REPORT

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November 2012

FOUNDATION INVESTIGATION REPORT

LLOYDTOWN – AURORA ROAD UNDERPASS HIGHWAY 400 WIDENING FROM NORTH OF KING ROAD TO SOUTH CANAL ROAD MINISTRY OF TRANSPORTATION, ONTARIO G.W.P. 2835-02-00

Submitted to:
URS Canada Inc.
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Markham, Ontario L3T 7N9

GEOCRES NO.: 31D-550

Report Number: 09-1111-0018-1

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Golder Associates

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1.0 INTRODUCTION

Golder Associated Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the widening and replacement of the Lloydtown - Aurora Road underpass structure. The proposed work is part of the overall widening of Highway 400 from north of King Road to South Canal Road in the Regional Municipality of York, Ontario, including replacement of the 16th Side Road, Highway 9 and the southbound and northbound South Canal Bridges, culvert extensions and replacements, retaining walls, and the widening of high fill embankments and deep cuts.

The Terms of Reference for the foundation engineering services are outlined in the Terms of Reference of MTO's Request for Proposal, dated May 2008 that form part of the Consultant's Agreement (Number 2007-E-0002) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for this project, dated October 2010.

This report addresses the investigation carried out for the Lloydtown - Aurora Road underpass and its associated approach embankments. The purpose of this investigation is to establish the subsurface conditions at the location of the proposed replacement structure, including the associated approach embankments, by borehole drilling and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Lloydtown - Aurora Road underpass structure is located at the intersection of Highway 400 and Lloydtown - Aurora Road in the Regional Municipality of York, Ontario. The existing structure consists of an approximately 34 m long, 15 m wide single-span bridge, with the abutments supported on spread footings.

In general, the topography in the area of the overall project site consists of rolling terrain covered by agricultural fields and densely treed areas, with commercial facilities located along Highway 400. The existing natural ground surface at the Lloydtown - Aurora Road site is at approximately Elevation 304.5 m. The existing Highway 400 grade is slightly above this level, at about Elevation 304.8 m to 305.0 m in the immediate vicinity of the underpass.

Lloydtown - Aurora Road has been constructed on embankment fill that is between approximately 6 m and 7 m high, with the pavement grade at about Elevation 310.8 m to 311.0 m.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

During the preliminary foundation investigation phase of the work two boreholes (Borehole Nos. 87 and 88) were advanced in October 2000 within the vicinity of the structure. The results of this investigation are presented in Golder's Preliminary Foundation Investigation Report (Report No. 001-1122F-7) dated May 2001, and a copy of the borehole records are presented in Appendix B. Reference to the subsurface conditions at these two borehole locations is made in the following sections of this report to augment the subsurface information gathered during the detail foundation investigation phase of the work.

3.2 Current Investigation

The field work for the detail foundation investigation was carried out in October and November 2010, during which time a total of six boreholes (designated Boreholes LA1 to LA6) were advanced at the bridge site. One borehole was drilled near the proposed west abutment; two boreholes were drilled near the proposed centre pier location; one borehole was advanced near the east abutment; and one borehole was drilled at the toe of both the east and west approach embankments. The boreholes for the previous and current foundation investigation were advanced at the locations shown in plan on Drawing 1.

The field investigation was carried out using a D-90 track-mounted drill rig, supplied and operated by Walker Drilling Inc. of Utopia, Ontario. The boreholes were advanced using 210 mm outside diameter continuous flight hollow stem augers and 108 mm outside diameter continuous flight solid stem augers with wash boring as required. Soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586-08a). All the boreholes at the site were advanced into a stratum of equivalent SPT "N"-values equal to or greater than "100-blow" when corrected for the higher energy automatic hammer used during the current investigation. In general, the depths of the boreholes range from about 6.6 m to 18.9 m below existing ground surface, and are summarized below.

The groundwater conditions in the open boreholes were observed during the drilling operations and one piezometer was installed in Borehole LA2 to permit monitoring of the water level at this location. The groundwater conditions were also observed in the piezometers installed in Boreholes 87 and 88 during the previous (2000) investigation. The piezometer installed in Borehole LA2 consists of 50 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented following the text of the report. All boreholes in which standpipe piezometers were not installed were backfilled to ground surface with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, directed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

The borehole locations and the ground surface elevations were surveyed by Callon Dietz, a professional surveying company retained by URS. The borehole locations, including the boreholes advanced during the preliminary field investigation, in MTM NAD 83 northing and easting coordinates, and the ground surface elevations referenced to geodetic datum, are summarized below and are shown on Drawing 1.

Borehole	Location (MTM NAD 83)		Ground Surface Elevation (m)	Depth Drilled (m)
	Northing (m)	Easting (m)		
LA1	4873466.0	297858.4	304.4	6.6
LA2	4873500.8	297864.6	310.8	18.9
LA3	4873501.2	297910.1	305.0	9.7
LA4	4873526.5	297904.2	304.8	17.4
LA5	4873525.8	297942.3	311.0	18.7
LA6	4873563.2	297951.0	304.3	6.7

The location and elevation of Boreholes 87 and 88 which were advanced as part of the preliminary study in October 2000, are presented below.

Borehole	Location (MTM NAD 83)		Ground Surface Elevation (m)	Depth Drilled (m)
	Northing (m)	Easting (m)		
87	4873552	297915	305.0	9.6
88	4873483	297887	305.0	9.6

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This 23 km section of Highway 400 traverses, in a south–north direction, the physiographic regions known as South Slope, Oak Ridges Moraine and Simcoe Lowland, according to *The Physiography of Southern Ontario* (Chapman and Putman, 1984)[1]. Along Highway 400, the South Slope is present south of King Road, the Oak Ridge Moraines extends from north of King Road to south of Highway 9 and the Simcoe Lowlands occupy a 4 km wide strip extending from south of Highway 9 to Holland River. The Lloydtown - Aurora Road underpass structure is located within the Oak Ridges Moraine physiographic region.

The surficial soils of the South Slope region are generally cohesive tills. The Oak Ridges Moraine predominately consists of sand and gravel, although in the King Township area these soils are often overlain by till. It is understood that during grading for the initial construction of Highway 400 in this area, deep cuts exposed up to about 10 m of till overlying the sands and gravels.

The Holland River valley, which crosses Highway 400 in the vicinity of Highway 9 and South Canal Road, is located within the Simcoe Lowlands region. This valley extends to the southwest from Cook Bay at the south end of Lake Simcoe, and was once a shallow extension of the lake. The floor of the valley consists of peat, soft clays and loose sands. It is understood that during initial construction of Highway 400, a layer of peat about 2 m to 3 m thick was removed in order to construct the road upon the underlying sand and clay.

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

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

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced for the detail foundation investigation together with results of the laboratory tests carried out on selected soil samples are provided on the Record of Borehole sheets in Appendix A. The Record of Boreholes 87 and 88 sheets are presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. The interpreted stratigraphy in profile along Lloydtown - Aurora Road and in cross section at the abutment and pier locations is shown on Drawings 1 and 2 and is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions in the area consist of topsoil/asphalt and fill on the roadway and highway alignments, underlain in places by clayey silt or sand and silt. Till deposits are encountered below the fill or clayey silt/sand and silt deposits, underlain by a sand to sand and silt to sandy silt deposit, which in turn is underlain in places by a clayey silt deposit.

4.2.1 Asphalt

A layer of asphalt about 0.1 m thick was encountered in Boreholes LA2 and LA5 advanced on the existing grade of Lloydtown - Aurora Road. In Boreholes LA3 and LA4, advanced through the inside shoulder of the northbound lane of Highway 400, the asphalt layer is about 0.4 m thick.

4.2.2 Topsoil

A layer of topsoil about 0.2 m thick was encountered at the existing ground surface in Boreholes LA1, LA6, 87 and 88.

4.2.3 Fill

At all boreholes drilled for this structure, with the exception of Borehole 88, fill was encountered underlying the topsoil or asphalt. In Boreholes LA2 and LA5 which were drilled along Lloydtown - Aurora Road through the existing fill embankment, the fill extends to depths of about 7.2 m and 6.6 m below ground surface (Elevation 303.6 m and 304.4 m), respectively. At the other borehole locations the fill extends to depths between about 0.6 m and 3.2 m below ground surface (Elevation 301.6 m and 304.4 m).

The fill material is variable in composition and thickness, and consists of cohesionless soil grading from sand and silt to silty sand to sandy silt to sand and gravel and cohesive fill consisting of clayey silt. The fill in places contains rootlets and organics (i.e. Boreholes LA2 to LA6 and 87) and sand and silt pockets (Boreholes LA1, LA4 and LA5).

The SPT “N”-values measured within the cohesionless portions of the fill generally range from 5 blows to 47 blows per 0.3 m of penetration, indicating a loose to dense relative density. Two SPT “N”-values of 63 blows per 0.3 m penetration and 97 blows per 0.23 m of penetration were encountered in Borehole LA2, within the

cohesionless fill and are attributed to the presence of gravel. The SPT "N"-values measured within the cohesive fill range from 4 blows to 14 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

Atterberg limits tests were carried out on three samples of the cohesive fill material and yielded liquid limits between about 16 per cent and 33 per cent, plastic limits between about 11 per cent and 16 per cent and corresponding plasticity indices between about 5 per cent and 17 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure 1 in Appendix A and indicate that this material is clayey silt of low plasticity. Grain size distribution tests were carried out on three samples of the cohesive fill and the results are shown on Figure 2 in Appendix A.

Grain size distribution tests were carried out on five samples of the cohesionless fill and the results are shown on Figure 3 in Appendix A.

The natural water content measured on samples of the cohesionless portions of the fill deposit range from 7 per cent to 14 per cent. The natural water content measured on samples of the cohesive fill ranges from 12 per cent to 27 per cent.

4.2.4 Sand and Silt to Silty Sand (Upper Deposit)

A cohesionless deposit of sand and silt, trace clay to silty sand containing some gravel, trace clay and organics was encountered in Boreholes LA2 and 88, below the fill deposit and the topsoil layer, respectively. The top of this deposit was encountered at about Elevation 303.6 m and Elevation 304.8 m and the base of the deposit extends to Elevation 302.1 and 302.7 m in Boreholes LA2 and 88, respectively.

The SPT "N"-values measured within the upper sand and silt to silty sand deposit range from 17 blows to 40 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The natural water content measured on two samples of the cohesionless deposit is 12 per cent and 13 per cent.

4.2.5 Clayey Silt to Silty Clay (Upper Deposit)

Underlying the fill material in Boreholes LA5 and 87, a clayey silt to silty clay deposit containing trace to some gravel, trace to some sand, rootlets and organics was encountered at depths of 6.6 m and 3.9 m below ground surface, respectively, corresponding to Elevation 304.4 m. The thickness of the deposit is about 2.1 m and 3.3 m in Boreholes LA5 and 87, respectively.

The SPT "N"-values measured within the upper clayey silt to silty clay deposit range from 1 blow to 19 blows per 0.3 m of penetration, suggesting a soft to very stiff consistency.

An Atterberg limits test carried on one sample of this deposit yielded a liquid limit of about 24 per cent, a plastic limit of about 18 per cent and a plasticity index of 6 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure 4 presented in Appendix A, and indicated that this material is a clayey silt of low plasticity.

The natural water content measured on samples within this deposit ranges from 9 per cent to 24 per cent. The organic content measured on a sample of this deposit is about 2 per cent.

4.2.6 Clayey Silt Till

A till deposit comprised of clayey silt with sand and trace gravel to clayey silt containing trace to some sand and gravel was encountered in Boreholes LA1, LA2, LA6, 87 and 88, underlying the fill deposit or the upper sand and silt to silty sand deposit or the upper clayey silt deposit. The top of this deposit was encountered between about Elevation 302.9 m and Elevation 301.1 m and its thickness ranges from about 0.8 m to 4.8 m. The clayey silt till deposit was also encountered at a depth of about 6.3 m below ground surface (Elevation 298.1 m) underlying the sand and silt till deposit, in Borehole LA1. This borehole was terminated within the clayey silt till deposit at a depth of 6.6 m below ground surface (Elevation 297.8 m).

The SPT "N"-values measured within the clayey silt till deposit range from 13 blows to 179 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

Atterberg limits tests were carried out on five samples of this deposit and yielded liquid limits between about 16 per cent and 31 per cent, plastic limits between about 9 per cent and 15 per cent and plasticity indices between about 5 per cent and 16 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure 5 in Appendix A and indicate that the material is a clayey silt of low plasticity.

Grain size distribution tests were carried out on two samples of this deposit and the results are shown on Figure 6 in Appendix A.

The natural water content measured within this deposit ranges from 8 per cent to 18 per cent.

