REPORT

May 11, 2017

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

WIDENING OF DEEP CUTS AND HIGH FILL EMBANKMENTS, HIGHWAY 12 MEMORIAL AVENUE TO HORSESHOE VALLEY ROAD ENVIRONMENTAL ASSESSMENT
CITY OF ORILLIA, ONTARIO
W.O. 011-20002

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Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the widening/upgrades to Highway 12, from Horseshoe Valley Road to Memorial Avenue, in the City of Orillia, Ontario.

This report addresses the widening of deep cuts and high fill embankments at the following locations within the project boundaries:

- Northwest and Southwest quadrants of Highway 12 / Old Barrie Road Interchange
  - Cuts between 6 m and 14 m deep.
- Southeast quadrant of Highway 12 / Old Barrie Road Interchange
  - Embankment fills between 10 m to 14 m high.
- Southwest and southeast quadrants of Highway 12 / Coldwater Road Interchange
  - Embankment fills between 6 m and 9 m high.
- North side of Highway 12, east of Wainman Line
  - Embankment fill between 4 m and 5 m high.
- North side of Highway 12, west of Fairgrounds Road
  - Embankment fill between 4 m and 5 m high.

The terms of reference and scope of work for the foundation engineering services are outlined in Section 5.8 of MTO's Request for Proposal (RFP) for Assignment No. 2011-E-0024 dated February 2013, and in Section 5.8 of the *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

The deep cuts and high fill embankments addresses in this report are located throughout the project boundaries along Highway 12, between Horseshoe Valley Road and Memorial Avenue, in the City of Orillia, Ontario. The major deep cuts and high fills are located in proximity to the Old Barrie Road / Highway 12 Interchange and the Coldwater Road / Highway 12 Interchange. Two additional fill areas are located on the stretch of Highway 12 between the Coldwater Road Interchange and Horseshoe Valley Road. Site specific descriptions are provided below for the proposed deep cuts and high fill embankments.

2.1 Deep Widening Cut Highway 12 / Old Barrie Road Interchange

The top of the existing embankment at the north end of this section, near Boreholes BH15-01 and BH15-02, is about 7 m above the existing highway grade and is inclined at about 3 Horizontal to 1 Vertical (3H:1V). The slopes of the embankment are vegetated with long grasses, shrubs, and small trees. The central portion of this section, near Borehole BH15-18, is about 12 m above existing highway grade and similarly inclined at about 2H:1V. The slope is vegetated with short and tall grasses, shrubs and small trees. The southern portion of this section, near Boreholes BH15-4 and BH15-05, is about 3 m above existing highway grade and inclined at about 2.5H:1V. The

slope is vegetated with grasses and mature trees line the crest. No signs of deep seated slope instability were observed during the investigation along any of the slope sections; however, some erosion of the surficial soils at the toe of the slope were observed near the southern portion of this roadway section.

2.2 High Fill Embankment Widening at Highway 12 / Old Barrie Road Interchange

The top of the existing embankment supporting the existing Highway 11 Northbound off-ramp ranges in height from 11 m at the north end of this section of ramp to level grade where it matches existing highway grade at the south end of this section. The embankment is inclined at about 2.5H:1V and is vegetated with grasses and occasional shrubs. No signs of slope instability were noted during the field investigation.

2.3 High Fill Embankment Widening at Highway 12 / Coldwater Road Interchange

The existing embankments support the approach as to the bridge overpass and the on/off ramps on the south side of the interchange. The top of existing embankments are about 5 m to 6 m above the existing highway and are inclined at about 1.5H:1V. The slopes are vegetated with grass and small groves of mature trees are present at the toe of the slope. No signs of instability were observed during the investigation.

2.4 High Fill Embankment Widening at Highway 12 / Wainman Lane

The top of the existing embankment is about 4 m to 5 m high and is inclined at about 1.5H:1V. The slope is densely vegetated with grasses and mature trees both at the toe of the slope and on the slope face. No signs of slope instability were noted during the investigation.

2.5 High Fill Embankment Widening at Highway 12 / Fairgrounds Road

The top of the existing embankment is about 3 m to 4 m high and is inclined at about 2H:1V. The slope is vegetated with long grass and no signs of slope instability were noted during the investigation.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out between September 16 and October 6, 2015, during which time a total of 17 boreholes were drilled at the locations shown on Drawing 1 to 6.

The boreholes were drilled using a track-mounted drill rig, supplied and operated by Davis Drilling Ltd., of Milton, Ontario. The boreholes were advanced using 200 mm diameter hollow stem augers, with soil samples obtained at 0.75 m and 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1].

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and a standpipe piezometer was installed in Borehole BH15-12 (at the Coldwater Road High Fill Embankment Site) to permit monitoring of the groundwater level at this location. The piezometer consists of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within

[1] ASTM D1586, Standard Test Method for Standard Penetration Test.

the borehole. The piezometer installation details and water level readings are indicated on the borehole records contained in Appendix A. All remaining boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's staff who observed the drilling, sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water contents, Atterberg limits and grain size distributions were carried out on selected soil samples.

The borehole locations and ground surface elevations were obtained from the digital terrain model provided by AECOM. The borehole locations, including MTM NAD83 (Zone 10) northing and easting coordinates and ground surface elevations referenced to Geodetic datum and the drilled depths, are summarized below and are shown on Drawings 1 to 6.

In addition, Boreholes B15-S1, B15-S4, B15-S5 and B15-N1 drilled between September 14 and October 1, 2015, associated with the Highway 11/Old Barrie Road – Hwy 12 Interchange and the Highway 11 Coldwater Rd. – Hwy 12 Interchange are utilized herein in describing the subsurface conditions for the High Fill Embankment and Deep Cut Widening in these area.

Borehole No.	MTM NAD83 Zone 10 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH15-01	4939276.9	308979.1	289.4	11.1
BH15-02	4939050.1	308964.9	282.4	14.0
BH15-03	4938871.2	308899.6	276.9	14.0
BH15-04	4938561.1	309062.0	250.9	11.1
BH15-05	4938317.4	309096.5	238.0	11.1
BH15-06	4938950.1	309452.2	251.1	16.9
BH15-08	4938741.0	309182.3	247.8	20.2
BH15-09	4938634.0	309180.3	248.7	15.7
BH15-10	4941196.4	308977.4	259.8	12.6
BH15-11	4941122.0	309272.1	263.3	12.6
BH15-12	4941159.4	309141.8	257.6	8.1
BH15-13	4941127.5	309192.2	256.5	8.1
BH15-14	4941527.0	306223.6	263.4	11.1
BH15-15	4941547.2	306169.0	260.6	5.0
BH15-16	4941429.6	307559.3	282.2	5.0
BH15-17	4941416.0	307461.1	286.0	11.1
BH15-18	4938858.7	308980.4	276.8	15.4
BH15-S1	4938798.8	309031.3	268.9	20.0
BH15-S4	4938799.8	309083.1	260.7	13.5
BH15-S5	4938838.0	309128.1	266.8	23.1

Borehole No.	MTM NAD83 Zone 10 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
BH15-N1	4941197.4	309188.3	257.3	30.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 11 lies within the Simcoe Uplands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2]. The soil deposits are typically glacial tills comprised of sandy loam, deposited in broad, rolling plains which are separated by steeps-sided, flat-floored valleys. In some areas within the Simcoe Uplands, localized areas of sands and silts have been surficially deposited.

4.2 Subsurface Conditions

As part of the subsurface investigation, 17 boreholes were advanced within the proposed deep cut and high fill embankment widening areas, supplemented with four boreholes advanced for the Highway 11/Old Barrie Road – Highway 12 Interchange structures and the Highway 11 / Coldwater Road – Highway 12 Interchange. The borehole locations and ground surface elevations at each of the cut and fill locations are shown on Drawings 2 to 6.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A of this report; the results of geotechnical laboratory testing are also presented in Appendix B. The results of the in situ field tests (i.e. SPT "N" values) as presented on the Record of Borehole Sheets and in Sections 4 are uncorrected. The stratigraphic boundaries shown on the borehole records 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.

A more detailed discussion on the subsurface conditions at the deep cut and high fill embankment widening sites is provided in the following sections:

- Section 4.3 addresses the deep cut widening to the northwest and southwest of the of the Highway 12 / Old Barrie Road Interchange;
- Section 4.4 addresses the high fill embankment widening at the southeast quadrant of Highway 12 / Old Barrie Road Interchange;
- Section 4.5 addresses the high fill embankment widening at the southwest and southeast quadrants of Highway 12 / Coldwater Road Interchange;

[2] Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

- Section 4.6 addresses the high fill embankment widening along the north side of Highway 12, east of Wainman Line; and
- Section 4.7 addresses the high fill embankment widening along the north side of Highway 12, west of Fairgrounds Road.

4.3 Deep Widening Cut at Highway 12 / Old Barrie Road Interchange

The deep cut for the widenings of Highway 12 in the northwest and southwest quadrants of the Highway 12 / Old Barrie Road Interchange range between 6 m and 14 m. Boreholes BH15-01 to BH15-05, and BH15-18 were advanced in the cut areas, supplemented with Borehole BH15-S1 drilled for the interchange structure. The borehole locations for these deep cut areas are shown on Drawing 1 and the stratigraphic profile along the cut section and the cross-sections through the N – E / W and E / W - S Ramps are shown on Drawings 2 and 3, respectively.

In summary, the subsurface conditions encountered in the boreholes in this cut areas consist of a surface layer of topsoil or a pavement structure underlain by soil deposits comprised of variable fill materials, and silt to some sand and gravel glacial till, clayey silt, silty sand and silty sand to sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

4.3.1 Topsoil / Pavement Structure

Each of the boreholes encountered topsoil or a pavement structure surficially. The thickness of the topsoil and pavement structure encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
BH15-01	-	130	370
-	-	150	450
BH15-03	200	-	-
BH15-04	300	-	-
BH15-05	100	-	-
BH15-18	-	-	-
BH15-S1	200	-	-

4.3.2 Fill

Boreholes BH15-02 and BH15-18 encountered fill materials underlying the pavement structure and topsoil, respectively. The elevations of the surface and base of the fill and the thickness of the fill materials as encountered in the boreholes are summarized below.

Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-02	281.8	1.5	280.3
BH15-18	276.6	6.9	269.7
BH15-S1	268.7	8.4	260.3

The fill materials are comprised of silt and sand containing trace to some clay and gravel. The fill in Boreholes BH15-02 and BH15-18 contains trace organic material to a depth of about 2.0 m. Auger grinding was noted in Borehole BH15-18 at a depth of about 4.9 m

The water content measured on samples of the fill deposits ranged between 6 per cent and 9 per cent.

The measured Standard Penetration Test (SPT) "N"-values within the silt and sand fill deposit range from 4 blows to 20 blows per 0.3 m of penetration, indicating the fill is loose to compact in relative density.

The results of grain size distribution tests completed on three selected samples of the fill are shown on Figure B1. Atterberg limits testing was carried out on the three samples of the fill and measured plastic limits ranging between 11 per cent and 13 per cent, liquid limits ranging between 14 per cent and 16 per cent and plasticity indices ranging between 2 per cent and 4 per cent. The results, which are plotted on the plasticity chart on Figure B2 in Appendix B, confirms that the tested samples of the fill consists of silt and sand of slight plasticity.

4.3.3 Silt and Sand Till

A till deposit was encountered in Boreholes BH15-01, BH15-02, and BH15-18 underlying the fill and in Borehole BH15-03 underlying a sand layer and interlayered within the silty sand to clayey silt deposits in Borehole 15-51. The till deposit is comprised silt and sand in Boreholes BH15-01 to BH15-03 and BH15-18 and consists of separate layers of silty sand and gravelly clayey silt with sand in Borehole BH15-S1. The till deposits in Ontario typically contain cobbles and boulders and these materials should be anticipated to be present throughout the till deposit encountered at the site as inferred by auger grinding in three of the boreholes.

The elevations of the surface and base of the till deposit and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-01	288.9	> 10.6	Below 278.3
BH15-02	280.3	> 11.9	Below 268.4
BH15-03	275.5	> 12.6	Below 262.9
BH15-18	269.7	> 8.3	Below 261.4
BH15-S1	255.7	1.5	254.2
	254.2	1.5	252.7

The measured SPT "N" value within the till deposit(s) range from 11 blows to greater than 100 blows per 0.3 m of penetration, indicating the till is compact to very dense, and generally very dense, in relative density.

The water content measured on samples of the till deposits ranged between 5 per cent and 8 per cent.

The result of grain size distribution tests completed on six samples of the till deposit are shown on Figures B3 and B4 in Appendix B. Atterberg limits testing was carried out on four selected samples of the till deposit and measured plastic limit ranging between 10 per cent and 11 per cent, liquid limits ranging between 12 per cent and 14 per cent and plasticity indices ranging between 2 per cent and 5 per cent. These results, which are plotted on the plasticity chart on Figure B5 in Appendix B, confirms that the tested samples of the deposit consist of silt of slight plasticity.

4.3.4 Silt to Sand and Gravel

Interlayered non-cohesive deposits of variable composition were encountered in Boreholes BH15-03, BH15-04, and BH15-05. The materials encountered range from silt, to silt and sand, to sand, to sand and gravel. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-03	276.3	0.8	275.5
BH15-04	250.6	5.3	245.3
BH15-05	237.9	10.9	227.0
BH15-S1	260.3	4.6	255.7
	249.8	>0.9	Below 247.9

The measured SPT "N"-values in the non-cohesive deposits range from 15 blows to 68 blows per 0.3 m of penetration, and one value of 100 blows for 0.13 m penetration, indicating this deposit is compact to very dense in relative density.

The water content measured on samples of the sand and gravel to silt deposits ranged between 4 per cent and 23 per cent.

The results of grain size distribution tests carried out on two selected samples of the silt and sand to silty sand, three selected samples of the silt, and one selected sample of the sand and gravel portions of the deposits are shown on Figures B6, B7, and B8, respectively.

4.3.5 Silty Clay to Clayey Silt

Layers of clayey silt were encountered in Boreholes BH15-03, BH15-04, and BH15-05. The elevation of the surface and base of these layers and their thickness as encountered in the boreholes are summarized below.

Borehole No.	Silty Clay to Clayey Silt Surface Elevation (m)	Silty Clay to Clayey Silt Thickness (m)	Silty Clay to Clayey Silt Base Elevation (m)
BH15-03	276.7	0.4	276.3
BH15-04	245.3	> 5.5 m	Below 239.8
BH15-05	227.0	> 0.1	Below 226.9
BH15-S1	252.7	2.9	249.8

The measured SPT “N”-values within the clayey silt layers range from 10 blows to 37 blows per 0.3 meters of penetration, with two values of 100 blows for 0.18 m and for 0.15 m of penetration, suggesting a stiff to hard consistency.

The water content measured on samples of the clayey silt layer range between 16 per cent and 20 per cent.

The result of a grain size distribution test completed on one selected sample of the clayey silt stratum is shown on Figure B9 in Appendix B. Atterberg limits testing was carried out on one selected sample of the deposit and measured a plastic limit of 15 per cent, a liquid limit of 25 per cent and a plasticity index of 10 per cent. This result, which is plotted on the plasticity chart on Figure B10 in Appendix B, confirms that the tested sample of the deposit consists of clayey silt of low plasticity.

4.4 High Fill Embankment Widening at Highway 12 / Old Barrie Road Interchange

The height of the embankment in the high fill area in the southeast quadrant of the Highway 12 / Old Barrie Road Interchange, at the location of the existing off-ramp from Highway 11 northbound will be up to about 14 m. Boreholes BH15-06, BH15-08, and BH15-09 were advanced within the fill area approximately at the locations shown on Drawing 1. A stratigraphic profile along the Highway 11/12 S – E / W Ramp and a cross section through the ramp are shown in Drawing 3.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial fill or a pavement structure underlain by variable deposits of sand and gravel, glacial till, clayey silt, silty sand, and silty sand to sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

4.4.1 Pavement Structure / Fill

Boreholes BH15-06, BH15-S4 and BH15-S5, advanced through the pavement structure of the off-ramp, penetrated a layer of asphalt 270 mm to 300 mm thick and the underlying granular fill layer about 430 mm to 1.4 m thick.

4.4.2 Fill

All of the boreholes in this area encountered fill, either from ground surface or beneath the pavement structure. The elevations of the surface and base of the fill and the thickness of the fill layer as encountered in the boreholes are summarized below.

Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-06	250.2	6.2	244.0
BH15-08	247.8	0.6	247.2
BH15-09	248.7	4.0	244.7
BH15-S4	260.0	6.4	253.6
BH15-S5	265.4	14.8	250.6

The fill materials are primarily non-cohesive, and are comprised of silt and sand to sand, whereas in Borehole BH15-08 the fill is comprised of sandy organic silt containing trace fibrous organics; organics were also noted in the fill in Borehole BH15-09. The non-cohesive fill in Borehole BH15-S4 is underlain by a fill layer of sandy clayey silt.

The water content measured on samples of the fill deposits ranged between 3 per cent and 15 per cent.

The measured SPT “N”-values in the non-cohesive fill layers range from 4 blows to 101 blows per 0.3 m of penetration, indicating the fill deposit is compact to very dense in relative density; the SPT-“N”-value measured in the sandy clayey silt fill layer is 16 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The results of grain size distribution tests completed on two selected samples of the non-cohesive fill are shown on Figure B11.

4.4.3 Clayey Silt

A clayey silt stratum was encountered in Boreholes BH15-08, BH15-09 and BH15-S4. The elevation of the surface and base of the deposit and the thickness of the stratum as encountered in the boreholes are summarized below.

Borehole No.	Silty Clay to Clayey Silt Surface Elevation (m)	Silty Clay to Clayey Silt Thickness (m)	Silty Clay to Clayey Silt Base Elevation (m)
15-08	236.1	3.0	233.1
15-09	244.7	7.7	237.0
15-S4	250.8	2.7	248.1

The measured SPT “N”-values within the clayey silt deposit range from 11 blows to 48 blows per 0.3 m of penetration, with three values of 100 blows for less than 0.3 m of penetration, suggesting a stiff to hard consistency.

The water content measured on samples of the clayey silt deposits ranged between 8 per cent and 25 per cent.

The results of grain size distribution tests completed on three selected samples of the clayey silt deposit are shown on Figure B12 in Appendix B. Atterberg limits testing was carried out on two selected samples of the deposit and measured plastic limits of 12 percent and 16 per cent, liquid limit of 23 per cent and 22 per cent and plasticity indices 8 per cent and 10 per cent. These results, which are plotted on the plasticity chart on Figure B13 in Appendix B, confirms that the tested samples of the deposit consist of clayey silt of low plasticity.

4.4.4 Sandy Gravel to Silt

Non-cohesive deposits were encountered in Boreholes BH15-06, BH15-08 and BH15-09. The materials encountered range from silt to silty sand, to sand, to sandy gravel. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-06	241.0	1.7	239.3
BH15-08	247.2 and 233.1	11.1 and > 5.5	236.1 and Below 227.6
BH15-09	237.0	> 4.0	Below 233.0
BH15-S4	25.6 and 241.1	2.8 and 0.9	250.8 and Below 249.2
BH15-S5	245.3	1.6	Below 243.7

The measured SPT “N”-values in the non-cohesive deposits range from 12 blows to 70 blows per 0.3 m of penetration with five “N”-values greater than 100 blows per less than 0.3 m of penetration, indicating this deposit is compact to very dense in relative density.

The water content measured on samples of the silt to sandy gravel deposits ranged between 7 per cent and 24 per cent.

The results of grain size distribution tests carried out on three samples of the silty sand to sand and the silt portions of the deposit are shown on Figures B14 and B15.

4.4.5 Silty Sand to Sand to Sand and Gravel Till

A glacial till deposit was encountered in Borehole BH15-06 underlying the fill and sandy gravel layer and in Borehole BH15-S5 underlying the fill. The till deposit is comprised of silty sand to sand or sand and gravel.

The elevations of the surface and base of the till deposit and the deposit thickness encountered in Borehole BH15-06 are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-06	244.0 and 239.3	3.0 and > 5.1	241.0 and Below 234.2
BH15-S5	250.6	5.3	245.3

The measured SPT "N" value within the till deposit range from 11 blows to 100 blows per 0.3 m of penetration, with four "N"-values of 100 blows for less than 0.23 m of penetration, indicating the till is very dense in relative density.

The water content measured on samples of the till deposits ranged between 5 per cent and 10 per cent.

The results of grain size distribution tests completed on three selected sample of the till deposit are shown on Figure B16 in Appendix B. An Atterberg limits test carried out on the fines portion of the sand and gravel till measured a plastic limit of 16 per cent, a liquid limit of 24 per cent and a plasticity index of 8 per cent, as shown on Figure 17, indicating that the fines consist of clayey silt of low plasticity.

4.5 High Fill Embankment Widening at Highway 12 / Coldwater Road Interchange

The height of the embankment in the high fill areas in the southwest and southeast quadrants of the Highway 12 / Coldwater Road Interchange range between 6 m and 9 m. Boreholes BH15-10, BH15-11, BH15-12, and BH15-13 were advanced within of the fill footprint and along the toe of the widening. The borehole locations for these high fill areas as well as the profile along the fill area and cross-section through the embankment are shown on Drawing 4.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil or fill and/or a pavement structure, underlain by non-cohesive deposits ranging from sand to silt. A more detailed description of the subsurface conditions is provided in the following subsections.

4.5.1 Pavement Structure / Fill

Boreholes 15-10 and 15-11 were advanced through pavement structures at the site; Boreholes BH15-12 and BH15-13 were advanced from the landscaped/grassed areas and encountered topsoil at ground surface. The thickness of the topsoil and pavement structure encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
BH15-10	-	150	450
BH15-11	-	160	540
BH15-12	100	-	-
BH15-13	300	-	-
BH15-N1	200	-	-

4.5.2 Fill

Boreholes BH15-10, BH15-11 and BH15-12 encountered fill materials underlying the pavement structure and topsoil. The elevations of the surface and base of the fill and the thickness of the fill materials as encountered in the boreholes are summarized below.

Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-10	259.2	3.4	255.8
BH15-11	262.6	6.4	256.2
BH15-12	257.5	2.0	255.5
BH15-N1	257.1	2.1	255.0

The fill materials are comprised of silt and sand to silty sand to sand to gravelly sand. Organics were also noted in the fill in Boreholes BH15-10, BH15-12, and BH15-13; auger grinding was noted in Borehole BH15-11.

The water content measured on samples of the fill deposits ranged between 3 per cent and 10 per cent.

The measured SPT “N”-values in the non-cohesive deposits range from 6 blows to 43 blows per 0.3 penetration, with one “N”-value of 100 blows per 0.2 m of penetration, indicating the fill is loose to very dense in relative density.

The results of grain size distribution tests completed on three selected samples of the fill are shown on Figure B18. Atterberg limits testing was carried out on one selected sample of fill and measured a plastic limit of 12 per cent, a liquid limit of 15 per cent and a plasticity index of 3 per cent. This result, which is plotted on the plasticity chart on Figure B19 in Appendix B, indicates that the tested sample of the fill consists of silt and sand of slight plasticity.

4.5.3 Silt to Sand

Non-cohesive deposits of variable composition, ranging from silt to silt and sand to silty and to sand were encountered in Boreholes BH15-10, BH15-11, BH15-12 and BH15-13. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-10	255.8	> 8.6	Below 247.2
BH15-11	256.2	> 5.5	Below 250.7
BH15-12	255.5	> 6.0	Below 249.5
BH15-13	256.2	> 7.8	Below 248.4
BH15-N1	255.0 242.7	10.8 10.6	244.2 232.1

The SPT “N”-values measured in the non-cohesive deposits range from 3 blows to 46 blows per 0.3 m of penetration, indicating this deposit is very loose to very dense in relative density.

The water content measured on samples of the sand to silt deposits ranged between 7 per cent and 28 per cent.

The results of grain size distribution tests carried out on six selected samples of the silt to sand deposit are shown on Figures B20 and B21 in Appendix B.

4.6 High Fill Embankment Widening at Highway 12 / Wainman Line

The height of the embankment in the high fill area along the north side of Highway 12, east of Wainman Line ranges between 4 m and 5 m. Boreholes BH15-14 and BH15-15 were advanced within and immediately adjacent to the fill footprint as shown on Drawings 5. A stratigraphic cross-section across the embankment is also shown on drawings.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil/pavement structure and fill underlying the pavement structure underlain by a deposit of silt and sand and interlayered deposits of silty sand, silty clay, sand to sand and gravel fill and gravelly sand deposits. A more detailed description of the subsurface conditions is provided in the following subsections.

4.6.1 Topsoil / Pavement Structure

Borehole BH15-14 was advanced through the pavement structure on Highway 12 and Borehole BH15-15 was advanced through topsoil at the toe of the existing embankment. The thickness of the pavement structure and the topsoil encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Asphalt Thickness (mm)	Granular Fill Thickness (mm)
BH15-14	-	220	680
BH15-15	200	-	-

4.6.2 Fill

Borehole BH15-14 encountered a deposit of silt and sand fill underlying the pavement structure. The elevations of the surface and base of the fill and the thickness of the fill deposit as encountered in the boreholes are summarized below.

Borehole No.	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
BH15-14	262.5	3.1	259.4

The SPT “N”-values measured in the fill deposit range from 4 blows to 19 blows per 0.3 m of penetration, indicating this deposit is loose to compact in relative density.

The water content measured on samples of the fill is 5 per cent and 8 per cent.

The result of a grain size distribution test completed on one sample of the fill is shown on Figure B22. An Atterberg limits test was carried out on the same sample of the fill material and measured a plastic limit of 11 per cent, a liquid limit of 13 per cent and a plasticity index of 2 per cent. This result, which is plotted on the plasticity chart on Figure B23 in Appendix B, confirms that the tested sample of the fill consists of silt and sand of slight plasticity.

4.6.3 Silt to Sand

A primary deposit of silt and sand and interlayered deposits of non-cohesive material were encountered in Boreholes BH15-14 and BH15-15. The interlayered deposits encountered ranged from silty sand and gravelly

sand. The elevations of the surface and base of the non-cohesive deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-14	259.4	> 7.1	Below 252.3
BH15-15	260.4 256.6	1.2 > 1.0	259.2 Below 255.6

The measured SPT "N"-values in the non-cohesive deposits range from 4 blows to 32 blows per 0.3 m of penetration with one "N"-value of 100 blows for less than 0.3 m of penetration, indicating this deposit is loose to very dense in relative density.

The water content measured on samples of the silt to sand deposits ranged between 3 per cent and 16 per cent.

The results of grain size distribution tests carried out on two selected samples of the silt and sand portion of the deposit are shown on Figure B24 in Appendix B.

4.6.4 Silty Clay

A layer of silty clay was encountered in Borehole BH15-15 underlying the silty sand deposit. The elevation of the surface and base of this layer and the thickness of the stratum as encountered in the borehole are summarized below.

Borehole No.	Silty Clay Surface Elevation (m)	Silty Clay Thickness (m)	Silty Clay Base Elevation (m)
BH15-15	259.2	0.7	258.5

The measured SPT "N"-value within the silty clay deposit was 5 blows per 0.3 meters of penetration, suggesting a firm consistency.

4.6.5 Sand to Sand and Gravel Till

A sand to sand and gravel till deposit was encountered in Borehole BH15-15 underlying the silty clay deposit. The elevations of the surface and base of the till deposit and the deposit thickness encountered in Borehole BH15-15 are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-15	258.5	1.9	256.6

The SPT "N"-values measured in the sand to sand and gravel till deposit are 23 blows and 24 blows per 0.3 m of penetration, indicating this deposit is compact in relative density.

The water content measured on a sample of the till deposit is 11 per cent.

The result of a grain size distribution test completed on one selected sample of the till deposit is shown on Figure B25 in Appendix B.

4.7 High Fill Embankment Widening at Highway 12 Fairgrounds Road

The height of the embankment in the high fill area along on the north side of Highway 12, west of Fairgrounds Road ranges between 4 m and 5 m. Boreholes BH15-16 and BH15-17 were advanced within and immediately adjacent to the fill footprint. The borehole locations for this high fill area are shown on Drawing 6. A stratigraphic cross-section across the embankment is also shown on Drawing 6.

In summary, the subsurface conditions encountered in the boreholes in this area consist of surficial topsoil and granular fill deposits underlain by silty sand to sand in places, underlain by a silt and sand till. A more detailed description of the subsurface conditions is provided in the following subsections.

4.7.1 Topsoil / Fill

Borehole BH15-16 was advanced through a layer of topsoil beyond the roadway shoulder, whereas Borehole BH15-17 was advanced through the gravel shoulder and embankment fill of Highway 12. The thickness of the topsoil and the fill layers encountered in the boreholes is indicated below.

Borehole No.	Topsoil Thickness (mm)	Fill Thickness (mm)
BH15-16	200	-
BH15-17	-	2.1

The fill deposit is comprised of an upper layer of gravelly sand and a lower layer of sandy silt. Laboratory testing indicates that the sample of the lower layer of fill tested has an organic content of approximately 2.2 per cent.

The water content measured on a sample of the fill is 15 per cent.

The SPT “N”-values measured in the fill range from 6 blows to 7 blows per 0.3 m of penetration, indicating this deposit is loose in relative density.

4.7.2 Silty Sand to Sand

A silty sand to sand deposit was encountered in Borehole BH15-16 underlying the topsoil. The elevations of the surface and base of the silty sand to sand deposit and the deposit thickness encountered at the borehole location are summarized below.

Borehole No.	Surface Elevation (m)	Thickness (m)	Base Elevation (m)
BH15-16	282.0	1.9	280.1

The SPT "N"-values measured in the non-cohesive deposits range from 6 blows to 14 blows per 0.3 m of penetration, indicating this deposit is loose to compact in relative density.

The water content measured on a sample of the silty sand to sand deposit is 5 per cent.

The result of a grain size distribution test completed on one selected sample of the silty sand to sand is shown on Figure B26.

4.7.3 Silt and Sand Till

A glacial till deposit comprised of silt and sand was encountered underlying the silty sand to sand deposit in Borehole BH15-16 and underlying the fill in Borehole BH15-17. The elevations of the surface and base of the till deposit and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Till Surface Elevation (m)	Till Thickness (m)	Base of Till Elevation (m)
BH15-16	280.1	> 2.9	Below 277.2
BH15-17	283.9	> 9.0	Below 274.9

The SPT "N"-values measured within the till deposit range from 17 blows to 77 blows per 0.3 m of penetration, with one "N"-value of 100 blows for less than 0.3 m of penetration, indicating the till is compact to very dense in relative density.

The water content measured on samples of the till deposits range between 7 per cent and 8 per cent.

The results of grain size distribution tests completed on three selected samples of the till deposit are shown on Figure B27 in Appendix B. Atterberg limits testing was carried out on two selected samples of the till deposit and measured plastic limits of 10 per cent and 11 per cent and corresponding liquid limits of 15 per cent and 14 per cent and plasticity indices of 5 per cent and 3 per cent. These results, which are plotted on the plasticity chart on Figure B28 in Appendix B, confirms that the tested samples of the deposit consist of silt and sand of slight plasticity.

