



April 2016

REPORT ON

Foundation Investigation Tri-Chord Overhead Signs Highway 417 (East) Ottawa, Ontario W.P. 4184-15-01

Submitted to:

Ontario Ministry of Transportation
1355 John Counter Boulevard
Kingston, Ontario
K7L 5A3

REPORT



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TRI-CHORD OVERHEAD SIGNS, HWY 417 (EAST)
OTTAWA, ONTARIO

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PART A

FOUNDATION INVESTIGATION REPORT
TRI-CHORD OVERHEAD SIGNS
HIGHWAY 417 (EAST)
OTTAWA, ONTARIO
W.P. 4184-15-01



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the design and construction of proposed replacement overhead sign structures on Highway 416 and Highway 417 in Ottawa, Ontario.

The original assignment included foundation investigation at a total of 26 proposed replacement tri-chord overhead signs. This report presents the results of a foundation assessment conducted for eight of the overhead signs on Highway 417 between Parkdale Avenue and Nicholas Street. The approximate sign locations are shown on Drawings 1 to 3. The purpose of the investigation was to assess the subsurface conditions at the locations of the existing signs by borehole drilling and carrying out in-situ and laboratory testing on selected samples.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Work Item Order Form for Assignment No. 3 as part of Agreement No. 4014-E-0012 received on September 22, 2015, and in Golder's Work Item Quote Form and Understanding of Scope documents submitted on September 22, 2015 and approved by MTO on September 29, 2015.



2.0 SITE DESCRIPTION

2.1 General

The locations of the existing tri-chord overhead signs that are to be replaced are along eastbound and westbound Highway 417 between Parkdale Avenue and Nicholas Street in Ottawa, Ontario. The proposed sign locations are shown on Drawings 1 to 3 and are summarized in the following table:

Sign Number		Highway	Sign Description
Golder	MTO		
06	417-121.7	417 (Westbound)	Island Park Dr., Carling Ave., Kirkwood Ave (Advanced) / Parkdale Ave. (Exit)
07	417-121.3	417 (Westbound)	Parkdale Ave. (Advanced)
10	417-118.4	417 (Westbound)	Bronson Ave. (Advanced) / Metcalfe St., Catherine St. (Exit)
11	417-118.1	417 (Westbound)	417 West / Metcalfe St., Catherine St. (Advanced)
13	417-121.4	417 (Eastbound)	Rochester St. (Advanced)
14	417-120.6	417 (Eastbound)	Bronson Ave. (Advanced) / Rochester St. (Exit)
18	417-117.9	417 (Eastbound)	Nicholas St., Gatineau, Lees Ave. (Advanced)
19	417-117.6	417 (Eastbound)	Riverside Dr., Vanier Pkwy. (Advanced) / Nicholas St., Lees Ave. (Exit)

In the area of interest, Highway 417 is generally constructed on embankments ranging in height from about 2 to 6 m above the natural ground surface.

2.2 Regional Geology

This area of Highway 417 lies within the physiographic region known as the Ottawa Valley Clay Flats adjacent to the Ottawa River, as delineated in The Physiography of Southern Ontario¹.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silty clay and silt that were deposited within the 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.¹

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*. Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.



3.0 INVESTIGATION PROCEDURES

The subsurface investigation for the proposed tri-chord overhead sign replacements was carried out between September 30 and October 28, 2015. During that time, a total of 15 boreholes were advanced at the locations of the proposed sign foundations as part of the overall assignment. This report addresses nine of the boreholes put down at the eight proposed sign locations listed in Section 2.1.

The boreholes were advanced adjacent to or within the shoulder or median lane using 108 mm inside diameter continuous-flight hollow-stem augers with a truck-mounted drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths of up to about 10.7 m below the existing pavement/ground surface in the overburden. Where encountered within the upper 7 m, the boreholes were then cored about 3 m into the bedrock using NQ-size coring equipment.

Soil samples in the boreholes were obtained at vertical intervals of about 0.76 to 1.52 m, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. In situ vane testing (using an MTO N-size vane) was carried out within the cohesive deposits where possible.

The boreholes were backfilled with bentonite pellets mixed with native soils in the overburden, bentonite pellets in the bedrock, and compacted cold-patch asphalt at surface. The site conditions were restored following completion of work.

The field work was supervised by members of Golder's technical staff, who located the boreholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's laboratory facility in Ottawa for further examination. Index and classification tests consisting of grain size distributions, Atterberg limits, and water contents were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength tests were carried out on selected rock core samples in Golder's Mississauga laboratory. All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

The borehole locations were determined by Golder in relation to the existing signs, based on information on the proposed sign locations provided by MTO. The plan location and ground surface elevation at each borehole was surveyed by Golder using a precision GPS survey unit. The boreholes and locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized in the following table and are shown on Drawings 1 to 3.



FOUNDATION REPORT
TRI-CHORD OVERHEAD SIGNS, HWY 417 (EAST)
OTTAWA, ONTARIO

Borehole Number	Sign Number		Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Golder	MTO	Northing (m)	Easting (m)		
15-06A	06	417-121.7	5029079.8	365617.4	70.7	5.4
15-07A	07	417-121.3	5029307.2	366012.4	76.7	8.7
15-10A	10	417-118.4	5030541.0	368615.6	73.1	10.6
15-11A	11	417-118.1	5030673.9	368885.3	74.2	10.4
15-13A	13	417-121.4	5029386.8	366196.8	76.5	8.3
15-13B			5029374.7	366202.7	76.1	8.9
15-14A	14	417-120.6	5029511.3	366539.1	67.3	8.4
15-18A	18	417-117.9	5030617.9	368781.6	74.6	10.4
15-19A	19	417-117.6	5030795.3	369086.9	68.9	10.7

Notes: 1) Northing and Easting coordinates shown are relative to the MTM NAD83 (Zone 9) coordinate system.
2) Ground surface elevations shown are relative to Geodetic Datum.



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Subsurface Conditions

The detailed subsurface soil, bedrock and groundwater conditions encountered in the boreholes advanced as part of this investigation, together with the results of related in-situ and laboratory testing, are given on the Record of Borehole and Drillhole sheets contained in Appendix A. The results of geotechnical laboratory testing carried out as part of this investigation are also included in Figures B1 to B7, in Appendix B.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous 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.

In general, the subsurface conditions at the site consist of pavement structure and embankment fill overlying silt and sand which is, in turn, underlain by silty clay and dolostone or limestone bedrock.

The following table summarizes the subsurface conditions encountered at the borehole locations, and a more detailed description of the soils and bedrock is provided in the subsections that follow.

Sign Number		Borehole Number(s)	Summary of Subsurface Conditions Encountered in Boreholes
Golder	MTO		
06	417-121.7	15-06A	Asphaltic concrete is underlain by 1.0 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by dolostone bedrock. The bedrock surface is at about Elevation 69.4 m. Bedrock was proven to a depth of about 5.4 m (Elevation 65.3 m) below the existing Highway 417 grade.
07	417-121.3	15-07A	Asphaltic concrete is underlain by 0.5 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by 3.8 m of embankment fill. A deposit of sandy silt about 1.4 m thick was encountered below the embankment fill to a depth of about 6.0 m and is underlain by limestone bedrock. The bedrock surface is at about Elevation 70.7 m. Bedrock was proven to a depth of about 8.7 m (Elevation 68.0 m) below the existing Highway 417 grade.
10	417-118.4	15-10A	Asphaltic concrete is underlain by 0.3 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by 5.7 m of embankment fill. A layer of about 200 mm of silt and sand containing organics (topsoil) was encountered below the embankment fill. Silty sand was encountered beneath the topsoil to a depth of 7.6 m and is underlain by silty clay. The borehole was terminated within the silty clay at a depth of 10.6 m (Elevation 62.5 m) below the existing Highway 417 grade.
11	417-118.1	15-11A	Asphaltic concrete is underlain by 0.4 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by about 6.1 m of embankment fill consisting of sand with trace gravel and silt. A 0.6 m thick layer of silt and sand containing organics (topsoil) was encountered under the embankment fill, which is underlain by 0.7 m of silty sand. The silty sand is underlain by silty clay that was proven to a depth of 10.4 m (Elevations 63.8 m) below the existing Highway 417 grade.



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TRI-CHORD OVERHEAD SIGNS, HWY 417 (EAST)
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Sign Number		Borehole Number(s)	Summary of Subsurface Conditions Encountered in Boreholes
Golder	MTO		
13	417-121.4	15-13A, 15-13B	Asphaltic concrete is underlain by 0.2 m to 0.5 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by about 3.3 m to 4.7 m of embankment fill. A 0.5 m thick layer of silt and sand containing organics and rootlets (topsoil) was encountered beneath the embankment fill in Borehole 15-13A. Glacial till was encountered below the fill and topsoil and was proven to refusal to augering at depths of 8.3 m and 8.9 m (Elevation 68.2 and 67.2 m) below the existing Highway 417 grade.
14	417-120.6	15-14A	Asphaltic concrete is underlain by 0.6 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by embankment fill consisting of silty sand with varying amounts of gravel and clay as well as other deleterious material (e.g. concrete and brick pieces). The borehole was terminated within the embankment fill at auger refusal, encountered at a depth of 8.4 m (Elevation 58.9 m) below the existing Highway 417 grade.
18	417-117.9	15-18A	Asphaltic concrete is underlain by 0.4 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by 7.0 metres of sand embankment fill. A 1.6 m thick layer of silty sand was encountered below the embankment fill. Silty clay was encountered below the silty sand to the termination of the borehole at a depth of 10.4 m (Elevation 64.2 m) below the existing Highway 417 grade.
19	417-117.6	15-19A	Asphaltic concrete is underlain by 0.4 m of granular base and subbase consisting of gravelly sand which is, in turn, underlain by 2.4 m of sand and gravelly sand embankment fill. The embankment fill is underlain by silty clay to the termination of the borehole at a depth of 10.7 m (Elevation 58.2 m) below the existing Highway 417 grade.