4.2.7 Sand and Silt to Silty Sand Till

Underlying the clayey silt till deposit, upper clayey silt or the fill deposit, a till deposit comprised of sand and silt to silty sand containing trace to some gravel, trace to some clay, sand pockets and sand seams was encountered in Boreholes LA1 to LA6 and 88. The top of this granular till deposit was encountered between about Elevation 302.8 m and Elevation 300.6 m and the thicknesses of the deposit ranges from about 2.5 m to 4.8 m. Borehole LA6 was terminated within the sand and silt till deposit at a depth of about 6.7 m below ground surface (Elevation 297.5 m). In Borehole LA2, the augers were noted to be grinding on possible cobbles or boulders at depths between 11.3 m and 12.2 m below ground surface.

The SPT "N"-values measured within this till deposit range from 14 blows to 160 blows per 0.3 m of penetration, indicating a compact to very dense relative density. An SPT "N"-value of 9 blows per 0.3 m of penetration was recorded in Borehole LA2 at a depth of about 14 m below ground surface and is attributed to disturbance of the deposit due to groundwater inflow into the augers.

Atterberg limits tests were carried out on three samples of this deposit and yielded liquid limits of 15 per cent, plastic limits between about 11 per cent and 12 per cent and plasticity indices between about 3 per cent and 4 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure 7 in Appendix A and indicate that the sand and silt till exhibits a slight plasticity.

Grain size distribution tests were carried out on twelve samples within this deposit and the results are shown on Figures 8A and 8B in Appendix A.

The natural water content measured within this deposit ranges from 2 per cent to 16 per cent.

4.2.8 Sand to Sand and Silt to Sandy Silt (Lower Deposit)

Underlying the sand and silt to silty sand till deposit or the clayey silt till deposit, a cohesionless deposit comprised of sand to sand and silt to sandy silt, trace to some clay was encountered in Boreholes LA2 to LA5, 87 and 88. The top of this deposit was encountered between about Elevation 299.3 m and Elevation 296.0 m. Boreholes LA2, LA3, LA5, 88 and 87 were terminated within this deposit between about Elevation 295.5 m and Elevation 291.9 m. This deposit is 6.8 m thick where it was fully penetrated at Borehole LA4 and the base of the deposit extends to a depth of about 14.8 m below ground surface (Elevation 290.1 m).

The SPT "N"-values measured within this deposit range from 57 blows per 0.3 m of penetration to 171 blows per 0.25 m of penetration, indicating a very dense relative density.

The results of grain size distribution tests carried out on six samples of this deposit are shown on Figure 9 in Appendix A.

The natural water content measured on samples of the lower sand to sand and silt deposit ranges from 12 per cent to 21 per cent.

4.2.9 Clayey Silt (Lower Deposit)

A cohesive deposit comprised of clayey silt, containing trace to some sand and trace gravel was encountered underlying the lower sand to sand and silt deposit in Borehole LA4. The top of this deposit was encountered at about a depth of about 14.8 m below ground surface (Elevation 290.1 m) and Borehole LA4 was terminated within the deposit at a depth of about 17.4 m below ground surface (Elevation 287.5 m).

The SPT "N"-values measured within the clayey silt deposit are 72 blows and 87 blows per 0.3 m of penetration, suggesting a hard consistency.

An Atterberg limits test was carried out on one sample of this deposit and yielded a liquid limit of 24 per cent, a plastic limit of 15 per cent and plasticity index of 9 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure 10 in Appendix A and indicate that material is a clayey silt of low plasticity.

The result of a grain size distribution test carried out on one sample of this deposit is shown on Figure 11 in Appendix A.

The natural water content measured within the lower clayey silt deposit is 14 per cent.

4.3 Groundwater Conditions

Piezometers were installed in Borehole LA2 during the current investigation and in Boreholes 87 and 88 during the previous investigation to permit the monitoring of the groundwater levels at the site. In general, the overburden samples taken in the boreholes advanced in this area were moist. Details of the piezometer installation are shown on the Record of Borehole sheets presented in Appendix A and Appendix B. The water level in the piezometer in Borehole LA2 was measured on May 27, 2011 at a depth of about 1.5 m below ground surface and the tip of the water level finder contained bentonite corresponding to the depth of the top of the piezometer screen. Therefore, it is considered that the piezometer was damaged during installation. The groundwater levels measured in the piezometer installed during the previous investigation are summarized below.

Borehole No.	Ground Surface Elevation (m)	Stratum Sealed Into	Piezometer Tip Elevation (m)	Groundwater Elevation (m)	Date of Measurement
87	305.0	Clayey Silt with Sand Till/Sand	296.5	298.2	October 19, 2000
				298.7	December 20, 2000
				--*	January 19, 2001
88	305.0	Sand and Silt Till/Sand	298.0	299.8	October 20, 2000
				Dry	December 20, 2000
				Dry	January 19, 2001

*Piezometer destroyed – unable to obtain water level

It should be noted that in Boreholes LA2 to LA5 and 88, drilling fluid was used to advance the boreholes between Elevation 298.3 m and Elevation 295.6 m due to “blowing” sands; as a result, water levels could not be determined in these boreholes upon completion of drilling.

It should also be noted that groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Olta Kociu, EIT and reviewed by Ms. Sandra McGaghran, P.Eng., a senior geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., Golder's Designated MTO Contact for this project and a Principal with Golder, conducted an independent quality control review of the report.

GOLDER ASSOCIATES LTD.

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Senior Geotechnical Engineer

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

OK/TVA/SMM/JMAC/jl

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MINISTRY OF TRANSPORTATION, ONTARIO

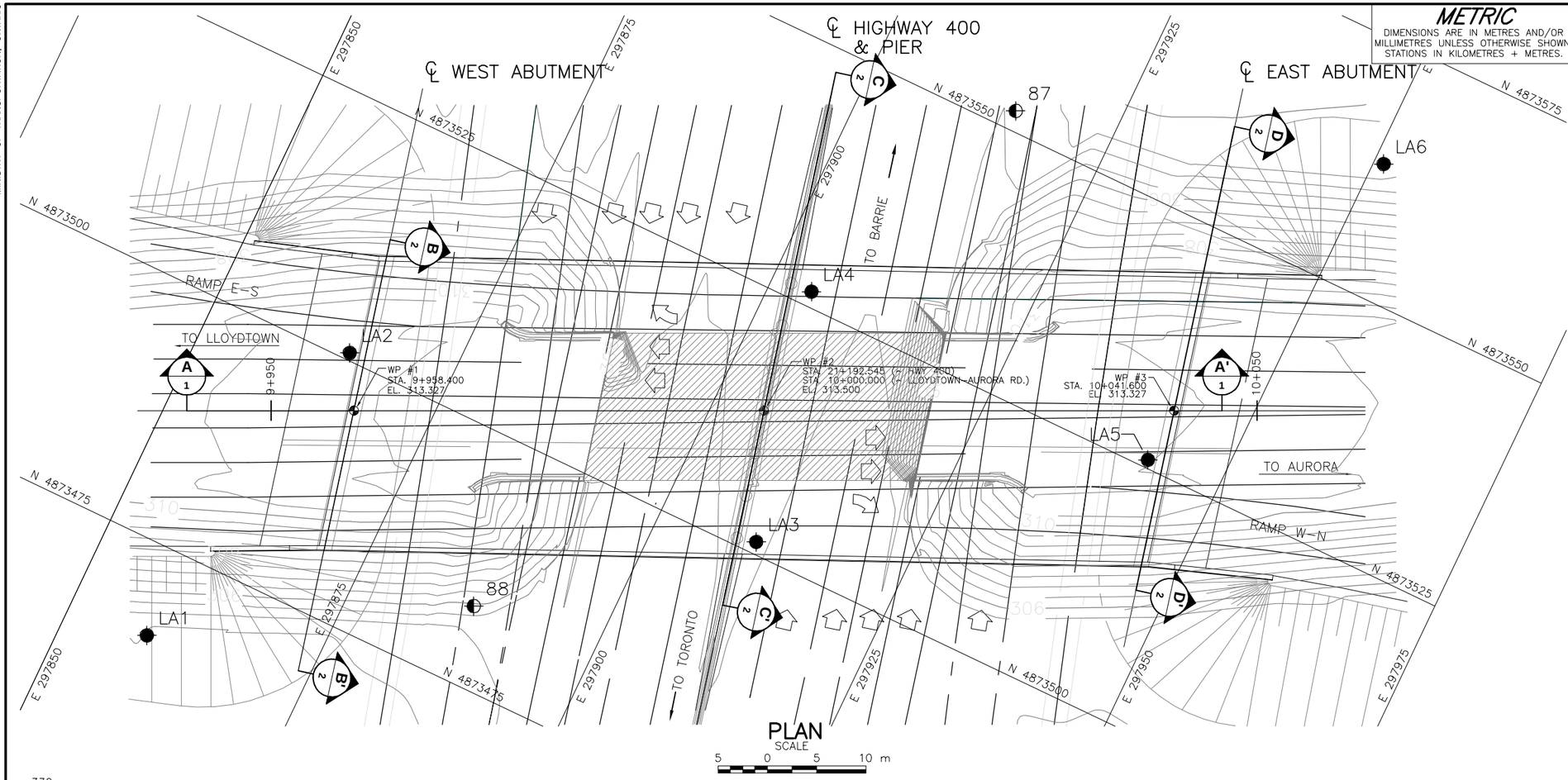
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

HIGHWAY 400
LLOYDTOWN – AURORA ROAD UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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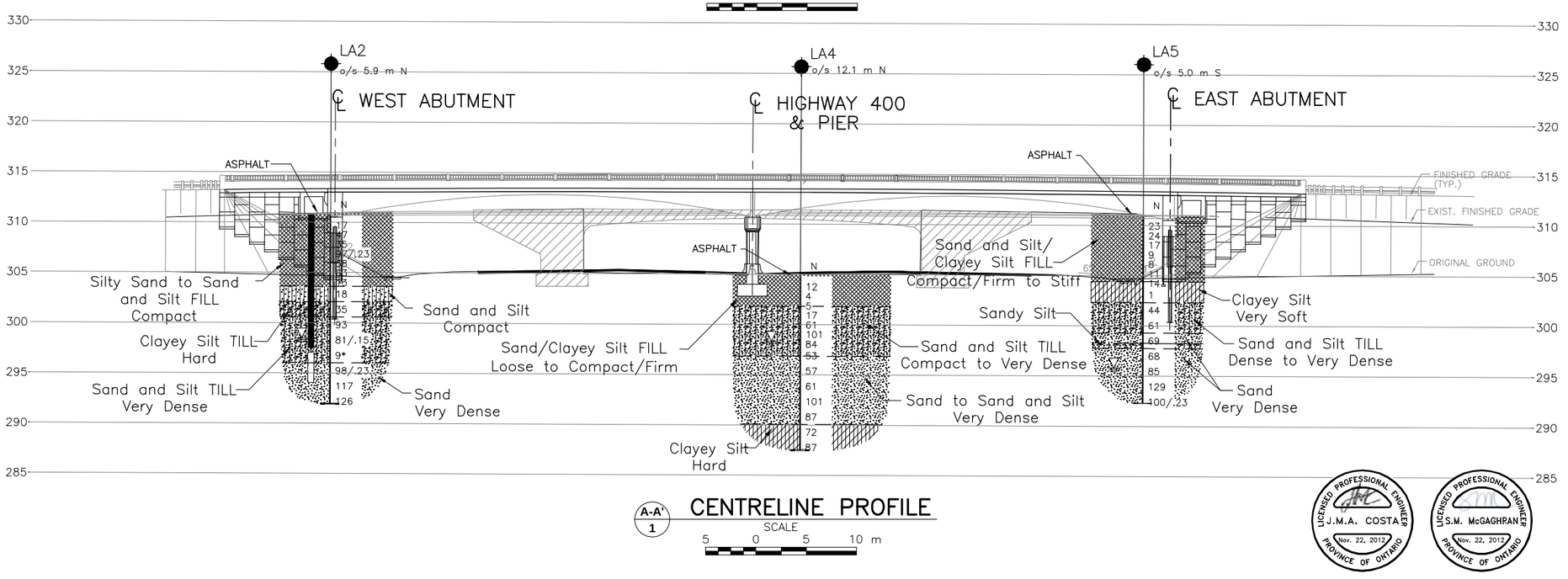

A-A'
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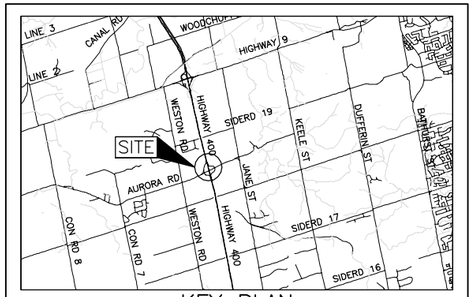


KEY PLAN
SCALE
2 0 2 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation, Golder Associates Ltd. Report No. 001-1122F-7, dated May, 2001
- 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 May 28, 2011
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
87	305.0	4873552.0	297915.0
88	305.0	4873483.0	297887.0
LA1	304.4	4873466.0	297858.4
LA2	310.8	4873500.8	297864.6
LA3	305.0	4873501.2	297910.1
LA4	304.8	4873526.5	297904.2
LA5	311.0	4873525.8	297942.3
LA6	304.3	4873563.2	297951.0

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file no. Aurora Rd Underpass GA.dwg, received November 17, 2010.

