FOUNDATION INVESTIGATION AND DESIGN REPORT EMBANKMENT WIDENINGS HIGHWAY 7 BETWEEN DRUMMOND LINE AND 150 M EAST OF HIGHWAY 28 PETERBOROUGH, ONTARIO G.W.P. 583-93-00

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TABLE OF CONTENTS

SECTION **PAGE**

PART A - FOUNDATION INVESTIGATION REPORT

In Order Following Page 31

Lists of Abbreviations and Symbols
Records of Boreholes 08-01 to 08-07, 08-09, 08-09A, 08-10 to 08-21, and 08-31 to 08-36
Drawings 1 to 3
Figures 1 to 19
Appendix A

LIST OF DRAWINGS

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
EMBANKMENT WIDENINGS

HIGHWAY 7 BETWEEN DRUMMOND LINE AND 150 M EAST OF HIGHWAY 28 PETERBOROUGH, ONTARIO G.W.P. 583-93-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Genivar on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detailed design for the widening of Highway 7 from Drummond Line to 150 m east of Highway 28, in Peterborough, Ontario.

This report addresses the widening of the existing Highway 7 embankment over six swamp/wet ground areas within the project limits, as follows:

Approximate Station	***Work Description***
13+300 to 13+450	Southward widening of the existing 2 m to 3 m high Highway 7 embankment, which crosses over a swamp/wet ground in this area.
14+300 to 14+400	Southward widening of the existing 3 m to 3.5 m high Highway 7 embankment, which crosses over a swamp/wet ground in this area.
14+550 to 14+600 and Henderson Line	Southward widening of the existing 1.5 m high Highway 7 embankment, and possible widening of the existing 0.5 m to 0.6 m high Henderson Line platform; both Highway 7 and Henderson Line cross over a swamp/wet ground in this area.
15+600 to 15+800	Northward widening of the existing 1.5 m to 2 m high Highway 7 embankment (to accommodate the acceleration lane from the new N-W Ramp), which crosses over a swamp/wet ground in this area.
15+800 to 16+075 N-W Ramp	Construction of the new N-W Ramp in the northwest quadrant of the Highway 7-28 intersection, which cross over a swamp/wet ground in this area.
15+800 to 15+900	Southward widening of the existing 2 m to 3 m high Highway 7 embankment, which crosses over a swamp/wet ground in this area.

The scope of work for the foundation investigation services associated with the embankment widening areas is outlined in Golder's letters dated July 22, 2008 and September 22, 2008.

2.0 SITE DESCRIPTION

The embankment widening and swamp/wet ground crossing areas addressed in this report are located along the existing two-lane Highway 7 between Drummond Line and Highway 28, near Peterborough, Ontario. In general, the terrain within each of the areas addressed in this report is relatively flat, poorly drained and swampy. The overall surface topography along Highway 7 slopes upward toward the east, from about Elevation 205 m at Station 13+300, to Elevation 231 m at Station 15+600 and Elevation 229 m at Station 15+900.

Descriptions of the embankment widening and swamp/wet ground crossing areas addressed in this report are provided below:

Area	***Description***
Station 13+300 to 13+450 (South)	This area is located immediately east of Providence Line. The natural ground surface to the south of Highway 7 is at approximately Elevation 204.5 m to 205 m, and covered with swamp-like vegetation; at the time of the borehole investigation in August 2008, approximately 0.2 m to 0.3 m of standing water was present on top of the ground surface to the south of the existing Highway 7 embankment. Highway 7 has been constructed on an approximately 2 m to 3 m high embankment, with its grade rising eastward from about Elevation 206.5 m to 207.5 m. The existing embankment slope on the south side of Highway 7 is oriented at approximately 2 to 2.5 horizontal to 1 vertical (2H:1V to 2.5H:1V); no evidence of distress or surficial erosion was observed on the south embankment shoulder or south slope at the time of the borehole investigation in this area. The existing Highway 7 pavement was observed to be in relatively good condition at the time of the borehole investigation, with limited cracking and no maintenance patching.
Station 14+300 to 14+400 (South)	This area is located west of Henderson Line, near Leanne Avenue. The natural ground surface to the south of Highway 7 declines from about Elevation 208 m at Station 14+300, to Elevation 207 m at Station 14+400; this area is covered with swamp-like vegetation. Highway 7 has been constructed on an approximately 3 m to 3.5 m high embankment, with its grade declining eastward from about Elevation 211.5 m to 210 m. The existing embankment slope on the south side of Highway 7 is oriented at approximately 2H:1V to 2.5H:1V; no evidence of distress or surficial erosion was observed on the south embankment shoulder or south slope at the time of the borehole investigation in this area. The existing Highway 7 pavement was observed to be in relatively good condition at the time of the borehole investigation, with limited cracking and no maintenance patching.

Area	*Description*
Station 14+550 to 14+600 (South) and Henderson Line	This area is located along the south side of Highway 7 immediately east of Henderson Line, and south along Henderson Line for a distance of approximately 100 m. The natural ground surface to the south of Highway 7 is between Elevation 208.3 m and 208.7 m, rising toward the east; this area is covered with swamp-like vegetation. Highway 7 has been constructed on an approximately 1.5 m high embankment, with its grade rising slightly eastward from about Elevation 209.7 m to 210 m. Henderson Line has been constructed with approximately 0.5 m to 0.6 m of embankment fill, with its grade rising slightly toward the south from Elevation 208.8 m near Highway 7, to Elevation 209.1 m approximately 100 m south of Highway 7. The existing embankment slope on the south side of Highway 7 is oriented at approximately 2H:1V to 2.5H:1V; no evidence of significant settlement/distortions or instability was observed on the south embankment shoulder or south slope at the time of the borehole investigation in this area, nor have Highway 7 embankment performance problems been reported by the MTO for this area. The existing Highway 7 pavement is in relatively good condition in this area, with limited cracking and no maintenance patching observed at the time of the drilling investigation. Henderson Line is unpaved, but "alligator cracking" of the granular/soil surface was observed in this area.
Station 15+600 to 15+800 (North)	This area is located west of Highway 28. The natural ground surface to the north of Highway 7 declines toward the east, from about Elevation 229.5 m to 230 m near Station 15+600, to about Elevation 226.5 m to 227 m near Station 15+800. Standing water was present to the north of Highway 7 near Station 15+800 at the time of the borehole investigation in September 2008. Highway 7 has been constructed on an approximately 1.5 m to 2 m high embankment, with its grade declining toward the east from about Elevation 230.7 m at Station 15+600 to about Elevation 228.7 m at Station 15+800. The existing embankment slope on the north side of Highway 7 is oriented at approximately 2H:1V to 2.5H:1V; no evidence of distress was observed on the north embankment shoulder or north slope at the time of the borehole investigation. The existing Highway 7 pavement was observed to be in relatively good condition at the time of the borehole investigation, with occasional transverse cracking observed.
Station 15+800 to 16+075, New N-W Ramp	This area is located in the northwest quadrant of the existing Highway 7-28 intersection. The natural ground surface northwest of the intersection varies from about Elevation 226.5 m to 227 m at Station 15+800 on Highway 7, to about Elevation 227.8 m at Station 15+940, then about Elevation 226.8 m northward to Station 16+075 along Highway 28. Standing water was present throughout the northwest quadrant of the intersection at the time of the borehole investigation in August and September 2008. Highway 7 has been constructed on an approximately 1.5 m high embankment in this area, with its grade at about Elevation 228.7 m to 228.8 m, while Highway 28 has been constructed on an approximately 1.5 m to 2 m high embankment, with its grade at about Elevation 227.6 m at Station 16+075, rising southward to about Elevation 229 m at the intersection with Highway 7.

Area	*Description*
Station 15+800 to 16+075, New N-W Ramp (Continued)	The existing north embankment slope for Highway 7 and west embankment slope for Highway 28 are oriented at approximately 2H:1V to 2.5H:1V; no evidence of distress was observed on the embankment shoulder or north/west slopes at the time of the borehole investigation in this area. The existing Highway 28 pavement was observed to be in relatively good condition at the time of the borehole investigation in this area, with some longitudinal cracking near the west edge of the pavement.
Station 15+800 to 15+900 (South)	This area is located west of Highway 28. The natural ground surface to the south of Highway 7 in this area is at about Elevation 226.7 m to 226.9 m; standing water was present from approximately Station 15+800 to 15+850 at the time of the borehole investigation in August 2008. Highway 7 has been constructed on an approximately 2 m high embankment (relative to the ground surface south of the highway), with its grade at approximately Elevation 228.7 m to 228.8 m. The existing Highway 7 south embankment slope is oriented at approximately 2H:1V to 2.5H:1V. No evidence of distress was observed on the embankment shoulder or south slope in this area, and the existing Highway 7 pavement was observed to be in relatively good condition at the time of the borehole investigation in this area.

3.0 INVESTIGATION PROCEDURES

A borehole investigation was carried out in August, September and October 2008, during which time twenty-seven boreholes (Boreholes 08-01 to 08-07, 08-09, 08-09A, 08-10 to 08-21, and 08-31 to 08-36) were advanced to investigate the subsurface conditions in the swamp/wet ground crossings for the proposed embankment widening areas addressed in this report. The boreholes were located in order to provide coverage at approximately 50 m spacing through these swamp/wet ground areas. The borehole locations are shown on Drawings 1 to 3.

Boreholes 08-1 to 08-7, 08-9, 08-9A, and 08-10 to 08-21 were drilled using portable drilling equipment, while Boreholes 08-31 to 08-35 were drilled using a track-mounted D50 drill rig, all supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes drilled with portable equipment were advanced through the overburden using casing, to depths ranging from 3.4 m to 6.7 m below the ground surface, and terminated in hard clayey silt or compact to very dense cohesionless soils that would offer resistance to settlement/instability of the embankment widening. The boreholes drilled using the full-size, track-mounted drill rig were advanced through the overburden using 210 mm outer diameter hollow stem augers, to depths ranging from 3.7 m to 9.8 m below the ground surface, and terminated in compact to dense cohesionless soil that would offer resistance to settlement/instability of the embankment widening in this area. In the boreholes drilled using portable or track-mounted drilling equipment, soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven in accordance with Standard Penetration Test (SPT) procedure. Field vane shear tests were carried out in very soft to stiff organic silt (marl) and clayey silt soils. An “N”-size vane was used in Boreholes 08-03 and 08-33, and a “B”-size vane was used in Boreholes 08-06 and 08-07; appropriate conversion factors have been applied to the field measurements take account of the vane size.

Boreholes 08-11 to 08-15, located between Stations 15+600 and 15+800, were advanced by Golder personnel using a shovel and hand auger, due to proximity to underground utilities in this area. In addition, Borehole 08-36 near Henderson Line was advanced using a hand auger, to supplement the other borehole information. These hand-augered boreholes were extended to a depth of 1.5 m or auger refusal, whichever was encountered first, in accordance with the scope of work for the area between Stations 15+600 and 15+800.

The groundwater conditions in the open boreholes were observed during the drilling operations. A standpipe piezometer was installed in each of Boreholes 08-02, 08-06, 08-09, 08-17, 08-19 and 08-21, to allow for monitoring of the groundwater level at the embankment widening sites. Each standpipe piezometer consists of a 1.5 m long, 50 mm diameter slotted screen installed within a filter sand pack, then sealed to ground surface with bentonite pellets. The piezometer installation details and recorded water level readings are included in the Record of Borehole sheets. For boreholes in which a piezometer was not installed, the boreholes were backfilled to ground

surface using bentonite pellets as per Ontario Regulation 128 (amendment to Ontario Regulation 903).

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

The locations of the as-drilled borehole locations were measured in the field by Golder personnel relative to existing site features, and the ground surface elevation at the borehole locations was determined from the digital terrain model for the project. The borehole locations (NAD83 MTM Zone 12 coordinates) and the ground surface elevation at the borehole locations (relative to geodetic datum) are summarized in the following table.

Station	***Borehole Number***	***MTM NAD83 Northing (m)***	***MTM NAD83 Easting (m)***	***Ground Surface Elevation (m)***
13+300 to 13+450 (South)	08-01	4,908,248.0	406,101.6	204.9
	08-02	4,908,271.0	406,146.1	204.7
	08-03	4,908,292.0	406,191.5	204.7
	08-04	4,908,313.0	406,236.9	204.7
14+300 to 14+400 (South)	08-05	4,908,666.0	407,009.7	207.8
	08-06	4,908,689.0	407,054.5	207.8
	08-07	4,908,711.0	407,099.2	207.3
14+550 to 14+600 (South) and Henderson Line	08-31	4,908,689.0	407,274.3	209.1
	08-32	4,908,795.2	407,264.4	209.8
	08-33	4,908,791.0	407,255.3	209.7
	08-34	4,908,784.7	407,263.2	208.7
	08-35	4,908,783.3	407,252.9	208.3
	08-36	4,908,736.3	407,258.6	208.8
15+600 to 15+800 (North)	08-11	4,909,181.0	408,202.4	229.8
	08-12	4,909,182.0	408,253.3	228.5
	08-13	4,909,185.0	408,304.5	227.2
	08-14	4,909,182.0	408,350.1	226.8
	08-15	4,909,178.0	408,390.4	226.6
15+800 to 16+075 (N-W Ramp)	08-16	4,909,176.0	408,430.1	226.7
	08-17	4,909,168.0	408,479.2	227.0
	08-18	4,909,211.0	408,515.3	227.8
	08-19	4,909,253.0	408,500.0	226.6
	08-20	4,909,295.0	408,488.1	226.8
	08-21	4,909,349.0	408,470.6	226.8
15+800 to 15+900 (South)	08-09	4,909,130.0	408,450.3	226.8
	08-09A	4,909,135.0	408,400.5	226.7
	08-10	4,909,126.0	408,474.9	226.9

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], the study area for this assignment lies within the physiographic region known as the Peterborough Drumlin Field.

The surficial soils in the Peterborough Drumlin Field consist of drumlinized till. Toward the southwestern portion of this physiographic region, near the Oak Ridges Moraine, the till is typically sandy. Some of the drumlins in this area have shallow coverings of silt and fine sand, ranging in thickness from about 0.5 m to 2.5 m. "Wave-washed" drumlins, with exposed bouldery surfaces, are also present near the Simcoe Lowlands immediately south and east of Lake Simcoe. Localized deposits of silt, clay and peat are found in the low-lying areas between drumlins.

4.2 Subsurface Conditions – Station 13+300 to 13+450 (South)

Boreholes 08-01 to 08-04 were advanced within the limits of this swamp/wet ground crossing, at the locations shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes are given on the borehole records. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Approximately 150 mm to 250 mm of standing water was present at the borehole locations within this swamp/wet ground crossing area at the time of the borehole investigation. Boreholes 08-01 to 08-04, which were drilled south of the existing embankment toe, encountered a layer of topsoil/root mat overlying organic silty sand and peat, in turn underlain by a deposit of stiff to hard clayey silt and compact to very dense silty sand to sandy silt. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil, Organic Soil and Peat

Approximately 100 mm to 200 mm of topsoil/root mat/peat was encountered immediately below the ground surface in Boreholes 08-01 to 08-04.

Organic-containing silty sand and peat were encountered below the topsoil/root mat in Boreholes 08-02 and 08-04. In Borehole 08-02 near Station 13+350, the organic-containing silty sand and peat extend from Elevation 204.7 m to 202.8 m (i.e., to a depth of 1.9 m below ground surface),

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

for a total thickness of 1.8 m. In Borehole 08-04 near Station 14+450, the organic-containing silty sand extends from Elevation 204.5 m to Elevation 202.7 m (i.e., to a depth of 2.0 m below ground surface), for a total thickness of 1.8 m.

4.2.2 Upper Sand to Sandy Silt

An upper cohesionless soil deposit was encountered immediately below the topsoil/root mat in Boreholes 08-01 and 08-03. This surficial deposit varies in composition from sand containing trace to some silt, to silty sand, to sandy silt containing trace clay. The surficial deposit encountered in these two boreholes is at a similar elevation/depth to the organic-containing soils encountered in Boreholes 08-02 and 08-04; however, the surficial deposit in Boreholes 08-01 and 08-03 does not contain significant quantities of organic material or peat.

In Borehole 08-01 near Station 13+300, the surface of the cohesionless soil deposit was encountered at Elevation 204.8 m (i.e., at a depth of 0.1 m), and the deposit is approximately 4.4 m in thickness, with its base at about Elevation 200.5 m. In Borehole 08-03 near Station 13+400, the surface of the cohesionless soil deposit was encountered at Elevation 204.6 m (i.e., at a depth of 0.1 m), and the deposit is approximately 1.6 m in thickness, with its base at about Elevation 203.0 m.

The measured Standard Penetration Test (SPT) "N" values within the upper sand to sandy silt deposit range from 11 to 47 blows per 0.3 m of penetration, indicative of a compact to dense relative density.

4.2.3 Clayey Silt

A deposit of clayey silt was encountered below the topsoil, organic soils and peat, and upper sand to sandy silt deposit in all four boreholes within this area. The surface of the deposit was encountered at a depth of 4.4 m (Elevation 200.5 m) in Borehole 08-01 near Station 13+300; in the remaining boreholes to the east, the surface of the deposit was encountered at a depth of 1.7 m to 2.0 m, between Elevations 202.7 m and 203.0 m. The deposit was fully penetrated in Boreholes 08-02 to 08-04, where it was found to be between 1.7 m and 2.3 m in thickness; the base of the deposit was encountered between Elevations 200.4 m and 201.2 m.

The measured SPT "N" values in the clayey silt deposit vary from 9 to 46 blows per 0.3 m of penetration; in Borehole 08-01, an SPT "N" value of 80 blows per 0.15 m of penetration was measured. These results are indicative of a stiff to hard, and typically very stiff to hard, consistency.

4.2.4 Lower Silty Sand to Sandy Silt

A lower deposit of silty sand to sandy silt was encountered below the clayey silt deposit in Boreholes 08-02 to 08-04. The surface of this lower deposit was encountered at a depth of 3.5 m to 4.3 m, corresponding to Elevation 200.4 m to 201.2 m. This deposit was not fully penetrated in the boreholes at this site; it is at least 0.6 m to 1.4 m in thickness at the borehole locations.

The measured SPT "N" values within the lower silty sand to sandy silt deposit range from 22 to 35 blows per 0.3 m of penetration, with one SPT "N" value of 75 blows per 0.15 m of penetration. These results are indicative of a compact to very dense, but typically compact to dense relative density.

4.2.5 Groundwater Conditions

At the time of the borehole investigation in August 2008, between 150 mm and 250 mm of standing water was present throughout this swamp/wet ground crossing area, and the soils encountered in the boreholes were generally saturated.

A standpipe piezometer was installed in Borehole 08-02 to monitor the groundwater level within this swamp/wet ground crossing area; details of the piezometer installation are shown on the borehole record. The water level measured in the piezometer is summarized in the following table.

Borehole No.	***September 8, 2008***	
	Depth to Groundwater	***Groundwater Elevation***
08-02	0.0 m	204.7 m

Based on the observations at the time of the borehole investigation and the piezometer measurement as summarized above, the groundwater level in this area should be expected to be at or above the ground surface. The groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year (for example, during spring run-off conditions).

4.3 Subsurface Conditions – Station 14+300 to 14+400 (South)

Boreholes 08-05 to 08-07 were drilled south of the existing Highway 7 embankment toe within the limits of this swamp/wet ground crossing, at the locations shown on Drawing 2. The detailed subsurface soil and groundwater conditions encountered in the boreholes are given on the borehole records and on Figures 1 to 5. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between

soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the soils encountered in the boreholes at this swamp/wet ground crossing area consist of peat and organic silty/clayey silt overlying an upper deposit of loose to dense silty sand to sand and silt, overlying a deposit of stiff to very stiff clayey silt, in turn underlain by a lower deposit of compact to dense silty sand. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.3.1 Peat and Organic Silt/Clayey Silt

The upper 1.5 m to 2.3 m of soil encountered in Boreholes 08-05, 08-06 and 08-07 consists of organic-rich soil: topsoil, fibrous peat and organic silt/clayey silt. The base of these organic soils was encountered between Elevation 206.3 m and 205.1 m, declining toward the east as encountered in the boreholes, as summarized in the following table:

Borehole No.	*Approximate Station*	*Surface Elevation*	*Thickness of Peat/Organic Soil*	*Base Elevation*	*Description*
08-05	14+300	207.8 m	1.5 m	206.3 m	Peat containing a 600 mm thick layer of soft organic silt
08-06	14+350	207.8 m	2.3 m	205.6 m	800 mm of peat overlying 1.5 m of soft to firm organic silt
08-07	14+400	207.3 m	2.2 m	205.1 m	Soft organic silt/ clayey silt

Grain size distribution testing was completed on two selected samples of the organic silt/clayey silt layer encountered in Borehole 08-07; the results of this testing are shown on Figure 1. Atterberg limits testing was also completed on two samples from this layer, and measured plastic limits of 46 and 68 per cent, liquid limits of 66 and 97 per cent, and plasticity indices of 20 and 30 per cent; the results, which are plotted on a plasticity chart on Figure 2, confirm that this material is an organic silt/clayey silt material. The high water contents, varying from 130 to 318 per cent, measured on five samples of the peat and organic silt/clayey silt are also indicative of the organic nature of these soils.

The measured SPT "N" values within the peat and organic silt/clayey silt soils range from 2 to 4 blows per 0.3 m of penetration. In situ vane testing was carried out at four locations within the organic silt/clayey silt deposit, and measured undrained shear strengths of approximately 15 kPa to 28 kPa. These results indicate that the fibrous peat has a soft consistency, and the organic silt/clayey silt has a soft to firm consistency.