4.1.1 Pavement Structure and Embankment Fill

Boreholes 15-06A, 15-07A, 15-10A, and 15-11A were advanced through the pavement structure of the westbound median lane of Highway 417. Boreholes 15-13A, 15-14A, 15-18A, and 15-19A were advanced through the pavement structure of the eastbound median lane of Highway 417. Borehole 15-13B was advanced through the pavement structure of the eastbound shoulder lane of Highway 417. The pavement structure generally consists of 300 to 400 mm of asphaltic concrete overlying up to about 0.2 to 1.0 m of gravelly sand fill.

With the exception of at Borehole 15-06A, the pavement structure in the boreholes is underlain by granular embankment fill which generally consists of silty sand, silty clay, and clayey silt with varying amounts of gravel. The embankment fill contains cobbles, boulders, ash, and asphaltic concrete pieces. The embankment fill was penetrated at depths ranging from about 3.1 to 7.8 m below the existing roadway surface. The embankment fill in borehole 15-14A was not fully penetrated but was proven to a depth of about 8.4 m below the existing roadway surface.



The Standard Penetration Test (SPT) “N” values measured within the embankment fill range from 4 to greater than 100 blows per 0.3 m of penetration, indicating loose to very dense relative density. More generally, the SPT “N” values are typically 20 blows per 0.3 m of penetration or greater, indicating a compact to very dense relative density. The higher blow counts recorded in the fill likely reflects the presence of the cobbles and boulders rather than the relative density of the soil matrix.

The results of grain size distribution testing carried out on samples of fill are shown on Figures B1 to B3 in Appendix B.

Atterberg limit determination testing carried out on one sample of the fines portion of the clayey embankment fill gave a plasticity index value of about 15 percent and a liquid limit value of about 28 percent, indicating that the tested sample consists of silty clay of low plasticity. The measured water contents of 30 samples of the embankment fill range from 2 and 35 percent.

4.1.2 Sand and Silt (Topsoil)

A layer of buried topsoil consisting of sand and silt that contains organics was encountered below the embankment fill in boreholes 15-10A, 15-11A, and 15-13A. The topsoil has a thickness ranging from about 0.2 to 0.6 m and was encountered to depths ranging from about 4.6 to 7.5 m (Elevation 66.6 to 71.9 m) below the existing Highway 417 grades.

The measured water contents of three samples of the topsoil range from 18 and 51 percent.

The results of grain size distribution testing carried out on one sample of the sand and silt topsoil are shown on Figure B4 in Appendix B.

4.1.3 Sand and Silt

A deposit of silty sand to sandy silt, exists beneath the embankment fill and topsoil (where encountered) in Boreholes 15-07A, 15-10A, 15-11A, and 15-18A at depths ranging from about 4.6 to 7.8 m and was encountered to depths ranging from about 6.0 to 9.4 m (Elevations 65.2 to 70.7 m) below the existing ground surface.

The SPT “N” values measured within the silty sand to sandy silt deposit range from 6 to 17 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The measured water contents of five samples of the silty sand to sandy silt range from about 19 to 26 percent.

The results of grain size distribution testing carried out on one sample of the sand and silt are shown on Figure B4 in Appendix B.

4.1.4 Silty Clay to Clay

A deposit of silty clay to clay was encountered beneath the embankment fill, and/or native sand and silt in Boreholes 15-10A, 15-11A, 15-18A and 15-19A. Where encountered, the clay deposit was proven to depths of about 10.4 m to 10.7 m below the existing Highway 417 grades (Elevations 58.2 m to 64.2 m).

The full depth of the clay encountered in Boreholes 15-10A and 15-18A, and the upper portion of the clay in Boreholes 15-11A and 15-19A has been weathered to a grey brown crust. The weathered crust has a thickness ranging from about 0.9 m to greater than 3.0 m. The weathered deposit contains trace amounts of sand.



The clay encountered below the depth of weathering in Boreholes 15-11A and 15-19A is grey in colour. The grey clay was proven to depths ranging from about 10.4 and 10.7 m below the existing ground surface.

The SPT “N” values measured within the weathered clay crust range from 1 to 6 blows per 0.3 m of penetration indicating a stiff to very stiff consistency. The SPT “N” values measured within the clay below the depth of weathering range from ‘weight of hammer’ to 3 blows per 0.3 m of penetration. In situ vane testing carried out within the clay below the depth of weathering gave undrained shear strength ranging from 42 to greater than 96 kilopascals indicating a firm to very stiff consistency. Atterberg limit determination testing carried out on four samples of the clay deposit gave plasticity index values ranging from about 29 to 68 percent and liquid limit values ranging from about 68 to 94 percent, indicating that the tested samples consist of clay of a high plasticity. The measured water content of the deposit ranged from approximately 48 to 71 percent.

The results of grain size distribution testing carried out on five samples of the clay are shown on Figure B5 in Appendix B.

4.1.5 Glacial Till

A deposit of glacial till consisting of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand was encountered beneath the embankment fill and topsoil (where encountered) in Boreholes 15-013A and 15-13B at a depth of about 4.6 and 5.2 m. The glacial till was proven to a depth of about 8.3 and 8.9 m (Elevation 68.2 and 67.2 m) below the existing ground surface.

The SPT “N” value of measured within the glacial till range from 10 to greater than 50 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The higher SPT “N” values within this deposit (i.e. greater than 50 blows per 0.3 m of penetration) may reflect the presence of cobbles and/or boulders within the deposit.

The results of grain size distribution testing carried out on four samples of glacial till are shown on Figure B6 in Appendix B.

The measured water content of seven samples of the glacial till range from about 7 to 9 percent.

4.1.6 Auger Refusal and Bedrock

SPT sampler and auger refusal was encountered in Boreholes 15-13A, 15-13B, and 15-14A at depths ranging from about 8.3 to 8.9 m below the existing ground surface. Bedrock was encountered beneath the pavement structure, embankment fill, and silty sand to sandy silt (where encountered) at Boreholes 15-06A and 15-07A where it was cored in NQ-size between about 4.1 m and 2.7 m, respectively. Boreholes 15-10A, 15-11A, 15-18A, and 15-19A were terminated within the overburden at the target depth.

The following table summarizes the bedrock surface depths and elevations as encountered at the borehole locations. The bedrock surface elevation varies at each proposed foundation location.



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TRI-CHORD OVERHEAD SIGNS, HWY 417 (EAST)
OTTAWA, ONTARIO

Borehole Number	Sign Number		Existing Ground Surface Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)
	Golder	MTO			
15-06A	06	417-121.7	70.7	1.3	69.4
15-07A	07	417-121.3	76.7	6.0	70.7
15-10A	10	417-118.4	73.1	N/A ⁽²⁾	N/A ⁽²⁾
15-11A	11	417-118.1	74.2	N/A ⁽²⁾	N/A ⁽²⁾
15-13A	13	417-121.4	76.5	8.3	68.2 ⁽¹⁾
15-13B			76.1	8.9	67.2 ⁽¹⁾
15-14A	14	417-120.6	67.3	8.4	58.9 ⁽¹⁾
15-18A	18	417-117.9	74.6	N/A ⁽²⁾	N/A ⁽²⁾
15-19A	19	417-117.6	68.9	N/A ⁽²⁾	N/A ⁽²⁾

Notes: 1) Bedrock surface inferred from auger refusal encountered within the borehole.

2) Bedrock not encountered within the advancement depth.

The bedrock encountered in Borehole 15-06A consists of dark grey dolostone bedrock. The dolostone bedrock is fresh, thinly to thickly bedded, fine to medium grained, non-porous, and medium strong. The bedrock encountered in Borehole 15-07A consists of dark grey limestone bedrock. The limestone bedrock is fresh, thinly to medium bedded, fine to medium grained, non-porous, and strong with black shale partings, laminations and thin interbeds of shale.

The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples typically ranged from about 27 to 97 percent, but were typically between about 60 and 100 below the upper metre of bedrock, indicating fair to excellent quality rock. The discontinuities observed in the rock core were associated with the joints, veins, faults and fractures of the bedrock.

Laboratory unconfined compressive strength testing was carried out on a selected specimen of the bedrock core from Borehole 15-06A. The results of the testing carried out on one sample of the dolostone bedrock indicate unconfined compressive strength of about 66 MPa, which correspond to strong rock (Canadian Foundation Engineering Manual, 2006). The results of the unconfined compressive strength tests are provided on Figure B7 in Appendix B.

4.1.7 Groundwater Conditions

Due to access constraints, the field work was carried out at night and the boreholes were backfilled before stabilized water levels were established. The elevations of the base of the weathered clay crust at the borehole locations give some indication of the inferred groundwater level and are summarized in the table below:



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TRI-CHORD OVERHEAD SIGNS, HWY 417 (EAST)
OTTAWA, ONTARIO

Borehole Number	Sign Number		Existing Ground Surface Elevation (m)	Bottom of Weathered Crust of Clay Deposit	
	Golder	MTO		Estimated Depth (m)	Estimated Elevation (m)
15-06A	06	417-121.7	70.7	N/A ⁽¹⁾	N/A ⁽¹⁾
15-07A	07	417-121.3	76.7	N/A ⁽¹⁾	N/A ⁽¹⁾
15-10A	10	417-118.4	73.1	>10.6 ⁽²⁾	<62.3 ⁽²⁾
15-11A	11	417-118.1	74.2	9.1	65.1
15-13A	13	417-121.4	76.5	N/A ⁽¹⁾	N/A ⁽¹⁾
15-13B			76.1	>8.9 ⁽²⁾	<67.2 ⁽²⁾
15-14A	14	417-120.6	67.3	N/A	N/A
15-18A	18	417-117.9	74.6	>10.4 ⁽²⁾	<64.2 ⁽²⁾
15-19A	19	417-117.6	68.9	4.6	64.3

Notes: 1) Stabilized or inferred groundwater level not observed in borehole.

2) Groundwater level inferred to be below termination depth of borehole.

It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.