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Nov. 22, 2012 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.M. McGAGHRAN Nov. 22, 2012 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D-550

HWY. 400		PROJECT NO. 09-1111-0018	DIST.
SUBM'D. TT	CHKD. SMM	DATE: 11/22/2012	SITE:
DRAWN: JFC	CHKD. SMM	APPD. JMAC	DWG. 1

PLOT DATE: November 22, 2012
FILENAME: K:\Projects\2009\09-1111-0018 (URS, York Region)\~#B~ (AURORA RD)\09111101MB001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

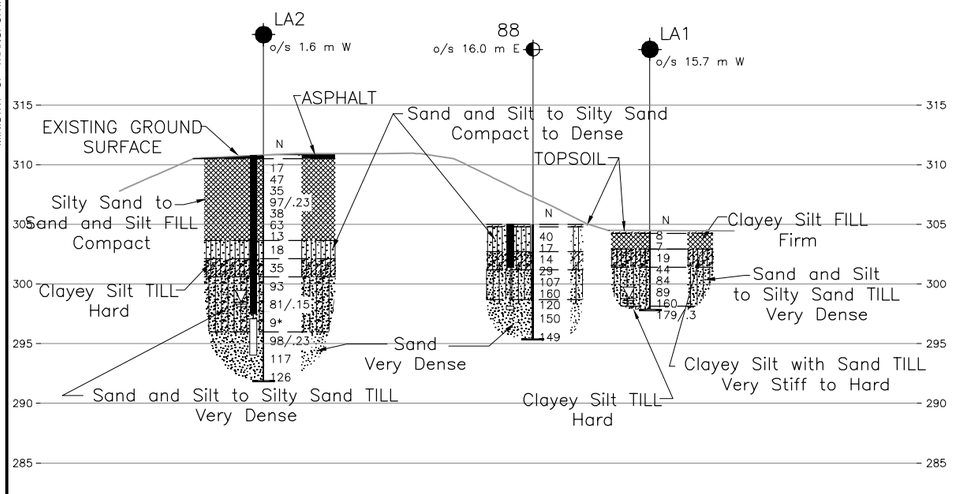
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

HIGHWAY 400
LLOYDTOWN – AURORA ROAD UNDERPASS
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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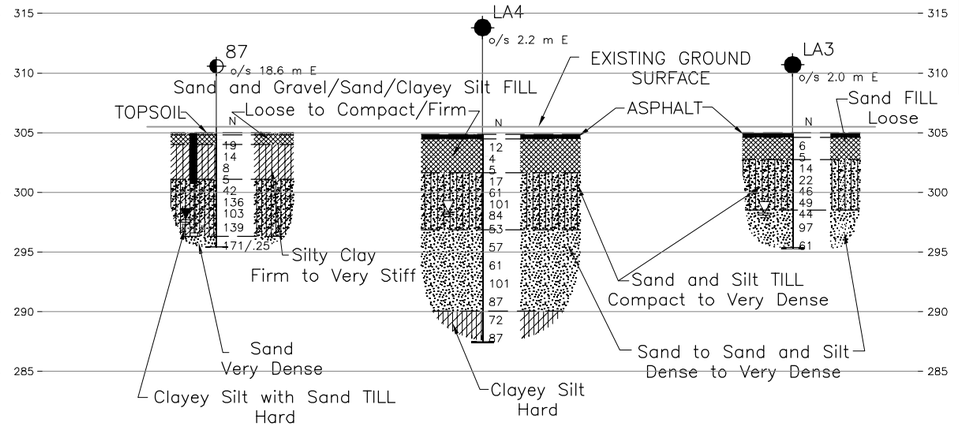

C-C' 1 **CENTRE PIER**
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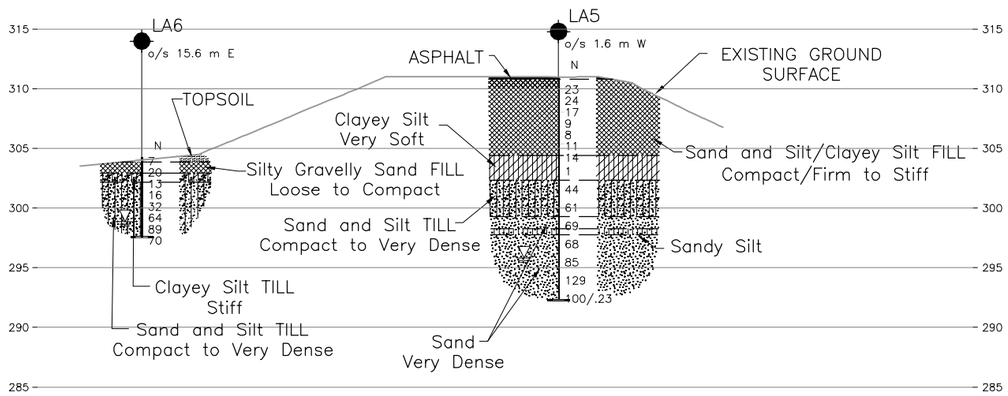

D-D' 1 **EAST ABUTMENT**
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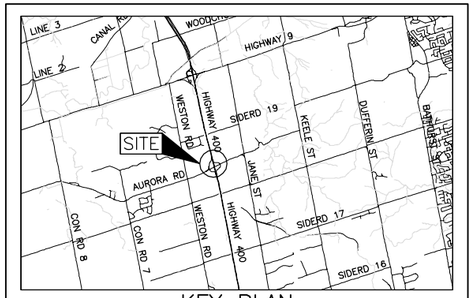


KEY PLAN
SCALE 2 0 2 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation, Golder Associates Ltd. Report No. 001-1122F-7, dated May, 2001
- 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 May 28, 2011
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
87	305.0	4873552.0	297915.0
88	305.0	4873483.0	297887.0
LA1	304.4	4873466.0	297858.4
LA2	310.8	4873500.8	297864.6
LA3	305.0	4873501.2	297910.1
LA4	304.8	4873526.5	297904.2
LA5	311.0	4873525.8	297942.3
LA6	304.3	4873563.2	297951.0

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS, drawing file no. Aurora Rd Underpass GA.dwg, received November 17, 2010.

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Nov. 22, 2012 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.M. McGAGHRAN Nov. 22, 2012 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31D-550

HWY. 400	PROJECT NO. 09-1111-0018		DIST.
SUBM'D. TT	CHKD. SMM	DATE: 11/22/2012	SITE:
DRAWN: JFC	CHKD. SMM	APPD. JMAC	DWG. 2

PLOT DATE: November 27, 2012
FILENAME: P:\Projects\2009\09-1111-0018 (URS, York Region)\-4B- (AURORA RD)\09111100184B002.dwg

APPENDIX A

Record of Borehole Sheets and Laboratory Test Results

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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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) 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

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

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

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
σ_1, σ_2, σ_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 δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

2 shear strength = (compressive strength)/2

Golder Associates

RECORD OF BOREHOLE No LA1

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00(b) LOCATION N 4873466.0 ;E 297858.4 ORIGINATED BY CS
DIST Central HWY 400 BOREHOLE TYPE 108 mm Outside Diameter Continuous Flight Solid Stem Auger COMPILED BY SKB
DATUM Geodetic DATE October 25, 2010 CHECKED BY SMM

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
304.4	GROUND SURFACE										
0.0	TOPSOIL										
0.2	Clayey silt, some sand, trace gravel, containing rootlets (FILL) Firm Brown Moist		1	SS	8		304				
303.0			2	SS	7		303				
1.5	CLAYEY SILT with SAND, trace gravel (TILL) Very stiff to hard Brown Moist		3	SS	19						1 31 50 18
301.4			4	SS	44		302				
3.0	SAND and SILT to Silty SAND, trace clay, trace gravel, some sand pockets and sand seams (TILL) Very dense Brown Moist		5	SS	84		301				
			6	SS	89		300				4 53 37 6
			7	SS	160	▽	299				
298.2			8A	SS	179/.28						5 66 23 6
297.9	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist		8B				298				
6.6	END OF BOREHOLE										

NOTE:
1. Water level in open borehole at a depth of 5.6 m below ground surface (Elevation 298.8 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No LA2

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4873500.8 ;E 297864.6
ORIGINATED BY CS/TT
DIST Central HWY 400
BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger
COMPILED BY SKB
DATUM Geodetic
DATE October 26-28, 2010
CHECKED BY SMM

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
310.8	GROUND SURFACE										
0.0	ASPHALT										
0.3	GRANULAR FILL Silty sand, trace clay, trace gravel (FILL) Compact Brown Moist		1	SS	17		310				
309.4											
1.5	Sand and silt, trace to some clay, trace gravel (FILL) Compact to very dense Brown Moist		2	SS	47		309				
	- Occasional sandy silt and clayey silt layers/pockets between the depths of 1.5 m and 5.6 m (Elev. 309.3 m and 305.2 m)		3	SS	35		308				1 50 41 8
			4	SS	97/.23						
			5	SS	38		307				
			6	SS	63		306				3 49 38 10
	- Containing rootlets and sand seams/pockets between the depths of 5.6 m and 7.2 m (Elev. 305.2 m and 303.6 m)		7	SS	13		305				1 46 45 8
303.6							304				
7.2	SAND and SILT, trace clay, occasional silty sand layers Compact Grey Moist		8	SS	18		303				
302.1											
8.7	CLAYEY SILT, trace to some sand, trace gravel, sand lenses (TILL) Hard Brown Moist		9	SS	35		302				
300.6							301				
10.2	SAND and SILT, trace to some clay, trace gravel (TILL) Very dense Brown Moist		10	SS	93		300				3 45 46 6
	- Augers grinding between 11.3 m and 12.2 m depth		11	SS	81/.15	▽	299				
			12	SS	9*		298				
296.0							297				5 43 46 6
14.8							296				

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No LA2

SHEET 2 OF 2 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4873500.8 ;E 297864.6 ORIGINATED BY CS/TT
DIST Central HWY 400 BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger COMPILED BY SKB
DATUM Geodetic DATE October 26-28, 2010 CHECKED BY SMM

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, some silt Very dense Brown Wet		13	SS	98/.23		295				
			14	SS	117		294		○		0 84 14 2
							293				
291.9			15	SS	126		292		○		0 84 14 2
18.9	END OF BOREHOLE										

NOTES:

1. * SPT "N" Value considered to be affected by sample disturbance due to groundwater inflow to borehole.

2. A hydrostatic head of water and drilling fluid was required inside the augers at a depth of 15.2 m below ground surface (Elev. 295.6 m) in order to advance the borehole due to "blowing " sands.

3. Water level in open borehole at a depth of 12.3 m below ground surface (Elev. 298.5 m) during drilling on October 27, 2010.

4. Borehole advanced using drilling mud; water level not measured upon completion of drilling as it is not reflective of in-situ water conditions.