4.8 Groundwater Conditions

The observed water levels in the open boreholes following completion of drilling, and the water levels measured in the piezometers installed in Borehole BH15-12 and BH15-S1 are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depths Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BH15-01	289.4	Dry	-	Upon Completion of drilling – Sept. 29, 2015
BH15-02	282.4	13.5	268.9	Upon Completion of drilling – Sept. 29, 2015
BH15-03	276.9	13.2	263.7	Upon Completion of drilling – Sept. 30, 2015
BH15-04	250.9	9.9	241.0	Upon Completion of drilling – Sept. 24, 2015
BH15-05	238.0	6.7	231.3	Upon Completion of drilling – Sept. 24, 2015
BH15-06	251.1	10.8	240.3	Upon Completion of drilling – Sept. 17, 2015

Borehole No.	Ground Surface Elevation (m)	Depths Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
BH15-08	247.8	Not Measured*	-	Used Drilling Mud
BH15-09	248.7	8.5	240.2	Upon Completion of drilling – Sept. 28, 2015
BH15-10	259.8	11.8	248.0	Upon Completion of drilling – Sept. 20, 2015
BH15-11	263.3	Dry	-	Upon Completion of drilling – Sept. 20, 2015
BH15-12	257.6	7.1 7.1	250.5 250.5	Upon Completion of drilling – Sept. 21, 2015 Standpipe Piezometer – September 30, 2015
BH15-13	256.5	6.8	249.72	Upon Completion of drilling – Sept. 30, 2015
BH15-14	263.4	Dry	-	Upon Completion of drilling – Sept. 23, 2015
BH15-15	260.6	Dry	-	Upon Completion of drilling – Sept. 30, 2015
BH15-16	282.2	Dry	-	Upon Completion of drilling – Sept. 30, 2015
BH15-17	286.0	Dry	-	Upon Completion of drilling – Oct. 6, 2015
BH15-18	276.8	Dry	-	Upon Completion of drilling – Oct. 6, 2015
BH15-S1	268.9	Dry Dry	- -	Upon Completion of drilling – Oct. 22, 2015 Standpipe Piezometer – September 30, 2015
BH15-S4	260.7	Dry	-	Upon Completion of drilling – Oct. 22, 2015
BH15-S5	266.8	Dry	-	Upon Completion of drilling – Oct. 30, 2015
BH15-N1	257.3	8.9	248.4	Upon Completion of drilling – December 10, 2014

The groundwater level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and other wet periods of the year.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Nick La Posta, P. Eng., and revisions made by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge M.A. Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant for Golder carried out a quality control review of the final report.

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PART B

PRELIMINARY DESIGN REPORT
WIDENING OF DEEP CUTS AND HIGH FILL EMBANKMENTS
HIGHWAY 12 MEMORIAL AVENUE TO HORSESHOE VALLEY ROAD
ENVIRONMENTAL ASSESSMENT
CITY OF ORILLIA, ONTARIO
WO 11-20002

May 11, 2017
Report No. 13-1111-0026

Golder Associates

6.0 DISCUSSION AND ENGINEERING RECOMMENDATION

6.1 General

This section of the report provides preliminary foundation design recommendations for the proposed widening of deep cut and high fill embankments associated with the widening of the Highway 12, from Memorial Avenue to Horseshoe Valley Road, in the City of Orillia, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during a subsurface investigation at the deep cut and high fill embankment widening locations. The interpretation and recommendations are intended to provide the designers with sufficient information for the preliminary geotechnical design of the cut and fill embankment widenings. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

The following sections of this report address the construction and stability of the cut slope widening areas, and subgrade preparation (topsoil stripping soft/loose soils removal) requirements, embankment stability, embankment settlement, and associated construction concerns for the proposed high fill embankment widening areas.

6.2 Cut Slope Widening

Based on correspondence with AECOM widening of the existing cut slope on the west side of Highway 12, north and south of Old Barrie Road is required as follows:

- Cuts between 6 m to 9 m deep in the northwest quadrant of Highway 12 and Old Barrie Road to accommodate widening of the highway, as well as for re-grading of the E / W-S on-Ramp and the N – E / W off-Ramp in this quadrant;
- Cuts of up to 6 m deep in the southwest quadrant of Highway 12 and Old Barrie Road to accommodate widening of the highway along the west side.

Based on the subsurface conditions encountered in Boreholes BH15-01 to BH15-05, BH15-18, and BH15-S1 conventional earth cut slopes inclined at 2 Horizontal to 1 Vertical (2H:1V) or shallower can be used for the cut widening in each of these areas. Given the compact to very dense relative density of the silt and sand till and the silt to silty sand to sand to gravelly silty sand deposits throughout and into which the cut will be made, and the presence of the groundwater level between about 4 m and 8 m below the base of the cut, it is expected that there will not be any slope stability issues associated with the cut slopes. Global slope stability analyses of the cut slope(s) should be confirmed during the detailed design.

6.2.1 Embankment Stability

Slope stability analyses have been performed for the proposed deep cut using the commercially available program *SLIDE 7.0*, produced by Rocscience Inc., to check that a minimum factor of safety of 1.3 is achieved for the proposed cut and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed deep cut on this project, considering the design requirements and the available field and laboratory testing data.

The stability analyses was completed based on the deepest proposed cut of 9 m and the soil conditions encountered within the deep cut area. An effective stress analysis is applicable for the deep cut area. The

following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Soil Conditions	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Gravelly silty sand, compact to very dense	20	32°	-
Silty sand till, dense	21	32°	-
Gravelly clayey silt with sand till, hard	21	32°	-
Clayey silt, hard	21	33°	-
Silty sand, very dense	21	35°	-

The analysis results indicate that the deep cut side slopes inclined no steeper than 2 horizontal to 1 vertical (2H:1V) will have a factor of safety greater than 1.3 against global instability. Localized surficial sloughing may occur in places based on the results of the slope stability analysis; however, no deep seated failures are present. The results of static global stability analyses for the deep cut area is presented on Figure 1.

6.2.1.1 Surficial Stability / Erosion Protection

The cut widening will generally be carried out through till deposits in the northwest quadrant of the Highway 12 / Old Barrie Road interchange, and interlayered deposits of silt to silty sand, to sand. In accordance with MTO's standard practice, a minimum 2 m wide bench should be provided where cut slopes are equal to or greater than 6 m high, such that the uninterrupted slope height does not exceed 6 m. Vegetation cover should be established on all cut slope faces to protect against surficial erosion, as per OPSS 802 (Topsoil) and OPSS.PROV 804 (Seed and Cover). Alternatively, the slope face could be protected with pegged soil as per OPSS 803 (Sodding). Where space permits, an interceptor ditch may be considered along the crest of the cut slope to minimize surface water flow over the crest and slope face, thereby minimizing surface erosion potential.

6.3 High Fill Embankment Widening

AECOM has identified four areas of high fill which are required for the embankment widening within the project limits:

- Southeast quadrant of Highway 12 / Old Barrie Road Interchange
  - Fill embankment up to 14 m high;
  - Accommodate a new S / E-W off-Ramp alignment
- Southwest and southeast quadrants of Highway 12 / Coldwater Road Interchange
  - Fill embankments between 6 m and 9 m high;
  - Accommodate the new alignment of the Coldwater Road Underpass Structure.
- North side of Highway 12, east of Wainman Line
  - Fill embankment up to 5 m high;

- Accommodate realignment of the intersection

- North side of Highway 12, west of Fairgrounds Road
  - Fill embankment up to 5 m high;
  - Accommodate realignment of the intersection

Embankment stability and settlement of the high fill embankment for each of the areas are discussed in the following sections.

6.3.1 Southeast quadrant of Highway 12 / Old Barrie Road Interchange

6.3.1.1 Embankment Stability

Slope stability analysis have been performed for the proposed embankment widening areas using the commercially available program *SLIDE 7.0*, produced by Rocscience Inc., to check that a minimum factor of safety of 1.3 is achieved for the proposed embankment heights and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed embankment widening on this project, considering the design requirements and the available field and laboratory testing data.

The stability analyses were completed for each of the general widening areas based on the highest embankment height and the soil conditions encountered within the high fill embankment areas. An effective stress analysis is applicable for the embankment widening areas. The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Soil Conditions	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Embankment fill, new	20	32°	-
Loose to very dense silt and sand fill	19	32°	-
Stiff to very stiff clayey silt	20	30°	-
Compact sand	20	32°	-

The analysis results indicate that the widened embankment side slopes inclined no steeper than 2 horizontal to 1 vertical (2H:1V) will have a factor of safety greater than 1.3 against global instability, assuming appropriate subgrade preparation and proper placement of the embankment fill materials localized. Surficial sloughing may occur in places based on the results of the slope stability analysis; however, no deep seated failures are present. The results of static global stability analyses for high fill embankment area is presented on Figure 2.

6.3.1.2 Settlement

Settlement analyses were carried out for the foundation soils using the following parameters based on field and laboratory test data and correlations suggested by Bowles (1984). The stratigraphy encountered in Borehole BH15-08 was used for the settlement analysis.

Soil Layer	Thickness (m)	Bulk Unit Weight (kN/m^3)	Deformation Properties (MPa)
Compact Silt	2.1	19	E_s = 10
Dense Silt	1.9	20	E_s = 20
Dense to Very Dense Sand	7.7	20	E_s = 75
Hard Clayey Silt	3.0	20	E_s = 75
Dense to Very Dense Silty Sand	1.4	20	E_s = 30
Very Dense Sand to Silty Sand	4.1	21	E_s = 50

The settlement analyses assume that all organic and very loose / soft surficial soils have been removed prior to embankment fill placement.

6.3.1.2.1 Results of Analysis

The results of the analyses indicate a total settlement of up to approximately 110 mm would occur below the embankment, for the maximum 14 m high section of the embankment (refer to Drawing 3, Cross-Section D-D'). The majority of the settlement is expected to occur during or shortly after construction in response to filling based on the non-cohesive nature of the soil deposits. Although post-construction settlement should be minimal, to further reduce post-construction settlement, it is recommended that the embankment be constructed as early as practicable in the Contract and allowed to settle (i.e. preload) prior to final paving.

6.3.1.2.2 Settlement of New Embankment Fill

Provided that the embankment fill material consists of properly placed and compacted granular fill, the settlement of the new embankment fill itself is expected to be less than 25 mm, and the majority of settlement will occur during or shortly after construction.

6.3.2 Highway 12 / Coldwater Road Interchange

6.3.2.1 Embankment Stability

Slope stability analysis have been performed for the proposed embankment widening areas using the commercially available program *SLIDE 7.0*, produced by Rocscience Inc., to check that a minimum factor of safety of 1.3 is achieved for the proposed embankment heights and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed embankment widening on this project, considering the design requirements and the available field and laboratory testing data.

The stability analysis were completed for each of the two widening areas based on the highest embankment height and the soil conditions encountered within the high fill embankment areas. An effective stress analysis is applicable for the embankment widening areas. The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Soil Conditions	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Embankment fill, new and existing	20	30°	-
Loose to dense silt and sand	18	30°	-

The analysis results indicate that the widened embankment side slopes inclined no steeper than 2 horizontal to 1 vertical (2H:1V) will have a factor of safety greater than 1.3 against global instability, assuming appropriate subgrade preparation and proper placement of the embankment fill materials. Localized surficial sloughing may occur in places based on the results of the slope stability analysis; however, no deep seated failures are present. The results of static global stability analyses for high fill embankment area is presented on Figure 3.

6.3.2.2 Settlement

Settlement analyses were carried out for the foundation soils using the following parameters based on field and laboratory test data and correlations suggested by Bowles (1984).

Location	Soil Layer	Thickness (m)	Bulk Unit Weight (kN/m^3)	Deformation Properties (MPa)
Southwest area (Borehole BH15-12)	Existing Granular Fill (Silt and sand to gravelly sand	2.1	21	E_s = 30
	Loose to Compact Silt and Sand	2.0	18	E_s = 10
	Compact to Dense Silt and Sand	4.0	19	E_s = 20
Southeast area (Borehole BH15-13)	Loose Sand	4.0	17	E_s = 5
	Compact Silty Sand	2.3	19	E_s = 15
	Compact to Dense Sand	1.8	20	E_s = 25

The settlement analyses assume that all organic and very loose / soft surficial soils have been removed prior to embankment fill placement.

6.3.2.2.1 Results of Analysis

The results of the analyses indicate total settlements of up to about 50 mm and 170 mm would occur below the southwest (6 m high) embankment and southeast (9 m high) embankment, respectively. The majority of the settlement is expected to occur during or shortly after construction in response to filling based on the non-cohesive nature of the soil deposits. Although post-construction settlement should be minimal, to further reduce post-construction settlement, it is recommended that the embankments be constructed as early as practicable in the Contract and allowed to settle (i.e. preload) prior to final paving.

6.3.2.2.2 Settlement of New Embankment Fill

Provided that the embankment fill material consists of properly placed and compacted granular fill, the settlement of the new embankment fill itself is expected to be less than 25 mm, and the majority of settlement will occur during or shortly after construction.

6.3.3 Highway 12, Wainman Line and Fairgrounds Road

6.3.3.1 Embankment Stability

Slope stability analysis have been performed for the two proposed embankment widening areas (Wainman Line and Fairgrounds Road) using the commercially available program *SLIDE 7.0*, produced by Rocscience Inc., to check that a minimum factor of safety of 1.3 is achieved for the proposed embankment heights and geometries under static conditions. This minimum factor of safety is considered appropriate for the proposed embankment widening on this project, considering the design requirements and the available field and laboratory testing data.

The stability analysis were completed for each of the general widening areas based on the highest embankment height and the soil conditions encountered within the high fill embankment areas. An effective stress analysis is applicable for the embankment widening areas. The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Soil Conditions	Bulk Unit Weight (kN/m^3)	Effective Friction Angle	Undrained Shear Strength (kPa)
Embankment fill, new and existing	20	30°	-
Loose to very dense silt and sand to sand to sand and gravel	19	30°	-
Loose to compact silty sand to sand	18	30°	-
Compact to very dense silt and sand till	20	34°	-

The analysis results indicate that the widened embankment side slopes inclined no steeper than 2 horizontal to 1 vertical (2H:1V) will have a factor of safety greater than 1.3 against global instability, assuming appropriate subgrade preparation and proper placement of the embankment fill materials. The results of static global stability analysis for high fill embankment areas are presented on Figures 4 and 5.

6.3.3.2 Settlement

Static settlement analyses were carried out for the foundation soils using the following parameters based on field and laboratory test data and correlations suggested by Bowles (1984).

Location	Soil Layer	Thickness (m)	Bulk Unit Weight (kN/m^3)	Deformation Properties (MPa)
Wainman Line (Borehole BH15-15)	Compact Silty Sand	1.2	19	E_s = 10
	Firm Silty Clay	0.7	18	E_s = 10
	Compact Sand Till	1.9	20	E_s = 30
	Dense Gravelly Sand	1.0	21	E_s = 40

Location	Soil Layer	Thickness (m)	Bulk Unit Weight (kN/m^3)	Deformation Properties (MPa)
Fairgrounds Road (Borehole BH15-16)	Loose to Compact Silty Sand to Sand	1.9	18	E_s = 10
	Compact to Very Dense Silt and Sand Till	2.9	20	E_s = 50

The analyses assume that all organic and very loose / soft surficial soils have been removed prior to embankment fill placement.

6.3.3.3 Results of Analysis

The results of the analyses indicate total settlements of up to about 30 mm would occur below the approximately 5 m high embankments at the two fill locations. The majority of the settlement is expected to occur during or shortly after construction in response to filling based on the non-cohesive nature of the soil deposits. Although post-construction settlement should be minimal, to further reduce post-construction settlement, it is recommended that the approach embankments be constructed as early as practicable in the Contract and allowed to settle (i.e. preload) prior to final paving.

6.3.3.4 Settlement of New Embankment Fill

Provided that the embankment fill material consists of properly placed and compacted granular fill, the settlement of the new embankment fill itself is expected to be less than 25 mm, and the majority of settlement will occur during or shortly after construction.

6.3.4 Embankment Construction

It is recommended that all topsoil/organic material or loose / soft materials present within the footprint of any new embankments to be constructed be removed prior to placement of new embankment fill.

In the southeast quadrant of Highway 12 / Old Barrie Road Interchange, an extensive fill deposit was encountered in Borehole BH15-06, extending to a depth of 7.1 m and in Borehole BH16-09, extending to a depth of 4.0 m. Traces of wood were encountered in the fill at Borehole BH15-06 from depths of 1.5 m to 4.6 m and trace organics were encountered in the fill below 3.0 m depth in Borehole 15-09. In the southwest quadrant of Highway 12 / Coldwater Road Interchange, a 4 m thick fill deposit was encountered in Borehole BH15-10. Trace fibrous organic material was encountered in the fill below 3.0 depth. It is recommended that at the detail design stage additional investigation be carried out to assess the quality of the existing fill materials and verify if the fill containing organics should be removed prior to placement of new fill, or if the organics content is minimal such that the fill can be left in place.

The embankment fill for the widening areas should be placed and compacted in accordance with OPSS.PROV 501 (Compacting). Benching of the existing embankment side slopes should be carried out to “key in” the new fill materials for the widening, in accordance with OPSD 208.010 *(Benching of Earth Slopes).*

Fill for construction of the embankment widening could consist of clean earth fill or granular fill. From a geotechnical/foundations perspective, granular fill will provide relatively good compatibility with the existing embankment fill materials which are predominantly granular in composition.

In accordance with MTO's standard practice, a minimum 2 m wide bench should be provided where the embankment side slopes are equal to or greater than 8 m in high, such that the uninterrupted slope height does not exceed 8 m. It is anticipated that, based on the embankment fill thickness / heights provided by AECOM, that slope benches will be required at the Old Barrie Road and Coldwater Road embankments.

6.3.4.1 Stability of Embankment Fill

Additional slope stability analysis of the widened fill embankments should be carried out during the detail design stage, including seismic stability to confirm that an adequate factor of safety has been obtained – note that under the revised Canadian Highway Bridge Design Code (56-14, 2014, an adequate factor of safety for embankments and cut slopes for the permanent condition is 1.54 compared to 1.33 for the temporary condition.

In regard to the embankment which will be constructed as part of the Highway 12 northbound off-ramp to Old Barrie Road (i.e. the S-E / W off Ramp), AECOM has indicated that in order to minimize encroachment into the environmental natural features in the southeast quadrant of the interchange, consideration be given to steepening the slope in this area to 1H:1V. A slope with this configuration could be feasible provided the slope is properly constructed as a geosynthetic - reinforced slope, utilizing proprietary reinforcement composed of geogrid mesh / geotextile / geoweb basket and vegetated. As an alternative to a 1H:1V slope configuration, consideration should also be given to a Reinforced Soil System (RSS) retaining wall configuration to provide adequate clearance from the environmental area.

It is noted that the embankments of the fill in the Highway 12 / Old Barrie Road area will be up to about 14 m high; as such, a mid-height slope bench will be required for any sections of the embankments higher than 8 m as shown in OPSD 202.010 (Slope Flattening).

6.4 Recommendations for Future Work during Detail Design

Additional investigation is recommended along the alignments of the proposed deep cut and high fill embankments during the detail design stage of the project to further assess and/or confirm the subsurface conditions, shallow groundwater conditions, and to confirm the preliminary recommendations provided herein, as follows:

- Confirmation of the existing ground surface, subsoil conditions (including observations or confirmation of obstructions) and groundwater elevations along the proposed deep cut and high fill embankments footprints.
- Confirmation of the type strength, and thickness of the existing fill present along the proposed high fill embankments locations to assess competency of the existing fill for use as possible foundation soils;
- Assessment of the presence, depth/thickness and extent/content of topsoil/organics and unsuitable fill materials for stripping requirements within the footprint of the high fill embankments;
- Review and revise, if necessary, all preliminary design assumptions, including confirmation of global stability and settlement analysis and recommendations, based on the results of the additional geotechnical investigations as more details of the deep cut and high fill embankments are known; and an assessment of potential practical mitigation measures/works to address stability/settlement issues.

- The current groundwater levels at the site, for more detailed assessment of the groundwater control requirements and measures during construction.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Nick La Posta, P. Eng., and revision were made by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant of Golder carried out a quality control review of the final report.

GOLDER ASSOCIATES LTD.

Nikol Kochmanová, Ph.D., P. Eng., PMP
Geotechnical Engineer

Jorge M. A. Costa, P.Eng.
Designated MTO Foundations Contact, Senior Consultant

NK/JMAC/sm

\\golder.gds\gal\mississauga\active\2013\1111\13-1111-0026 urs - hwy 12 memorial ave. - orillia\reports\cut, fills\final report\wo 011-20002 - fidr - cut and fills - 2017-05-11.docx

REFERENCES

Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition. McGraw Hill Book Company, New York.

Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*. Ontario Geological Survey, Special Volume 2, 3rd Edition. Ontario Ministry of Natural Resources.

Canadian Standards Association (CSA), 2014. Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6-14. CSA Special Publication, S6.1-14.

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 802	Construction Specification for Topsoil
OPSS 803	Construction Specification for Sodding

Ontario Provincial Standard Drawings (OPSD)

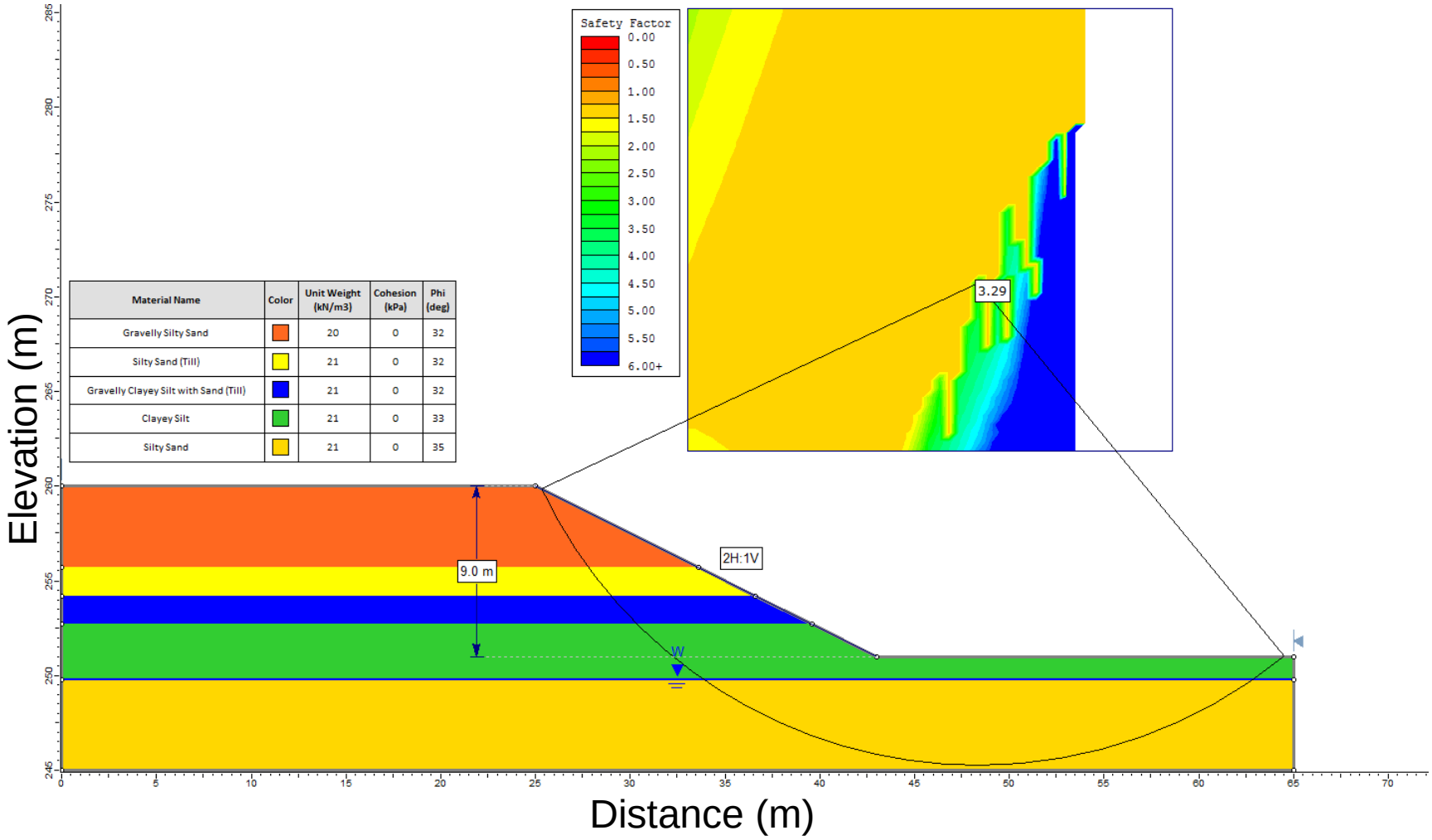
OPSD 208.010	Benching of Earth Slopes
OPDS 202.010	Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment

Commercial Software:

Slide 7.0 by Rocscience Inc.

STATIC GLOBAL STABILITY ANALYSIS
HIGHWAY 12 / OLD BARRIE ROAD INTERCHANGE
DEEP WIDENING CUT

Figure 1



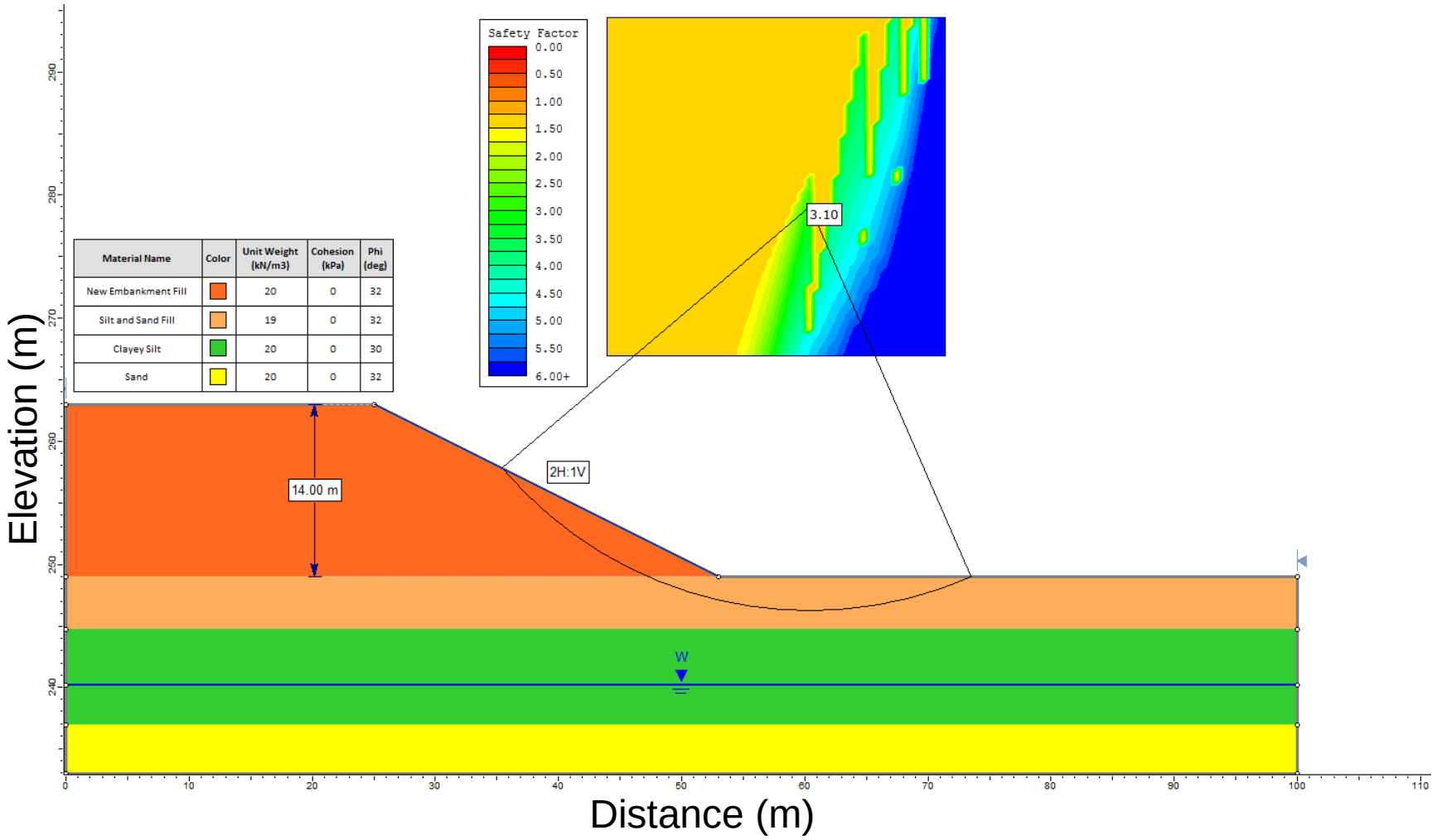
Date: May 11, 2017
Project No.: 13-1111-0026