5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Alex Meacoe, P.Eng. and Mr. Matt Kennedy, P.Eng., geotechnical engineers with Golder. Mr. Fin Heffernan, P.Eng., the Designated MTO Foundations Contact for this assignment, conducted an independent review of this report.

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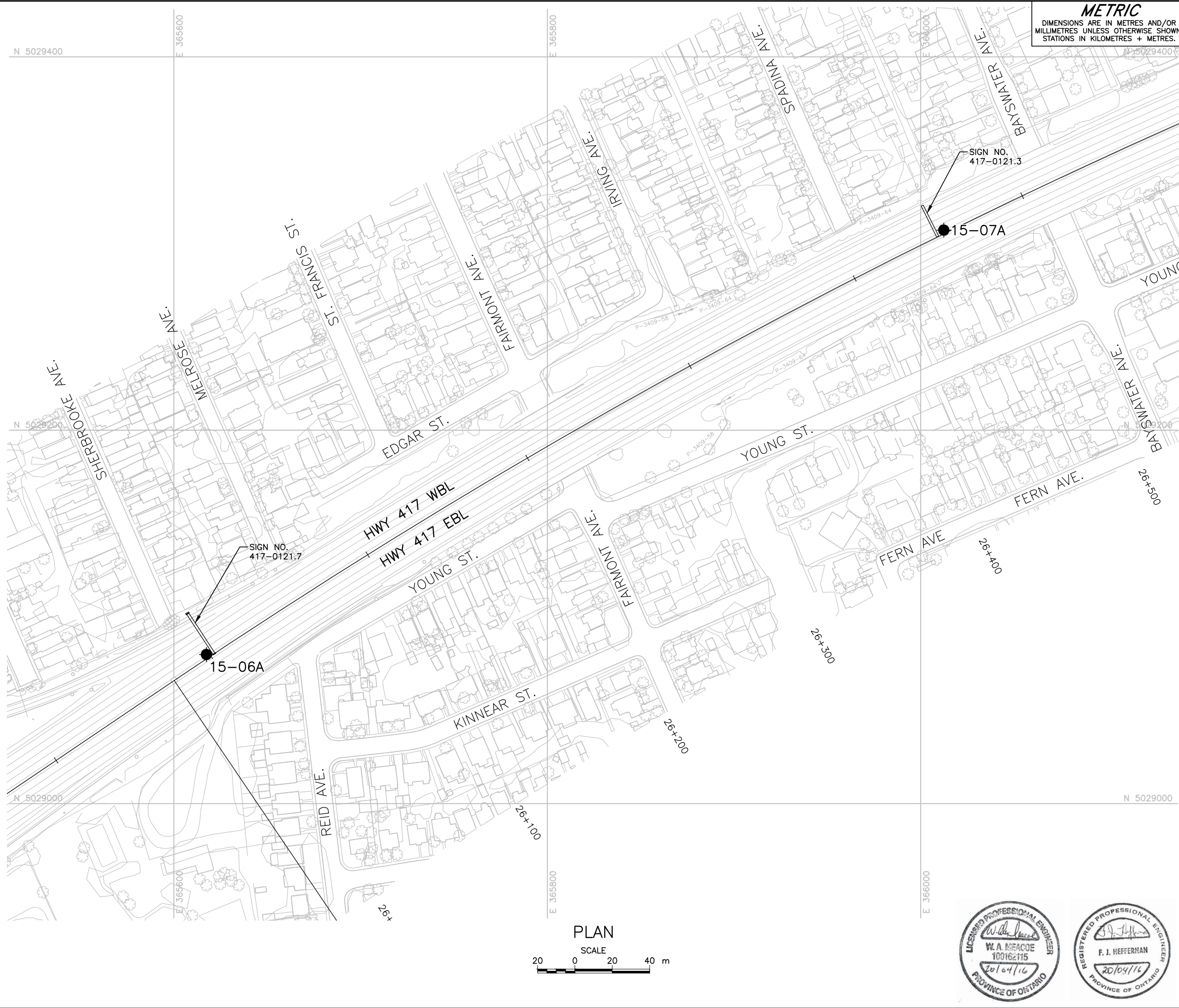


Fin Heffernan, P.Eng.
Designated MTO Foundations Contact



WAM/MJK/FJH/ob

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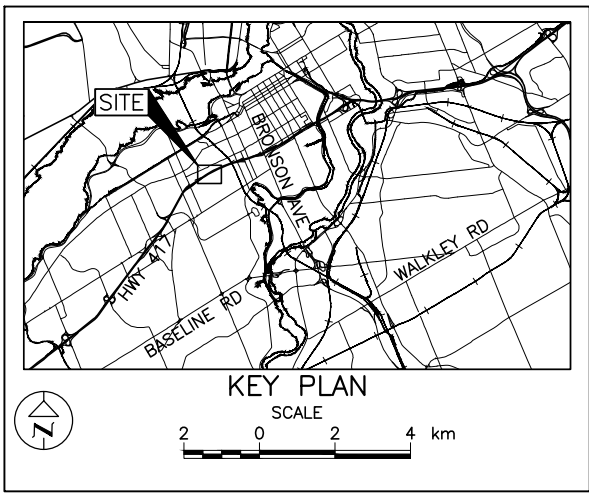


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.4184-15-01

TRI-CHORD OVERHEAD SIGNS
HIGHWAY 417 (EAST)
BOREHOLE LOCATIONS
1413191-1020-002-001

SHEET



LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
15-06A	70.7	5029079.8	365617.4
15-07A	76.7	5029307.2	366012.4
15-10A	73.1	5030541.0	368615.6
15-11A	74.2	5030673.9	368885.3
15-13A	76.5	5029386.8	366196.8
15-13B	76.1	5029374.7	366202.7
15-14A	67.3	5029511.3	366539.1
15-18A	74.6	5030617.9	368781.6
15-19A	68.9	5030795.3	369086.9

NOTES

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

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

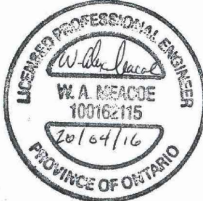
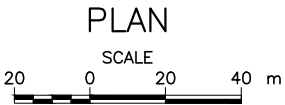
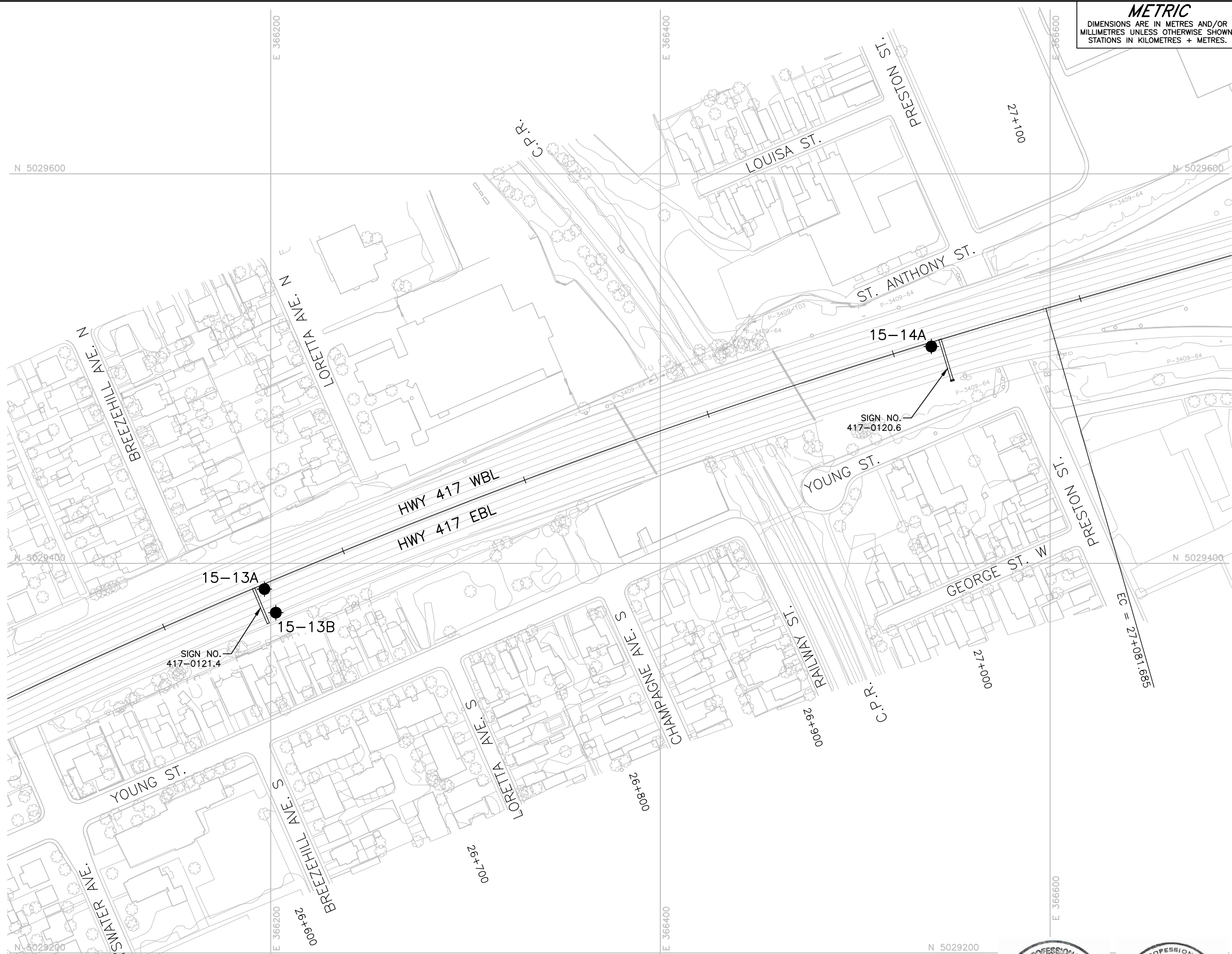
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. bc52-417-2a.dwg and bc52-417-2b.dwg, received Dec. 07, 2015.