5. Water level measurement in the piezometer:

Date	Depth (m)	Elev. (m)
11/25/10	1.8	309.0
12/02/10	1.7	309.1

6. Piezometer damaged - unable to obtain water level reading on May 27, 2011.

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

Golder Associates

RECORD OF BOREHOLE No LA3

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4873501.2 ;E 297910.1 ORIGINATED BY TT
DIST Central HWY 400 BOREHOLE TYPE 108 mm Outside Diameter Continuous Flight Solid Stem Auger, Wash Boring COMPILED BY SKB
DATUM Geodetic DATE November 2, 2010 CHECKED BY SMM

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
305.0	GROUND SURFACE										
0.0 / 304.7	ASPHALT										
0.4	Sand, some silt, trace gravel, trace clay, containing pockets of clayey silt and organics (FILL) Loose Brown Moist to wet		1	SS	6		304				
302.8			2	SS	5		303				
2.2	SAND and SILT, trace clay, trace to some gravel, containing sand seams and pockets (TILL) Compact to dense Brown Moist becoming wet below 3.1 m depth		3	SS	14		302				10 38 47 5
			4A 4B	SS	22		301				
			5	SS	46						
			6	SS	49		300				3 51 40 6
298.6			7	SS	44	▽	299				
6.5	SAND, some silt Dense to very dense Brown Moist		8	SS	97		298				0 84 15 1
295.3			9	SS	61		297				
9.7	END OF BOREHOLE						296				

NOTE:

1. A hydrostatic head of water and drilling fluid was required inside the hollow stem augers at a depth of 6.7 m below ground surface (Elev. 298.3 m) in order to advance the borehole due to "blowing " sands; water level could not be determined upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No LA4

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4873526.5 ;E 297904.2
ORIGINATED BY TT
DIST Central HWY 400
BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger, Wash Boring
COMPILED BY SKB
DATUM Geodetic
DATE November 1-2, 2010
CHECKED BY SMM

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
304.8	GROUND SURFACE										
0.0 / 304.5	ASPHALT										
0.4	Sand, some silt, trace gravel, trace clay, containing clayey silt layers (FILL) Loose to compact Brown Moist		1	SS	12		304				
303.0			2	SS	4		303				
1.8	Clayey silt, trace to some sand, trace gravel (FILL) Firm Brown Moist		3	SS	5		302				2 11 54 33
301.6											
3.2	SAND and SILT, trace gravel, trace clay (TILL) Compact to very dense Brown Moist		4	SS	17		301				
			5	SS	61						6 49 39 6
			6	SS	101		300				
	- Containing sand pockets between the depths of 6.1 m and 6.7 m (Elev. 298.7 m and 298.1 m)		7	SS	84	▽	299				2 47 44 7
296.8			8	SS	53		298				
8.0	SAND, some silt, trace clay to SAND and SILT Very dense Brown Wet						297				
			9	SS	57		296				0 86 12 2
			10	SS	61		295				
			11	SS	101		294				
							293				0 62 38 0
			12	SS	87		292				
290.0							291				
14.8							290				

Continued Next Page

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

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

Golder Associates

RECORD OF BOREHOLE No LA4

SHEET 2 OF 2 **METRIC**

PROJECT 09-1111-0018 | G.W.P. 2835-02-00 | LOCATION N 4873526.5 ;E 297904.2 | ORIGINATED BY TT

DIST Central | HWY 400 | BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger, Wash Boring | COMPILED BY SKB

DATUM Geodetic | DATE November 1-2, 2010 | CHECKED BY SMM

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 + FIELD VANE ● QUICK TRIAXIAL × 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 ---									
	CLAYEY SILT, trace to some sand, trace gravel Hard Grey Moist		13	SS	72		289			0 8 65 27
							288			
287.4			14	SS	87					
17.4	END OF BOREHOLE NOTE: 1. A hydrostatic head of water and drilling fluid was required inside the augers at a depth of 6.5 m below ground surface (Elev. 298.3 m) in order to advance the borehole due to "blowing " sands; water level could not be determined upon completion of drilling.									

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

Golder Associates

RECORD OF BOREHOLE No LA5

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4873525.8 ;E 297942.3
BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger, Wash Boring
DATE October 29 & November 19, 2010

ORIGINATED BY TT
COMPILED BY SKB
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.0	GROUND SURFACE						
0.0	ASPHALT						
0.1	Sand and silt, trace to some clay, trace gravel (FILL) Compact Brown Moist	1	SS	23	310		
		2	SS	24	309		
		3	SS	17			3 37 53 7
308.0					308		
3.0	Clayey silt with sand, trace gravel, containing rootlets and sand and silt pockets (FILL) Stiff Brown Moist	4	SS	9			
		5	SS	8	307		2 45 44 9
		6	SS	11			
305.9					306		
5.1	Sandy silt, trace gravel (FILL) Brown to grey Moist						
305.4							
5.6	Clayey silt with sand, containing sandy silt seams (FILL) Stiff Brown to grey Moist	7A 7B	SS	14	305		0 27 61 12
304.4							
6.6	CLAYEY SILT, trace to some sand, trace gravel, containing rootlets and organics between the depths of 6.6 m and 8.1 m (Elev. 304.4 m and 302.9 m) Very soft Grey Moist	8A 8B	SS	1	304		
					303	O.C.=2.1%	
302.3							
8.7	SAND and SILT, trace to some clay, trace gravel (TILL) Dense to very dense Brown Moist	9	SS	44	302		3 46 44 7
		10	SS	61	301		
299.3					300		
11.7	SAND, some silt Very dense Brown Moist	11	SS	69			
298.3					299		
12.8	Sandy SILT, trace clay Brown Moist				298		
297.7							
13.3	SAND, trace to some silt Very dense Brown Wet	12	SS	68	297		

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

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

PROJECT 09-1111-0018

RECORD OF BOREHOLE No LA5

SHEET 2 OF 2

METRIC

G.W.P. 2835-02-00 LOCATION N 4873525.8 ;E 297942.3 ORIGINATED BY TT

DIST Central HWY 400 BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger, Wash Boring COMPILED BY SKB

DATUM Geodetic DATE October 29 & November 19, 2010 CHECKED BY SMM

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		
	SAND, trace to some silt Very dense Brown Wet					▽					
			13	SS	85				○		0 90 9 1
							295				
			14	SS	129		294				
292.3							293				
			15	SS	100/.23						
18.7	END OF BOREHOLE										
	NOTE: 1. A hydrostatic head of water and drilling fluid was required inside the augers at a depth of 15.2 m below ground surface (Elev. 295.8 m) in order to advance the borehole due to "blowing " sands; water level could not be determined upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No LA6

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4873563.2 ;E 297951.0 ORIGINATED BY CS
DIST Central HWY 400 BOREHOLE TYPE 210 mm Outside Diameter Continuous Flight Hollow Stem Auger COMPILED BY SKB
DATUM Geodetic DATE October 22, 2010 CHECKED BY SMM

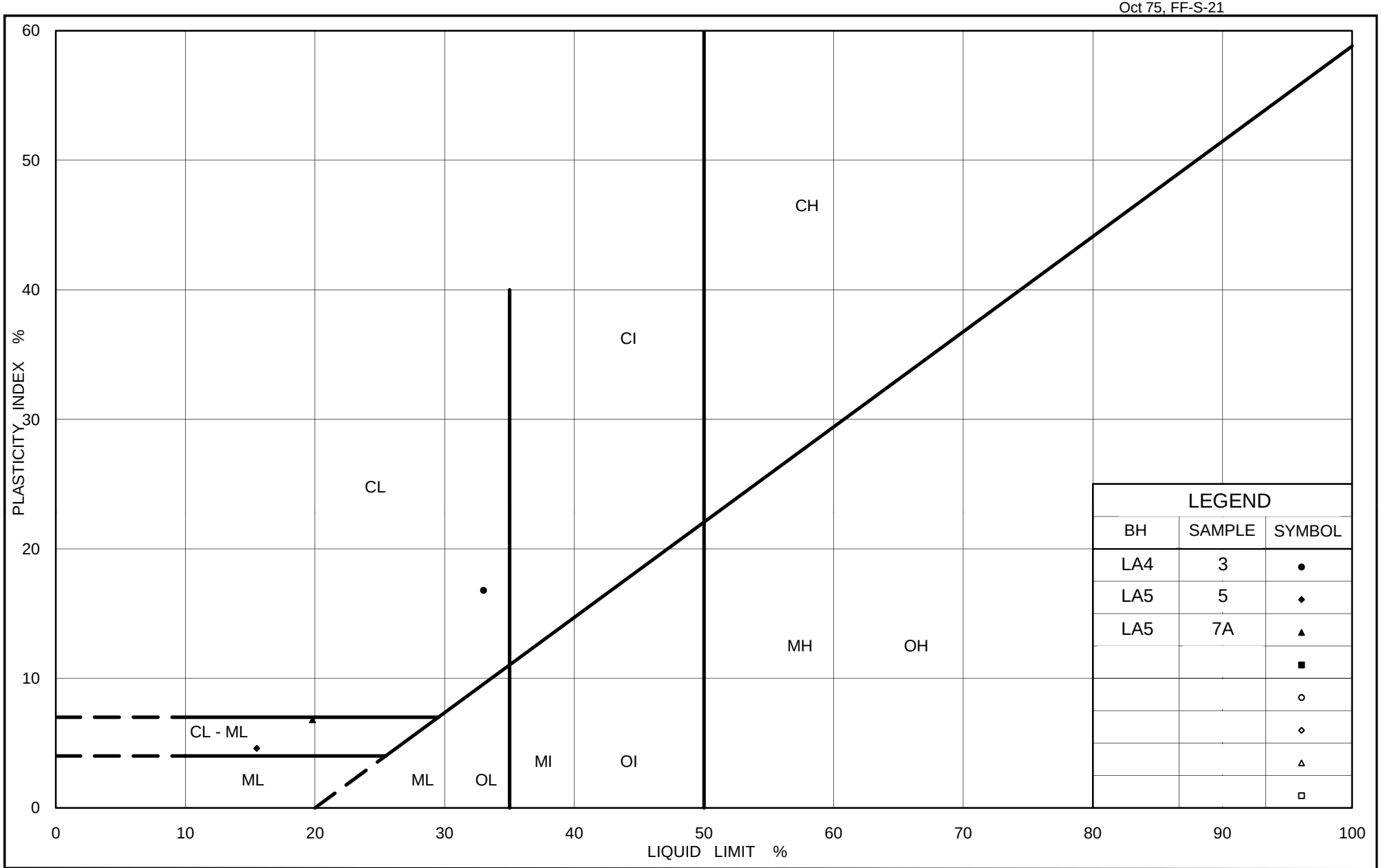
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
304.3	GROUND SURFACE										
0.0	TOPSOIL										
0.2	Silty gravelly sand, trace to some clay, containing rootlets (FILL) Loose to compact Brown Moist		1	SS	7		304				
303.0			2	SS	20		303				27 40 25 8
1.3	CLAYEY SILT, some sand, trace gravel (TILL) Stiff Brown Moist		3	SS	13						
302.2							302				
2.1	SAND and SILT, trace to some clay, trace gravel (TILL) Compact to very dense Brown Moist		4	SS	16						4 39 48 9
			5	SS	32		301				
			6	SS	64		300				3 49 40 8
			7	SS	89						
						▽	299				
			8	SS	70		298				
297.6											
6.7	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 5.4 m below ground surface (Elevation 298.9 m) upon completion of drilling.

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

GTA-MTO 001 0911110018.GPJ GAL-GTA.GDT 11/22/12 SIB



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Fill

Figure No. 1

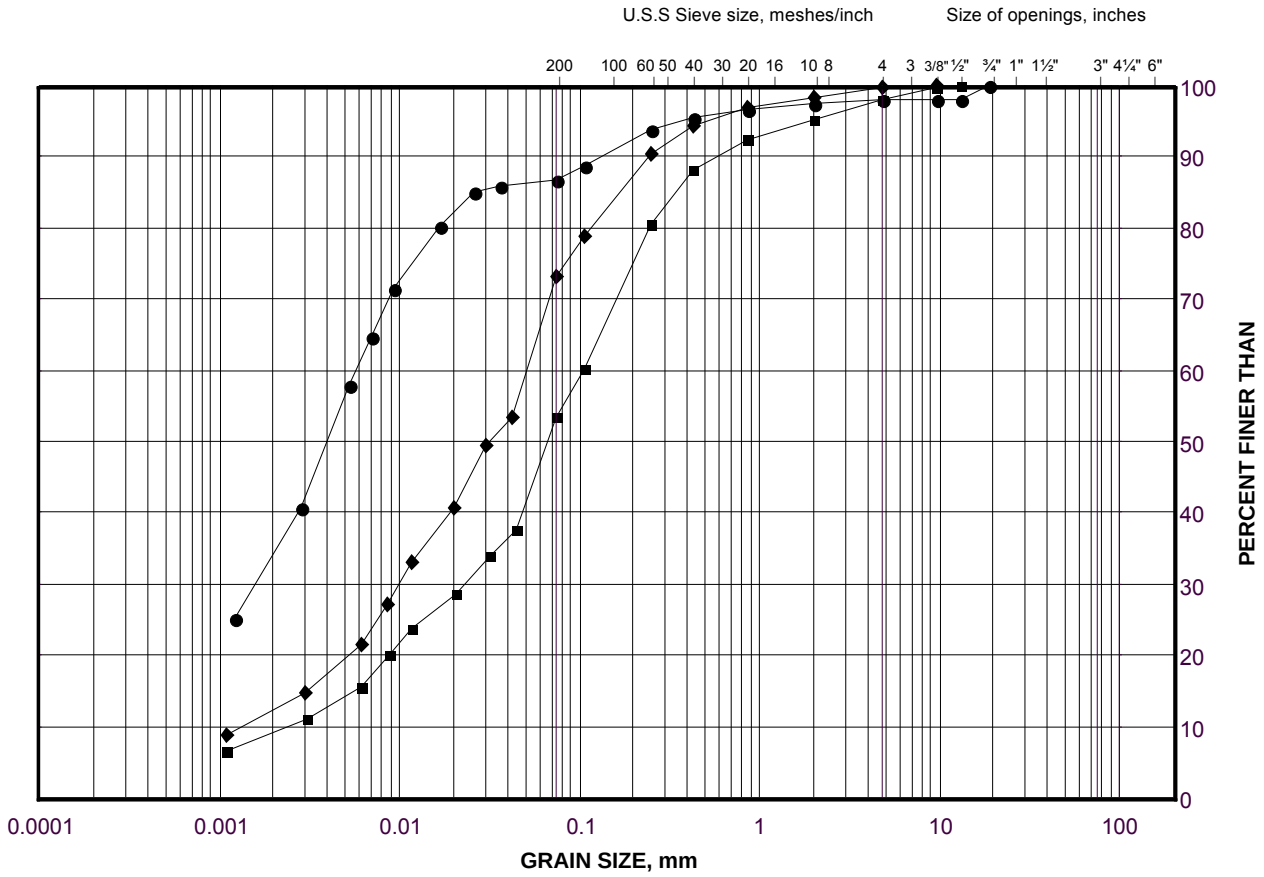
Project No. 09-1111-0018-1

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt Fill

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA4	3	302.2
■	LA5	5	306.9
◆	LA5	7A	304.8