Analysis By: NK **Reviewed By:** JMAC

Golder Associates

STATIC GLOBAL STABILITY ANALYSIS
HIGHWAY 12 / OLD BARRIE ROAD INTERCHANGE
HIGH FILL EMBANKMENT WIDENING

Figure 2



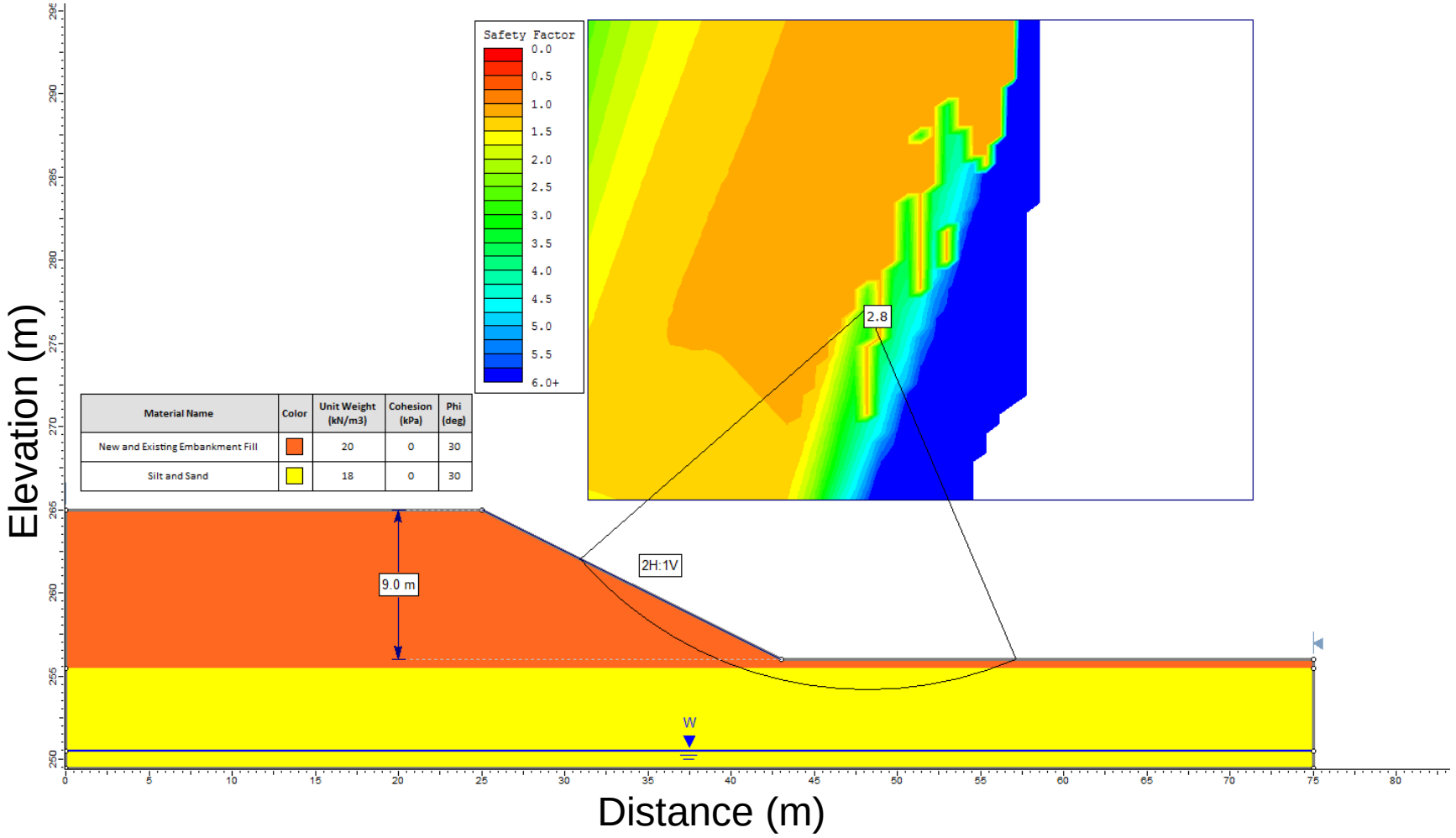
Date: May 11, 2017
Project No.: 13-1111-0026

Analysis By: NK **Reviewed By:** JMAC

Golder Associates

STATIC GLOBAL STABILITY ANALYSIS
HIGHWAY 12 / COLDWATER ROAD INTERCHANGE
HIGH FILL EMBANKMENT WIDENING

Figure 3



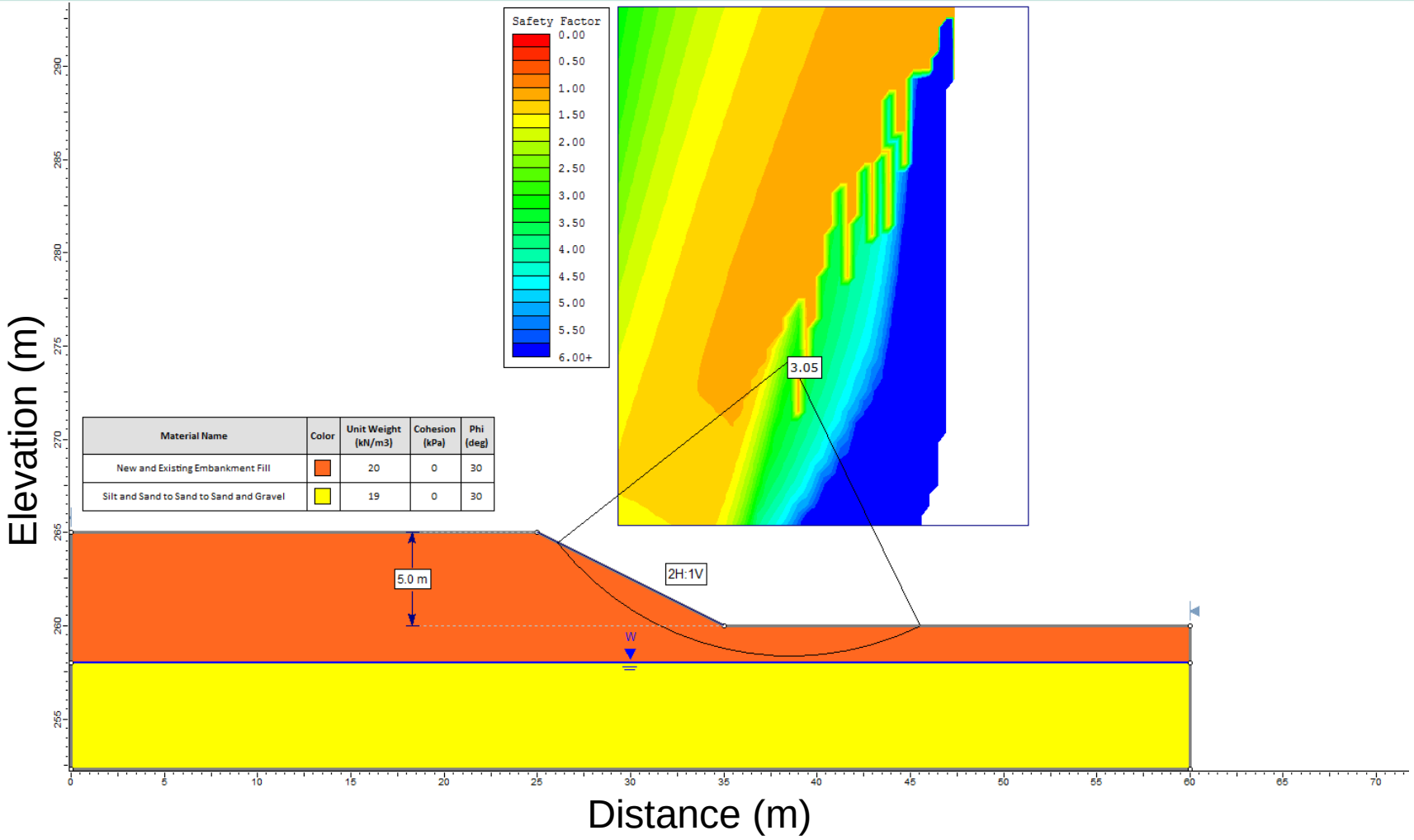
Date: May 11, 2017
Project No.: 13-1111-0026

Analysis By: NK **Reviewed By:** JMAC

Golder Associates

STATIC GLOBAL STABILITY ANALYSIS
HIGHWAY 12 / WAINMAN LINE INTERCHANGE
HIGH FILL EMBANKMENT WIDENING

Figure 4



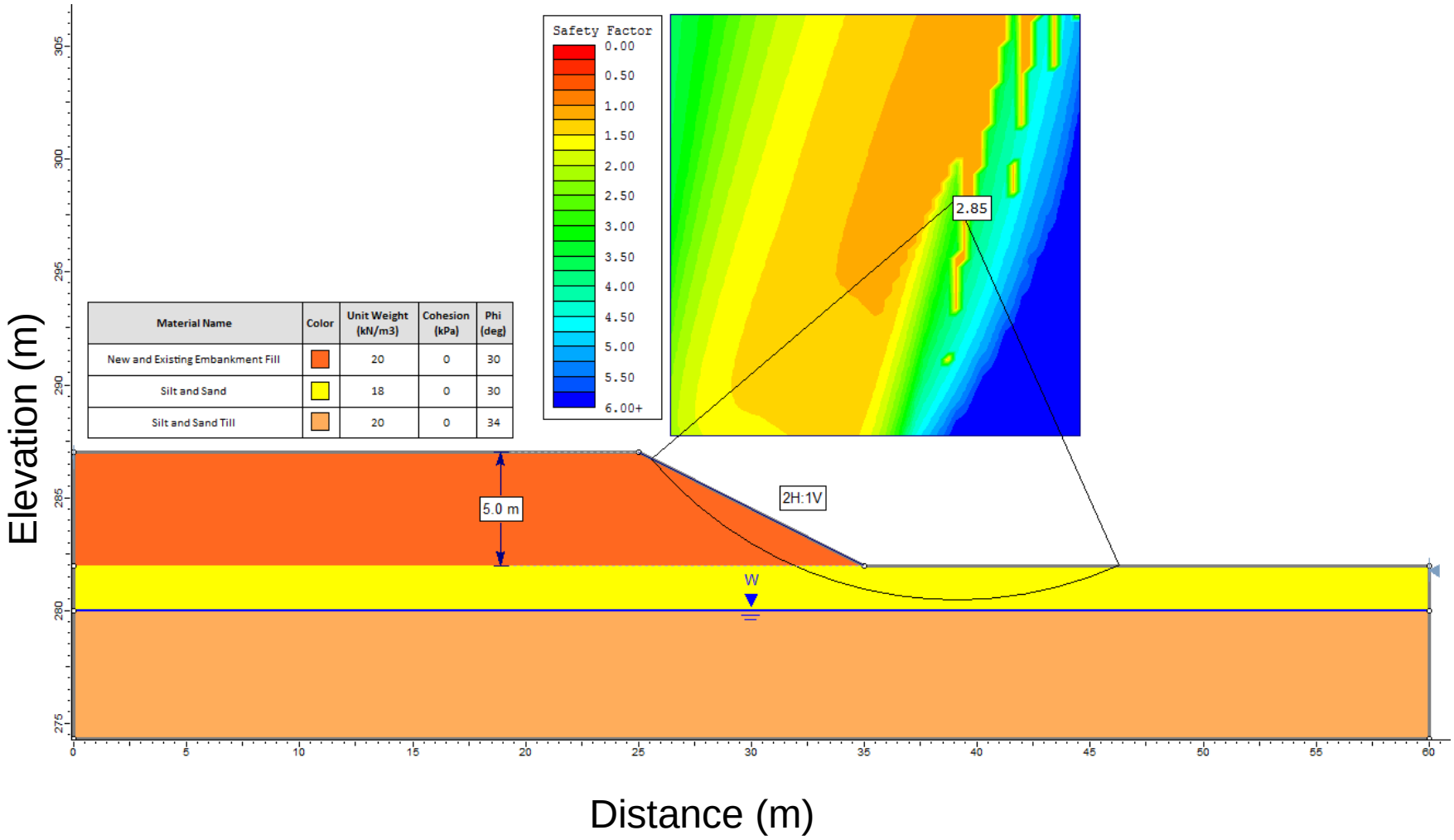
Date: May 11, 2017
Project No.: 13-1111-0026

Analysis By: NK **Reviewed By:** JMAC

Golder Associates

STATIC GLOBAL STABILITY ANALYSIS
HIGHWAY 12 / FAIRGROUNDS ROAD INTERCHANGE
HIGH FILL EMBANKMENT WIDENING

Figure 5



Date: May 11, 2017
Project No.: 13-1111-0026

Analysis By: NK **Reviewed By:** JMAC

Golder Associates

MINISTRY OF TRANSPORTATION, ONTARIO

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

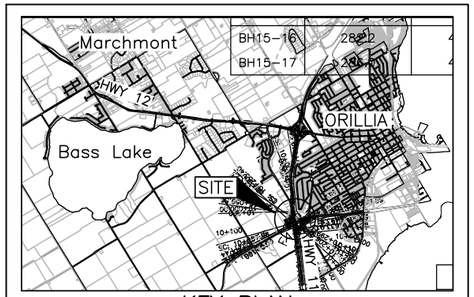
CONT No.
WO No.11-20002

HIGHWAY 11/12 (OLD BARRIE ROAD)
INTERCHANGE DEEP CUT/HIGH FILL

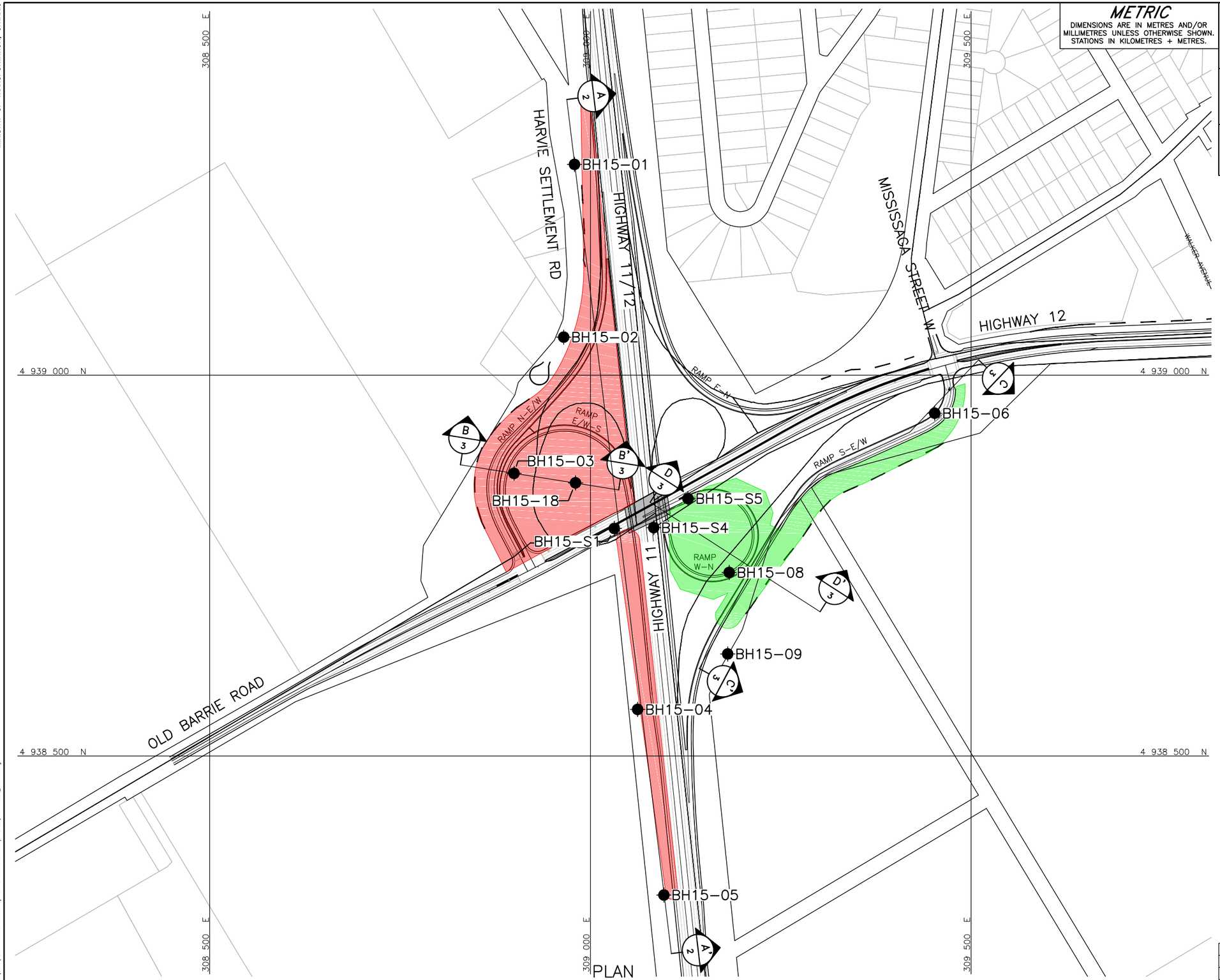
BOREHOLE LOCATIONS

SHEET
.

Golder Associates



KEY PLAN
SCALE
1.5 0 1.5 3 km



PLAN
SCALE
50 0 50 100 m

LEGEND

- Borehole Location
- Cut Area
- Fill Area

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15-01	289.4	4939276.9	308979.1
BH15-02	282.4	4939050.1	308964.9
BH15-03	276.9	4938871.2	308899.6
BH15-04	250.9	4938561.1	309062.0
BH15-05	238.0	4938317.4	309096.5
BH15-06	251.1	4938950.1	309452.2
BH15-08	247.8	4938741.0	309182.3
BH15-09	248.7	4938634.0	309180.3
BH15-18	276.8	4938858.7	308980.4
BH15-S1	268.9	4938798.8	309031.3
BH15-S4	260.7	4938799.8	309083.1
BH15-S5	266.8	4938838.0	309128.1

NOTES

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

REFERENCE

Base plans provided in digital format by AECON, drawing file no, Old Barrie Rd IC_Corridors.dwg received FEB 25, 2016.

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA MAY 11, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 MAY. 11, 2017 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D-647

HWY. 12	PROJECT NO. 13-1111-0026		DIST. .
SUBM'D. .	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 1

PLOT DATE: May 11, 2017
FILENAME: K:\Projects\2013\13-1111-0026 ure - hwy 12 memorial over-ostfb\CIVIL 3D\1311110026_Cut-Fill.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

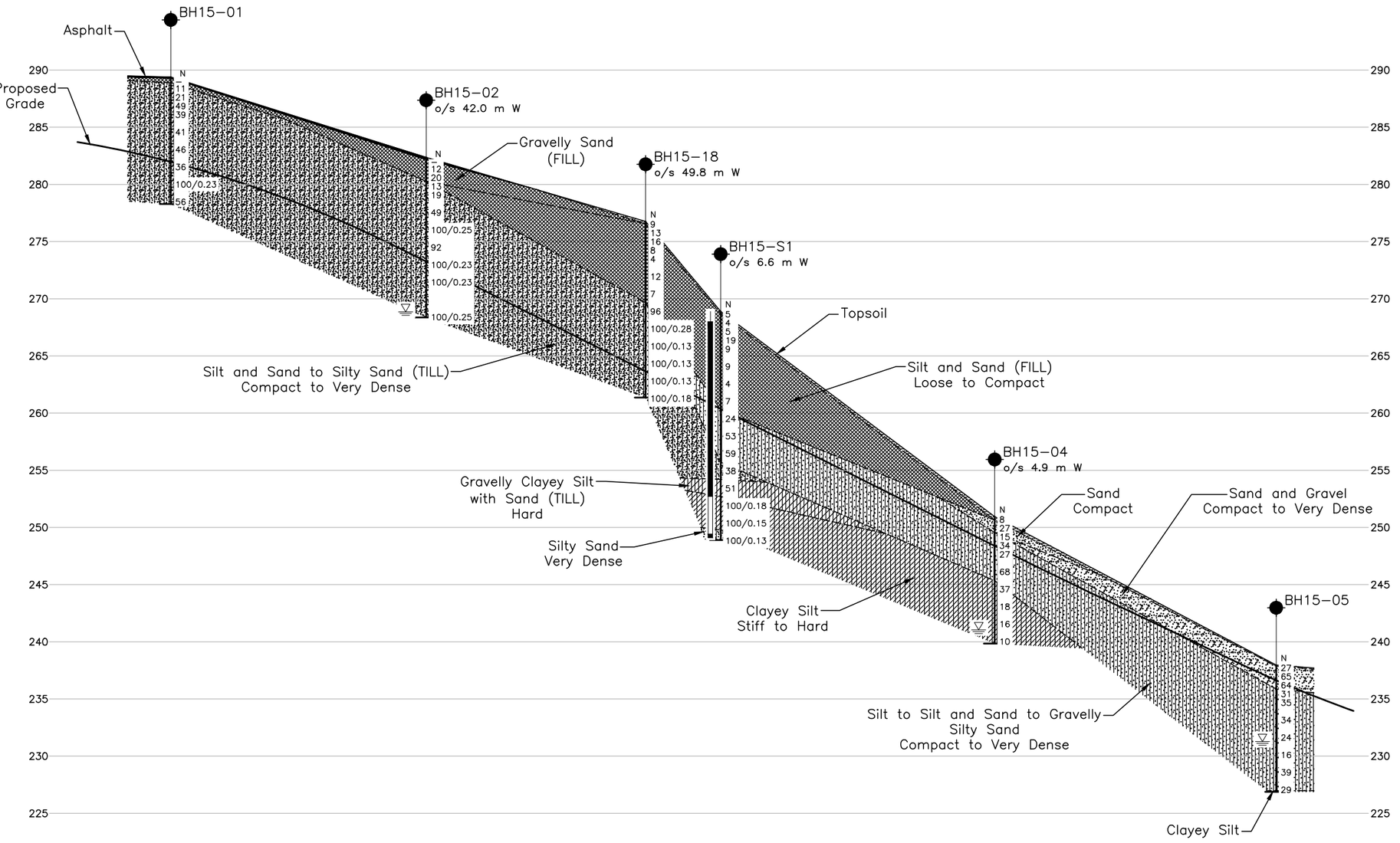
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WO No.11–20002

HIGHWAY 11/12 (OLD BARRIE ROAD)
INTERCHANGE DEEP CUT/HIGH FILL
SOIL STRATA

SHEET

Golder Associates



A–A'
1
PROFILE HIGHWAY 11/12

HORIZONTAL SCALE
40 0 40 80 m
4 0 4 8 m
VERTICAL SCALE

LEGEND

- Borehole Location
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO–ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH15–01	289.4	4939276.9	308979.1
BH15–02	282.4	4939050.1	308964.9
BH15–04	250.9	4938561.1	309062.0
BH15–05	238.0	4938317.4	309096.5
BH15–18	276.8	4938858.7	308980.4
BH15–S1	268.9	4938798.8	309031.3

NOTES

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REFERENCE

Base plans provided in digital format by Aecom, drawing file no. Old Barrie Rd IC_Corridors.dwg, received FEB 25, 2016.

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA MAY 11, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 MAY. 11, 2017 PROVINCE OF ONTARIO

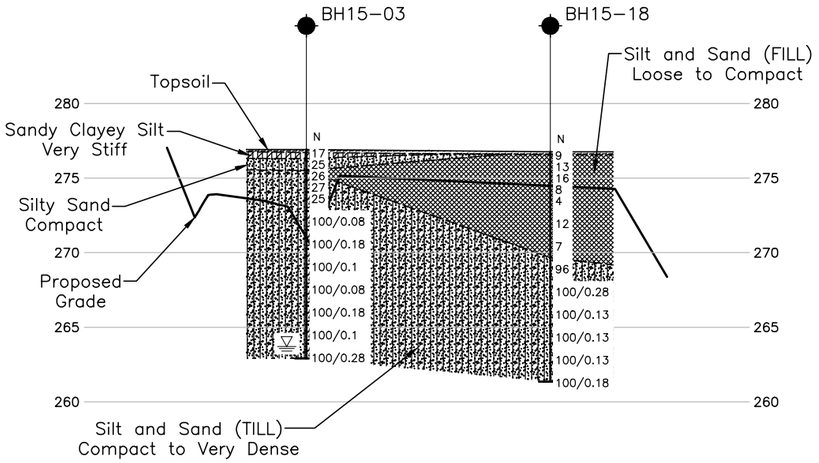
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D–647

HWY. 12		PROJECT NO. 13–1111–0026	DIST. .
SUBM'D. .	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 2

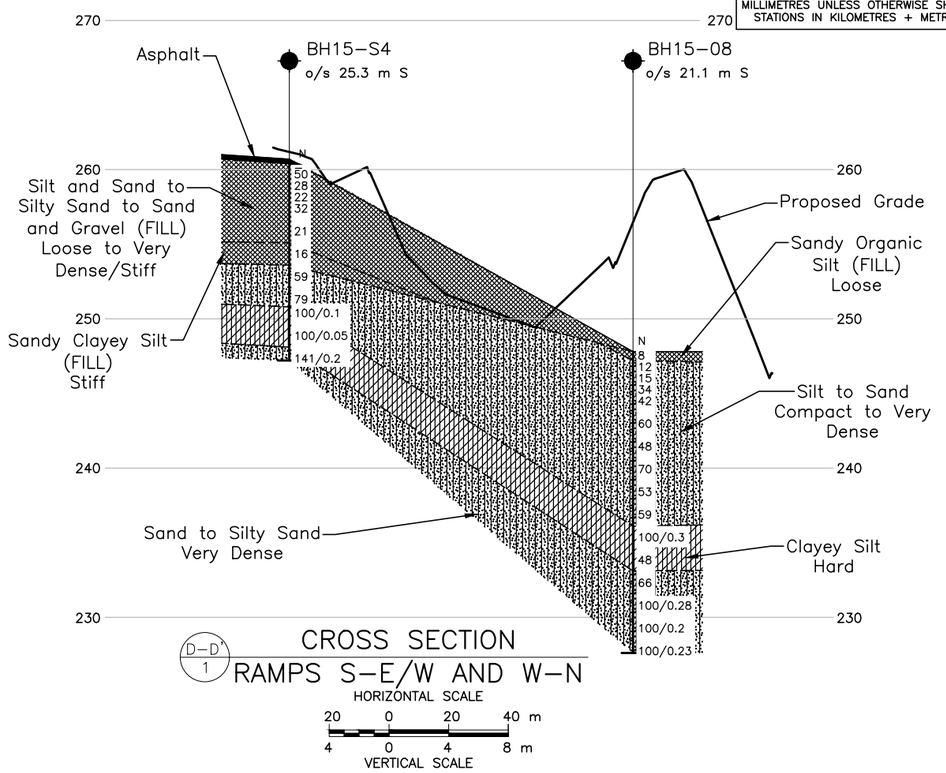
PLOT DATE: May 11, 2017
FILENAME: K:\Projects\2013\13-1111-0026 uns - hwy 12 memorial ave-orillia\CIVIL 3D\131111026b_Cut-Fill.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



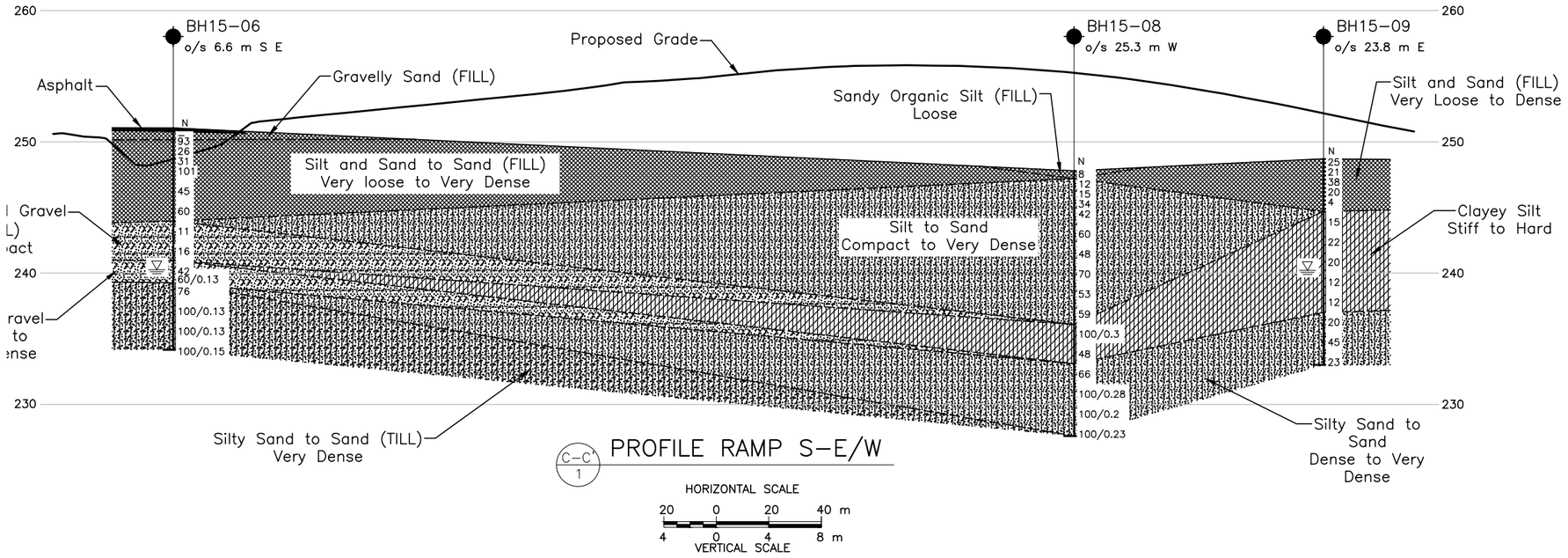
B-B' / 1 CROSS-SECTION
RAMPS N-E/W AND E/W-S

HORIZONTAL SCALE
20 0 20 40 m
4 0 4 8 m
VERTICAL SCALE



D-D' / 1 CROSS SECTION
RAMPS S-E/W AND W-N

HORIZONTAL SCALE
20 0 20 40 m
4 0 4 8 m
VERTICAL SCALE



C-C' / 1 PROFILE RAMP S-E/W

HORIZONTAL SCALE
20 0 20 40 m
4 0 4 8 m
VERTICAL SCALE

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

CONT No.
WO No.11-20002

HIGHWAY 11/12 (OLD BARRIE ROAD)
INTERCHANGE DEEP CUT/HIGH FILL

SOIL STRATA

SHEET .

Golder Associates

LEGEND

- Borehole Location
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15-03	276.9	4938871.2	308899.6
BH15-06	251.1	4938950.1	309452.2
BH15-08	247.8	4938741.0	309182.3
BH15-09	248.7	4938634.0	309180.3
BH15-18	276.8	4938858.7	308980.4
BH15-S4	260.7	4938799.8	309083.1

NOTES

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

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. Old Barrie Rd IC_Corridors.dwg, received FEB 25, 2016.

