REPORT

August 25, 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

Culverts at Lloydtown-Aurora Road Interchange Highway 400 Widening from North of King Road to South Canal Road Ministry of Transportation, Ontario G.W.P. 2835-02-00

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GEOCRES No. 31D-612

Report Number: 09-1111-0018-9

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Golder Associates

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TO NORTH OF SOUTH CANAL ROAD
MINISTRY OF TRANSPORTATION, ONTARIO
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for new proposed culverts and the culvert replacements and extensions as part of the proposed widening of Highway 400 from north of King Road to South Canal Road in the Regional Municipality of York, Ontario.

This report addresses two new culverts and the replacement or extension of three existing culverts. The locations of the culverts were determined using MTO stationing for King Township from the survey plans provided by URS and are presented on Drawing 1. The proposed locations, dimensions, type, and invert elevation for the existing culverts that are to be replaced or extended and the new proposed culverts, as well as the approximate embankment height, are summarized as follows:

Culvert ID	Station	Existing Culvert Dimensions/ Type	Proposed New or Replacement Structure/ Extension Details	Proposed Culvert or Extension Length (m)	Approximate Embankment Height (m)	Invert Elevation (m)	
						Inlet	Outlet
C38 Replacement	20+310 (Hwy 400)	1220 x 1220 mm x 59.9 m* Open Bottom With 1200 mm Corrugated Steel Pipe (CSP) Extension (East and West)	1220 x 1220 mm Concrete Box**	E 15.2 W 15.5	3	307.1	307.0
C39 Replacement	20+670 (Hwy 400)	1220 x 1000 mm x 59.7 m* Open Bottom With 1200 mm CSP Extension (East and West)	1220 x 1000 mm Concrete Box**	E 20.0 W 18.2	3	305.0	305.0
C40 Extension	22+023 (Hwy 400)	1220 x 650 mm x 49.7 m* Open Bottom	1220 X 650 mm Concrete Box**	E13.1 W 12.2	2	290.6	290.5
C5-6 New	21+307 (Hwy 400)	N/A	1800 x 900 mm Concrete Box	71.0	2	302.4	302.0
C5-7 New	9+933 (E-S Ramp, Hwy 400)	N/A	1800 x 900 mm Concrete Box	30.0	2.5	302.6	302.0

*Culvert size at opening. Culvert type may vary along the length and details are unknown.

** Cast-in-place replacement box culvert. Dimensions vary for pre-cast box culvert.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated May 2008. The scope of services to be provided by Golder is outlined in Golder's proposal 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.

2.0 SITE DESCRIPTION

The culvert sites addressed in this report are located in the vicinity of the Lloydtown-Aurora interchange in the Regional Municipality of York, Ontario. 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. Culverts C5-6 and C5-7 are located under the Highway 400 northbound lanes (NBL) and southbound lanes (SBL) and the E-S Ramp, respectively, at the Lloydtown-Aurora Road underpass. Culverts C38 to C40 are located under Highway 400 NBL and SBL to the south and to the north of the Lloydtown-Aurora Road underpass to about 300 m south of 18th Sideroad. It is understood that the culvert replacements and extensions will be completed using conventional open cut methods. It is further understood that the proposed new culverts (C5-6 and C5-7) may be installed using conventional open cut methods, with the alternative that C5-6 may be installed using trenchless methods depending on construction staging.

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 600 m south of the Lloydtown - Aurora Road is at approximately Elevation 307 m, sloping down to the Lloydtown - Aurora Road interchange area between approximately Elevations 303 m and 304.5 m. The topography continues sloping downward to approximately Elevation 291 m about 500 m north of the interchange. The existing Highway 400 grade is at about Elevation 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 ranging from about Elevations 310.8 m to 311.0 m.

3.0 INVESTIGATION PROCEDURES

The field work for the subsurface investigation for Culverts C38 to C40 was carried out between the periods of November 24 to November 26 and December 8 and 9, 2010, March 24 and July 26, 2011 during which time a total of 12 boreholes (designated as C38-1 to C38-4, C39-1 to C39-4, and C40-1 to C40-4) were advanced approximately at the locations shown on Drawings 2 to 4. The field investigation for Culverts C38 to C40 was carried out using a D-50 track-mounted drill rig and a D-90 truck-mounted drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. Additionally, a CME-55 track-mounted drill rig supplied and operated by DBW Drilling of North York, Ontario was used to drill Borehole C40-4.

The field work for the subsurface investigation for Culverts C5-6 and C5-7 was carried out between November 27, 2013 and December 5, 2013 during which time a total of seven (7) boreholes (designated as C5-6-1 to C5-6-5, C5-7-1 and C5-7-2) were advanced approximately at the locations shown on Drawings 5 and 6. The field investigation for Culverts C5-6 and C5-7 was carried out using a track-mounted D-55 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario.

The boreholes from both investigations were advanced to depths ranging from about 4.3 m to 17.4 m below the existing ground surface. The boreholes were advanced using either 108 mm inside diameter or 200 mm outer diameter hollow stem augers, or 101 mm, 108 mm or 127 mm diameter solid stem augers. Soil samples were 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 D1586-08a).

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. Standpipe piezometers were installed in each of Boreholes C38-4, C39-4, and C5-7-2 to permit monitoring of the groundwater level. The piezometers consist of a 50 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. In two boreholes the borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets/grout, whereas at one borehole a bentonite seal was placed above the sand pack and the remainder of the borehole was backfilled with sand to the ground surface. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. All boreholes in which standpipe piezometers were not installed were backfilled 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, observed 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. Index and classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. The results of the laboratory testing are included in Appendix B.

The borehole locations and ground surface elevations were surveyed by Callon Dietz Incorporated, Ontario Land Surveyors, a professional surveying company retained by URS. The borehole locations, including MTM NAD 83 northing and easting coordinates and the ground surface elevations referenced to Geodetic datum, are presented below and on the Record of Borehole sheets in Appendix A and are summarized on Drawing 2 to 6.

Culvert ID	Station	Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
C38	20+310 (Hwy 400)	C38-1	4,872,648.6	298,065.2	307.2	8.2
		C38-2	4,872,639.6	298,082.1	309.6	15.9
		C38-3	4,872,656.0	298,113.2	309.8	15.9
		C38-4	4,872,658.9	298,129.5	307.2	4.3
C39	20+670 (Hwy 400)	C39-1	4,872,996.5	297,994.7	305.1	11.0
		C39-2	4,872,992.7	298,005.9	307.7	17.4

Culvert ID	Station	Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
		C39-3	4,873,010.0	298,040.5	307.9	15.7
		C39-4	4,873,012.8	298,056.0	305.1	11.3
C40	20+023 (Hwy 400)	C40-1	4,874,313.6	297,678.5	291.6	4.7
		C40-2	4,874,318.3	297,691.6	292.2	6.3
		C40-3	4,874,361.6	297,716.8	291.7	7.9
		C40-4	4,874,316.9	297,744.2	290.7	9.6
C5-6	21+307 (Hwy 400)	C5-6-1	4,873,633.0	297,916.5	304.0	10.9
		C5-6-2	4,873,628.1	297,891.8	304.4	12.6
		C5-6-3	4,873,624.5	297,880.6	304.4	12.6
		C5-6-4	4,873,621.9	297,865.3	304.5	11.1
		C5-6-5	4,873,618.7	297,846.5	303.0	11.1
C5-7	9+933 (E-S Ramp, Hwy 400)	C5-7-1	4,873,602.1	297,828.2	303.1	12.6
		C5-7-2	4,873,586.6	297,829.2	304.0	12.5

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The 23 km section of Highway 400 included in this project traverses, in a south–north direction, the physiographic regions known as South Slope, Oak Ridges Moraine and Simcoe Lowlands, 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

[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.

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.

4.2 Subsurface Conditions

As part of the subsurface investigation, a total of 19 boreholes were advanced near the proposed culvert replacements, extensions and new culvert locations. The borehole locations, ground surface elevations and interpreted stratigraphic conditions at each culvert site 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 Record of Borehole sheets in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B10 contained in Appendix B.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic sections on Drawings 2 to 6 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 and the stratigraphy shown on the culvert centreline profile on Drawings 2 to 6 are interpretations of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected, however, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. For the purposes of this report the, the Highway 400 alignment is a north-south orientation. Therefore, the directions indicated in the text may differ from those shown on the drawings.

In general, the stratigraphy consists of surficial layers of topsoil over native ground or asphalt overlying fill in the Highway platform/embankment areas. The fill is generally underlain by a clayey silt deposit that is further underlain by a till deposit that varies in composition from clayey silt to silt and sand. The till deposit is generally underlain by a cohesionless deposit that varies in composition from silt to sand. Interlayers and pockets of cohesive and cohesionless deposits were encountered throughout the till and silt to sand deposit.

Detailed descriptions of the subsurface conditions are provided on the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit.

4.2.1 Asphalt

Approximately 200 mm to 355 mm of asphalt was encountered immediately below the existing ground surface in Boreholes C39-3 and C5-6-2 to C5-6-4, which were drilled on Highway 400.

4.2.2 Topsoil

An approximately 100 mm to 200 mm thick layer of topsoil was encountered immediately below the existing ground surface in the following boreholes, which were advanced near the toe of the Highway 400 embankment, or within the Highway 400 median area:

Culvert Location	Borehole No.	Topsoil Thickness (mm)
C38 Station 20+310	C38-4	100
C39 Station 20 +670	C39-1	<100
	C39-4	100
C40 Station 22+023	C40-1	200
	C40-4	100
C5-6 Station 21+307	C5-6-1	200
	C5-6-5	200
C5-7 Station 9+933	C5-7-1	200
	C5-7-2	200

4.2.3 Fill

Fill was encountered in 12 of the boreholes immediately below the ground surface, topsoil or asphalt. The fill was generally encountered in boreholes drilled on Highway 400 or through the embankment. The elevation of the base of the fill and the thickness of the fill as encountered in the boreholes is summarized below.

Culvert Location	Borehole No.	Thickness of Fill (m)	Elevation of Base of Fill (m)
C38 Station 20+310	C38-2	3.0	306.6
	C38-3	3.7	306.1
C39 Station 20 +670	C39-1	1.1	304.0
	C39-2	3.0	304.7
	C39-3	3.5	304.2
C40 Station 22+023	C40-2	2.0	290.2
	C40-3	3.0	288.7
C5-6 Station 21+307	C5-6-1	1.2	302.6
	C5-6-2	1.8	302.2
	C5-6-3	2.8	301.4
	C5-6-4	1.9	302.4
	C5-6-5	1.1	301.7

The fill encountered in the boreholes through the Highway 400 embankment generally consists of non-cohesive granular material underlain by cohesive earth materials. For boreholes drilled beyond / adjacent to the Highway 400 embankment, the fill generally consists of cohesive materials. The non-cohesive fill varies in composition from sand and gravel, to sandy silt containing some clay, trace gravel and organics, to sand and silt containing some clay, trace to some gravel, sand lenses and organics, to silty sand containing trace gravel, to sand containing trace to some silt and trace clay. In Borehole C40-2, a layer of organic silty sand fill was encountered at the ground surface with a thickness of about 0.3 m. The cohesive fill consists of clayey silt trace sand to clayey silt with sand, trace to some gravel, sand pockets, organics, and rootlets.

Grain size distribution tests were carried out on two (2) samples of the non-cohesive fill and the results are shown on Figure B1 in Appendix B. Grain size distribution tests were carried out on three (3) samples of the cohesive fill deposit and the results are shown on Figure B2 in Appendix B.

Atterberg limits testing was conducted on two (2) samples of the non-cohesive fill and measured plastic limits of about 10 per cent and 17 per cent, liquid limits of about 13 per cent and 20 per cent and corresponding plasticity indices of about 3 per cent and 4 per cent. The test results, which are plotted on a plasticity chart on Figure B3 in Appendix B, indicate that the fines of the non-cohesive fill exhibit slight plasticity. Atterberg limits testing was conducted on four (4) samples of the cohesive fill and measured plastic limits ranging from about 12 per cent to 17 per cent, liquid limits ranging from about 16 per cent to 29 per cent, and plasticity indices ranging from about 4 per cent to 12 per cent. The test results, which are plotted on a plasticity chart on Figure B4 in Appendix B, indicate that the cohesive fill consists of clayey silt of low plasticity.

The natural water content measured on twelve (12) selected samples of the cohesionless fill ranges from about 6 per cent to 18 per cent. The natural water measured on seven (7) samples of the cohesive fill ranges from about 12 per cent to 26 per cent.

The measured Standard Penetration Test (SPT) “N”-values within the non-cohesive portions of the fill range from 3 blows to 24 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The SPT “N”-values recorded within the cohesive portions of the fill range from 3 blows to 13 blows per 0.3 m of penetration, suggesting that the cohesive fill has a soft to stiff consistency.

4.2.4 Clayey Silt to Clayey Silt with Sand

A deposit of clayey silt to clayey silt with sand was encountered in 12 of the boreholes. The clayey silt to clayey silt with sand deposit was encountered immediately below the existing ground surface, underlying surficial topsoil, or below the fill. The thickness of the clayey silt to clayey silt with sand deposit varies from about 0.5 m to 2.7 m. The elevations of the surface and base of the deposit and the thickness as encountered in the boreholes are summarized below.

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
C38 Station 20+310	C38-1	0.0	307.2	1.5	305.7
	C38-2	3.0	306.6	2.6	304.0
C39 Station 20+670	C39-2	3.0	304.7	1.5	303.2
	C39-4	0.1	305.0	0.6	304.4
C40 Station 22+023	C40-1	0.2	291.4	0.5	290.9
	C40-4	0.1	290.6	0.6	290.0
C5-6 Station 21+307	C5-6-1	1.4	302.6	0.8	301.8
	C5-6-2	2.2	302.2	1.5	300.7
	C5-6-3	3.0	301.4	0.7	300.7

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
	C5-6-4	2.1	302.4	1.6	300.8
	C5-6-5	1.3	301.7	0.9	300.8
C5-7 Station 9+933	C5-7-2	0.2	303.8	1.0	302.8

The clayey silt deposit contains trace to with sand and trace gravel. Sand pockets, organics, rootlets, and zones of oxidation staining were observed within the deposit at some locations as noted on the Record of Borehole sheets in Appendix A. The results of grain size distribution tests completed on five (5) samples of the clayey silt to clayey silt with sand deposit are shown on Figure B5 in Appendix B.

Atterberg limits testing was conducted on seven (7) samples of the clayey silt to clayey silt with sand deposit and measured plastic limits ranging from about 12 per cent to 19 per cent, liquid limits ranging from about 20 per cent to 27 per cent, and plasticity indices ranging from about 8 per cent to 13 per cent. The test results, which are plotted on a plasticity chart on Figure B6 in Appendix B, confirm that the deposit consists of clayey silt of low plasticity.

The natural water content measured on 14 selected samples of the clayey silt to clayey silt with sand ranged from about 9 per cent to 27 per cent.

The measured SPT “N”-values within the clayey silt to clayey silt with sand range from 2 blows to 13 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency.

4.2.5 Sandy Silt to Sand Interlayer

A sandy silt to sand interlayer was encountered underlying the clayey silt deposit in Boreholes C40-1 and C5-6-4 and below the topsoil in Borehole C5-7-1. The elevations of the surface and base of the deposit and the thickness as encountered in the boreholes are summarized below.

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
C40 Station 22+023	C40-1	0.7	290.9	0.9	290.0
C5-6 Station 21+307	C5-6-4	3.7	300.8	1.9	298.9
C5-7 Station 9+933	C5-7-1	0.2	302.9	0.5	302.4

The deposit consists of sand and silt containing trace clay and trace gravel, to sand containing some silt and trace clay, to sandy silt containing trace gravel and rootlets. The result of the grain size distribution test completed on one sample of the sand portion of the deposit is presented on Figure B7 in Appendix B.

The natural water content measured on three samples of the deposit ranges from about 11 per cent to 22 per cent.

The measured SPT "N"-values within this deposit generally ranges from 4 blows to 57 blows per 0.3 m of penetration and typically range between 23 and 57 blows per 0.3 m of penetration, indicating that the deposit is generally very loose to very dense, but typically compact to dense in relative density.

4.2.6 Clayey Silt to Sand and Silt Till

A till deposit was encountered underlying the topsoil in Borehole C38-4; underlying the fill in Borehole C38-3, C39-1, C39-3, C40-2, and C40-3; underlying the clayey silt to clayey silt with sand in Boreholes C38-1, C39-2, C39-4, C40-4, C5-6-1 to C5-6-3, C5-6-5, and C5-7-2; and underlying the sandy silt to sand interlayer in Boreholes C39-3, C40-1, and C5-6-4. In Borehole C39-3, a lower till deposit composed of clayey silt with sand was encountered underlying the lower sand deposit. The elevations of the surface and base of the till deposit and the deposit thickness as encountered in the boreholes are summarized below.

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)	Soil Type
C38 Station 20+310	C38-1	1.5	305.7	4.1	301.6	Sand and Silt Till
	C38-3	3.7	306.1	1.9	304.2	Clayey Silt with Sand Till
	C38-4	0.1	307.1	>4.2	Below 302.9	Sand and Silt Till
C39 Station 20+670	C39-1	1.1	304.0	6.1	297.9	Sand and Silt Till
	C39-2	4.5	303.2	7.7	295.5	Sand and Silt Till
	C39-3	3.7	304.2	5.0	299.2	Sand and Silt Till
		14.8	293.1	>0.9	Below 292.2	Clayey Silt with Sand Till
	C39-4	0.7	304.4	0.8	303.7	Clayey Silt Till
		1.5	303.7	4.2	299.5	Sand and Silt Till
C40 Station 20+023	C40-1	1.6	290.0	>3.1	Below 286.9	Clayey Silt with Sand Till
	C40-2	2.0	290.2	>4.3	Below 285.9	Sand and Silt Till
	C40-3	3.0	288.7	>4.9	Below 283.8	Sand and Silt Till
	C40-4	0.7	290.0	1.7	288.4	Sandy Silt Till
		2.3	288.4	3.3	285.1	Sand and Silt Till

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)	Soil Type
		5.6	285.1	>4.0	Below 281.1	Clayey Silt Till
C5-6 Station 21+307	C5-6-1	2.2	301.8	6.9	294.9	Sand and Silt to Silty Sand Till
	C5-6-2	3.7	300.7	4.1	296.6	Clayey Silt with Sand Till
	C5-6-3	3.7	300.7	3.4	297.3	Clayey Silt with Sand Till
	C5-6-4	5.6	298.9	3.0	295.9	Clayey Silt with Sand to Sand and Silt Till
	C5-6-5	2.2	300.8	3.4	297.4	Clayey Silt with Sand Till
C5-7 Station 9+933	C5-7-1	0.7	302.4	5.5	296.9	Clayey Silt with Sand Till
	C5-7-2	1.2	302.8	7.4	295.4	Sand and Silt Till

The till deposit varies in composition from sand and silt containing trace to some clay and trace to some gravel, to clayey silt containing trace to with sand and trace to some gravel. Sand pockets were observed within the deposit at some locations as noted on the Record of Borehole sheets in Appendix A. A 25 mm thick sand seam was encountered in Borehole C39-4 at a depth of about 4.5 m (Elevation 300.6 m). Sand seams and pockets were encountered in Borehole C39-1 to a depth of about 5.2 m (Elevation 299.9 m). The presence of cobbles is also inferred from difficulties advancing augers (auger grinding) in Boreholes C40-1, C40-2, C5-6-1 to C5-6-3, and C5-7-2 at depths ranging from about 2.3 m to 7.6 m below ground surface (about Elevations 299.4 m and 288.5 m) during the drilling operations. The results of grain size distribution tests completed on 31 samples of the deposit are shown on Figures B8A to B8E in Appendix B.

Atterberg limits testing was conducted on 19 selected samples of the till deposit. One test indicated that the material is non-plastic and the remainder of the tests measured plastic limits ranging from about 9 per cent to 13 per cent, liquid limits ranging from about 10 per cent to 18 percent, and plasticity indices ranging from about 1 per cent to 6 per cent. The test results, which are plotted on a plasticity chart on Figures B9A to B9C in Appendix B, confirm that the till deposit consists of clayey silt of low plasticity to sand and silt of slight plasticity and zone(s) of non-plastic fines.

The natural water content measured on 58 samples of the till deposit range from about 7 per cent to 19 per cent.

The SPT “N”-values recorded within the sand and silt till deposit range from 4 blows per 0.3 m of penetration to 100 blows per 0.18 m of penetration, indicating that the sand and silt till deposit has a loose to very dense relative density. The SPT “N”-values recorded within the clayey silt till portions of the deposit range from 4 blows per 0.3 m of penetration to 125 blows per 0.15 m of penetration suggesting a soft to hard consistency.

4.2.7 Silt to Sand

A silt to sand deposit was encountered below the clayey silt to clayey silt with sand deposit in Borehole C38-2 and below the till deposit in the remainder of the boreholes except Boreholes C38-4 and C40-1 to C40-4 at the location of Culverts C38 and C40, respectively. At some locations, this deposit is interlayered with clayey silt layers. The elevations of the surface and base of the silt to sand deposit and the deposit thickness as encountered in the boreholes are summarized below:

Culvert Location	Borehole No.	Depth to Surface of Deposit (m)	Deposit Surface Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)	Soil Type
C38 Station 20+310	C38-1	5.6	301.6	>2.6	Below 299.0	Silt
	C38-2	5.6	304.0	3.5	300.5	Sand and Silt
		9.1	300.5	>6.8	Below 293.8	Silt
	C38-3	5.6	304.2	6.1	298.1	Silty Sand
		11.7	298.1	1.6	296.5	Silt
		13.3	296.5	>2.6	Below 293.9	Sandy Silt
C39 Station 20+670	C39-1	7.2	297.9	2.2	295.7	Sand and Silt
		9.9	295.2	>1.1	Below 294.1	Sand and Silt
	C39-2	12.2	295.5	>5.2	Below 290.3	Silty Sand
	C39-3	8.7	299.2	6.1	293.1	Sand
	C39-4	5.6	299.5	0.7	298.8	Silty Sand
		6.3	298.8	0.9	297.9	Silt
		7.2	297.9	0.8	297.1	Silty Sand
		8.0	297.1	0.7	296.4	Sandy Silt
		8.7	296.4	>2.6	Below 293.8	Sand and Silt
C5-6 Station 22+023	C5-6-1	9.1	294.9	>1.8	Below 293.1	Sand
	C5-6-2	7.8	296.6	2.3	294.3	Sand and Silt
		10.1	294.3	>2.5	Below 291.8	Sand
	C5-6-3	7.1	297.3	3.0	294.3	Sand and Silt
		10.1	294.3	>2.5	Below 291.8	Sand
	C5-6-4	8.6	295.9	>2.5	Below 293.4	Sand
	C5-6-5	5.6	297.4	1.5	295.9	Silty Sand
		7.1	295.9	>4.0	Below 291.9	Sand
C5-7 Station 9+933	C5-7-1	6.2	296.9	>6.4	Below 290.5	Sand
	C5-7-2	8.6	295.4	>3.9	Below 291.5	Sand

This deposit varies in composition from sand containing trace clay, trace to some silt, to silty sand to sandy silt containing trace gravel and trace clay, to silt containing trace to some clay, trace to some sand, and trace gravel. Borehole C39-1 penetrated a clayey silt interlayer within the silt to sand deposit at a depth of about 9.4 m below ground surface (Elevation 295.7 m), for a thickness of about 0.5 m. The results of grain size distribution tests completed on 18 samples of the silt to sand deposit are shown on Figures B10A to B10C in Appendix B.

The natural water content measured on 37 samples of the silt to sand deposit range from about 8 per cent to 25 per cent.

The measured SPT "N"-values in this deposit generally range from 0 blows (weight of hammer) per 0.3 m of penetration to 50 blows per 0.13 m of penetration but typically SPT "N"-values one greater than 30 blows per 0.3 m of penetration, indicating that the deposit is generally loose to very dense, but typically dense to very dense in relative density.

4.2.8 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. A standpipe piezometer was installed in Boreholes C38-4, C39-4, and C5-7-2 to permit monitoring of the groundwater level at this site. Details of the piezometer installations and measured groundwater levels are shown on the Record of Borehole sheets in Appendix A. The groundwater levels recorded in the open boreholes and piezometers are summarized below:

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
C38-1	307.2	4.6	302.6	November 26, 2010	Open Borehole
C38-2	309.6	6.1	303.5	November 26, 2010	Open Borehole
C38-3	309.8	10.1	299.7	March 24, 2011	Open Borehole
C38-4	307.2	Dry 2.1 2.0 0.1	-- 305.1 305.0 307.1	November 24, 2010 December 16, 2010 February 1, 2011 April 7, 2011	Open Borehole Piezometer Piezometer Piezometer
C39-1	305.1	3.0	302.1	November 26, 2010	Open Borehole
C39-2	307.7	6.1	301.6	November 24, 2010	Inside Augers
C39-3	307.9	10.1	297.8	March 25, 2011	Open Borehole
C39-4	305.1	2.4 0.6	302.7 304.5	February 1, 2011 April 7, 2011	Piezometer Piezometer
C40-1	291.6	2.2	289.4	December 8, 2010	Open Borehole
C40-2	292.2	1.4	290.8	December 9, 2010	Open Borehole
C40-3	291.7	3.8	287.9	March 24, 2011	Open Borehole
C40-4	290.7	4.3	286.4	July 26, 2011	Open Borehole

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
C5-6-1	304.0	5.3	298.7	December 5, 2013	Open Borehole
C5-6-2	304.4	Dry	--	December 5, 2013	Open Borehole
C5-6-3	304.4	Dry	--	December 2, 2013	Open Borehole
C5-6-4	304.5	4.3	300.2	November 27, 2013	Open Borehole
C5-6-5	303.0	3.0	300.0	November 27, 2013	Open Borehole
C5-7-1	303.1	Dry	--	November 28, 2013	Open Borehole
C5-7-2	304.0	Dry 4.6	-- 299.4	December 1, 2013 January 7, 2013	Open Borehole Piezometer

Blowing sands were encountered in the hollow stem augers in Borehole C39-2 prior to sampling at a depth of 10.7 m below ground surface (Elevation 297.0 m).

