	9.08
	Resistivity	1	ohm-cm		2860	5560	6670	5560
Others	SO4	0.01	%		0.02	0.02	<0.01	0.01

Group	Analyte	MRL	Units	Guideline	Lab I.D. / Sample Matrix / Sample Type / Sampling Date / Sample I.D.
					1440660 Soil 2019-06-20 19-410 sa 5
Anions	Cl	0.002	%		0.038
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.17
	pH	2.00			8.55
	Resistivity	1	ohm-cm		5880
Others	SO4	0.01	%		<0.01

Guideline = *** = Guideline Exceedence**

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 D

Non-Standard Special Provisions

NSSP – Boulder/Obstructions During Excavation
NSSP – Control of Overburden Soil

NON-STANDARD SPECIAL PROVISIONS

RECOMMENDED WORDING FOR "NSSP – 902.07.05 EXCAVATION"

Subsection 902.07.05 of OPSS 902 is amended by the addition of the following:

Excavations at the site may be impeded by obstructions within the existing fill and glacial till. The contractor shall be prepared to dislodge and remove these obstructions and extend the excavations to the design depths.

RECOMMENDED WORDING FOR "NSSP CONTROL OF OVERBURDEN SOILS"

Excavations for the caisson installation will be advanced through granular fill materials, various interlayers of granular native material through/into glacial till and into the limestone bedrock at some locations. The granular soils could slough (if dry) or flow (if water-bearing) into unsupported auger holes during caissons installation. Appropriate construction procedures and equipment will be required to minimize ground loss during drilling, caisson installation and concrete placement.

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