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA MAY 11, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 MAY. 11, 2017 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D-647

HWY. 12	PROJECT NO. 13-1111-0026		DIST. .
SUBM'D. .	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 3

PLOT DATE: May 11, 2017
FILENAME: K:\Projects\2013\13-1111-0026 uns - hwy 12 memorial ave-orillia\CIVIL 3D\13111102S6_Cad-Fill.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

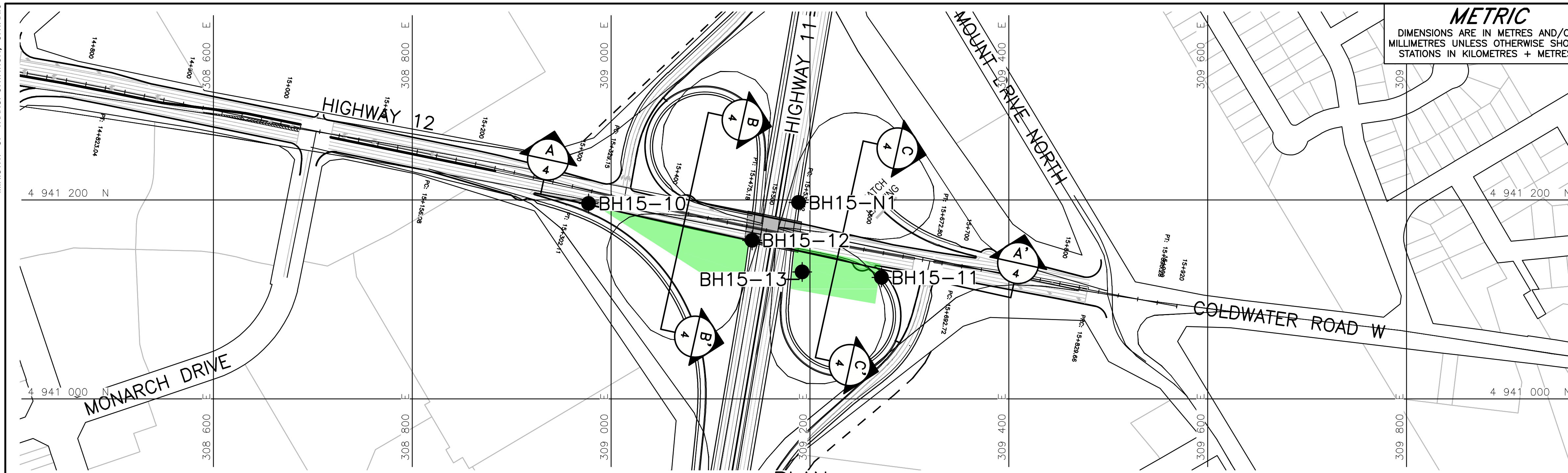
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WO No.011-20002

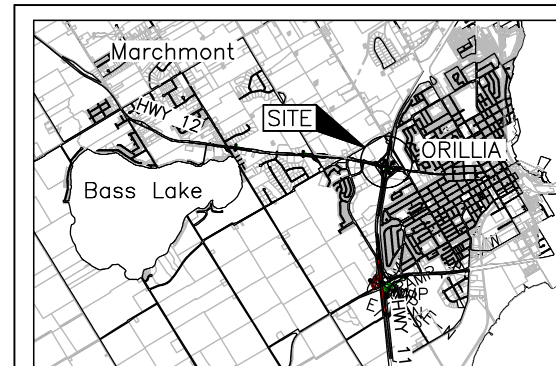
SHEET

HIGHWAY 12
COLDWATER ROAD BRIDGE
BORHOLE LOCATIONS AND SOIL STRATA

Golder Associates



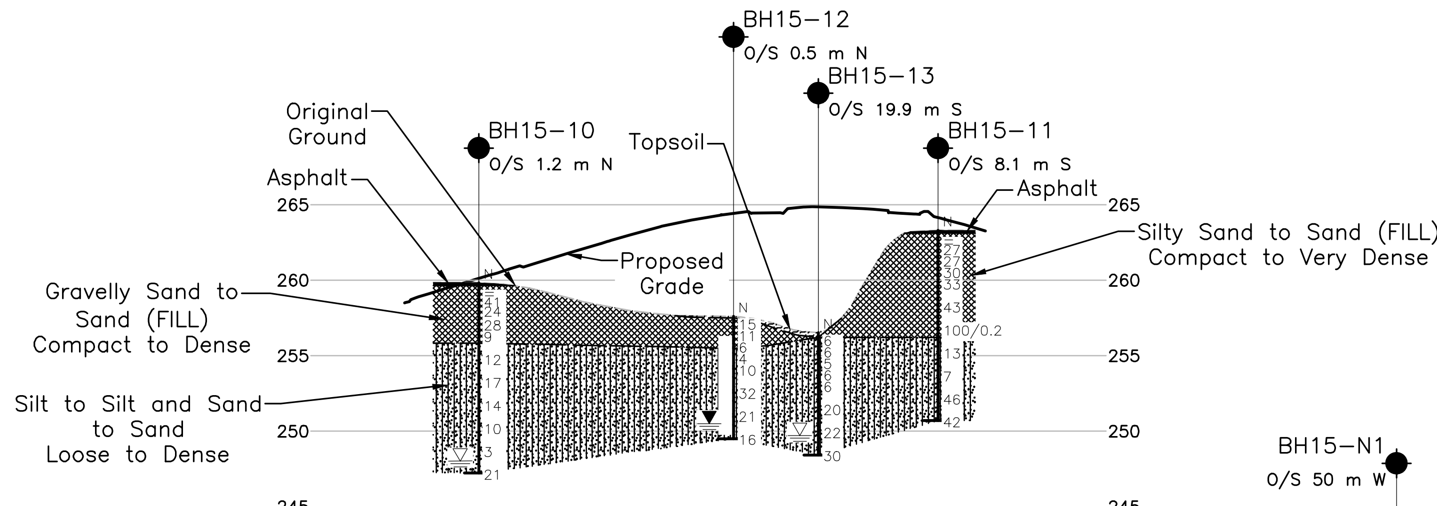
PLAN
SCALE
50 0 50 100 m



KEY PLAN
SCALE
1.5 0 1.5 3 km

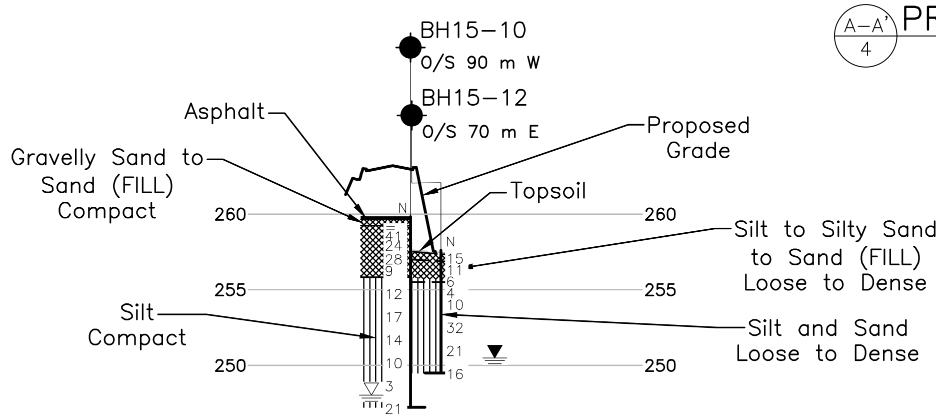
LEGEND

Symbol	Description
●	Borehole Location
(green)	Fill Area
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▼	WL in piezometer, measured on SEP 30, 2015
▽	WL upon completion of drilling



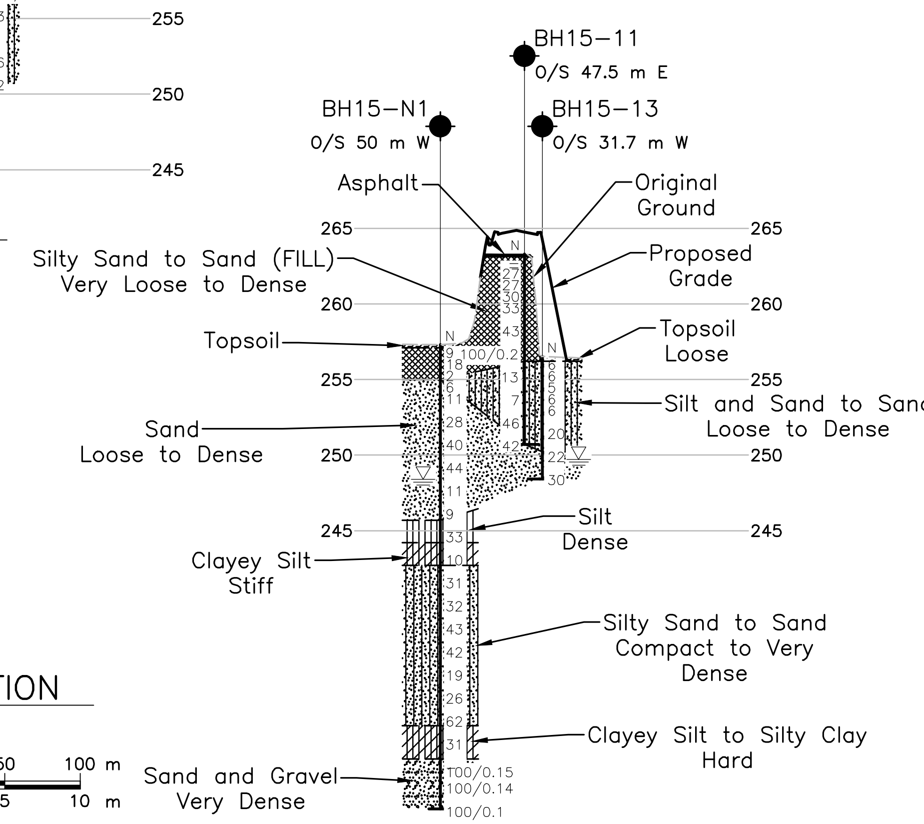
PROFILE ALONG HWY 12 (A–A' / 4)

50 0 50 100 m
5 0 5 10 m



SECTION (B–B' / 4)

50 0 50 100 m
5 0 5 10 m



SECTION (C–C' / 4)

50 0 50 100 m
5 0 5 10 m

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15-10	259.8	4941196.4	308977.4
BH15-11	263.3	4941122.0	309272.1
BH15-12	257.6	4941159.4	309141.8
BH15-13	256.5	4941127.5	309192.2
BH15-N1	257.3	4941197.4	309188.6

NOTES

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

REFERENCE

Base plans provided in digital format by AECON, drawing file ColdwaterIC_Corridors.dwg and X-Existing Surfaces.dwg, received Feb. 25, 2016.

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA MAY 11, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 MAY 11, 2017 PROVINCE OF ONTARIO

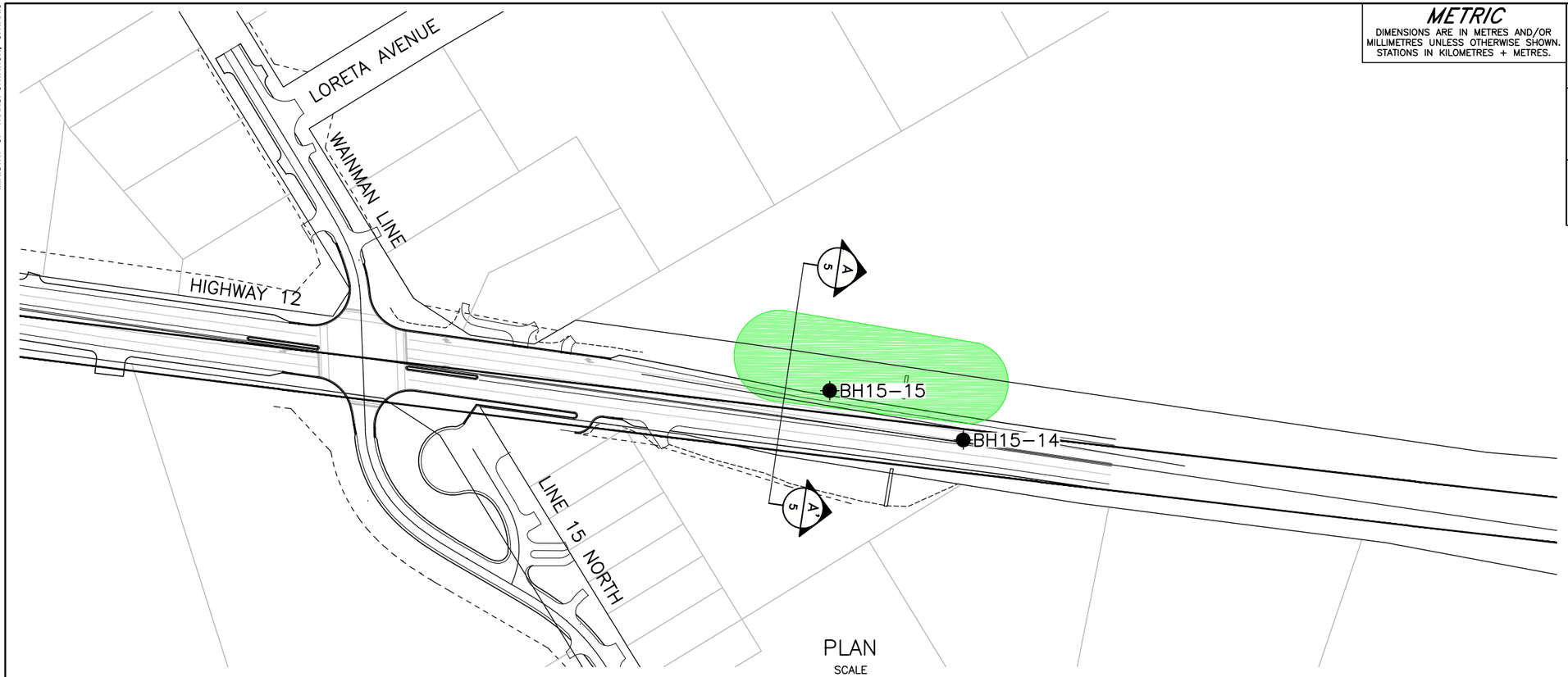
NO.	DATE	BY	REVISION
.	.	.	

Geocres No. 31D-647

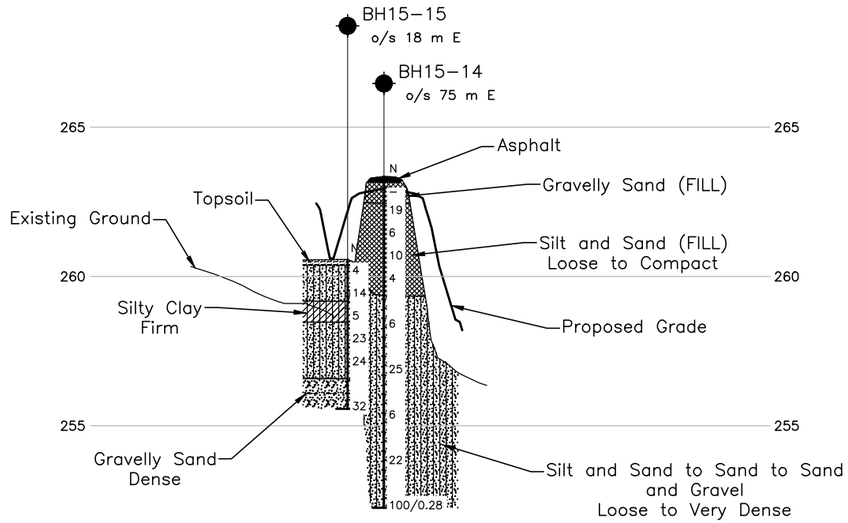
HWY. 12	PROJECT NO. 13-1111-0026		DIST.
SUBM'D.	CHKD. NK	DATE: 5/11/2017	SITE:
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 4

PLOT DATE: May 11, 2017
FILENAME: H:\Projects\2013\13-1111-0026 urs - hwy 12 memorial ave-orillia\CIVIL 3D\1311110026_Cut-Fill.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
20 0 20 40 m



A–A'
5
SECTION ALONG HWY 12

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m

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

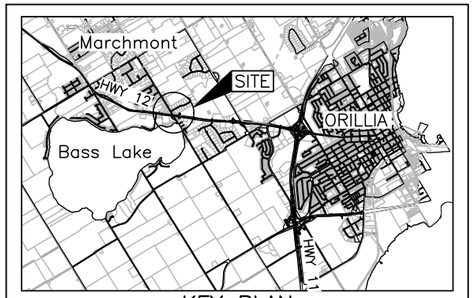
CONT No.
WO No.11–20002

N

HIGHWAY 12
EMBANKMENT WIDENING AT WAINMAN LINE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
.

Golder Associates



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

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

BOREHOLE CO–ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH15–14	263.4	4941527.0	306223.6
BH15–15	260.6	4941547.2	306169.0

NOTES

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

REFERENCE

Base plans provided in digital format by Aecom, drawing file no. Wainman_Intersection_Corridors.dwg, received FEB 25, 2016.

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA MAY 11, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 MAY. 11, 2017 PROVINCE OF ONTARIO

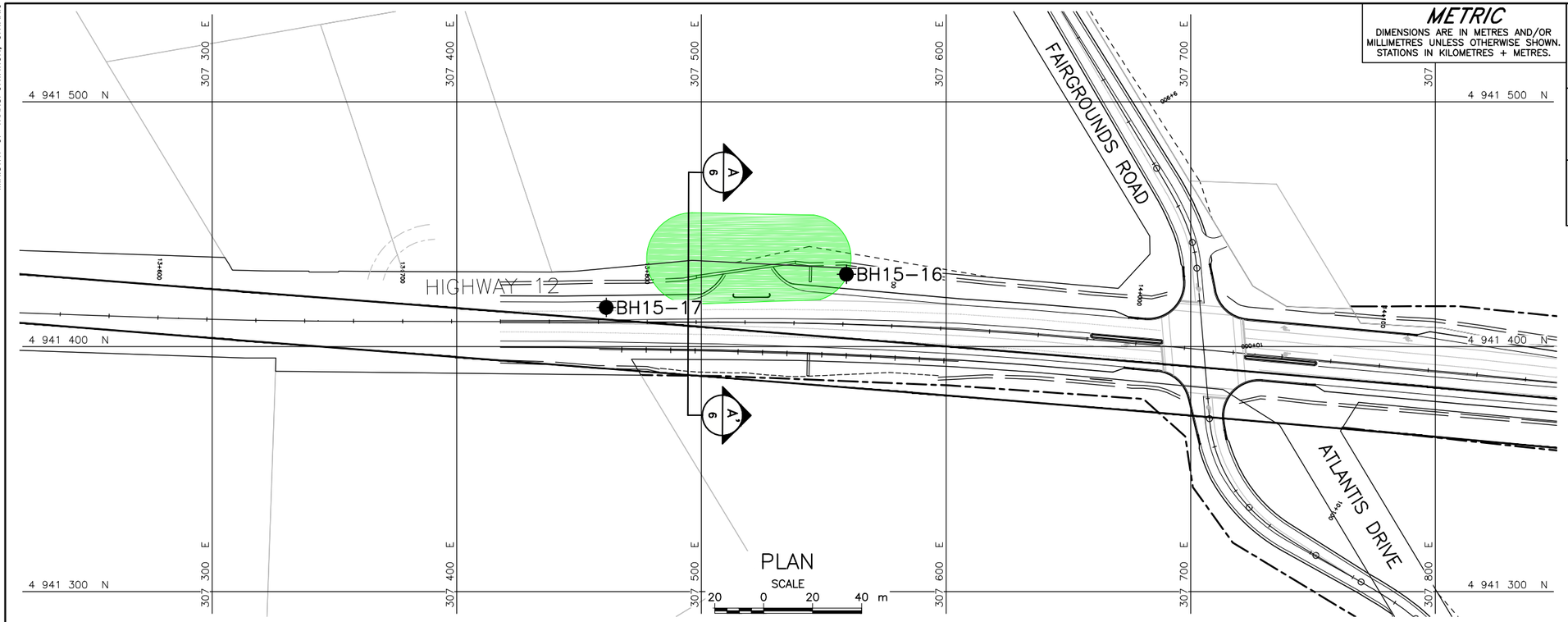
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D–647

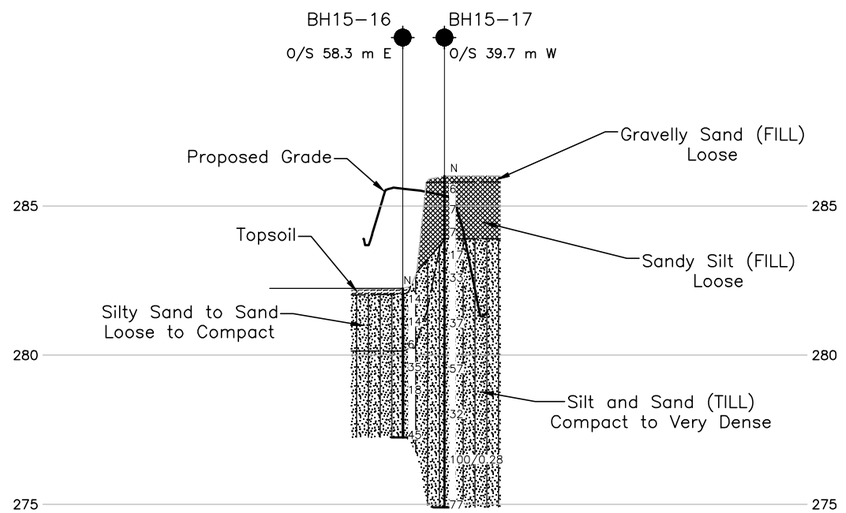
HWY. 12	PROJECT NO. 13–1111–0026		DIST. .
SUBM'D. .	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 5

PLOT DATE: May 11, 2017
FILENAME: K:\Projects\2013\13-1111-0026 urs - hwy 12 memorial ave-orillia\CIVIL 3D\13111100026_Cst-Plt.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
20 0 20 40 m



A–A'
6
SECTION ALONG HWY 12

HORIZONTAL SCALE
20 0 20 40 m
VERTICAL SCALE
2 0 2 4 m

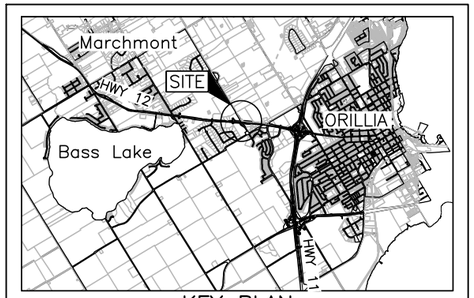
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WO No.11–20002

HIGHWAY 12
EMBANKMENT WIDENING AT FAIRGROUNDS ROAD
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
.

Golder Associates



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole Location
- Fill Area
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH15–16	282.2	4941429.6	307559.3
BH15–17	286.0	4941416.0	307461.1

NOTES

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

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

REFERENCE

Base plans provided in digital format by Aecon, drawing file no. Fairgrounds_Intersection_Corridors.dwg, received FEB 25, 2016.

LICENSED PROFESSIONAL ENGINEER
J.M.A.COSTA
MAY 11, 2017
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
N. KOCHMAN
100117863
MAY. 11, 2017
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D–647

HWY. 12		PROJECT NO. 13–1111–0026	DIST. .
SUBM'D. .	CHKD. NK	DATE: 5/11/2017	SITE: .
DRAWN: TB	CHKD. NLP	APPD. JMAC	DWG. 6

PLOT DATE: May 11, 2017
FILENAME: K:\Projects\2013\13-1111-0026 wp - hwy 12 memorial ave-orillia\CIVIL 3D\13111110026_Cad-Fill.dwg

APPENDIX A

Borehole Records

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, 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 (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

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

Density Index / Relative Density	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

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

Golder Associates

RECORD OF BOREHOLE No BH15-01

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4939276.9; E 308979.1 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 29, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.4	GROUND SURFACE										
0.0	ASPHALT (130 mm)										
0.1	Gravelly sand, trace silt (FILL) Brown Moist		1	SS	-		289				
288.9 0.5	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Bown Moist		2	SS	11				○H		10 48 35 7
			3	SS	21		288				
			4	SS	49		287		○		
			5	SS	39		286				
			6	SS	41		285		○		
	Auger grinding at 6.1 m depth.		7	SS	46		284				
			8	SS	36		283		○H		11 47 32 10
	Cobbles/boulders inferred from 9.2 to 9.5 m depth..		9	SS	100/0.23		282				
278.3			10	SS	56		281		○		
11.1	END OF BOREHOLE						280				
	Note: 1. Borehole dry upon completion of drilling.						279				

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-02

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4939050.1; E 308964.9 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 29, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.4	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Gravelly sand, trace silt, trace cobbles (FILL) Brown Moist		1	CS	-						
281.8 / 0.6	Silt and sand, trace to some gravel, trace to some clay (FILL) Compact Brown Moist		2	SS	12						
	Trace organics noted in Sample 2.		3	SS	20				○ H		19 44 32 5
280.3 / 2.1	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist		4	SS	13						
			5	SS	19				○		
			6	SS	49						
			7	SS	100/0.25				○ H		12 46 32 10
			8	SS	92						
			9	SS	100/0.23				○		
			10	SS	100/0.23						

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-02

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4939050.1; E 308964.9 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 29, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist						270				
						▽	269				
268.4			11	SS	100/0.25				○		
14.0	END OF BOREHOLE Note: 1. Water level inside augers at a depth of 13.5 m below ground surface (Elev. 268.9 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-03

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938871.2; E 308899.6 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 29 and 30, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
276.9	GROUND SURFACE										
0.0	TOPSOIL		A								
0.2	Sandy CLAYEY SILT, some gravel, trace organics		1 B	SS	17						
276.3	Very stiff										
0.6	Dark brown Moist										
	SILTY SAND Compact Brown		2	SS	25		276		○		0 71 (29)
275.5	Moist										
1.4	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist		3	SS	26		275				
			4	SS	27				○		
							274				
			5	SS	25						
							273				
			6	SS	100/0.08				○		7 50 33 10
	Augers grinding below 4.9 m depth.						272				
							271				
			7	SS	100/0.13						
							270				
			8	SS	100/0.1				○		
							269				
							268				
			9	SS	100/0.08						
							267				
			10	SS	100/0.13		266		○		
							265				

Continued Next Page

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

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PROJECT 13-1111-0026

RECORD OF BOREHOLE No BH15-03

2 OF 2 **METRIC**

W.P. 11-20002 LOCATION N 4938871.2; E 308899.6 ORIGINATED BY DM

DIST CENTRAL HWY 12 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NL

DATUM GEODETIC DATE September 29 and 30, 2015 CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Brown to grey Moist		11	SS	100/0.1	▽	264				
262.9			12	SS	100/0.28		263		○		
14.0	END OF BOREHOLE Note: 1. Water level at a depth of 13.2 m below ground surface (Elev. 263.7 m) upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-04

1 OF 2 **METRIC**

PROJECT 13-1111-0026
W.P. 11-20002
DIST CENTRAL HWY 12
DATUM GEODETIC

LOCATION N 4938561.1; E 309062.0
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
DATE September 24, 2015

ORIGINATED BY DM
COMPILED BY NL
CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.9	GROUND SURFACE										
0.0 / 250.6	TOPSOIL		A 1 B	SS	8						
0.3	SAND, trace silt, trace to some gravel Compact Brown Moist Cobbles and boulders inferred at 1.2 m depth.		2	SS	27		250				
249.5											
1.4	SILT, trace to some sand, trace to some clay Compact to very dense Brown Moist to wet		3	SS	15		249		○		0 7 81 12
			4	SS	34						
			5	SS	27		248		○		0 5 94 1
			6	SS	68		247				
245.3							246				
5.6	CLAYEY SILT, trace sand, trace gravel Stiff to hard Grey Moist		7	SS	37		245		○		
			8	SS	18		244				
			9	SS	16	▽	243		⊢○⊣		0 1 75 24
			10	SS	10		242				
239.8							241				
11.1							240				

Continued Next Page

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

Golder Associates

PROJECT 13-1111-0026

RECORD OF BOREHOLE No BH15-04

2 OF 2 **METRIC**

W.P. 11-20002 LOCATION N 4938561.1; E 309062.0 ORIGINATED BY DM

DIST CENTRAL HWY 12 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NL

DATUM GEODETIC DATE September 24, 2015 CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE										
	Note:										
	1. Water level at 9.9 m below ground surface (Elev. 241.0 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-05

1 OF 2 **METRIC**

PROJECT 13-1111-0026
W.P. 11-20002
DIST CENTRAL HWY 12
DATUM GEODETIC

LOCATION N 4938317.4; E 309096.5
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
DATE September 24, 2015

ORIGINATED BY DM
COMPILED BY NL
CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.0	GROUND SURFACE										
0.0	TOPSOIL		B 1 A	SS	27						
0.1	SAND and GRAVEL, trace to some silt Compact to very dense Brown Moist		2	SS	65		237				
	Augers grinding from 1.5 m to 2.3 m depth.		3	SS	64				○		50 40 (10)
235.9							236				
2.1	SILT and SAND, trace to some clay Compact to dense Brown Moist to wet		4	SS	31						
	Increased clay content in Sample 5.		5	SS	35		235		○		1 34 52 13
			6	SS	34		234				
	Increased clay content in Sample 7.		7	SS	24	▽	233		○		
229.4							232				
8.6	SILT, trace to some sand, trace to some clay Dense Grey Wet		8	SS	16		231				
			9	SS	39		230		○		0 10 82 8
227.9							229				
10.1	SAND Compact Grey Wet		A 10 B	SS	29		228				
227.0							227				
11.1	CLAYEY SILT, some sand, varved Grey Moist										

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

PROJECT 13-1111-0026

RECORD OF BOREHOLE No BH15-05

2 OF 2 **METRIC**

W.P. 11-20002 LOCATION N 4938317.4; E 309096.5 ORIGINATED BY DM

DIST CENTRAL HWY 12 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NL

DATUM GEODETIC DATE September 24, 2015 CHECKED BY JMAC

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 (%) (10 20 30)	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 ---										
	END OF BOREHOLE Note: 1. Water level at a depth of 6.7 m below ground surface (Elev. 231.3 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-06

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938950.1; E 309452.2 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 16 and 17, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.1	GROUND SURFACE						251				
0.0 / 250.8	ASPHALT (270 mm)										
0.3 / 250.2	Gravelly sand, trace silt, trace to some cobbles (FILL) Brown Moist		1	AS	-						
0.9	Silty sand to sand, trace gravel (FILL) Compact to very dense Brown Moist		2	SS	93		250		○		
	Traces of wood debris noted between 1.5 m and 4.6 m depth.		3	SS	26						
			4	SS	31		249		○		
			5	SS	101		248				
			6	SS	45		247		○		2 87 (11)
244.0			7	SS	60		246				
7.1	SAND and GRAVEL, some silt, trace to some clay, trace organics (TILL) Compact Brown to black Moist to wet		8	SS	11		245		○		
			9	SS	16		244		○		33 45 16 6
241.0							243				
10.1	Sandy GRAVEL Dense to very dense Brown Wet						242				
	Cobbles and boulders inferred from augers grinding.		10	SS	42	▽	241		○		
			11	SS	60/0.13		240				
239.3											
11.8											

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-06

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938950.1; E 309452.2 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 16 and 17, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY SAND to SAND, some gravel, trace clay (TILL) Very dense Brown to grey Moist to wet		12	SS	76		239	○	○		
							238				
			13	SS	100/0.13		237		○		16 69 13 2
							236				
			14	SS	100/0.13				○		
							235				
234.2			15	SS	100/0.15						
16.9	END OF BOREHOLE Note: 1. Water level at a depth of 10.8 m below ground surface in augers (Elev. 240.3 m) upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-08

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938741.0; E 309182.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 28, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
247.8	GROUND SURFACE										
0.0	Sandy organic silt, some gravel, some fibrous organics (FILL) Loose Brown to black Moist		1	SS	8						
247.2											
0.6	SILT, trace to some sand, trace clay Compact to dense Brown Moist		2	SS	12		247		○		
			3	SS	15		246		○		0 9 89 2
			4	SS	34				○		
			5	SS	42		245				
243.8							244				
4.0	SAND, trace to some silt Dense to very dense Brown Moist to wet		6	SS	60		243		⊖		0 82 (18)
			7	SS	48		242				
			8	SS	70		241				
			9	SS	53		240		○		
			10	SS	59		239				
236.1							238				
11.7							237		○		
							236				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-08

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938741.0; E 309182.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 28, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace to some sand, trace to some gravel Hard Brown Moist to wet		11	SS	100/0.3				○		12 8 68 12
							235				
			12	SS	48		234		○		
233.1											
14.7	SILTY SAND to SAND Very dense Brown to grey						233				
			13	SS	66						
							232				
			14	SS	100/0.28		231		○		
							230				
			15	SS	100/0.2						
							229				
							228				
			16	SS	100/0.23				○		
227.6											
20.2	END OF BOREHOLE Note: 1. Water level could not be observed upon completion of drilling due to use of drilling mud within the augers.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-09