4.3.2 Upper Silty Sand to Sand and Silt

An upper cohesionless soil deposit was encountered immediately below the peat/organic soils in Boreholes 08-05 to 08-07. The surface of the deposit was encountered at a depth of 1.6 m to 2.3 m (corresponding to Elevation 206.2 m to 205.1 m, declining toward the east) in the boreholes. The deposit was between 1.5 m and 2.2 m in thickness as encountered in the boreholes, with its base at a depth of 3.7 m to 3.8 m (corresponding to Elevation 203.6 m to 204.0 m).

This upper deposit varies in composition from silty sand containing sandy silt and clayey silt seams, to sand and silt containing trace clay. The result of a grain size distribution test on one sample of sand and silt is shown on Figure 3.

The measured SPT "N" values within the upper silty sand to sand and silt deposit range from 7 to 35 blows per 0.3 m of penetration, but are typically between about 10 and 30 blows per 0.3 m of penetration. These results are indicative of a loose to dense but typically compact relative density.

4.3.3 Clayey Silt

A deposit of clayey silt was encountered below the upper silty sand to sand and silt deposit in Boreholes 08-05 to 08-07. The surface of the deposit was encountered at a depth of 3.7 m to 3.8 m (Elevation 203.6 m to 204.0 m), and its base was encountered at a depth of 4.5 m to 4.9 m (Elevation 202.8 m to 203.2 m); the deposit has a thickness of 0.8 m to 1.1 m as encountered in the boreholes.

The deposit consists of clayey silt containing trace sand and gravel; sand seams were observed within the sample recovered from Borehole 08-07, as noted on the borehole record. The results of grain size distribution testing on three samples of the clayey silt are shown on Figure 4. Atterberg limits testing was conducted on two samples of this deposit, and measured plastic limits of 14 per cent, liquid limits of 21 and 22 per cent, and plasticity indices of 7 and 8 per cent; these results, which are plotted on a plasticity chart on Figure 5, confirm that this material is a clayey silt of low plasticity.

The measured SPT "N" values in the clayey silt deposit vary from 4 to 26 blows per 0.3 m of penetration. In situ vane testing was completed in Borehole 08-06 (where the lower SPT "N" value of 4 blows was measured), and measured an undrained shear strength of approximately 54 kPa and a remoulded shear strength of approximately 36 kPa. The vane and SPT results indicate that this deposit has a stiff to very stiff consistency, with low sensitivity.

4.3.4 Lower Silty Sand

A lower silty sand deposit was encountered below the clayey silt deposit in Boreholes 08-05, 08-06 and 08-07. The surface of this lower deposit was encountered at a depth of 4.5 m to 4.9 m, corresponding to Elevation 202.8 m to 203.2 m. This deposit was not fully penetrated in any of the boreholes; it is at least 0.6 m to 1.4 m in thickness at the borehole locations.

The measured SPT "N" values within the lower silty sand deposit vary from 15 to 32 blows per 0.3 m of penetration, indicative of a compact to dense relative density.

4.3.5 Groundwater Conditions

At the time of the borehole investigation in August 2008, the groundwater level in the open boreholes was typically near the ground surface, and the soils encountered in the boreholes were generally saturated. Standing surface water was present at the location of Borehole 08-07, near Station 14+400.

A standpipe piezometer was installed in Borehole 08-06 to monitor the groundwater level within this swamp/wet ground crossing area; details of the piezometer installation are shown on the borehole record. The water level measured in the piezometer is summarized in the following table.

Borehole No.	***September 8, 2008***	
	Depth to Groundwater	***Groundwater Elevation***
08-06	0.4 m above ground surface	208.2 m

Based on the observations at the time of the borehole investigation and the piezometer measurement as summarized above, the groundwater level in this area should be expected to be at or above the ground surface. The groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year (for example, during spring run-off conditions).

4.4 Subsurface Conditions – Station 14+550 to 14+600 (South) and Henderson Line

Boreholes 08-32 to 08-35 were drilled south of the existing Highway 7 embankment toe within the limits of this swamp/wet ground crossing, and Boreholes 08-31 and 08-36 were drilled along Henderson Line approximately 60 m and 110 m south of Highway 7, at the locations shown on Drawing 2. The detailed subsurface soil and groundwater conditions encountered in the boreholes are given on the borehole records and on Figures 6A and 6B. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and,

therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

The boreholes drilled through the Highway 7 shoulder encountered topsoil/embankment fill overlying peat and organic silt layers; the boreholes drilled through the Henderson Line platform also encountered fill overlying a thin layer of peat. The borehole advanced to the south of the Highway 7 embankment toe encountered peat immediately below the ground surface. In all of the boreholes, the peat/organic silt is underlain by a native cohesionless deposit that varies in composition from sand to silt. A more detailed description of the soil deposits and bedrock encountered in the boreholes is provided in the following sections.

4.4.1 Fill

Highway 7 Embankment Fill

Boreholes 08-32 and 08-33 were advanced through the south shoulder of the existing Highway 7 embankment and encountered 1.5 m of fill material. The base of the fill was encountered at Elevations 208.2 m and 208.3 m in these boreholes.

The fill varies in composition from topsoil (comprising the upper portion of the fill encountered in Borehole 08-32), to sand and gravel, to clayey silt with sand to some sand, to silty sand, containing trace gravel, organics and rootlets.

The measured SPT "N" values in the fill vary from 6 to 15 blows per 0.3 m of penetration, indicative of a loose to compact relative density/firm to stiff consistency.

Henderson Line Fill

Boreholes 08-31 and 08-36 were advanced through the Henderson Line platform and encountered approximately 0.6 m and 0.5 m of fill, respectively. The base of the fill was encountered at Elevations 208.5 m and 208.3 m in these boreholes.

The fill varies in composition from sand and gravel below the travelled portion of Henderson Line (Borehole 08-31), to silty sand containing trace clay and gravel, rootlets and organics toward the outer edge of Henderson Line (Borehole 08-32).

4.4.2 Peat and Organic Silt

Peat and organic silt layers were encountered below the existing Highway 7 fill in Boreholes 08-32 and 08-33, below the Henderson Line fill in Boreholes 08-31 and 08-36, and immediately below the ground surface in Boreholes 08-34 and 08-35 (which were advanced south of the

existing Highway 7 embankment toe). The approximate elevation of the surface and base of the peat/organic silt layer(s), and the thickness of the layer(s), is summarized in the following table:

Borehole No.	*Approximate Station*	*Approximate Offset*	*Surface Elevation*	*Thickness*	*Base Elevation*
08-31	10+110 Henderson Line	3 m E	208.5 m (below fill)	0.2 m	208.3 m
08-32	14+585 Highway 7	8 m S	209.0 m (below fill)	1.5 m	207.5 m
08-33	14+575 Highway 7	8 m S	208.2 m (below fill)	1.5 m	206.7 m
08-34	14+580 Highway 7	18 m S	208.7 m	0.9 m	207.8 m
08-35	14+570 Highway 7	15 m S	208.3 m	0.9 m	207.4 m
08-36	10+060 Henderson Line	4 m E	208.3 m	1.0 m	207.3 m

SPT "N" values of 2 to 5 blows per 0.3 m of penetration were measured in the peat, indicating that this material has a soft to firm consistency. An SPT "N" values of 7 blows per 0.3 m of penetration was measured in the organic silt layer that was encountered below the peat in Borehole 08-33; this value indicates that the layer has a loose relative density.

4.4.3 Sand to Silt

A cohesionless soil deposit, ranging in composition from sand to silt, was encountered below the peat/organic silt in all of the boreholes, as follows:

Borehole No.	*Approximate Station*	*Approximate Offset*	*Depth to Deposit Surface*	*Surface Elevation*
08-31	10+110 Henderson Line	3 m E	0.8 m	208.3 m
08-32	14+585 Highway 7	8 m S	2.3 m	207.5 m
08-33	14+575 Highway 7	8 m S	3.1 m	206.7 m
08-34	14+580 Highway 7	18 m S	0.9 m	207.8 m
08-35	14+570 Highway 7	15 m S	0.9 m	207.4 m
08-36	10+060 Henderson Line	4 m E	1.5 m	207.3 m

This deposit varies in composition from sand containing trace to some silt and trace gravel, to silty sand, sand and silt or sandy silt containing trace to some gravel and trace clay, to silt containing some sand. Clayey silt layers/seams were noted within some of the recovered samples. Grain size distribution testing was conducted on eleven samples of the sand to silt layers of this deposit, and the results are shown on Figures 6A and 6B.

The measured SPT "N" values within the sand to silt deposit range from 5 to 38 blows per 0.3 m of penetration, but are typically between 10 and 30 blows per 0.3 m of penetration. These results indicate that the deposit has a loose to dense but typically compact relative density.

4.4.4 Groundwater Conditions

Based on observations in the open boreholes during drilling and immediately following completion of drilling, as noted on the borehole records, the groundwater level should be expected to be at or near the original ground surface in this area. The groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year (for example, during spring run-off conditions).

4.5 Subsurface Conditions – Station 15+600 to 15+800 (North) and Station 15+800 to 16+075 (N-W Ramp)

Boreholes 08-11 to 08-21 were drilled along the north side of Highway 7 and the west side of Highway 28, at the locations shown on Drawing 3. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of laboratory tests are given on the Record of Borehole sheets and on Figures 7 to 11. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

At the time of the borehole investigation in August and September 2008, standing surface water was present east of approximately Station 15+800, along the proposed N-W Ramp alignment. In general, the native soils in this area consist of surficial silty sand or clayey silt deposits overlying a deposit of clayey silt till. The surficial deposits, or portions of the surficial deposits, contain organic materials. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.5.1 Fill

Approximately 1.5 m of fill was encountered in Boreholes 08-14 and 08-15, near Stations 15+750 and 15+800 respectively. The boreholes were terminated in the fill at Elevation 225.3 m and 225.1 m.

The fill consists of clayey silt with sand to silty sand, containing trace to some gravel and organic material. The results of grain size distribution tests completed on three samples of the fill are shown on Figure 7. Atterberg limits testing was conducted on two samples of the cohesive fill, and measured plastic limits of 13 and 15 per cent, liquid limits of 22 and 23 per cent, and

plasticity indices of 8 and 9 per cent; these results, which are plotted on a plasticity chart on Figure 8, confirm that the cohesive fill is a clayey silt of low plasticity.

4.5.2 Topsoil

Approximately 100 mm to 200 mm of topsoil/root mat was encountered immediately below the ground surface in Boreholes 08-16 to 08-18 and 08-21, along the N-W Ramp alignment.

4.5.3 Surficial Silty Sand and Clayey Silt

Thin surficial deposits of silty sand and clayey silt were encountered immediately below ground surface or below the topsoil/root mat in Boreholes 08-11 to 08-13, and 08-16 to 08-21. These deposits are between 0.5 m and 1.3 m in thickness (though more typically between 0.5 m and 0.7 m in thickness) as encountered at the borehole locations. The base of the surficial deposit was encountered at Elevation 229.3 m in Borehole 08-11 at the western limit of this section (near Station 15+600), and declines toward the east to approximately Elevation 225.9 m in Borehole 08-16 and 226.2 m in Borehole 08-17 (near the Highway 7-28 intersection); northward from this point, the base of the deposit varied between Elevation 225.4 m and 226.7 m.

In the majority of the boreholes, the surficial deposit consists of silty sand containing trace to some gravel and trace clay, although this varies to sand and silt containing trace to some gravel and trace clay in Borehole 08-21; the result of a grain size distribution test on one sample of the sand and silt is shown on Figure 9. However, in Borehole 08-12, the surficial deposit contains a layer of clayey silt, some sand; and the surficial layer is comprised entirely of clayey silt, trace sand in Boreholes 08-13 and 08-16. The surficial soils, or portions of the surficial soil deposits, generally contain organic material.

Where measured, SPT “N” values of 2 to 4 blows per 0.3 m of penetration were typically obtained in the surficial silty sand and surficial clayey silt layers, indicative of a soft to firm consistency or loose relative density. One higher SPT “N” value of 48 blows per 0.3 m of penetration was measured in Borehole 08-21, indicating that the lower portion of the surficial sand and silt encountered in this borehole has a dense relative density.

4.5.4 Clayey Silt Till

A till deposit was encountered below the surficial silty sand and surficial clayey silt in all of the boreholes, except Boreholes 08-14 and 08-15 which were terminated in fill. The surface of the till deposit was encountered at Elevation 229.3 m in Borehole 08-11 at the western limit of this section (near Station 15+600), declining toward the east to approximately Elevation 225.9 m in Borehole 08-16 and 226.2 m in Borehole 08-17 (near the Highway 7-28 intersection); northward

from this point, the surface of the till deposit was encountered between Elevation 225.4 m and 226.7 m. All of the boreholes were terminated within this deposit.

The till consists of clayey silt with sand to some sand, containing trace to some gravel; the results of grain size distribution tests completed on twelve samples of the till are shown on Figures 10A and 10B. Atterberg limits testing was conducted on ten samples of the till, and measured plastic limits of 10 to 18 per cent, liquid limits of 14 to 33 per cent, and plasticity indices of 4 to 17 per cent. These results, which are plotted on a plasticity chart on Figure 11, confirm that the till consists of clayey silt of low plasticity.

The measured SPT "N" values within the till range from 8 to greater than 100 blows per 0.3 m of penetration, but are generally above 15 blows per 0.3 m of penetration; these results are indicative of a generally very stiff to hard consistency. The lower SPT "N" values of 8, 10 and 11 blows per 0.3 m of penetration were measured immediately below the surface of the surficial soil/till interface in three of the boreholes, indicating that the upper portion of the till has a stiff consistency at some locations.

4.5.5 Groundwater Conditions

At the time of the borehole investigation in August 2008, standing water was present from approximately Station 15+800 eastward and northward along the proposed N-W Ramp alignment; the soils encountered in the boreholes in this area were generally saturated.

A standpipe piezometer was installed in Boreholes 08-19 and 08-21 to monitor the groundwater level(s) within this swamp/wet ground crossing area; details of the piezometer installation are shown on the borehole records. The water level measured in the piezometer is summarized in the following table.

Borehole No.	***September 8, 2008***	
	Depth to Groundwater	***Groundwater Elevation***
08-19	0.1 m	226.5 m
08-21	0.0 m	226.8 m

Based on the observations at the time of the borehole investigation and the piezometer measurement as summarized above, the groundwater level in this area should be expected to be at or slightly above the ground surface. The groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year (for example, during spring run-off conditions).

4.6 Subsurface Conditions – Station 15+800 to 15+900 (South)

Boreholes 08-09, 08-09A and 08-10 were drilled south of the existing Highway 7 embankment toe within the limits of this swamp/wet ground crossing, at the locations shown on Drawing 3. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of laboratory tests are given on the Record of Borehole sheets and on Figures 12 to 15. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Approximately 100 mm of standing water was present in the vicinity of Boreholes 08-09 and 08-09A, located at approximately Stations 15+850 and 15+800 respectively, at the time of the borehole investigation. In general, the subsurface conditions in this area consist of a thin layer of topsoil/root mat overlying a firm to very stiff surficial clayey silt deposit, in turn underlain by a very stiff to hard/compact to very dense clayey silt till to sand till deposit. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.6.1 Topsoil and Organic Silty Sand

A 200 mm thick layer of topsoil/root mat and organic silty sand was encountered immediately below the ground surface in Borehole 08-09, and a 100 mm thick layer of topsoil/root mat was encountered immediately below the ground surface in Boreholes 08-09A and 08-10.

4.6.2 Surficial Clayey Silt

A 0.7 m to 1.3 m thick, surficial clayey silt deposit was encountered below the topsoil/root mat in Boreholes 08-09, 08-09A and 08-10 in this area. The surface of the deposit was encountered between Elevation 226.6 m and 226.8 m in the boreholes. The base of the deposit was encountered between Elevation 225.3 m and 226.1 m; the deposit base was lowest in Borehole 08-09, which is located at approximately Station 15+850, near the middle of the swamp/wet ground that is mapped in this area, rising to Elevation 225.9 m to the west and 226.1 m to the east as encountered in the boreholes.

This surficial deposit consists of clayey silt containing trace sand; grain size distribution testing was completed on one sample of the surficial clayey silt, and the result is shown on Figure 12.

The measured SPT “N” values range from 4 to 23 blows per 0.3 m of penetration, but typically 4 blows per 0.3 m of penetration. These results indicate that the surficial clayey silt has a firm to very stiff but typically firm consistency.

4.6.3 Clayey Silt Till / Sand Till

A till deposit is present below the surficial clayey silt deposit in Boreholes 08-09, 08-09A and 08-10. The surface of the till was encountered at a depth of 0.8 m to 1.5 m, corresponding to Elevation 225.3 m to 226.1 m, with the lowest point measured in Borehole 08-09 at approximately Station 15+850, near the centre of the swamp/wet ground that has been mapped in this area. Boreholes 08-09 and 08-09A were terminated in this deposit, which was penetrated for a depth of 2.6 m to 3.7 m; in Borehole 08-10, the till is underlain by or interlayered with sandy gravel (as discussed in the following sub-section), and the till has a thickness of 2.2 m at this location.

The till varies in composition from clayey silt with sand to trace to some sand, trace to some gravel, to sand containing some silt, trace gravel and clay. Grain size distribution testing was completed on three samples of the clayey silt till and sand till, and the results are shown on Figure 13. Atterberg limits testing was conducted on four samples of the till, and measured plastic limits of 11 to 19 per cent, liquid limits of 16 to 33 per cent, and plasticity indices of 5 to 14 per cent. These results, which are plotted on a plasticity chart on Figure 14, confirm that the cohesive portion of the till consists of clayey silt of low plasticity.

The measured SPT "N" values within the till deposit range from 11 to 58 blows per 0.3 m of penetration, with one measured value of 65 blows per 0.15 m of penetration. These results indicate that the cohesive portions of the till have a stiff to hard consistency, while the cohesionless portion of the till (as encountered in Borehole 08-09) has a compact to dense relative density.

4.6.4 Sandy Gravel

A lower sandy gravel layer was encountered below, or interlayered with, the clayey silt till in Borehole 08-10. The surface of this layer was encountered at a depth of 3.0 m (Elevation 223.9 m). The borehole was terminated within this layer at a depth of 3.7 m (Elevation 223.2 m), corresponding to a thickness of at least 0.7 m.

The sandy gravel layer contains trace silt and clay. The result of grain size distribution testing on the recovered sample from this layer is shown on Figure 15.

One SPT "N" value of 34 blows per 0.3 m of penetration was measured in the sandy gravel layer, indicative of a dense relative density.

4.6.5 Groundwater Conditions

At the time of the borehole investigation in August 2008, standing water was present around Stations 15+800 to 15+850, and the soils encountered in the boreholes were generally saturated.

A standpipe piezometer was installed in Borehole 08-09 to monitor the groundwater level within this swamp/wet ground crossing area; details of the piezometer installation are shown on the borehole record. The water level measured in the piezometer is summarized in the following table.

Borehole No.	***September 8, 2008***	
	Depth to Groundwater	***Groundwater Elevation***
08-09	0.0 m	226.8 m

Based on the observations at the time of the borehole investigation and the piezometer measurement as summarized above, the groundwater level in this area should be expected to be at or slightly above the ground surface. The groundwater level will be subject to seasonal variations, and will tend to be higher during wet periods of the year (for example, during spring run-off conditions).

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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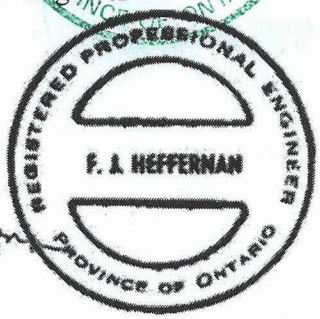

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PART B

FOUNDATION DESIGN REPORT
EMBANKMENT WIDENINGS

HIGHWAY 7 BETWEEN DRUMMOND LINE AND 150 M EAST OF HIGHWAY 28 PETERBOROUGH, ONTARIO G.W.P. 583-93-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the proposed widening of embankments over swamp/wet ground areas, associated with the widening of Highway 7 from Drummond Line to 150 m east of Highway 28. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during a subsurface investigation at the swamp/wet ground crossing sites. The interpretation and recommendations are intended to provide the designers with sufficient information for the geotechnical design of the embankment widenings. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

Surficial organic layers, consisting of relatively thin topsoil or thicker deposits of peat/organic soils, are present along many of the proposed swamp/wet ground crossings, as discussed in Sections 4.2 to 4.6 of this report. If the peat/organic soils were left in place below these embankment widening areas, significant primary consolidation settlement of the peat would occur, followed by ongoing secondary ("creep") settlement, resulting in poor performance and ongoing maintenance of the widened portions of the highway. Even with preloading and/or surcharging of the embankment widening areas, ongoing "creep" settlement of the underlying peat/organic materials would occur following paving, again resulting in poor performance and ongoing maintenance for the widened portions of the highway in these areas. The peat/organic soils are unsuitable for support of the proposed embankment widening and, therefore, it is recommended that the peat and organic soils be subexcavated and replaced with granular fill.

The following sections of this report address subgrade preparation (topsoil stripping and peat removal) requirements, embankment stability under static and seismic conditions, embankment settlement, and associated construction concerns (supplemented with appropriate Operational Constraints) for the proposed embankment widening work.