The groundwater level observations at this site are short term and will be subject to seasonal fluctuations and precipitation events, therefore the water levels should be expected to be higher during the spring season or during any period of heavy precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Haley Schafer, EIT, and reviewed by Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact for Golder and a Principal of Golder, conducted an independent quality control review of this report.

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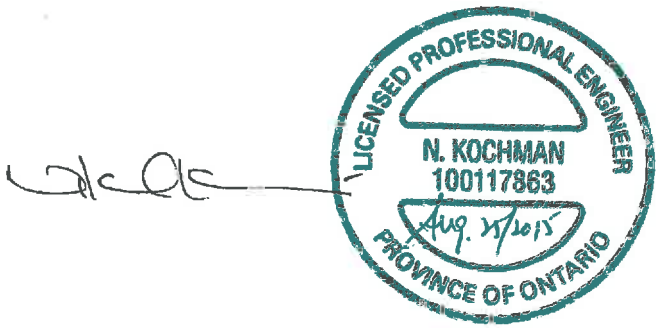

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PART B

FOUNDATION DESIGN REPORT
CULVERTS AT LLOYDTOWN-AURORA ROAD INTERCHANGE
HIGHWAY 400 WIDENING FROM NORTH OF KING ROAD
TO NORTH OF SOUTH CANAL ROAD
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 2835-02-00

August 25, 2015
Report No. 09-1111-0018-9

Golder Associates

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the proposed new culverts, culvert replacements and culvert extensions in the general area of the Highway 400 and the Lloydtown-Aurora Road interchange. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible culvert foundation alternatives as well as the feasible trenchless installation methods/open cut excavations and to carry out the design of the culvert foundations.

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 or operational constraints may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Foundations for Culvert

6.2.1 Foundation Options

It is understood that two new culverts, two culvert replacements and one culvert extension are proposed in the vicinity of the Highway 400/Lloydtown-Aurora Road interchange. Details regarding the proposed culverts are provided below.

Culvert ID	Station	Existing Culvert Dimensions/ Type	Proposed New or Replacement Structure/ Extension Details	Proposed Culvert/ Extension Length (m)	Approximate Embankment Height (m)	Invert Elevation (m)	
						Inlet	Outlet
C38 Replacement of CSP Extension	20+310 (Hwy 400)	1220 x 1220 mm x 59.9 m* Open Bottom With 1200 mm Corrugated Steel Pipe (CSP) Extension (East and West)	1220 x 1220 mm Concrete Box**	E 15.2 W 15.5	3	307.1	307.0
C39 Replacement of CSP Extension	20+670 (Hwy 400)	1220 x 1000 mm x 59.7 m* Open Bottom With 1200 mm CSP Extension (East and West)	1220 x 1000 mm Concrete Box**	E 20.0 W 18.2	3	305.0	305.0

Culvert ID	Station	Existing Culvert Dimensions/ Type	Proposed New or Replacement Structure/ Extension Details	Proposed Culvert/ Extension Length (m)	Approximate Embankment Height (m)	Invert Elevation (m)	
						Inlet	Outlet
C40 Extension	22+023 (Hwy 400)	1220 x 650 mm x 49.7 m* Open Bottom	1220 X 650 mm Concrete Box**	E13.1 W 12.2	2	290.6	290.5
C5-6 New	21+307 (Hwy 400)	N/A	1800 x 900 mm Concrete Box	71.0	2	302.4	302.0
C5-7 New	9+933 (E-S Ramp, Hwy 400)	N/A	1800 x 900 mm Concrete Box	30.0	2.5	302.6	302.0

*Culvert size at opening. Culvert type may vary along the length and details are unknown.

** Cast-in-place replacement box culvert. Dimensions vary for pre-cast box culvert.

Although it is recognized that the culvert extensions will likely be required to match the existing culverts, in accordance with the MTO Terms of Reference for this assignment this section of the report presents advantages, disadvantages and geotechnical recommendations for new box culverts as well as box culvert replacements and extensions and open footing culvert replacements and extensions.

Either box culverts or “open footing” (shallow foundation) concrete culverts are feasible for replacement or extension of the existing culverts or for new structures. Associated retaining walls, if required, should be supported on shallow foundations. Deep foundations are not required at any of the culvert sites, as shallow foundations will provide sufficient bearing resistance and acceptable settlement performance. Both pre-cast concrete elements (box culvert segments or footing elements) and cast-in-place concrete elements are also feasible from a foundations perspective.

The advantages and disadvantages associated with both the pre-cast box culvert and cast-in-place open footing new culvert and culvert replacement and extension options are summarized in Table 1 following the text of this report. From a foundations perspective, pre-cast box culverts are preferred for every site over cast-in-place open footing culvert replacements, although an open footing structure is a suitable alternative for Culvert C40, based on the following:

- Pre-cast box culvert extensions minimize the depth of excavation and groundwater control requirements as compared with open footings.
- Pre-cast box culvert segments can usually be installed more expeditiously than cast-in-place open footing culverts, resulting in shorter durations for dewatering and surface water pumping.
- Pre-cast box culvert segments are more tolerant of total and differential settlement if the highway or ramp embankment is widened at the culvert extension site to accommodate construction staging requirements.

It is noted, however, that a box culvert extension may not satisfy fisheries requirements related to channel substrate, in which case an open footing culvert is geotechnically feasible (though not preferred from a geotechnical perspective).

Recommendations for both new or replacement box culverts and extensions, and open footing new/replacement culverts and extensions are provided in the following sections.

6.2.2 Founding Elevations and Sub-excavation Requirements

6.2.2.1 Box Culvert – New, Replacements or Extensions

It is not necessary to found new box culverts or box culvert replacements and extensions at the standard depth for frost protection purposes, as the box structures are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. Box culverts should, however, be founded below any existing fill and surficial organic materials. Table 2, following the text of the report, provides recommended founding elevations and sub-excavation requirements for new or replacement box culverts or extensions, based on an assumed base slab thickness of 250 mm. In addition, it is recommended that the box culvert segments be placed on a minimum thickness of 150 mm (or more depending on the requirements for excavation backfill and bedding as noted in Table 2) of granular bedding material meeting Ontario Provincial Standard Specification (OPSS.PROV) 1010 Granular A (Aggregates).

For sites where sub-excavation is recommended below replacement or extension box culverts (as per Table 2), the width of the required sub-excavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert base slab, outward and downward at 1H:1V, as shown schematically on Figure 1 following the text of this report. Depending on the depth of sub-excavation required relative to the existing culvert base or footings, temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during sub-excavation. In wet conditions, the excavation backfill/bedding should be comprised of OPSS.PROV 1010 Granular B Type II material.

The box culvert subgrade should be inspected by a Quality Verification Engineer following sub-excavation to ensure that all existing fill, peat and surficial organic soils or other unsuitable material have been removed, in accordance with OPSS 422 (Box Culverts and Box Sewers in Open Cut) and OPSS 902 (Excavating and Backfilling Structures). Following inspection, the sub-excavated area should be backfilled with granular material meeting OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material) Granular A or Granular B Type II as noted above that is placed and compacted in accordance with OPSS 501 (Compaction).

Groundwater and/or surface water control will be required for excavation and construction of box culvert for many of the culvert sites. As discussed further in Section 6.5 (Construction Considerations), it is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to address groundwater control requirements for the culvert sites. An example NSSP is provided in Appendix C.

The subgrade for the box culvert replacements and extensions will be susceptible to loosening/softening and degradation on exposure to water and construction traffic. As discussed further in Section 6.5, as an alternative to the placement of granular bedding material on the native soil below the base slab, a 100 mm thick concrete working slab could be placed on the subgrade to protect it from degradation followed by the required backfill

bedding to the underside of the levelling course. In any case, a 75 mm thick layer of OPSS.PROV 1010 Granular A or concrete fine aggregate meeting the gradation requirements set out in OPSS.PROV 1002 (Aggregates - Concrete) should be placed on top of the leveling or concrete working slab as applicable to provide a "levelling pad" for the box culvert replacement or extension. An NSSP for the working slab is included in Appendix C.

6.2.2.2 Open Footing Culvert – New, Replacements and Extensions

Strip footings for open footing new or culvert replacements and extensions, and for any associated concrete wing walls/retaining walls, should be founded at a minimum depth of 1.5 m below the lowest surrounding grade to provide adequate protection against frost penetration, as per Ontario Provincial Standard Drawing (OPSD) 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario). In addition, the footings should extend below any existing fill and surficial organic materials, where present. Table 3, following the text of the report, provides recommended founding elevations and sub-excavation requirements for strip footings for the proposed culvert replacements and extensions.

For sites where open footing culverts are to be constructed on a granular backfill pad rather than on the native subgrade at greater depth in subexcavation areas, the width of the sub-excavation should be defined by lines extending from 0.3 m beyond the outside edges of the proposed culvert base slab, outward and downward at 1H:1V, as shown schematically on Figure 1 following the text of this report. Depending on the depth of sub-excavation required relative to the existing culvert base or footings, temporary excavation support may be required to prevent loss of bedding material and/or native soils from below the existing culvert during sub-excavation.

The footing subgrade should be inspected by a Quality Verification Engineer following excavation, in accordance with OPSS 902 (Excavating and Backfilling Structures) to check that all existing fill, peat and surficial organic soils or other unsuitable material have been removed. Where sub-excavation is required to remove unsuitable materials, the sub-excavated area should be backfilled with granular material meeting OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material) Granular A or Granular B Type II that is placed and compacted in accordance with OPSS.PROV 501 (Compacting).

Groundwater and/or surface water control will be required for excavation and construction of open footing culverts for the majority of the culvert sites. As discussed further in Section 6.5 (Construction Considerations), it is recommended that an NSSP be included in the Contract Documents to address groundwater control requirements for the culvert sites.

The footing subgrade will be susceptible to loosening and degradation on exposure to water and construction traffic. As discussed further in Section 6.5, it is recommended that a 100 mm thick concrete working slab be placed on the inspected and approved footing subgrade, to protect the subgrade from degradation and to form a working mat for construction of the culverts. An example NSSP for the working slab is included in Appendix C.

6.2.3 Geotechnical Resistance

Tables 2 and 3, following the text of this report, provide factored geotechnical resistances at Ultimate Limit State (ULS) and geotechnical resistances at Serviceability Limit State (SLS) for the box culvert option and open footing option at each culvert site, respectively.

6.2.3.1 Box Culverts – New, Replacements or Extensions

New or replacement box culverts or extensions placed on the properly prepared subgrade, at or below the founding elevations recommended in Table 2, should be designed based on the recommended factored geotechnical resistances at ULS and the geotechnical resistances at SLS (for 25 mm of settlement) as given in Table 2. These recommendations are based on the box culvert span as given in Table 2.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert span or founding elevation differs significantly from that given in Table 2.

The geotechnical resistances provided in Table 2 are based on loading applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the Canadian Highway Bridge Design Code (CHBDC, 2006).

6.2.3.2 Open Footing Culvert Replacements and Extensions

Strip footings placed on the properly prepared subgrade, at or below the founding elevations recommended in Table 3, should be designed based on the factored geotechnical resistances at ULS and the geotechnical resistances at SLS (for 25 mm of settlement) as given in Table 3. These recommendations are based on an assumed footing width of 0.6 m.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width or founding elevation differs significantly from those given in Table 3.

The geotechnical resistances provided in Table 3 are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the CHBDC (2006).

6.2.4 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the base slab or concrete footings for the culvert replacements or extensions and the subgrade should be calculated in accordance with Section 6.7.5 of the CHBDC. Table 4, following the text of this report, provides recommended coefficients of friction between pre-cast concrete box culvert sections and Granular A bedding, and between cast-in-place concrete footings and the native subgrade soils.

6.2.5 Settlement and Global Stability

Depending on construction staging requirements, the existing Highway 400 and ramp embankments could be widened by up to 16 m at the culvert locations, which would require placement of a vertical thickness of up to approximately 2.5 m to 3 m of additional fill atop the existing embankment side slopes. This embankment widening will induce some settlement in the foundation soils beneath the culvert in the widened areas.

The settlement analysis for culvert sites was carried out using both hand calculations and the commercially-available program Settle-3D from Rocscience, using estimated elastic deformation moduli as given below, based on correlations with the SPT 'N'-values, published literature (Bowles, 1982) and engineering judgement from experience with similar soils in this region of Ontario.

Soil Deposit	Bulk Unit Weight	Elastic Modulus
Embankment fill (existing and new)	21 kN/m^3	N/A
Stiff clayey silt	20 kN/m^3	15 MPa
Hard clayey silt with sand (till)	21 kN/m^3	75 MPa
Very dense sand	21 kN/m^3	100 MPa
Compact to very dense sand and silt to silty sand to silt (till)	21 kN/m^3	100 MPa

The settlement of the foundation soils under the approximately 2.5 to 3 m thickness of additional fill that may be placed on the embankment side slope to facilitate construction staging is estimated to be less than 25 mm under the actual widening area, decreasing to less than 10 mm under the shoulder of the existing embankment and at the toe of the widened embankment. Table 5, following the text of this report, provides predicted settlement values at each culvert site.

The embankments at the culvert locations are generally on the order of 2 m to 3 m high, with 2 horizontal to 1 vertical (2H:1V) side slopes. Based on visual observations during the field program, the existing side slopes appear to be in good condition. Based on the SPT "N"-values of the fill and native materials encountered at the culvert locations, the global stability of these relatively low embankments will exceed the target minimum factor of safety of 1.3 normally used in the design of slopes under static conditions.

6.3 Culvert Bedding, Backfill and Erosion Protection

For the new or replacement box culvert or extension, the levelling pad bedding and backfill requirements should be in accordance with OPSS 422 (Box Culverts and Box Sewers in Open Cut) for pre-cast rigid frame culverts. New box culverts, replacements and extensions should be provided with at least 150 mm of OPSS 1010 Granular A material for bedding purposes, or alternatively a 100 mm thick concrete working slab, and 75 mm thick levelling course.

Backfill and cover for the culverts should be completed in accordance with OPSD 803.010 (Backfill and Cover for Concrete Culverts). Backfill to culvert walls should consist of granular fill meeting the requirements of

OPSS.PROV 1010 Granular A or Granular B Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill and bedding should be placed and compacted in accordance with OPSS 501 (Compacting). The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 400 mm. The culvert replacements or extensions should be designed for the full overburden and hydrostatic pressures, and live load, assuming that the embankment fill has a unit weight of 22 kN/m^3 for Granular A, and 21 kN/m^3 for Granular B Type II or select earth fill above and/or surrounding the culvert.

Backfill placement for reconstruction of the widening embankments over and along the culverts should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the new fill into the existing embankment fill along the cut faces and existing embankment side slopes.

To prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a concrete or clay cut-off wall should be provided at the upstream end of box culvert, while a clay seal should be provided at the upstream end of open footing culvert. Clay seals should also be placed adjacent to the culvert inlet opening for both box culvert and open footing structure types. The clay material should meet the requirements of OPSS 1205 (Clay Seal). The clay seal should have a thickness of 1 m, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including treatment of the adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high water level, whichever is higher.

If the creek flow velocities are sufficiently high, provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) at the culvert inlet and outlet, including in front of any wing walls/retaining walls adjacent to the creek channel. The requirements for and design of erosion protection measures for the culvert inlet should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSD 810.010 (Rip-Rap Layout for Sewer and Culvert Outlets), with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket if adopted, including the creek side slopes and embankment fill slope adjacent to the culverts.

Excavation, bedding and backfilling operations should be inspected by a Quality Verification Engineer in accordance with OPSS 902 (Excavating and Backfilling Structures).

6.4 Lateral Earth Pressures for Design

The lateral earth pressures acting on the culvert walls and on any associated head and wing walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of the surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls. These design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free-draining granular fill meeting the specifications of OPSS.PROV 1010 Granular A or Granular B Type II (but with less than 5 per cent passing the 200 sieve) should be used as backfill behind the walls.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the culvert walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS 501 (Compaction). Other surcharge loadings should be accounted for in the design as required.
- The granular fill may be placed either in a zone with the width equal to at least 1.5 m behind the back of the walls (see Figure C6.20(a) of the Commentary to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5H:1V extending up and back from the rear face of the footing (see Figure C6.20(b) of the Commentary to the CHBDC, 2006).
- For a retaining wall, the pressures are based on the existing embankment fill materials and the existing overburden soils and the following parameters (unfactored) may be used:

	Existing Fill
Soil unit weight:	20 kN/m^3
Coefficients of static lateral earth pressure:	
Active, K_a	0.33
At rest, K_o	0.50

- For an unrestrained wall, where the pressures are based on OPSS.PROV 1010 Granular A or Granular B Type II fill behind the wall, the following parameters (unfactored) may be assumed:

	Granular A	**Granular B Type II**
Soil unit weight:	22 kN/m^3	21 kN/m^3
Coefficients of static lateral earth pressure:		
Active, K_a	0.27	0.27
At rest, K_o	0.43	0.43

Where the culvert wall support does not allow lateral yielding, at-rest earth pressures should be assumed for the geotechnical design. Where culvert wing walls or retaining walls are required and their support allows lateral yielding of the stem, active earth pressures should be used in the geotechnical design of the wall structure(s). The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the Commentary to the CHBDC (2006).

6.5 Construction Considerations

6.5.1 Surface Water and Groundwater Control

Control of surface water and groundwater will be necessary for the construction of the new or replacement culverts and extensions, to allow excavation and foundation construction to be carried out in dry conditions.

Depending on the creek flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe, or diverted by pumping from behind a temporary cofferdam. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the sensitive silty clay to clay subgrade soils; further discussion on this aspect is provided in Section 6.5.3.

As noted in Section 6.2.2, groundwater control will be required at the culvert locations, as the foundation excavations are expected to extend below the groundwater level at many of the culvert sites depending on the selected culvert type. Where the excavation will be advanced through existing fill and cohesive soils to terminate within cohesive soils (i.e., no excavation through water-bearing non-cohesive soils), seepage into the excavation should be adequately controlled by pumping from properly filtered sumps. Where the excavation will be advanced through or into water-bearing cohesionless soils, appropriate dewatering of the water-bearing granular soil deposits will be required to maintain the water level below the founding level for the culverts during excavation and construction. It is recommended that a NSSP be included in the Contract Documents to warn the Contractor of the soil conditions and the requirement for design and installation of groundwater control for the culvert replacements. An example NSSP is given in Appendix C.

6.5.1.1 Permit to Take Water Requirements for Dewatering

The potential daily pumping rate to dewater the excavations associated with the new or replacement culverts and extensions has been assessed to determine whether a Permit to Take Water (PTTW) is likely to be required for dewatering at individual culvert sites. The Ministry of Environment requires a PTTW for any site for which the dewatering volume exceeds 50,000 liters (50 m^3) per day.

The assessment of potential dewatering volumes was completed based on the borehole information (soil type and thickness, and groundwater elevation) and geotechnical laboratory testing (grain size distribution test results), together with the recommended founding elevations as given in Tables 2 and 3. This assessment is based on dewatering of one-half of the culvert length at any one time, based on the anticipated construction staging approach for the culvert construction.

The culvert sites for which a PTTW would likely be required, based on the anticipated maximum pumping rate near the early stages of construction dewatering are presented below.

Culvert ID	Culvert Location	Borehole Nos.	Highest Measured Groundwater Level/Elevation	Proposed Culvert Inlet End and Outlet End Invert Elevation	PTTW Required
C38 Replacement	20+310 (Hwy 400)	C38-1 to C38-4	0.1 m / 307.1 m	307.1 m / 307.0 m	Yes
C39 Replacement	20+670 (Hwy 400)	C39-1 to 39-4	0.6 m / 304.5 m	305.0 m / 305.0 m	Yes
C40 Extension	22+023 (Hwy 400)	C40-1 to C40-4	1.4 m / 290.8 m	290.6 m / 290.5 m	No
C5-6 New	21+307 (Hwy 400)	C5-6-1 to C5-6-5	3.0 m / 300.0 m	302.4 m / 302.0 m	No
C5-7 New	9+933 (E-S Ramp, Hwy 400)	C5-7-1 and C5-7-2	4.6 m / 299.4 m	302.6 m / 302.0 m	No

6.5.2 Excavations and Temporary Roadway Protection

The existing CSP extensions at Culverts C38 and C39 are to be replaced with box culverts. The proposed invert of the existing CSP culverts is about the same as the proposed invert of the box culvert replacements. The recommendations for excavation and protections systems provided below may be used for the removal of the existing culverts.

Temporary excavations for the culvert will be made through the existing embankment fill and native soils, which generally vary from loose to dense cohesionless soils, and soft to stiff cohesive soils. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects. The existing fill and the weaker portions of the clayey silt or sand/silt soils would be classified as Type 3 soil, according to the Occupation Health and Safety Act, assuming that proper groundwater control is in place to dewater non-cohesive soil deposits prior to excavation, where necessary. Where space permits, and provided that proper groundwater control is in place, temporary open-cut excavations through these materials should be made with side slopes formed no steeper than 1H:1V. In wet ground conditions, the excavations should be made at side slopes no steeper than 3H:1V.

Temporary protection systems will be required to facilitate construction staging to maintain traffic on Highway 400 and the ramps during the culvert replacement works and for the new culvert installations. Temporary protection systems may be required for the culvert extension work.

The temporary excavation support systems for the culvert should be designed and constructed in accordance with OPSS PROV 539 (Construction Specification for Temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS PROV 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

The protection system will be required for excavation depth of approximately 3 m. Although the selection and design of the protection system will be the responsibility of the Contractor, it is considered that either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable for the roadway protection at these culvert sites, based on the subsurface soil and groundwater conditions. An interlocking sheetpile system would contribute to both ground and groundwater control. For the soldier pile and lagging system, it would be necessary to lower the groundwater level to control seepage from the non-cohesive fill or native soils, or include measures to mitigate loss of soil particles through the lagging boards.

The sheetpiles or soldier piles would have to be socketted to sufficient depth to provide the necessary passive resistance for the retained soil height of approximately 3 m. Lateral support to the sheetpiles or soldier piles could be provided in the form of rakers or temporary anchors.

6.5.3 Obstructions

The soils at this site are glacially derived and while not encountered in the boreholes except for broken rock fragments and grinding of the augers (e.g. in Boreholes C40-2, C5-6-1 to C5-6-3, C5-7-1 and C5-7-2), should be expected to contain cobbles and boulders, which could affect the installation of shallow foundations, temporary roadway protection systems or trenchless installations. If conditions warrant, an NSSP should be included in the Contract Documents to identify to the contractor the possible presence of cobbles and/or boulders within the overburden soils; an example NSSP is included in Appendix C.

6.5.4 Subgrade Protection

The subgrade soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade. Alternatively, as discussed in Section 6.2.2.1, subgrade protection for box culverts could be provided by 150 mm of granular bedding. This requirement can be addressed with a note on the General Arrangement drawing and/or with an NSSP. A sample NSSP for the concrete working slab is included in Appendix C.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng., with technical input from Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal of Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact for Golder and a principal of Golder, conducted an independent quality control review of this report.

GOLDER ASSOCIATES LTD.

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

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HLS/NK/LCC/JMAC/nk/sm

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Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code* and *Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.

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.

ASTM International

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

Ontario Provincial Standard Specifications

OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1002	Material Specification for Aggregates - Concrete
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS 1205	Material Specification for Clay Seal

Ontario Provincial Standard Drawings

OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	Granular Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Depths for Southern Ontario

Ontario Water Resources Act

Ontario Regulation 903/90 Wells: O. Reg. 468/10 Amendment to Ontario Regulation 903

Ontario Occupational Health and Safety Act

Ontario Regulation 213 (Construction Projects)

Commercial Software

Settle 3D (Version 2.016) by Rocscience Inc.

Table 1: Comparison of Foundation Alternatives for Culvert Replacements and Extensions

Option	Advantages	Disadvantages	Risks/Consequences
Box culvert: new; replacement; or extension (Most appropriate for Culvert C38, C39, C40, C5-6 and C5-7 from a foundations perspective)	■ Minimizes depth of excavation, excavation support and dewatering requirements compared to open footing option. ■ In some cases, avoids the need for a Permit to Take Water associated with construction dewatering (see Section 6.5.1.1) when compared with an open footing culvert replacement option. ■ Pre-cast box sections expected to allow faster construction than cast-in-place open footings, with shorter duration for dewatering and surface water pumping.	■ Where excavation extends below the groundwater level, dewatering would still be required.	■ Some risk of disturbance of the sensitive silty clay to clayey silt subgrade, and loose granular materials during construction.
Open footing culvert: new; replacement; or extension (Most appropriate alternative for Culvert C40 from a foundations perspective)	■ Would satisfy fisheries requirements related to natural channel substrate, if applicable ■ May be feasible to build culvert replacement on pre-cast footing sections, to accelerate construction schedule and reduce time for dewatering and surface water pumping	■ Excavation depths are greater than for box culvert option to found footings at/below depth of frost penetration, resulting in increased excavation support and dewatering requirements, including need for Permit to Take Water at some sites ■ Cast-in-place footings may require a longer duration for construction, including dewatering and surface water pumping, as compared with pre-cast culvert segments or footing elements	■ Some risk of disturbance of the sensitive silty clay to clayey silt subgrade, and loose granular materials during construction

Table 2: Box Culvert Replacement or Extension Option
Founding Elevations, Sub-Excavation Requirements and Geotechnical Resistances

Culvert ID	Culvert Location	Reference Boreholes	Proposed Culvert Invert Elevation [1] Upstream/Downstream	Sub-excavation Required?	Culvert Span	Highest Base Slab Founding Elevation [2] Upstream/Downstream	Estimated Approx. Bedding/Backfill Thickness Required	Factored Geotechnical Resistance at ULS [3]	Geotechnical Resistance at SLS [3]
C38	20+310 (Hwy 400)	C38-1 to C38-4	307.1 m / 307.0 m (East End / West End)	Yes, to Elevation 305.7 m on West Side and to Elevation 304.8 m on East Side	1.22 m	306.85 m / 306.75 m	1.075 m to 1.875 m	125 kPa	75 kPa
C39	20+670 (Hwy 400)	C39-1 to C39-4	305.0 m / 305.0 m (West End / East End)	Yes, to Elevation 304.0 m on West Side and to Elevation 302.0 m on East Side	1.22 m	304.75 m / 304.75 m	0.675 m to 2.675 m	125 kPa	75 kPa
C40	22+023 (Hwy 400)	C40-1 to C40-4	290.5 m / 290.6 m (West End / East End)	Yes, to Elevation 288.7 m on East Side	1.22 m	290.25 m / 290.35 m	1.475 m	125 kPa	100 kPa
C5-6	21+307 (Hwy 400)	C5-6-1 to C5-6-5	302.4 m / 302.0 m (East End / West End)	Yes, to Elevation 301.7 m on West Side and middle span of culvert to Elevation 301.4 m	1.8 m	302.15 m / 301.75 m	0.075 m to 0.675 m	175 kPa	125 kPa

Culvert ID	Culvert Location	Reference Boreholes	Proposed Culvert Invert Elevation [1] Upstream/Downstream	Sub-excavation Required?	Culvert Span	Highest Base Slab Founding Elevation [2] Upstream/Downstream	Estimated Approx. Bedding/Backfill Thickness Required	Factored Geotechnical Resistance at ULS [3]	Geotechnical Resistance at SLS [3]
C5-7	9+933 (E-S Ramp, Hwy 400)	C5-7-1 C5-7-2	302.6 m / 302.0 m (South End / North End)	Yes, to Elevation 302.0 m	1.8 m	302.35 m / 301.75 m	0.275 m	350 kPa	225 kPa

Reviewed by: JMAC

NOTES:

1. Proposed culvert invert elevations provided by URS Canada Inc.
2. Highest founding elevation based on an assumed base slab thickness of 250 mm. As per Section 6.2, it is recommended that the base slab be founded on either a 150 mm thick layer of compacted OPSS Granular A (including a 75 mm levelling course) or a 100 mm thick concrete working slab overlain by 75 mm of OPSS.PROV 1010 Granular A or OPSS.PROV 1002 concrete fine aggregate levelling course.
3. The geotechnical resistances given above are based on the culvert span (width) as listed for each culvert. The recommended geotechnical resistances should be reviewed if the founding elevation and/or culvert span (width) differ significantly from those given above. SLS resistance for 25 mm settlement.