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938634.0; E 309180.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 28, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.7	GROUND SURFACE										
0.0	Silt and sand, some gravel, trace clay, trace organics (FILL) Very loose to dense Brown Moist		1	SS	25		248				
	Trace cohesive fines below 0.8 m depth. Asphalt fragments observed at 0.8 m depth.		2	SS	21				○		
	Augers grinding at 1.5 m depth.		3	SS	38		247				
	Trace organics below 2.3 m depth.		4	SS	20		246		○		15 33 47 5
	Trace organics below 3.0 m depth.		5	SS	4		245				
244.7											
4.0	CLAYEY SILT, trace sand, varved Stiff to very stiff Brown Moist		6	SS	15		244		○		
			7	SS	22		243				
			8	SS	20	▽	242		⊢○⊣		0 2 83 15
			9	SS	12		241				
			10	SS	12		240		○		
237.0							239				
11.7							238				
							237				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-09

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938634.0; E 309180.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 28, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND, trace to some silt Compact Brown Wet		11	SS	20		236				
			12	SS	45		235		○		
	Sandy silt seam encountered at 14.1 m depth.						234				
233.0			13	SS	23						
15.7	END OF BOREHOLE Note: 1. Water level at a depth of 8.5 m below ground surface in augers (Elev. 240.2 m) upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-10

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941196.4; E 308977.4 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 20, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.8	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
0.2	Gravelly sand, trace silt (FILL) Brown		1	AS	-						
259.2	Moist		2	SS	-						
0.6	Sand, some silt, trace clay, trace gravel (FILL) Compact to dense Brown Moist		3	SS	41		259		○		
			4	SS	24		258				
			5	SS	28				○		2 78 17 3
	Trace fibrous organic material below 3.0 m depth.		6	SS	9		257				
255.8							256				
4.0	SILT, trace to some sand, trace clay, trace gravel Compact Brown Moist to wet		A 7 B	SS	12		255		○		0 13 82 5
			8	SS	17		254				
			9	SS	14		253				
	Trace gravel observed at 9.1 m.		10	SS	10		252				
			11	SS	3		251				
	Sample 11 very loose, likely due to sample disturbance by groundwater pressure.					▽	250				
							249				5 1 94 0
							248				

Continued Next Page

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

Golder Associates

PROJECT 13-1111-0026

RECORD OF BOREHOLE No BH15-10

2 OF 2 **METRIC**

W.P. 11-20002 LOCATION N 4941196.4; E 308977.4 ORIGINATED BY DM

DIST CENTRAL HWY 12 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NL

DATUM GEODETIC DATE September 20, 2015 CHECKED BY JMAC

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 (%) (10 20 30)	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 ---										
247.2	1" thick coarse sand pocket observed at 12.2 m depth.		12	SS	21						
12.6	END OF BOREHOLE Note: 1. Water level at a depth of 11.8 m below ground surface in augers (Elev. 248.0 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-11

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | LOCATION N 4941122.0; E 309272.1 | ORIGINATED BY DM
DIST CENTRAL HWY 12 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | COMPILED BY NL
DATUM GEODETIC | DATE September 20, 2015 | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
263.3	GROUND SURFACE										
0.0	ASPHALT (160 mm)										
0.2	Sand, trace gravel, trace silt Brown Moist		1	AS	-		263		○		
262.6			2	AS	-						
0.7	Silty sand to sand, trace gravel (FILL) Compact to very dense Brown Moist		3	SS	27		262				
			4	SS	27				○		
			5	SS	30		261				
	Some cobbles observed in Sample 6.		6	SS	33		260		○		5 71 24 0
	Augers grinding below 4.6 m depth.		7	SS	43		259				
			8	SS	100/0.2		258				
256.2							257		○		
7.1	SILT and SAND Loose to dense Brown to grey Moist to wet		9	SS	13		256				
			10	SS	7		255				
			11	SS	46		254		○		0 48 52 0
							253				
							252				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-11

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941122.0; E 309272.1 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 20, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
250.7	SILT and SAND Loose to dense Brown to grey Moist to wet		12	SS	42		251		○		
12.6	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-12

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941159.4; E 309141.8 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 21, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.6	GROUND SURFACE										
0.0	TOPSOIL										
0.1	Gravelly sand, trace silt, trace bitumous material (FILL) Compact Brown Moist		1	SS	15						
257.0							257				
0.6	Silt and sand, trace to some clay, some gravel, trace organics (FILL) Compact Brown Moist		2	SS	11				○ H		15 46 32 7
256.2							256				
1.4	Silty sand, trace gravel, trace organics (FILL) Loose Brown Moist		3	SS	6						
255.5							255				
2.1	SILT and SAND Loose to dense Brown Moist		4	SS	4				○		
			5	SS	10						
							254				
			6	SS	32		253		○		0 54 46 0
							252				
			7	SS	21						
							251				
	Grey below 7.6 m depth.		8	SS	16		250		○		
249.5											
8.1	END OF BOREHOLE										

Note:

1. Water level in piezometer at a depth of 7.1 m below ground surface (Elev. 250.5 m) upon completion of installation.

2. Groundwater level at a depth of 7.1 m below ground surface (Elev. 250.5 m) in monitoring piezometer on September 30, 2015.

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-13

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941127.5; E 309192.2 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 23, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
256.5	GROUND SURFACE										
0.0 / 256.2	Sandy ORGANIC SILT, TOPSOIL, some fibrous organics		A 1 B	SS	6		256				
0.3	Loose, Dark brown, Moist										
	SAND, some silt Loose Brown Moist Minor oxidation staining below 0.8 m depth.		2	SS	6				○		
			3	SS	5		255				
			4	SS	6		254		○		0 83 16 1
			5	SS	6		253				
252.5											
4.0	SILTY SAND Compact Brown Moist to wet		6	SS	20		252		○		
250.2			A 7 B	SS	22		251				
6.3	SAND, trace to some silt Compact to dense Brown Wet					▽	250				
			8	SS	30		249		○		0 87 11 2
248.4											
8.1	END OF BOREHOLE Note: 1. Water level at a depth of 6.8 m below ground surface (Elev. 249.7 m) upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-14

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941527.0; E 306223.6 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 30, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
263.4	GROUND SURFACE										
0.0	ASPHALT (220 mm)										
0.2	Gravelly sand, some silt (FILL) Brown Moist		1	SS	-		263				
262.5											
0.9	Silt and sand, trace gravel, trace to some clay (FILL) Loose to compact Brown Moist		2	SS	19				○		
			3	SS	6		262				
			4	SS	10		261		○ H		5 50 37 8
			5	SS	4		260				
259.4											
4.0	SILT and SAND, trace clay, trace gravel, trace organics Loose to very dense Brown Moist		6	SS	6		259		○		0 57 43 0
			7	SS	25		258				
			8	SS	6		257				
			9	SS	22		256		○		
			10	SS	100/0.28		255				
252.3							254				
							253				
11.1	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.								○		3 60 34 3

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-15

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941547.2; E 306169.0 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 30, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.6	GROUND SURFACE										
0.0	TOPSOIL		A								
0.2	SILTY SAND, trace organics Loose to compact Reddish brown Moist		1 B	SS	4		260				
			2	SS	14						
259.2											
1.4	SILTY CLAY, some sand Firm Brown Moist		3	SS	5		259				
258.5											
2.1	SAND, some gravel to SAND and GRAVEL, some silt, trace clay (TILL) Compact Brown Moist		4	SS	23		258		○		33 50 14 3
			5	SS	24						
256.6							257				
4.0	Gravelly SAND, trace silt Dense Brown Moist										
			6	SS	32		256		○		
255.6											
5.0	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-16

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941429.6; E 307559.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE October 6, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.2	GROUND SURFACE										
0.0	TOPSOIL		A				282				
0.2	SILTY SAND to SAND, some silt, trace gravel Loose to compact Brown Moist to wet		1 B	SS	14						
			2	SS	14		281		○		0 88 12 0
			3	SS	6						
280.1											
2.1	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to dense Brown to grey Moist		4	SS	35		280		○		
			5	SS	18		279				
							278				
277.2			6	SS	45				○ ⊢		11 45 33 11
5.0	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-17

1 OF 1 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941416.0; E 307461.1 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE October 6, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.0	GROUND SURFACE										
0.0	Gravelly sand, trace silt (FILL) Loose Brown Moist		1	SS	6						
0.2	Sandy silt, some gravel, trace organics (FILL) Loose Brown to black Moist		2	SS	7		285		○		OC = 2.2%
			3	SS	7						
283.9							284				
2.1	SILT and SAND, some gravel, trace clay (TILL) Compact to very dense Brown Moist		4	SS	17				○		15 51 31 3
			5	SS	33		283				
							282				
			6	SS	37				○		
							281				
							280				
			7	SS	57						
							279				
			8	SS	32				○ H		20 43 34 3
							278				
							277				
			9	SS	100/0.28						
							276				
274.9			10	SS	77		275		○		
11.1	END OF BOREHOLE										

Note:

1. Borehole dry upon completion of drilling.

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-18

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938858.7; E 308980.4 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 22, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
276.8	GROUND SURFACE										
0.0	TOPSOIL, trace gravel		A								
0.2	Loose Dark brown Moist		1 B	SS	9						
	Trace organics observed from 0.2 m to 0.5 m depth.										
	Silt and sand, trace to some gravel, trace to some clay (FILL) Loose to compact Brown Moist		2	SS	13		276		○		
			3	SS	16		275				
	Trace fibrous organics, minor organic staining, brown mottled black observed from 1.5 m to 2.0 m depth.		4	SS	8		274		○ H		4 51 42 3
			5	SS	4		273				
			6	SS	12		272		○		
	Augers grinding from 4.9 m to borehole termination depth.						271				
			7	SS	7		270				
269.7											
7.1	SILT and SAND, trace to some clay, trace to some gravel (TILL) Very dense Brown Moist		8	SS	96		269		○ H		13 47 35 5
			9	SS	100/0.28		268				
							267				
			10	SS	100/0.13		266		○		
							265				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-18

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938858.7; E 308980.4 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 22, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT and SAND, trace to some clay, trace to some gravel (TILL) Very dense Brown Moist		11	SS	100/0.13						
							264				
	Sample 12 non-plastic.		12	SS	100/0.13		263		○		11 54 32 3
							262				
261.4			13	SS	100/0.13						
15.4	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-S1

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938798.8; E 309031.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 22, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
268.9	GROUND SURFACE										
0.0	TOPSOIL		A 1 B	SS	5		268				
0.2	Silt and sand, trace clay, trace to some gravel (FILL) Loose to compact Brown Moist Trace fibrous organics from 0.2 m to 0.5 m depth.		2	SS	4						
			3	SS	5		267				
			4	SS	19						
			5	SS	9		266		H		6 52 38 4
	Some black mineral fragments at 4.6 m depth.		6	SS	9		265				
			7	SS	4		264				
			8	SS	7		263				
260.3							262				
8.6	Gravelly Silty SAND, trace clay, some rock fragments Compact to very dense Brown Moist to wet Cobbles and boulders inferred from auger grinding and rock fragments in samples.		9	SS	24		261				23 54 22 1
			10	SS	53		260				
							259				
							258				
							257				

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-S1

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938798.8; E 309031.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE September 22, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
			11	SS	59		256		○		
255.7											
13.2	SILTY SAND, some gravel, trace clay (TILL) Dense Brown Moist		12	SS	38		255				
254.2											
14.7	Gravelly CLAYEY SILT with SAND (TILL) Hard Brown Moist		13	SS	51		254		○		24 34 26 16
252.7							253				
16.2	CLAYEY SILT, trace sand Hard Brown Moist		14	SS	100/0.1		252				
			15	SS	100/0.1		251		○		
249.8							250				
19.1	SILTY SAND, trace gravel Very dense Brown Moist										
248.9			16	SS	100/0.13		249				
20.0	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling. 2. Piezometer dry on September 30, 2015.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-S4

1 OF 2 **METRIC**

PROJECT 13-1111-0026
W.P. 11-20002
DIST CENTRAL HWY 12
DATUM GEODETIC

LOCATION N 4938799.8; E 309083.1
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
DATE September 14, 2015

ORIGINATED BY DM
COMPILED BY NL
CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.7	GROUND SURFACE										
0.0 / 260.4	ASPHALT (330 mm)										
0.3 / 260.0	Sand and gravel, trace silt (FILL) Brown Moist		1	AS	-						
0.7	Silt and sand to silty sand, some gravel, trace clay, trace organics (FILL) Compact to very dense Brown to grey Moist Presence of cobbles/boulders inferred by grinding at 1.5 m depth. Compact to dense below 1.5 m depth.		2	SS	50		260		○		
			3	SS	28		259				
			4	SS	22		258		○		3 55 38 4
			5	SS	32		257				
			6	SS	21		256		○		
255.1											
5.6	Sandy clayey silt, trace gravel, trace organics (FILL) Stiff Brown to grey, mottled Moist		7	SS	16		255				
253.6											
7.1	Silty SAND, some gravel, trace to some clay, trace organics Very dense Brown to grey Moist		8	SS	59		254				
							253		○		20 47 26 7
			9	SS	79		252				
250.8							251				
9.9	CLAYEY SILT, some sand, trace gravel Hard Brown Moist		10	SS	100/0.1				○		3 22 62 13
			11	SS	100/0.05		250				
							249				

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

PROJECT 13-1111-0026

RECORD OF BOREHOLE No BH15-S4

2 OF 2 **METRIC**

W.P. 11-20002 LOCATION N 4938799.8; E 309083.1 ORIGINATED BY DM

DIST CENTRAL HWY 12 BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers COMPILED BY NL

DATUM GEODETIC DATE September 14, 2015 CHECKED BY JMAC

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 ---							20 40 60 80 100	10 20 30		
248.1											
12.6	Silty SAND Very dense Brown Moist						248				
247.2			12	SS	141/0.2				○		
13.5	END OF BOREHOLE Note: 1. Water level could not be observed upon completion of drilling due to use of drilling mud in augers.										

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

Golder Associates

RECORD OF BOREHOLE No BH15-S5

1 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938838.0; E 309128.1 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE October 1, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.8	GROUND SURFACE										
0.0	ASPHALT (230 mm)										
0.2	Gravelly sand, trace silt, trace cobbles (FILL) Compact Brown Moist		1	AS	-						
			2	SS	22		266		○		
265.4											
1.4	Silt and sand to silty sand, trace to some clay, some gravel to gravelly (FILL) Loose to very dense Brown Moist		3	SS	10		265				
			4	SS	25				○		16 47 30 7
			5	SS	9		264				
							263				
	Auger grinding from 4.6 m depth.		6	SS	11		262		○		
							261				
			7	SS	9						
							260				
			8	SS	16		259		○		23 44 26 7
							258				
			9	SS	52		257				
			10	SS	16		256		○		
							255				

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-S5

2 OF 2 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4938838.0; E 309128.1 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE October 1, 2015

ORIGINATED BY DM | COMPILED BY NL | CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Silt and sand to silty sand, trace to some clay, some gravel to gravelly (FILL) Loose to very dense Brown Moist Minor organic staining, trace fibrous organics observed at 12.2 m depth.		11	SS	28		254				
			12	SS	9		253		○		16 51 26 7
	Organic staining, some fibrous organics observed at 15.2 m depth.		13	SS	18		252				
250.6							251				
16.2	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Moist		14	SS	57		250		○		4 60 31 5
			15	SS	100		249				
	A 150 mm thick silty sand pocket observed at 20.0 m depth.		16	SS	100/0.23		248				
245.3							247		○		
21.5	Sandy SILT Very dense Brown Moist		A 17 B	SS	100/0.23		246				
243.7							245				
			18	SS	100/0.25		244		○		
23.1	END OF BOREHOLE Note: 1. Water level could not be observed upon completion of drilling due to the use of drilling mud.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-N1

1 OF 3 **METRIC**

PROJECT 13-1111-0026
W.P. 11-20002
DIST CENTRAL HWY 12
DATUM GEODETIC

LOCATION N 4941197.4; E 309188.3
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
DATE December 2 and 10, 2014

ORIGINATED BY OS
COMPILED BY NL
CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.3	GROUND SURFACE										
0.0	TOPSOIL										
0.2	Gravelly silty sand, trace rootlets (FILL) Loose to compact Brown Moist		1	SS	9		257				
			2	SS	18				○		
255.8							256				
1.5	Silty sand, some gravel, trace clay (FILL) Very loose Brown Wet		3	SS	2						
255.0							255				
2.3	SAND, trace to some silt Loose to dense Brown Moist		4	SS	6				○		0 93 5 2
			5	SS	11		254				
	A 50 mm silty clay seam at 4.6 m depth.		A 6 B	SS	28		253		○ ○		
			7	SS	40		252				
	Increase silt content noted in Sample 8.		8	SS	44		251		○		
			9	SS	11	▽	250				0 97 3 0
			A 10 B	SS	9		249		○ ○		
245.7							248				
11.6							247				
							246				

Continued Next Page

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BH15-N1

2 OF 3 **METRIC**

PROJECT 13-1111-0026
W.P. 11-20002
DIST CENTRAL HWY 12
DATUM GEODETIC
LOCATION N 4941197.4; E 309188.3
BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers
DATE December 2 and 10, 2014
ORIGINATED BY OS
COMPILED BY NL
CHECKED BY JMAC

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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT, trace to some clay, trace sand Dense Brown Moist		11	SS	33		245		○		0 3 90 7
244.2											
13.1	CLAYEY SILT, trace sand, trace to some gravel Stiff Grey Wet		12	SS	10		244		⊢○		7 2 71 20
242.7							243				
14.6	SILTY SAND to SAND Compact to very dense Brown Wet		13	SS	31		242				
			14	SS	32		241		○		
			15	SS	43		240				
			16	SS	42		239				
			17	SS	19		238		○		
			18	SS	26		237				
							236				
							235				
							234		○		

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BH15-N1

3 OF 3 **METRIC**

PROJECT 13-1111-0026 | W.P. 11-20002 | DIST CENTRAL HWY 12 | DATUM GEODETIC

LOCATION N 4941197.4; E 309188.3 | BOREHOLE TYPE 200 mm Diameter Hollow Stem Augers | DATE December 2 and 10, 2014

ORIGINATED BY OS | COMPILED BY NL | CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY SAND to SAND Compact to very dense Brown Wet		19	SS	62		233				
232.1											
25.2	CLAYEY SILT to SILTY CLAY, trace sand, trace gravel Hard Grey Wet		20	SS	31		232		○		
229.9							231				
27.4	SAND and GRAVEL, trace to some silt Very dense Grey Wet		21	RC	-		230				
			22	SS	100/0.15				○		39 53 6 2
			23	SS	100/0.14		229				
							228				
226.6			24	SS	100/0.1		227				
30.7	END OF BOREHOLE Note: 1. Water level at a depth of 8.9 m below ground surface (Elev. 248.4 m) inside casing upon completion of drilling.										

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

SUD-MTO 001 1311110026.GPJ GAL-MISS.GDT 15/04/16 DATA INPUT:

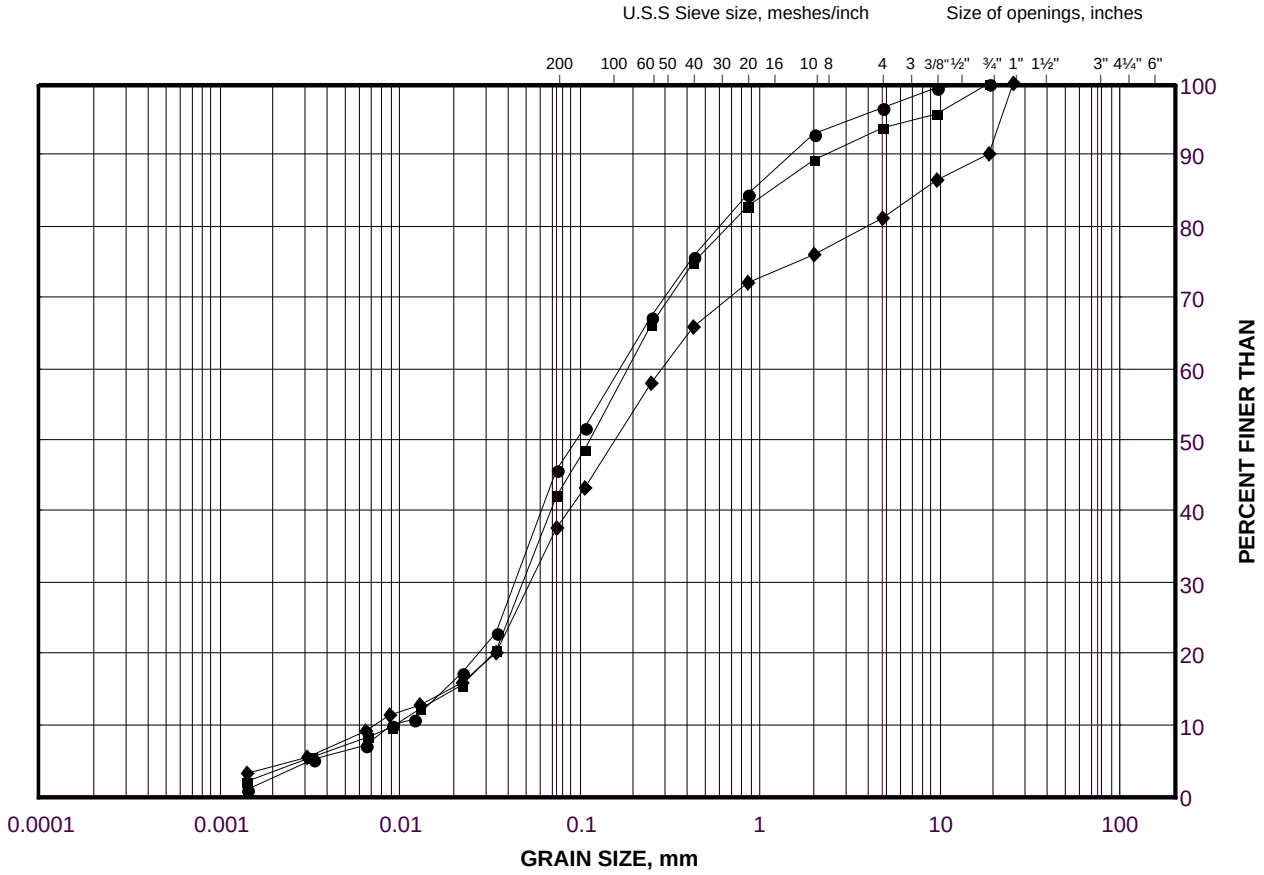
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B1



LEGEND

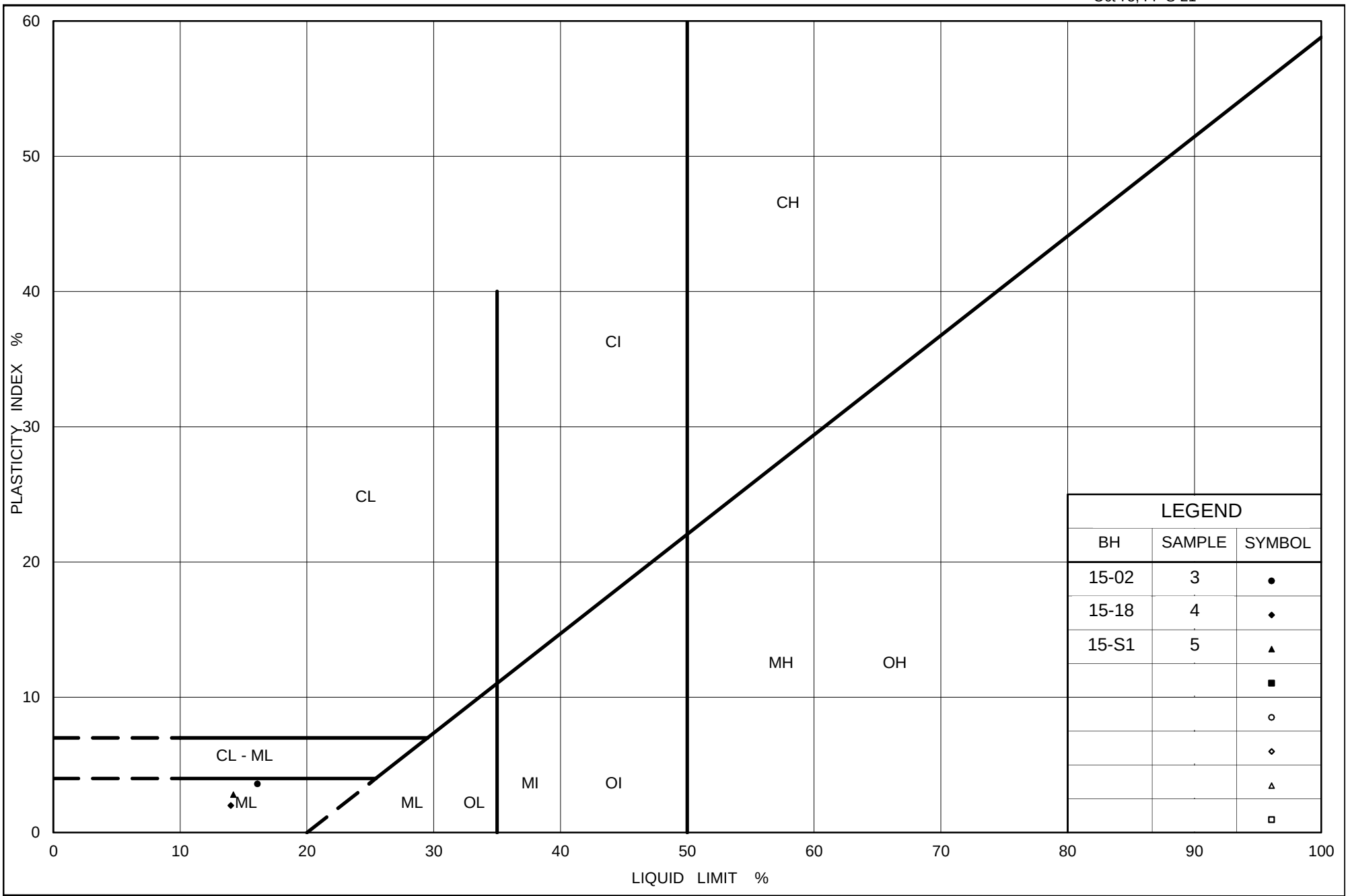
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-18	4	247.3
■	15-S1	5	265.7
◆	15-02	3	280.7

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 06-May-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Fill)

Figure No. B2

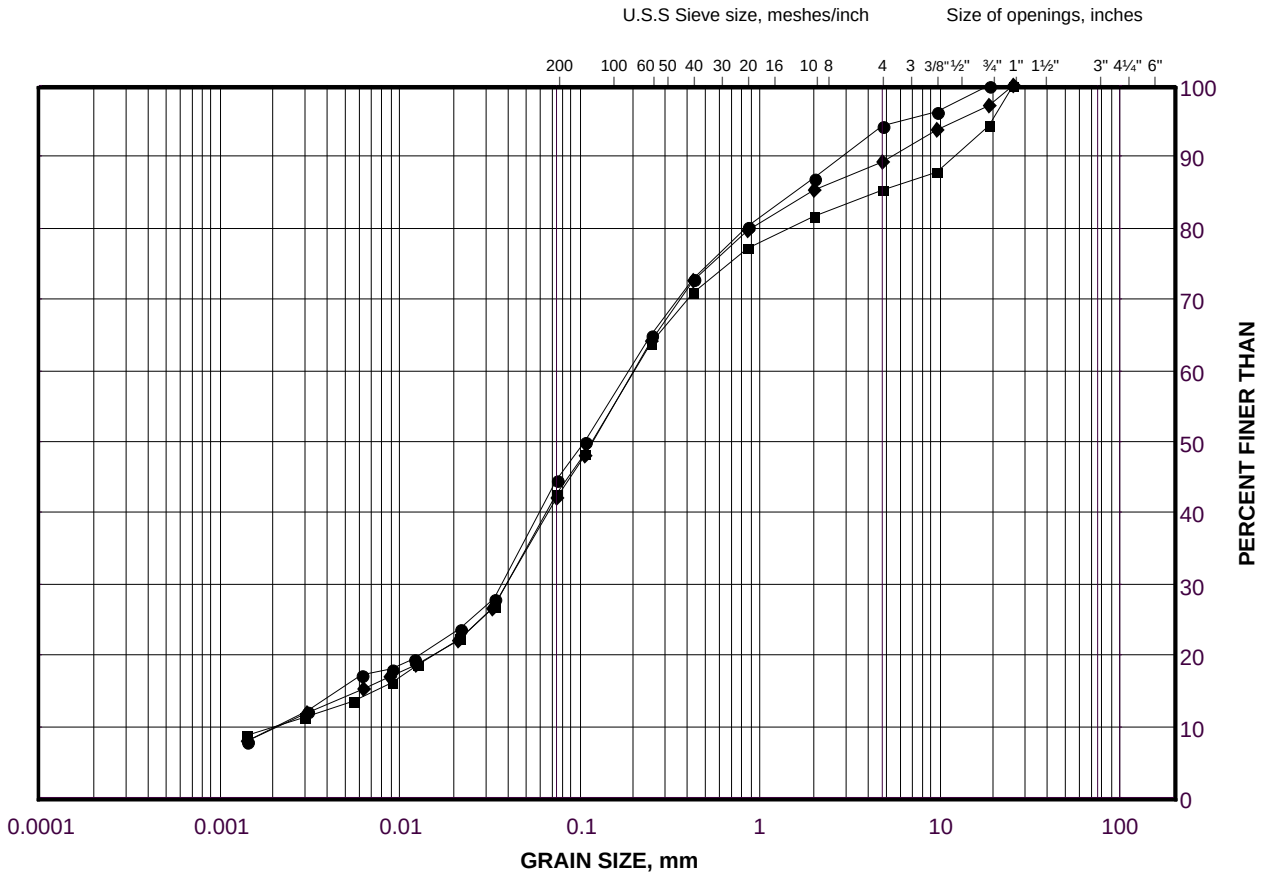
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-03	6	272.3
■	15-02	7	276.1
◆	15-01	8	281.6