6.2 Subgrade Preparation Requirements – Stripping of Peat/Organic Soils

6.2.1 Depth of Subexcavation

The thickness of the topsoil and peat/organic soils as encountered in the boreholes is summarized in Table 1, following the text of this report, for each of the embankment widening areas. The recommended subexcavation depths as provided in Table 1 should be considered in conjunction

with geotechnical/pavement investigation data for the same swamp/wet ground crossing areas, where such data is available. The zone of subexcavation for each of the embankment widening areas should be defined by a line drawn at 1H:1V downwards from the crest of the proposed embankment widening to the base of the subexcavation, as per Ontario Provincial Standard Drawing (OPSD) 203.02.

6.2.2 Subexcavation Procedures

Construction procedures for the widening of the existing Highway 7 embankment should implement the guidelines of OPSD 203.020, which require that the side slope of the existing Highway 7 embankment be temporarily excavated to a 1H:1V profile to allow for removal of peat/organic material from below the existing embankment fill, such as was encountered in the area of Station 14+550 to 14+600 (South) near Henderson Line. Following these guidelines may still result in some organic deposits remaining in place below the transition area between the existing and widened embankments; further discussion on this aspect is provided in Section 6.5.3 of this report.

Based on the results of the subsurface investigation, subexcavation of up to approximately 2.3 m below the original ground surface will be required. The groundwater table/surface water level is at or near the original ground surface at all of the swamp/wet ground crossing sites addressed in this report. The subexcavation works could be carried out subaqueously below the groundwater/surface water level; alternatively, dewatering of the groundwater/surface water could be carried out prior to and during subexcavation and backfilling works. The use of subaqueous excavation will increase the factor of safety against instability and excavation base heave as compared with unwatered conditions, and will be less expensive than unwatering/dewatering of the lengths of excavation associated with the embankment widening work. Although a greater level of compaction could be achieved on the backfill with the use of dewatering, it is considered that acceptable performance of the backfill material will be achieved provided that the recommendations given in Section 6.2.3 are followed. Therefore, it is considered that subaqueous excavation will be suitable for this contract.

In order to maintain an adequate factor of safety against instability of the existing Highway 7 or Highway 28 embankments, special subexcavation procedures will be required adjacent to or below the toe of the existing embankment(s), where such subexcavation extends to a depth of greater than 1 m below the original ground surface at the embankment toe. An operational constraint has been developed (refer to Appendix A of this report) for inclusion in the Contract Documents to address these items, as follows:

- Excavation of the existing embankment fill, peat and organic soils within the embankment widening footprint will have to be carried out in short sections perpendicular to the highway alignment, with the excavation width (as measured parallel to the highway direction) not more than 3 m at any time.

- Excavation and backfilling operations will have to be carried out simultaneously such that the excavation is not left open for more than 3 m in width at any given time.

- Subexcavation works should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities. In this regard, any existing embankment fill or soils above the water table would be classified as Type 3 soil. Temporary excavation through the existing embankment fill shall be made, where required, with side slopes no steeper than 1H:1V from the crest of the existing highway embankment to the base of the excavation. Temporary excavation side slopes (i.e., back slopes) through the peat/organic soils shall be no steeper than 2H:1V.

- Some distress to the existing highway embankment may occur during subexcavation; provisions for traffic control measures shall be included to maintain the safe operation of Highway 7 during excavation and backfilling operations.

With respect to the proposed temporary backslope geometry, Genivar has confirmed that there is adequate room within the existing MTO right-of-way, and that the subexcavation will not encroach on private property.

With respect to the potential for distress to the existing highway embankment during subexcavation, it is recommended that visual monitoring be completed each day for any sections of highway embankment adjacent to active subexcavation/backfilling works. This visual monitoring could be completed as part of the Contract Administrator assignment.

6.2.3 Backfill of Subexcavated Areas

Based on the results of the subsurface investigation, subexcavation of up to approximately 2.3 m below the original ground surface will be required. The groundwater table/surface water level is at or near the original ground surface at all of the swamp/wet ground crossing sites addressed in this report. As was discussed in Section 6.2.2, it is recommended that the subexcavation works and backfilling works will be carried out below the groundwater/surface water level.

Because of the wet conditions, it is recommended that the subexcavation areas be backfilled using Granular “B” Type II fill. This fill material contains limited fine soil particles, and will not tend to segregate during placement; in addition, because this fill material is from a crushed source, the angular particles will perform better than non-crushed (i.e. rounded) soil particles during compaction of subsequent lifts of embankment fill.

Alternatively, rock fill could be used for backfill of the subexcavation areas. However, in order to avoid loss of fine soil particles from the native soils below or adjacent to the rock fill into voids within the rock fill, a “transition layer” of Granular “A” or Granular “B” Type II fill would be required between the native soils and the rock fill. This transition layer should have a minimum

thickness of 0.3 m below the base of the rock fill. Beyond the "toe" of the subexcavation area, the transition layer should have a minimum width of 0.5 m between the rock fill and the native soils to the south or north, for the full height of the subexcavation.

6.3 Embankment Construction

The embankment fill for the widening areas should be placed and compacted in accordance with MTO's Special Provisions 206S03 and 105S10. Benching of the existing embankment side slopes should be carried out to "key in" the new fill materials for the widenings, in accordance with OPSD 208.010. Additional fill for construction of the embankment widening above the level of the original ground surface (i.e., above the groundwater level) could consist of clean earth fill, granular fill or rock fill.

From a geotechnical/foundations perspective, earth or granular fill is preferred for the construction of the embankment widening above the level of the original ground surface (i.e., above the groundwater level), as it will provide better compatibility with the existing embankment fill materials – both those fill materials remaining in-place in the existing embankment side slope, and any existing embankment fill that is re-used for the widening after being cut from the benches. To reduce surface water erosion on the widened embankment side slopes, where earth fill or granular fill is used for the widening, placement of topsoil and seeding or pegged sod is recommended.

If rock fill is adopted for the embankment widening areas, the native soils/subexcavation backfill should first be covered with a minimum 300 mm thick sand and gravel blanket (OPSS 1010 Granular "B" Type II or similar). It will not be acceptable to "interlayer" any soil fill excavated from the benches in the existing embankment side slopes with the rock fill, unless the surface of each rock fill layer is carefully graded and "chinked"; without proper grading and chinking of each rock fill layer, there would be potential for migration of soil particles into the voids in underlying rock fill layers, potentially resulting in settlement/sinkholes propagating to the ground surface. The final surface of the rock fill must be properly chinked, or a separation layer placed, before placing any granular fill for the pavement structure.

6.4 Embankment Stability

6.4.1 Static Global Stability

Slope stability analyses have been performed for the proposed embankment widening areas using the commercially available program SLOPE/W, produced by GeoSlope International Ltd., to check that a minimum factor of safety of 1.3 is achieved for the proposed embankment heights and geometries under static conditions. This minimum factor of safety is considered appropriate

for the embankment widening works on this project, considering the design requirements and the available field and laboratory testing data.

The stability analyses were completed for each embankment widening area based on the highest embankment height (from the design profiles) and the "worst case" soil conditions encountered along each of the swamp/wet ground crossing areas. The following parameters have been used in the analyses, based on field and laboratory test data as well as accepted correlations:

Embankment Widening Area and Soil Conditions	*Bulk Unit Weight (kN/m^3)*	*Effective Friction Angle*	*Undrained Shear Strength (kPa)*	*Approximate Maximum Embankment Height**
Station 13+300 to 13+450 (South):				
Embankment fill (earth or granular)	20 – 22	30°-35°	–	3 m
Embankment fill (rock fill)	19	40°	–	
Compact to dense upper sand to sandy silt	20	30°	–	
Stiff to hard clayey silt	20	32°	–	
Compact to dense lower sand/silt	20	32°	–	
Station 14+300 to 14+400 (South):				
Embankment fill (earth or granular)	20 – 22	30°-35°	–	3.5 m
Embankment fill (rock fill)	19	40°	–	
Compact upper sand/silt	20	30°	–	
Stiff to very stiff clayey silt	20	32°	–	
Compact to dense lower silty sand	20	32°	–	
Station 14+550 to 14+600 (South) and Henderson Line:				
Embankment fill (earth or granular)	20 – 22	30°-35°	–	2 m
Embankment fill (rock fill)	19	40°	–	
Compact sand to silt	20	30°	–	
Station 15+800 to 16+075 (N-W Ramp):				
Embankment fill (earth or granular)	20 – 22	30°-35°	–	2 m
Embankment fill (rock fill)	19	40°	–	
Stiff to hard clayey silt till	21	32°	–	
Station 15+800 to 15+900 (South):				
Embankment fill (earth or granular)	20 – 22	30°-35°	–	3 m
Embankment fill (rock fill)	19	40°	–	
Firm surficial clayey silt	19	28°	40	
Stiff to hard clayey silt till	21	32°	–	

* Maximum embankment height measured relative to original ground surface at toe of embankment.

The piezometric conditions used in the stability analyses were based on the water levels observed during and/or immediately following completion of drilling and measured in piezometers installed at the sites; in general, the groundwater level was taken to be at or above the ground surface.

The analysis results indicate that embankment widenings and the new N-W Ramp, where constructed with earth or granular fill with side slopes maintained no steeper than 2H:1V, will

have a factor of safety of greater than 1.3 against global instability, assuming appropriate subgrade preparation and proper placement and compaction of the embankment fill materials. If rock fill is used for the embankment widenings, a factor of safety of 1.3 will be achieved against global instability provided that the widened embankment side slopes are constructed no steeper than 1.25H:1V. The results of static global stability analyses for both earth/granular fill and rock fill conditions for two of the higher embankments (the 3.5 m high embankment in the area of Station 14+300 to 14+400 South, and the 3 m high embankment in the area of Station 15+800 to 15+900 South) in two distinct subsurface conditions, are presented on Figures 16 through 19 of this report.

6.4.2 Seismic Stability

Under earthquake conditions, the stability of embankment side slopes is assessed using conventional pseudo-static methods of slope stability analysis under the earthquake-induced peak ground acceleration. A calculated factor of safety of 1.0 is considered appropriate for global stability under seismic conditions; however, a factor of safety less than 1.0 does not indicate full-scale failure of the slope due to the application of the peak ground acceleration in one direction for a short period of time.

A seismic global stability analysis has been performed for the "worst case" embankment widening area – the approximately 3.5 m high embankment widening located between Stations 14+300 and 14+400 (South) – using the parameters summarized in the preceding section.

The pseudo-static seismic slope stability analyses for a 2H:1V embankment side slope configuration indicates that the widened embankment will have a factor of safety of greater than 1.0 against deep-seated slope instability, using a peak ground acceleration of 0.07g. This peak horizontal ground acceleration is based on the zonal acceleration ratio of 0.05g as given in the *Canadian Highway Bridge Design* Code (CHBDC) for the Peterborough area, with a soil amplification factor of 1.4 based on the soil conditions at the site. The results of the pseudo-static seismic stability analyses do indicate that some shallow sloughing could occur on the widened embankment side slopes during seismic events. This sloughing would not, however, impair the use of the highway, and would mainly be a maintenance issue. The potential for sloughing following seismic events could be reduced by providing well-vegetated side slopes, as recommended in the following section.

6.5 Embankment Settlement

Settlement of the embankment widening areas and the new N-W Ramp embankment will occur as a result of compression of the new embankment fill itself, as well as short-term compression of the cohesionless soils and very stiff to hard cohesive soils that underlie the embankment widening

areas, and longer-term consolidation settlement within firm cohesive soils of limited thickness that underlie the embankment widening area at Station 15+800 to 15+900 (South).

6.5.1 Settlement of Embankment Fill

Provided that the embankment widening material consists of clean earth fill or granular fill, the settlement of the embankment fill itself is expected to be less than 25 mm for the embankment heights under consideration on this project. The use of granular fill for the new embankment construction would reduce this magnitude of settlement, since the majority of settlement of granular fills will occur during construction, whereas the majority of the settlement of cohesive fill, if used, would occur after construction.

If rock fill is used for any embankment widening areas, post-construction settlement may occur within the rock fill as a result of rearrangement of rock particles under load and breakage of rock particles (i.e. local crushing and degradation). The actual magnitude of settlement within the rock fill will depend on the type of rock, and on the method and sequence of placement and compaction of the fill. Assuming that the rock fill is not end-dumped into its final position and that it is placed in accordance with the requirements outlined in the Special Provision Amendment to OPSS 206, the settlement of rock fill in embankments up to 10 m in height is estimated to be about 1 per cent of the embankment height (per "Rockfill in the Foundation Design of Highway Structures" prepared by the MTO Research and Development Branch, dated 1982). Therefore, for the 2 m to 3.5 m high rock fill embankments that could be adopted for the widenings associated with this project, the settlement of the rock fill itself is expected to be about 20 mm to 35 mm. It is anticipated that the majority of this settlement would occur during the first year following construction.

6.5.2 Settlement of Foundation Soils

Settlement analyses for the foundation soils were carried out using the commercially available computer program Unisettle. The immediate compression of cohesionless soil strata, including surficial sands and the sand and silt to sandy silt till deposit, was modelled using elastic deformation moduli, based on correlations with the measured SPT "N" values. The consolidation settlement of firm clayey silt strata, where present, was modelled based on estimates of consolidation parameters from correlations with the vane shear strength and Atterberg limit test results. The following parameters were used in the analyses:

Embankment Widening Area and Soil Conditions	*Bulk Unit Weight (kN/m^3)*	*Elastic Modulus (MPa)*	P_c'	e_o	C_c	C_r
Station 13+300 to 13+450 (South):						
Embankment fill (earth or granular)	20-22	–	–	–	–	–
Subexcavation replacement fill	21	5-10	–	–	–	–
Compact to dense upper sand to sandy silt	20	15	–	–	–	–
Stiff to hard clayey silt	20	25	–	–	–	–
Compact to dense lower sand/silt	20	20	–	–	–	–
Station 14+300 to 14+400 (South):						
Embankment fill (earth or granular)	20-22	–	–	–	–	–
Subexcavation replacement fill	21	5-10	–	–	–	–
Compact upper sand/silt	20	10	–	–	–	–
Stiff to very stiff clayey silt	20	20	–	–	–	–
Compact to dense lower silty sand	20	15	–	–	–	–
Station 14+550 to 14+600 (South) and Henderson Line:						
Embankment fill (earth or granular)	20-22	–	–	–	–	–
Subexcavation replacement fill	21	5-10	–	–	–	–
Compact sand to silt	20	10-15	–	–	–	–
Station 15+800 to 16+075 (N-W Ramp):						
Embankment fill (earth or granular)	20-22	–	–	–	–	–
Subexcavation replacement fill	5-10	5-10	–	–	–	–
Stiff to hard clayey silt till	21	30	–	–	–	–
Station 15+800 to 15+900 (South):						
Embankment fill (earth or granular)	20-22	–	–	–	–	–
Firm surficial clayey silt	19	5	200	0.95	0.2	0.02
Stiff to hard clayey silt till	21	25	–	–	–	–

The estimated magnitude of settlement of the foundation soils under the embankment widening areas is summarized in the table below. These estimates assume subexcavation of the peat/organic soils and subaqueous placement of backfill, resulting in a relatively loose granular fill layer below the embankment widening areas.

Embankment Widening Area	*Approximate Max. Embankment Height**	*Estimated Settlement Under Main Widening Area*	*Estimated Settlement of Existing Highway Shoulder*	*Estimated Settlement at Embankment Toe*
Station 13+300 to 13+450 (South)	3 m	15 mm	5 mm	5 mm
Station 14+300 to 14+400 (South)	3.5 m	25 mm	10 mm	<10 mm
Station 14+550 to 14+600 (South)	2 m	20-25 mm	10 mm	<10 mm
Station 15+800 to 16+075 (N-W Ramp)	2 m	10 mm	5 mm	5 mm
Station 15+800 to 15+900 (South)	3 m	15-20 mm	10 mm	<10 mm

Based on the estimated settlements as summarized above, the differential settlement between the existing highway shoulder and the new widening area will be approximately 5 mm to 15 mm; the

differential settlement will have a gradual transition based on the geometry of the embankment widenings.

The majority of the settlement in the granular backfill and the native soils will take place during and immediately following construction of the embankment widening works. For the embankment widening between Station 15+800 and 15+900 (South), where a firm surficial clayey silt deposit is present, it is estimated that the majority of the settlement will be completed within two to three months following completion of the fill placement.

6.5.3 Settlement of Organic Soils "Trapped" Below Transition Area

Organic materials are anticipated below the existing Highway 7 embankment shoulder/side slope in the area of Station 14+550 to 14+600 (South) near Henderson Line. The subexcavation procedures outlined in Section 6.2.2 of this report may still result in some organic materials remaining in place below the transition area between the existing and widened embankments.

The thickness of any such "trapped" organic materials is difficult to predict, and therefore the magnitude of settlement associated with these materials is also difficult to predict. However, it is estimated that the majority of primary consolidation settlement of any such "trapped" organic materials will be completed within six months to one year; ongoing "creep" settlement would still occur after this time. It is recommended that final paving over the transition areas be delayed as late as possible in the contract, with provision for some padding over affected transition areas if necessary. In addition, future maintenance may be required to accommodate secondary ("creep") settlement of trapped organic materials.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent quality control review of the report.

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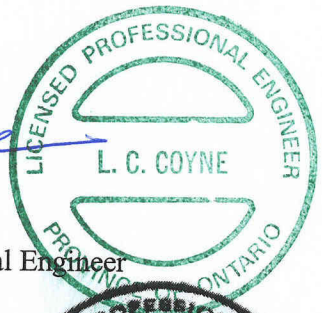

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LCC/FJH/lcc
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TABLE 1
SUMMARY OF SUBEXCAVATION REQUIREMENTS FOR TOPSOIL, PEAT AND ORGANIC SOILS
G.W.P 583-93-00

Swamp/ Wet Ground Crossing Area	*Borehole No.*	*Approximate Station (m)*	*Approximate Offset from Hwy 7 CL*	*Ground Surface Elevation*	*Topsoil/ Peat/Organic Thickness*	*Base Elevation of Topsoil/ Peat/Organics*
Station 13+300 to 13+450 (South)	08-01	13+300 Hwy 7	20 m S	204.9 m	0.1 m	204.8 m
	08-02	13+350 Hwy 7	18 m S	204.7 m	1.9 m	202.8 m
	08-03	13+400 Hwy 7	18 m S	204.7 m	0.1 m	204.6 m
	08-04	13+450 Hwy 7	18 m S	204.7 m	2.0 m	202.7 m
Station 14+300 to 14+400 (South)	08-05	14+300 Hwy 7	20 m S	207.8 m	1.5 m	206.3 m
	08-06	14+350 Hwy 7	18 m S	207.8 m	2.3 m	205.5 m
	08-07	14+400 Hwy 7	20 m S	207.3 m	2.2 m	205.1 m
Station 14+550 to 14+600 (South) and Henderson Line	08-31	10+110 Henderson	3 m E	209.1 m	0.8 m	208.3 m
	08-32	14+585 Hwy 7	8 m S	209.8 m	2.3 m	207.5 m
	08-33	14+575 Hwy 7	8 m S	209.7 m	3.1 m	206.6 m
	08-34	14+580 Hwy 7	18 m S	208.7 m	0.9 m	207.8 m
	08-35	14+570 Hwy 7	15 m S	208.3 m	0.9 m	207.4 m
	08-36	10+060 Henderson	4 m E	208.8 m	1.5 m	207.3 m
Station 15+600 to 15+800 (North Side)	08-11	15+600 Hwy 7	13 m N	229.8 m	0.5 m	229.3 m
	08-12	15+650 Hwy 7	13 m N	228.5 m	0.5 m	228.0 m
	08-13	15+700 Hwy 7	17 m N	227.2 m	0.6 m	226.6 m
	08-14	15+750 Hwy 7	18 m N	226.8 m	0.8 m	226.0 m
	08-15	15+790 Hwy 7	19 m N	226.6 m	0.9 m	225.7 m
Station 15+800 to 16+075 N-W Ramp	08-16	15+830 Hwy 7	22 m N	226.7 m	0.8 m	225.9 m
	08-17	15+880 Hwy 7	19 m N	227.0 m	0.8 m	226.2 m
	08-18	9+920 Hwy 28	16.5 m W	227.8 m	1.1 m	226.7 m
	08-19	9+875 Hwy 28	16 m W	226.6 m	0.8 m	225.8 m
	08-20	9+830 Hwy 28	12 m W	226.8 m	0.8 m	226.0 m
	08-21	9+773 Hwy 28	10 m W	226.8 m	0.6 m	226.2 m
Station 15+800 to 15+900 (South Side)	08-09	15+850 Hwy 7	23 m S	226.8 m	0.2 m	226.6 m
	08-09A	15+800 Hwy 7	24 m S	226.7 m	0.1 m	226.6 m
	08-10	15+880 Hwy 7	24 m S	226.9 m	0.1 m	226.8 m

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
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

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

IV. SOIL TESTS

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

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

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LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
v	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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	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_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p/σ'_{vo}

(d) Shear Strength

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

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

2 shear strength = (compressive strength)/2

* density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

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RECORD OF BOREHOLE No 08-01

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908248.0 ;E 406101.6 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY TB

DATUM Geodetic | DATE August 14, 2008 | 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
204.9	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat		1	SS	11						
	Silty SAND, trace gravel, containing organics Compact Brown to grey Wet		2	SS	29		204				
203.6 / 1.3	SAND, trace to some silt, trace clay Compact to dense Grey Wet		3	SS	24		203				
			4	SS	47						
201.4			5	SS	42		202				
3.5	Silty SAND to Sandy SILT, trace clay Compact Grey Wet		6	SS	32		201				
200.5			7	SS	80/0.15						
4.6	CLAYEY SILT, trace sand, trace to some gravel Hard Grey Wet										
	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at 0.2 m above ground surface (Elevation 205.1 m) during and on completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-02

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908271.0 ;E 406146.1 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY TB

DATUM Geodetic | DATE August 13, 2008 | 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
204.7	GROUND SURFACE										
0.0	TOPSOIL/Root Mat		1	SS	3						
204.1	Silty SAND, trace clay, trace gravel Very loose Grey Wet		2	SS	2		204				
0.6	PEAT Very soft Brown Wet		3	SS	3		203				
203.1	Organic Silty SAND Very loose Brown Wet		4	SS	15		202				
1.9	CLAYEY SILT, trace sand, trace gravel		5	SS	46						
201.1	Very stiff to hard Grey Wet		6	SS	35		201				
3.6	Silty SAND to Sandy SILT, trace gravel Dense to very dense Grey Wet		7	SS	75/0.15						
200.0	END OF BOREHOLE										
4.7											

NOTES:

1. Standing water present at site.
2. Water level at 0.2 m above ground surface (Elevation 204.9 m) during and on completion of drilling.
3. Water level in piezometer measured at 0 m depth (Elevation 204.7 m) on September 8, 2008.