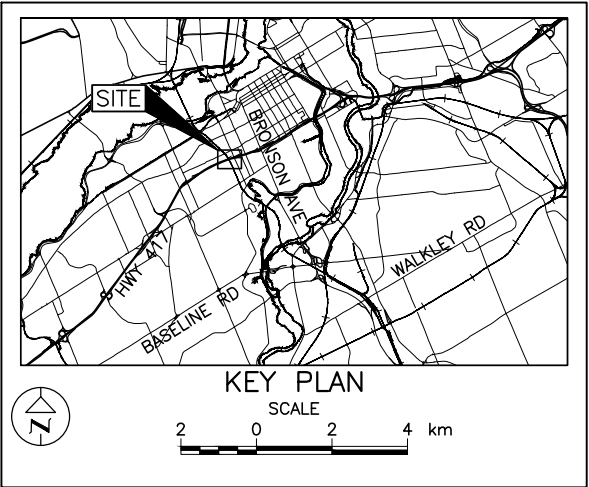
NO.	DATE	BY	REVISION
Geocres No. 3165-272			
HWY. 417	PROJECT NO. 1413191		DIST. EASTERN
SUBM'D. MJK	CHKD. MJK	DATE: 12/10/2015	SITE: .
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1



CONT No.
WP No.4184-15-01

TRI-CHORD OVERHEAD SIGNS
HIGHWAY 417 (EAST)
BOREHOLE LOCATIONS
1413191-1020-002-002

SHEET



LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
15-06A	70.7	5029079.8	365617.4
15-07A	76.7	5029307.2	366012.4
15-10A	73.1	5030541.0	368615.6
15-11A	74.2	5030673.9	368885.3
15-13A	76.5	5029386.8	366196.8
15-13B	76.1	5029374.7	366202.7
15-14A	67.3	5029511.3	366539.1
15-18A	74.6	5030617.9	368781.6
15-19A	68.9	5030795.3	369086.9

NOTES

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

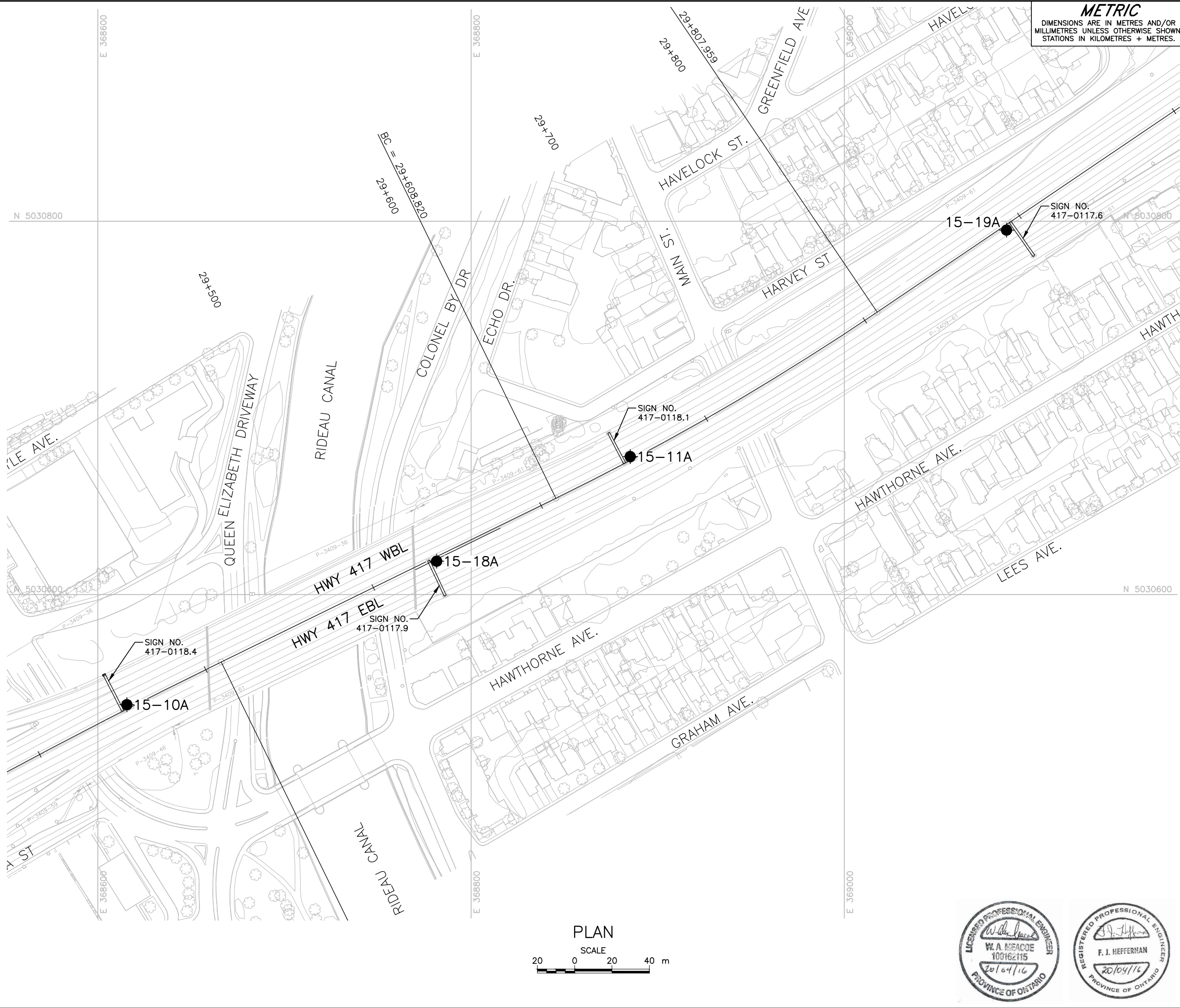
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. bc52-417-2a.dwg and bc52-417-2b.dwg, received Dec. 07, 2015.

NO.	DATE	BY	REVISION
Geocres No. 31G5-272			
HWY. 417	PROJECT NO. 1413191		DIST. EASTERN
SUBM'D. MJK	CHKD. MJK	DATE: 12/10/2015	SITE: .
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 2



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

CONT No.
WP No.4184-15-01

TRI-CHORD OVERHEAD SIGNS
HIGHWAY 417 (EAST)
BOREHOLE LOCATIONS
1413191-1020-002-003

SHEET

KEY PLAN
SCALE
2 0 2 4 km

LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
15-06A	70.7	5029079.8	365617.4
15-07A	76.7	5029307.2	366012.4
15-10A	73.1	5030541.0	368615.6
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15-13A	76.5	5029386.8	366196.8
15-13B	76.1	5029374.7	366202.7
15-14A	67.3	5029511.3	366539.1
15-18A	74.6	5030617.9	368781.6
15-19A	68.9	5030795.3	369086.9

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by MTO, drawing file nos. bc52-417-2a.dwg and bc52-417-2b.dwg, received Dec. 07, 2015.



NO.	DATE	BY	REVISION
Geocres No. 31G5-272			
HWY. 417	PROJECT NO. 1413191		DIST. EASTERN
SUBM'D. MJK	CHKD. MJK	DATE: 12/10/2015	SITE: .
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 3



APPENDIX A

Borehole and Drillhole Records

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		III. SOIL DESCRIPTION		
AS	Auger sample	(a) Cohesionless Soils		
BS	Block sample	Density Index (Relative Density)		N
CS	Chunk sample			<u>Blows/300 mm</u>
DO or DP	Seamless open-ended, driven or pushed tube samplers			<u>Or Blows/ft.</u>
DS	Denison type sample		Very loose	0 to 4
FS	Foil sample		Loose	4 to 10
RC	Rock core		Compact	10 to 30
SC	Soil core		Dense	30 to 50
SS	Split spoon sampler		Very dense	over 50
ST	Slotted tube	(b) Cohesive Soils		
TO	Thin-walled, open	C_u or S_u		
TP	Thin-walled, piston	Consistency		
WS	Wash sample		<u>kPa</u>	<u>Psf</u>
DT	Dual tube sample		Very soft	0 to 12
DD	Diamond drilling		Soft	12 to 25
			Firm	25 to 50
			Stiff	50 to 100
			Very stiff	100 to 200
			Hard	Over 200
				Over 4,000
II. PENETRATION RESISTANCE		IV. SOIL TESTS		
Standard Penetration Resistance (SPT), N:		w	Water content	
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.).		w _p or PL	Plastic limited	
		w _l or LL	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	
Dynamic Cone Penetration Resistance (DCPT); N_d:		D _R	Relative density	
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive an uncased 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).		DS	Direct shear test	
		G _s	Specific gravity	
		M	Sieve analysis for particle size	
		MH	Combined sieve and hydrometer (H) analysis	
		MPC	Modified Proctor compaction test	
		SPC	Standard Proctor compaction test	
		OC	Organic content test	
		SO ₄	Concentration of water-soluble sulphates	
		UC	Unconfined compression test	
		UU	Unconsolidated undrained triaxial test	
		V	Field vane test (LV-laboratory vane test)	
		γ	Unit weight	
Cone Penetration Test (CPT):		Note:	¹ Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.	
An electronic cone penetrometer with a 60° conical tip and a projected 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 (u) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.				