Table 3: Open Footing Culvert Replacement or Extension Option
Founding Elevations, Sub-Excavation Requirements and Geotechnical Resistances

Culvert ID	Culvert Location	Reference Boreholes	Proposed Culvert Invert Elevation [1] Upstream/Downstream	Sub-excavation Required?	Highest Footing Founding Elevation [2] Upstream/Downstream	Factored Geotechnical Resistance at ULS [3]	Geotechnical Resistance at SLS [3]
C38	20+310 (Hwy 400)	C38-1 to C38-4	307.1 m / 307.0 m (East End / West End)	Yes, to Elevation 304.8 m on East Side	305.5 m / 305.4 m	225 kPa	150 kPa
C39	20+670 (Hwy 400)	C39-1 to C39-4	305.0 m / 305.0 m (West End / East End)	Yes, to Elevation 302.0 m on East Side	303.4 m / 303.4 m	225 kPa	150 kPa
C40	22+023 (Hwy 400)	C40-1 to C40-4	290.6 m / 290.5 m (East End / West End)	Yes, to Elevation 288.7 m on East Side	288.9 m / 289.0 m	300 kPa	200 kPa
C5-6	21+307 (Hwy 400)	C5-6-1 to C5-6-5	302.4 m / 302.0 m (East End / West End)	For footings only	300.8 m / 300.4 m	425 kPa	275 kPa
C5-7	9+933 (E-S Ramp, Hwy 400)	C5-7-1 C5-7-2	302.6 m / 302.0 m (South End / North End)	For footings only	301.0 m / 300.4 m	575 kPa	375 kPa

Reviewed by: JMAC

NOTES:
1. Proposed culvert invert elevations provided by URS Canada Inc.
2. Highest founding elevation based on minimum footing depth of 1.6 m below lowest surrounding grade, for frost protection purposes.
3. The geotechnical resistances given above are based on an assumed footing width of 0.6 m. The recommended geotechnical resistances should be reviewed if the footing founding elevation and/or footing width differ significantly from those given above.

Table 4: Open Footing and Box Culvert Replacement And Extension Options
Resistance To Lateral Loads/Sliding Resistance

Culvert ID	Culvert Location	Reference Boreholes	Proposed Culvert Invert Elevation Upstream/Downstream	Pre-Cast Concrete Box Culverts		Cast-in-Place Concrete Footings *	
				Coefficient of Friction, tan δ	*Base Slab Founding Material*	*Coefficient of Friction, tan φ'*	*Footing Founding Material*
C38	20+310 (Hwy 400)	C38-1 to C38-4	307.1 m / 307.0 m (East End / West End)	0.5	Compacted granular fill (Bedding)	0.55	Compact to dense sand and silt till/Stiff clayey silt/Stiff clayey silt till
C39	20+670 (Hwy 400)	C39-1 to C39-4	305.0 m / 305.0 m (West End / East End)	0.5	Compacted granular fill (Bedding)	0.55	Compact to dense sand and silt till
C40	22+023 (Hwy 400)	C40-1 to C40-4	290.6 m / 290.5 m (East End / West End)	0.5	Compacted granular fill (Bedding)	0.55	Compact to dense sand and silt till/Hard clayey silt till
C5-6	21+307 (Hwy 400)	C5-6-1 to C5-6-5	302.4 m / 302.0 m (East End / West End)	0.45	Loose sand fill (Levelling Course)	0.55	Hard clayey silt till/Compact sand and silt to silty sand till
C5-7	9+933 (E-S Ramp, Hwy 400)	C5-7-1 C5-7-2	302.6 m / 302.0 m (South End / North End)	0.45	Loose / Compacted granular fill (Leveling Course / Bedding)	0.55	Compact to dense sand and silt till/Hard clayey silt till

Reviewed by: JMAC

* If constructed on a granular fill pad, the Coefficient of Friction, tan φ', between the concrete footing and the compacted granular fill for use in design should be 0.50.

Table 5: Predicted Magnitude Of Settlement Under Embankment Widening At Culvert Locations

Culvert ID	Culvert Location	Reference Boreholes	Approximate Embankment Height	Settlement at Existing Embankment Crest	Settlement at New Embankment Toe
C38	20+310 (Hwy 400)	C38-1 to C38-4	3	<25 mm	< 5 mm
C39	20+670 (Hwy 400)	C39-1 to C39-4	3	<25 mm	< 5 mm
C40	22+023 (Hwy 400)	C40-1 to C40-4	2	<5 mm	< 5 mm
C5-6	21+307 (Hwy 400)	C5-6-1 to C5-6-5	2	<5 mm	< 5 mm
C5-7	9+933 (E-S Ramp, Hwy 400)	C5-7-1 C5-7-2	2.5	<5 mm	< 5 mm

Reviewed by: JMAC

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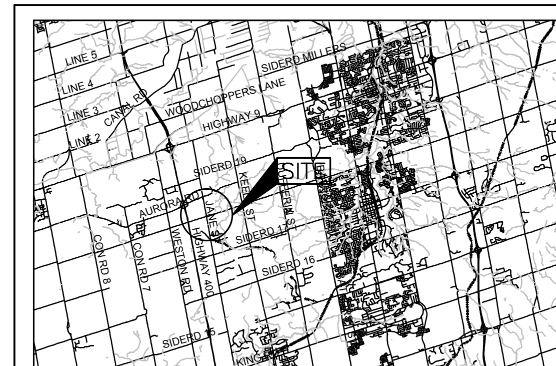
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

SHEET

HIGHWAY 400 WIDENING
CULVERT LOCATIONS
INDEX PLAN

Golder Associates



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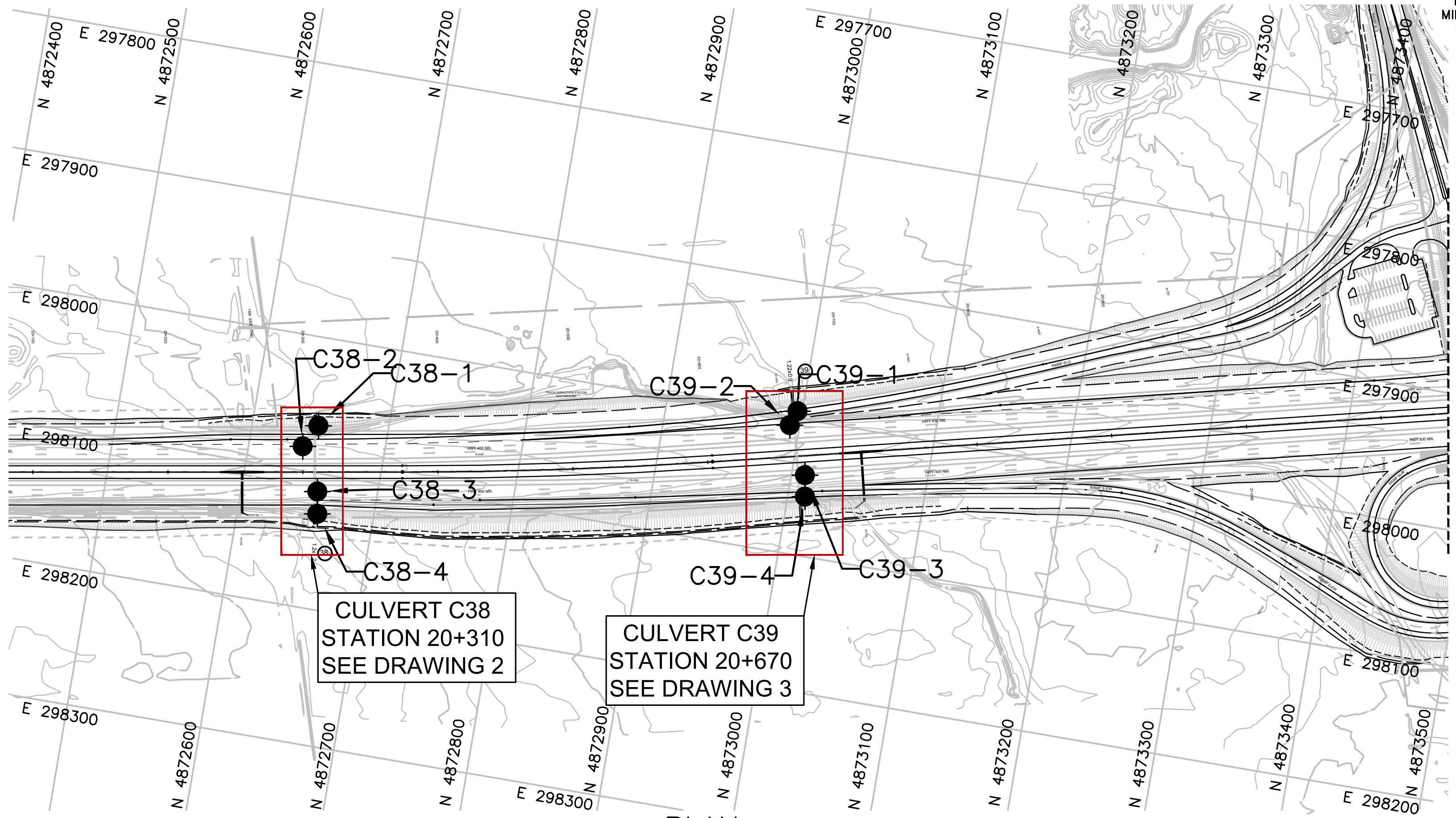

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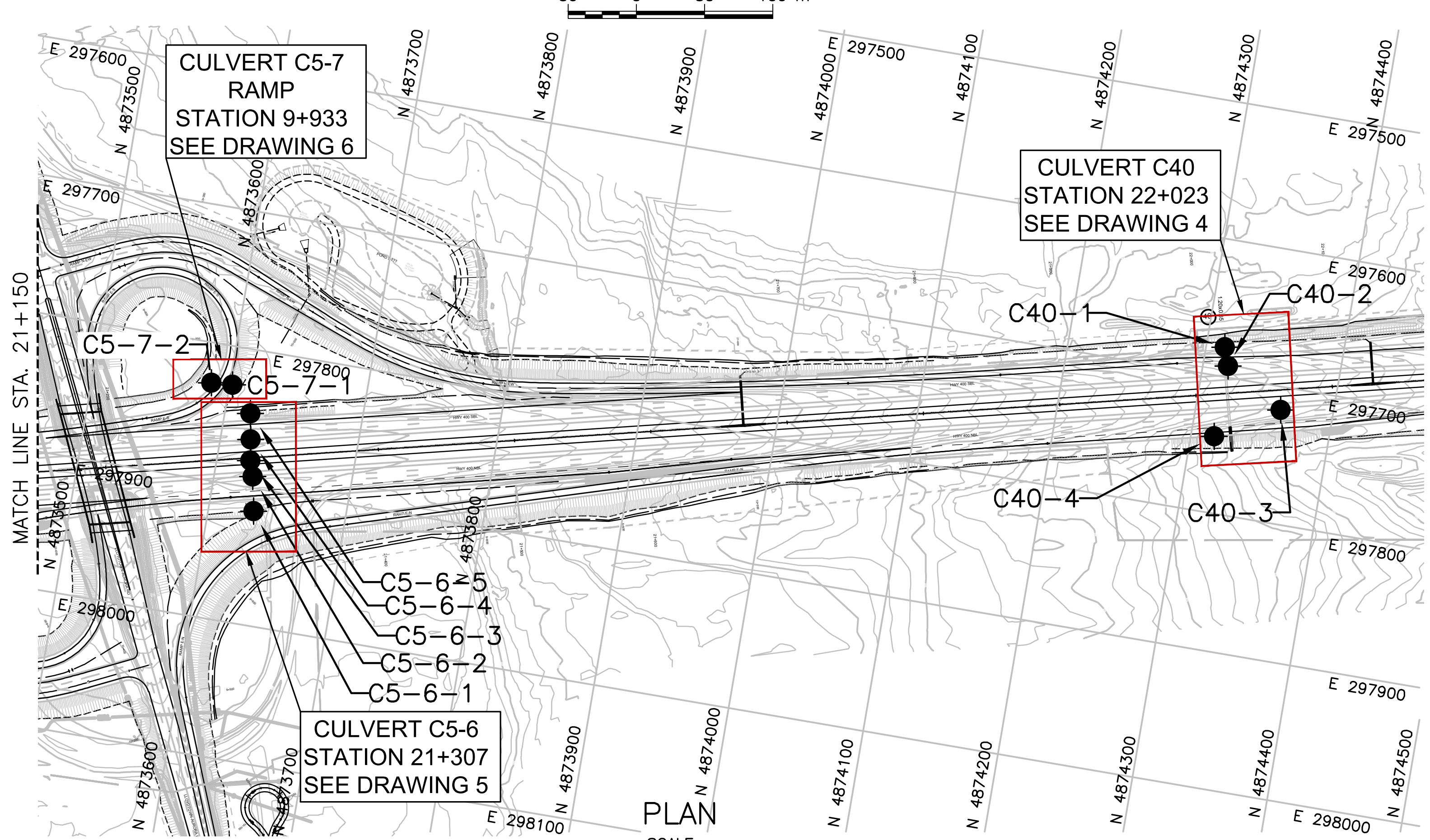

PLAN
SCALE
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NOTES

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 Hwy400_plan.dwg, received July 28, 2014 and Hwy400_contours.dwg, received July 12, 2011.

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No.

HWY. 400		PROJECT NO. 09-1111-0018	DIST.
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE:
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 1

PLOT DATE: August 24, 2015
FILENAME: f:\Projects\2009\09-1111-0018 (urs, york region)\-VA- Culverts\09-1111-0018VA001.dwg

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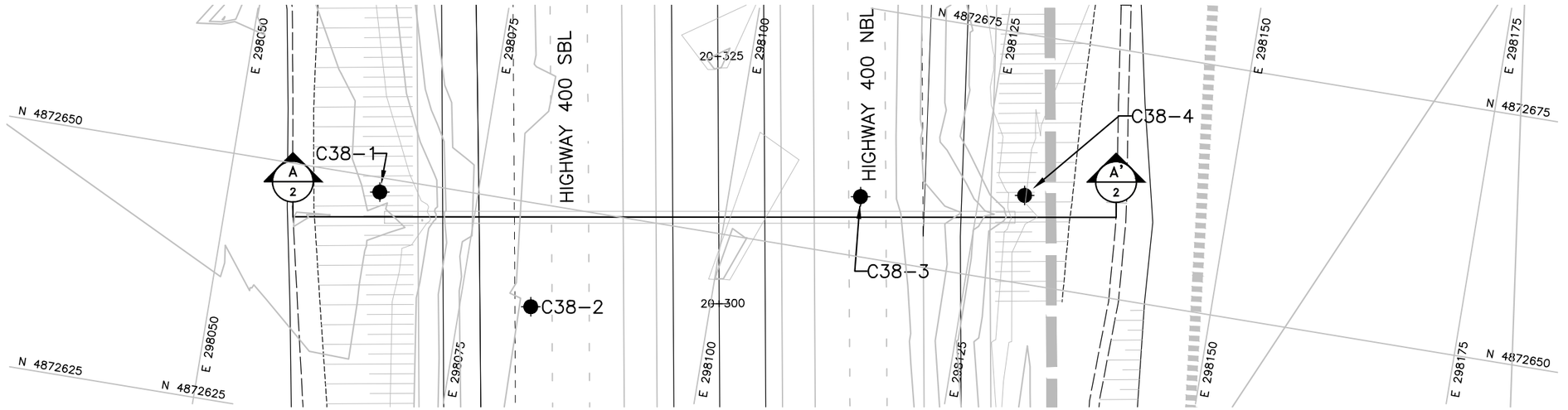
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. .
GWP No. 2835-02-00

HIGHWAY 400 WIDENING
CULVERT C38 AT STATION 20+310
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET .

Golder Associates



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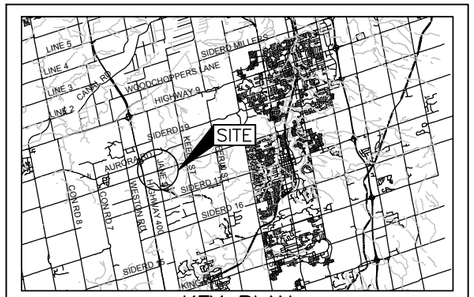

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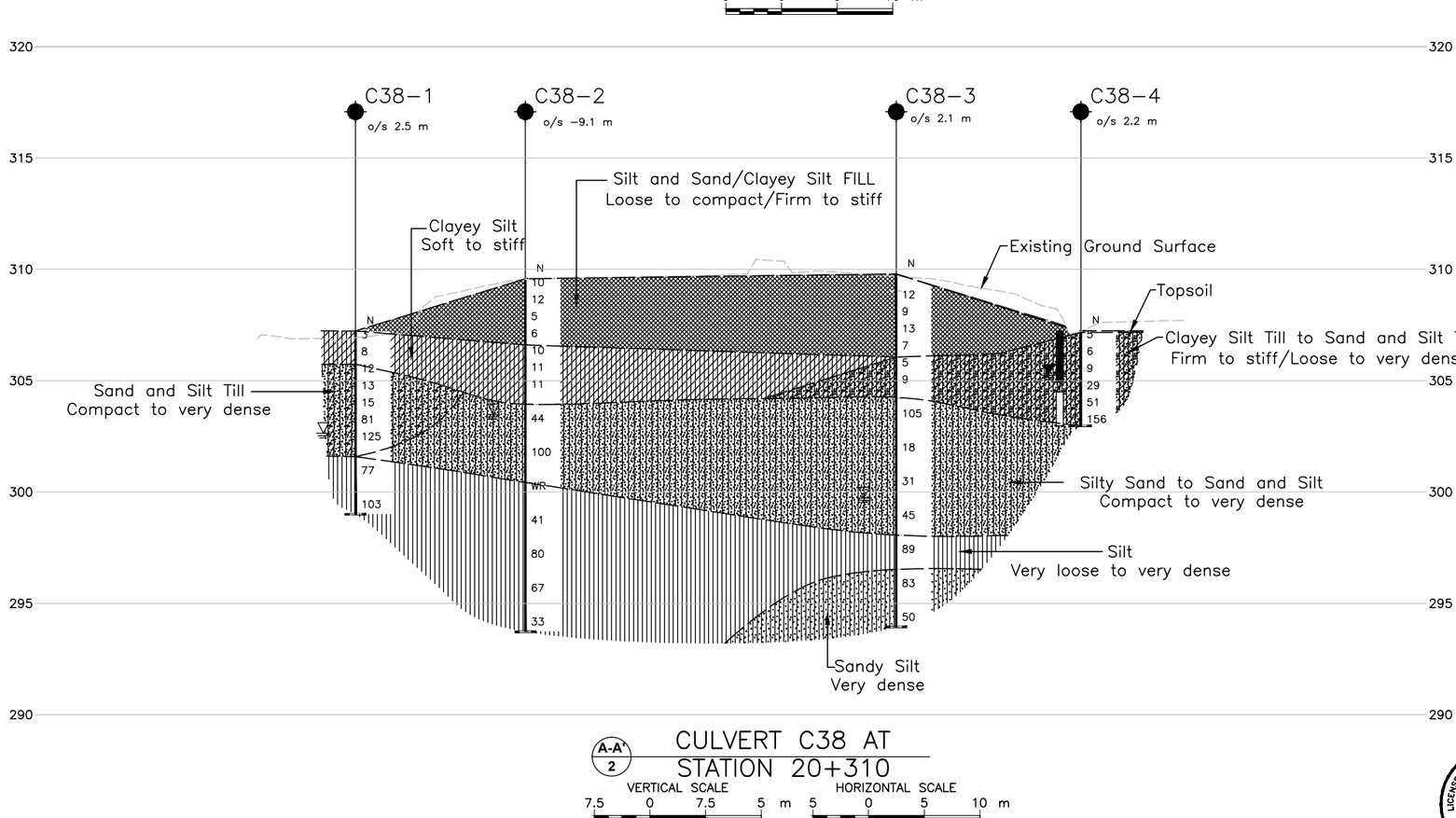

A-A'
2
CULVERT C38 AT STATION 20+310
VERTICAL SCALE 7.5 0 7.5 5 m
HORIZONTAL SCALE 5 0 5 10 m

LEGEND

- Borehole – Current Investigation
- 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 April 7, 2011
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C38-1	307.2	4872648.6	298065.2
C38-2	309.6	4872639.6	298082.1
C38-3	309.8	4872656.0	298113.2
C38-4	307.2	4872658.9	298129.5

NOTES

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LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Aug. 25, 2015 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Aug. 25, 2015 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. .