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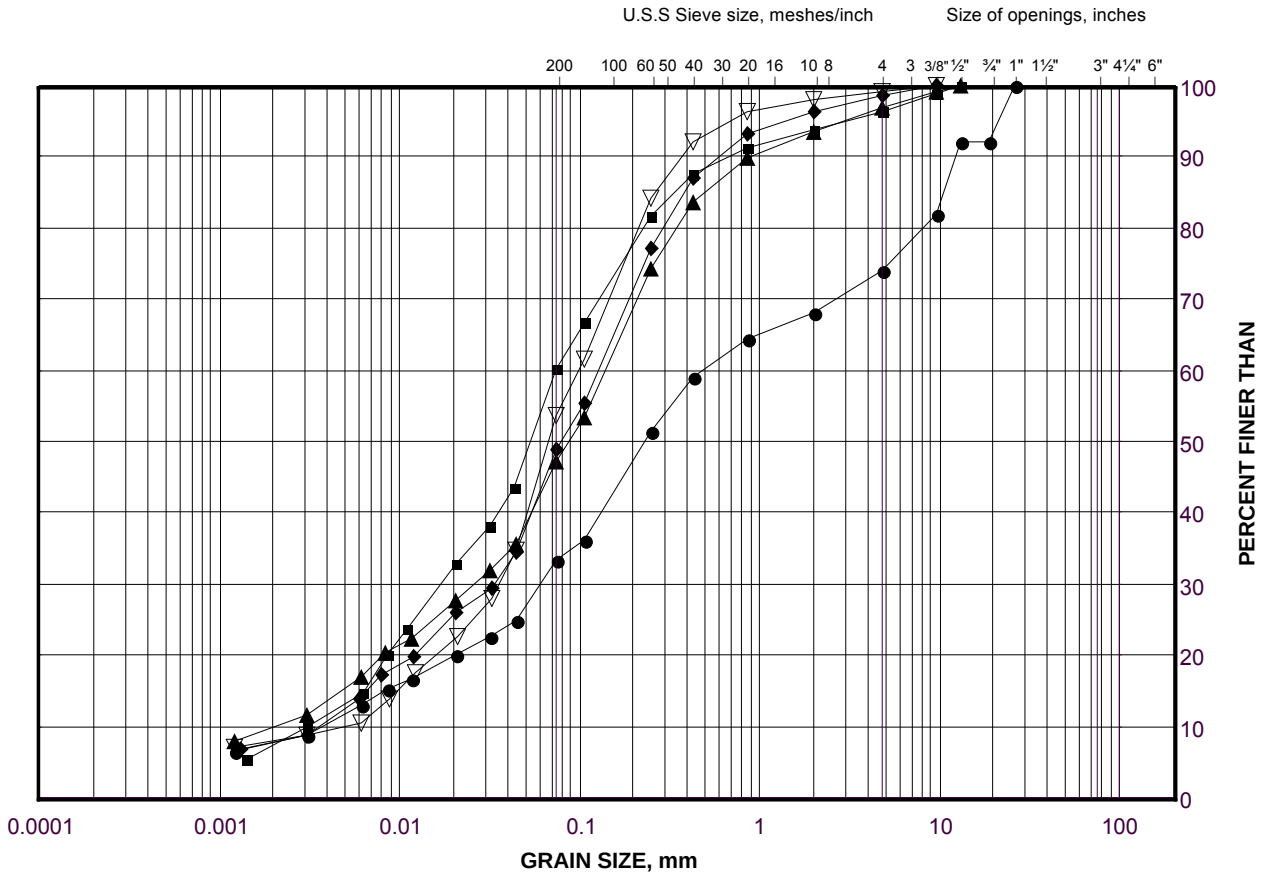
Date: 07-Mar-11

GRAIN SIZE DISTRIBUTION

Sand and Silt Fill to Silty Gravelly Sand Fill

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA6	2	303.2
■	LA5	3	308.4
◆	LA2	3	308.2
▲	LA2	6	305.9
▽	LA2	7	304.4

Project Number: 09-1111-0018-1

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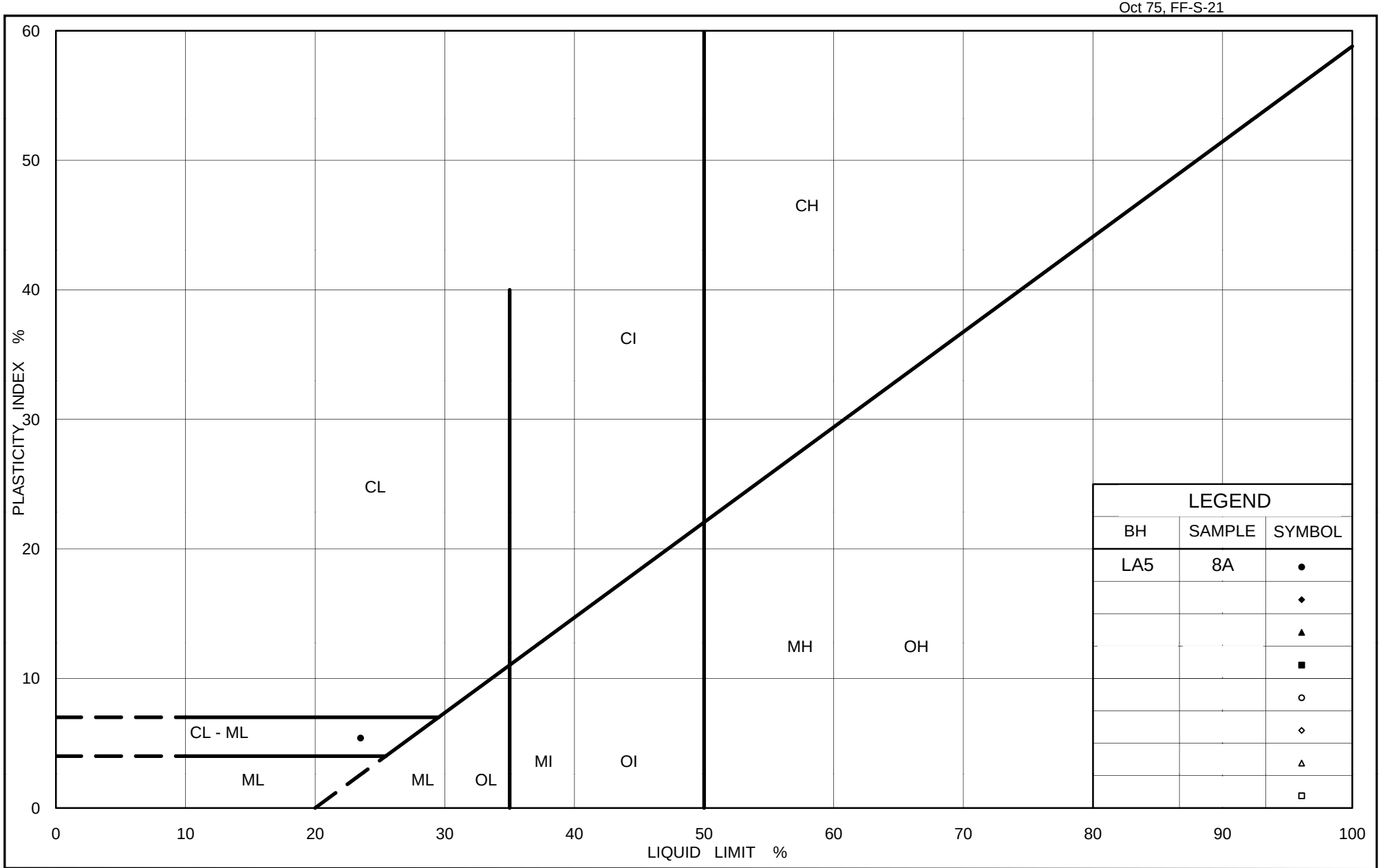
Date: 07-Mar-11

Oct 75, FF-S-21



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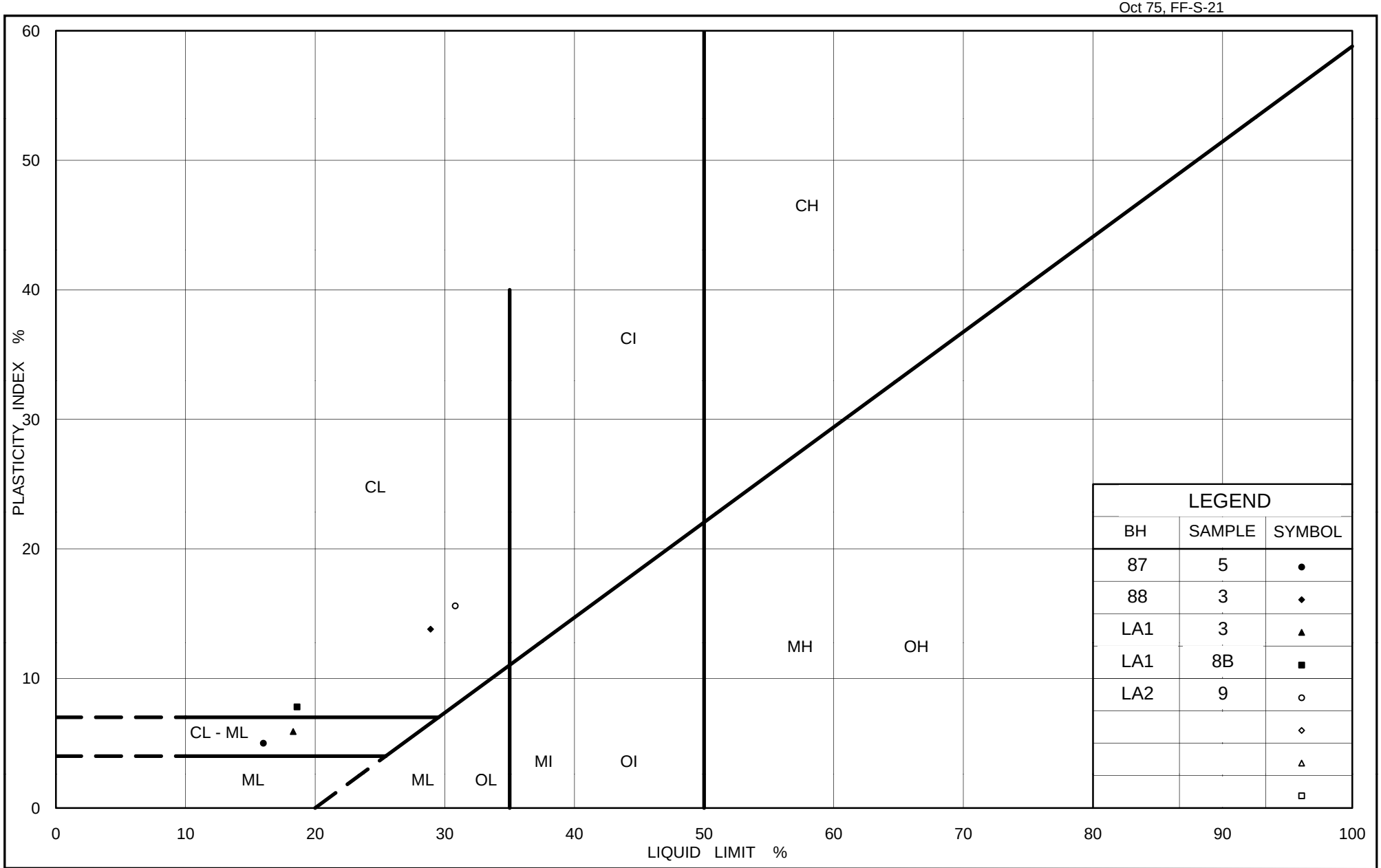
PLASTICITY CHART
Clayey Silt (Upper Deposit)