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density 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_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p or τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u or 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:

$$^1 \tau = c' + \sigma' \tan \phi'$$

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of rock material 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 texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very Thickly Bedded	> 2 m
Thickly Bedded	0.6 m to 2m
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	< 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very Wide	> 3 m
Wide	1 – 3 m
Moderately Close	0.3 – 1 m
Close	50 – 300 mm
Very Close	< 50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

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

CORE CONDITION

Total Core Recovery

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including naturally occurring fractures but not including mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

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

Description and Notes

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

Abbreviations

BD -	Bedding	PY -	Pyrite
FO -	Foliation/Schistosity	Ca -	Calcite
CL -	Clean	PO -	Polished
SH -	Shear Plane/Zone	K -	Slickensided
VN -	Vein	SM -	Smooth
FLT -	Fault	RO -	Ridged/Rough
CO -	Contact	ST -	Stepped
JN -	Joint	PL -	Planar
FR -	Fracture	IR -	Irregular
MB -	Mechanical Break	UN -	Undulating
BR -	Broken Rock	CU -	Curved
BL -	Blast Induced	TCA -	To Core Axis
Il -	Parallel To	STR -	Stress Induced
OR -	Orthogonal		

PROJECT <u>1413191</u>		RECORD OF BOREHOLE No 15-06A		SHEET 1 OF 2		METRIC	
G.W.P. <u>4184-15-01</u>		LOCATION <u>N 5029079.8 ; E 365617.4</u>		ORIGINATED BY <u>RI</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem), Rotary Drill NQ Core</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>		DATE <u>October 8, 2015</u>		CHECKED BY <u>MJK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						WATER CONTENT (%)			
70.7	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALTIC CONCRETE																
70.4																	
0.3	Gravelly sand (FILL) Grey																
70.0																	
0.7	Gravelly sand, some silt (FILL) Compact Brown Moist		1	SS	27												29 56 (15)
69.4																	
1.3	Dolostone (BEDROCK) Bedrock cored from depths of 1.3 m to 5.4 m For bedrock coring details refer to Record of Drillhole 15-06A		1	RC	REC 100%												RQD = 27%
			2	RC	REC 100%												RQD = 97%
			3	RC	REC 100%												RQD = 90%
65.3																	
5.4	END OF BOREHOLE																

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PROJECT: 1413191

RECORD OF DRILLHOLE: 15-06A

SHEET 2 OF 2

LOCATION: N 5029079.8 ; E 365617.4

DRILLING DATE: October 8, 2015

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
						TOTAL CORE %	SOLID CORE %			DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1	W2		W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
		Continued from Record of Borehole 15-06A		69.38																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

UCS = 65.6 MPa

DEPTH SCALE

1 : 50



LOGGED: RI

CHECKED: MJK

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\416_417_OVERHEADSIGNS_IDA02_DATA\GINT\1413191\1413191.GPJ GAL-MISS.GDT 01/28/16 JM

PROJECT 1413191		RECORD OF BOREHOLE No 15-07A		SHEET 1 OF 2		METRIC															
G.W.P. 4184-15-01		LOCATION N 5029307.2; E 366012.4		ORIGINATED BY HEC																	
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), Rotary Drill NQ Core		COMPILED BY JM																	
DATUM Geodetic		DATE October 8, 2015		CHECKED BY MJK																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
76.7	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	25 50 75											
0.0	ASPHALTIC CONCRETE																				
76.4																					
0.3	Gravelly sand (FILL) Grey																				
75.9																					
75.6	Sand (FILL) Compact Brown Moist		1	SS	14																
75.0	Silty clay (FILL) Compact Grey-brown Moist		2	SS	17																
74.6	Sand (FILL) Compact Brown Moist																				
74.6	Sandy clayey silt (FILL) Very stiff Grey-brown Moist		3	SS	104																
73.5	Gravelly silty sand, trace clay (FILL) Very dense Brown Moist		4	SS	64/0.20																
73.5	Clayey silt, contains cobbles and metal fragments (FILL) Brown Moist		5	RC	DD																
72.1			6	SS	5																
72.1	Silty SAND, trace gravel Loose Brown Moist		7	SS	6																
70.7			8	SS	6																
70.7	Limestone (BEDROCK)																				
68.0	Bedrock cored from depths of 6.0 m to 8.7 m For bedrock coring details refer to Record of Drillhole 15-07A		1	RC	REC 100%																
68.0			2	RC	REC 97%																
68.0	END OF BOREHOLE																				

PROJECT: 1413191

RECORD OF DRILLHOLE: 15-07A

SHEET 2 OF 2

LOCATION: N 5029307.2 ;E 366012.4

DRILLING DATE: October 8, 2015

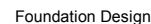
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
						RECOVERY		R.Q.D. %	FRACT. INDEX PER 100	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	W1		W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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		Continued from Record of Borehole 15-07A		70.69																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								



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

PROJECT <u>1413191</u>		RECORD OF BOREHOLE No 15-11A		SHEET 1 OF 2		METRIC	
G.W.P. <u>4184-15-01</u>		LOCATION <u>N 5030673.9; E 368885.3</u>		ORIGINATED BY <u>HEC</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>		DATE <u>October 5, 2015</u>		CHECKED BY <u>MJK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								<div><div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div></div><div><div>+ FIELD VANE</div><div>× REMOULDED</div></div></div>				<div><div>W_p</div><div>W</div><div>W_L</div></div>				
74.2	GROUND SURFACE						20	40	60	80	100					
0.0	ASPHALTIC CONCRETE															
73.8																
0.4	Gravelly sand, angular (FILL) Grey Moist															
73.4																
0.8	Sand, trace gravel and silt (FILL) Dense to very dense Brown Moist		1	SS	47											
			2	SS	78											
			3	SS	42											
			4	SS	61											
			5	SS	65											
			6	SS	59											
			7	SS	87											
68.1																
6.1	Sand (FILL) Compact Brown Moist		8	SS	27											
67.3																
6.9	Silt and sand, contains organic matter (TOPSOIL) Loose Dark brown to dark grey Moist		9	SS	7											
66.7																
7.5	SILTY SAND to Sandy SILT Compact Grey-brown Wet		10	SS	15											
66.0																
8.2	SILTY CLAY to CLAY, trace sand Very stiff Grey-brown, highly fissured Wet		11	SS	3											
65.1																
9.1	SILTY CLAY to CLAY Very stiff Grey Moist		12	SS	WH											

Continued Next Page

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

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

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PROJECT 1413191		RECORD OF BOREHOLE No 15-13A		SHEET 1 OF 1		METRIC											
G.W.P. 4184-15-01		LOCATION N 5029386.8 ; E 366196.8		ORIGINATED BY RI													
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem)		COMPILED BY JM													
DATUM Geodetic		DATE October 4, 2015		CHECKED BY MJK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	25 50 75				
76.5	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
76.2																	
0.3	Gravelly sand, angular (FILL) Grey						76										
75.7																	
0.8	Sand (FILL) Compact Brown Moist		1	SS	29		75										
75.0																	
1.5	Mixture of silty sand, trace gravel and silty clay (FILL) Dense Brown Moist		2	SS	30												
			3	SS	31		74										0 73 (27)
73.5																	
3.1	Silty clay, trace sand (FILL) Grey-brown Moist		4	SS	32		73										
73.2																	
3.4	Gravelly silty sand, contains organic matter, ash and asphalt (FILL) Dense to compact Grey-brown to dark brown Moist		5	SS	20												
72.4																	
4.1	Sand and silt, contains organic matter and rootlets (TOPSOIL) Compact Black to dark brown Moist		6	SS	28		72										14 41 35 10
71.9																	
4.6	SILTY SAND, some gravel (TILL) Compact to dense Grey-brown Moist to wet		7	SS	19		71										
			8	SS	20		70										
			9	SS	10												19 41 27 13
							69										
			10	SS	39												
68.2																	
8.3	END OF BOREHOLE AUGER REFUSAL																

PROJECT 1413191		RECORD OF BOREHOLE No 15-13B		SHEET 1 OF 1		METRIC																		
G.W.P. 4184-15-01		LOCATION N 5029374.7 ; E 366202.7		ORIGINATED BY RI																				
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem)		COMPILED BY JM																				
DATUM Geodetic		DATE October 7, 2015		CHECKED BY MJK																				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
76.1	GROUND SURFACE																							
0.0	ASPHALTIC CONCRETE																							
75.8																								
75.6	Gravelly sand (FILL) Grey																							
0.5	Mixture of silty clay and sand (FILL) Compact Brown Moist		1	SS	17																			
			2	SS	21																			
			3	SS	16																			
73.1	Silty clay, trace sand (FILL) Very stiff Grey-brown Moist		4	SS	6																			
72.6																								
3.5	Gravelly silty sand, possible cobbles and boulders (FILL) Loose to dense Dark brown Moist		5	SS	54/0.8																			
			6	RC	DD																			
			7	SS	55/0.10																			
			8	RC	DD																			
70.9																								
5.2	Gravelly SAND, some silt (TILL) Compact to very dense Grey-brown Moist		9	SS	23																			
			10	SS	31																			
			11	SS	11																			
			12	SS	53/0.11																			
			13	SS	65																			
67.2																								
8.9	END OF BOREHOLE AUGER REFUSAL																							
	NOTES: 1. Open borehole dry upon completion of drilling.																							

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PROJECT 1413191		RECORD OF BOREHOLE No 15-14A		SHEET 1 OF 1		METRIC											
G.W.P. 4184-15-01		LOCATION N 5029511.3 ; E 366539.1		ORIGINATED BY HEC													
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem)		COMPILED BY JM													
DATUM Geodetic		DATE October 4, 2015		CHECKED BY MJK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	25 50 75				
67.3	GROUND SURFACE																
0.0	ASPHALTIC CONCRETE																
67.0																	
0.3	Gravelly sand, angular (FILL) Grey																
66.4																	
0.9	Sand, trace silt and gravel (FILL) Compact to very dense Brown Moist		1	SS	45												
			2	SS	54												
			3	SS	29												
64.3																	
3.1	Silty sand to sand, some silt (FILL)																
63.9	Compact to loose		4	SS	9												
3.4	Brown Moist																
	Silty sand, some clay, trace gravel (FILL)																
	Loose to compact		5	SS	11												
	Brown to grey-brown Wet																
			6	SS	4												
62.0																	
5.3	Silty sand, some gravel, contains concrete and brick pieces (FILL)		7	SS	25												
	Moist																
			8	SS	49												
60.6																	
6.7	Silty sand, trace gravel and clay, contains cobbles (FILL)		9	SS	38												
	Brown to black Moist																
59.8																	
7.5	Silty sand and gravel (FILL)																
	Dense to very dense		10	SS	80/0.22												
	Grey Moist																
58.9																	
8.4	END OF BOREHOLE AUGER REFUSAL		11	SS	50/0.03												