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

Golder Associates

RECORD OF BOREHOLE No 08-03

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908292.0 ;E 406191.5 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY TB

DATUM Geodetic | DATE August 14, 2008 | 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 / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
204.7	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat		1	SS	3						
	Silty SAND Loose to compact Brown to grey Wet		2	SS	12		204				
203.0			3	SS	9		203	+ > 72 kPa			
1.7	CLAYEY SILT, trace sand Stiff to very stiff Grey Wet						202				
201.2			4	SS	24						
3.5	Silty SAND to Sandy SILT, trace gravel, trace clay Compact to dense Grey Wet		5	SS	26		201				
199.8			6	SS	32		200				
4.9	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at 0.3 m above ground surface (Elevation 204.9 m) during and on completion of drilling.

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

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

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RECORD OF BOREHOLE No 08-04

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908313.0 ;E 406236.9 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY TB

DATUM Geodetic | DATE August 15, 2008 | 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
204.7	GROUND SURFACE										
0.0	TOPSOIL/Root Mat		1	SS	4						
0.2	PEAT Very soft Brown Wet		2	SS	22		204				
	Organic SILTY SAND to SILTY SAND, trace gravel Loose to compact		3	SS	23		203				
202.7											
2.0	Brown to grey Wet		4	SS	33		202				
	CLAYEY SILT, trace sand Very stiff to hard Grey Wet		5	SS	26						
			6	SS	30		201				
200.4											
4.3	Silty SAND Compact Grey Wet		7	SS	22		200				
199.8											
4.9	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at 0.3 m above ground surface (Elevation 205.0 m) during and on completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No 08-05

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908666.0 ;E 407009.7 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 108 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 19, 2008 | 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
207.8	GROUND SURFACE										
0.0	PEAT		1	SS	4	▽	207		255.9 ○		
0.2	Organic SILT										
207.0	Soft										
0.8	Brown		2	SS	4						
	Wet										
206.3	PEAT (Fibrous)						206				
	Soft										
1.6	Brown		3	SS	7				○		0 61 35 4
	Wet										
	CLAYEY SILT										
	Firm		4	SS	35		205				
	Grey										
	Wet										
	SAND and SILT, trace clay		5	SS	8						
	Loose to dense										
204.0	Grey						204				
3.8	Wet		6	SS	26				○		0 8 71 21
	CLAYEY SILT, trace sand, trace gravel										
203.2											
4.6	Very stiff		7	SS	15		203		○		
	Grey										
	Wet										
	Silty SAND, trace gravel						202				
	Compact to dense										
	Grey										
	Wet										
201.1			8	SS	32						
6.7	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 0.2 m (Elevation 207.6 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-06

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908689.0 ;E 407054.5 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 20, 2008 | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
207.8	GROUND SURFACE							20 40 60 80 100	10 20 30		
0.0 / 207.1	PEAT (Fibrous) Soft Brown Wet		1	SS	4				317.8		
0.8 / 205.6	Organic SILT (Marl) Soft to firm Brown Wet		2	SS	2		207		145.8		
2.3 / 204.0	Silty SAND Compact to dense Grey Wet		3	SS	13		206	× +			
			4	SS	30		205	× +			
3.8 / 203.0	CLAYEY SILT, trace sand, trace gravel Stiff Grey Wet		5	SS	4		204				0 2 70 28
4.9 / 201.1	Silty SAND, trace gravel Compact Grey Wet		6	SS	22		203	× +			
							202				
6.7	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 0.9 m (Elevation 206.9 m) upon completion of drilling.

2. Water level in piezometer measured at 0.4 m above ground surface (at Elevation 208.2 m) on September 8, 2008.

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

Golder Associates

RECORD OF BOREHOLE No 08-07

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908711.0 ;E 407099.2 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 108 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 20-21, 2008 | 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
207.3	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat		1	SS	3		207		166.4		0 16 64 20
	Organic SILT to CLAYEY SILT, some sand (Marl) Soft Brown Wet										
205.1			2	SS	3		206	× + × +	129.6		0 9 75 16
2.2	Silty SAND containing sandy silt and clayey silt seams Compact Dark grey Moist to wet		3	SS	11		205				
204.3 / 3.0	Silty SAND Compact Grey Wet		4	SS	28		204				
203.6 / 3.7	CLAYEY SILT, containing sand seams Very stiff Grey Wet		5	SS	23		203				0 5 72 23
202.8 / 4.5	Silty SAND Grey Wet		6	WS	-		202				
201.3 / 6.0	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at 0.1 m above ground surface (Elevation 207.4 m) during and on completion of drilling.

3. Below a depth of 4.5 m, soils "blew up" inside casing during four washing and sampling attempts. Wash sample obtained.

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

Golder Associates

RECORD OF BOREHOLE No 08-09

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | DIST Eastern HWY 7 | DATUM Geodetic

LOCATION N 4909130.0 ;E 408450.3 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | DATE August 25, 2008

ORIGINATED BY PKS | COMPILED BY JB | 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
226.8	GROUND SURFACE										
0.0	TOPSOIL/Root Mat										
0.2	Organic Silty SAND Loose Brown Wet		1	SS	4						
			2	SS	23		226		○		0 4 83 13
225.3	CLAYEY SILT, trace sand										
1.5	Firm to very stiff Brown Wet		3	SS	14		225		○		0 7 61 32
	CLAYEY SILT, trace to some sand and gravel (TILL) Very stiff to hard Brown Wet		4	SS	33		224				
			5	SS	23				○		
			6	SS	40		223				
			7	SS	30		222		○		
221.6											
5.2	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level in open borehole at a depth of 0.6 m (Elevation 226.2 m) upon completion of drilling.

3. Water level in piezometer measured at 0 m (Elevation 226.8 m) on September 8, 2008.

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

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

Golder Associates

RECORD OF BOREHOLE No 08-09A

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909135.0 ;E 408400.5 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 108 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 22, 2008 | 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
226.7	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat										
225.9	CLAYEY SILT, trace sand Firm Brown Wet		1	SS	4		226				
0.8	SAND, some silt, trace gravel and clay to CLAYEY SILT with sand, trace gravel (TILL) Compact to very dense Brown Wet		2	SS	27						6 66 22 6
			3	SS	45		225				
			4	SS	58		224				
223.3			5	SS	65/0.15						
3.4	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 226.7) m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-10

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909126.0 ;E 408474.9 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 25, 2008 | 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
226.9	GROUND SURFACE										
0.0	TOPSOIL/Root Mat										
0.1	CLAYEY SILT, trace sand		1	SS	4	▽					
226.1	Firm										
0.8	Brown		2	SS	21		226				
	Wet										
	CLAYEY SILT with sand, trace to some gravel (TILL)										
	Stiff to very stiff		3	SS	11		225				16 40 32 12
	Brown										
	Wet		4	SS	21						
223.9							224				
3.0	Sandy GRAVEL, trace silt and clay		5	SS	34						65 22 9 4
223.2	Dense										
	Brown										
3.7	Wet										
	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 0.3 m (Elevation 226.6 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-11

1 OF 1 **METRIC**

PROJECT 06-1111-044
W.P. WP 583-93-00
LOCATION N 4909181.0 ;E 408202.4
ORIGINATED BY PKS
DIST Eastern HWY 7
BOREHOLE TYPE Hand Auger
COMPILED BY PKS
DATUM Geodetic
DATE September 8, 2008
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
229.8	GROUND SURFACE										
0.0 / 229.3	Silty SAND, trace clay, containing organics and rootlets		1	AS	-				○		
0.5 / 228.7	Brown Moist		2	AS	-		229		○		4 41 38 17
1.1	CLAYEY SILT with sand, trace gravel (TILL) Brown Moist										
	END OF BOREHOLE AUGER REFUSAL										
	NOTE: 1. Borehole dry upon completion of drilling.										

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

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/9/09 MSM/RJ/SAC

Golder Associates

RECORD OF BOREHOLE No 08-12

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909182.0 ;E 408253.3 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Hand Auger | COMPILED BY PKS

DATUM Geodetic | DATE September 8, 2008 | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.5	GROUND SURFACE								
0.0	Silty SAND, trace to some gravel, containing organics Brown Moist		1	AS	-	▽	228		
0.5			2	AS	-				0 29 45 26
227.3	Organic CLAYEY SILT, some sand, containing rootlets Brown Moist								
1.2	CLAYEY SILT with sand, trace gravel (TILL) Brown Wet								
	END OF BOREHOLE AUGER REFUSAL								

NOTE:

1. Water level in open borehole at a depth of 0.6 m (Elevation 227.9 m) on completion of drilling.

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

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

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

Golder Associates

RECORD OF BOREHOLE No 08-13

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909185.0 ;E 408304.5 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Hand Auger | COMPILED BY PKS

DATUM Geodetic | DATE September 8, 2008 | 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
227.2	GROUND SURFACE										
0.0 / 226.6	CLAYEY SILT, trace sand, containing rootlets and organics Brown Moist		1	AS	-	▽	227		48		
0.6 / 225.7	CLAYEY SILT, some sand, trace gravel (TILL) Brown Wet		2	AS	-		226				0 16 65 18
1.5	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 0.6 m (Elevation 226.6 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-14

1 OF 1 **METRIC**

PROJECT 06-1111-044
W.P. WP 583-93-00
LOCATION N 4909182.0 ;E 408350.1
ORIGINATED BY PKS
DIST Eastern HWY 7
BOREHOLE TYPE Hand Auger
COMPILED BY PKS
DATUM Geodetic
DATE September 8, 2008
CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (w_P w w_L) WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	10 20 30	γ kN/m^3	GR SA SI CL
226.8	GROUND SURFACE										
0.0	Clayey silt with sand, trace to some gravel, containing organics and rootlets (FILL) Brown Moist		1	AS	-	▽	226		○		
			2	AS	-				○		
225.3			3	AS	-				⊢○⊣		5 31 41 13
1.5	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.6 m (Elevation 226.2 m) upon completion of drilling.										

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

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

Golder Associates

RECORD OF BOREHOLE No 08-15

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909178.0 ;E 408390.4 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Hand Auger | COMPILED BY PKS

DATUM Geodetic | DATE September 8, 2008 | 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
226.6	GROUND SURFACE										
0.0 / 226.0	Silty sand, trace clay, containing organics (FILL) Brown / grey Wet		1	AS	-		226		○		
0.6			2	AS	-				○		4 41 43 12
225.1	Clayey silt with sand, trace to some gravel, containing organics (FILL) Brown / grey Wet		3	AS	-				⊢○⊣		13 45 32 10
1.5	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level in open borehole at a depth of 0.2 m (Elevation 226.4) m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-16

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909176.0 ;E 408430.1 | ORIGINATED BY JB

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS

DATUM Geodetic | DATE August 28, 2008 | CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
226.7	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat		1	SS	4						
225.9 / 0.8	CLAYEY SILT, some sand, trace gravel, containing organics Firm Brown Wet		2	SS	11		226				18 40 33 9
	CLAYEY SILT with sand, some gravel (TILL) Stiff to hard Brown Wet		3	SS	18		225				
			4	SS	35		224				
			5	SS	88		223				25 33 31 11
222.6			6	SS	106/0.15						
4.1	END OF BOREHOLE AUGER REFUSAL										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 226.7 m) upon completion of drilling.

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

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

Golder Associates

RECORD OF BOREHOLE No 08-17

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909168.0 ;E 408479.2 | ORIGINATED BY JB

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS

DATUM Geodetic | DATE August 28, 2008 | 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
227.0	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat										
226.2	Organic Silty SAND, trace clay Very loose Brown Soft		1	SS	4						
0.8	CLAYEY SILT, some sand, trace to some gravel (TILL) Stiff to hard Brown Wet		2	SS	10		226				
			3	SS	17		225				2 13 55 30
			4	SS	87		224				
			5	SS	38						
222.5			6	SS	32		223				
4.4	END OF BOREHOLE CASING REFUSAL										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 227.0 m) upon completion of drilling.

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

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/9/09 MSM/RJ/SAC

Golder Associates

RECORD OF BOREHOLE No 08-18

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909211.0 ;E 408515.3 | ORIGINATED BY JB

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS

DATUM Geodetic | DATE August 27, 2008 | 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
227.8	GROUND SURFACE										
0.0	TOPSOIL/Root Mat										
0.2	Organic Silty SAND, trace clay, containing rootlets Loose Brown Wet		1	SS	4						
226.7			2	SS	23		227				
1.1	CLAYEY SILT with sand, trace to some gravel (TILL) Very stiff to hard Brown Wet		3	SS	72		226				
			4	SS	16		225				
			5	SS	44						30 35 26 9
			6	SS	30		224				
222.6			7	SS	41		223				
5.2	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 227.8 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-19

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909253.0 ;E 408500.0 | ORIGINATED BY JB

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS

DATUM Geodetic | DATE August 27, 2008 | 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
226.6	GROUND SURFACE										
0.0 / 225.8	Silty SAND, trace clay, containing organics Loose Brown Wet		1	SS	2		226				
0.8	CLAYEY SILT with sand to some sand, trace to some gravel (TILL) Stiff to hard Brown Wet		2	SS	8						1 17 62 20
			3	SS	47		225				
			4	SS	41		224				27 35 30 8
			5	SS	52						
222.6			6	SS	110/0.1		223				
4.0	END OF BOREHOLE AUGER REFUSAL SPOON REFUSAL										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 226.6 m) upon completion of drilling.

3. Water level in piezometer measured at a depth of 0.1 m (Elevation 226.5 m) on September 8, 2008.

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

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

Golder Associates

RECORD OF BOREHOLE No 08-20

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909295.0 ;E 408488.1 | ORIGINATED BY JB

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS

DATUM Geodetic | DATE August 26, 2008 | 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
226.8	GROUND SURFACE										
0.0 / 226.0	Silty SAND, trace clay, containing organics Loose Brown Wet		1	SS	4						
0.8	CLAYEY SILT with sand to some sand, trace to some gravel (TILL) Very stiff to hard Brown Wet		2	SS	20		226				
			3	SS	22		225				12 45 30 13
			4	SS	25						13 39 34 14
			5	SS	50		224				
222.4			6	SS	103		223				
4.4	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 226.8 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-21

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909349.0 ;E 408470.6 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY JB

DATUM Geodetic | DATE August 26, 2008 | 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
226.8	GROUND SURFACE										
0.0 / 0.1	TOPSOIL/Root Mat		1	SS	4						
226.0	SAND and SILT, trace gravel, trace clay, containing organics						226				
0.8	Loose		2	SS	48						19 46 30 5
225.4	Black										
1.4	Wet										
	SAND and SILT, some gravel, trace clay		3	SS	21		225				21 37 30 12
	Dense										
	Brown										
	Wet		4	SS	35						
	CLAYEY SILT with sand, trace to some gravel (TILL)						224				
	Very stiff to hard		5	SS	46						
223.2	Brown										
3.7	Wet										
	END OF BOREHOLE										

NOTES:

1. Standing water present at site.

2. Water level at ground surface (Elevation 226.8 m) upon completion of drilling.

3. Water level in piezometer measured at 0 m (Elevation 226.8 m) on September 8, 2008.

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

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

Golder Associates

RECORD OF BOREHOLE No 08-22A

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4909124.0 ;E 408734.2 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Truck-Mounted D-25, 108 mm Diameter Solid Stem Augers | COMPILED BY JB

DATUM Geodetic | DATE September 9, 2008 | 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
229.2	GROUND SURFACE						229				
0.0 / 228.5	Silty sand, some gravel (FILL) Compact Brown Moist		1	SS	18						
0.8 / 226.9	Clayey silt, some sand, trace gravel (FILL) Stiff to very stiff Brown Moist		2	SS	28		228		○		
			3	SS	11						
2.3 / 226.3	CLAYEY SILT with sand, trace to some gravel, trace organics Stiff		4	SS	14		227				10 30 35 15
2.9	Brown / grey Moist		5	SS	37		226		○		19 43 31 7
	CLAYEY SILT with sand, some gravel, containing cobbles (TILL) Very stiff to hard Brown Moist to wet		6	SS	23						
			7	SS	36		225				
	Becoming grey at a depth of 6.1 m		8	SS	100/0.20		224				
						▽	223				
			9	SS	91		222		○		
							221				
219.5			10	SS	71		220				
9.8	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 7.6 m (Elevation 221.6) m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-31

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908689.0 ;E 407274.3 | ORIGINATED BY PKS

DIST Eastern HWY 7 | BOREHOLE TYPE Track-Mounted D50, 210 mm O.D. Hollow Stem Augers | COMPILED BY PKS/LCC

DATUM Geodetic | DATE October 16, 2008 | 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
209.1	GROUND SURFACE						209				
0.0 / 208.5	Sand and gravel (FILL) Compact Brown Moist		1	SS	23	▽					
0.8	PEAT Firm Brown Moist		2	SS	10		208		○		0 26 67 7
	Sandy SILT, trace clay and gravel Loose to compact Brown to grey-brown Moist becoming wet at a depth of 1.5 m		3	SS	12						
			4	SS	6		207				
			5	SS	10		206				
			6	SS	19		205		○		0 25 72 3
			7	SS	12		204				
			8	SS	28		203				
201.5							202				
7.6	Silty SAND, trace clay Dense Grey Wet		9	SS	38		201		○		0 67 30 3
199.4			10	SS	32		200				
9.8	END OF BOREHOLE										

Notes:

1. Borehole caved at a depth of 2.1 m (Elevation 207.0 m) upon completion of drilling

2. Water level at a depth of 0.6 m (Elevation 208.5 m) upon completion of drilling

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

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/9/09 MSM/RJ/SAC

Golder Associates

RECORD OF BOREHOLE No 08-32

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | DIST Eastern HWY 7 | DATUM Geodetic

LOCATION N 4908795.2 ;E 407264.4 | BOREHOLE TYPE Track-Mounted D50, 210 mm O.D. Hollow Stem Augers | DATE October 16, 2008

ORIGINATED BY PKS | COMPILED BY PKS/LCC | 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
209.8	GROUND SURFACE										
0.0 / 209.0	TOPSOIL		1	SS	6		209				
0.8 / 208.3	Clayey silt with sand to silty sand, trace to some gravel, trace clay, trace organics (FILL)		2	SS	8						
1.5 / 207.5	Loose Brown Moist		3	SS	5	▽	208				
2.3 / 206.8	PEAT layered with organic silt Firm Brown to grey Moist		4	SS	15		207		○		0 16 74 10
3.1 / 206.0	SILT, some sand, containing clayey silt seams and organics Compact		5	SS	15						
3.8	Brown Wet		6	SS	13		206		○		0 96 3 1
	Silty SAND, trace gravel, containing clayey silt seams Compact Brown Wet		7	SS	19		205				
	SAND, trace silt Compact Grey Wet		8	SS	11		204				
203.1											
6.7	END OF BOREHOLE										

Notes:

1. Borehole caved at a depth of 2.7 m (Elevation 207.1 m) upon completion of drilling

2. Water level at a depth of 2.4 m (Elevation 207.4 m) upon completion of drilling

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

MIS-MTO 001 06-1111-044.GPJ GAL-MISS.GDT 2/9/09 MSM/RJ/SAC

Golder Associates

RECORD OF BOREHOLE No 08-33

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908791.0 ;E 407255.3 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Track-Mounted D50, 210 mm O.D. Hollow Stem Augers | COMPILED BY PKS/LCC

DATUM Geodetic | DATE October 16, 2008 | 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 / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
209.7	GROUND SURFACE							20 40 60 80 100	10 20 30		
0.0 / 208.9	Sand and gravel (FILL) Compact Brown Moist		1	SS	15						
0.8 / 208.2	Clayey silt, some sand, trace gravel, containing organics and rootlets (FILL) Stiff Grey/brown Moist		2	SS	11		209				
207.7 / 2.0	PEAT Firm Brown Moist		3	SS	7	▽	208	× +	○	OC = 2.4%	
206.7 / 3.1	Organic SILT to sandy SILT, containing rootlets Loose Brown Wet		4	SS	14		207	+ > 48 kPa	○		2 94 3 1
206.0 / 3.7	SAND, trace silt and gravel Compact Brown Wet										
	END OF BOREHOLE										

Notes:

1. Borehole caved at a depth of 2.9 m (Elevation 206.8 m) upon completion of drilling

2. Water level at a depth of 2.7 m (Elevation 207.0 m) upon completion of drilling

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

Golder Associates

RECORD OF BOREHOLE No 08-34

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908784.7 ;E 407263.2 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS/LCC