HWY. 400	PROJECT NO. 09-1111-0018		DIST. .
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE: .
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 2

PLOT DATE: August 24, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (urs, york region)\-wa- Culverts\09-1111-0018WA002.dwg

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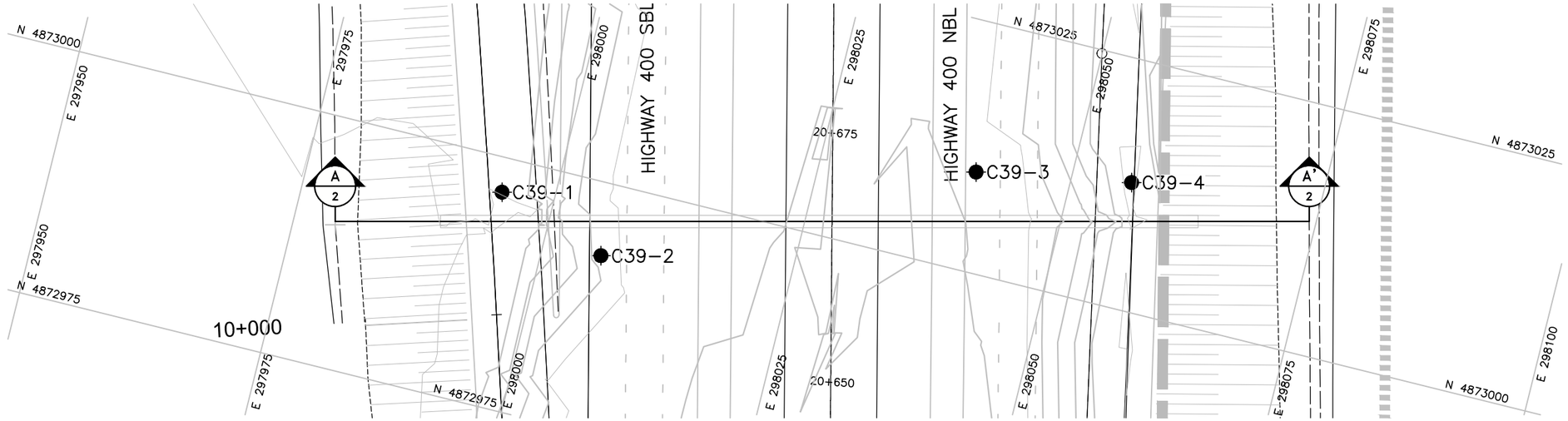
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

HIGHWAY 400 WIDENING
CULVERT C39 AT STATION 20+670
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates



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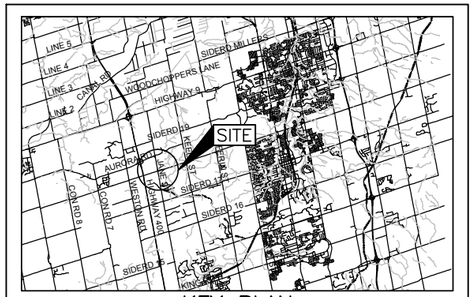
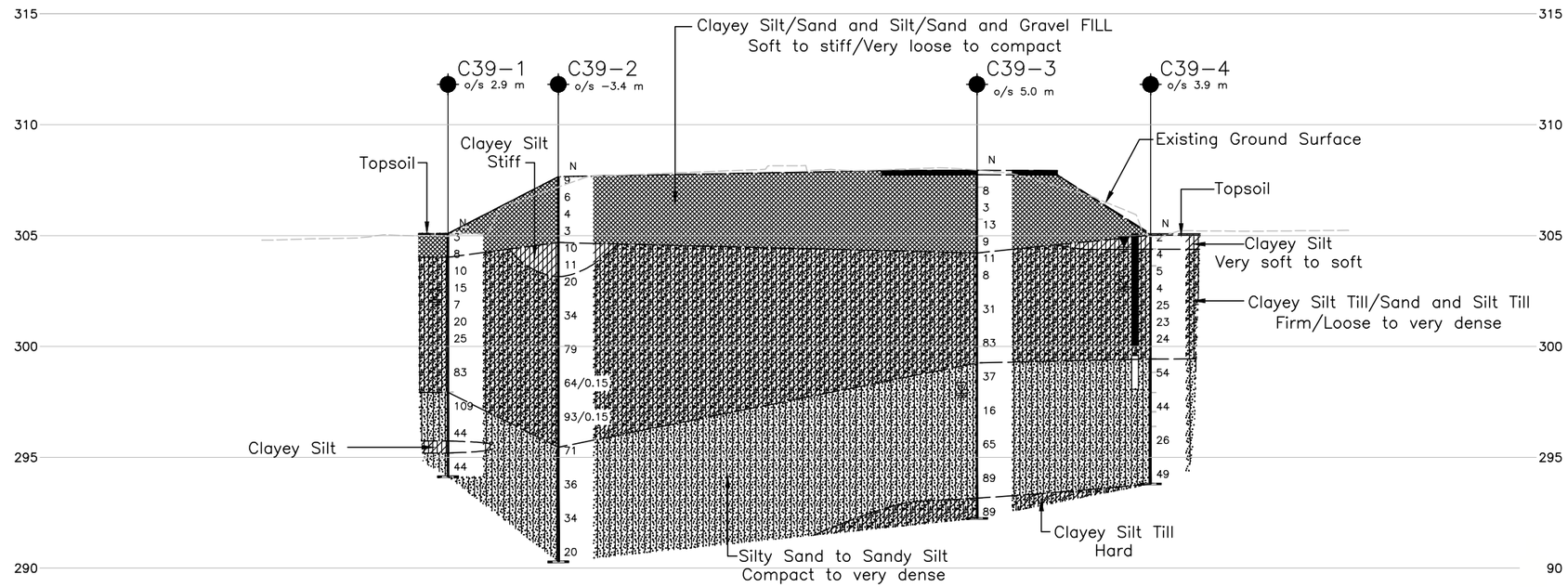


KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- Borehole – Current Investigation
- 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 April 7, 2011
- WL upon completion of drilling



A-A'
3

CULVERT C39 AT STATION 20+670

VERTICAL SCALE
7.5 0 7.5 5 m

HORIZONTAL SCALE
5 0 5 10 m

NOTES

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BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C39-1	305.1	4872996.5	297994.7
C39-2	307.7	4872992.7	298005.9
C39-3	307.9	4873010.0	298040.5
C39-4	305.1	4873012.8	298056.0

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Aug. 25, 2015 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Aug. 25, 2015 PROVINCE OF ONTARIO

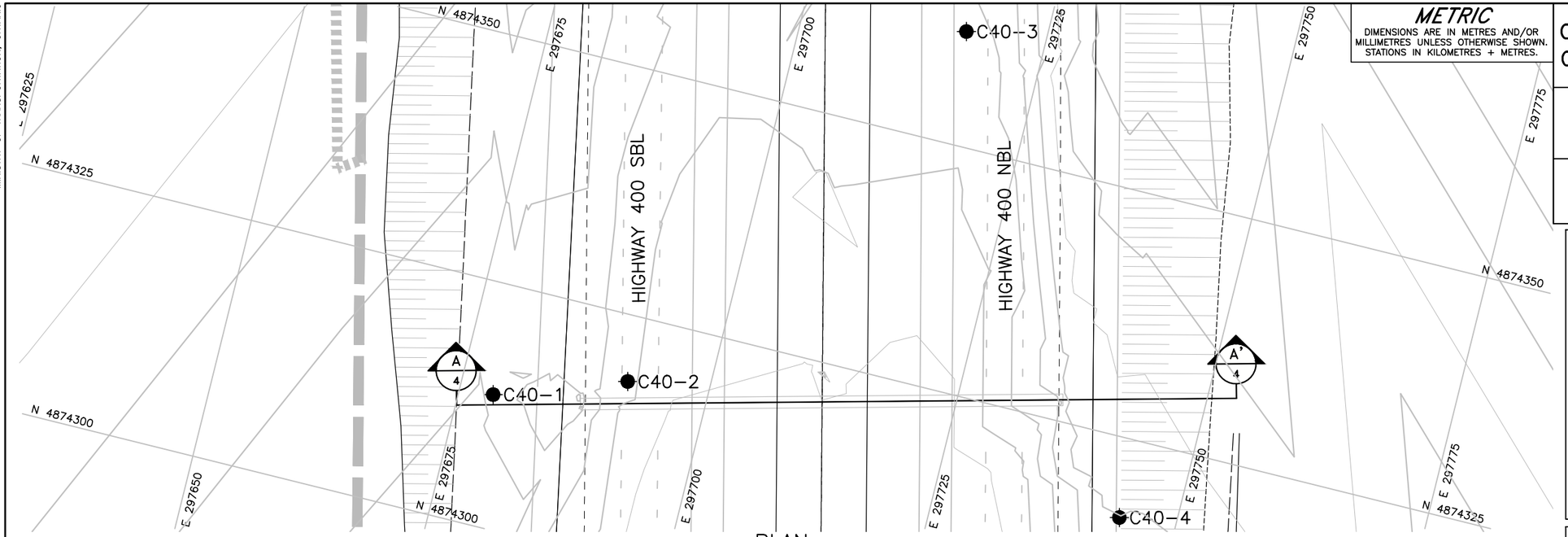
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No.:

HWY. 400	PROJECT NO. 09-1111-0018		DIST. :
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE: :
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 3

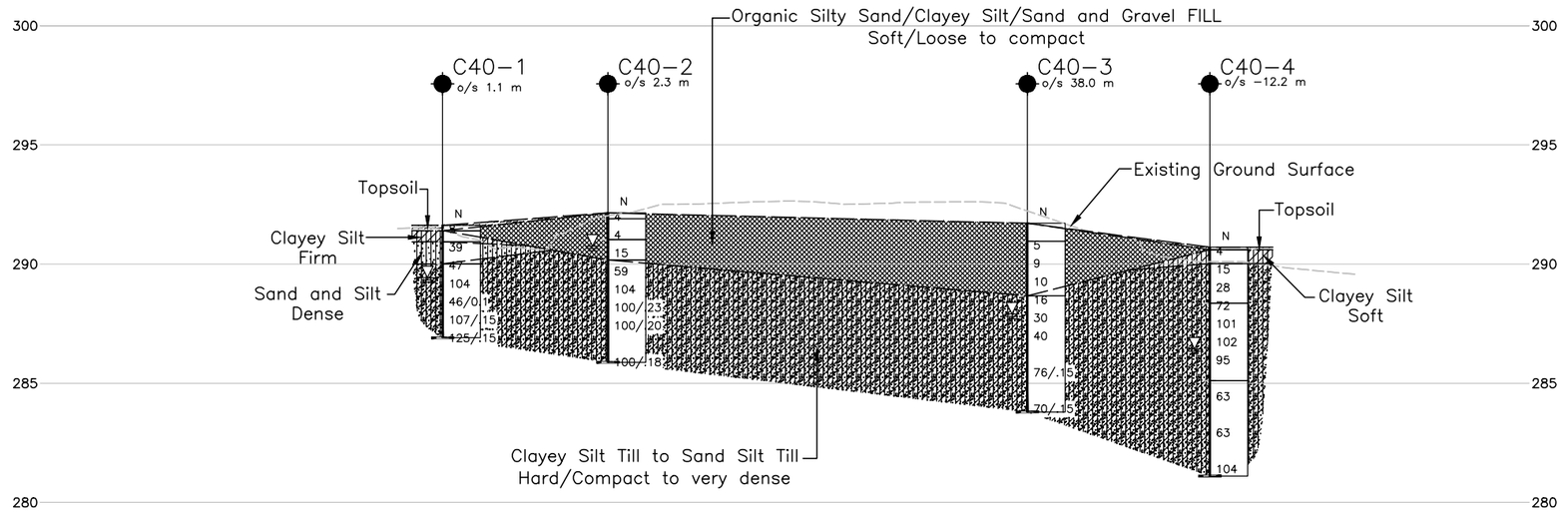
PLOT DATE: August 25, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (ont, york region)\..\Mc Culverts\09-1111-0018WO03.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE
5 0 5 10 m



A-A'
4

CULVERT C40 AT
STATION 22+023

VERTICAL SCALE
7.5 0 7.5 5 m

HORIZONTAL SCALE
5 0 5 10 m

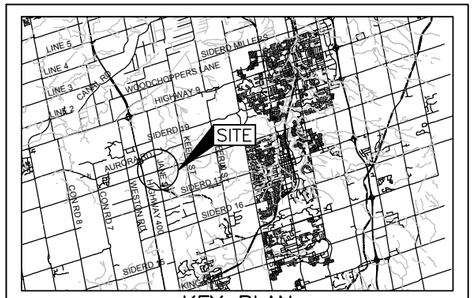
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

HIGHWAY 400 WIDENING
CULVERT C40 AT STATION 22+023
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
.

Golder Associates



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- Borehole – Current Investigation
- 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
C40-1	291.6	4874313.6	297678.5
C40-2	292.2	4874318.3	297691.6
C40-3	291.7	4874361.6	297716.8
C40-4	290.7	4874316.9	297744.2

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 Hwy400_plan.dwg, received July 28, 2014 and Hwy400_contours.dwg, received July 12, 2011.

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Aug. 25, 2015 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Aug. 25, 2015 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No.:

HWY. 400	PROJECT NO. 09-1111-0018		DIST. .
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE: .
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 4

PLOT DATE: August 24, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (ont, york region)\-\da- Culverts\09-1111-0018fig004.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

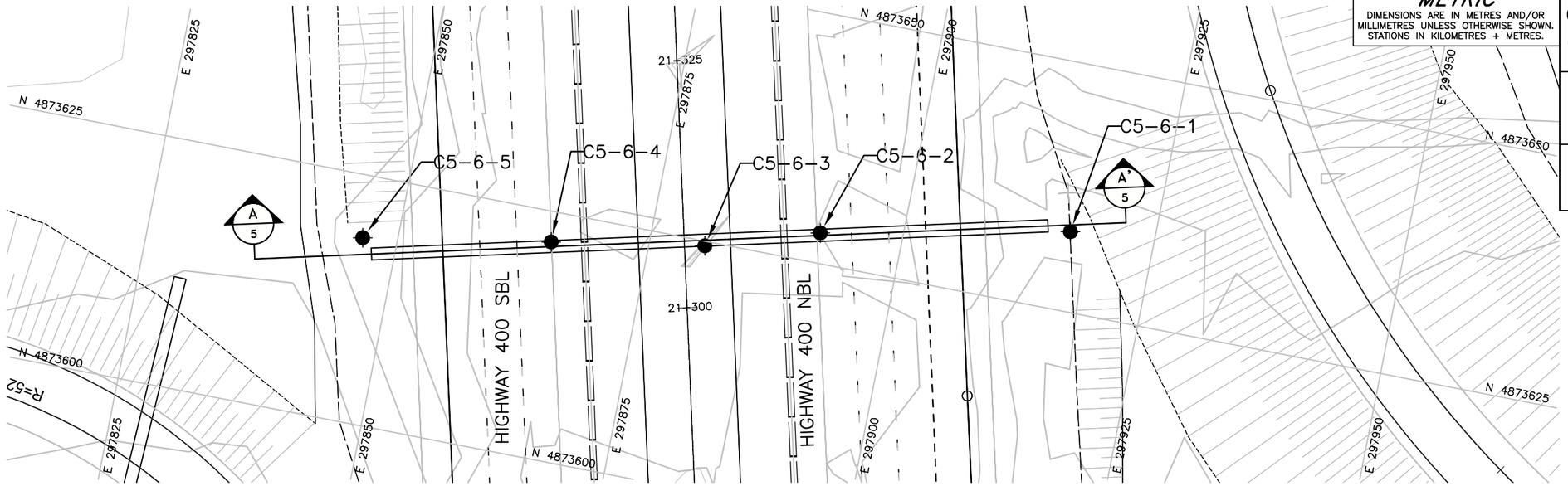
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2835-02-00

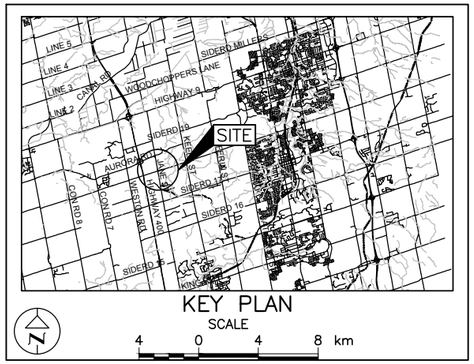
HIGHWAY 400 WIDENING
CULVERT C5-6 AT STATION 21+307
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET .

Golder Associates



PLAN
SCALE
5 0 5 10 m

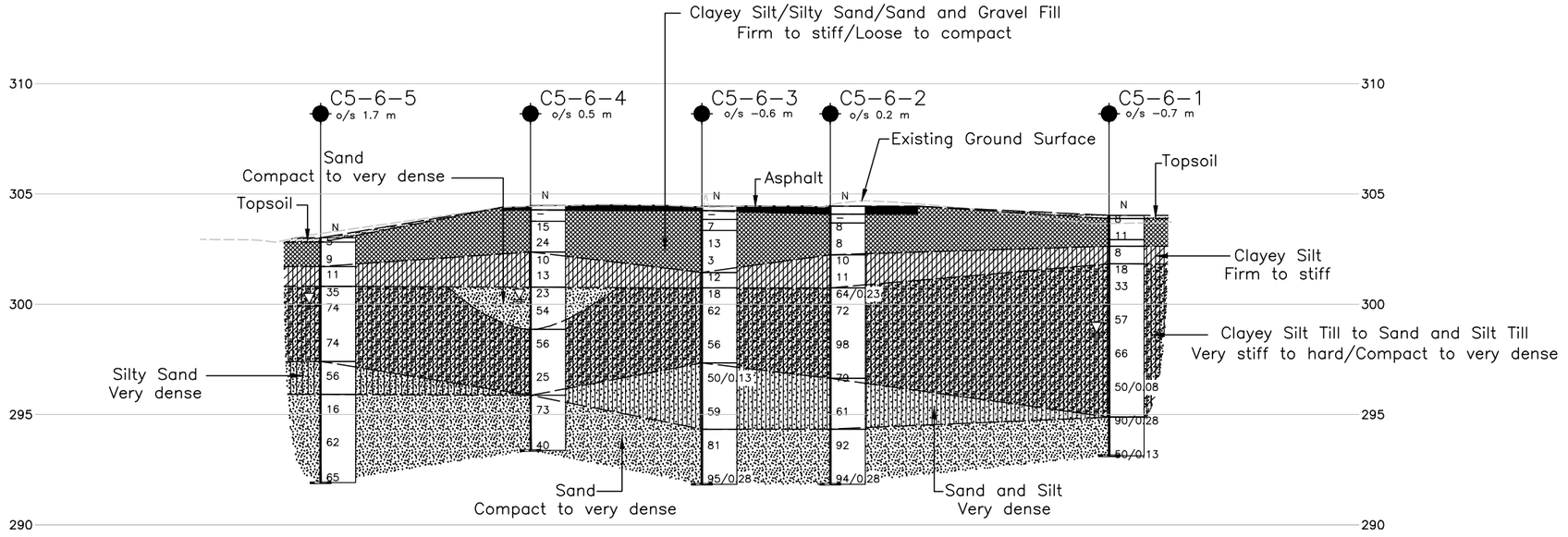


KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- Borehole – Current Investigation
- 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
C5-6-1	304.0	4873633.0	297916.5
C5-6-2	304.4	4873628.1	297891.8
C5-6-3	304.4	4873624.5	297880.6
C5-6-4	304.5	4873621.9	297865.3
C5-6-5	303.0	4873618.7	297846.5



A-A'
5

CULVERT C5-6 AT STATION 21+307

VERTICAL SCALE
7.5 0 7.5 5 m

HORIZONTAL SCALE
5 0 5 10 m

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 Hwy400_plan.dwg, received July 28, 2014, Hwy400_contours.dwg, received July 12, 2011 and Hwy400_plan+culverts.dwg, received March 9, 2015.

LICENSED PROFESSIONAL ENGINEER J.J.M.A. COSTA Aug. 25, 2015 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 Aug. 25, 2015 PROVINCE OF ONTARIO

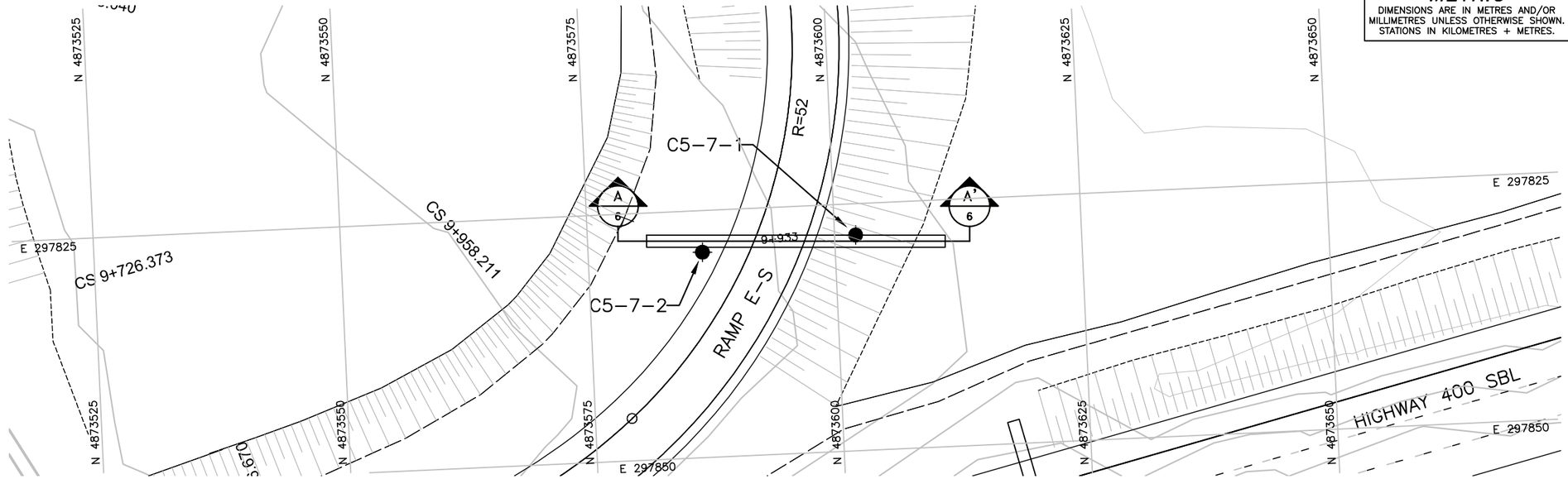
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. .

HWY. 400	PROJECT NO. 09-1111-0018		DIST. .
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE: .
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 5

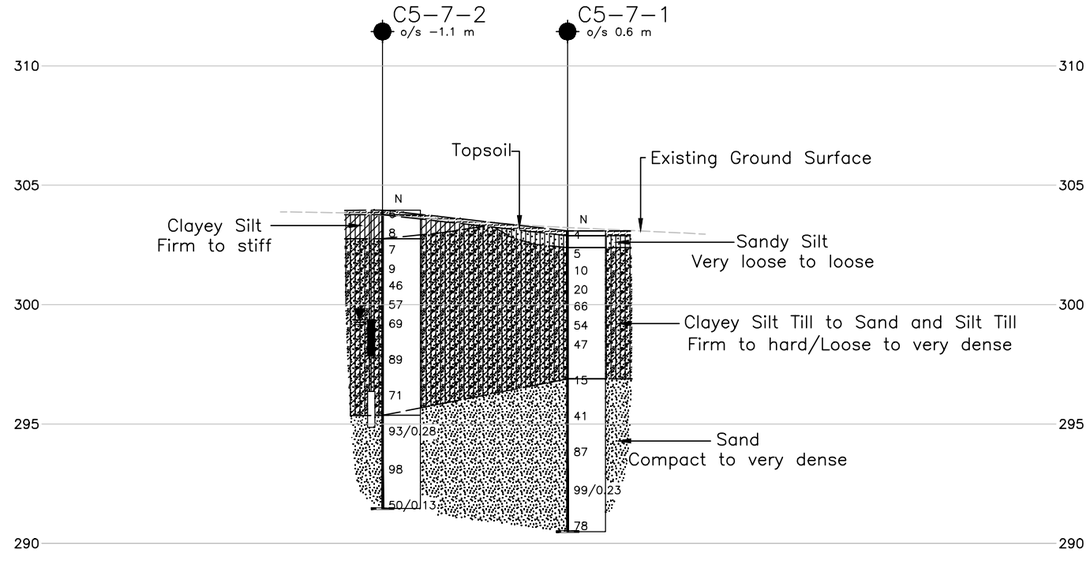
PLOT DATE: August 24, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (ont, york region)\-Var- Culverts\09-1111-0018MOD5.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE
5 0 5 10 m

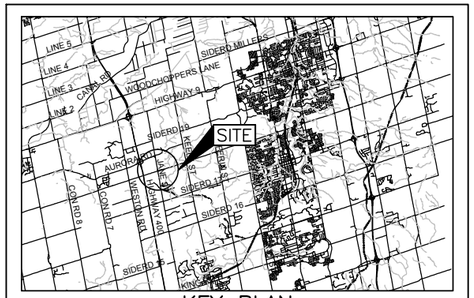


A-A'
6

CULVERT C5-7 AT RAMP
STATION 9+933

VERTICAL SCALE
7.5 0 7.5 5 m

HORIZONTAL SCALE
5 0 5 10 m



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- Borehole – Current Investigation
- 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 April 7, 2011
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C5-7-1	303.1	4873602.1	297828.2
C5-7-2	304.0	4873586.6	297829.2

NOTES

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REFERENCE

Base plans provided in digital format by URS, drawing file Hwy400_plan.dwg, received July 28, 2014, Hwy400_contours.dwg, received July 12, 2011 and Hwy400_plan+culverts.dwg, received March 9, 2015.

LICENSED PROFESSIONAL ENGINEER
J.M.A. COSTA
PROVINCE OF ONTARIO
Aug. 25, 2015

LICENSED PROFESSIONAL ENGINEER
N. KOCHMAN
100117863
PROVINCE OF ONTARIO
Aug. 25, 2015

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No.:

HWY. 400	PROJECT NO. 09-1111-0018		DIST.:
SUBM'D. HLS	CHKD. NK	DATE: 27/07/2015	SITE:
DRAWN: JFC	CHKD. NK	APPD. JMAC	DWG. 6

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

CONT No.:
GWP No. 2835-02-00

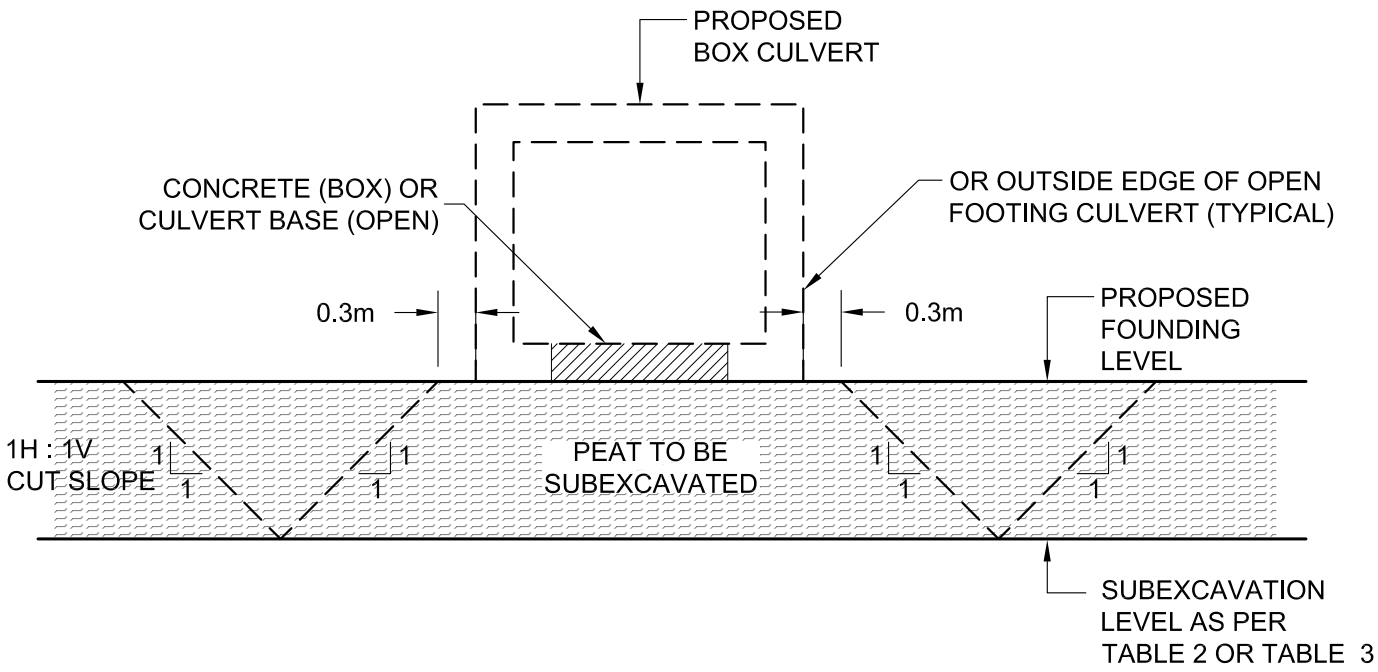
HIGHWAY 400 WIDENING
CULVERT C5-7 AT RAMP STATION 9+933
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
.