Figure No. 4

Project No. 09-1111-0018-1

Checked By:



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PLASTICITY CHART
Clayey Silt Till

Figure No. 5

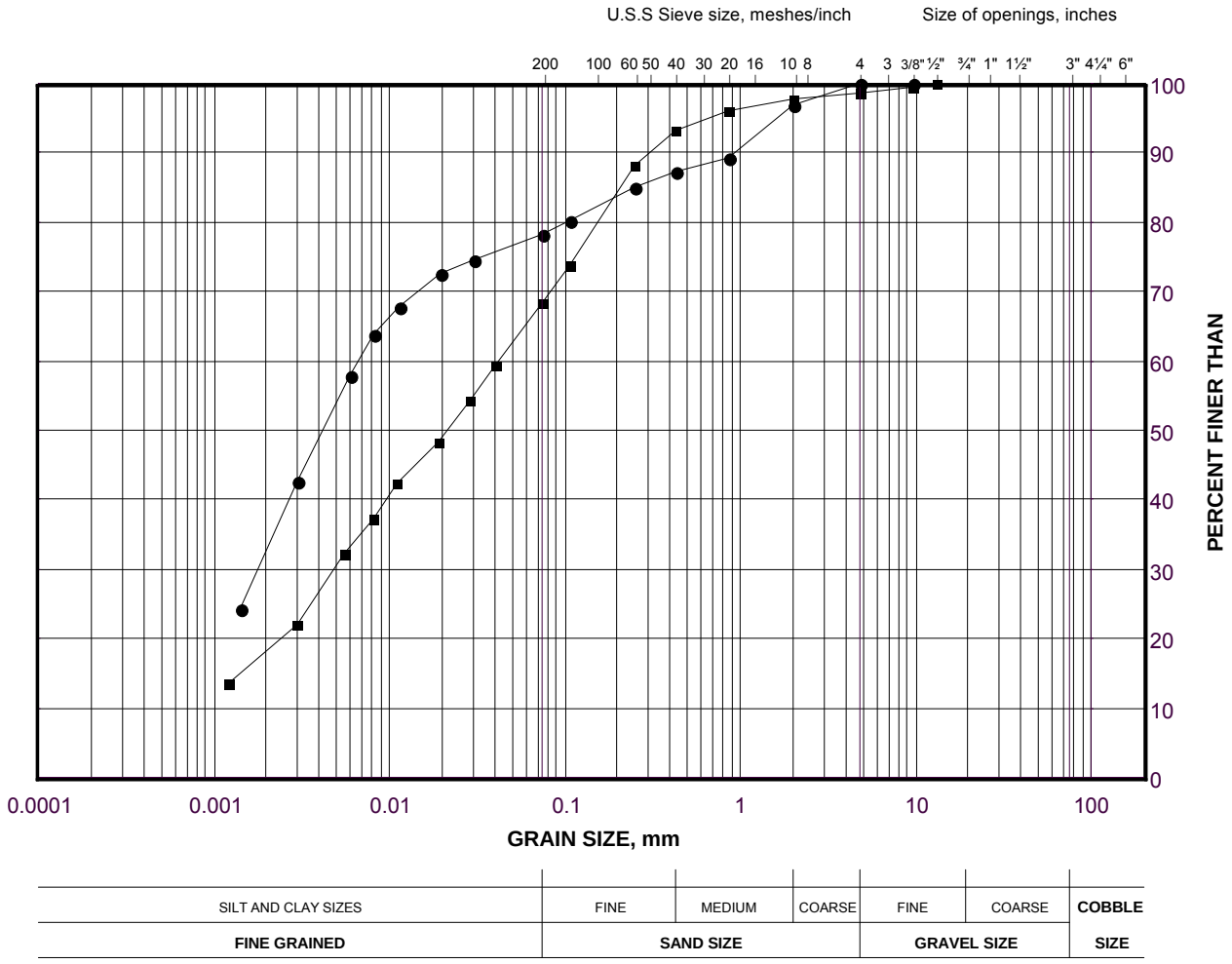
Project No. 09-1111-0018-1

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE 6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	88	3	302.4
■	LA1	3	302.6

Project Number: 09-1111-0018-1

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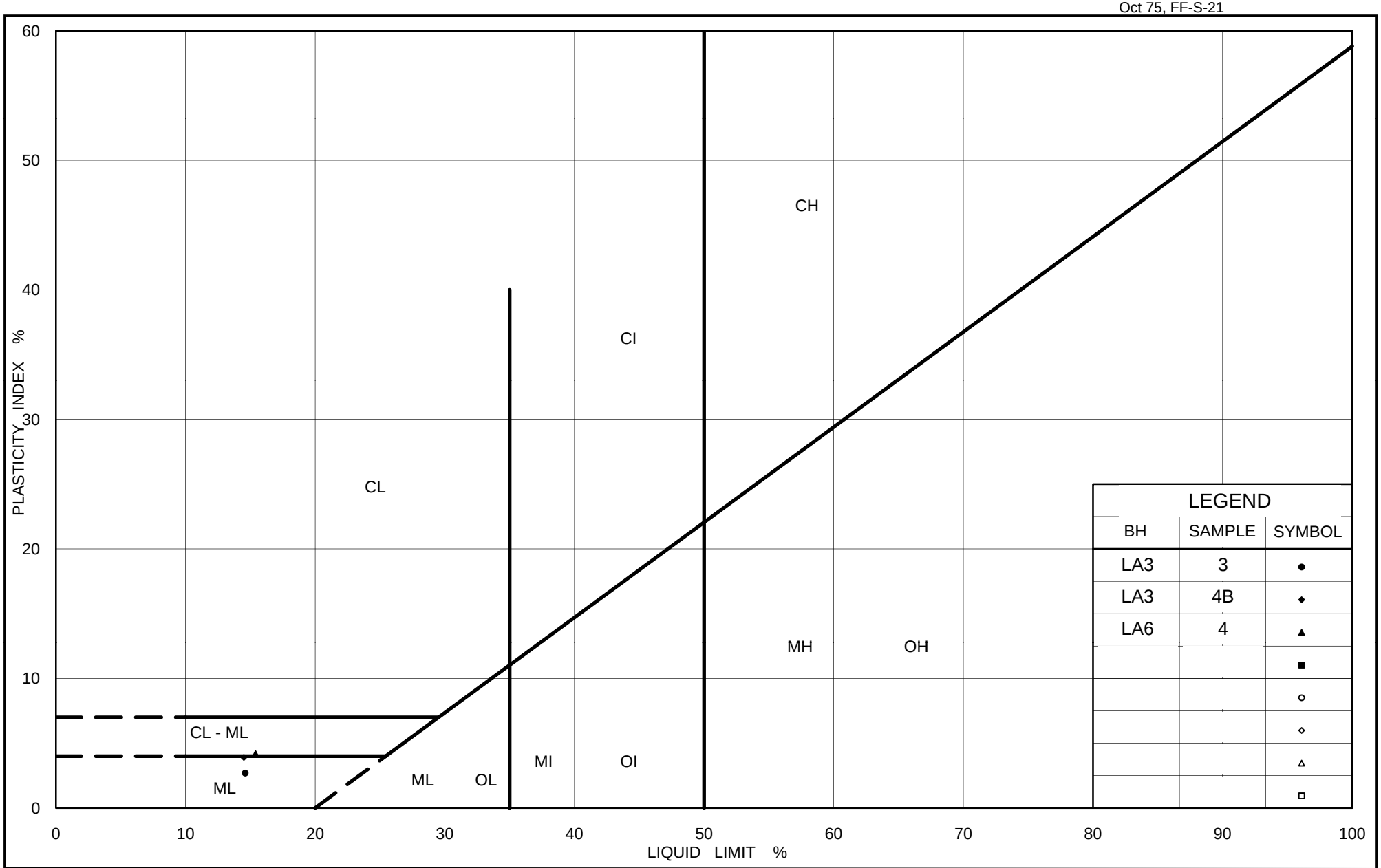
Date: 07-Mar-11



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PLASTICITY CHART
Sand and Silt Till

Figure No. 7

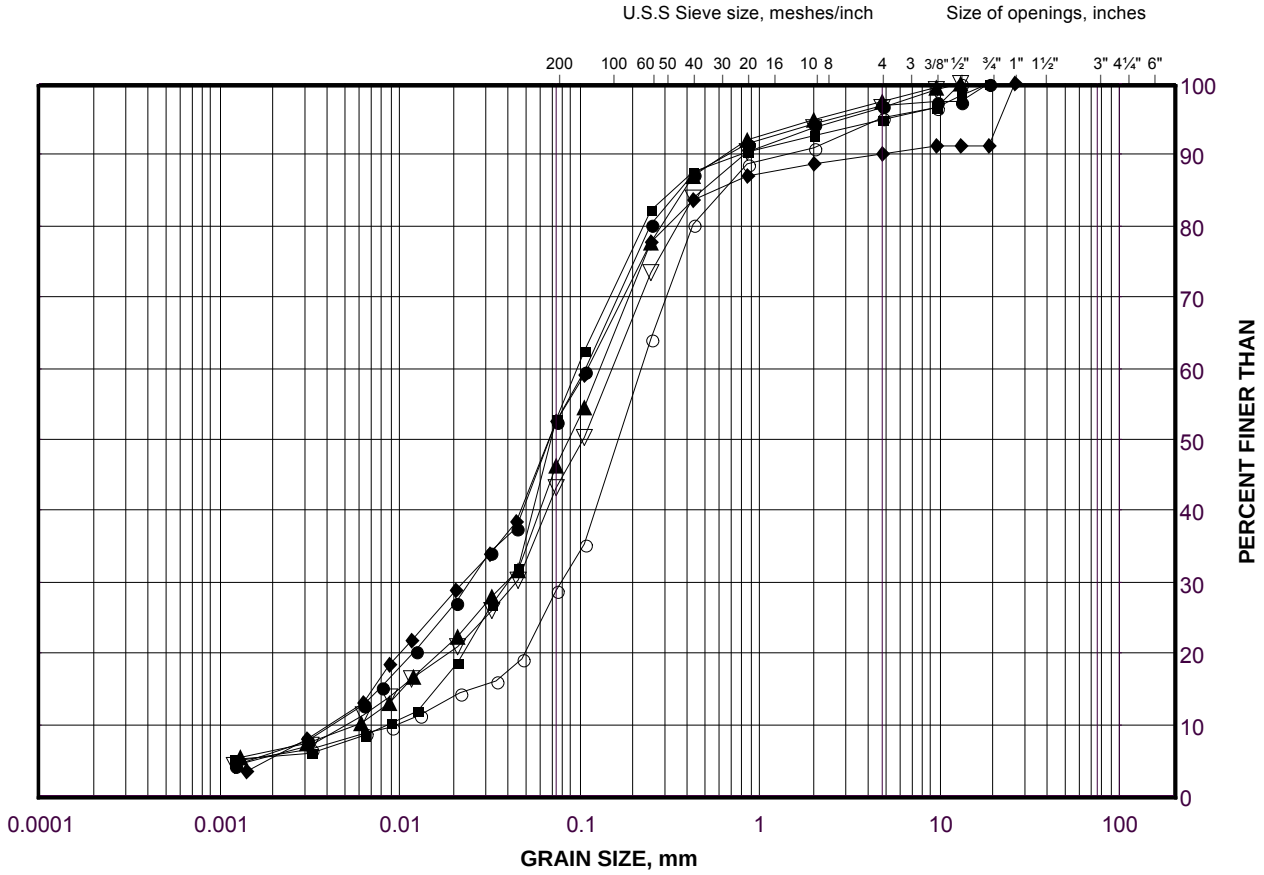
Project No. 09-1111-0018-1

Checked By:

GRAIN SIZE DISTRIBUTION

Sand and Silt Till to Silty Sand Till

FIGURE 8A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA2	10	299.8
■	LA2	12	296.8
◆	LA3	3	302.4
▲	LA3	6	300.1
▽	LA1	6	300.3
❍	LA1	8A	298.2