PROJECT <u>1413191</u>		RECORD OF BOREHOLE No 15-18A		SHEET 1 OF 2		METRIC	
G.W.P. <u>4184-15-01</u>		LOCATION <u>N 5030617.9; E 368781.6</u>		ORIGINATED BY <u>HEC</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>		DATE <u>October 6, 2015</u>		CHECKED BY <u>MJK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
								20	40	60	80	100								
74.6	GROUND SURFACE																			
0.0	ASPHALTIC CONCRETE																			
74.2																				
0.4	Gravelly sand, angular (FILL) Grey						74													
73.8																				
0.8	Sand, some gravel, contains wood pieces (FILL) Loose to compact Brown Moist		1	SS	15															
			2	SS	9															
72.3																				
2.3	Sand, trace gravel and silt, contains roots (FILL) Very dense Brown Moist		3	SS	79												3	89 (8)		
			4	SS	95															
			5	SS	66															
			6	SS	80												0	93 (7)		
			7	SS	67															
			8	SS	32															
			9	SS	54												0	95 (5)		
66.8																				
7.8	SILTY SAND, contains organic matter Compact Dark grey to black Wet		10	SS	21															
66.2																				
8.4	Layered SILTY SAND and Sandy SILT Compact Brown to grey Wet		11	SS	17															
65.2																				
9.4	SILTY CLAY to CLAY, trace sand Very stiff Grey-brown to grey, highly fissured Moist		12	SS	4															

Continued Next Page

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

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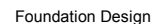


+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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



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

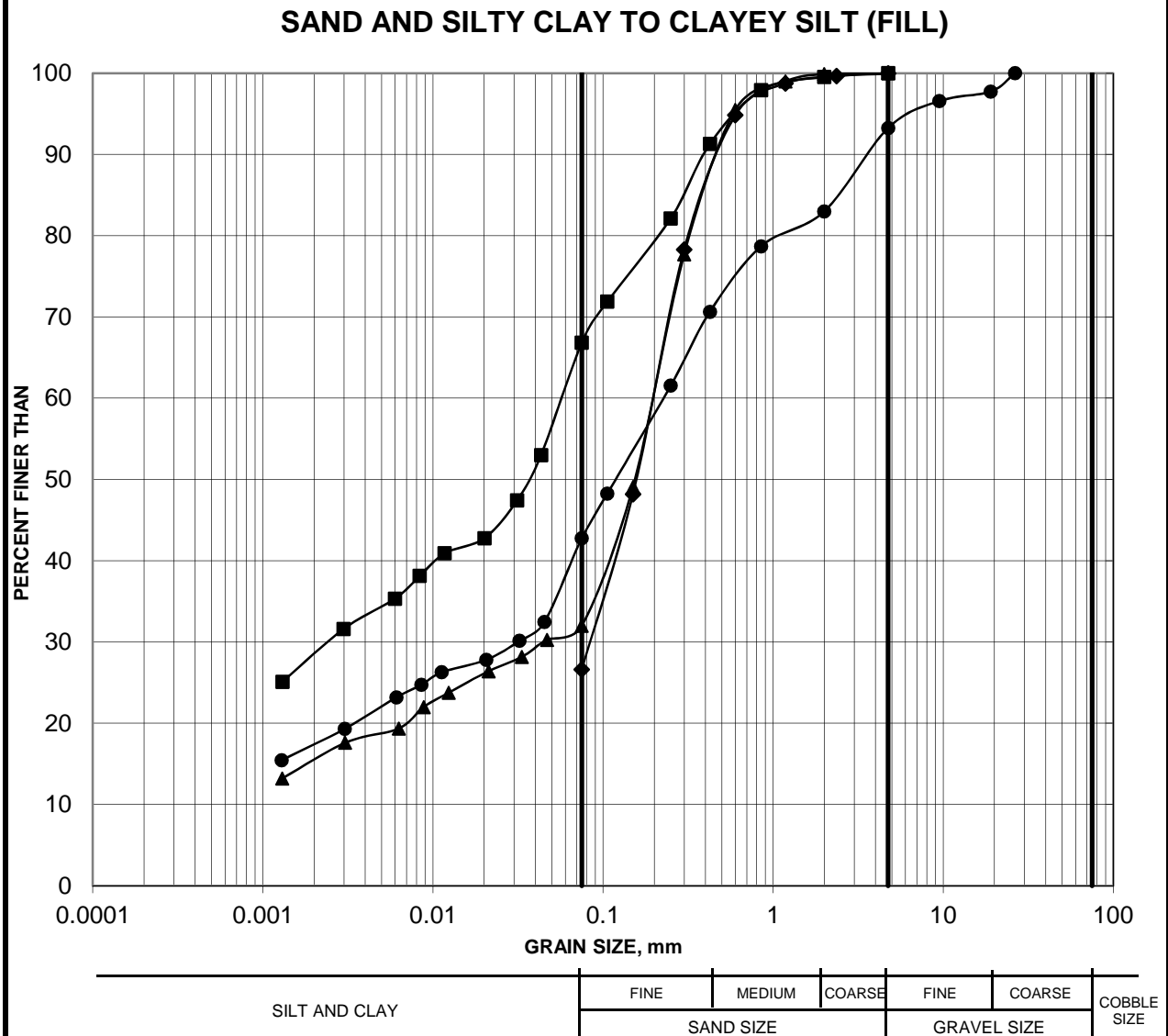


APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

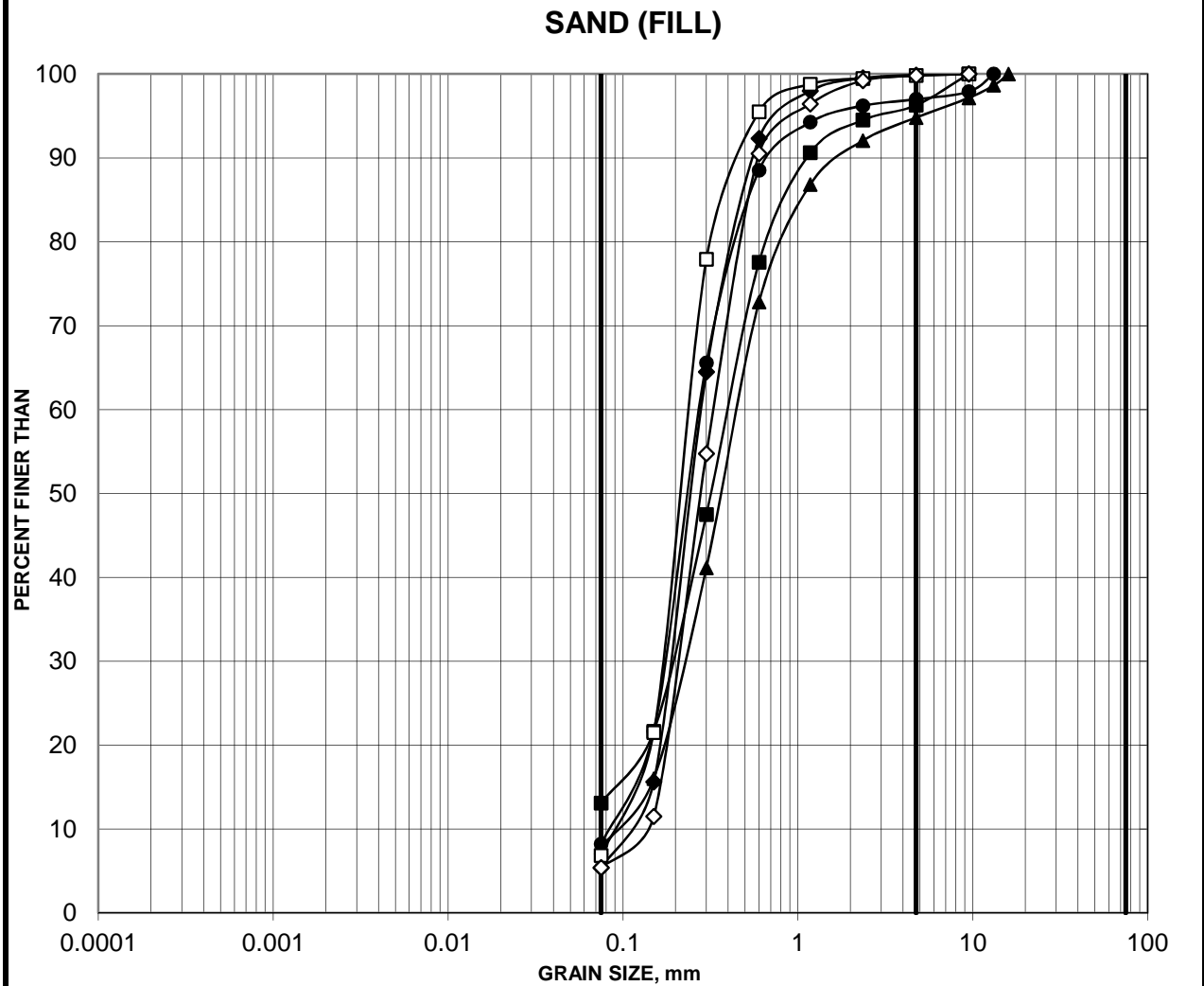
FIGURE B1



Borehole	Sample	Depth (m)
15-07A	2A	1.66-2.29
15-13A	3	2.29-2.90
15-13B	3	2.29-2.90
15-14A	6	4.57-5.03