Golder Associates

PLOT DATE: August 24, 2015
FILENAME: T:\Projects\2009\09-1111-0018 (ont, york region)\-Vic Culverts\09-1111-0018V4006.dwg

BEFORE SUBEXCAVATION



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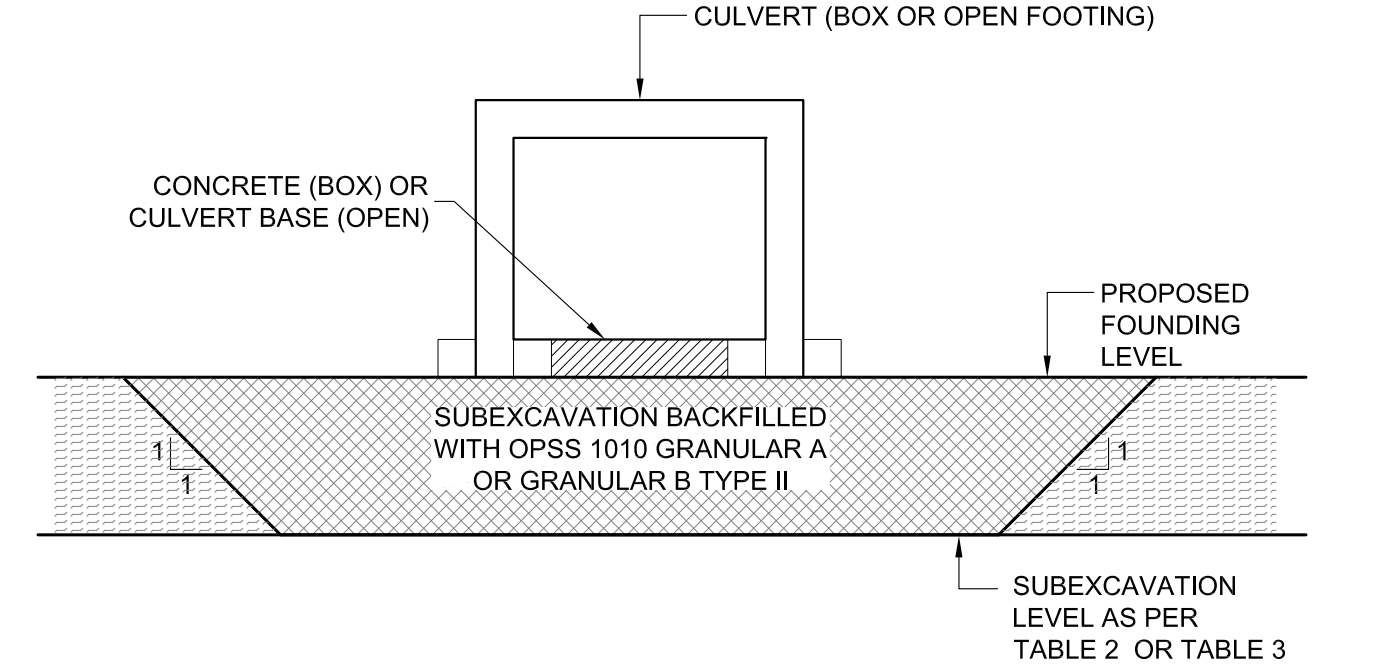

Golder Associates Sudbury, Ontario, Canada	SCALE NOT TO SCALE	TITLE	**PROPOSED CULVERT SUBEXCAVATION GEOMETRY**
	DATE NOV 2014		
	DESIGN JFC		
	CAD JFC		
FILE No. 0911110018HA005.dwg	CHECK SEMP	CULVERT REPLACEMENT HIGHWAY 400 WIDENING	FIGURE 1
PROJECT No. 09-1111-0018 REV. A	REVIEW TJG		

PLOT DATE: November 6, 2014
FILENAME: Z:\Projects\2009\09-1111-0018 HWY 400 Widening\CIVIL 3D\0911110018HA005.dwg

APPENDIX A

Record of Borehole Sheets

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 C38-1

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4872648.6 ;E 298065.2 ORIGINATED BY SKB

DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 108 mm Diameter Solid Stem Augers COMPILED BY SB/HS

DATUM Geodetic DATE November 26, 2010 CHECKED BY LCC

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
307.2	GROUND SURFACE										
0.0	CLAYEY SILT, trace to some sand, trace organics and some sand pockets to a depth of 0.7 m Soft to firm Brown and black Moist		1	SS	3		307				
			2	SS	8				○		
305.7							306				
1.5	SAND and SILT, trace to some clay, trace gravel (TILL) Compact to very dense Brown Moist		3	SS	12						2 45 40 13
			4	SS	13		305		○		
			5	SS	15		304				
			6	SS	81				○		
			7	SS	125	▽	303		○		1 40 47 12
301.6							302				
5.6	SILT, trace to some clay, trace to some sand, trace gravel, some silty sand layers Very dense Brown Moist		8	SS	77		301		○		0 9 80 11
			9	SS	103		300		○		
299.0											
8.2	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 4.6 m (Elev. 302.6 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No C38-2

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4872639.6 ;E 298082.1
ORIGINATED BY SB
DIST Central HWY 400
BOREHOLE TYPE D-90 Truck Mount, 108 mm Inner Diameter Hollow Stem Augers
COMPILED BY TT/HS
DATUM Geodetic
DATE November 25 and 26, 2010
CHECKED BY LCC

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
309.6	GROUND SURFACE										
0.0	Sand and silt, some clay, trace to some gravel (FILL) Loose to compact Brown Moist		1	SS	10		309				
			2	SS	12						
			3	SS	5		308				12 44 30 14
			4	SS	6		307				
306.6											
3.0	CLAYEY SILT, trace to some sand, trace organics to a depth of 3.7 m Stiff Brown and black to brown below 3.7 m Moist		5	SS	10		306				
			6	SS	11						0 8 54 38
			7	SS	11		305				
304.0											
5.6	SAND and SILT, trace clay, trace gravel Dense to very dense Brown Moist		8	SS	44	▽	304				
			9	SS	100		303				
							302				2 46 43 9
300.5							301				
9.1	SILT, some sand, trace clay Very loose to very dense Brown Wet		10	SS	WR		300				
			11	SS	41		299				
			12	SS	80		298				
			13	SS	67		297				
							296				0 18 78 4
							295				

Continued Next Page

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

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

Golder Associates

RECORD OF BOREHOLE No C38-2

SHEET 2 OF 2

METRIC

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

LOCATION N 4872639.6 ;E 298082.1
BOREHOLE TYPE D-90 Truck Mount, 108 mm Inner Diameter Hollow Stem Augers
DATE November 25 and 26, 2010

ORIGINATED BY SB
COMPILED BY TT/HS
CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
293.7	SILT, some sand, trace clay Very loose to very dense Brown Wet		14	SS	33		294		○ at w ≈ 18		
15.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 6.1 m (Elev. 303.5 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No C38-3

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4872656.0 ;E 298113.2
ORIGINATED BY AM
DIST Central HWY 400
BOREHOLE TYPE D-50 Track Mount, 108 mm Inner Diameter Hollow Stem Augers
COMPILED BY CS/HS
DATUM Geodetic
DATE March 24, 2011
CHECKED BY LCC

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
309.8	GROUND SURFACE										
0.0 / 309.0	Silty sand and gravel (FILL)										
0.8	Clayey silt, some sand, trace gravel (FILL) Firm to stiff Brown Moist		1	SS	12		309				
			2	SS	9		308				
	Rootlets at a depth of 2.4 m		3	SS	13		307				0 18 65 17
306.1			4	SS	7						
3.7	CLAYEY SILT with SAND, trace gravel (TILL) Firm to stiff Brown Wet to moist		5	SS	5		306				
			6	SS	9		305				1 44 45 10
304.2											
5.6	Silty SAND, trace clay, trace gravel Compact to very dense Brown Moist		7	SS	105		304				
							303				
			8	SS	18		302				0 68 28 4
							301				
			9	SS	31	▽	300				
			10	SS	45		299				
298.1											
11.7	SILT, trace sand, trace clay Very dense Grey Wet		11	SS	89		298				
							297				
296.5											
13.3	Sandy SILT, trace clay Very dense Grey Wet		12	SS	83		296				
							295				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No C38-3

SHEET 2 OF 2 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4872656.0 ;E 298113.2 ORIGINATED BY AM
DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY CS/HS
DATUM Geodetic DATE March 24, 2011 CHECKED BY LCC

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 ---										
293.9	Sandy SILT, trace clay Very dense Grey Wet		13	SS	50		294		○		0 23 73 4
15.9	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 10.1 m (Elev. 299.7 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No C38-4

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4872658.9 ;E 298129.5
ORIGINATED BY SKB
DIST Central HWY 400
BOREHOLE TYPE D-50 Track Mount, 101 mm Diameter Solid Stem Augers
COMPILED BY SB/HS
DATUM Geodetic
DATE November 24, 2010
CHECKED BY LCC

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
307.2	GROUND SURFACE										
0.0 / 0.1	TOPSOIL SAND and SILT, trace clay, trace gravel, sand pockets to 1.4 m (TILL) Loose to very dense Brown Moist Wet between depths of 0.7 m and 2.2 m		1	SS	5		307				
			2	SS	6		306				
			3	SS	9	▼					4 42 46 8
			4	SS	29		305				
			5	SS	51		304				2 39 53 6
302.9			6	SS	156		303				
4.3	END OF BOREHOLE Split-spoon sampler refusal										

NOTES:

1. Open borehole dry upon completion of drilling.

2. Water level measurements in monitoring well:

Date	Depth (m)	Elev. (m)
12/16/10	2.1	305.1
02/01/11	2.0	305.0
04/07/11	0.1	307.1

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

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

Golder Associates

RECORD OF BOREHOLE No C39-1

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4872996.5 ;E 297994.7 ORIGINATED BY SKB

DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 127 mm Diameter Solid Stem Augers COMPILED BY ARM/HS

DATUM Geodetic DATE November 26, 2010 CHECKED BY LCC

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
305.1	GROUND SURFACE						305				
0.0	TOPSOIL		1	SS	3						
	Clayey silt, trace to some sand, sand pockets, rootlets and zones of oxidation staining (FILL) Soft to firm Brown Moist										
304.0			2A	SS	8		304				
1.1	SAND and SILT, trace clay, trace gravel, sand seams and pockets to a depth of 5.2 m (TILL) Loose to very dense Brown to grey below 6.6 m Moist to wet below 1.5 m		2B								
			3	SS	10		303				1 43 50 6
			4	SS	15						
			5	SS	7	▽	302				3 44 45 8
			6	SS	20		301				
			7	SS	25						
							300				
			8	SS	83		299				
297.9											
7.2	SAND and SILT, trace clay Very dense to dense Brown Wet		9	SS	109		298				
							297				0 33 66 1
295.7			10A	SS	44		296				
9.4	CLAYEY SILT, trace sand Brown Wet		10B								
295.2							295				
9.9	SAND and SILT, trace clay Dense Brown Wet		11	SS	44						
294.1											
11.0	END OF BOREHOLE										

NOTES:

1. Borehole caved at a depth of 0.3 m above bottom of borehole before taking samples 10 and 11.
2. Water level in open borehole at a depth of 3.0 m (Elev. 302.1 m) upon completion of drilling.
3. Borehole caved at a depth of 4.9 m (Elev. 302.9 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C39-2

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4872992.7 ;E 298005.9 ORIGINATED BY SB

DIST Central HWY 400 BOREHOLE TYPE D-90 Truck Mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY AM/HS

DATUM Geodetic DATE November 24, 2010 CHECKED BY LCC

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
307.7	GROUND SURFACE										
0.0	Sand and silt, trace clay, trace gravel (FILL) Loose to very loose Brown Moist		1	SS	9		307				
			2	SS	6						
			3	SS	4		306				2 55 39 4
304.7			4	SS	3		305				
3.0	Sandy CLAYEY SILT, organics Stiff Brown and grey to brown below 3.7 m Moist		5	SS	10		304				
303.2			6	SS	11						0 22 58 20
4.5	SAND and SILT, some clay, trace to some gravel (TILL) Compact to very dense Brown to grey below 10.7 m Moist to wet		7	SS	20	▽	303				
			8	SS	34		302				
			9	SS	79		301				12 43 27 18
			10	SS	64/0.15		300				
	Up to 1.5 m of blowing sand encountered in hollow stem augers before sampling at a depth of 10.7 m (Elev. 297.0 m).		11	SS	93/0.15		299				4 43 41 12
295.5							298				
12.2	Silty SAND, trace clay Very dense to dense Moist Grey to brown below 13.7 m		12	SS	71		297				
			13	SS	36		296				
							295				
							294				
							293				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No C39-2

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4872992.7 ;E 298005.9 ORIGINATED BY SB

DIST Central HWY 400 BOREHOLE TYPE D-90 Truck Mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY AM/HS

DATUM Geodetic DATE November 24, 2010 CHECKED BY LCC

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 ---										
	Silty SAND, trace clay Very dense to dense Moist Grey to brown below 13.7 m										
			14	SS	34		292		○		0 77 20 3
							291				
290.3			15	SS	20				○		
17.4	END OF BOREHOLE										
	NOTES: 1. Water level inside augers at a depth of 6.1 m (Elev. 301.6 m) on completion of drilling. 2. Borehole caved to a depth of 9.1 m (Elev. 298.6 m) on withdrawal of augers; borehole dry at this depth.										

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

Golder Associates

RECORD OF BOREHOLE No C39-3

SHEET 1 OF 2

METRIC

PROJECT 09-1111-0018
G.W.P. 2835-02-00
LOCATION N 4873010.0 ;E 298040.5
ORIGINATED BY AM
DIST Central HWY 400
BOREHOLE TYPE D-50 Track Mount, 108 mm Inner Diameter Hollow Stem Augers
COMPILED BY CS/HS
DATUM Geodetic
DATE March 24 and 25, 2011
CHECKED BY LCC

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
307.9	GROUND SURFACE										
0.0	ASPHALT										
0.2	Sand and gravel (FILL) Brown Moist										
307.1											
0.8	Clayey silt with sand, trace gravel (FILL) Firm to soft Brown Moist		1	SS	8		307				
			2	SS	3		306				1 37 45 17
305.7											
2.2	Sand, some silt, trace clay (FILL) Compact Grey Moist		3	SS	13		305				
304.9											
3.0	Clayey silt, trace sand, trace gravel (FILL) Stiff Brown Moist		4	SS	9		304				
304.2											
3.7	SAND and SILT, trace to some clay, trace gravel (TILL) Loose to very dense Brown Moist		5	SS	11		304				
			6	SS	8		303				
			7	SS	31		302				
			8	SS	83		301				
299.2							300				
8.7	SAND, some silt, trace clay Compact to very dense Brown Wet		9	SS	37	▽	299				
			10	SS	16		298				0 84 16 0
			11	SS	65		297				
			12	SS	89		296				0 80 19 1
293.1							295				
14.8							294				

Continued Next Page

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

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

Golder Associates

RECORD OF BOREHOLE No C39-3

SHEET 2 OF 2

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4873010.0 ;E 298040.5 ORIGINATED BY AM

DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY CS/HS

DATUM Geodetic DATE March 24 and 25, 2011 CHECKED BY LCC

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
292.2	CLAYEY SILT with SAND, trace gravel (TILL) Hard Brown Moist		13	SS	89						
15.7	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 10.1 m (Elev. 297.8 m) upon completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No C39-4

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4873012.8 ;E 298056.0 ORIGINATED BY SKB
DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 127 mm Diameter Solid Stem Augers COMPILED BY ARM/HS
DATUM Geodetic DATE November 25, 2010 CHECKED BY LCC

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
305.1	GROUND SURFACE						305				
0.0	TOPSOIL										
0.1	CLAYEY SILT, trace to some sand, rootlets and organics Very soft Brown Moist		1	SS	2						
304.4							304				
0.7	CLAYEY SILT, trace to some sand, trace gravel, zones of oxidation staining (TILL) Firm Brown Wet		2	SS	4						
303.6											
1.5	SAND and SILT, trace to some clay, trace to some gravel, sand pockets (TILL) Loose to compact Brown Wet		3	SS	5		303				
			4	SS	4				○		2 44 46 8
			5	SS	25		302				
			6	SS	23		301		○		7 45 38 10
	25 mm thick sand seams below a depth of 4.5 m		7	SS	24						
299.5							300				
5.6	Silty SAND, some gravel Very dense Brown Wet		8A 8B	SS	54		299		○		0 10 87 3
298.8											
6.3	SILT, trace to some sand, trace clay Very dense Brown Wet						298				
297.9											
7.2	Silty SAND, trace gravel Dense Brown Wet		9A 9B	SS	44		297				
297.1											
8.0	Sandy SILT Dense Brown Wet						296		○		2 59 31 8
296.4											
8.7	SAND and SILT, trace clay, trace gravel Compact to dense Brown Wet		10	SS	26						
			11	SS	49		295				
293.8							294				
11.3	END OF BOREHOLE										

NOTES:

1. Borehole caved to a depth of 7.0 m (Elev. 298.1 m) upon completion of drilling.

2. Water level measurements in piezometer:

Date	Depth (m)	Elev. (m)
02/01/11	2.4	302.7
04/07/11	0.6	304.5

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

Golder Associates

RECORD OF BOREHOLE No C40-1

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4874313.6 ;E 297678.5 ORIGINATED BY TT
DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 108 mm Diameter Solid Stem Augers COMPILED BY MAS/HS
DATUM Geodetic DATE December 8, 2010 CHECKED BY LCC

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
291.6	GROUND SURFACE										
0.0	TOPSOIL										
0.2 / 290.9	CLAYEY SILT, some sand, trace gravel Firm Brown Moist		1	SS	8		291				
0.7 / 290.0	SAND and SILT, trace clay, trace gravel Dense Brown Moist		2	SS	39						
1.6	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Brown Moist Augers grinding at a depth of 2.3 m.		3	SS	47	▽	290		○ ⊢		
			4	SS	104		289				
			5	SS	46/0.1				○ ⊢		5 40 46 9
			6	SS	107/.15		288				
286.9			7	SS	125/.15		287				
4.7	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 2.2 m (Elev. 289.4 m) upon completion of drilling.

2. Borehole caved at a depth of 3.5 m (Elev. 288.1 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C40-2

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4874318.3 ;E 297691.6 ORIGINATED BY TT

DIST Central HWY 400 BOREHOLE TYPE D-50 Track Mount, 108 mm Diameter Solid Stem Augers COMPILED BY SKB/HS

DATUM Geodetic DATE December 9, 2010 CHECKED BY LCC

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
292.2	GROUND SURFACE										
0.0	Organic silty sand, trace rootlets (FILL)		1A	SS	4		292				
0.3	Loose Black Moist		1B								
291.1	Clayey silt, some sand (FILL)		2A	SS	4						
1.1	Soft Brown Moist		2B			▽	291				
	Sand and silt, trace gravel, trace clay, trace organics (FILL)		3A	SS	15				H		
290.2	Firm to stiff Brown		3B								
2.0	Moist to wet						290				
	SAND and SILT, trace to some gravel, trace clay, some sand pockets (TILL)		4	SS	59				○		5 45 45 5
	Very dense Brown to grey below 5.4 m Moist		5	SS	104		289		○ H		16 41 40 3
	Augers grinding at a depth of 3.7 m		6	SS	100/.23						
							288				
			7	SS	100/.20				○H		
							287				
285.9			8	SS	100/.18		286		○		3 41 49 7
6.3	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 1.4 m (Elev. 290.8 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C40-3

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4874361.6 ;E 297716.8 ORIGINATED BY SB

DIST Central HWY 400 BOREHOLE TYPE D-90 Truck Mount, 108 mm Inner Diameter Hollow Stem Augers COMPILED BY CS/HS

DATUM Geodetic DATE March 24, 2011 CHECKED BY LCC

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
291.7	GROUND SURFACE										
0.0	Sand and gravel (FILL) Compact Brown Moist										
290.9							291				
0.8	Clayey silt, trace sand, trace gravel (FILL) Firm to stiff Brown Moist		1	SS	5						
			2	SS	9		290				
			3	SS	10		289				
288.7											
3.0	SAND and SILT, trace to some clay, trace gravel (TILL) Compact to very dense Brown to grey below 7.0 m Moist		4	SS	16	▽	288				5 44 46 5
			5	SS	30						
			6	SS	40		287				3 36 48 13
			7	SS	76/.15		286				
							285				
283.8			8	SS	70/.15		284				3 37 54 6
7.9	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 3.8 m (Elev. 287.9 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C40-4

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4874316.9 ;E 297744.2 ORIGINATED BY TT
DIST Central HWY 400 BOREHOLE TYPE CME-55 Track Mount, 108 mm Diameter Solid and Inner Diameter Hollow Stem Augers COMPILED BY JC/HS
DATUM Geodetic DATE July 26, 2011 CHECKED BY LCC

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
290.7	GROUND SURFACE										
0.0	TOPSOIL										
0.1	CLAYEY SILT, some sand, trace gravel, trace organics and rootlets		1	SS	4		290				
290.0	Soft										
0.7	Brown Moist		2	SS	15						
	Sandy SILT, trace gravel, some clay (TILL) Very stiff Brown and grey Moist		3A 3B	SS	28		289				
288.4											
2.3	SAND and SILT, trace clay, trace gravel (TILL) Very dense Grey Moist		4	SS	72		288				
			5	SS	101						
			6	SS	102	▽	287				2 45 49 4
			7	SS	95		286				
285.1											
5.6	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Grey Moist		8	SS	63		285				
							284				
			9	SS	63		283				
							282				
281.1			10	SS	104						
9.6	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 4.3 m (Elev. 286.4 m) upon completion of drilling.

2. Open borehole caved at a depth of 5.2 m (Elev. 285.5 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C5-6-1

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4873633.0 ;E 297916.5 ORIGINATED BY RA

DIST Central HWY 400 BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY HS/NK

DATUM Geodetic DATE December 2 to 5, 2013 CHECKED BY LCC

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
304.0	GROUND SURFACE										
0.0	TOPSOIL		1A								
0.2	Clayey silt, trace sand, trace gravel, trace to some sand lenses and rootlets (FILL) Firm to stiff Brown Moist		1B	SS	8				○		
302.9			2A	SS	11		303				
302.6	Silty sand, trace gravel (FILL) Compact Brown Moist		2B								
1.4			3	SS	8		302		○		
301.8	CLAYEY SILT, trace sand, trace gravel Firm Brown Moist										
2.2			4	SS	18				○H		3 42 48 7
	SAND and SILT to Silty SAND, trace clay, trace to some gravel (TILL) Compact to very dense Brown with oxidation staining to grey below 6.1 m Moist to wet below 4.0 m		5	SS	33		301				
			6	SS	57	▽	300		○	NP	17 56 21 6
			7	SS	66		299				
	Augers grinding below a depth of 6.6 m						298				
			8	SS	50/0.08		297				
294.9							296				
9.1	SAND, some silt, trace clay Very dense Grey Wet		9	SS	90/0.28		295				
							294				
293.1			10	SS	50/0.13				○		0 86 10 4
10.9	END OF BOREHOLE										

NOTE:

1. Water level in augers measured at a depth of 5.3 m (Elev. 298.7) on December 5, 2013.

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

Golder Associates

RECORD OF BOREHOLE No C5-6-2

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018 | G.W.P. 2835-02-00 | LOCATION N 4873628.1 ;E 297891.8 | ORIGINATED BY RA

DIST Central HWY 400 | BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers | COMPILED BY HS/NK

DATUM Geodetic | DATE December 5, 2013 | CHECKED BY LCC

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 / 304.0	ASPHALT (355 mm)										
303.6 / 0.8	Sand and gravel (FILL) Brown Moist		1	AS	-		304				
	Sand and silt, some clay, trace gravel, trace organics, sand lenses (FILL) Loose Brown with black staining Moist		2	SS	8						
302.2			3	SS	8		303				
2.2	CLAYEY SILT, some sand, trace gravel Stiff Brown Moist		4	SS	10		302				
300.7			5	SS	11		301				0 18 56 26
3.7	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Brown Moist		6	SS	64/0.23						
			7	SS	72		300				5 39 44 12
			8	SS	98		299				
	Augers grinding below a depth of 6.6 m						298				
296.6			9A 9B	SS	79		297				
7.8	SAND and SILT, trace clay Very dense Brown and grey Wet										
			10	SS	61		296				
294.3							295				0 53 43 4
10.1	SAND, trace to some silt Very dense Brown and grey Wet		11	SS	92		294				
			12	SS	94/0.28		293				
291.8							292				
12.6	END OF BOREHOLE										

NOTE:

1. Borehole dry on completion of drilling.

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

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Golder Associates

RECORD OF BOREHOLE No C5-6-3

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4873624.5 ;E 297880.6 ORIGINATED BY RA

DIST Central HWY 400 BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY HS/NK

DATUM Geodetic DATE December 1 and 2, 2013 CHECKED BY LCC

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
304.4	GROUND SURFACE						304				
0.0	ASPHALT (200 mm)										
303.8	Sand and gravel (FILL) Brown Moist		1	AS	-						
0.6	Sand, trace silt (FILL) Loose		2A 2B	SS	7						
303.3	Brown Moist						303				
1.1	Clayey silt with sand, trace gravel, trace organics and topsoil inclusions (FILL) Soft to stiff Brown Moist		3	SS	13						3 39 46 12
			4	SS	3		302				
301.4											
3.0	CLAYEY SILT, trace to some sand, trace gravel Stiff Brown Moist		5	SS	12		301				
300.7											
3.7	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff to hard Brown becoming grey below 6.1 m Moist		6	SS	18						
			7	SS	62		300				8 40 43 9
	Augers grinding between depths of 5.0 m and 7.6 m										
							299				
			8	SS	56		298				2 42 43 13
297.3											
7.1	SAND and SILT, trace clay, trace to some gravel Very dense Grey Moist to wet below 8.5 m		9	SS	50/0.13		297				
							296				
			10	SS	59		295				0 66 33 1
294.3											
10.1	SAND, trace to some silt Very dense Grey Wet		11	SS	81		294				
							293				
291.8			12	SS	95/0.28		292				
12.6	END OF BOREHOLE NOTE: 1. Borehole dry on completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No C5-6-4

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0018 | G.W.P. 2835-02-00 | LOCATION N 4873621.9 ;E 297865.3 | ORIGINATED BY RA

DIST Central | HWY 400 | BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers | COMPILED BY HS/NK