DATUM Geodetic | DATE October 17, 2008 | 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
208.7	GROUND SURFACE										
0.0	PEAT Very soft to soft Brown		1	SS	2	▽	208				
207.8	Wet										
0.9	SAND, some silt, to Silty SAND, trace gravel and clay Loose to compact Brown Wet		2	SS	6						
			3	SS	26		207		○		7 74 17 2
			4	SS	17		206				
205.0			5	SS	23						
3.7	END OF BOREHOLE										

Notes:

1. Borehole caved at a depth of 1.2 m (Elevation 207.5 m) upon completion of drilling

2. Water level at a depth of 0.6 m (Elevation 208.1 m) upon completion of drilling

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

Golder Associates

RECORD OF BOREHOLE No 08-35

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908783.3 ;E 407252.9 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Portable Equipment, 57 mm Internal Diameter Casing | COMPILED BY PKS/LCC

DATUM Geodetic | DATE October 17, 2008 | 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
208.3	GROUND SURFACE										
0.0	PEAT Very soft to firm Brown		1	SS	2		208				
207.4	Moist										
0.9	SAND and SILT, containing clayey silt layers, trace to some gravel, trace organics Loose to compact Grey		2	SS	5				○		2 38 49 11
			3	SS	13		207		○		16 37 38 9
206.0	Wet										
2.3	SAND and SILT, trace gravel and clay Compact to dense Grey		4	SS	21		206				
			5	SS	34		205		○		3 32 60 5
204.6	Wet										
3.7	END OF BOREHOLE										

NOTES:

1. Water encountered below a depth of 0.9 m (Elevation 207.4 m) during drilling.

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

Golder Associates

RECORD OF BOREHOLE No 08-36

1 OF 1 **METRIC**

PROJECT 06-1111-044 | W.P. WP 583-93-00 | LOCATION N 4908736.3 ;E 407258.6 | ORIGINATED BY PKS

DIST Eastern | HWY 7 | BOREHOLE TYPE Hand Auger | COMPILED BY PKS/LCC

DATUM Geodetic | DATE October 17, 2008 | 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
208.8	GROUND SURFACE										
0.0 / 208.3	Organic silty sand, trace clay, trace gravel, containing rootlets (FILL)		1	AS		▽	208				
0.5	Brown/grey Moist										
	PEAT Brown		2	AS							
207.3	Wet		3	AS					○		0 82 11 7
1.7	SAND, some silt, trace clay Brown Wet										
	END OF BOREHOLE										

Notes:

1. Water level at a depth of 0.5 m (Elevation 208.3 m) upon completion of drilling

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

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

MINISTRY OF TRANSPORTATION, ONTARIO

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

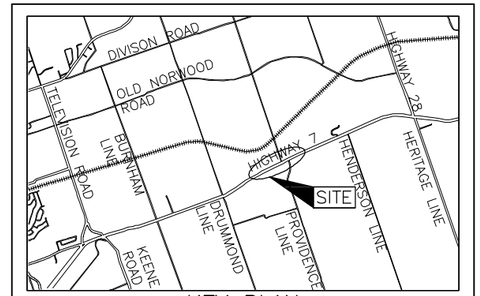
CONT No.
WP No. 583-93-00

SHEET

HIGHWAY 7
EMBANKMENT WIDENING
STATION 13+300 TO 13+450
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

PLAN
SCALE
20 0 20 40 m



KEY PLAN
SCALE
1.2 0 1.2 2.4 km

LEGEND

Borehole – Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-1	204.9	4908248.0	406101.6
08-2	204.7	4908271.0	406146.1
08-3	204.7	4908292.0	406191.5
08-4	204.7	4908313.0	406236.9

NOTES

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

The 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 plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007).

NO.	DATE	BY	REVISION

Geocres No.

HWY. HIGHWAY 7		PROJECT NO. 06-1111-044	DIST.
SUBM'D. PKS	CHKD. LCC	DATE: 19-Jan-2009	SITE:
DRAWN: JFC	CHKD. PKS	APPD. LCC	DWG. 1

PLOT DATE: January 19, 2009
FILENAME: T:\Projects\2006\06-1111-044 (Transenco, Peterborough)\-AC-\061111044C001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

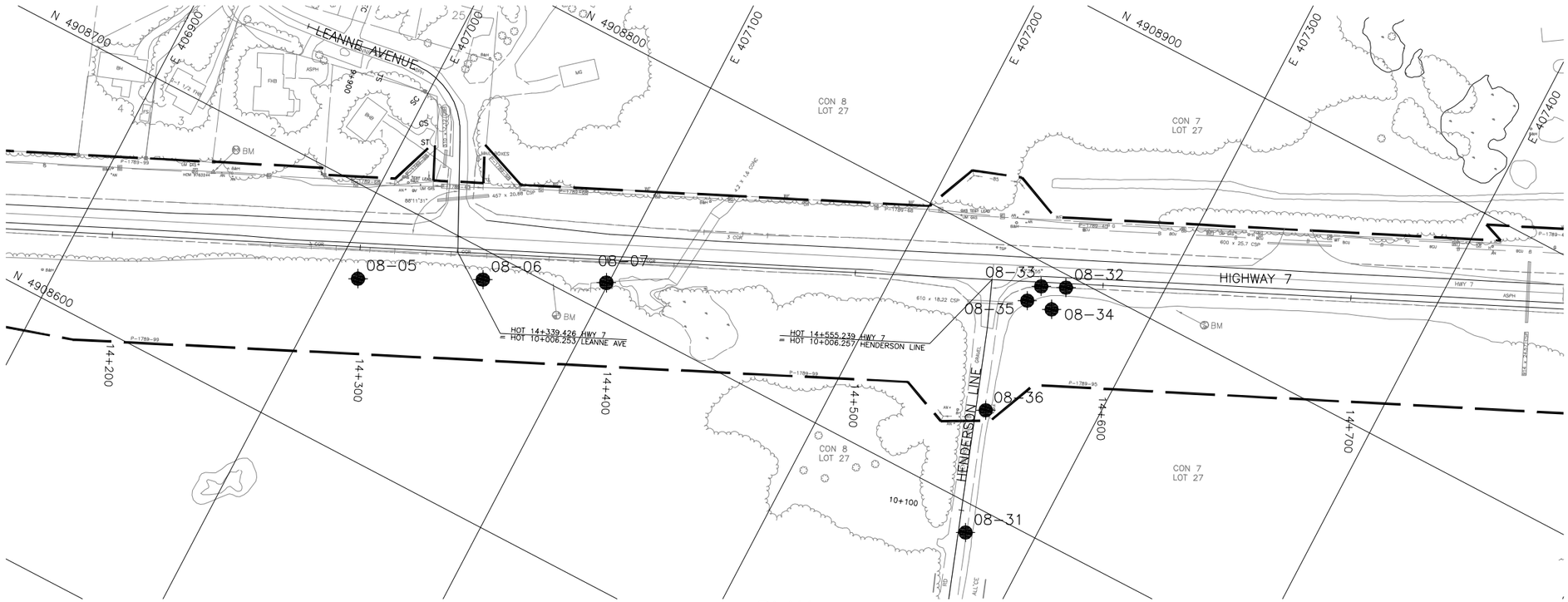
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 583-93-00

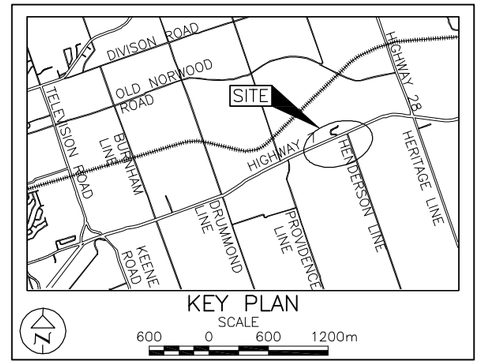
SHEET

HIGHWAY 7
EMBANKMENT WIDENING
STATION 14+300 TO 14+400 AND HENDERSON LINE
BOREHOLE LOCATIONS

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
20 0 20 40 m



KEY PLAN
SCALE
600 0 600 1200m

LEGEND

Borehole – Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-5	207.8	4908666.0	407009.7
08-6	207.8	4908689.0	407054.5
08-7	207.3	4908711.0	407099.2
08-31	209.1	4908689.0	407274.3
08-32	209.8	4908795.2	407264.4
08-33	209.7	4908791.0	407255.3
08-34	208.7	4908784.7	407263.2
08-35	208.3	4908783.3	407252.9
08-36	208.8	4908736.3	407258.6

NOTES

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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 plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007).

NO.	DATE	BY	REVISION

Geocres No.

HWY. HIGHWAY 7	PROJECT NO. 06-1111-044		DIST.
SUBM'D. PKS	CHKD. LCC	DATE: 19-Jan-2009	SITE:
DRAWN: JFC	CHKD. PKS	APPD. LCC	DWG. 2

PLOT DATE: January 19, 2009
FILENAME: h:\Projects\2006\06-1111-044 (Transenco, Peterborough)\AC-\061111044002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

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

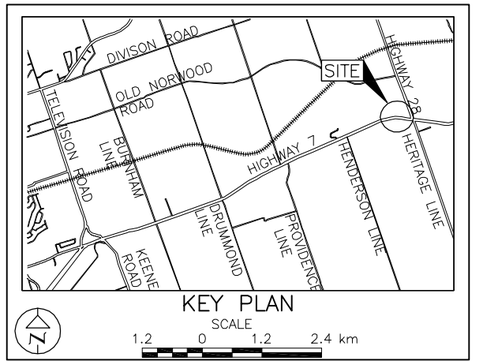
CONT No.
WP No. 583-93-00

HIGHWAY 7
EMBANKMENT WIDENING
STATION 15+600 TO 15+900 AND N-W RAMP
BOREHOLE LOCATIONS

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

PLAN
SCALE
20 0 20 40 m



KEY PLAN
SCALE
1.2 0 1.2 2.4 km

LEGEND

Borehole – Current Investigation

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
08-9	226.8	4909130.0	408450.3
08-9A	226.7	4909135.0	408400.5
08-10	226.9	4909126.0	408474.9
08-11	229.8	4909181.0	408202.4
08-12	228.5	4909182.0	408253.3
08-13	227.2	4909185.0	408304.5
08-14	226.8	4909182.0	408350.1
08-15	226.6	4909178.0	408390.4
08-16	226.7	4909176.0	408430.1
08-17	227.0	4909168.0	408479.2
08-18	227.8	4909211.0	408515.3
08-19	226.6	4909253.0	408500.0
08-20	226.8	4909295.0	408488.1
08-21	226.8	4909349.0	408470.6

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 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 plan provided in digital format by Transenco Engineering (drawing file "Plan Existing.dwg", received May 24, 2007).

NO.	DATE	BY	REVISION

Geocres No.

HWY. HIGHWAY 7	PROJECT NO. 06-1111-044		DIST.
SUBM'D. PKS	CHKD. LCC	DATE: 19-Jan-2009	SITE:
DRAWN: JFC	CHKD. PKS	APPD. LCC	DWG. 3

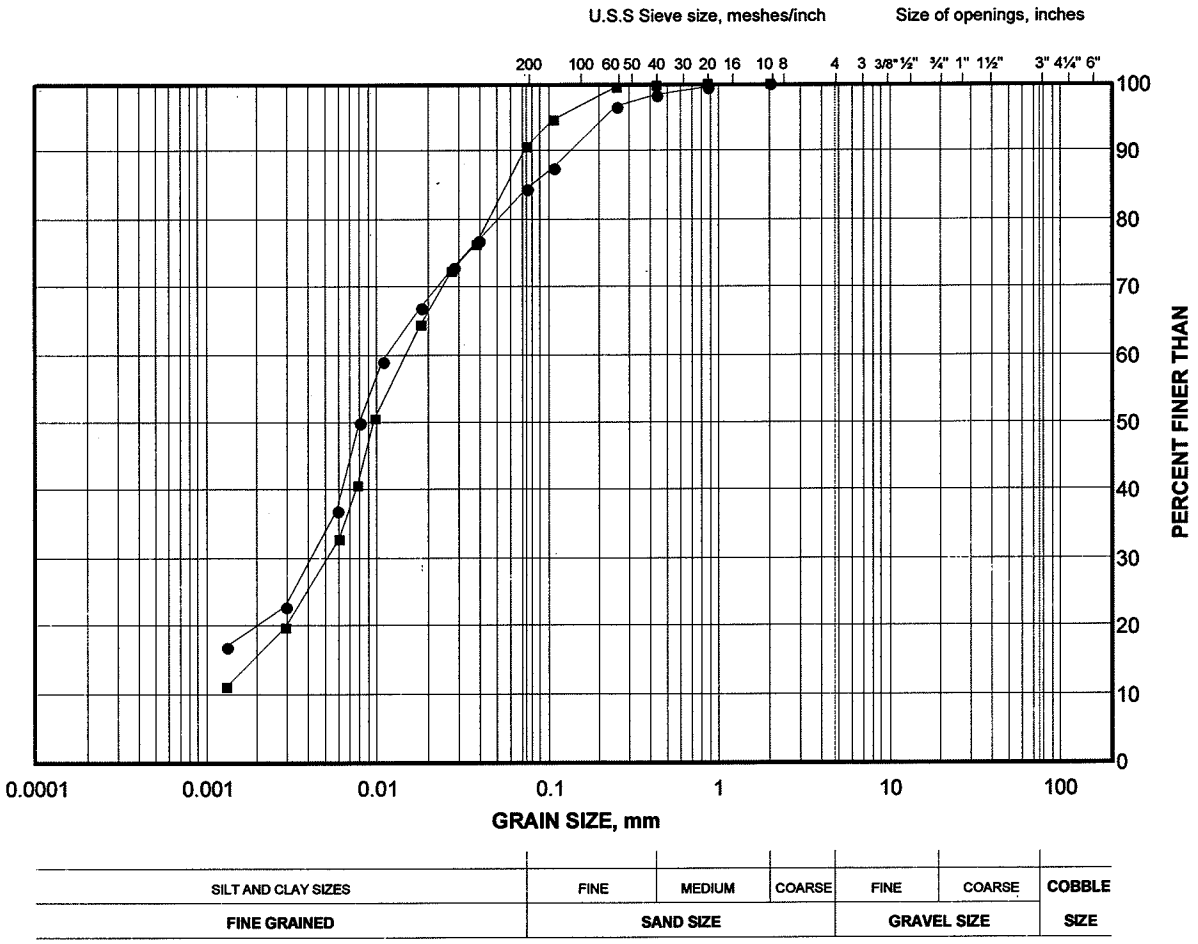
PLOT DATE: January 19, 2009
FILENAME: I:\Projects\2008\06-1111-044 (Transenco, Peterborough)\-MC-\061111044MC003.dwg

GRAIN SIZE DISTRIBUTION TEST RESULTS

Organic Silt / Clayey Silt

Station 14+300 to 14+400 (South)

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-07	1	207.0
■	08-07	2	205.5

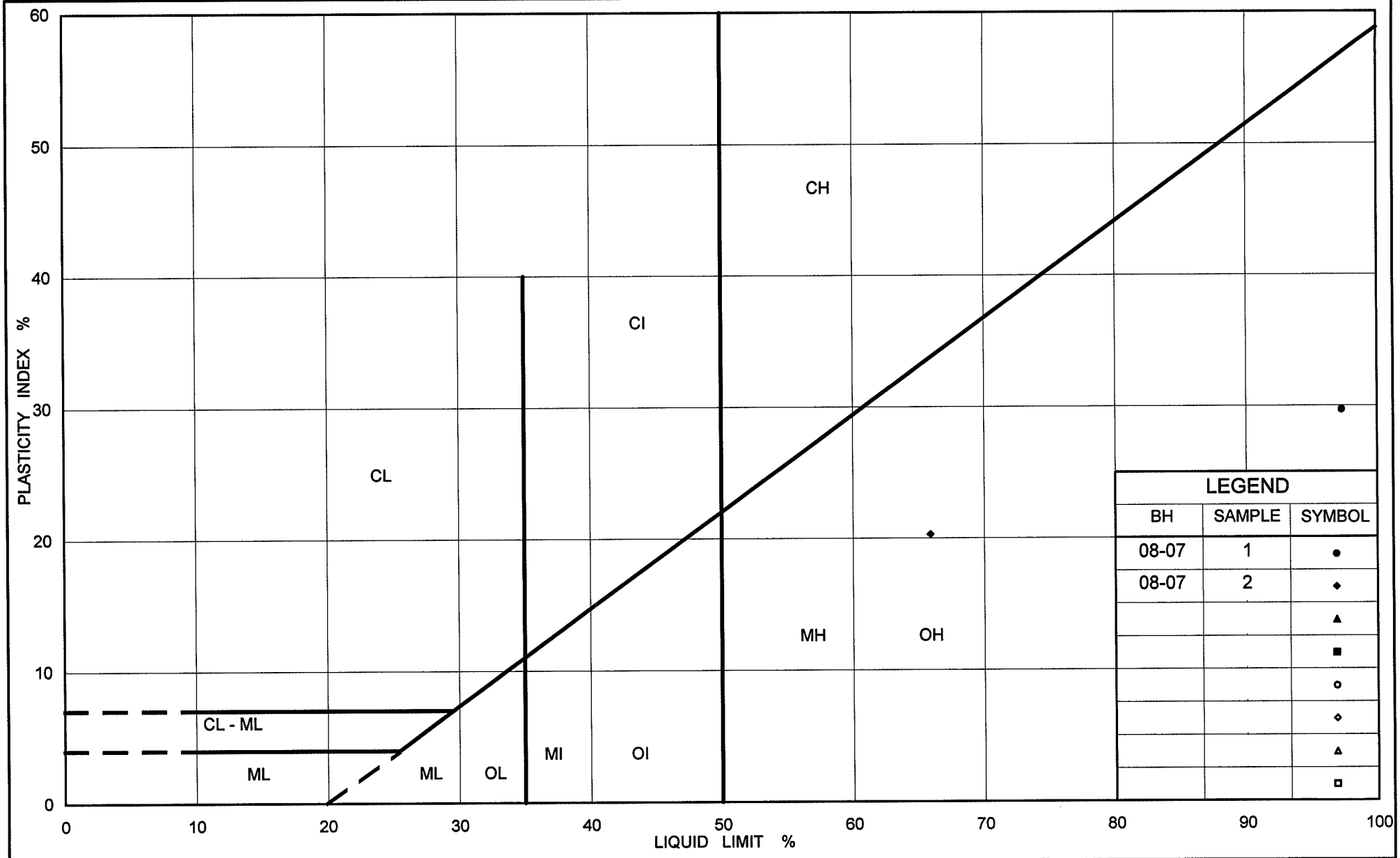
Project Number: 06-1111-044

Checked By: _____

Golder Associates

Date: 21-Jan-09

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Organic Silt / Clayey Silt
Station 14+300 to 14+400 (South)

Figure No. 2

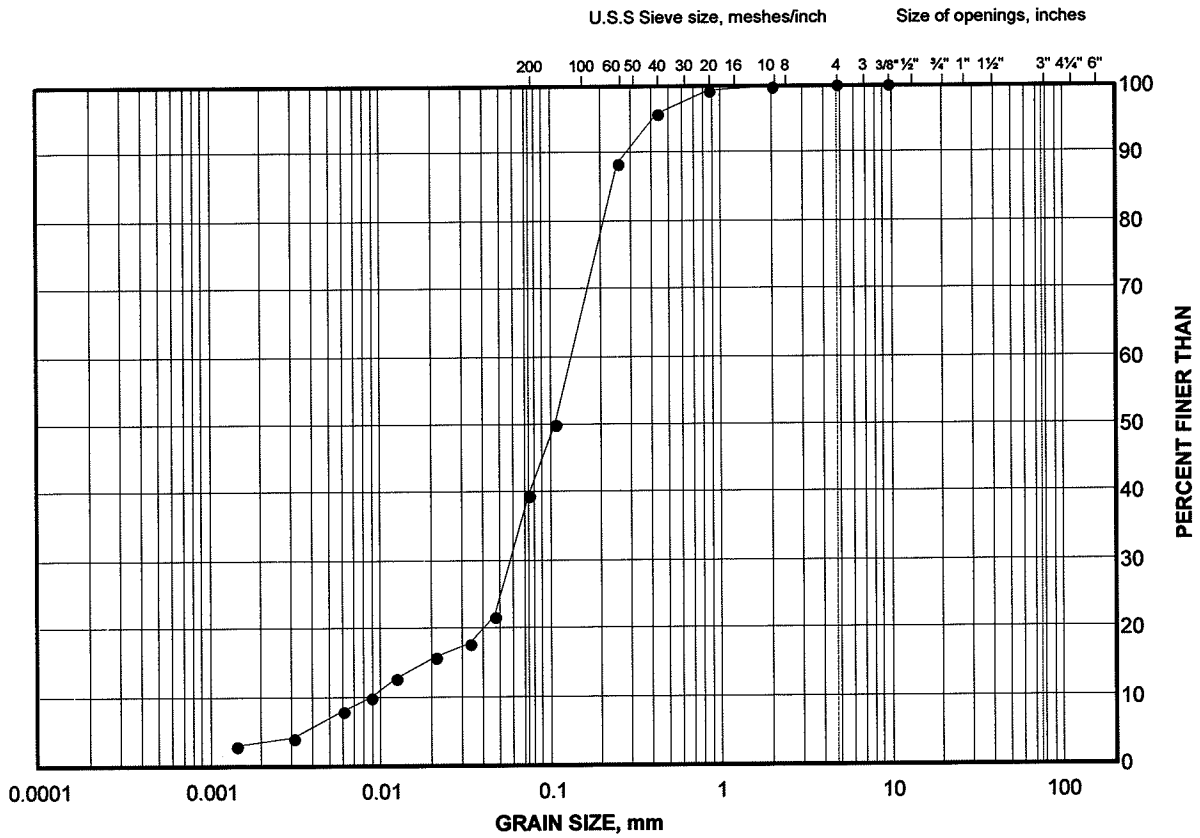
Project No. 06-1111-044

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULT

Upper Silty Sand to Sand and Silt
Station 14+300 to 14+400 (South)