GRAIN SIZE DISTRIBUTION

FIGURE B2



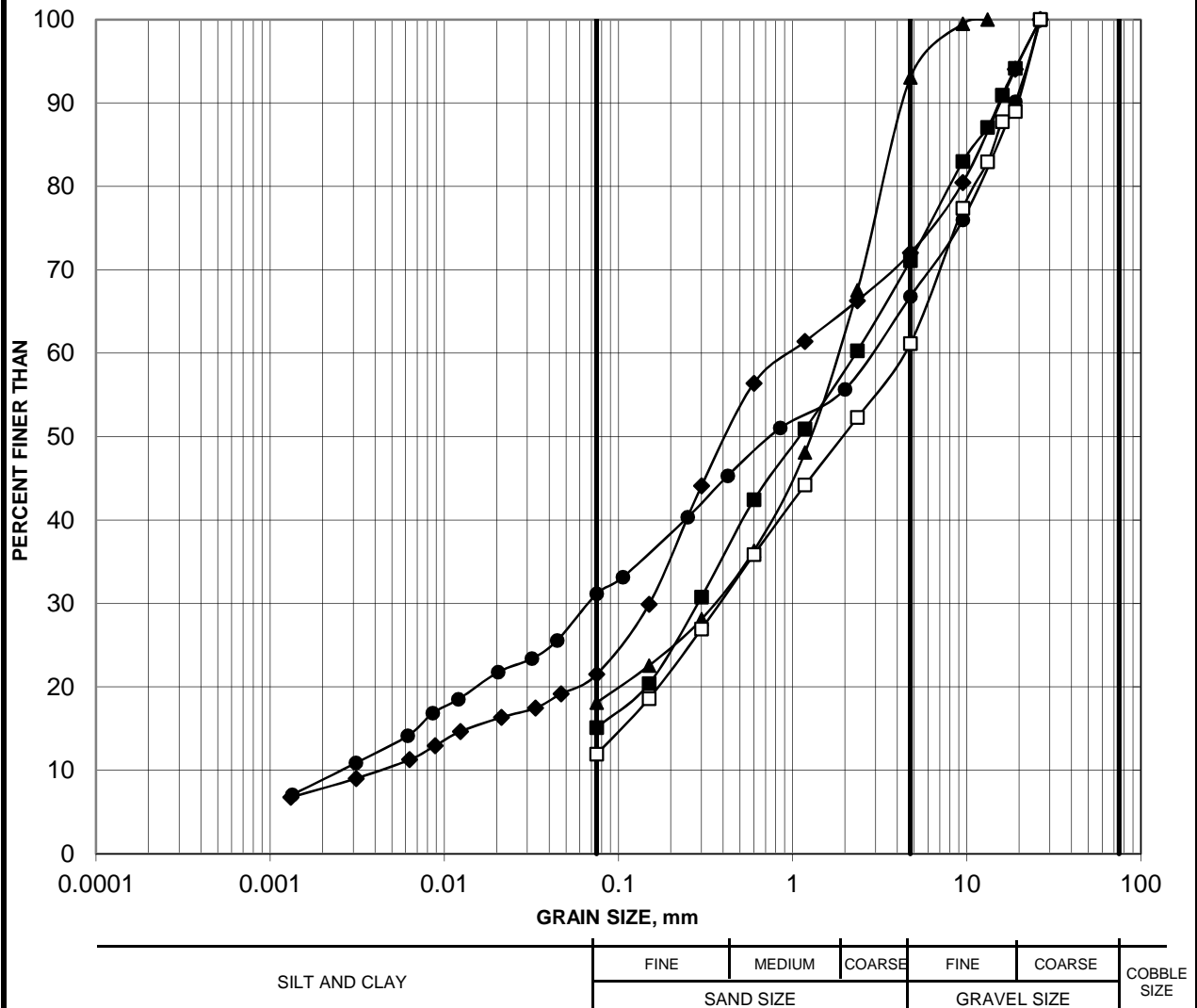
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
15-10A	3	2.29-2.90
15-11A	3	2.29-2.90
15-14A	2	1.52-2.13
15-18A	3	2.29-2.90
15-18A	6	4.57-5.18
15-18A	9	6.86-7.47

GRAIN SIZE DISTRIBUTION

FIGURE B3

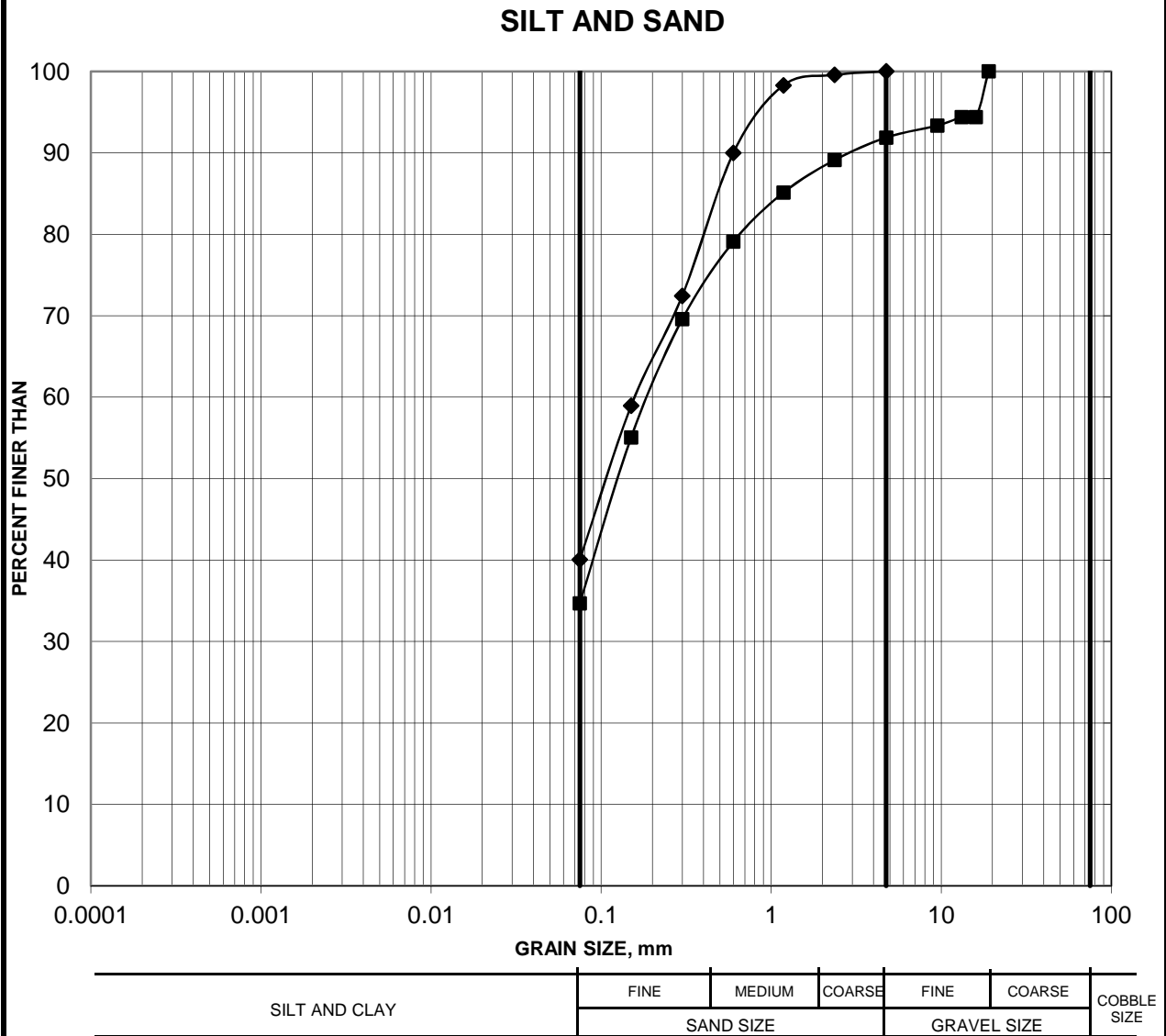
SILTY SAND AND GRAVEL (FILL)



Borehole	Sample	Depth (m)
15-06A	1	0.76-1.37
15-07A	3	2.29-2.90
15-10A	6	4.57-5.18
15-14A	10	7.62-8.08
15-19A	2	1.52-2.13