DATUM Geodetic | DATE November 27, 2013 | CHECKED BY LCC

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
304.5	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
0.2	Sand and gravel (FILL) Compact Brown		1	AS	-		304				
303.8											
0.7	Moist										
	Sandy silt, some clay, trace gravel, trace organics (FILL) Compact Brown with black staining Moist to wet		2	SS	15		303		○		
			3	SS	24				○		
302.4											
2.1	CLAYEY SILT, some sand, trace gravel Stiff Dark brown to brown Wet		4	SS	10		302		⊢○⊣		
			5	SS	13				⊢○⊣		3 17 48 32
300.8							301				
3.7	SAND, some silt, trace clay Compact to very dense Brown with oxidation stains Moist to wet		6	SS	23	▽			○		
			7	SS	54		300		○		0 88 11 1
298.9							299				
5.6	CLAYEY SILT with SAND to SILT and SAND, trace clay, trace gravel (TILL) Very stiff to hard/Compact to very dense Brown to brown and grey below 7.1 m Moist to wet below 7.1 m		8	SS	56		298		○		1 43 45 11
			9	SS	25		297		○		7 58 27 8
295.9							296				
8.6	SAND, some silt Dense to very dense Brown and grey Wet		10	SS	73		295		○		
			11	SS	40		294		○		
293.4											
11.1	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 4.3 m below ground surface (Elev. 300.2 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C5-6-5

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4873618.7 ;E 297846.5 ORIGINATED BY RA

DIST Central HWY 400 BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY HS/NK

DATUM Geodetic DATE November 27, 2013 CHECKED BY LCC

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
303.0	GROUND SURFACE										
0.0	TOPSOIL		1A								
0.2	Clayey silt, trace to some sand, trace gravel, containing rootlets (FILL) Firm to stiff Brown to dark brown Moist		1B	SS	5						
301.7			2	SS	9		302				
1.3	Sandy CLAYEY SILT, trace gravel Stiff Brown Moist		3	SS	11		301				1 27 53 19
300.8											
2.2	CLAYEY SILT with SAND, trace gravel (TILL) Hard Brown Moist to wet		4	SS	35	▽	300				
			5	SS	74				○		0 38 49 13
			6	SS	74		299				
297.4							298				
5.6	Silty SAND, trace clay, silt seams Very dense Brown Wet		7	SS	56		297		○		0 28 68 4
295.9							296				
7.1	SAND, trace to some silt, trace clay Compact to very dense Brown to grey Wet		8	SS	16		295				
			9	SS	62		294		○		0 87 12 1
291.9			10	SS	65		293				
11.1	END OF BOREHOLE						292				

NOTE:

1. Water level in open borehole at a depth of 3.0 m below ground surface (Elev. 300.0 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No C5-7-1

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0018

G.W.P. 2835-02-00 LOCATION N 4873602.1 ;E 297828.2 ORIGINATED BY RA

DIST Central HWY 400 BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY HS/NK

DATUM Geodetic DATE November 28, 2013 CHECKED BY LCC

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
303.1	GROUND SURFACE										
0.0	TOPSOIL		1A				303				
0.2	Sandy SILT, trace gravel, containing rootlets		1B	SS	4						
302.4	Very loose to loose										
0.7	Brown Moist CLAYEY SILT with SAND, trace gravel (TILL) Firm to hard Brown Moist		2	SS	5		302				
			3	SS	10						1 44 46 9
			4	SS	20		301				
	Broken rock fragments at a depth of 3.0 m		5	SS	66		300				
			6	SS	54		299				2 37 44 17
			7	SS	47		298				
296.9			8A				297				
6.2	SAND, some silt, trace clay Compact to very dense Brown Wet		8B	SS	15						
			9	SS	41		296				0 86 13 1
			10	SS	87		295				
			11	SS	99/0.23		294				
	Containing silt seams below a depth of 11.7 m						293				
290.5			12	SS	78		292				
12.6	END OF BOREHOLE						291				

NOTE:

1. Borehole dry on completion of drilling.

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

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Golder Associates

RECORD OF BOREHOLE No C5-7-2

SHEET 1 OF 2

METRIC

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

LOCATION N 4873586.6 ;E 297829.2
BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers
DATE November 28, 2013 to December 1, 2013

ORIGINATED BY RA
COMPILED BY HS/NK
CHECKED BY LCC

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
304.0	GROUND SURFACE										
0.0	TOPSOIL		1A								
0.2	CLAYEY SILT, some sand, trace gravel, sandy silt pockets and rootlets Firm to stiff Brown to dark brown Moist		1B	SS	6						
302.8			2	SS	8		303				
1.2	SAND and SILT, trace clay, trace to some gravel (TILL) Loose to very dense Brown Moist		3	SS	7		302				
			4	SS	9						3 42 46 9
			5	SS	46		301				
			6	SS	57		300				
			7	SS	69		299				3 49 40 8
	Augers grinding below a depth of 5.0 m										
			8	SS	89		298				
							297				
			9	SS	71		296				
295.4											
8.6	SAND, trace to some silt, trace clay Very dense Brown Wet		10	SS	93/0.28		295				0 93 6 1
							294				
	Containing sandy silt seams below a depth of 10.7 m		11	SS	98		293				
							292				
291.5			12	SS	50/0.13						
12.5											

Continued Next Page

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

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

Golder Associates

RECORD OF BOREHOLE No C5-7-2

SHEET 2 OF 2 **METRIC**

PROJECT 09-1111-0018
G.W.P. 2835-02-00 LOCATION N 4873586.6 ;E 297829.2 ORIGINATED BY RA
DIST Central HWY 400 BOREHOLE TYPE 200 mm O.D. Continuous Flight Hollow Stem Augers COMPILED BY HS/NK
DATUM Geodetic DATE November 28, 2013 to December 1, 2013 CHECKED BY LCC

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 NOTES: 1. Borehole caved in to a depth of 9.1 m (Elev. 294.9 m) upon removal of augers. 2. Borehole dry on completion of drilling. 3. Water level measurements in piezometer: Date Depth (m) Elev. (m) 01/07/14 4.6 299.4										

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

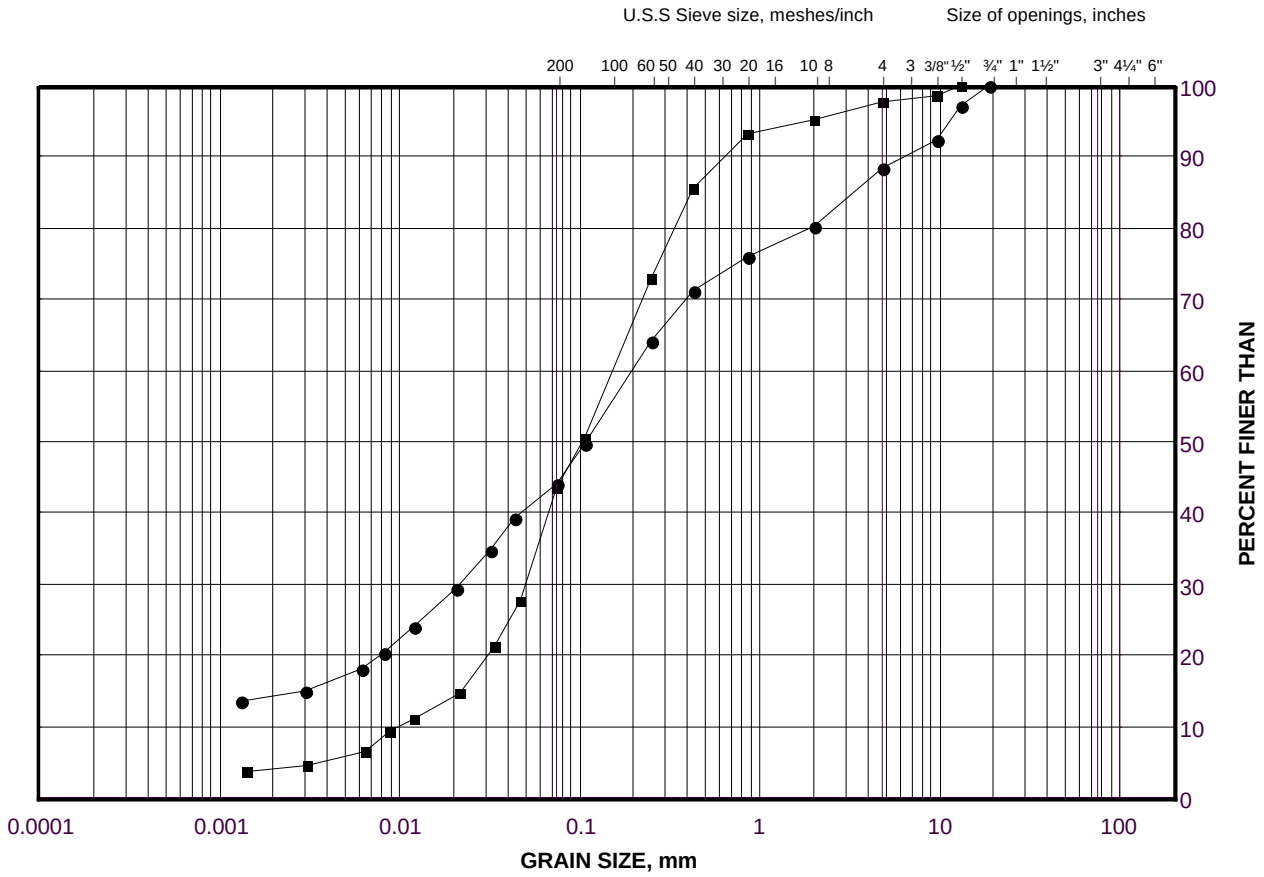
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand and Silt (Fill)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C38-2	3	307.8
■	C39-2	3	305.9

Project Number: 09-1111-0018

Checked By: NK

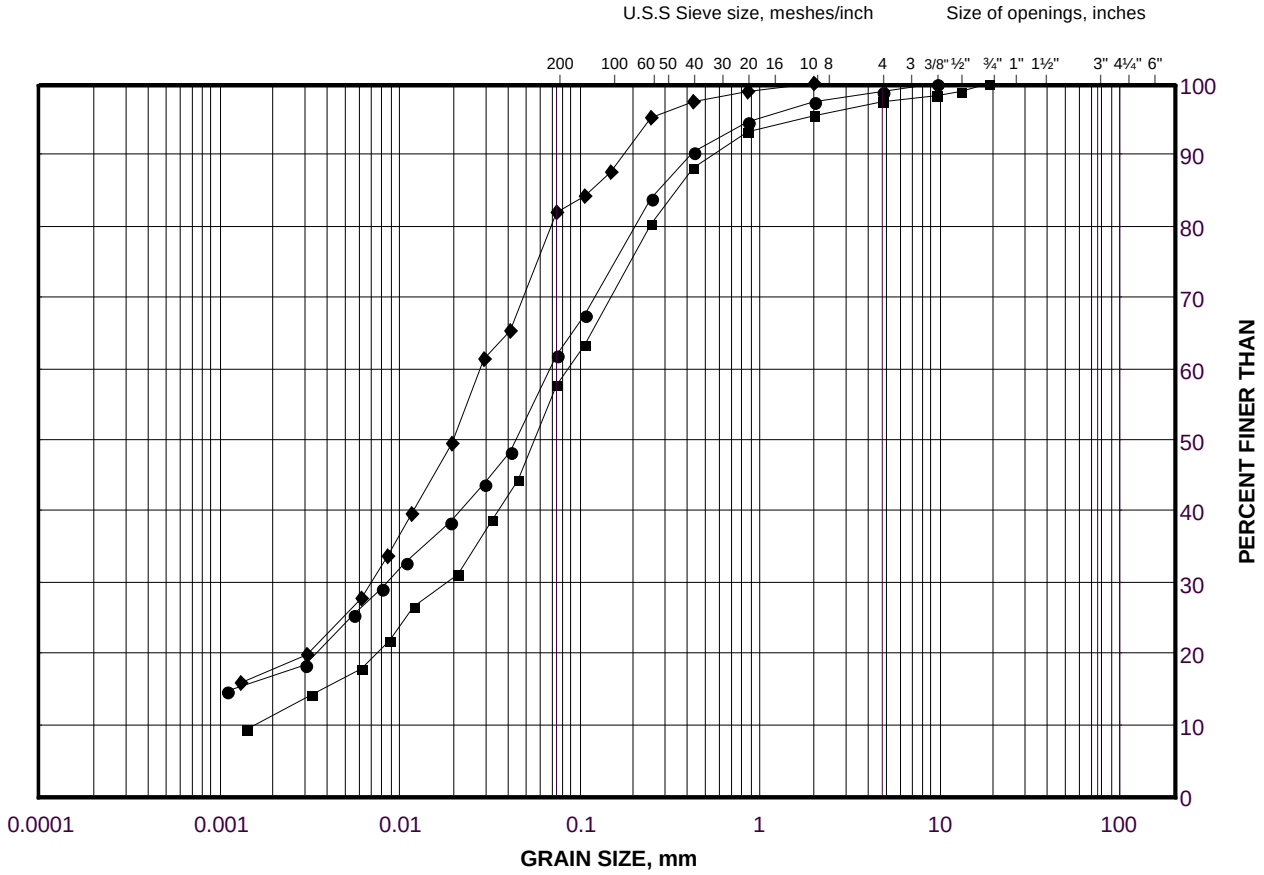
Golder Associates

Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (Fill)

FIGURE B2



LEGEND

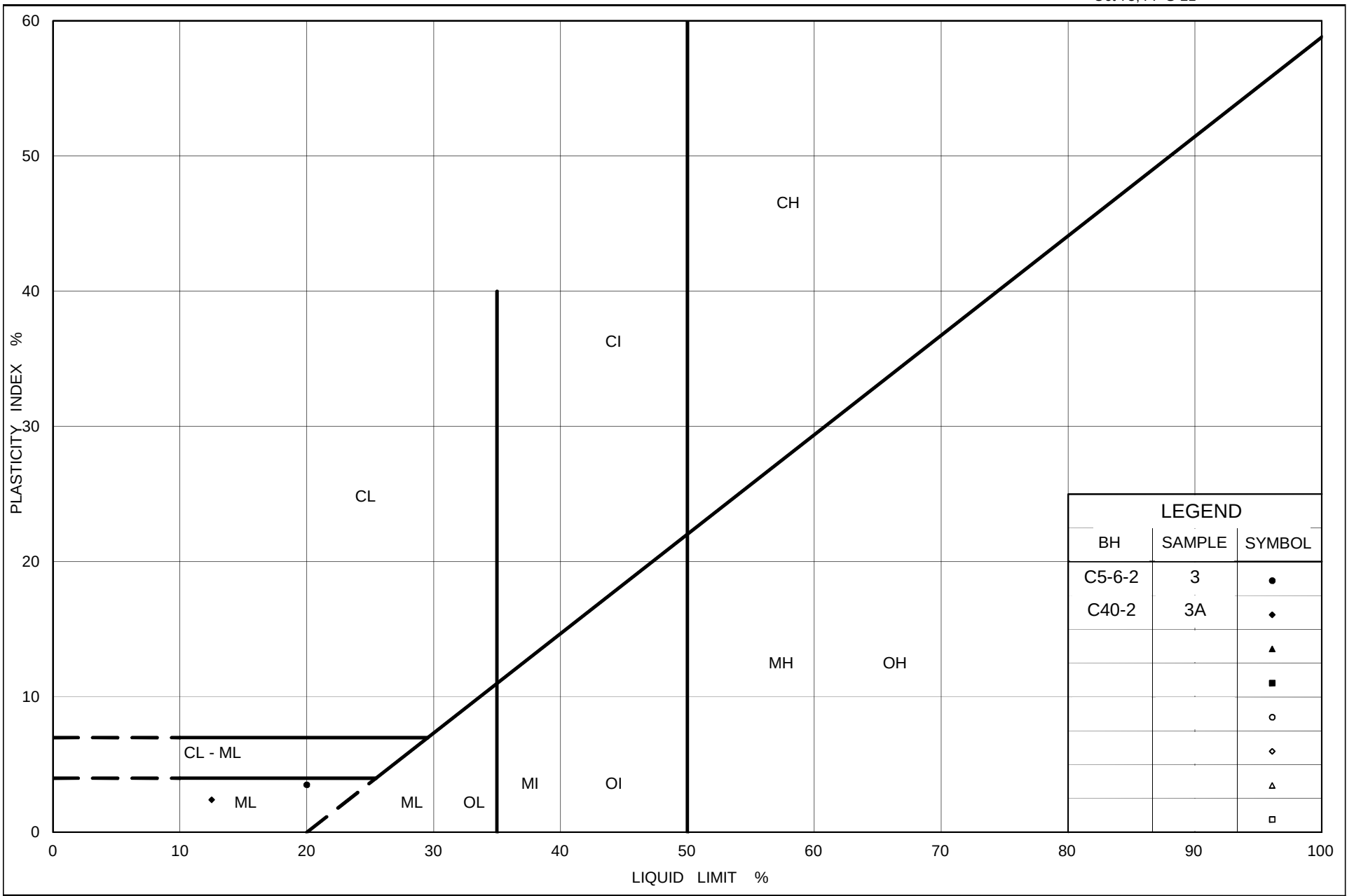
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C39-3	2	306.1
■	C5-6-3	3	302.6
◆	C38-3	3	307.2

Project Number: 09-1111-0018

Checked By: NK

Golder Associates

Date: 15-Jul-15



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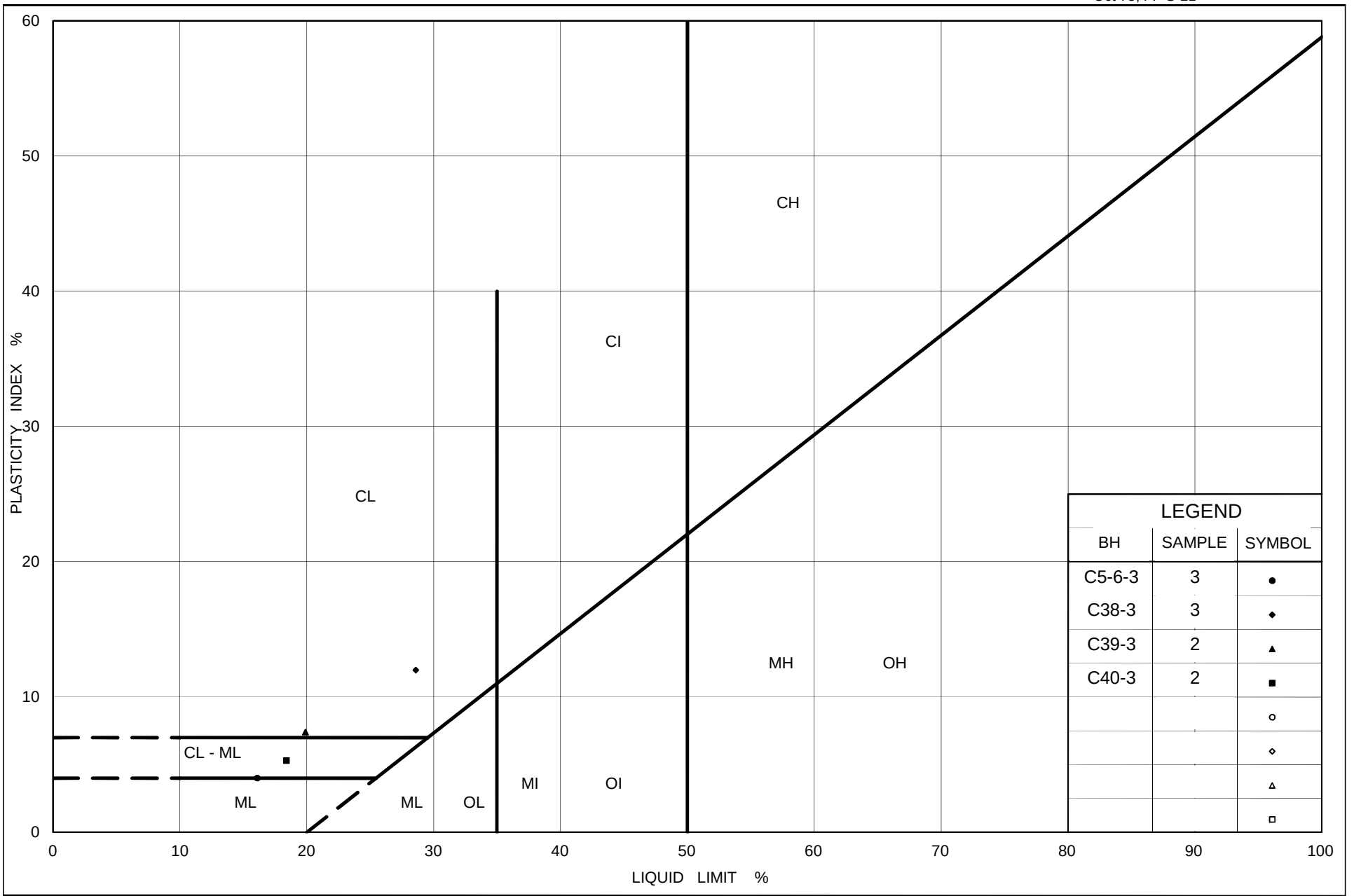
Ontario

PLASTICITY CHART
Sand and Silt (Fill)

Figure No. B3

Project No. 09-1111-0018

Checked By: NK



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PLASTICITY CHART
Clayey Silt to Clayey Silt with Sand (Fill)

Figure No. B4

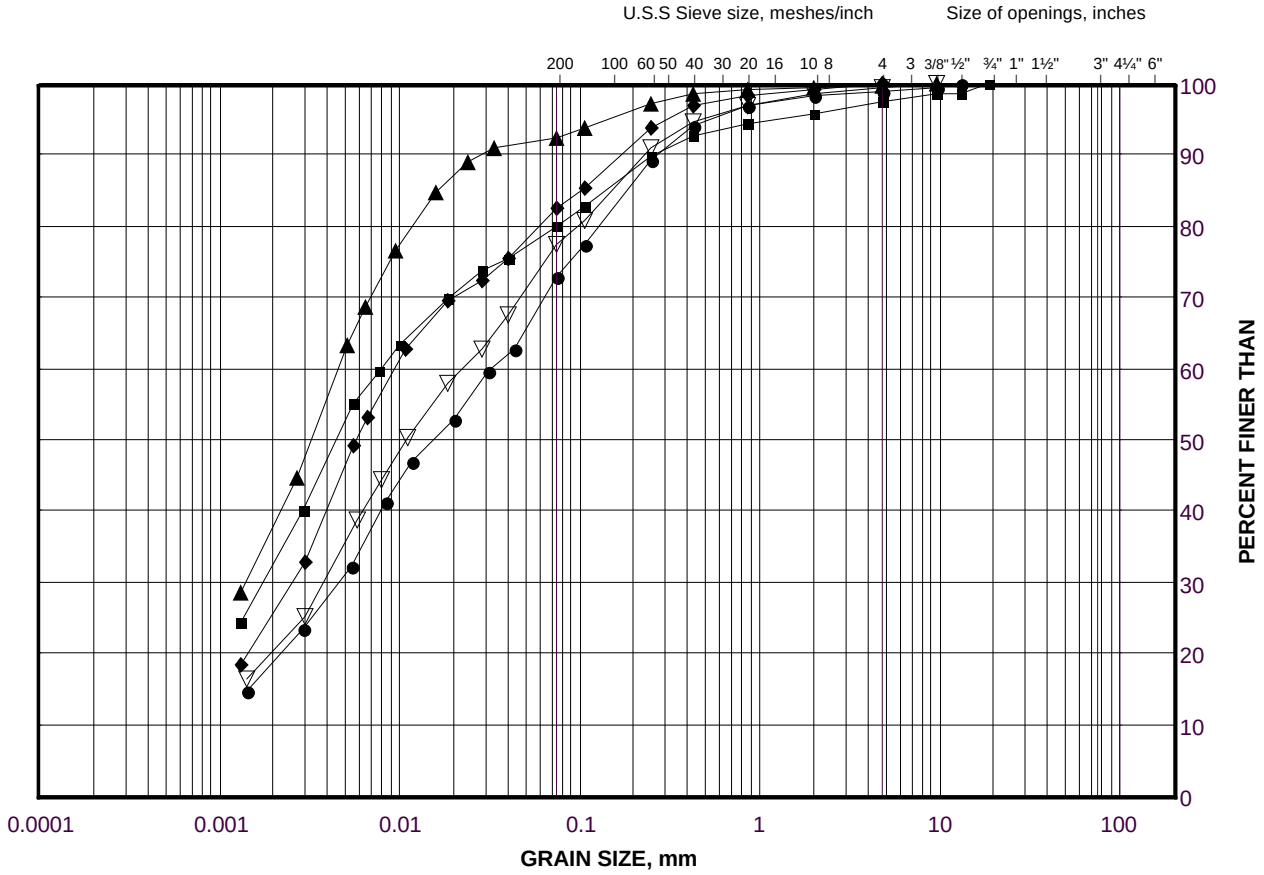
Project No. 09-1111-0018

Checked By: NK

GRAIN SIZE DISTRIBUTION

Clayey Silt to Sandy Clayey Silt

FIGURE B5



LEGEND

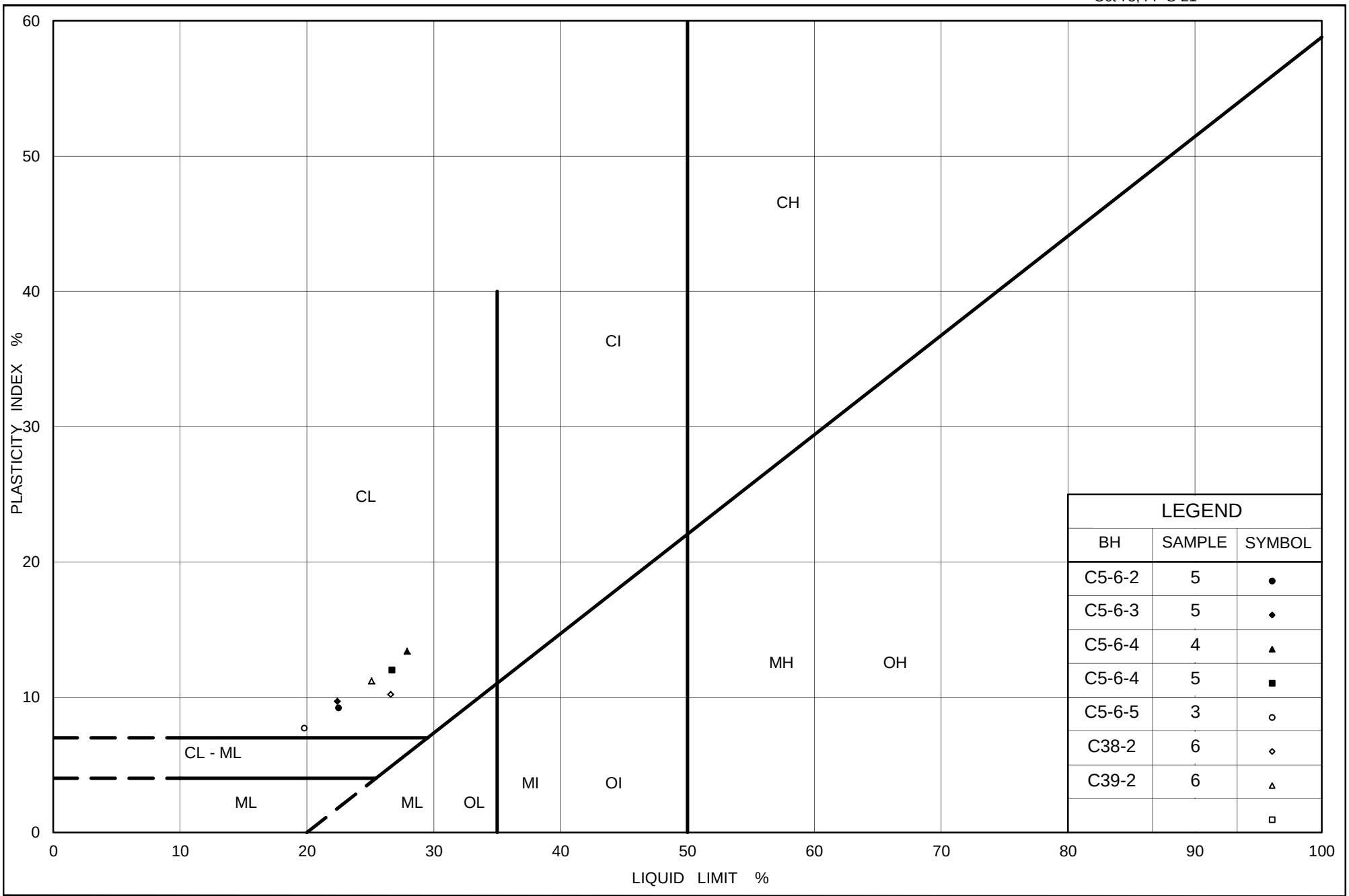
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-6-5	3	301.2
■	C5-6-4	5	301.2
◆	C5-6-2	5	301.1
▲	C38-2	6	305.6
▽	C39-2	6	303.6