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-05	3	205.9

Project Number: 06-1111-044

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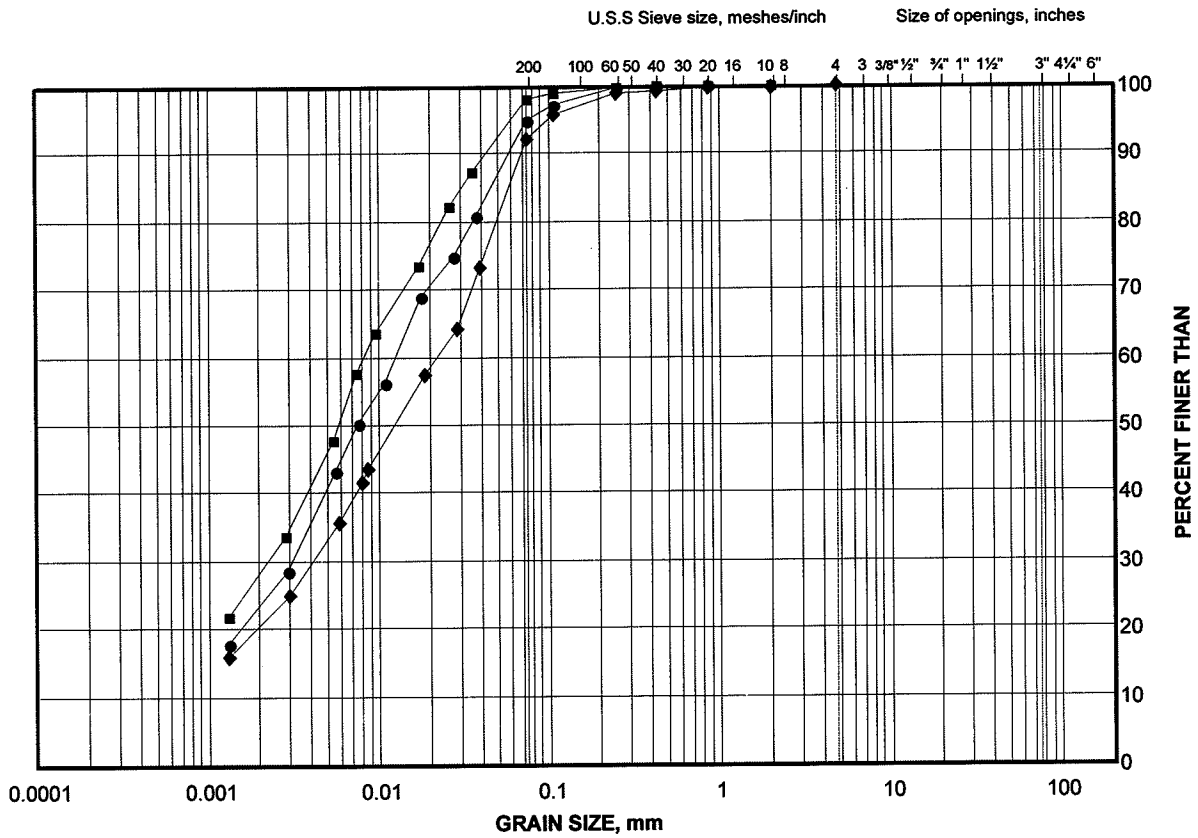
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt

Station 14+300 to 14+400 (South)

FIGURE 4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-07	5	203.3
■	08-06	5	203.7
◆	08-05	6	203.7

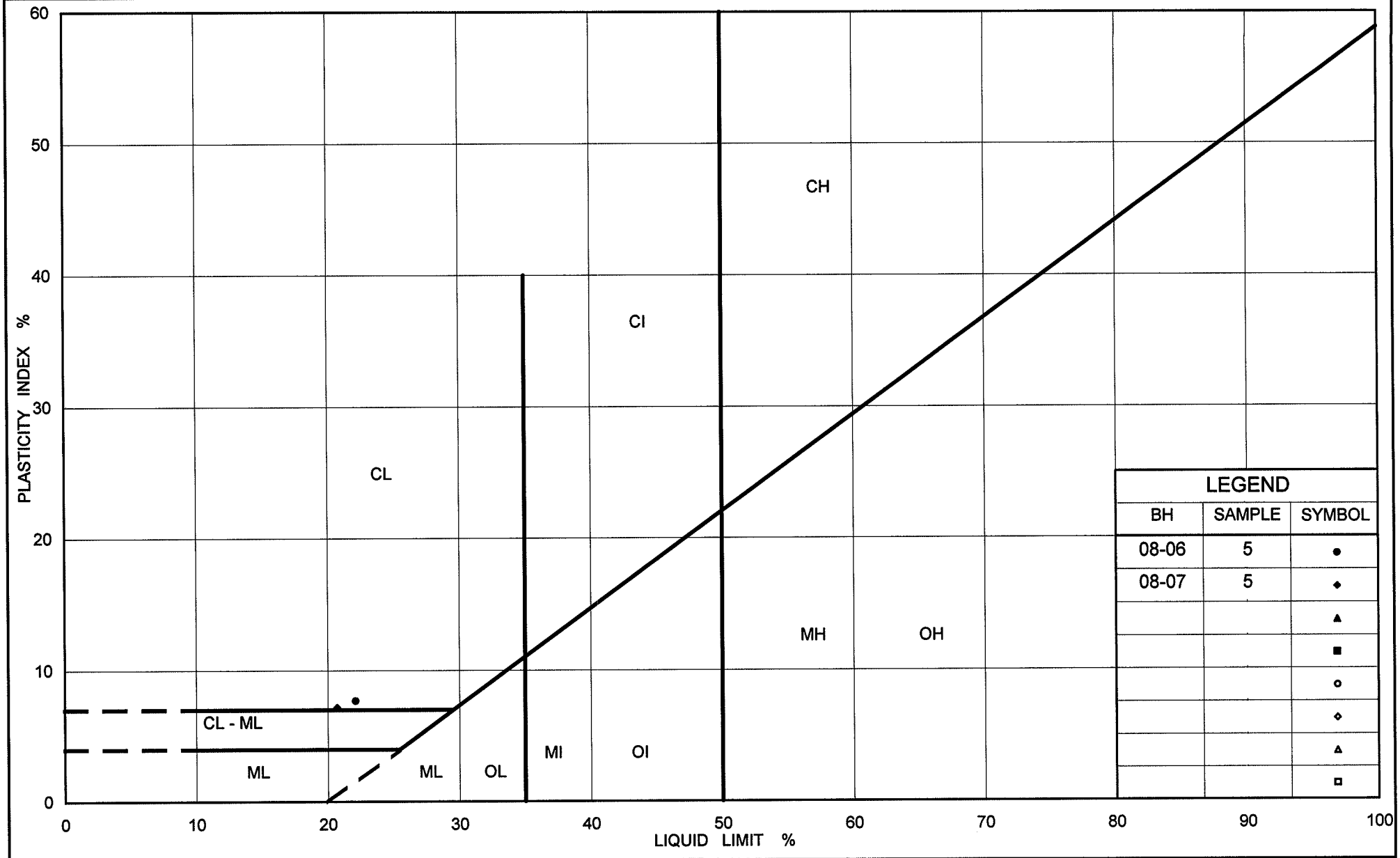
Project Number: 06-1111-044

Checked By: _____

Golder Associates

Date: 21-Jan-09

Oct 75. FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Station 14+300 to 14+400 (South)

Figure No. 5

Project No. 06-1111-044

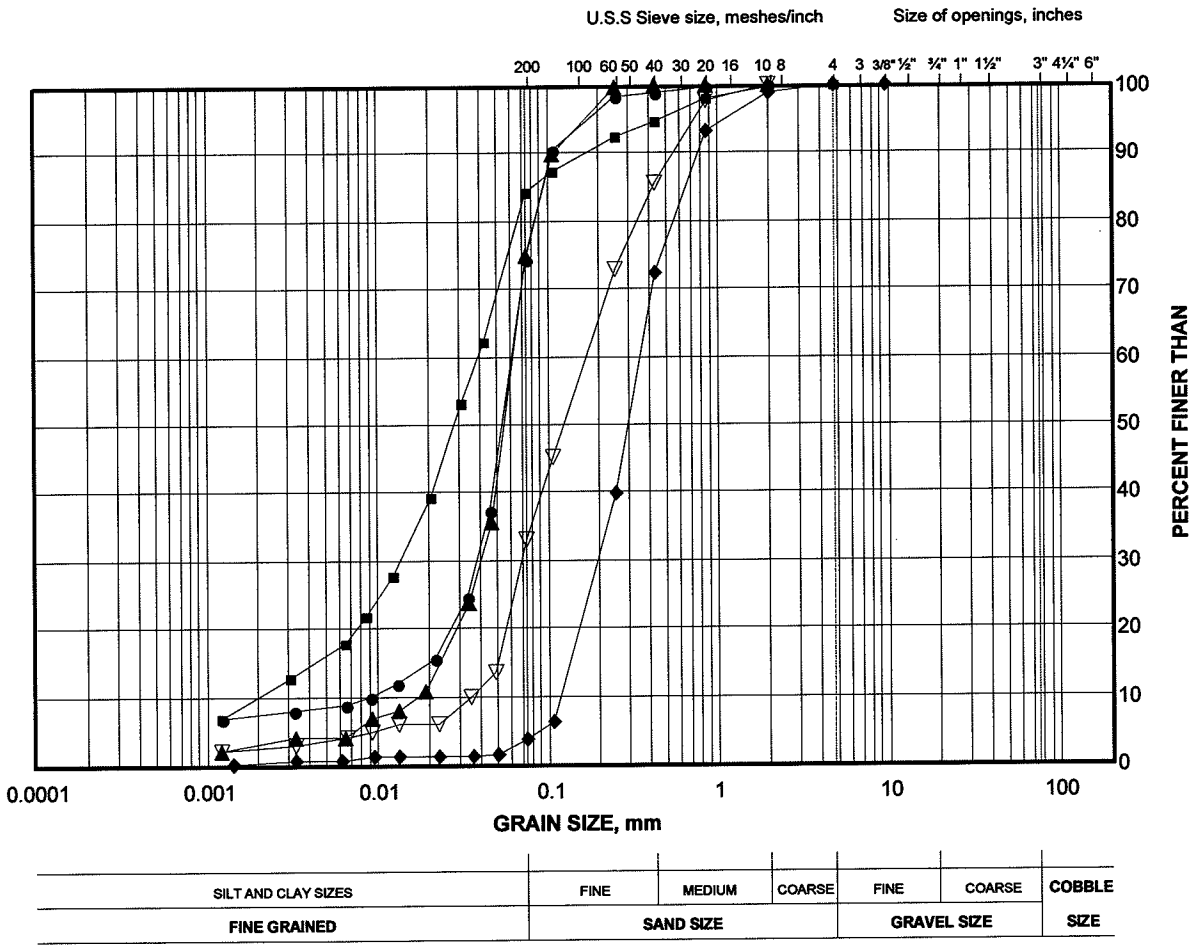
Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand to Silt

Station 14+550 to 14+600 (South) and Henderson Line

FIGURE 6A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-31	2	208.1
■	08-32	4	207.2
◆	08-32	6	205.7
▲	08-31	6	205.0
▽	08-31	9	201.2

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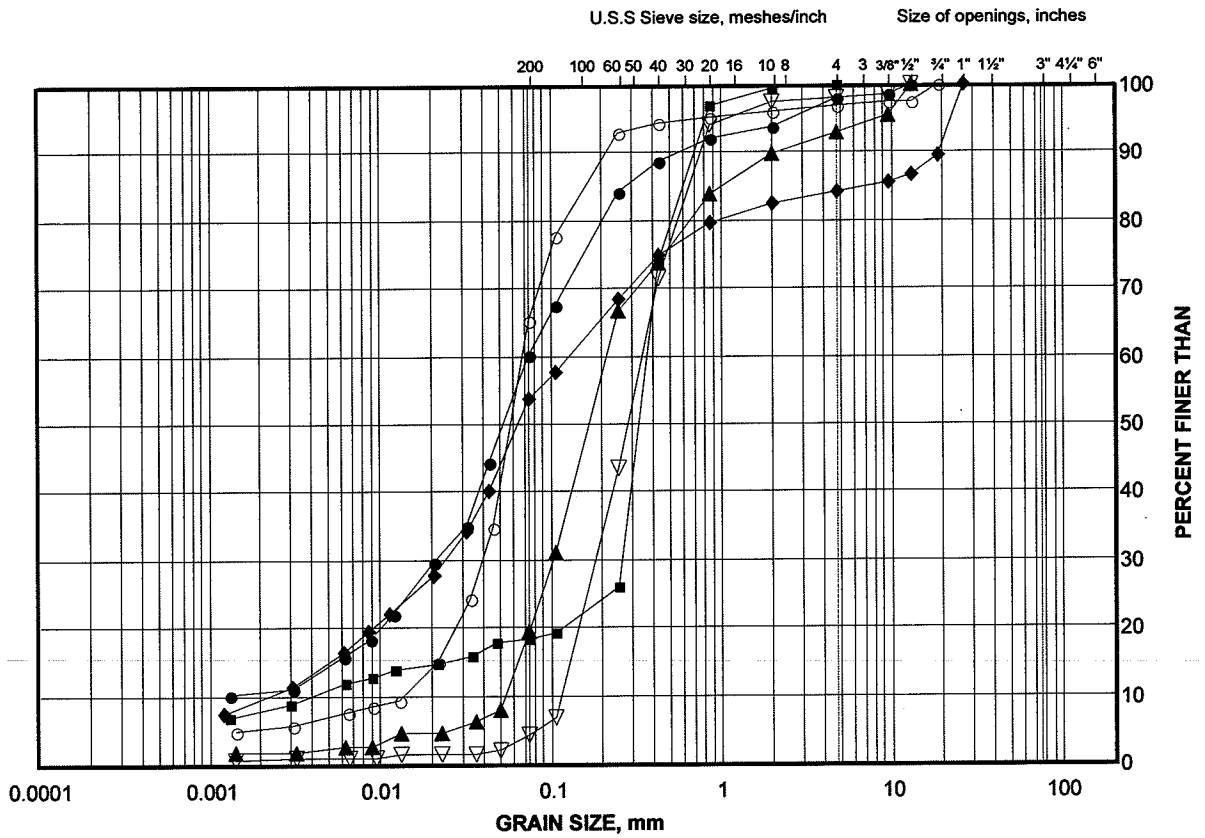
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sand to Silt

Station 14+550 to 14+600 (South) and Henderson Line

FIGURE 6B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-35	2B	207.3
■	08-36	3	207.2
◆	08-35	3	206.5
▲	08-34	3	206.8
▽	08-33	4	206.3
○	08-35	5	204.9

Project Number: 06-1111-044

Checked By: _____

Golder Associates

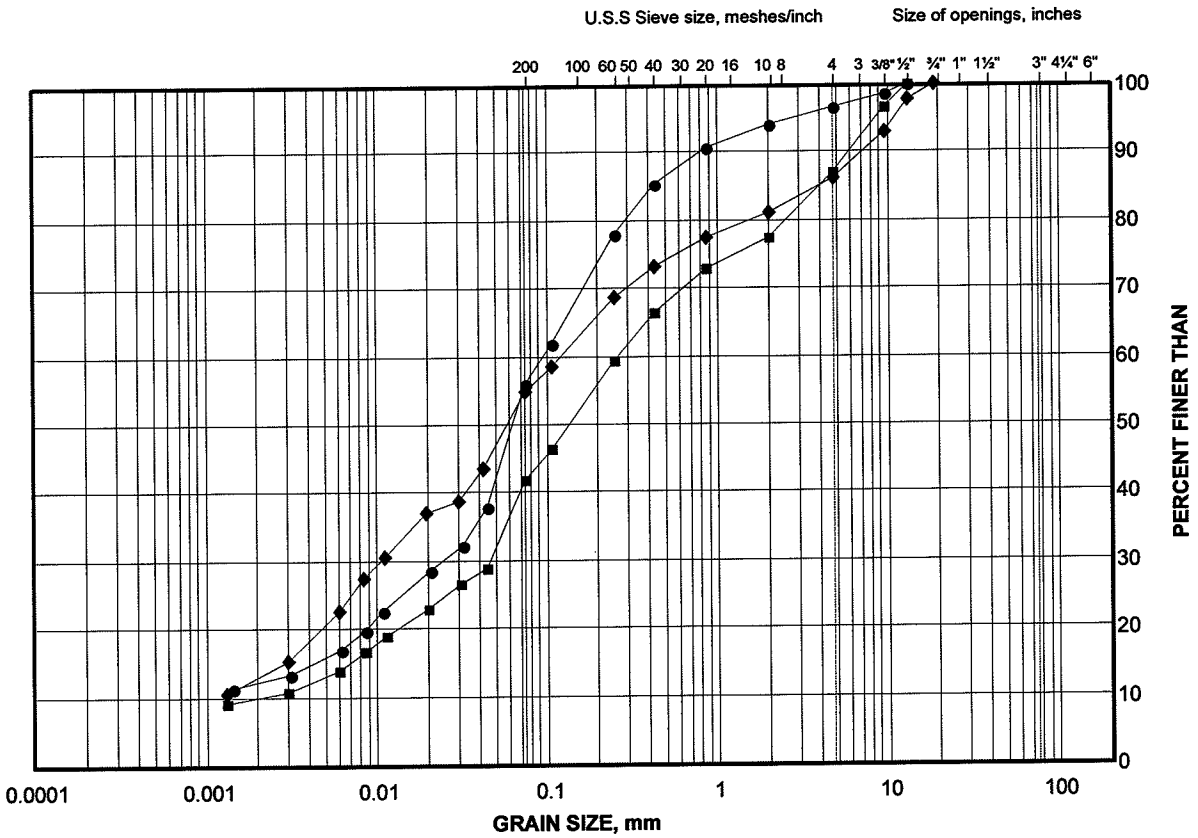
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Fill

Station 15+600 to 15+800 (North) and Station 15+800 to 16+075 (N-W Ramp)

FIGURE 7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-15	2	225.8
■	08-15	3	225.4
◆	08-14	3	225.6

Project Number: 06-1111-044

Checked By: _____

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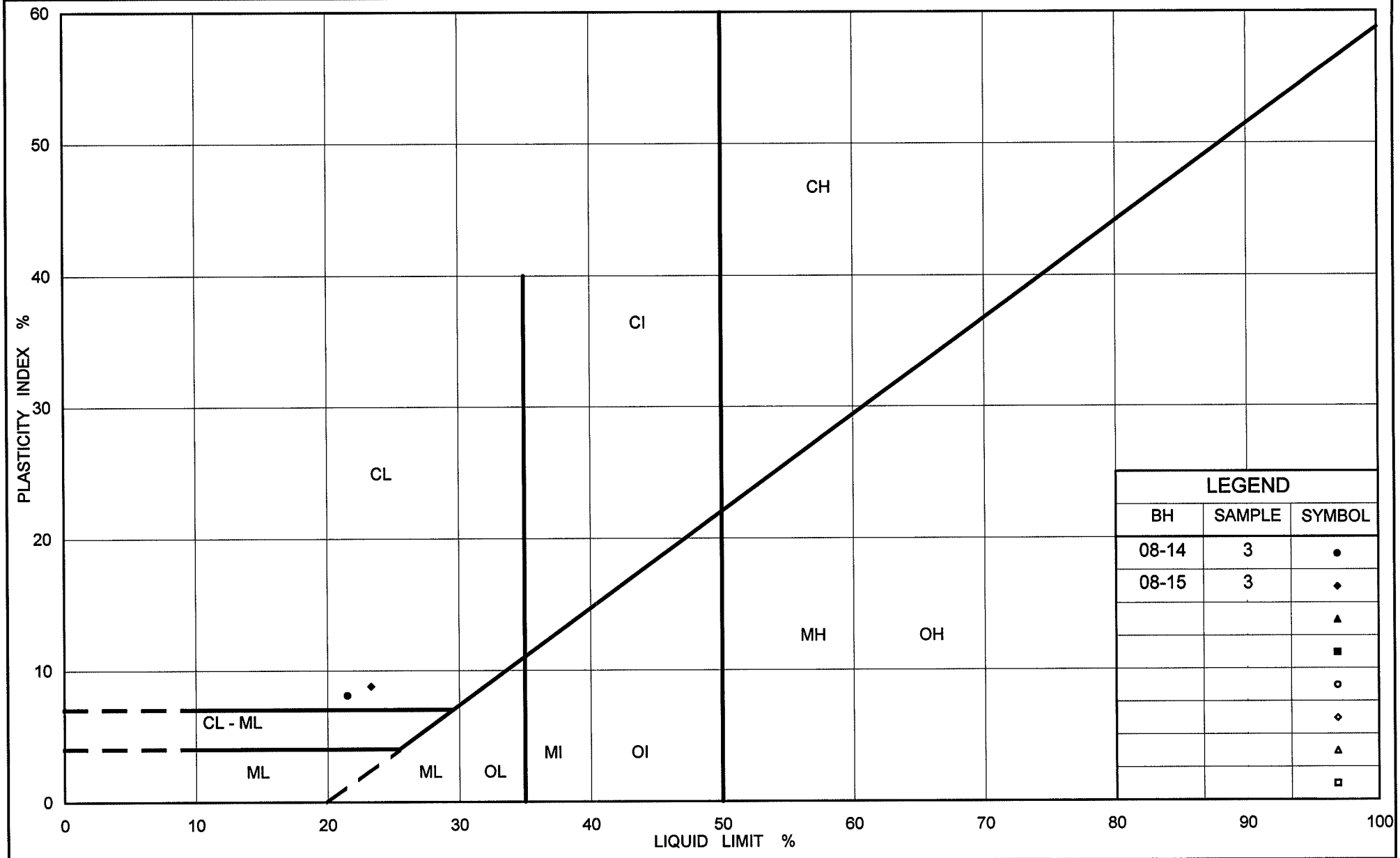
Date: 21-Jan-09