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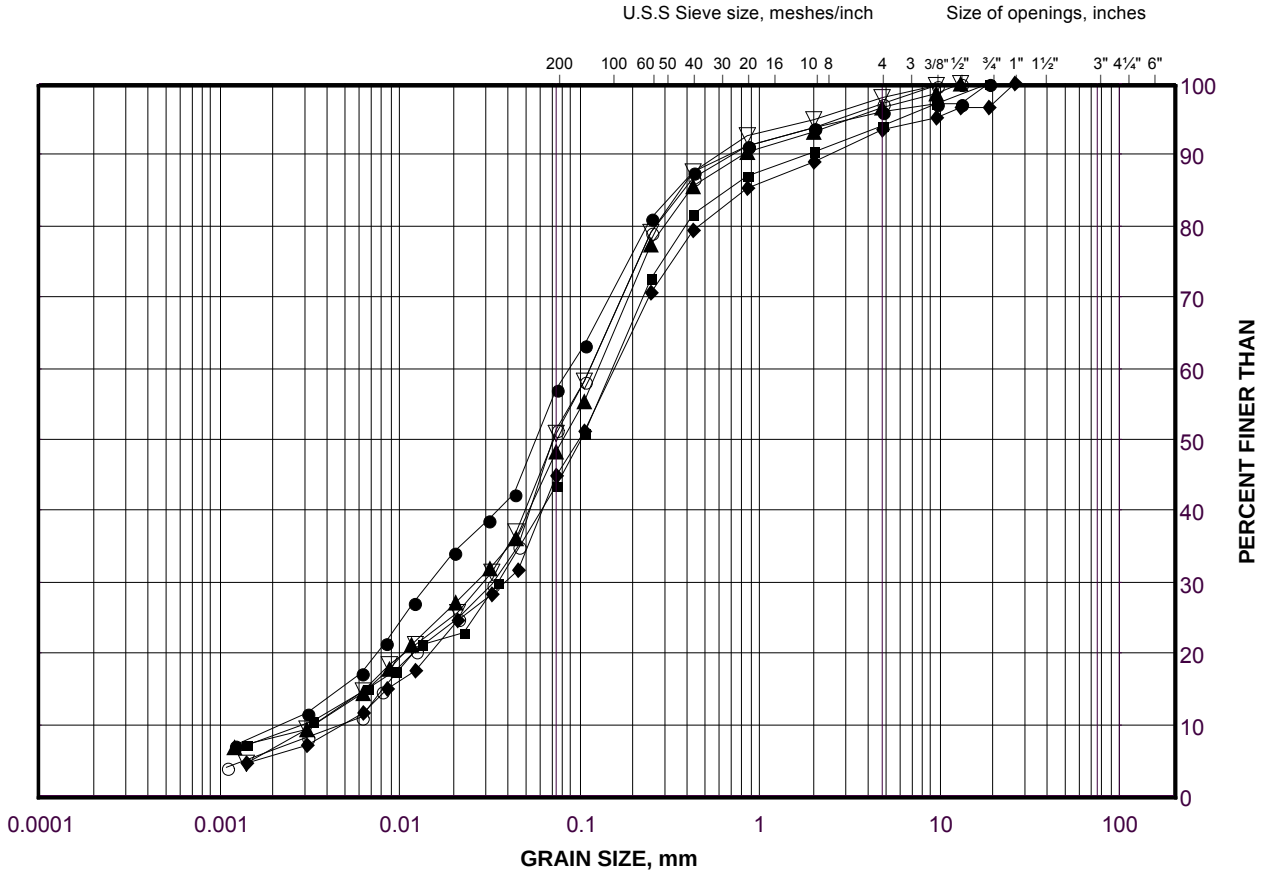
Date: 07-Mar-11

GRAIN SIZE DISTRIBUTION

Sand and Silt Till to Silty Sand Till

FIGURE 8B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA6	4	301.7
■	88	5	300.9
◆	LA4	5	300.7
▲	LA6	6	300.2
▽	LA4	7	298.4
❍	LA5	9	301.6

Project Number: 09-1111-0018-1

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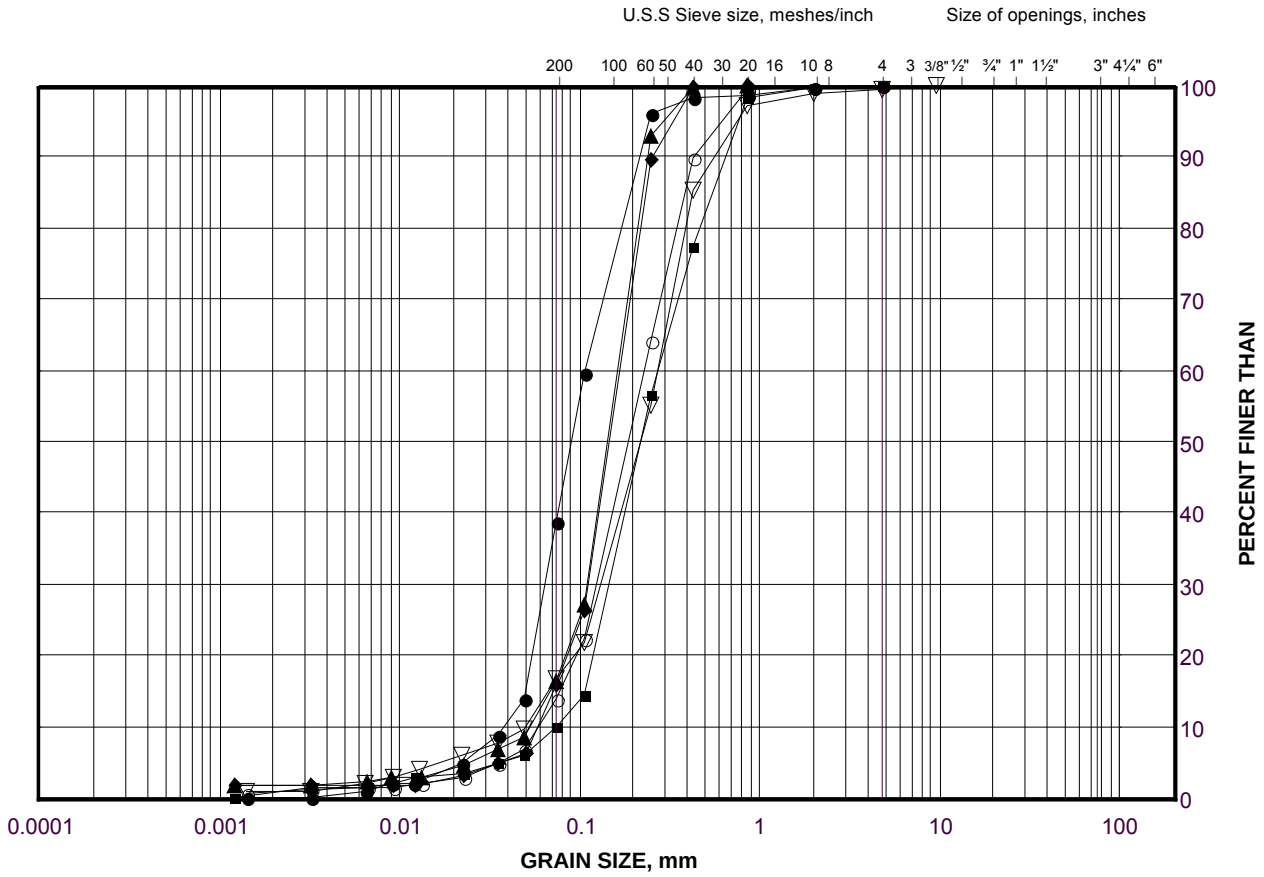
Date: 29-Nov-10

GRAIN SIZE DISTRIBUTION

Sand to Sand and Silt (Lower Deposit)

FIGURE 9



LEGEND

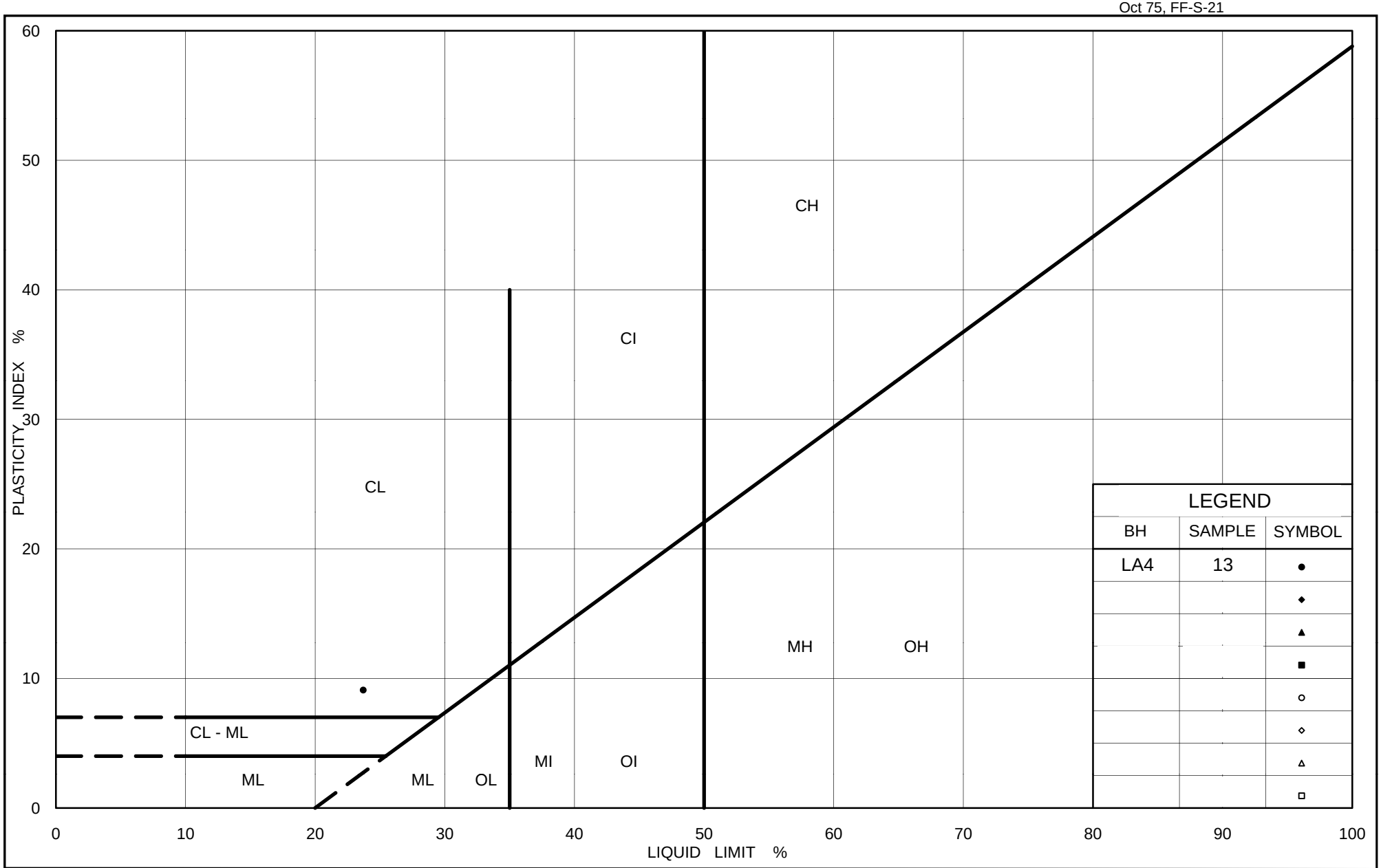
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA4	11	292.3
■	LA5	13	295.5
◆	LA2	14	293.7
▲	LA2	15	292.2
▽	LA3	8	297.1
❍	LA4	9	295.4

Project Number: 09-1111-0018-1

Checked By: _____

Golder Associates

Date: 07-Mar-11



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Ontario

PLASTICITY CHART
Clayey Silt (Lower Deposit)