Project Number: 09-1111-0018

Checked By: NK

Golder Associates

Date: 15-Jul-15



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Sandy Clayey Silt

Figure No. B6

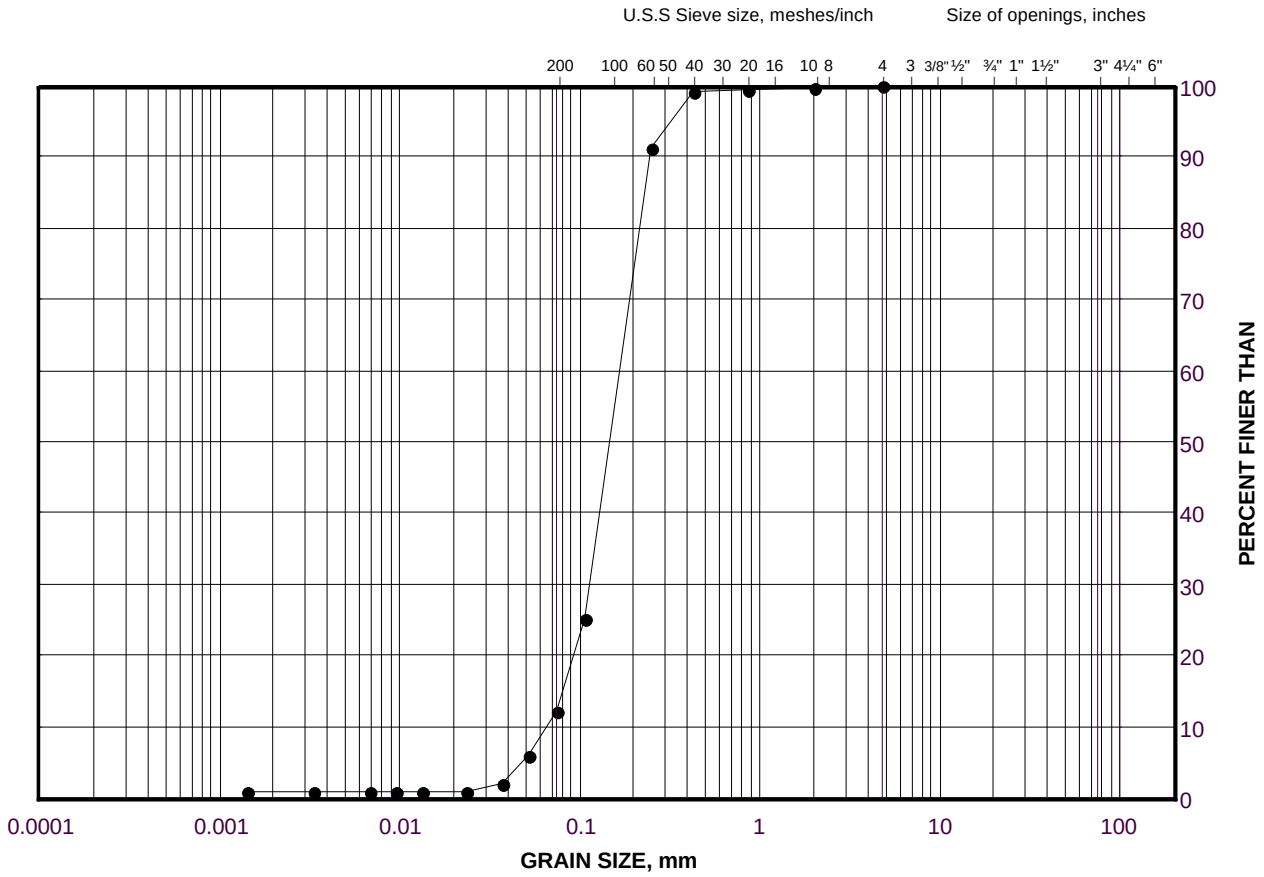
Project No. 09-1111-0018

Checked By: NK

GRAIN SIZE DISTRIBUTION

Sand

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-6-4	7	299.7

Project Number: 09-1111-0018

Checked By: NK

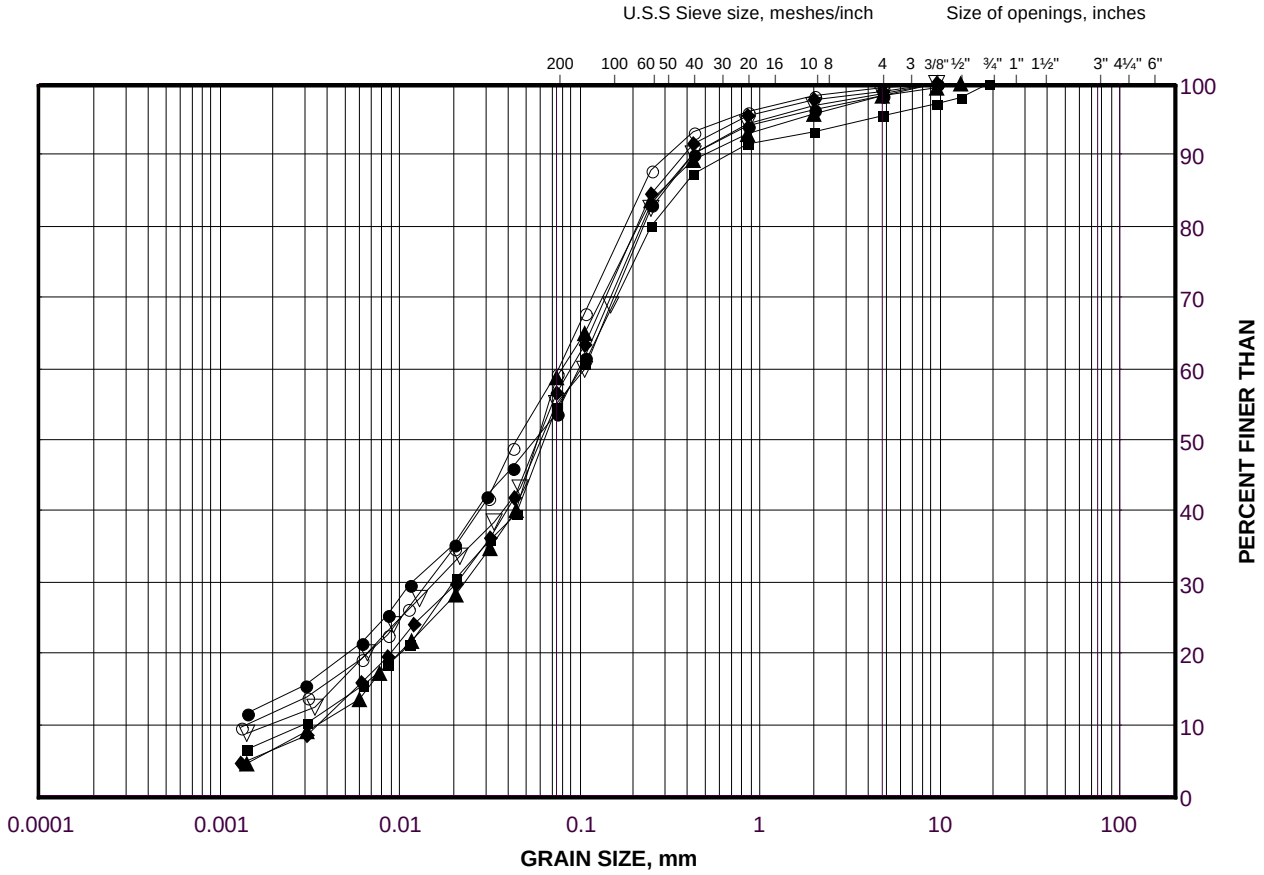
Golder Associates

Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE B8A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C38-1	3	305.4
■	C38-4	3	305.4
◆	C39-1	3	303.3
▲	C38-4	5	303.8
▽	C38-3	6	304.9
❍	C38-1	7	302.3

Project Number: 09-1111-0018

Checked By: NK

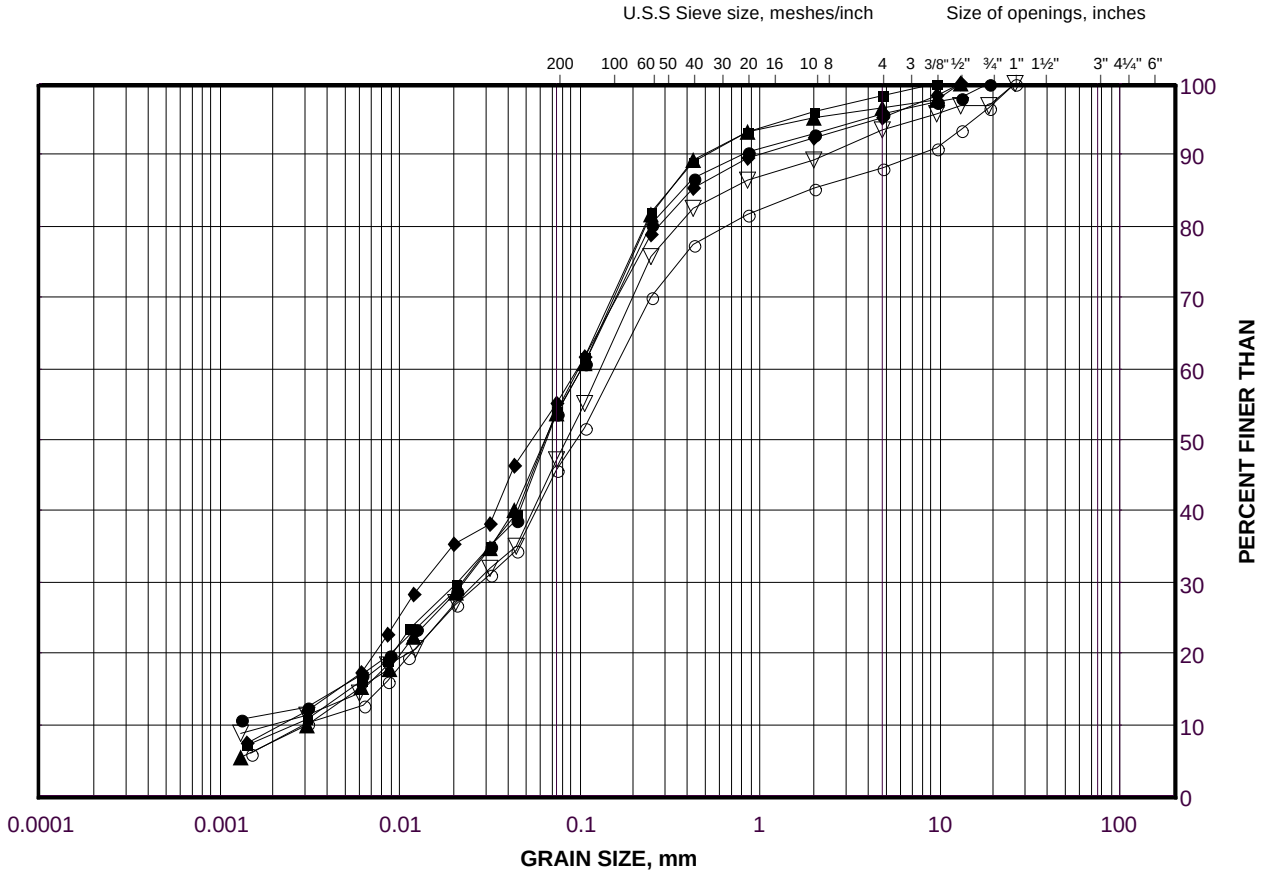
Golder Associates

Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Clayey Silt to Sand and Silt (Till)

FIGURE B8B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C39-2	11	296.9
■	C39-4	4	302.5
◆	C40-1	5	288.4
▲	C39-1	5	301.7
▽	C39-4	6	301.0
❍	C39-2	9	299.9

Project Number: 09-1111-0018

Checked By: NK

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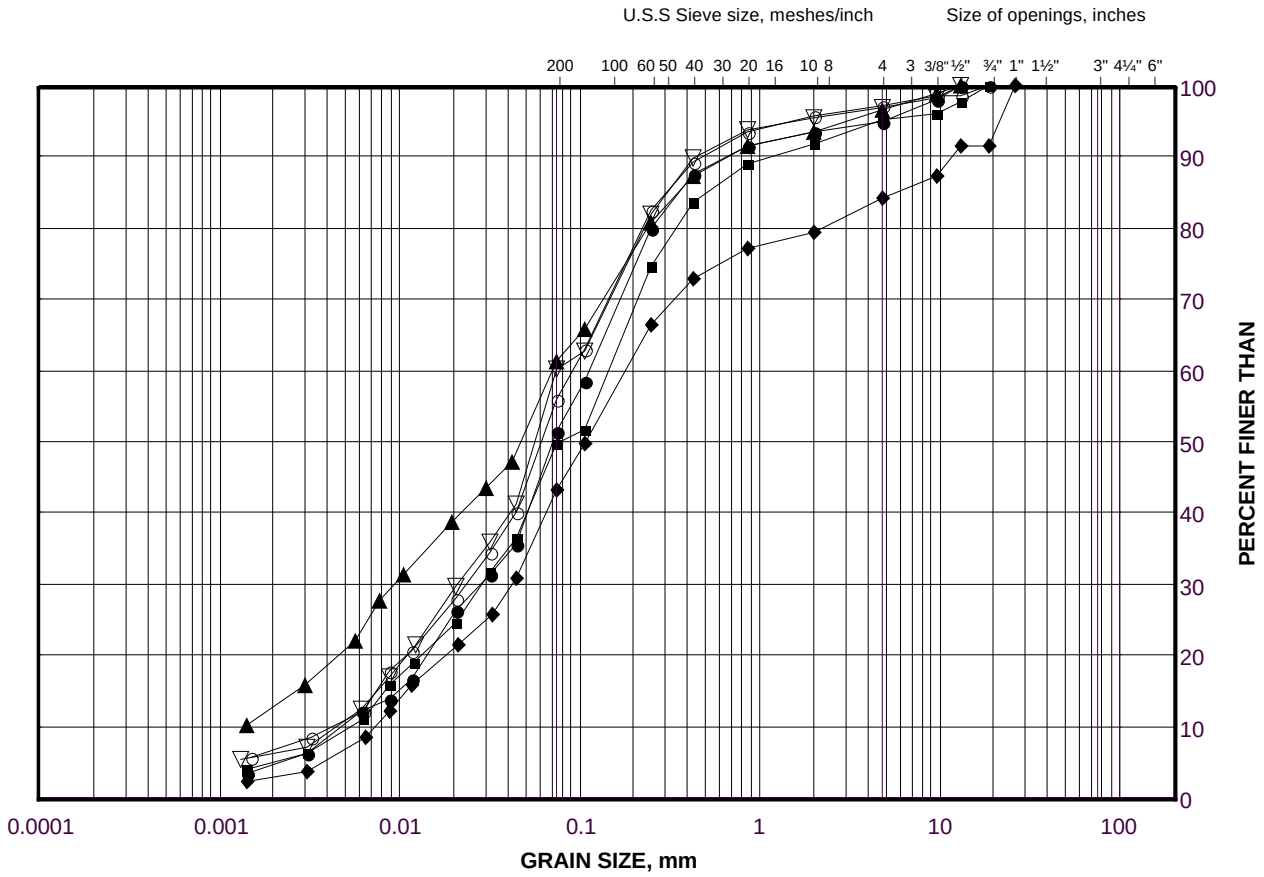
Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Sand and Silt (Till)

FIGURE B8C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C40-3	4	288.3
■	C40-2	4	289.6
◆	C40-2	5	288.9
▲	C40-3	6	286.8
▽	C40-3	8	283.9
❍	C40-2	8	286.0

Project Number: 09-1111-0018

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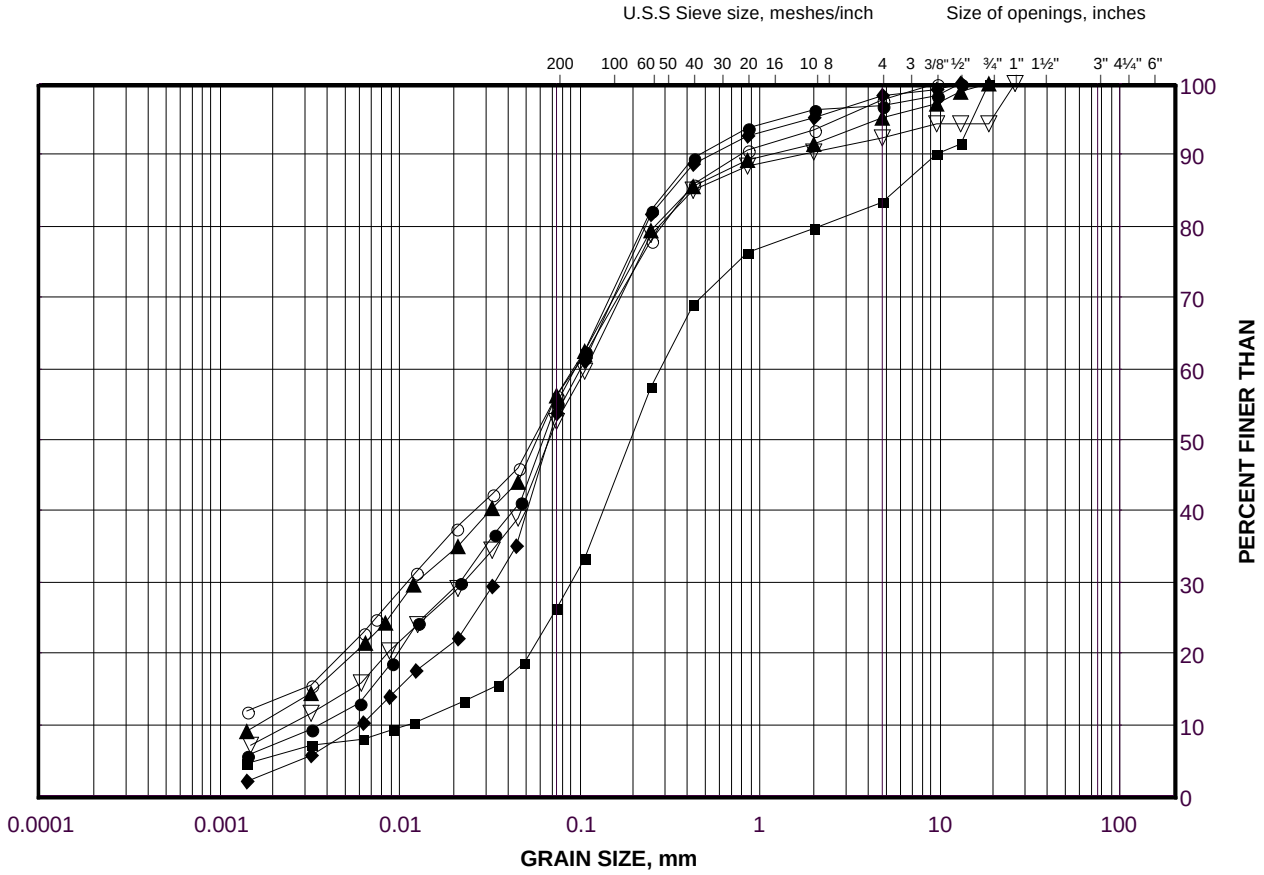
Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Sand (Till)

FIGURE B8D



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-6-1	4	301.4
■	C5-6-1	6	299.2
◆	C40-4	6	286.6
▲	C5-6-2	7	299.6
▽	C5-6-3	7	299.6
❍	C5-6-3	8	298.1

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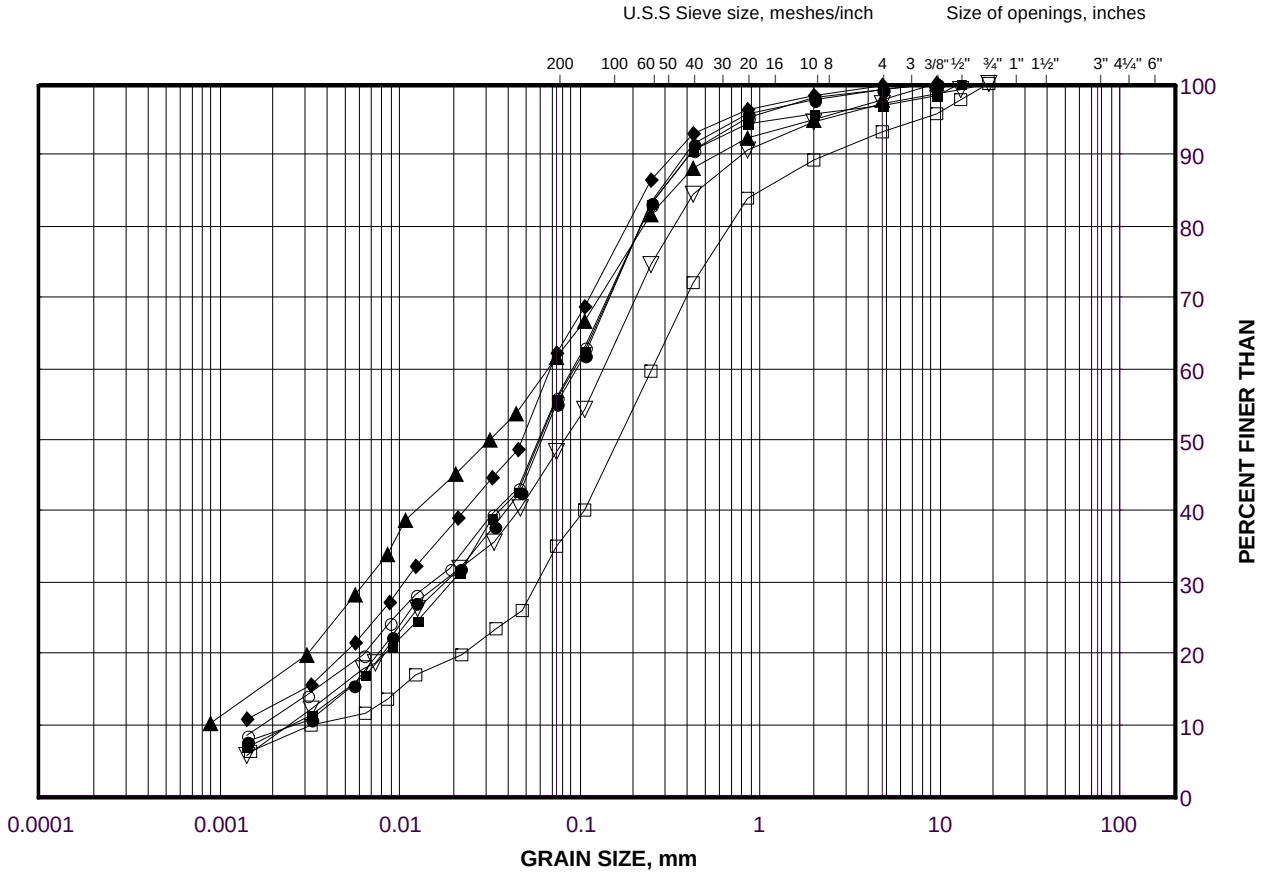
GRAIN SIZE DISTRIBUTION

Clayey Silt to Sand and Silt (Till)

FIGURE B8E



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-7-1	3	301.3
■	C5-7-2	4	301.4
◆	C5-6-5	5	299.8
▲	C5-7-1	6	299.1
▽	C5-7-2	7	299.2
❍	C5-6-4	8	298.2
□	C5-6-4	9	296.7