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt Fill

Station 15+600 to 15+800 (North) and 15+800 to 16+075 (N-W Ramp)

Figure No. 8

Project No. 06-1111-044

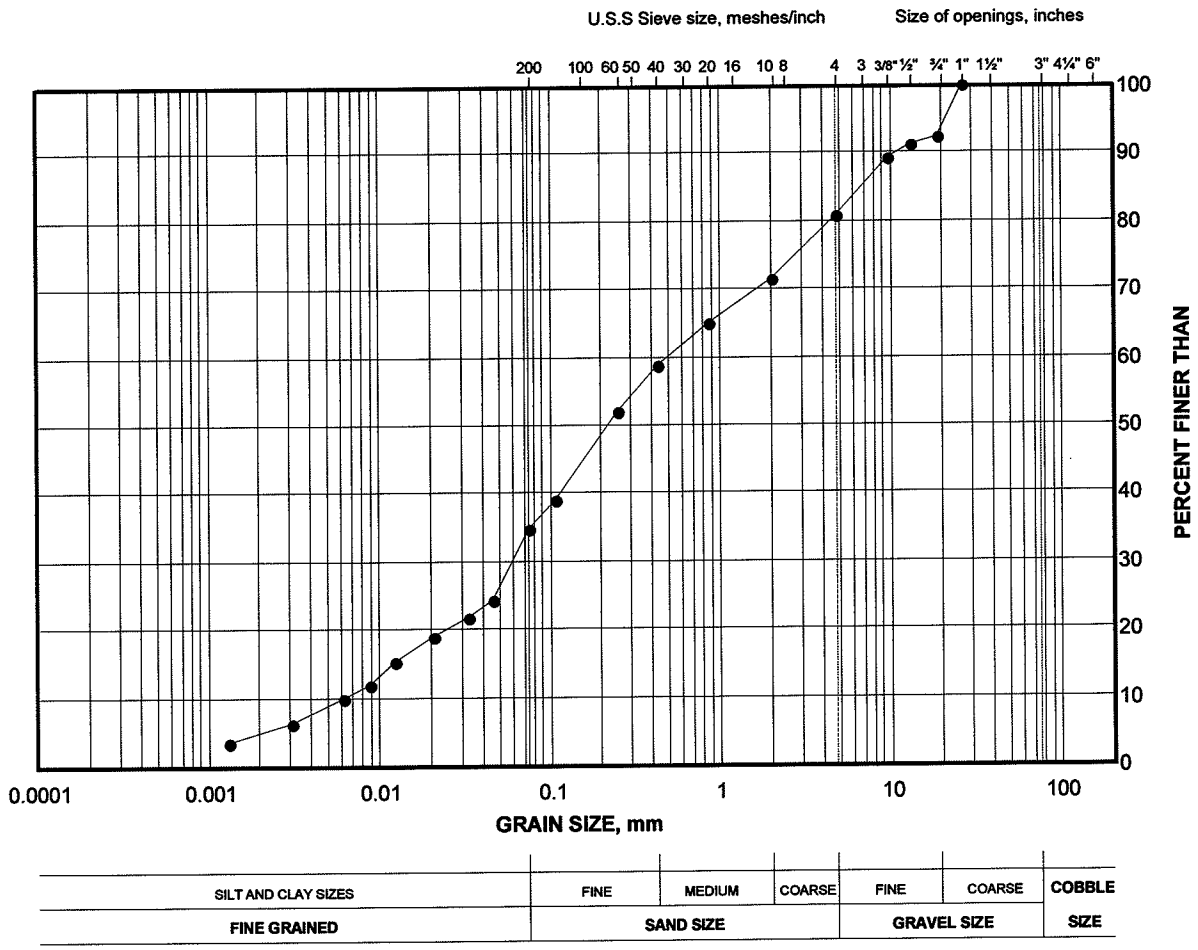
Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULT

Surficial Sand and Silt

Station 15+600 to 15+800 (North) and Station 15+800 to 16+075 (N-W Ramp)

FIGURE 9



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-21	2	225.8

Project Number: 06-1111-044

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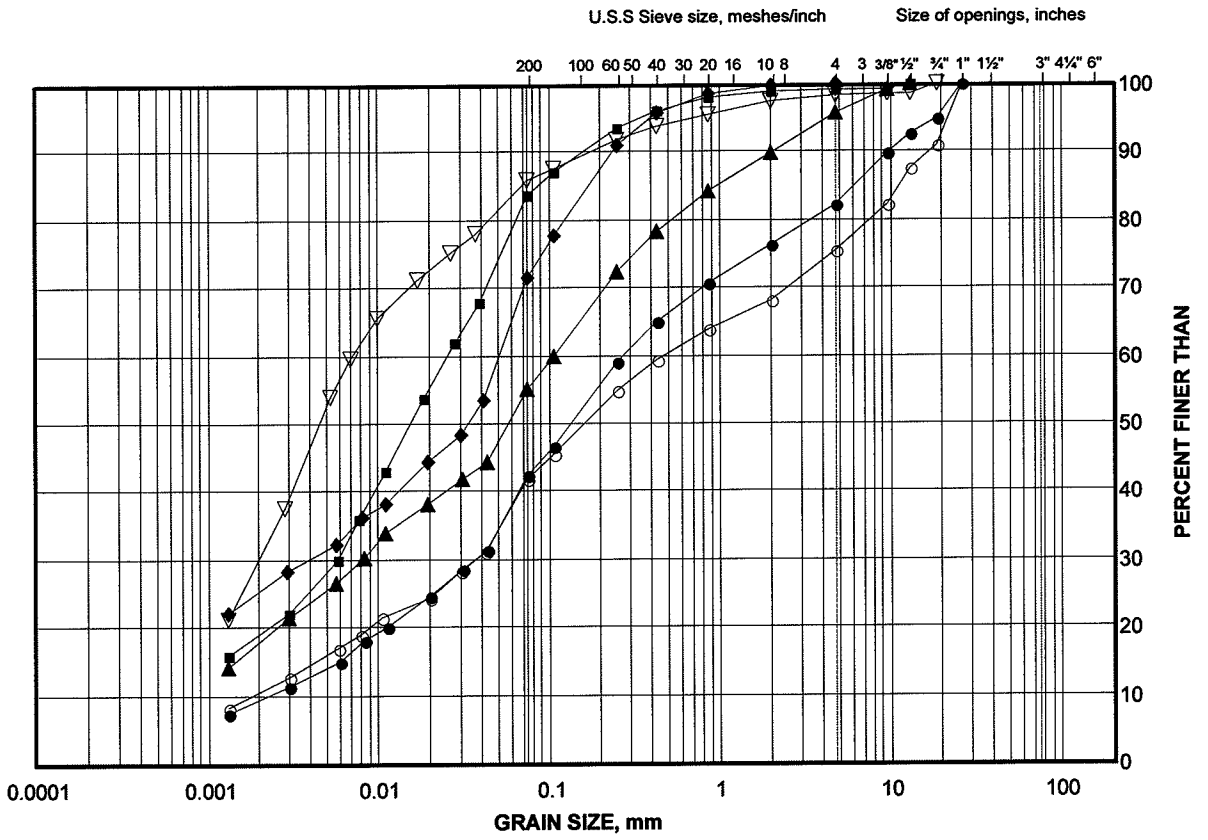
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

Station 15+600 to 15+800 (North) and Station 15+800 to 16+075 (N-W Ramp)

FIGURE 10A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-16	2	225.6
■	08-13	2	226.1
◆	08-12	2	227.7
▲	08-11	2	229.0
▽	08-17	3	225.1
○	08-16	5	223.3

Project Number: 06-1111-044

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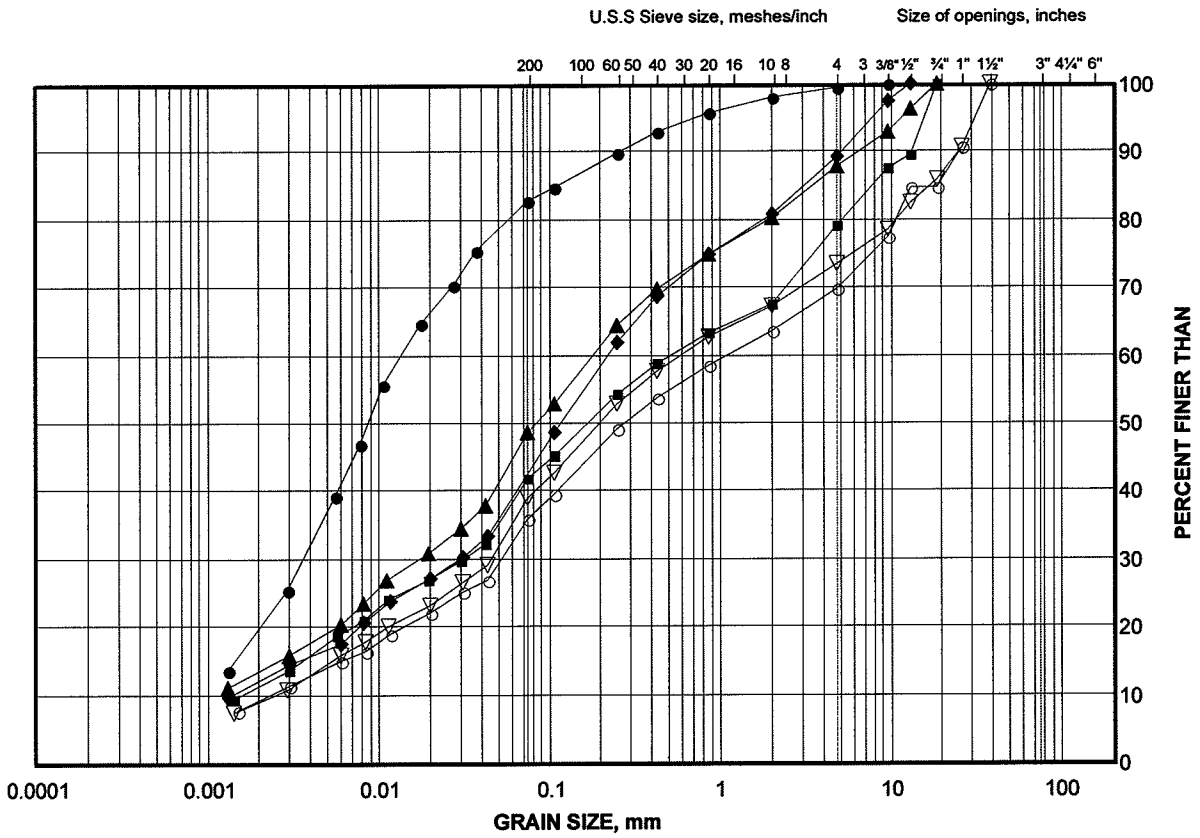
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

Station 15+600 to 15+800 (North) and Station 15+800 to 16+075 (N-W Ramp)

FIGURE 10B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-19	2	225.5
■	08-21	3	225.1
◆	08-20	3	225.0
▲	08-20	4	224.2
▽	08-19	4	224.0
○	08-18	5	224.5

Project Number: 06-1111-044

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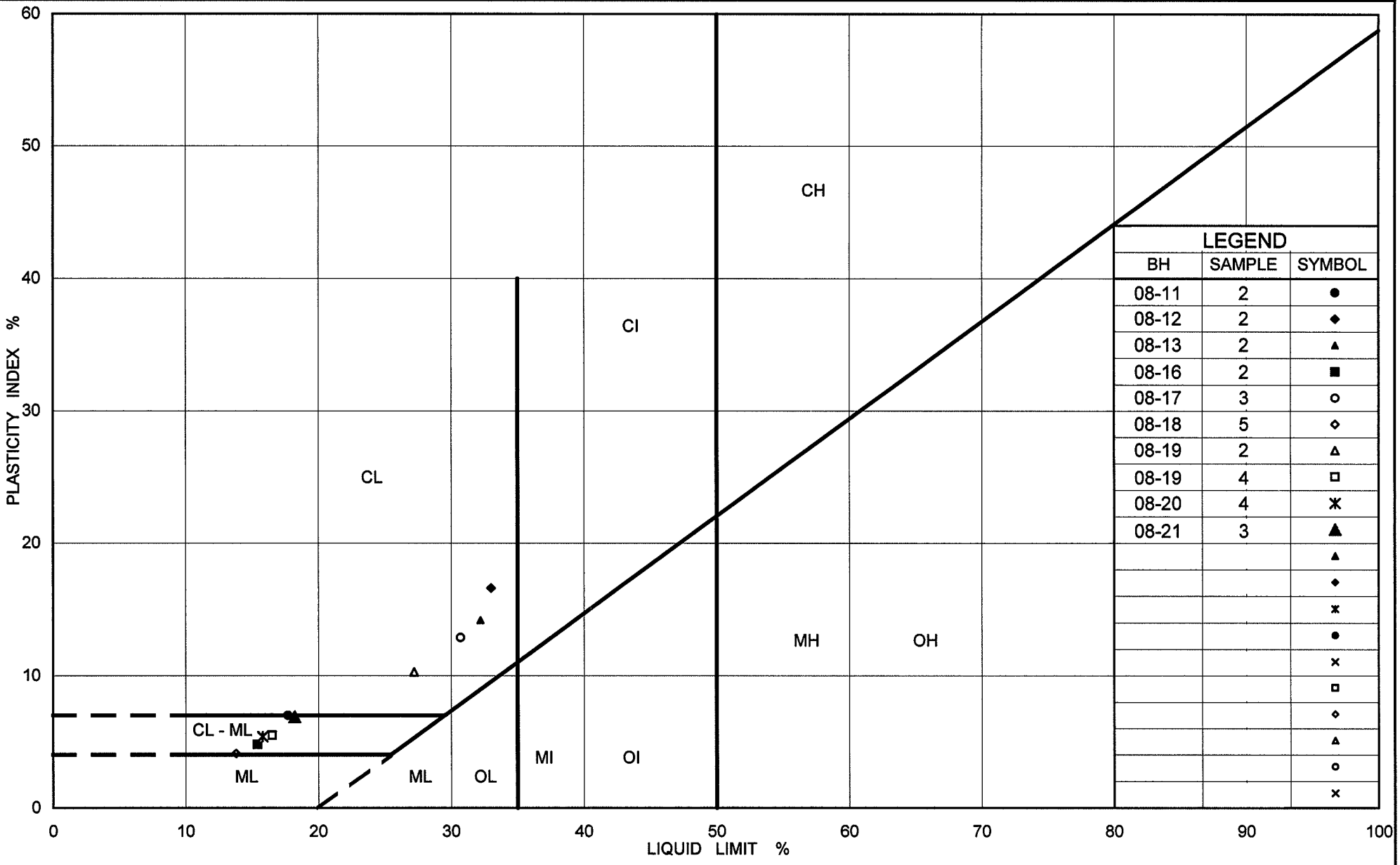
Date: 21-Jan-09

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt Till

Station 15+600 to 15+800 (North) and 15+800 to 16+075 (N-W Ramp)

Figure No. 11

Project No. 06-1111-044

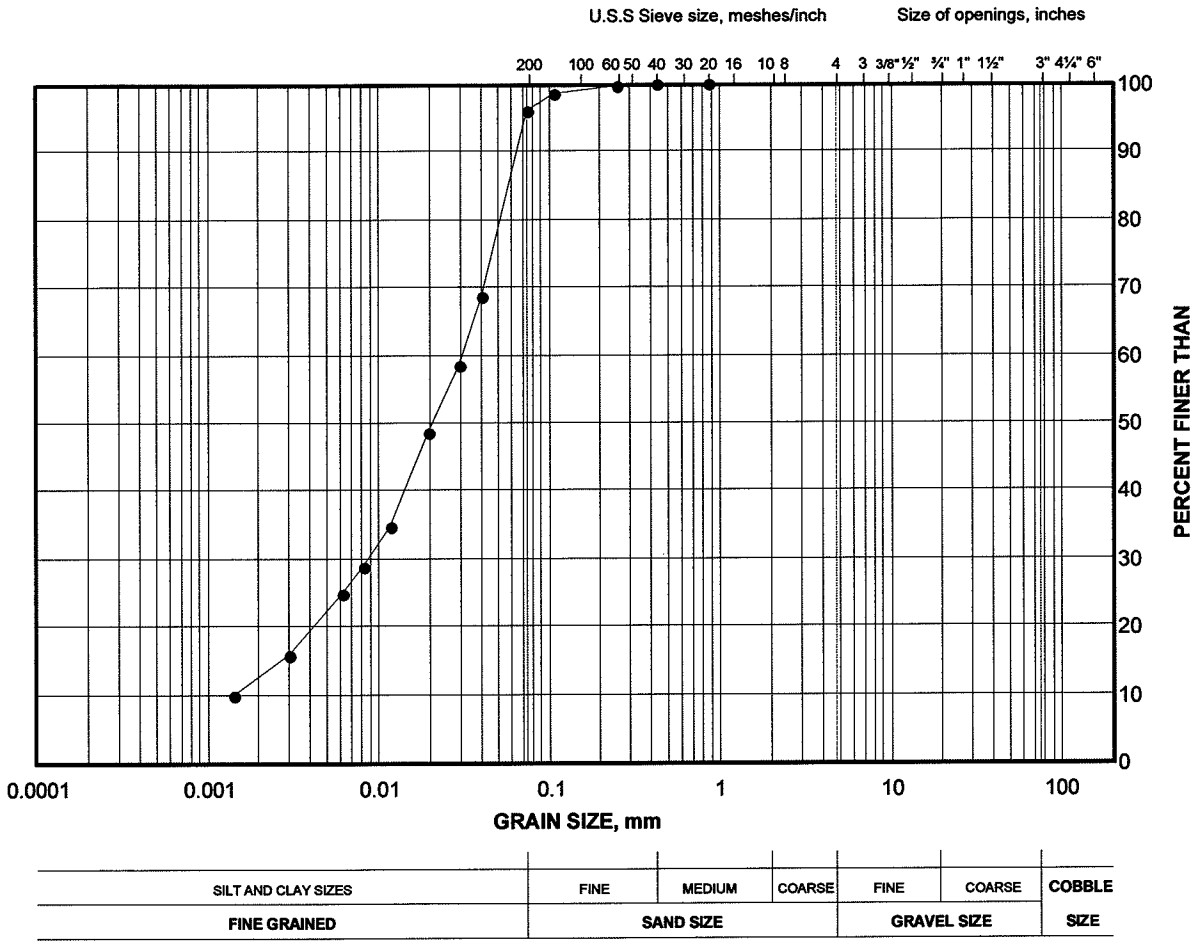
Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULT

Surficial Clayey Silt

Station 15+800 to 15+900 (South)

FIGURE 12



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-09	2	225.7

Project Number: 06-1111-044

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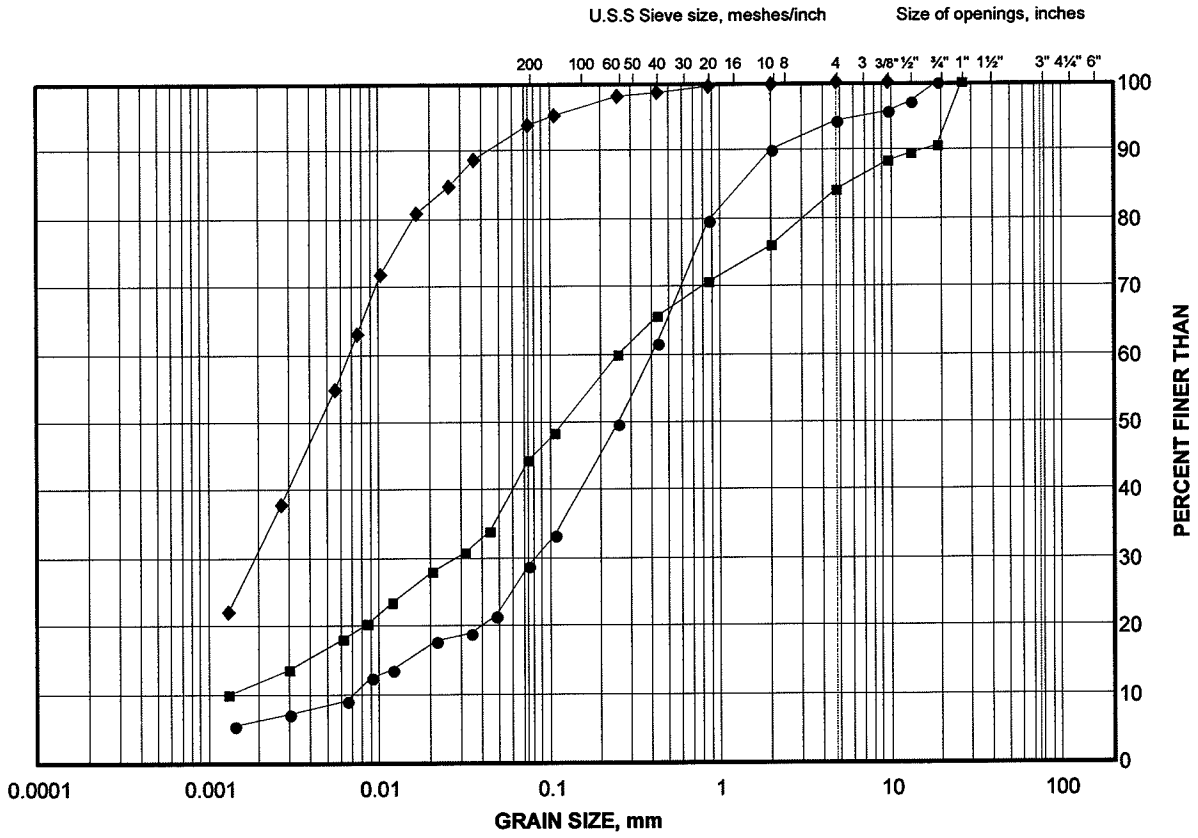
Date: 21-Jan-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till to Sand Till