Project Number: 13-1111-0026

Checked By: NK

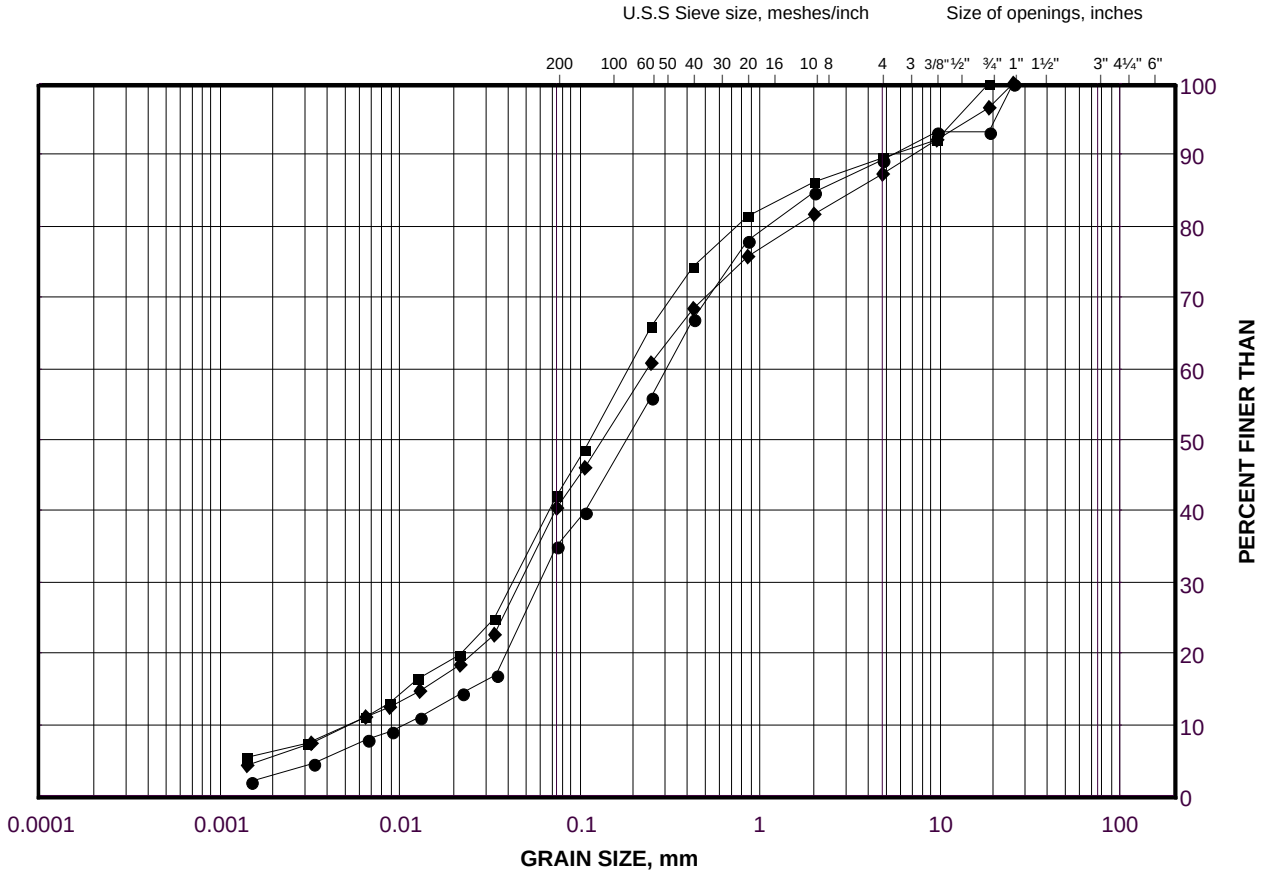
Golder Associates

Date: 04-Mar-16

GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B4



LEGEND

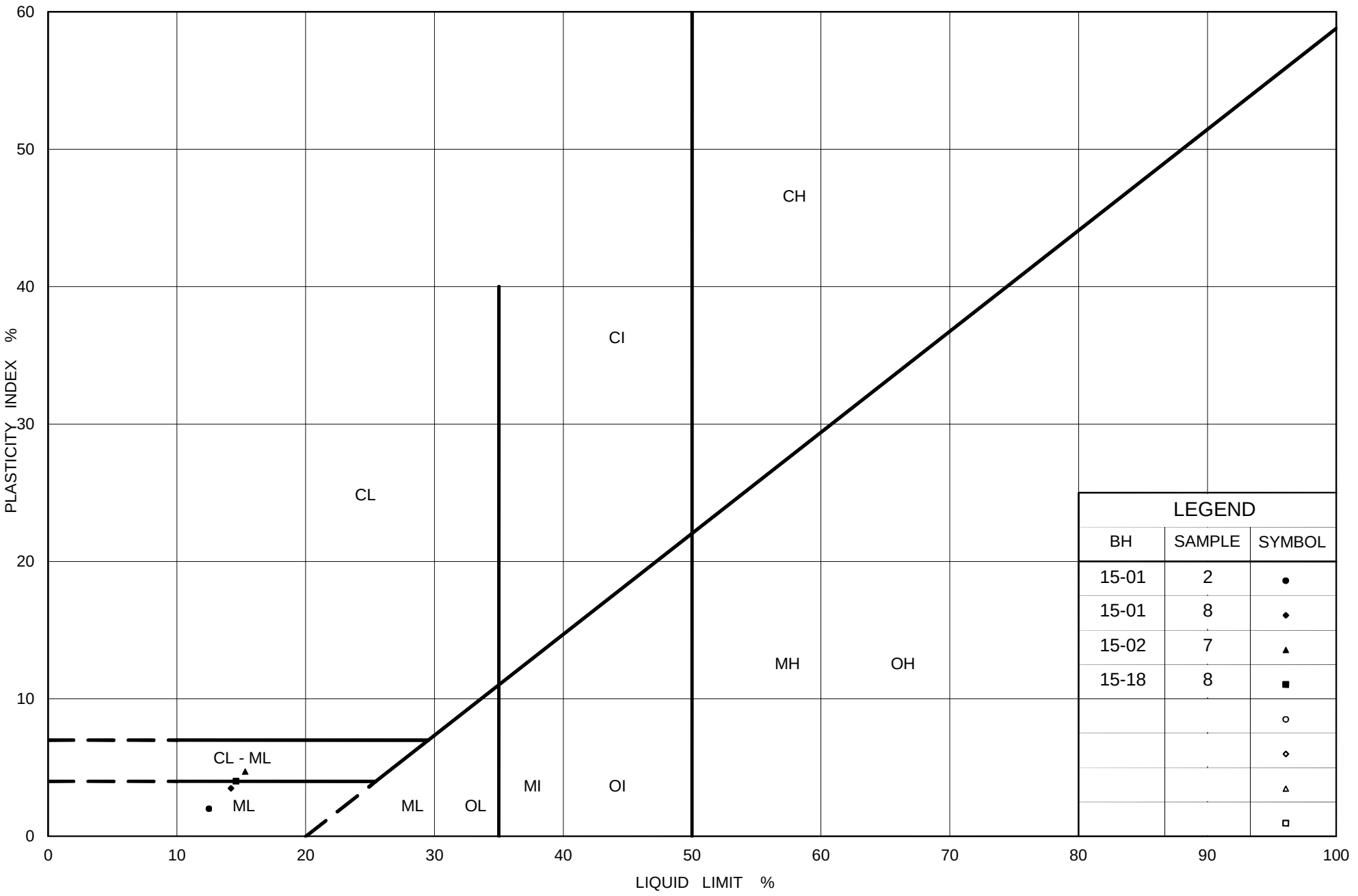
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-18	12	263.0
■	15-01	2	288.4
◆	15-18	8	268.9

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 04-Mar-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Till)

Figure No. B5

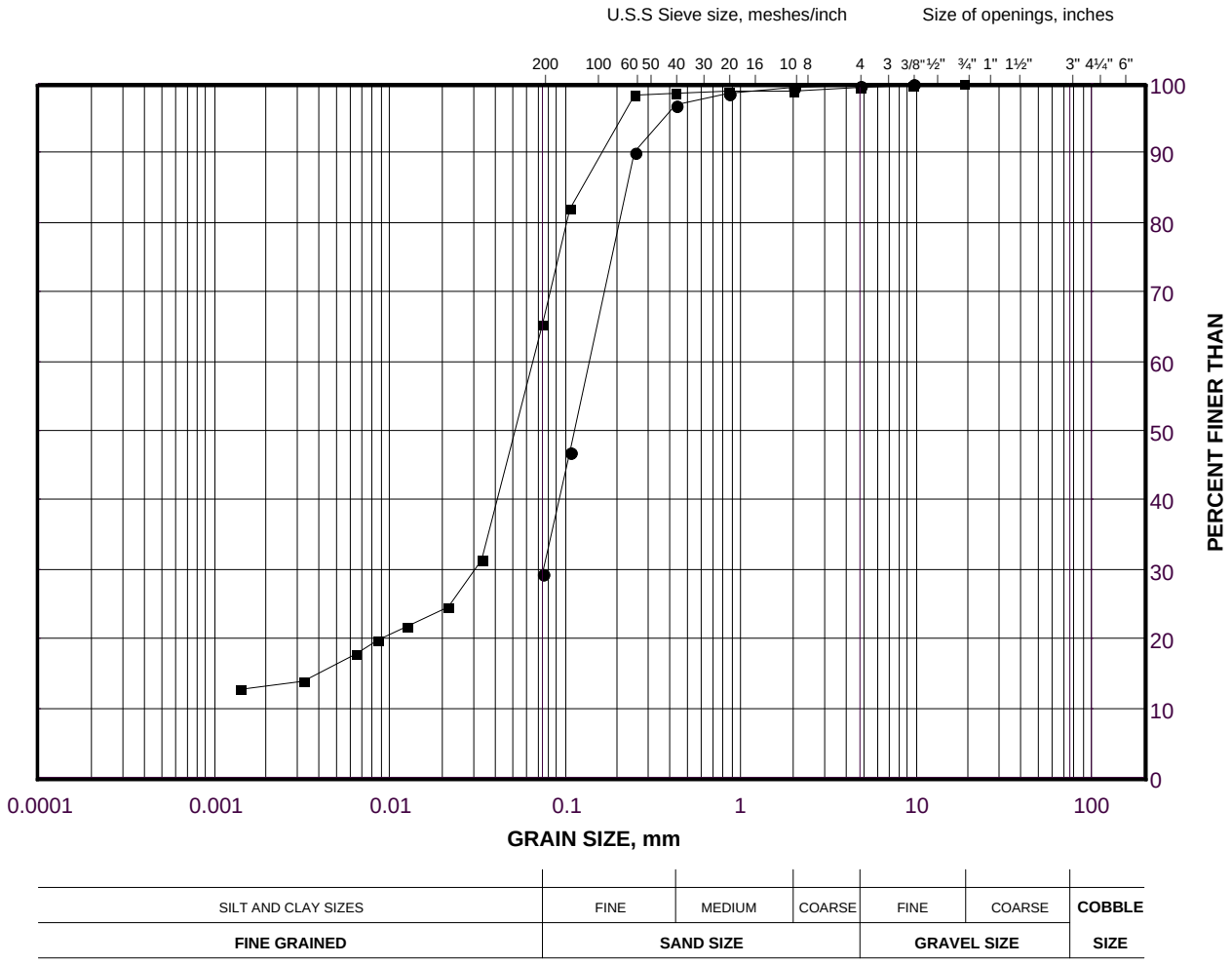
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE B6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-03	2	275.9
■	15-05	5	234.7

Project Number: 13-1111-0026

Checked By: NK

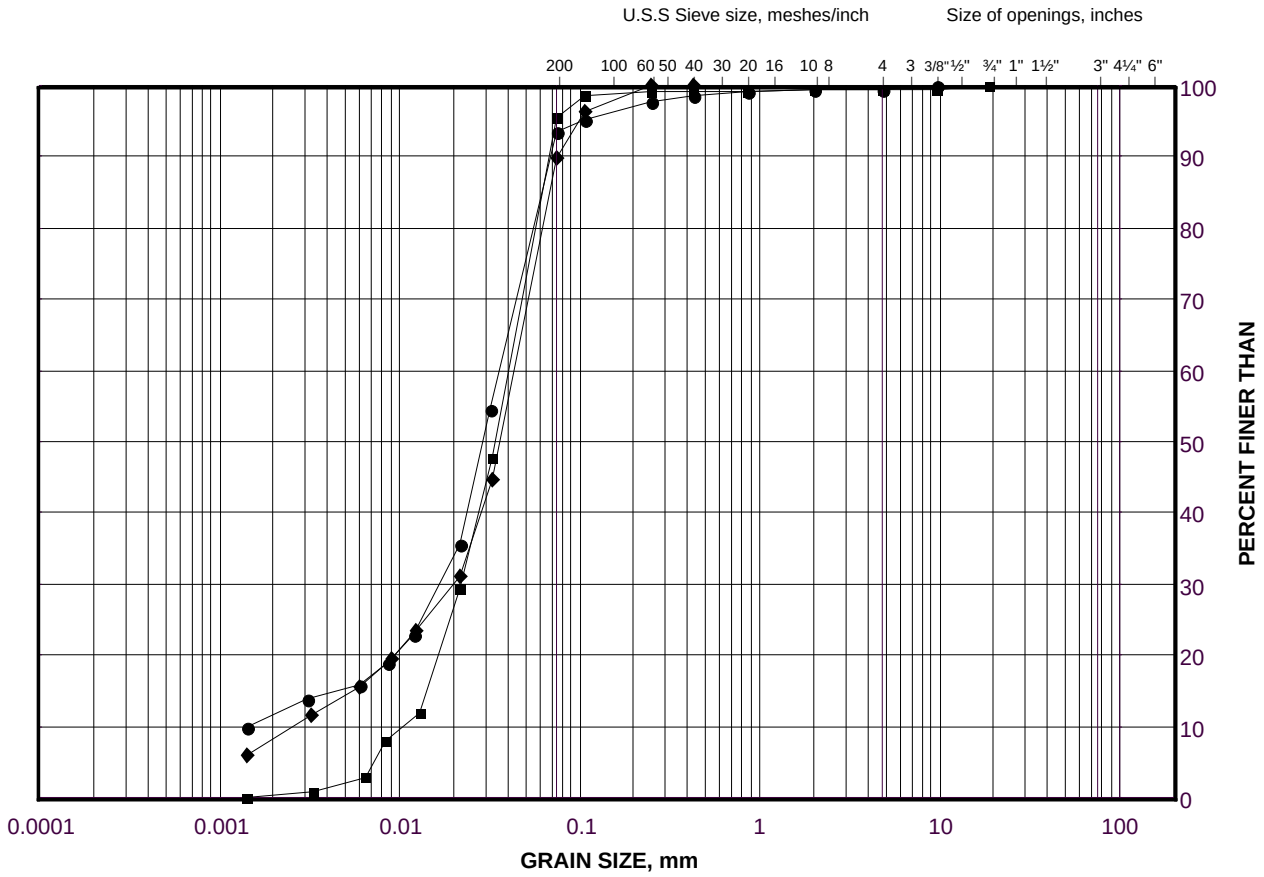
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-04	3	249.2
■	15-04	5	247.7
◆	15-05	9	228.7

Project Number: 13-1111-0026

Checked By: NK

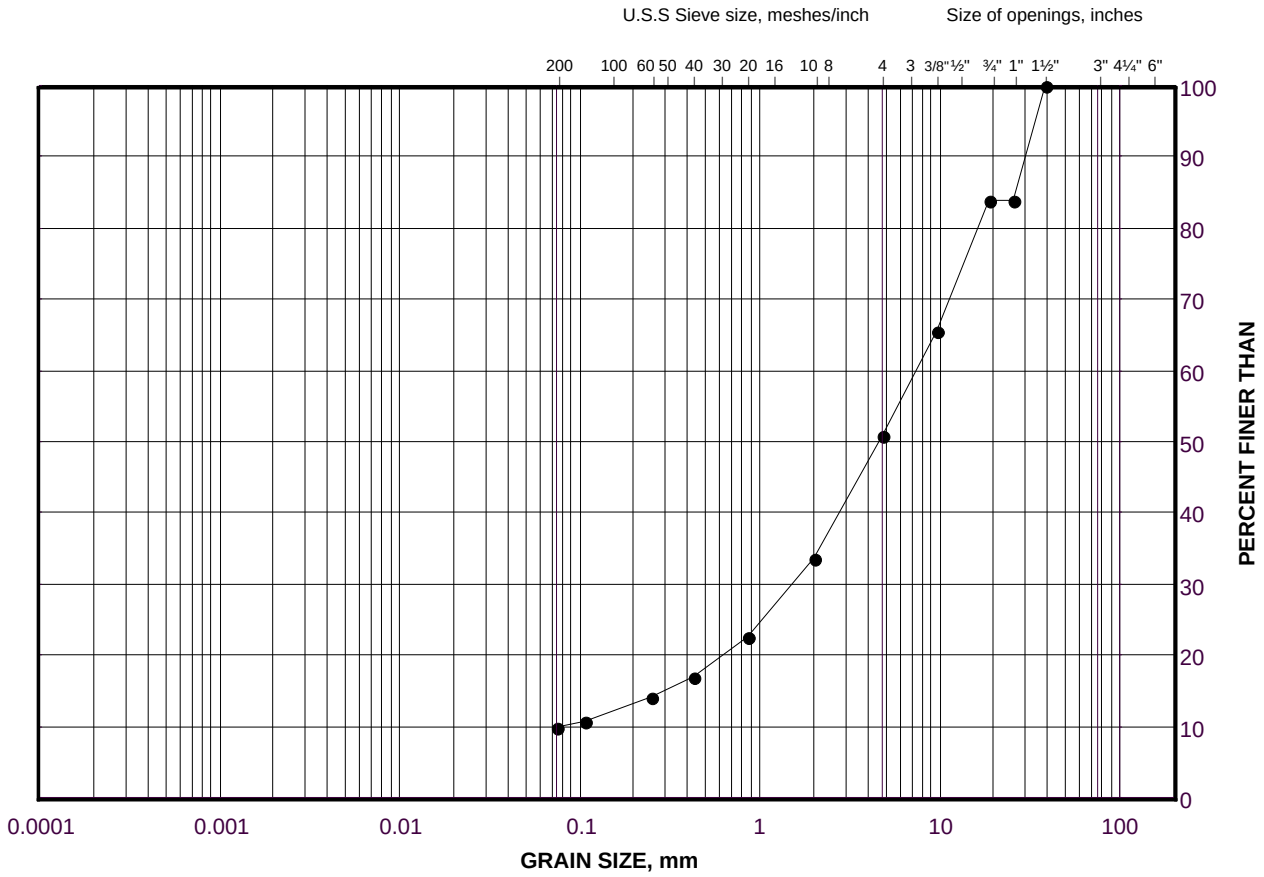
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B8



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-05	3	236.2

Project Number: 13-1111-0026

Checked By: NK

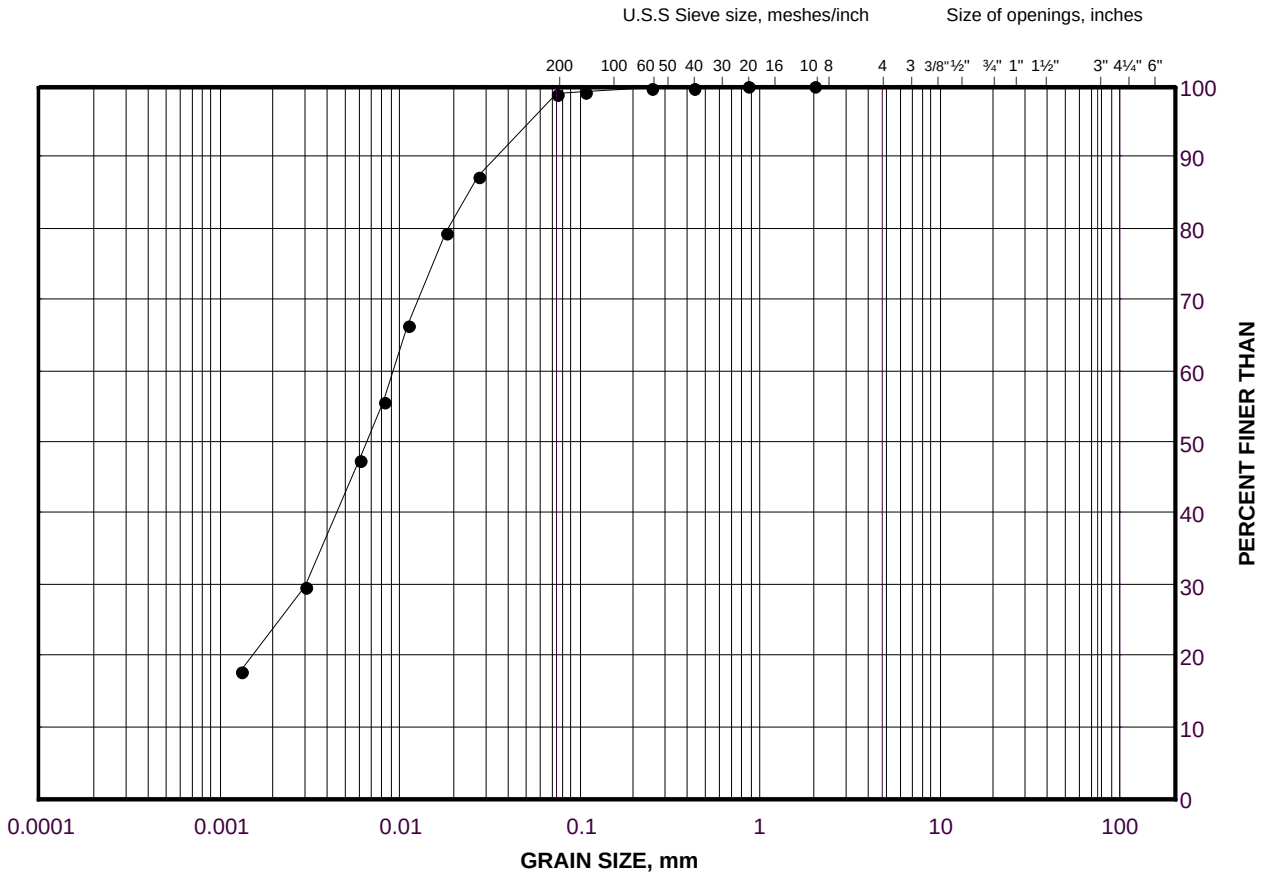
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B9



LEGEND

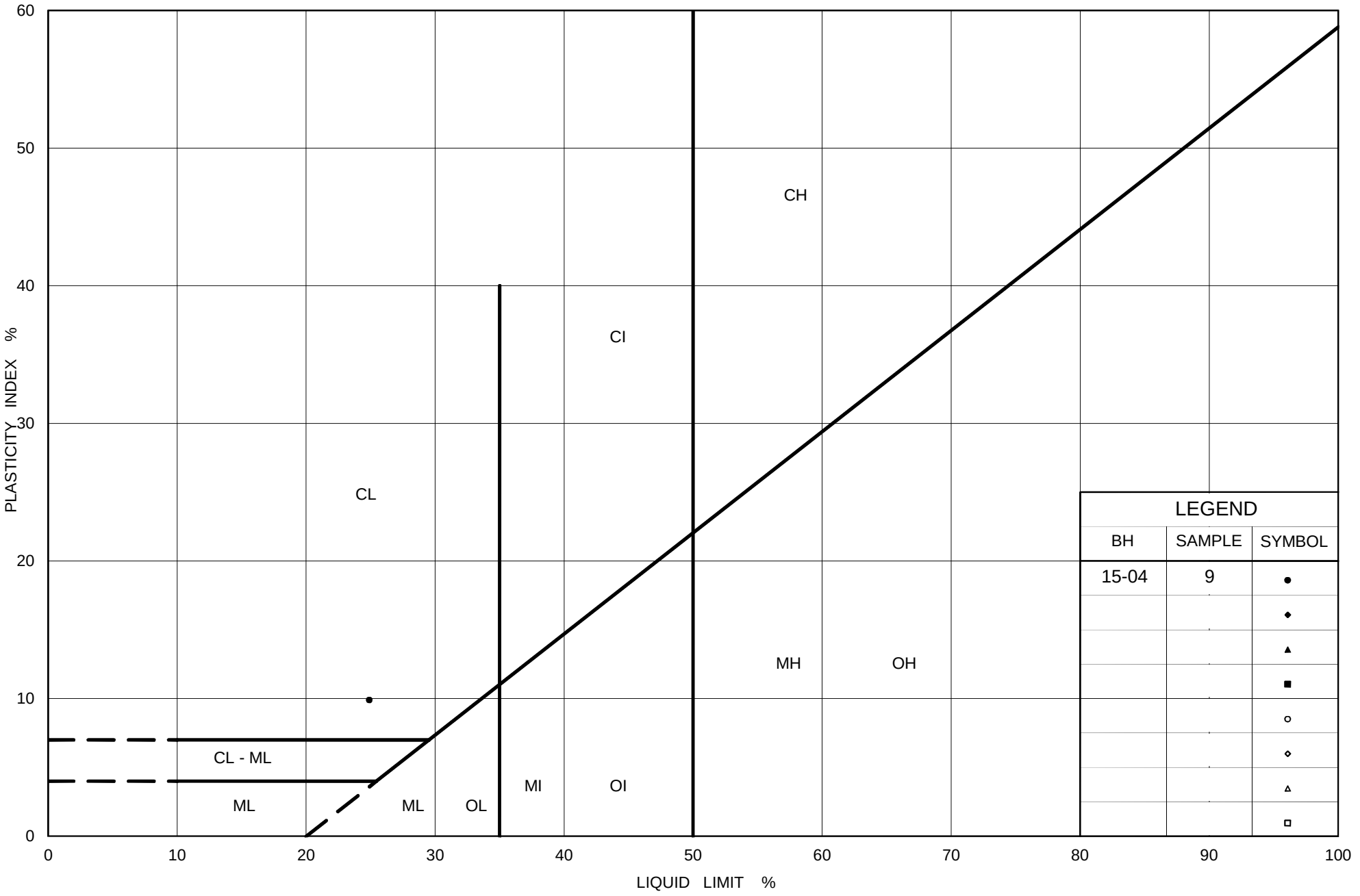
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-04	9	241.6

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 07-Jan-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B10

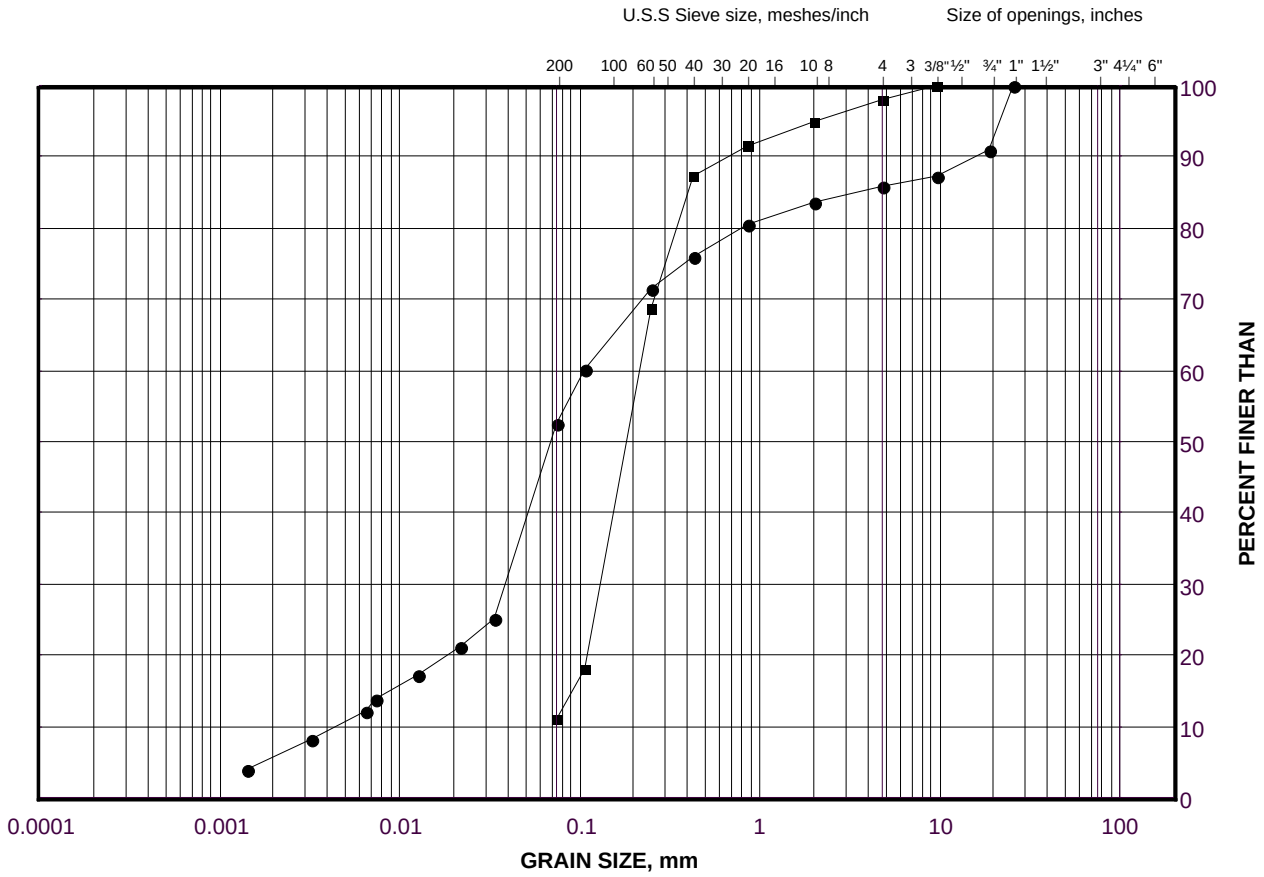
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand (Fill)

FIGURE B11



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-09	4	246.2
■	15-06	6	246.3

Project Number: 13-1111-0026

Checked By: NK

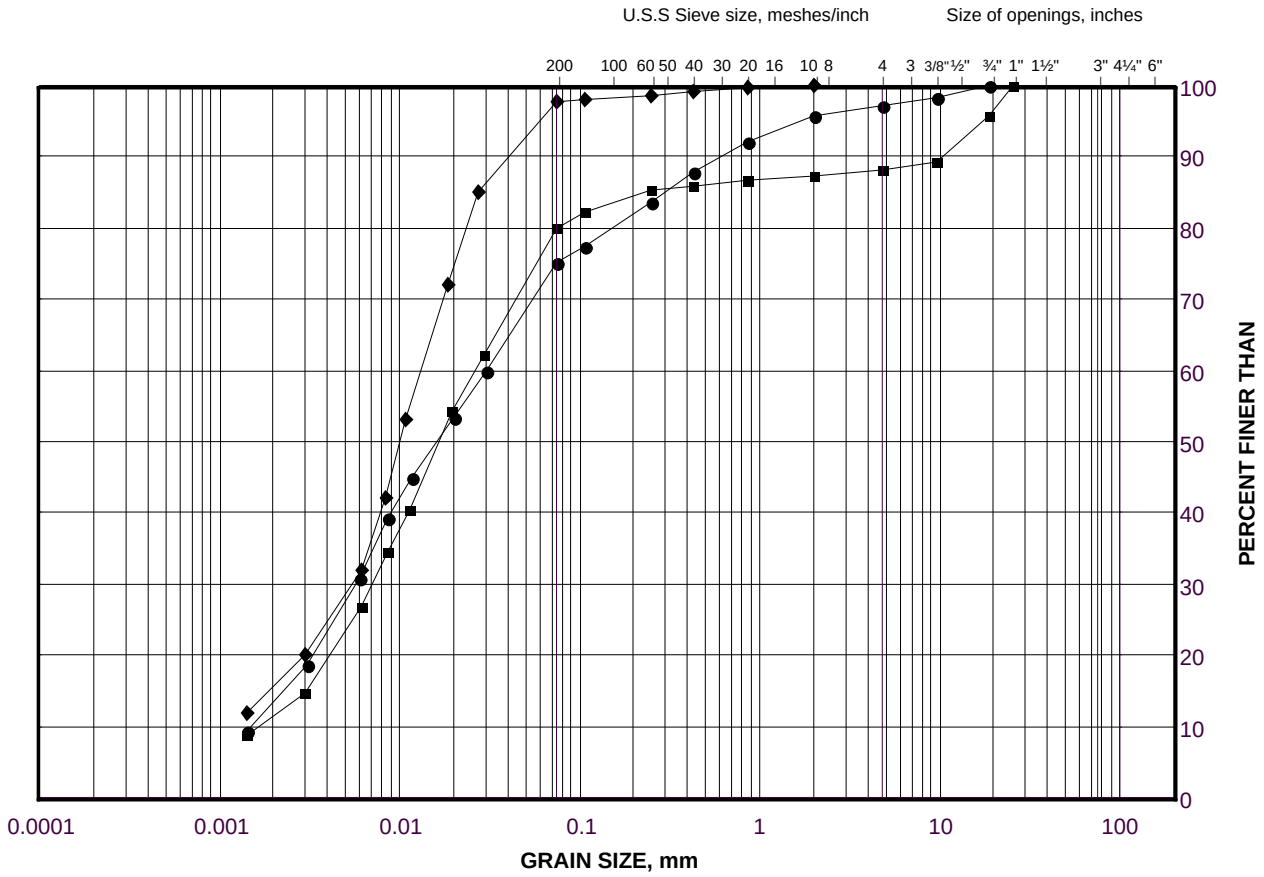
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B12