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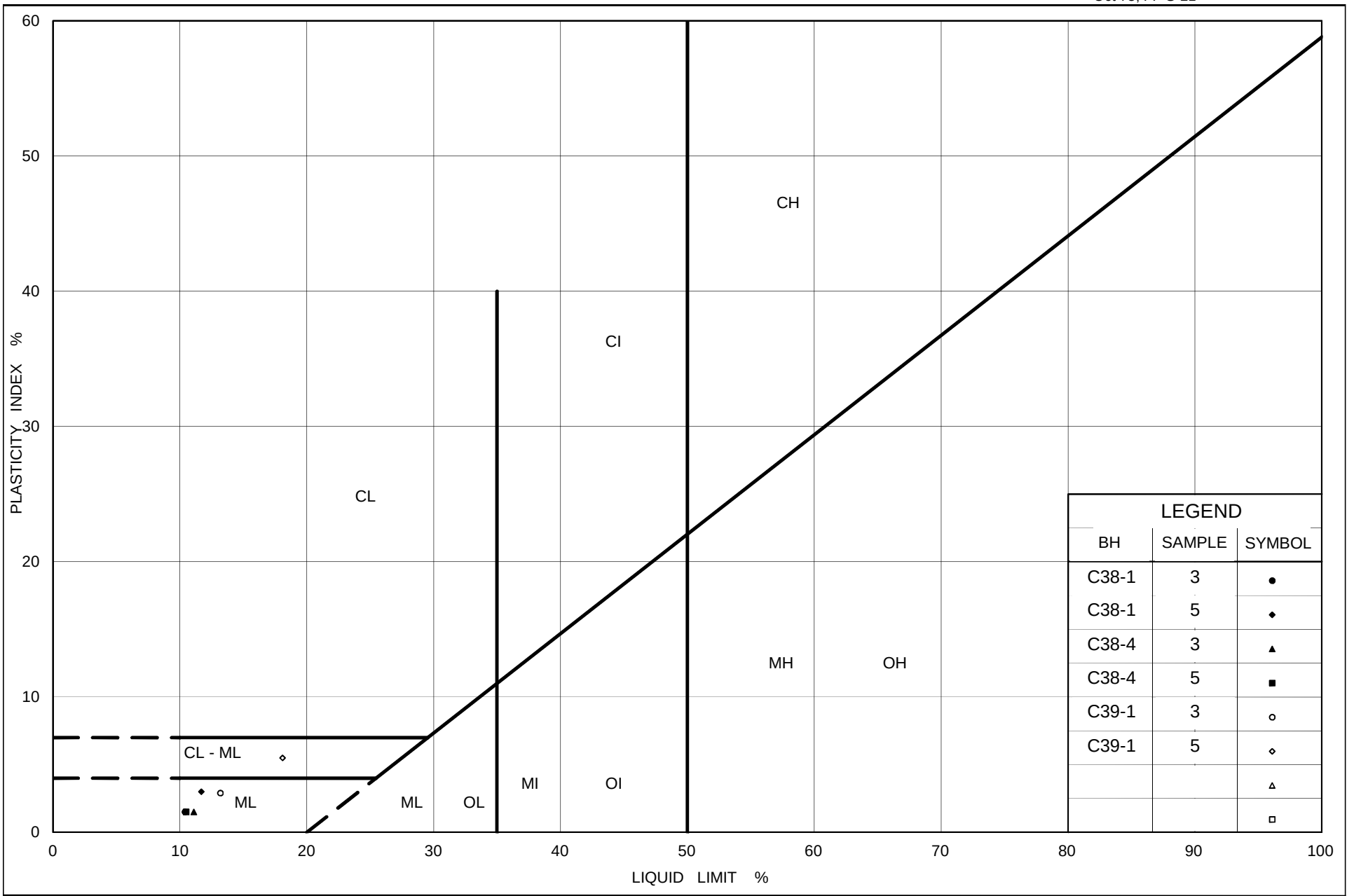


Ministry of Transportation

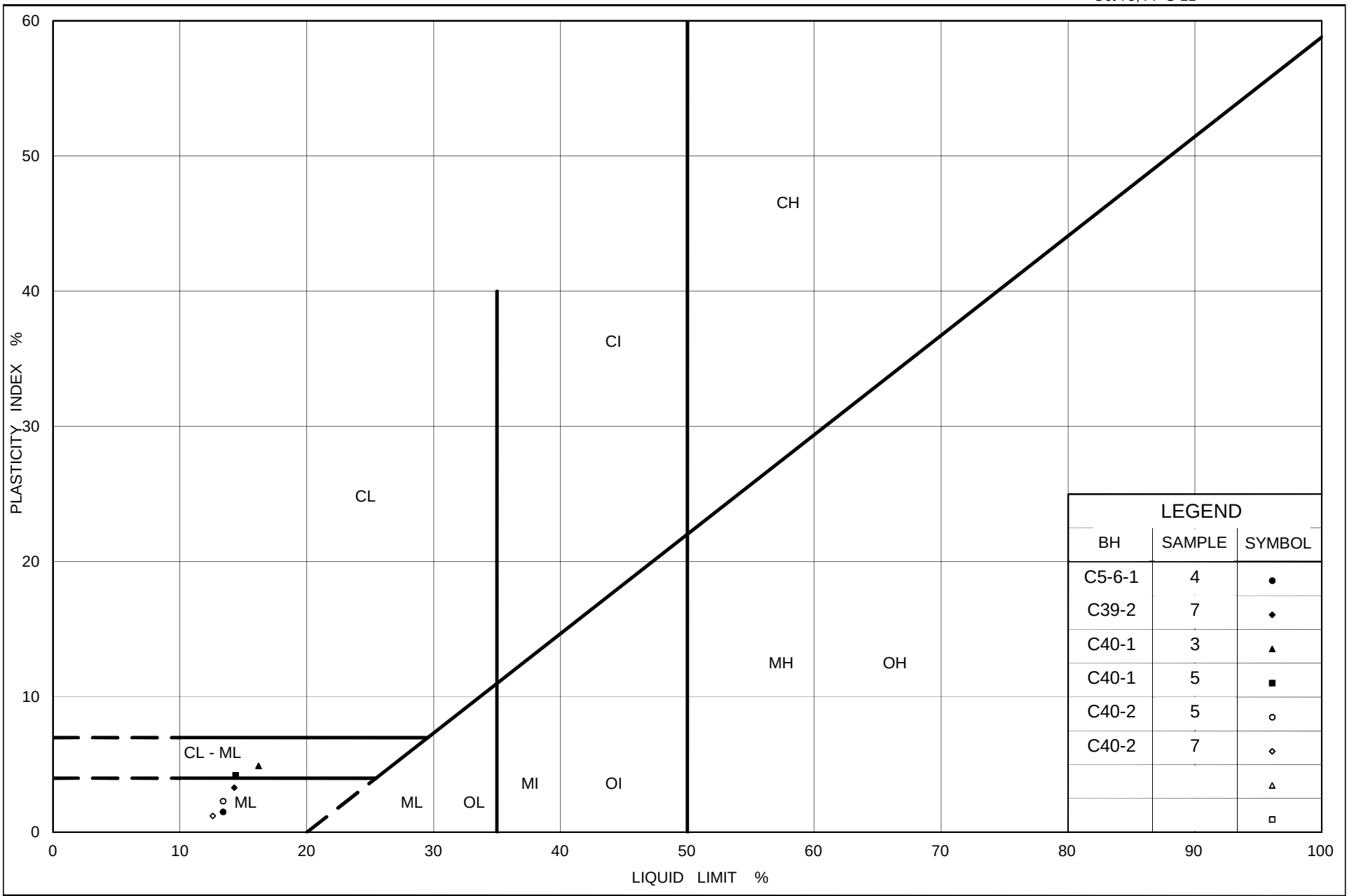
Ontario

PLASTICITY CHART
Clayey Silt to Sand and Silt (Till)

Figure No. B9A

Project No. 09-1111-0018

Checked By: NK



Ministry of Transportation

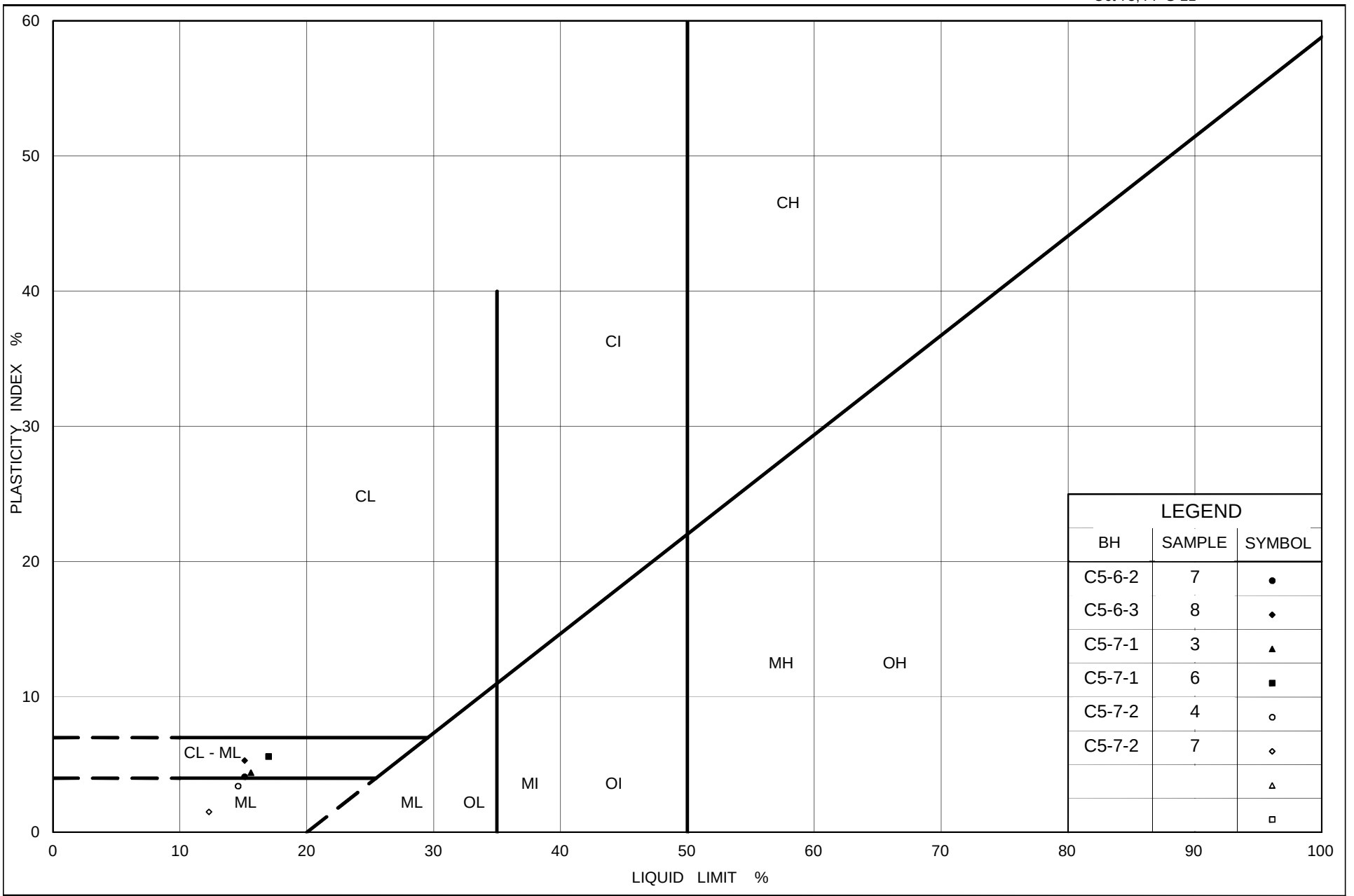
Ontario

PLASTICITY CHART
Clayey Silt with Sand to Sand and Silt (Till)

Figure No. B9B

Project No. 09-1111-0018

Checked By: NK



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Sand and Silt (Till)

Figure No. B9C

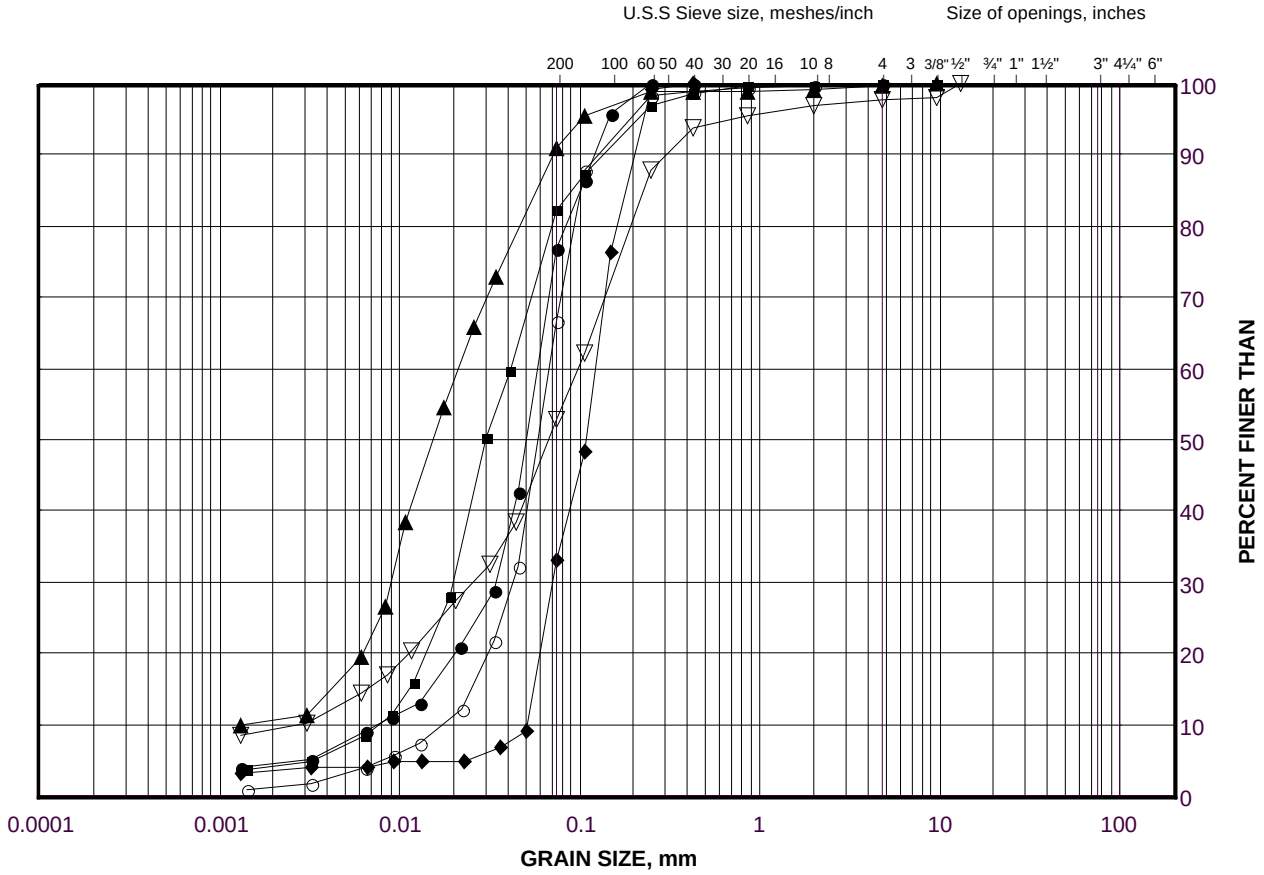
Project No. 09-1111-0018

Checked By: NK

GRAIN SIZE DISTRIBUTION

Sand to Silt

FIGURE B10A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C38-3	13	294.3
■	C38-2	13	295.6
◆	C38-3	8	301.9
▲	C38-1	8	300.8
▽	C38-2	9	301.7
❍	C39-1	9	297.2

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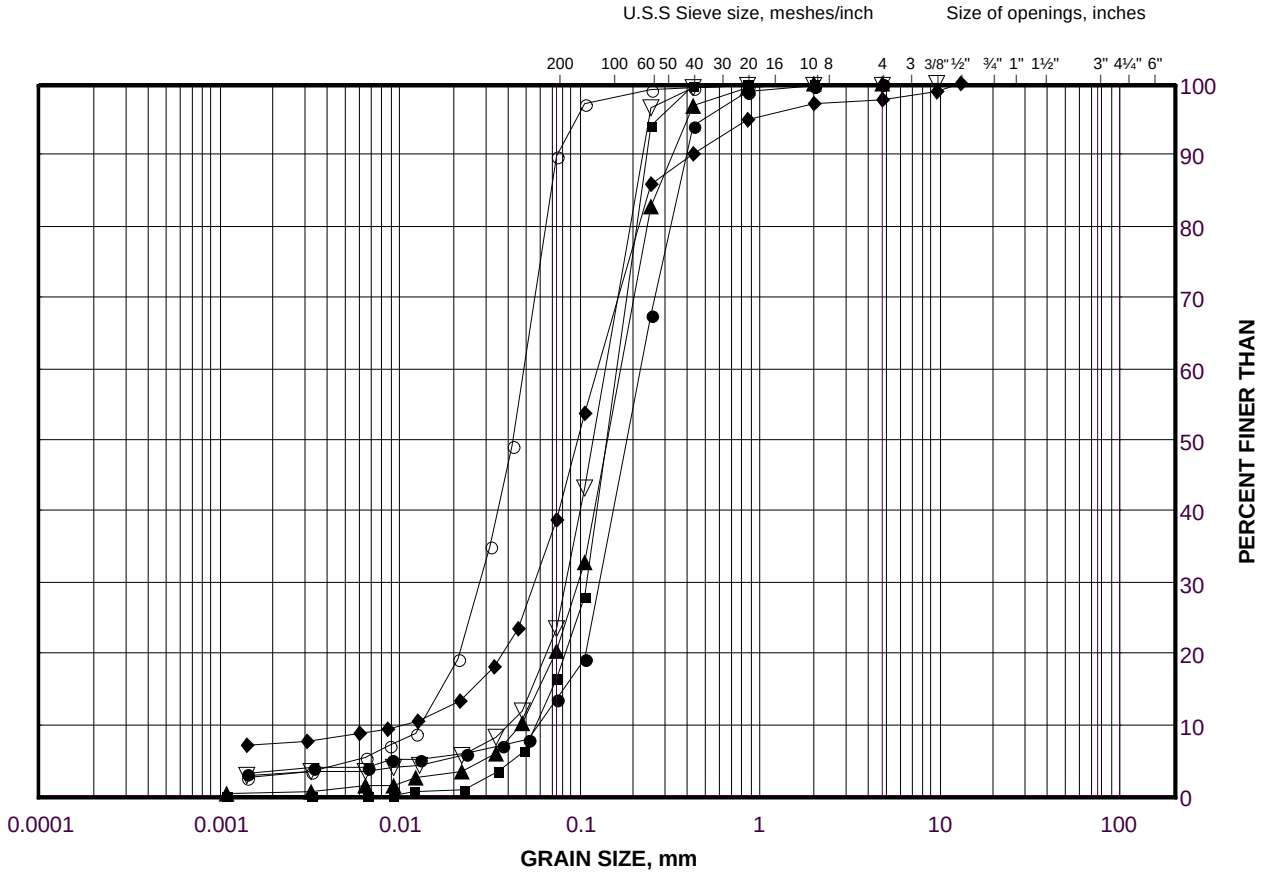
GRAIN SIZE DISTRIBUTION

Sand to Silt

FIGURE B10B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-6-1	10	293.2
■	C39-3	10	297.0
◆	C39-4	10	295.7
▲	C39-3	12	294.0
▽	C39-2	14	292.2
❍	C39-4	8B	298.6

Project Number: 09-1111-0018

Checked By: NK

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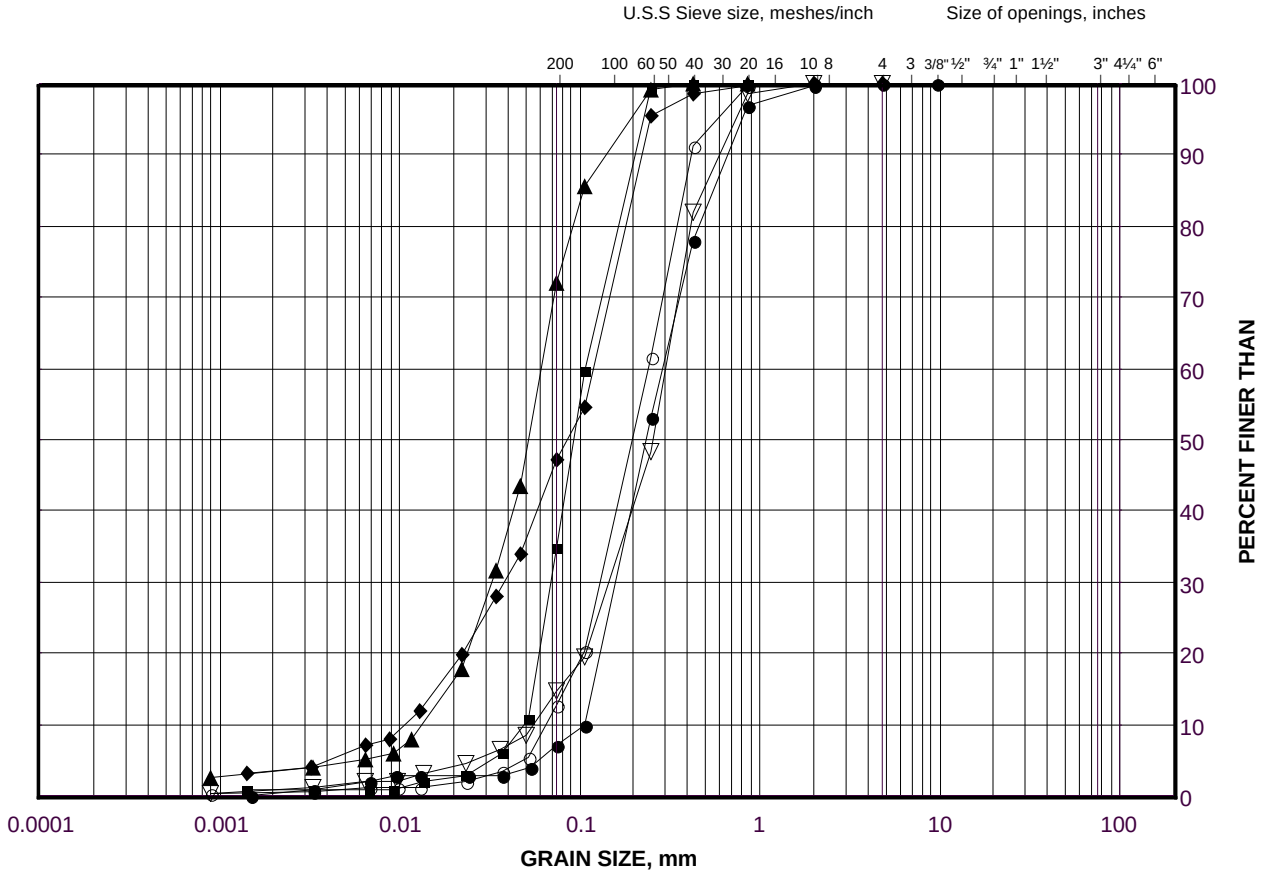
Date: 15-Jul-15

GRAIN SIZE DISTRIBUTION

Sand to Silt

FIGURE B10C



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C5-7-2	10	294.7
■	C5-6-3	10	295.0
◆	C5-6-2	10	295.0
▲	C5-6-5	7	296.7
▽	C5-7-1	9	295.3
❍	C5-6-5	9	293.7

Project Number: 09-1111-0018

Checked By: NK

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Date: 15-Jul-15

APPENDIX C

Non-Standard Special Provisions

DEWATERING – Item No.

Special Provision

SCOPE

The work under this item includes the design, installation, operation, maintenance and removal of temporary dewatering systems to facilitate the culvert replacements.

Foundations for the replacement culverts will require excavation below the groundwater level. Cohesionless soils below the groundwater table will be subjected to conditions of unbalanced hydrostatic head and can slough, boil and cave-in during temporary excavation work.

REFERENCES

OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS 518 Construction Specification for Control of Water from Dewatering Operations

SUBMISSION AND DESIGN REQUIREMENTS

Written details for the proposed dewatering system shall be submitted to the Contract Administrator for information purposes a minimum of ten business days prior to commencing dewatering operations. The Contractor shall reference borehole logs included in the Contract Documents as a guide in determining requirements.

CONSTRUCTION

Dewatering System

The Contractor is responsible for the design, installation, operation and maintenance of an adequate dewatering system to lower the groundwater level to at least 0.3 m below the founding level for the replacement culverts, to allow excavation, subgrade preparation and construction in dry conditions.

Operation

A continuous dewatering operation shall be provided to facilitate the installation of the replacement culverts at all times during the work. All components of the dewatering system shall be maintained in an effective, functioning and stable condition at all times during the work. Notwithstanding the above, the work shall be completed in accordance with the environmental and operational constraints specified elsewhere in the contract.

Restoration

All equipment and materials placed shall be removed from the right-of-way upon the completion of the work and all areas disturbed as part of this work shall be restored to their preconstruction conditions, unless specified otherwise.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

SUBGRADE PROTECTION - Item No.

Non-Standard Special Provision

The subgrade soils for the footing subgrade level may be susceptible to disturbance and loosening from construction traffic and ponded water.

If the concrete for the footings on the native or engineered fill pad for an open footing culvert cannot be poured immediately after excavation or the backfill/bedding for a box culvert cannot be placed on the prepared subgrade within four hours of its inspection and approval, a working mat of lean concrete or mass concrete, with minimum thickness of 100 mm, should be placed on the foundation subgrade in general accordance with OPSS 904. The lean concrete shall have a compressive strength of 20 MPa. A minimum 75 mm thick uncompacted levelling pad consisting of Granular 'A' material or concrete fine aggregate (meeting the grading requirements specified in OPSS PROV 1002) should be provided on top of the concrete working slab.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

OBSTRUCTIONS

Non-Standard Special Provision

The Contactor is hereby notified that the soils at the culvert sites are glacially derived and as such should be expected to contain cobbles and boulders as inferred in a number of boreholes from auger grinding and the presence of rock fragments, which could affect the installation of deep or shallow foundations and/or temporary shoring and roadway protection systems. Consideration of the presence of these obstructions must be made in selection of appropriate equipment and procedures for sub-excavation and installation of the foundations and temporary shoring and roadway protection systems.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

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