GRAIN SIZE DISTRIBUTION

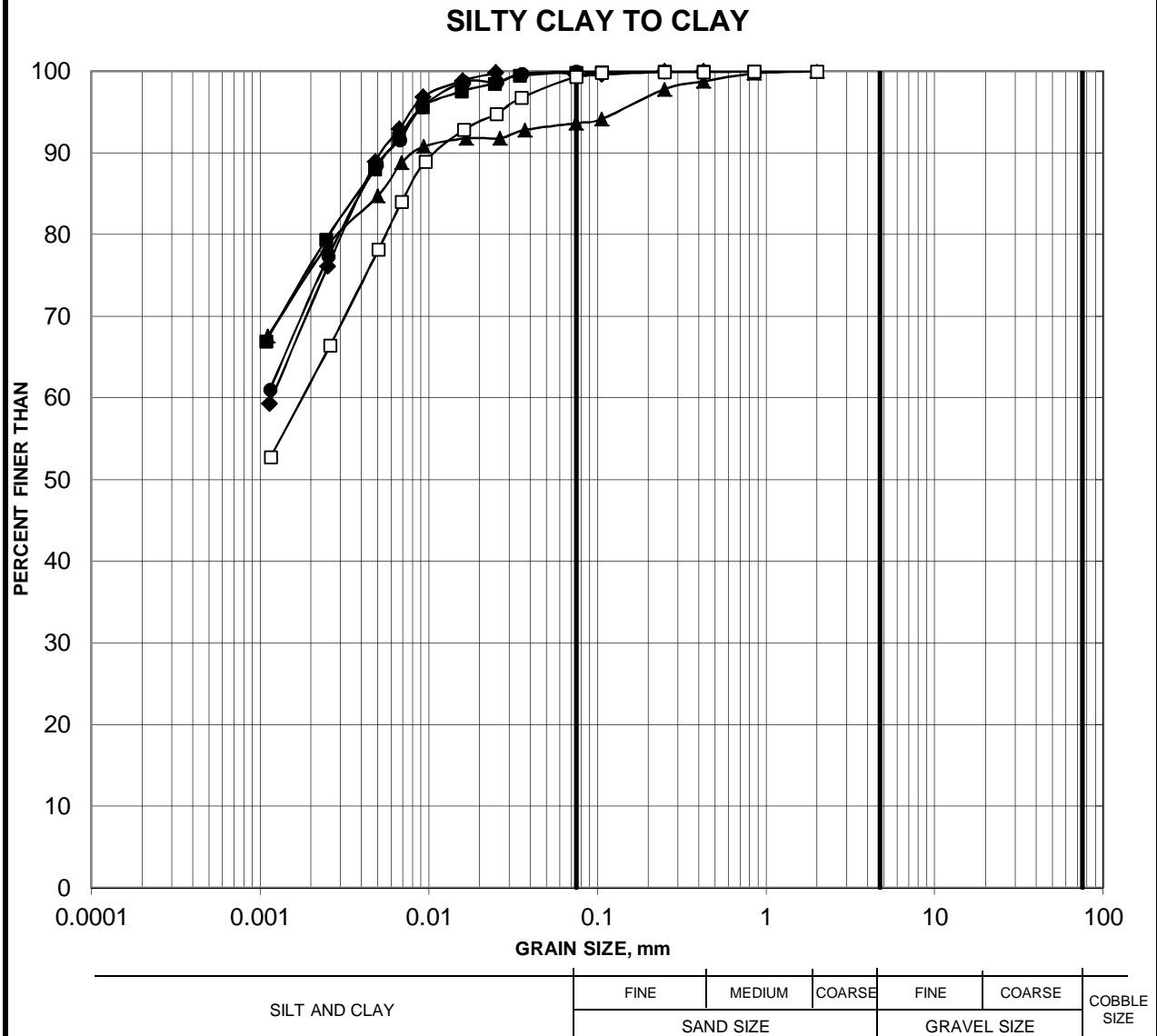
FIGURE B4



Borehole	Sample	Depth (m)
15-07A	8	5.34-5.95
15-11A	9	6.86-7.47

GRAIN SIZE DISTRIBUTION

FIGURE B5

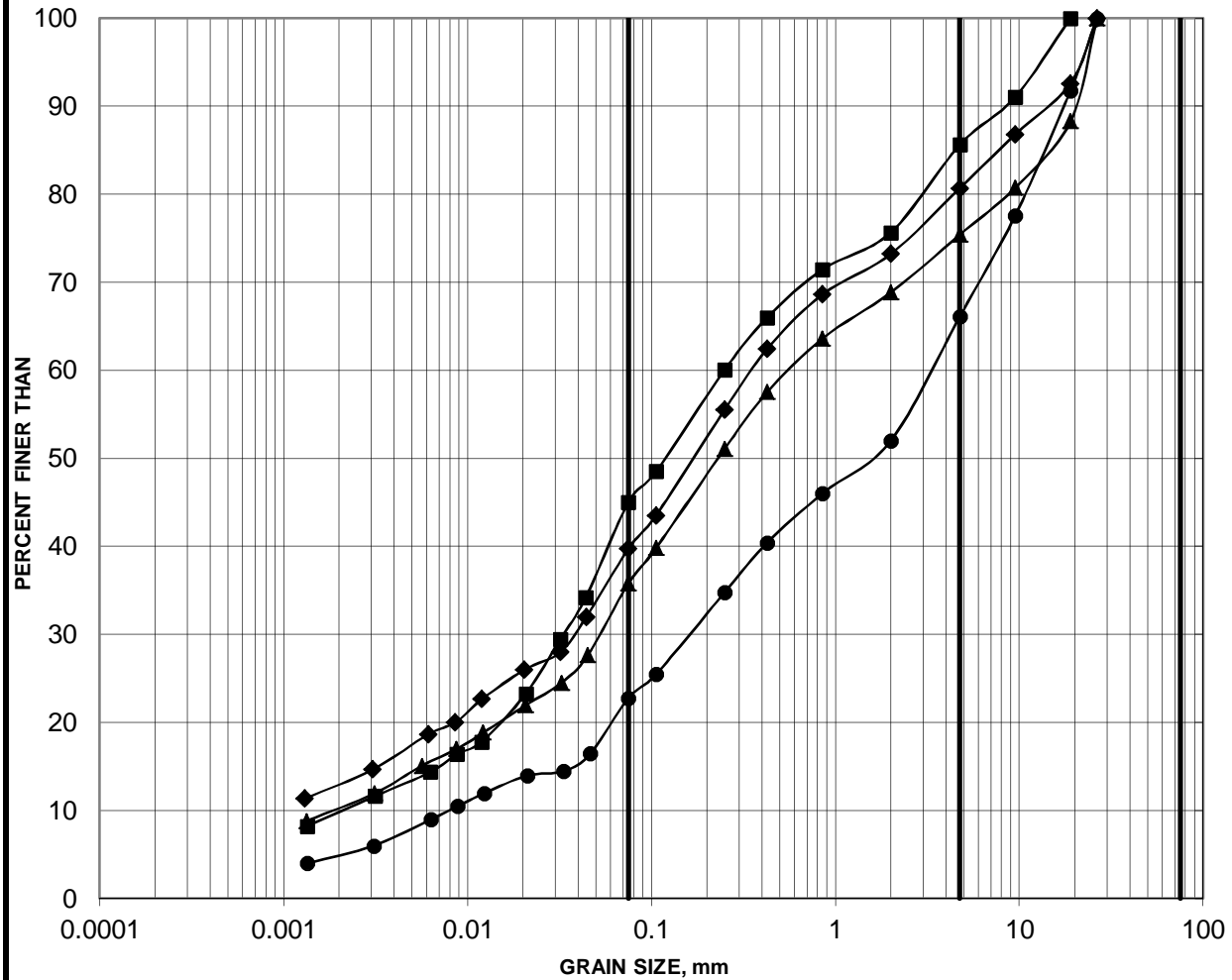


Borehole	Sample	Depth (m)
15-10A	12	9.15-9.76
15-11A	12	9.15-9.76
15-18A	13	9.76-10.37
15-19A	5	4.57-5.18
15-19A	8	9.15-9.76

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILT AND SAND, SOME GRAVEL TO GRAVELLY (GLACIAL TILL)

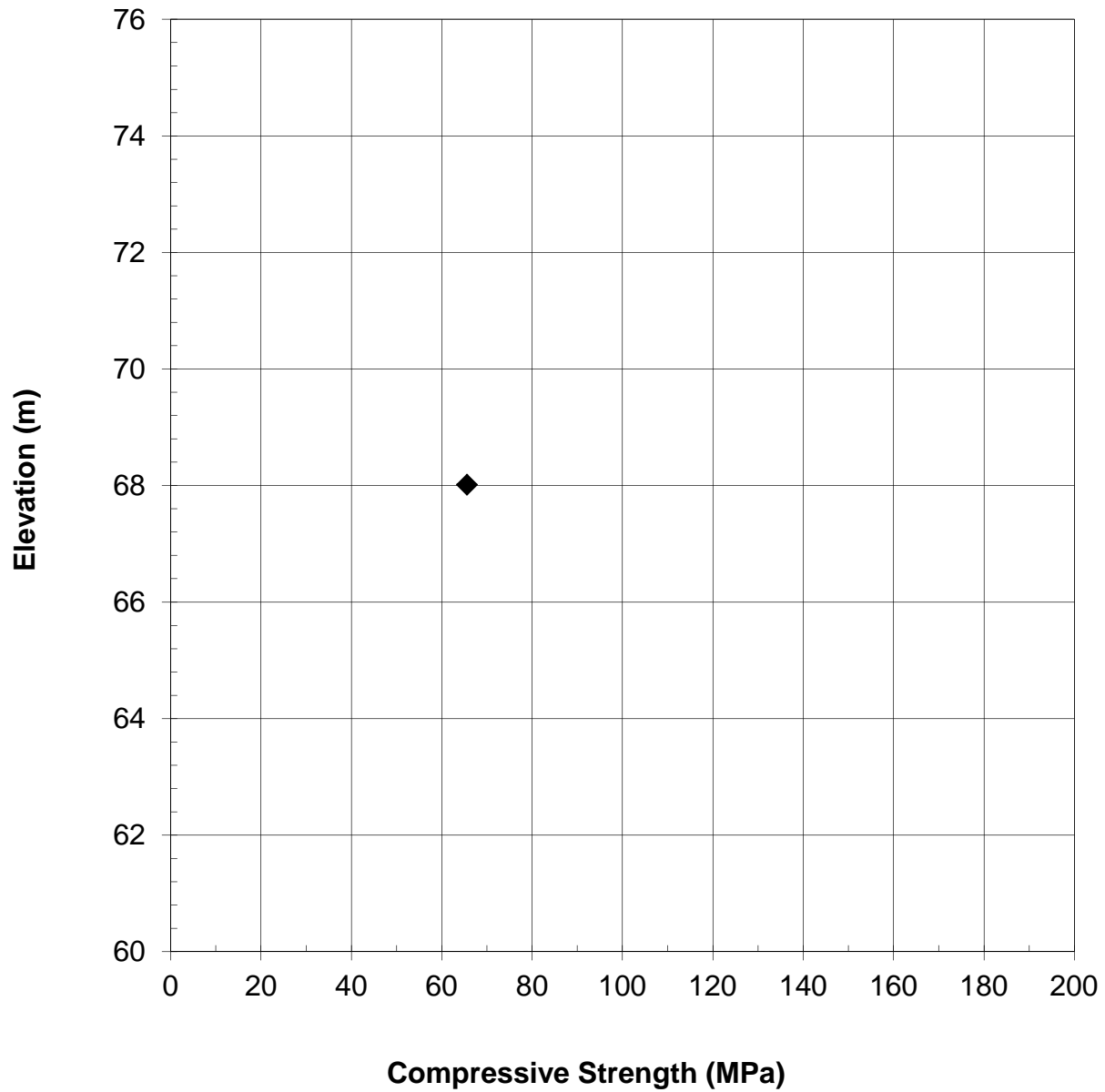


SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
15-13A	6	4.57-5.18
15-13A	9	6.86-7.47
15-13B	9	5.16-5.77
15-13B	13	7.39-8.87

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

FIGURE B7



◆ 15-06A

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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