LEGEND

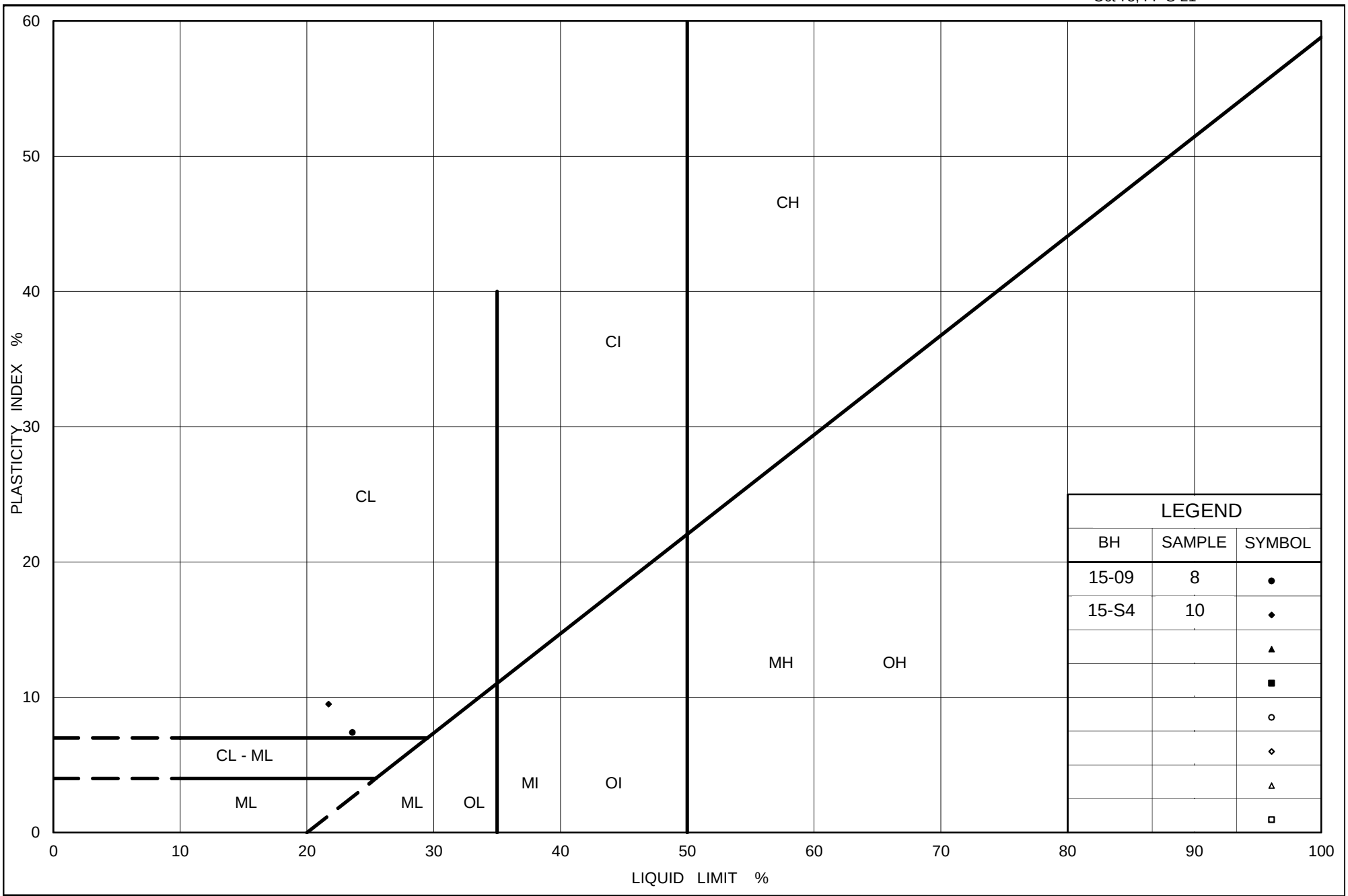
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-S4	10	250.5
■	15-08	11	237.7
◆	15-09	8	239.9

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 06-May-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B13

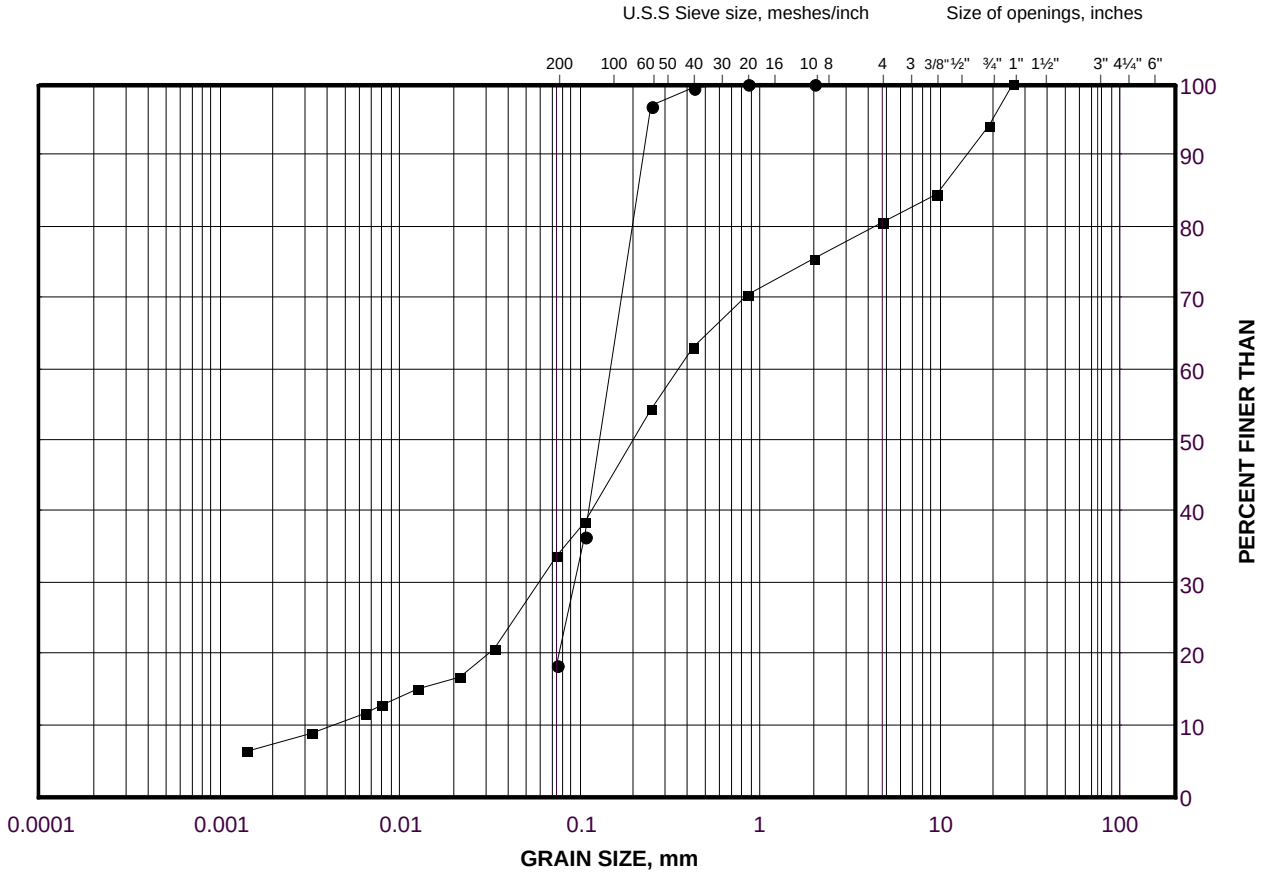
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE B14



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-08	6	243.0
■	15-S4	8A	252.9

Project Number: 13-1111-0026

Checked By: NK

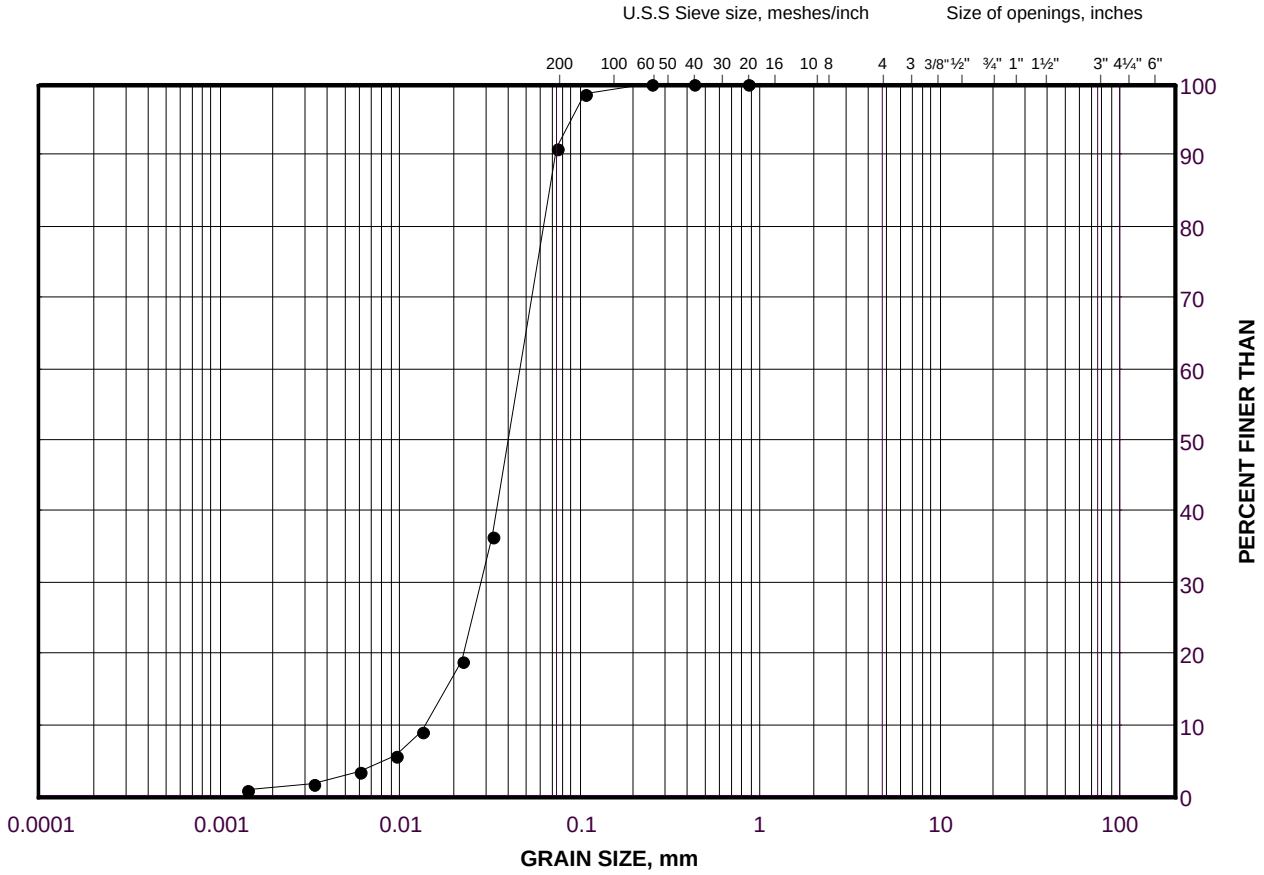
Golder Associates

Date: 06-May-16

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B15



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-08	3	246.0

Project Number: 13-1111-0026

Checked By: NK

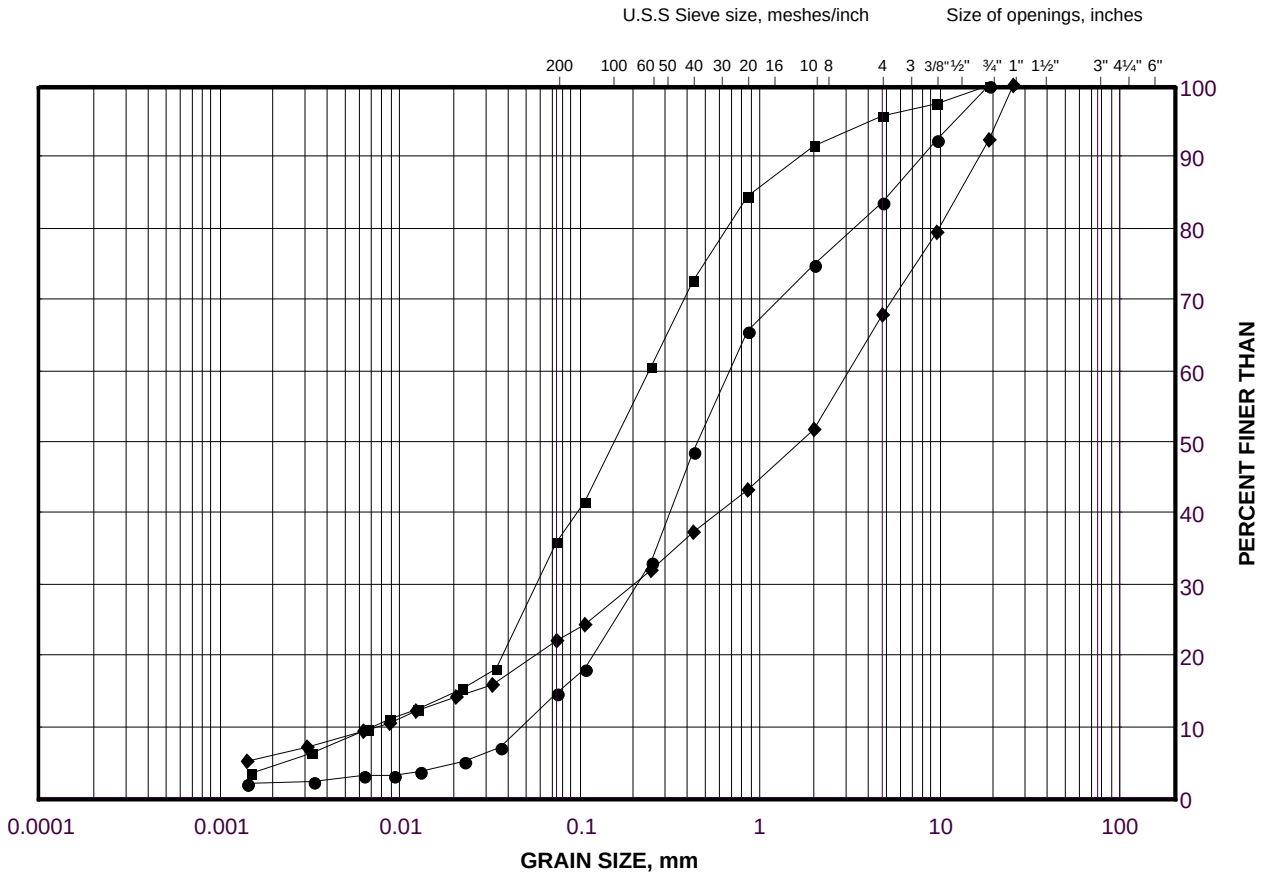
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Sand (Till)

FIGURE B16



LEGEND

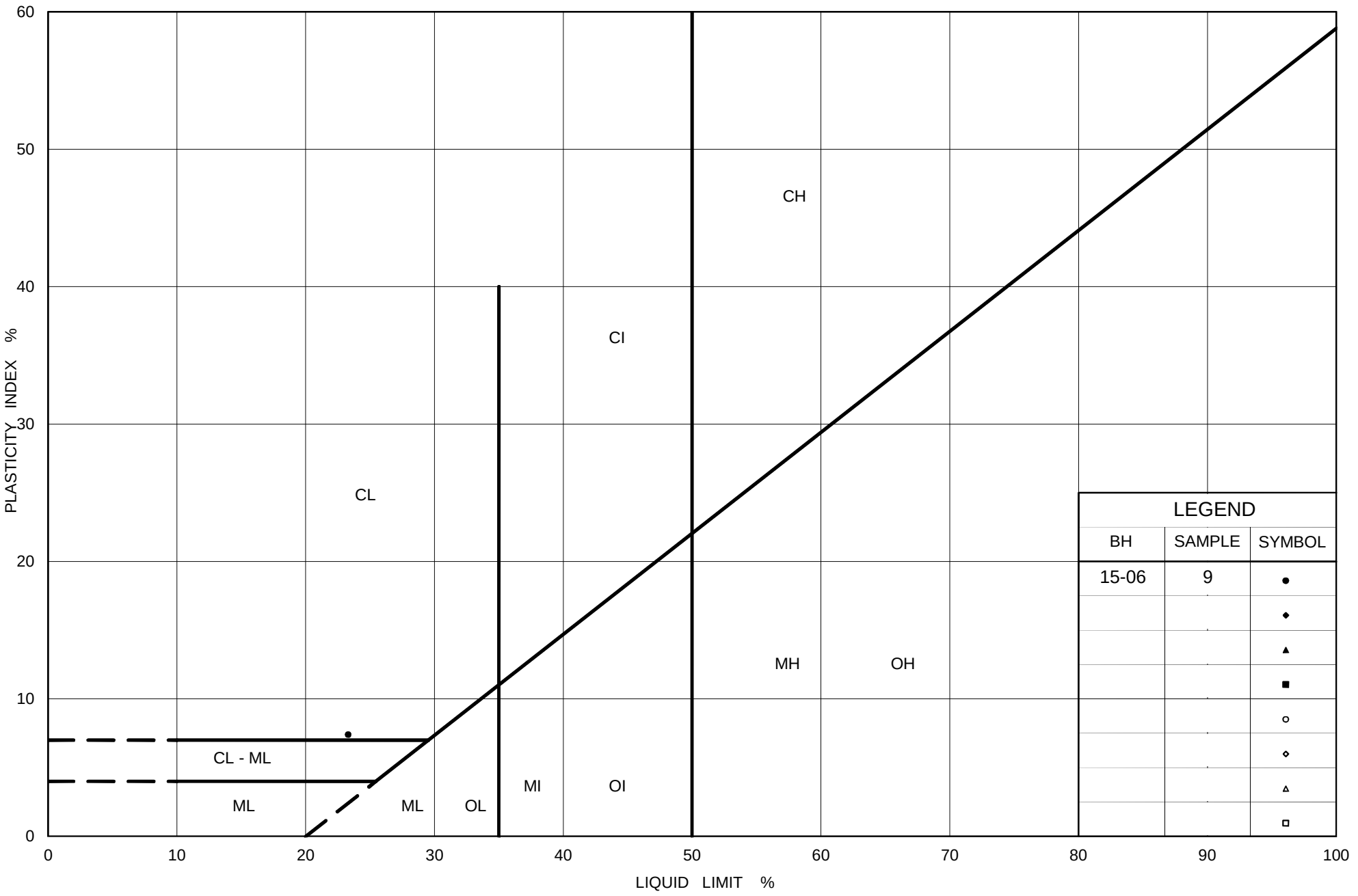
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-06	13	237.4
■	15-S5	14	249.9
◆	15-06	9	241.8

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 06-May-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Gravel (Till)

Figure No. B17

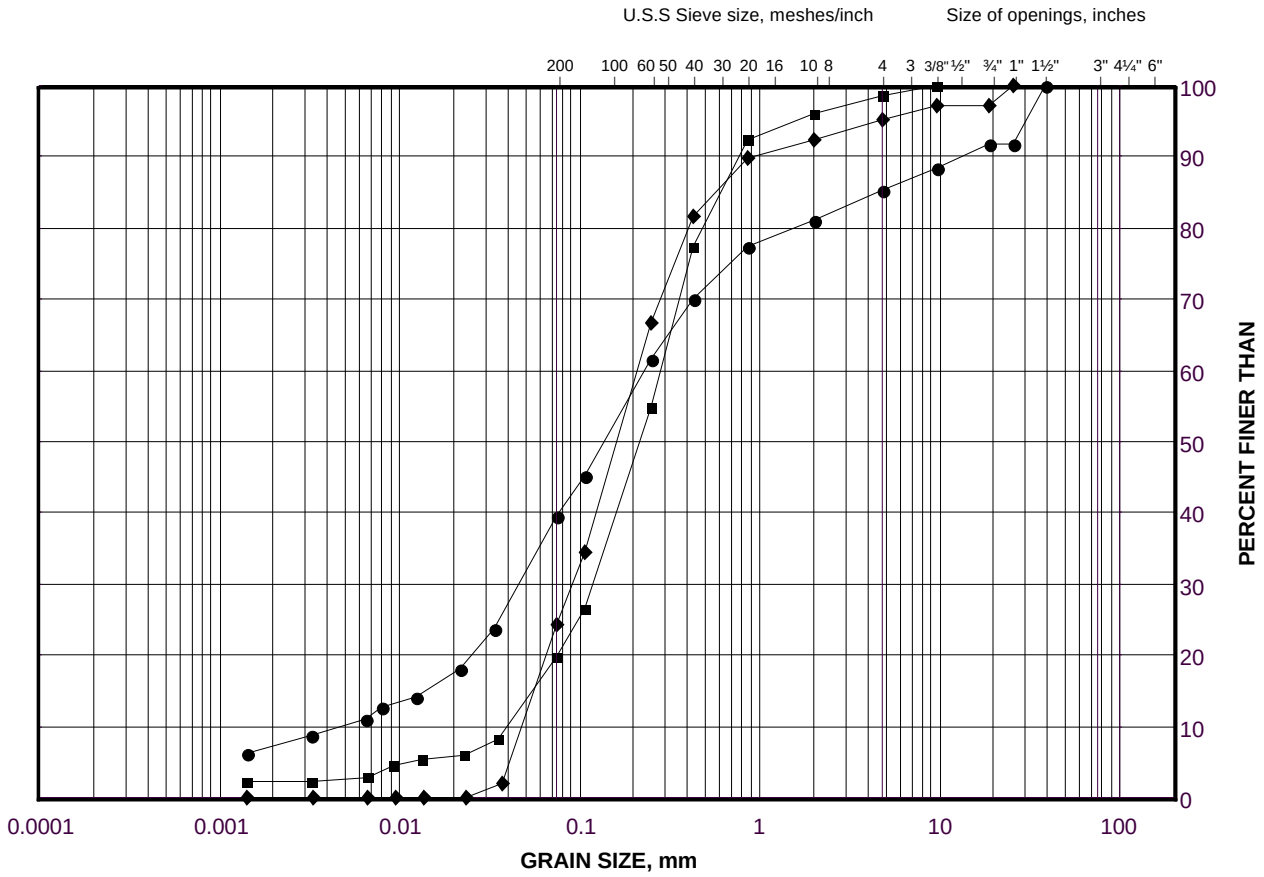
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand (Fill)

FIGURE B18



LEGEND

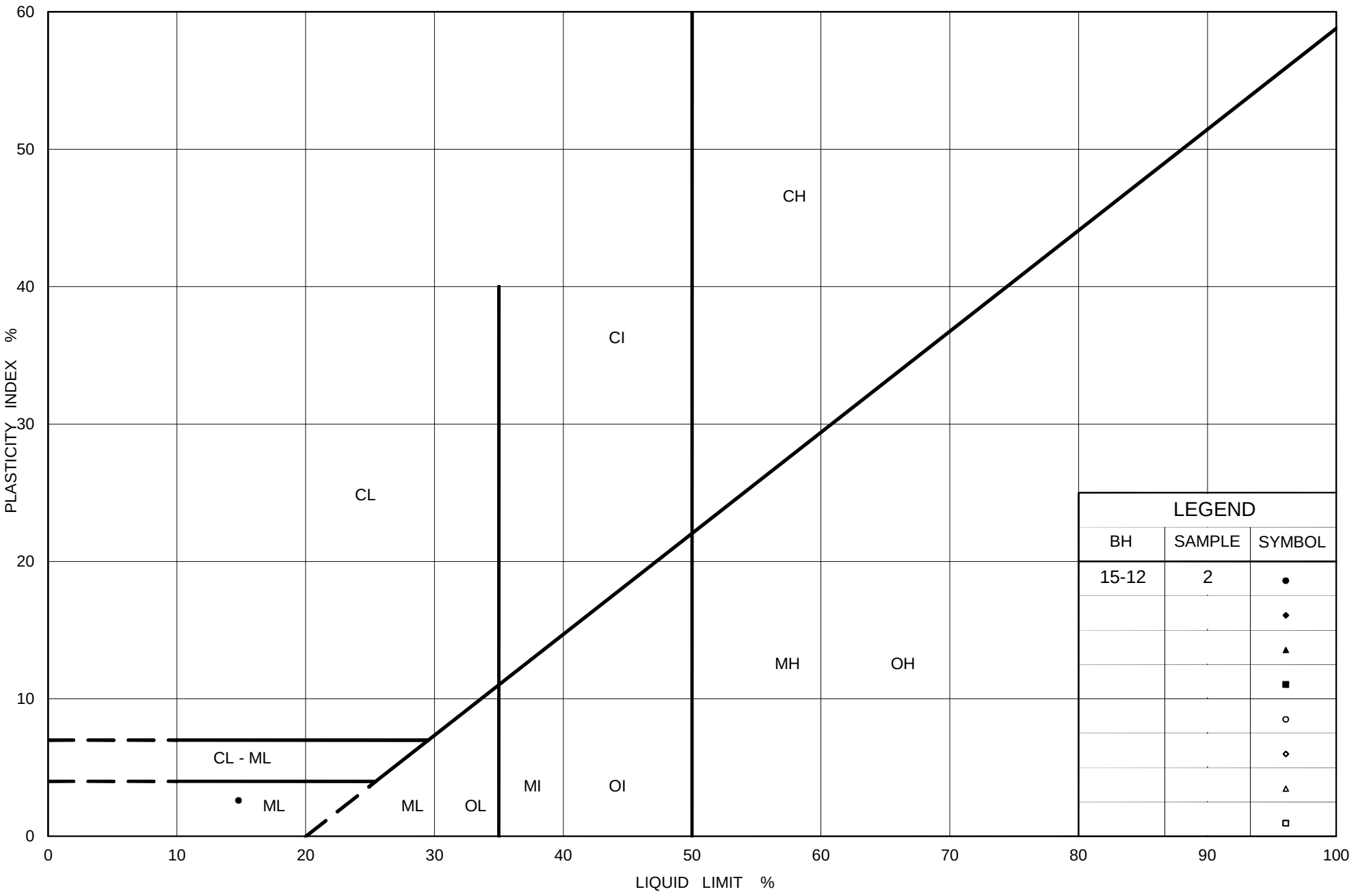
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-12	2	256.6
■	15-10	5	257.3
◆	15-11	6	260.0

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 11-Apr-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Fill)

Figure No. B19

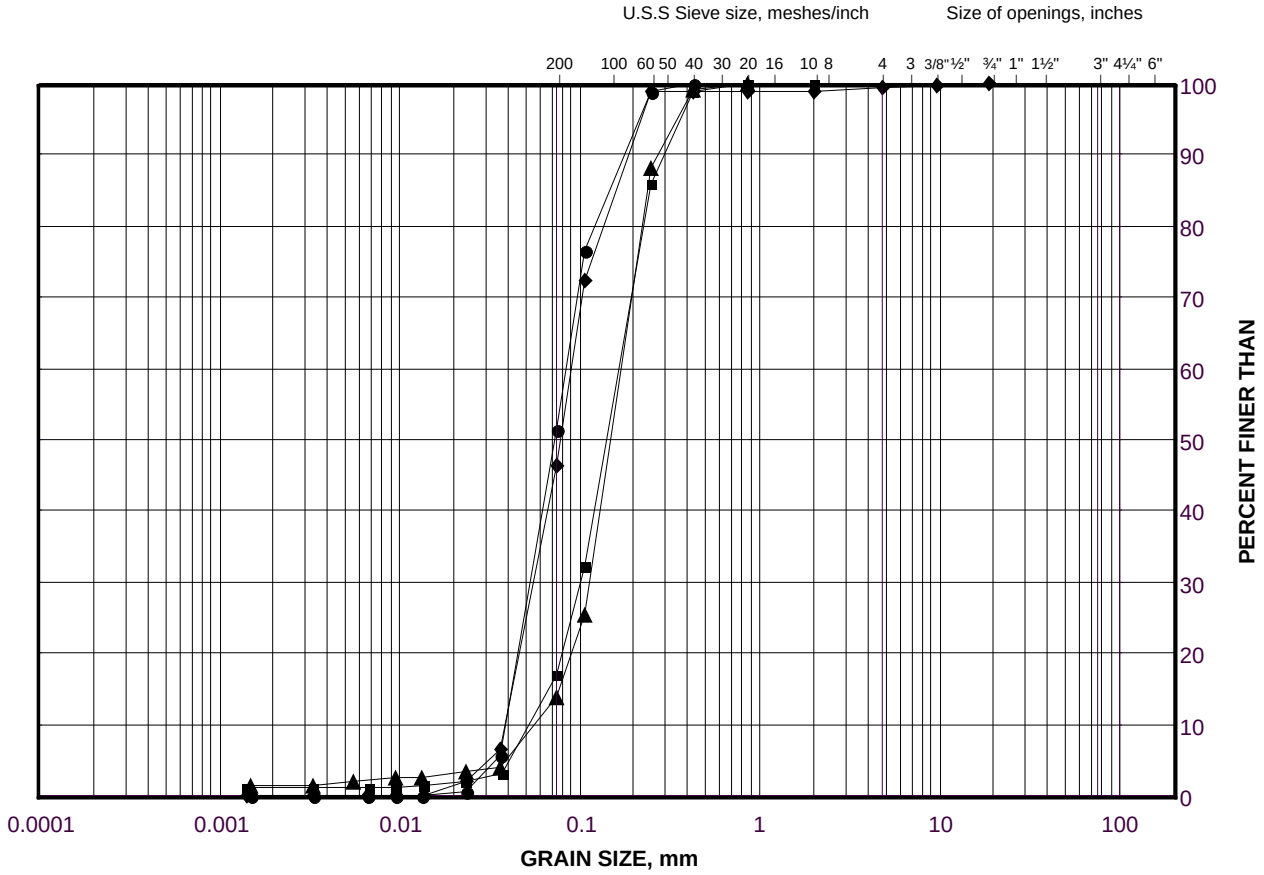
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand

FIGURE B20



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-11	10	253.9
■	15-13	4	254.0
◆	15-12	6	252.8
▲	15-13	8	248.6

Project Number: 13-1111-0026

Checked By: NK

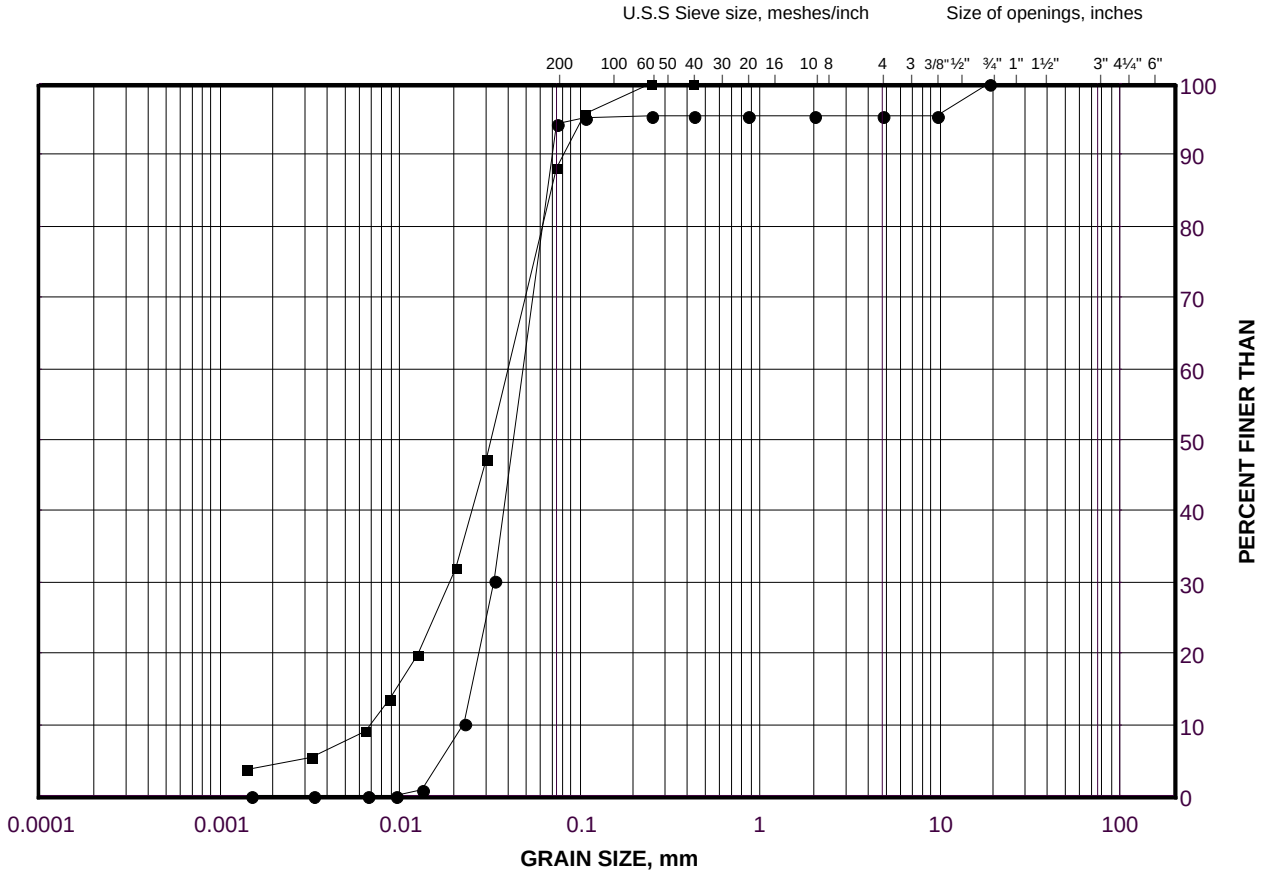
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B21



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-10	11	248.9
■	15-10	7A	255.2

Project Number: 13-1111-0026

Checked By: NK

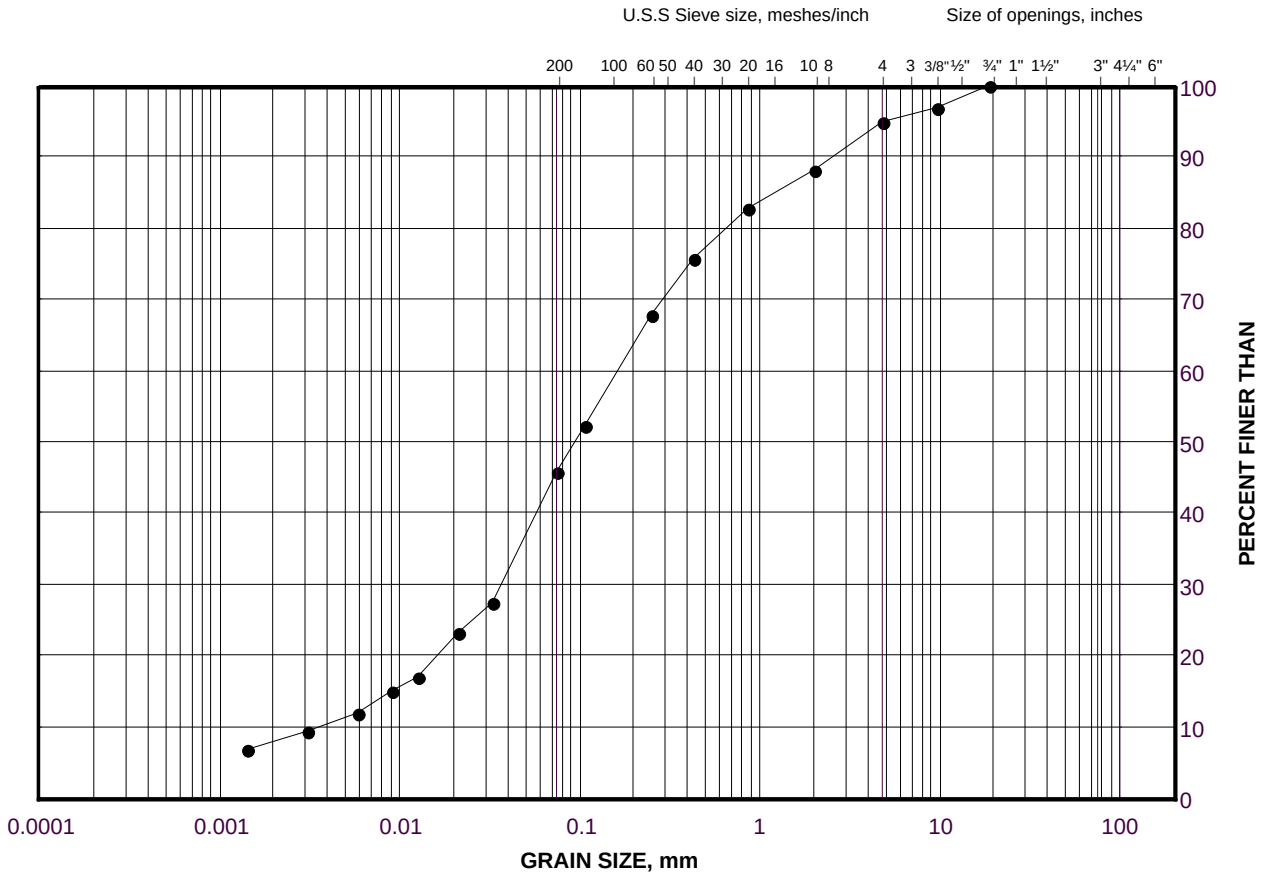
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B22



LEGEND

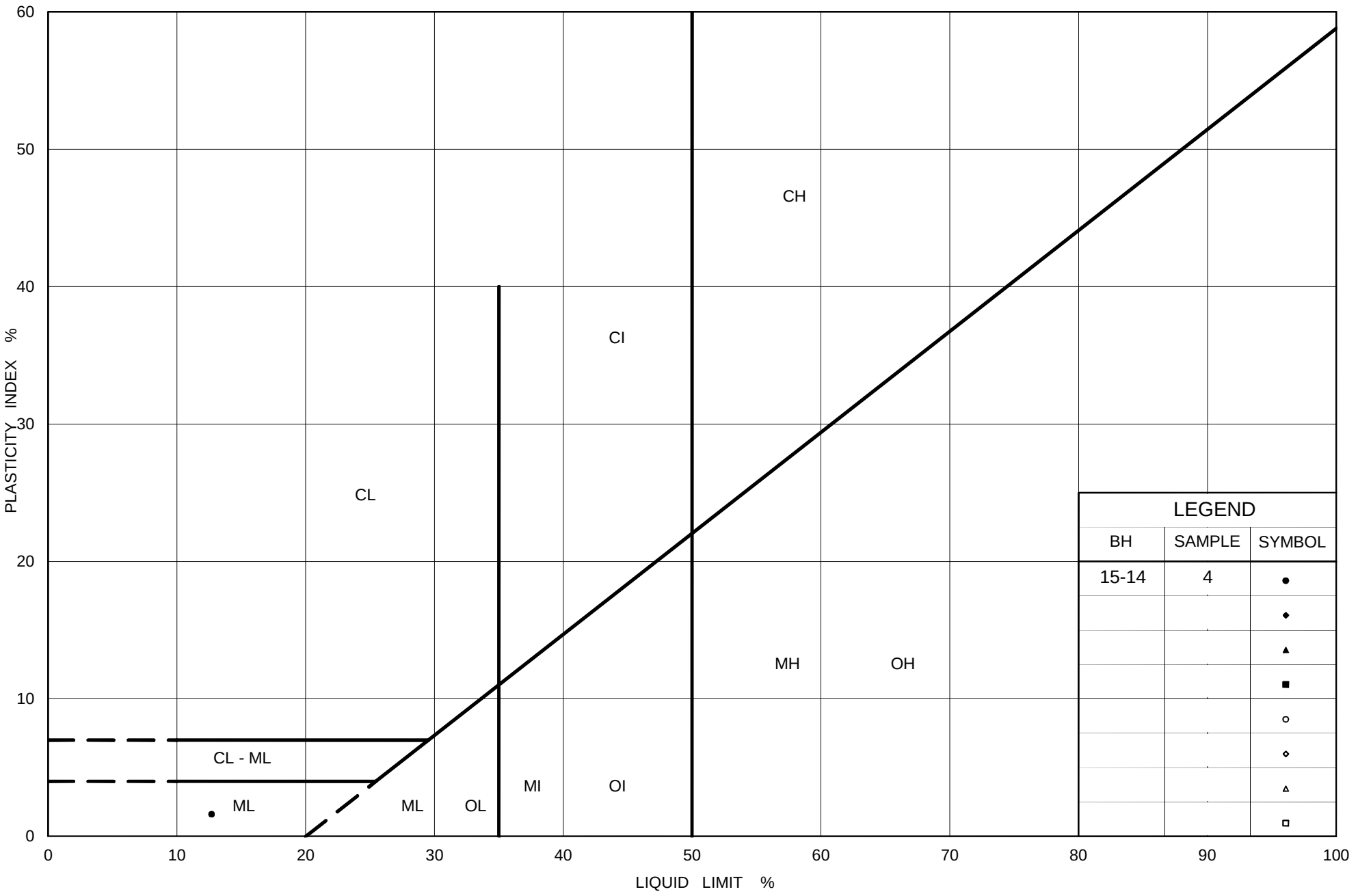
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-14	4	260.9

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 07-Jan-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Fill)

Figure No. B23

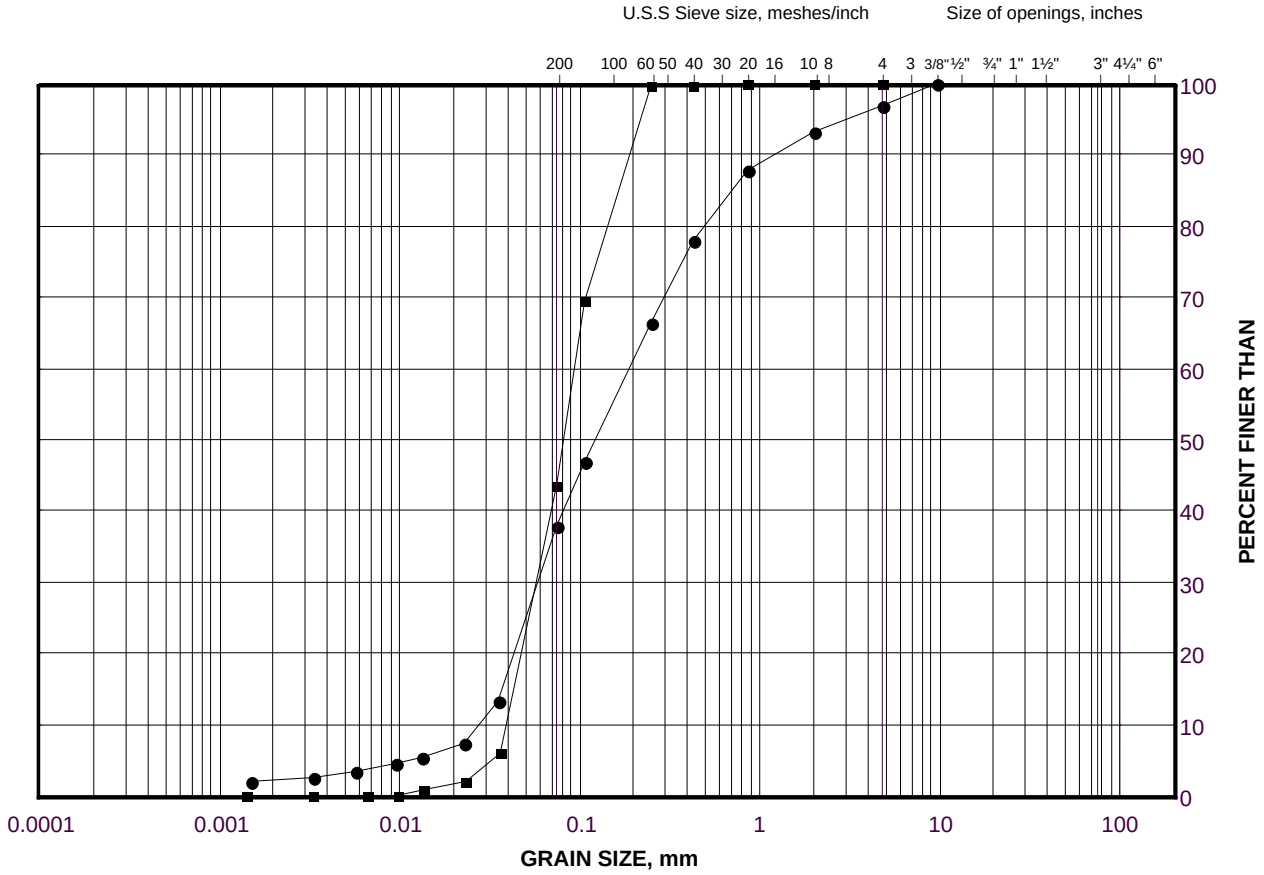
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B24



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-14	10	252.5
■	15-14	6	258.6

Project Number: 13-1111-0026

Checked By: NK

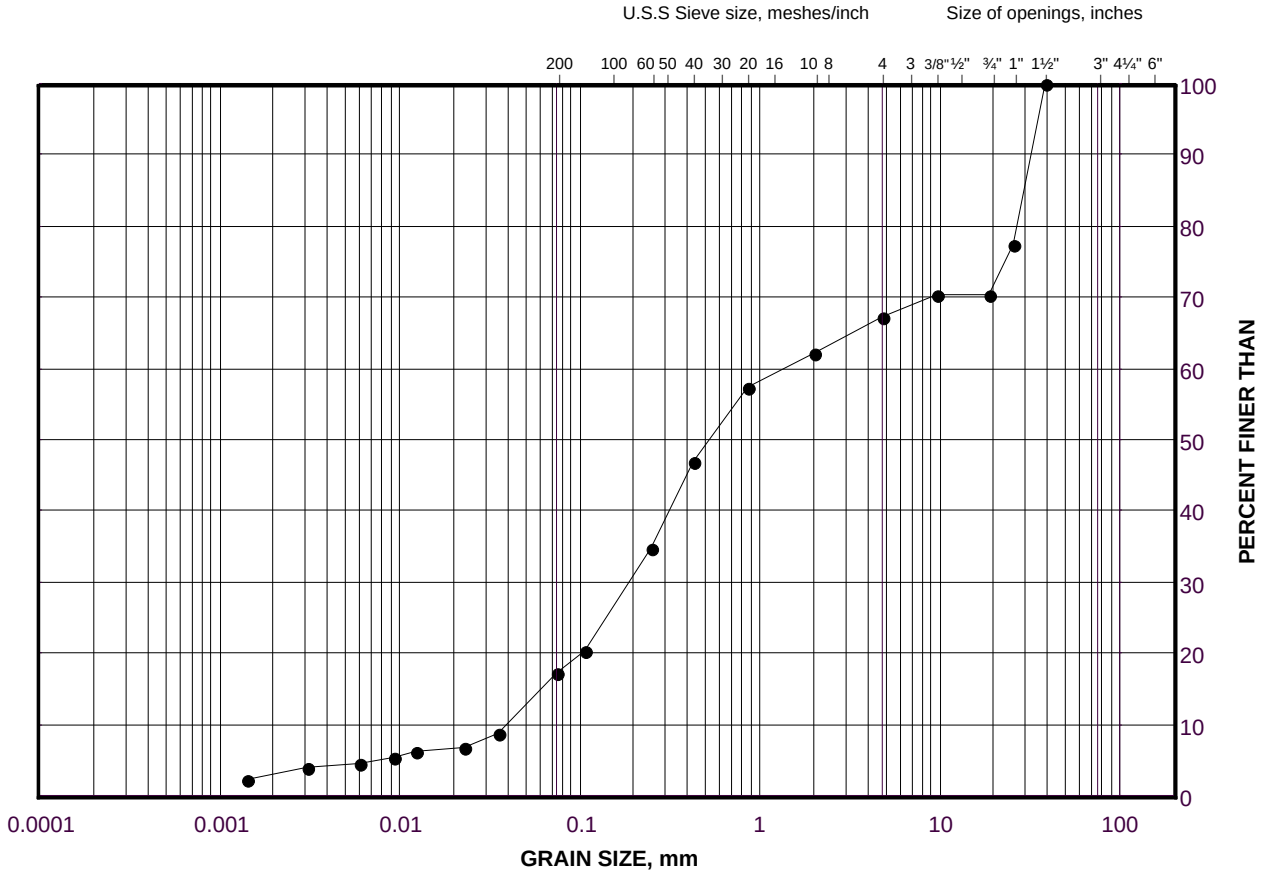
Golder Associates

Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Till)

FIGURE B25



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-15	4	258.1

Project Number: 13-1111-0026

Checked By: NK

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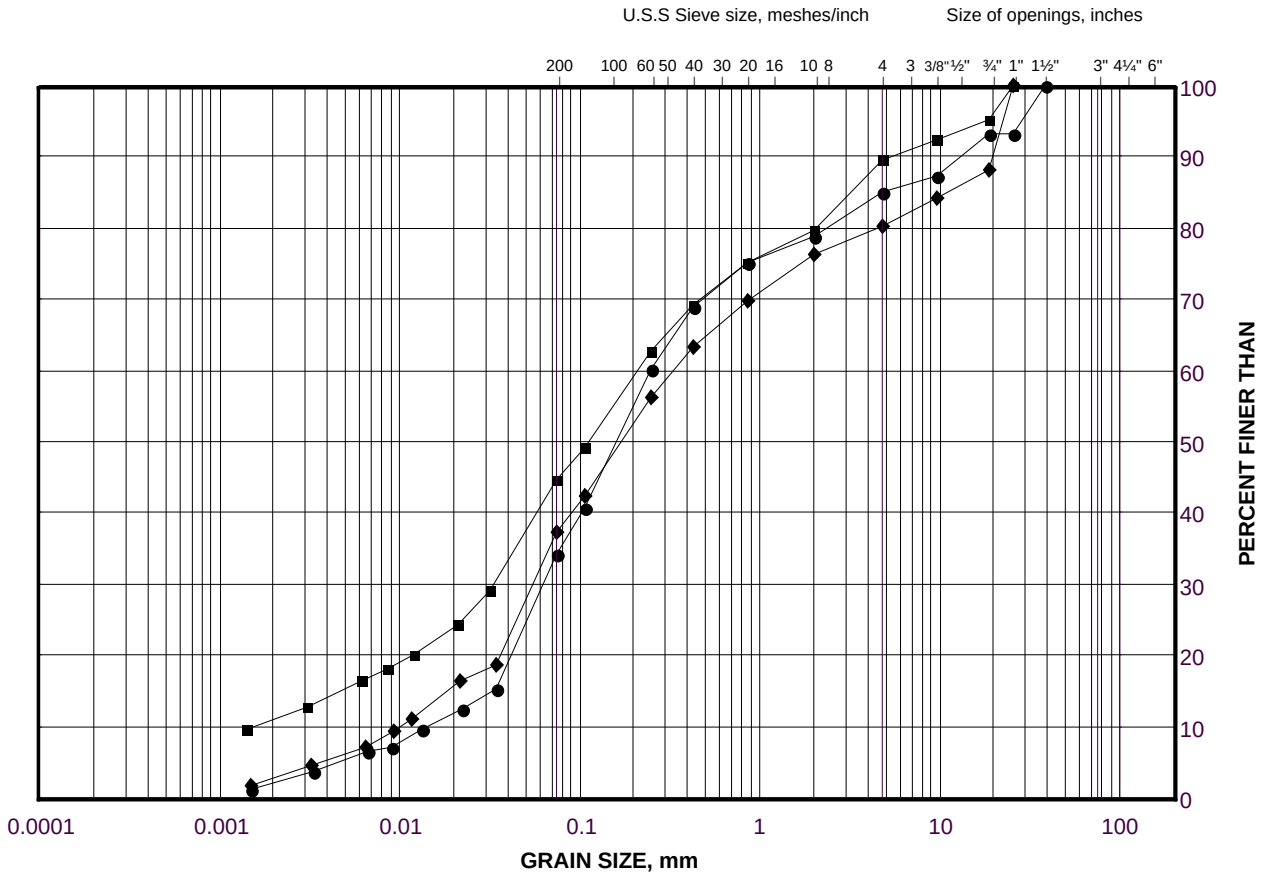
Date: 07-Jan-16

GRAIN SIZE DISTRIBUTION

Silt and Sand (Till)

FIGURE B26



LEGEND

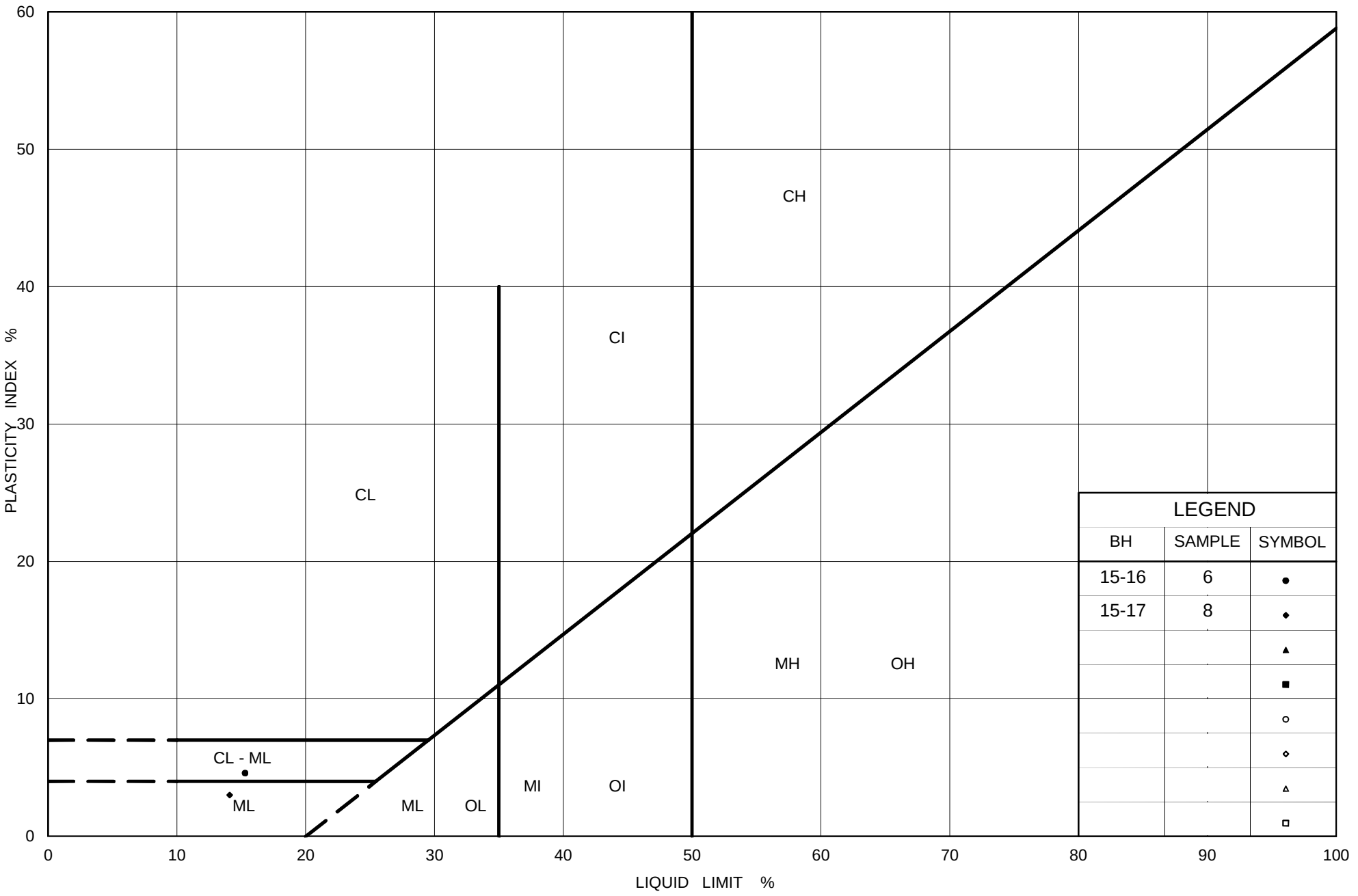
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-17	4	283.6
■	15-16	6	277.4
◆	15-17	8	278.2

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 04-Mar-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Till)

Figure No. B27

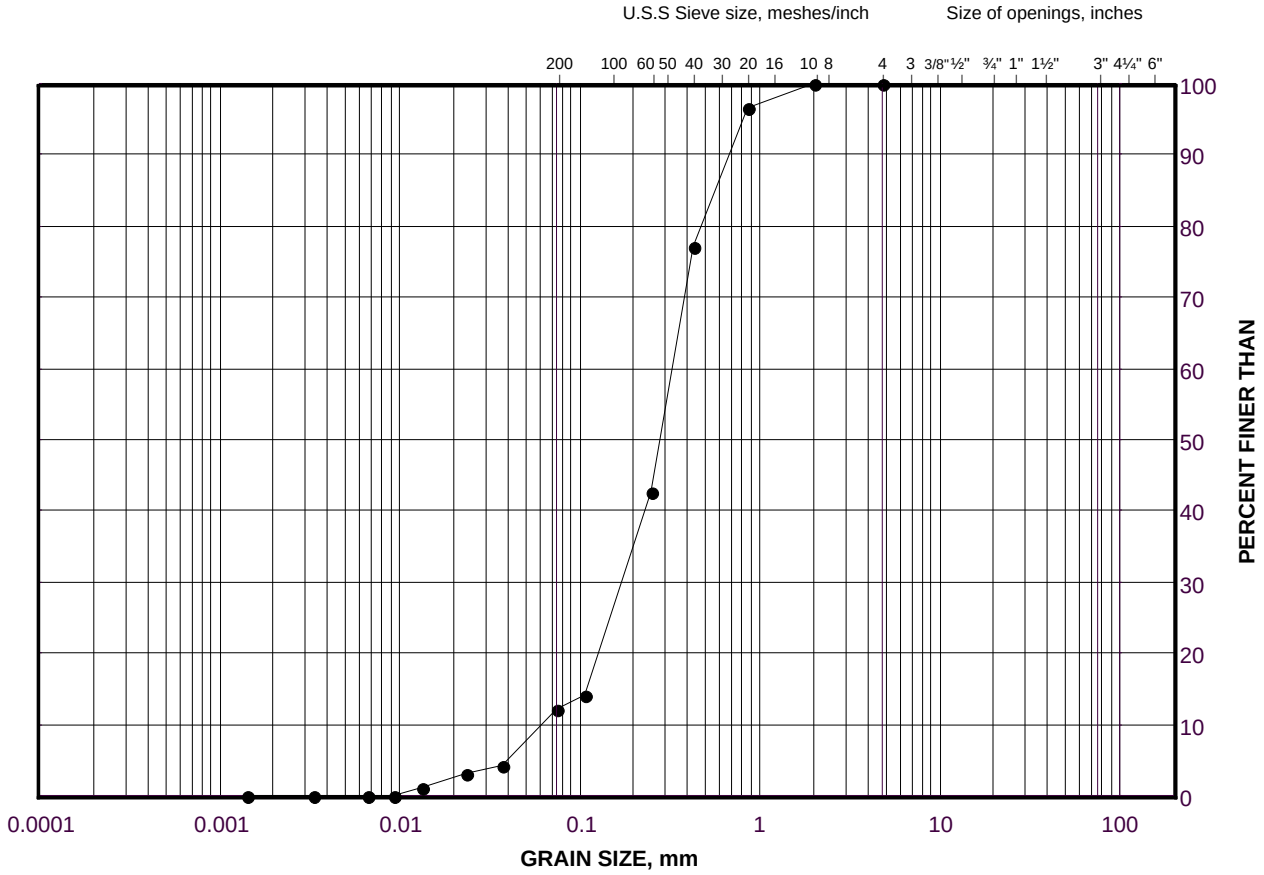
Project No. 13-1111-0026

Checked By: NK

GRAIN SIZE DISTRIBUTION

Sand

FIGURE B28



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	15-16	2	281.2

Project Number: 13-1111-0026

Checked By: NK

Golder Associates

Date: 04-Mar-16

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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