Figure No. 10

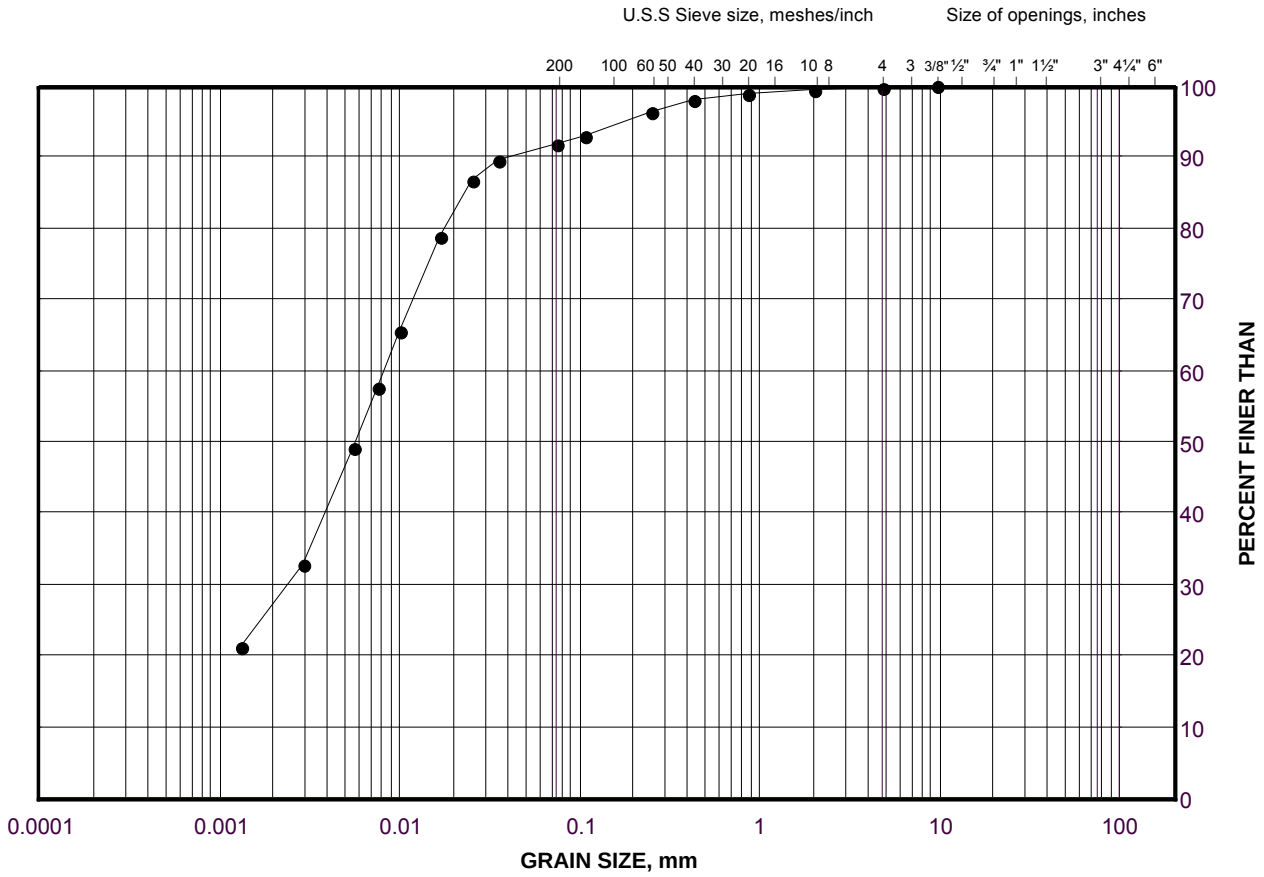
Project No. 09-1111-0018-1

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt (Lower Deposit)

FIGURE 11



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	LA4	13	289.3

Project Number: 09-1111-0018-1

Checked By: _____

Golder Associates

Date: 07-Mar-11

APPENDIX B

Record of Boreholes 87 and 88 and Figures 1 and 2, Golder Associates Ltd. Report No. 001-1122F, dated May 2001

RECORD OF BOREHOLE No 87

1 OF 1 **METRIC**

PROJECT 001-1122F
W.P. 222-97-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4873552; E 297915
BOREHOLE TYPE 108mm I.D. Hollow Stem Augers
DATE October 19, 2000

ORIGINATED BY AZ
COMPILED BY LCC
CHECKED BY ASP

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
305.0	GROUND SURFACE										
0.0	Topsoil										
0.2 / 304.4	Sand and Gravel (Fill)										
0.6	Silty Clay, some sand, trace to some gravel, trace black organics Firm to very stiff Brown Moist		1	SS	19		304				
			2	SS	4		303				
			3	SS	8						
301.1			4	SS	5		302				
3.9	Clayey Silt with sand, trace gravel (Till) Moist becoming wet at 7.3m depth Hard Brown		5	SS	42		301				
			6	SS	136		300				
	Pockets of sand to silty sand from 6.1m depth.		7	SS	103	▽	299				
			8	SS	139		298				
296.3							297				
8.7	Sand Very dense Brown Wet		9	SS	171/.25		296				
295.5											
9.6	END OF BOREHOLE Note: Water level in open borehole at 7.3m depth (Elev.298.7m) on completion of drilling operations. Water level in piezometer at 6.8m depth (Elev.298.2m) after installation on October 19, 2000. Water level in piezometer at 6.3m depth (Elev. 298.7m) on December 20, 2000. Piezometer destroyed - unable to obtain water level on January 19, 2001.										

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

RECORD OF BOREHOLE No 88

1 OF 1 **METRIC**

PROJECT 001-1122F
W.P. 222-97-00
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4873483; E 297887
BOREHOLE TYPE 108mm I.D. Hollow Stem Augers
DATE October 19, 2000

ORIGINATED BY AZ
COMPILED BY LCC
CHECKED BY ASP

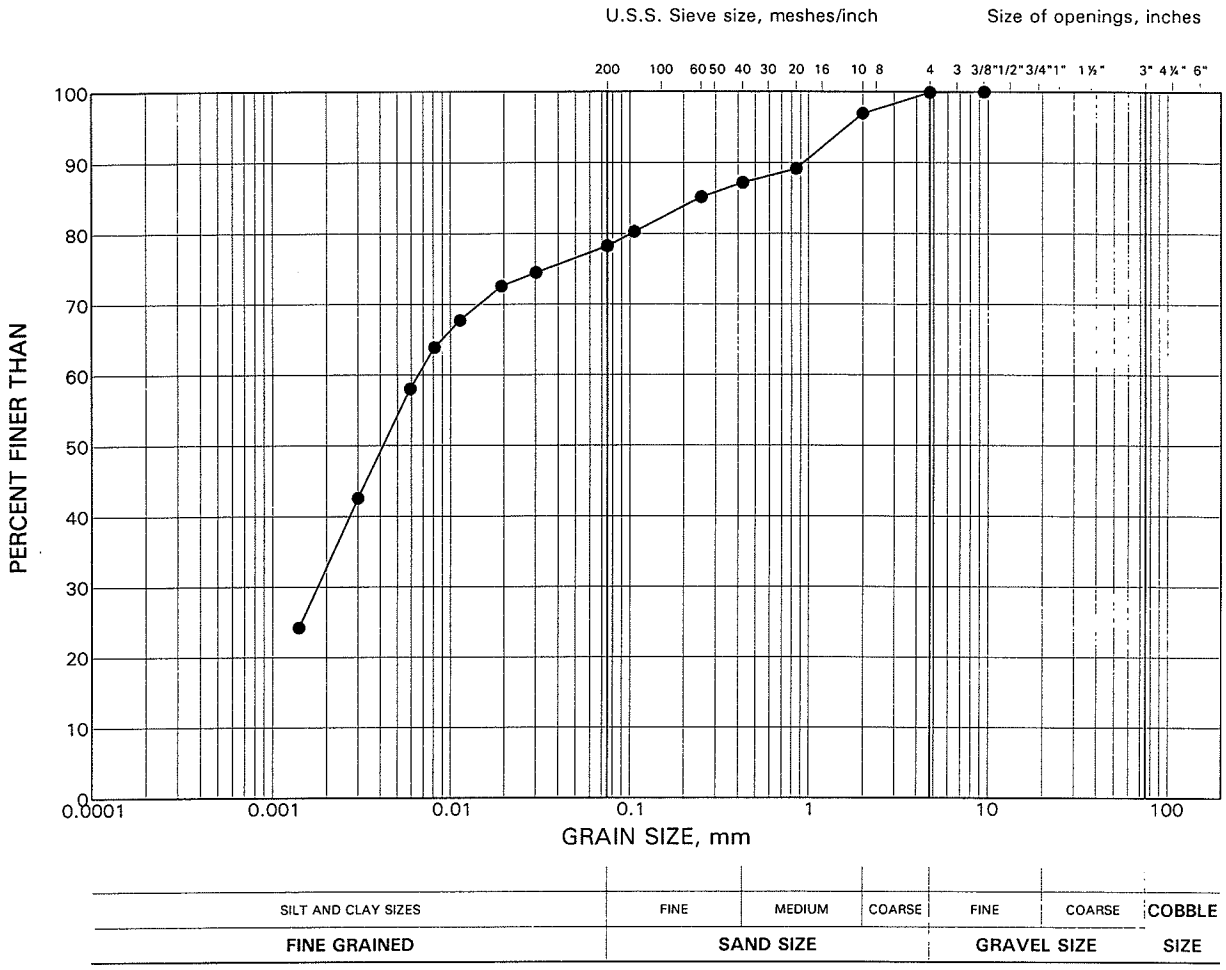
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT W_P / 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
305.0	GROUND SURFACE										
0.0	Topsoil										
0.2	Silty Sand, some gravel, trace clay, trace organics Compact to dense Brown becoming grey at 1.1m depth Moist		1	SS	40		304				
			2	SS	17		303				
302.7											
2.3	Silty Clay, trace sand, trace gravel (Till) Stiff to very stiff Mottled brown to brown Moist		3	SS	14						0 22 45 33
			4	SS	29		302				
301.2											
3.8	Sand and Silt, trace to some gravel, trace to some clay (Till) Very dense Brown Moist		5	SS	107		301				6 51 35 8
			6	SS	160		300				
298.7							299				
6.3	Sand, trace silt, trace gravel Very dense Brown Wet		7	SS	120		298				
			8	SS	150		297				
							296				
295.4			9	SS	149						
9.6	END OF BOREHOLE Note: Drilling mud was used below 7.5m depth to minimize "blowback" of sands into hollow stem augers. Water level on completion of drilling at 5.4m depth (Elev.299.6m). Water level in piezometer at 5.2m depth (Elev.299.8m) after installation on October 20, 2000. Piezometer dry on December 20, 2000 and January 19, 2001.										

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

ON_MOT 001-1122.GPJ ON_MOT.GDT 20/3/01

GRAIN SIZE DISTRIBUTION
Silty Clay Till

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	88	3	2.9

Project 001-1122F

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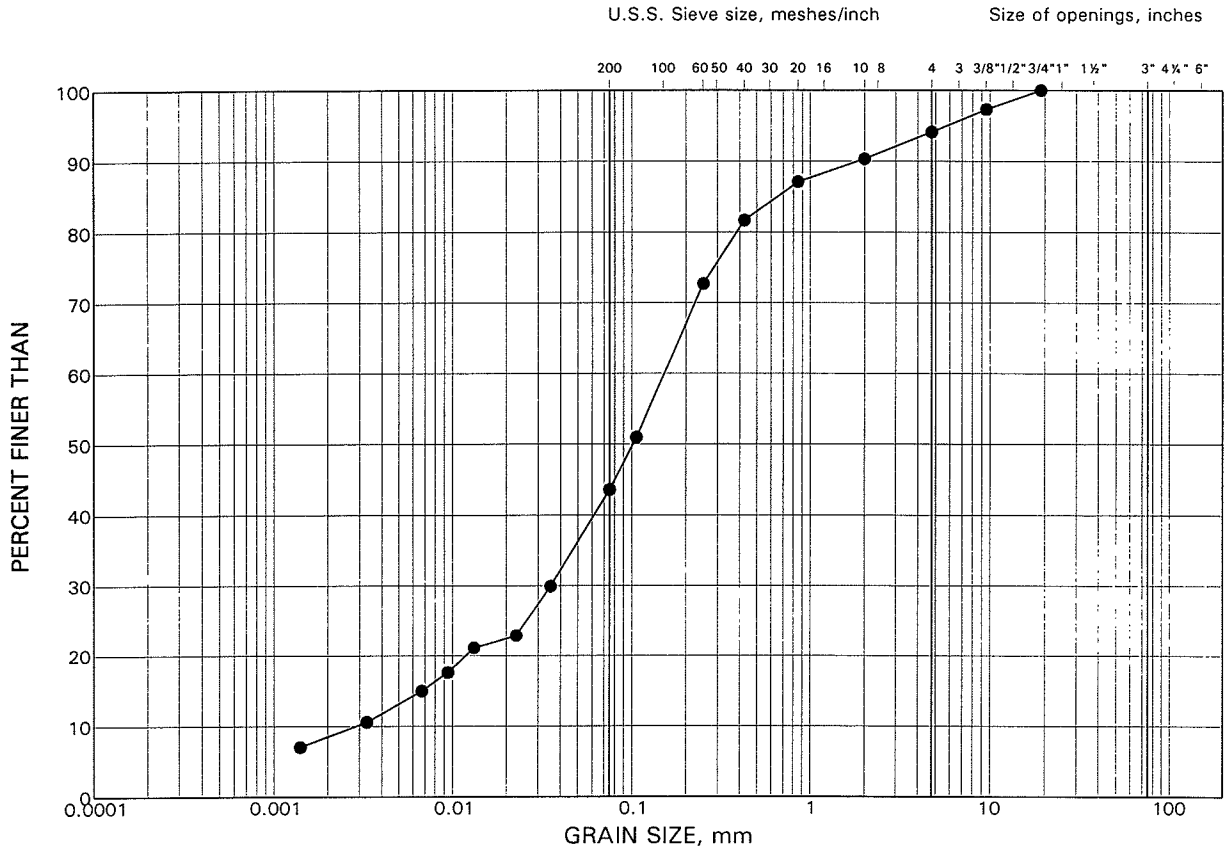
GRAIN SIZE DISTRIBUTION
Sand and Silt Till

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	88	5	4.4

Project 001-1122F

Golder Associates

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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