Station 15+800 to 15+900 (South)

FIGURE 13



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-09A	2	225.6
■	08-10	3	225.1
◆	08-09	3	225.0

Project Number: 06-1111-044

Checked By: _____

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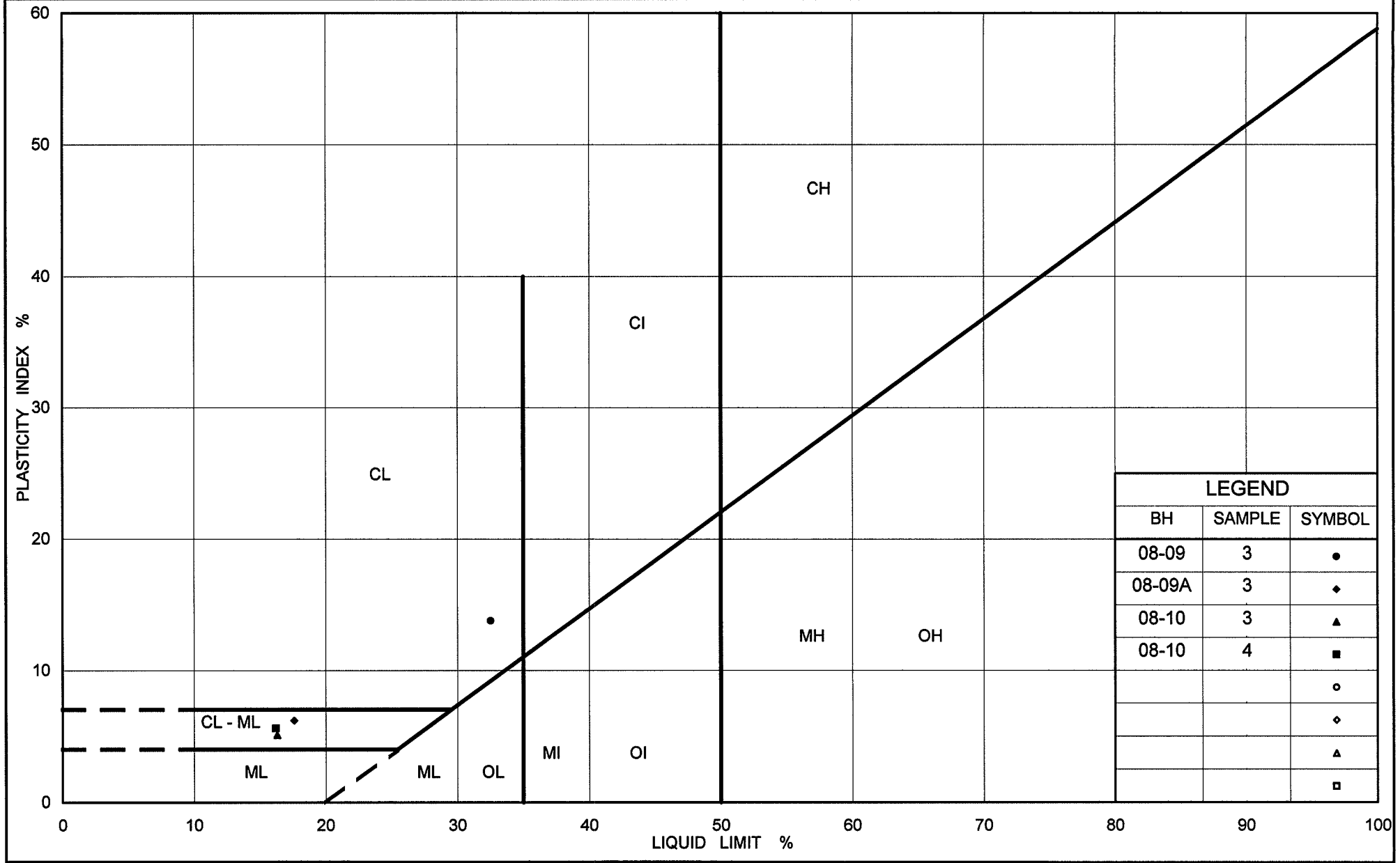
Date: 21-Jan-09

Oct 75, FF-S-21



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PLASTICITY CHART
Clayey Silt Till
Station 15+800 to 15+900 (South)

Figure No. 14

Project No. 06-1111-044

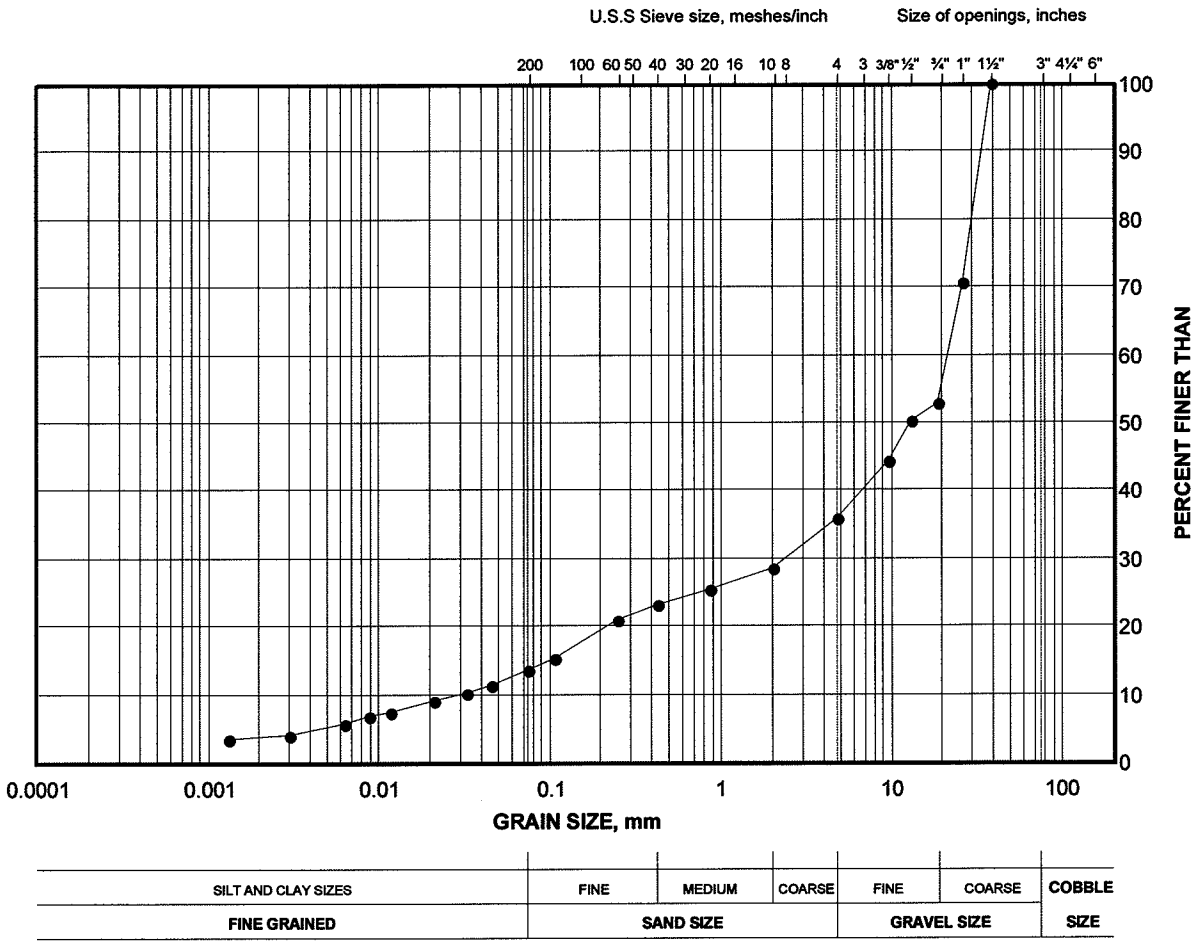
Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULT

Sandy Gravel

Station 15+800 to 15+900 (South)

FIGURE 15



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	08-10	5	223.5

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Checked By: _____

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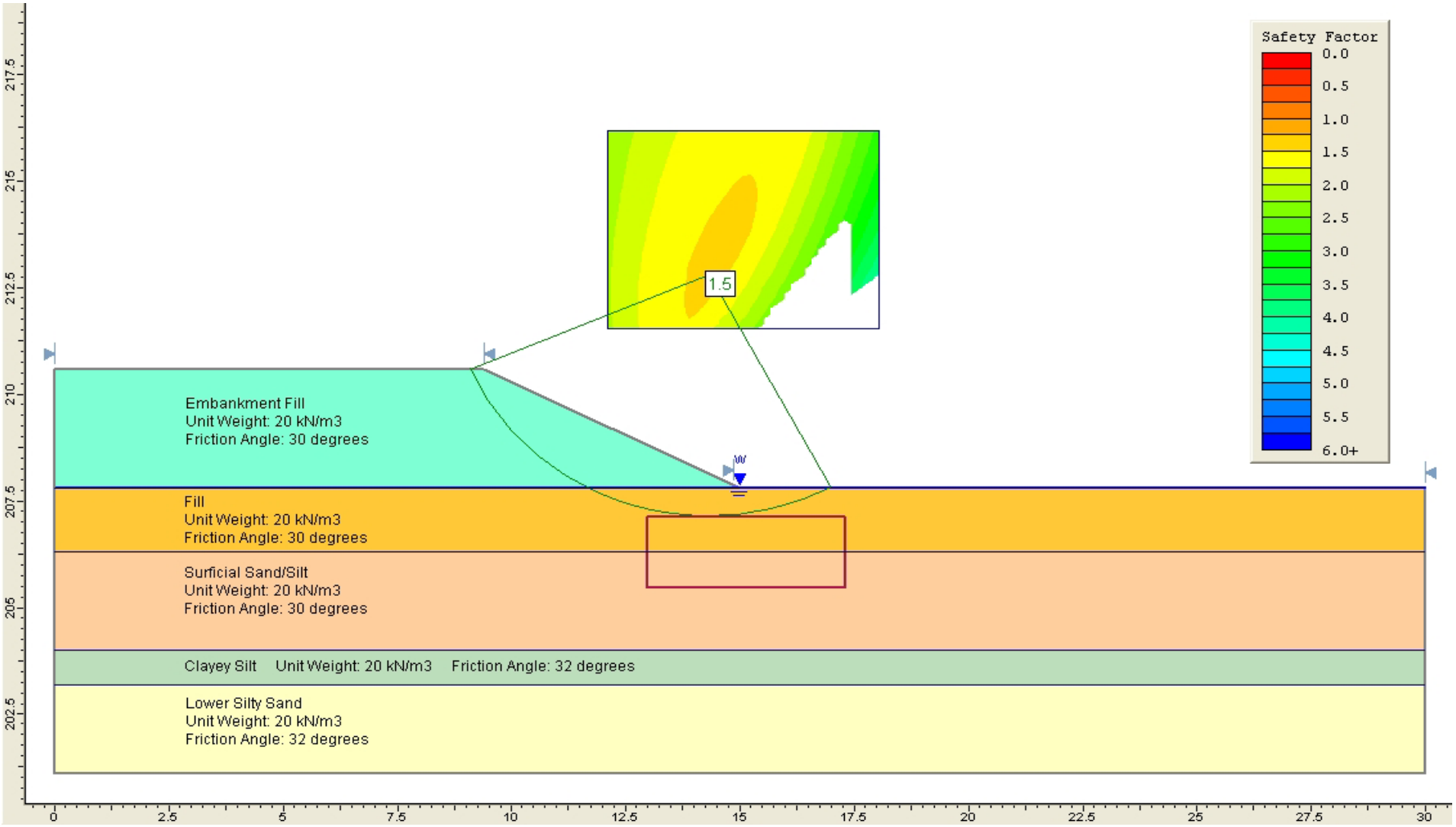
Date: 21-Jan-09

Static Global Stability Analysis Results
Highway 7 Embankment Widening, Station 14+300 to 14+450 (South)
2H : 1V Embankment Side Slope (Earth or Granular Fill)

Figure 16



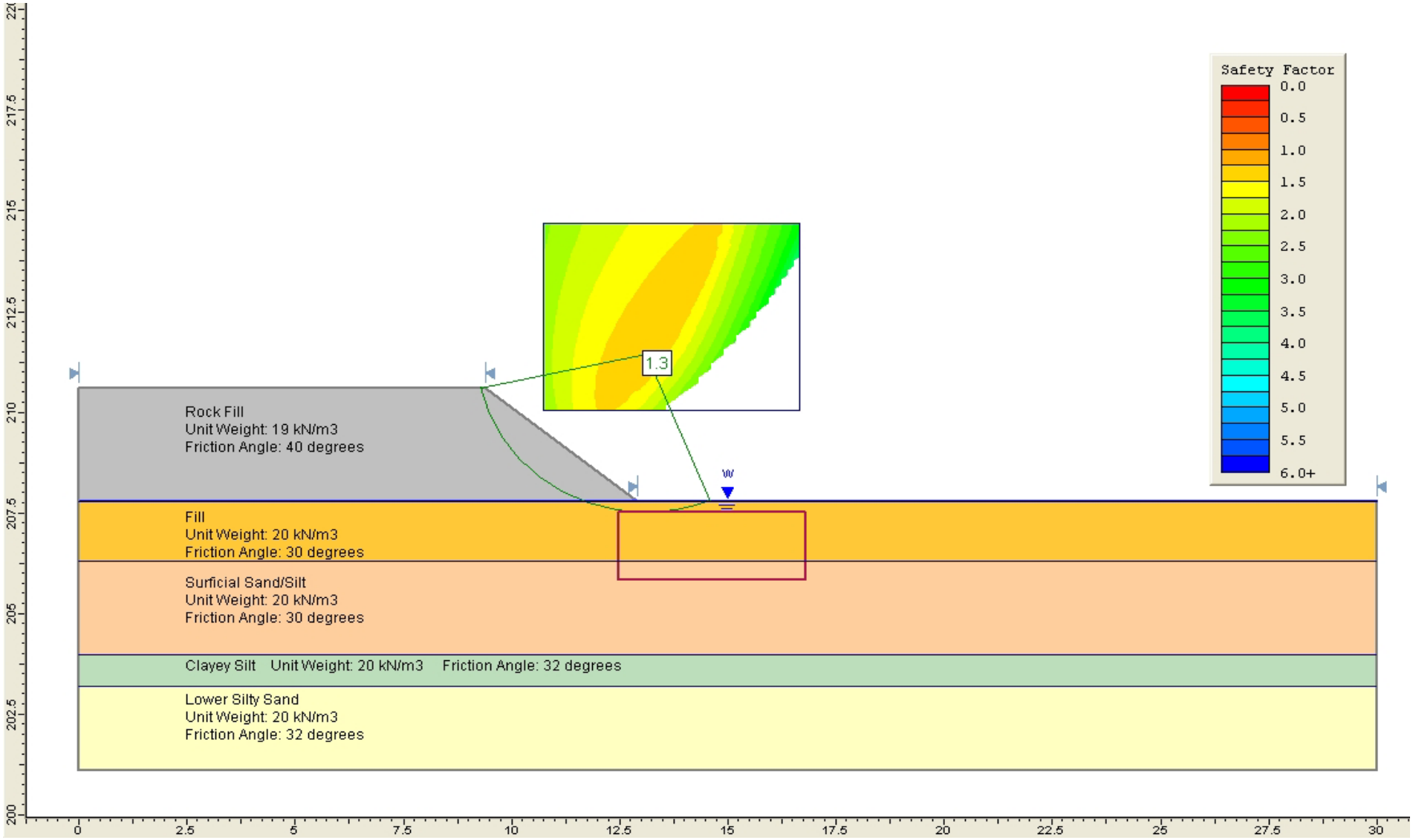
Date: January 2009
Project: 06-1111-044-3

Golder Associates

Drawn: TB
Checked: LCC

Static Global Stability Analysis Results
Highway 7 Embankment Widening, Station 14+300 to 14+450 (South)
1.25H : 1V Embankment Side Slope (Rock Fill)

Figure 17



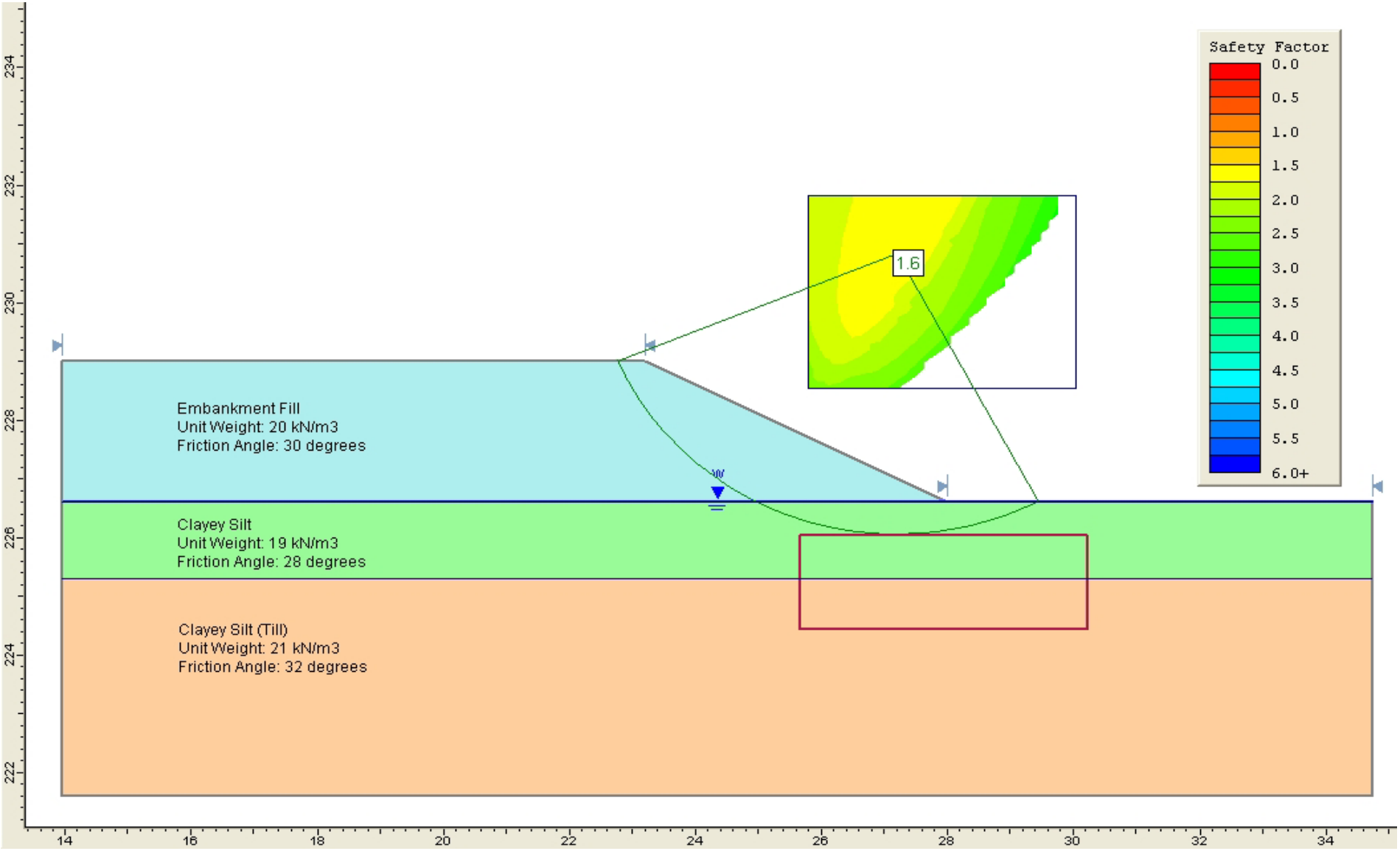
Date: January 2009
Project: 06-1111-044-3

Golder Associates

Drawn: TB
Checked: LCC

Static Global Stability Analysis Results
Highway 7 Embankment Widening, Station 15+800 to 15+900 (South)
2H : 1V Embankment Side Slope (Earth or Granular Fill)

Figure 18



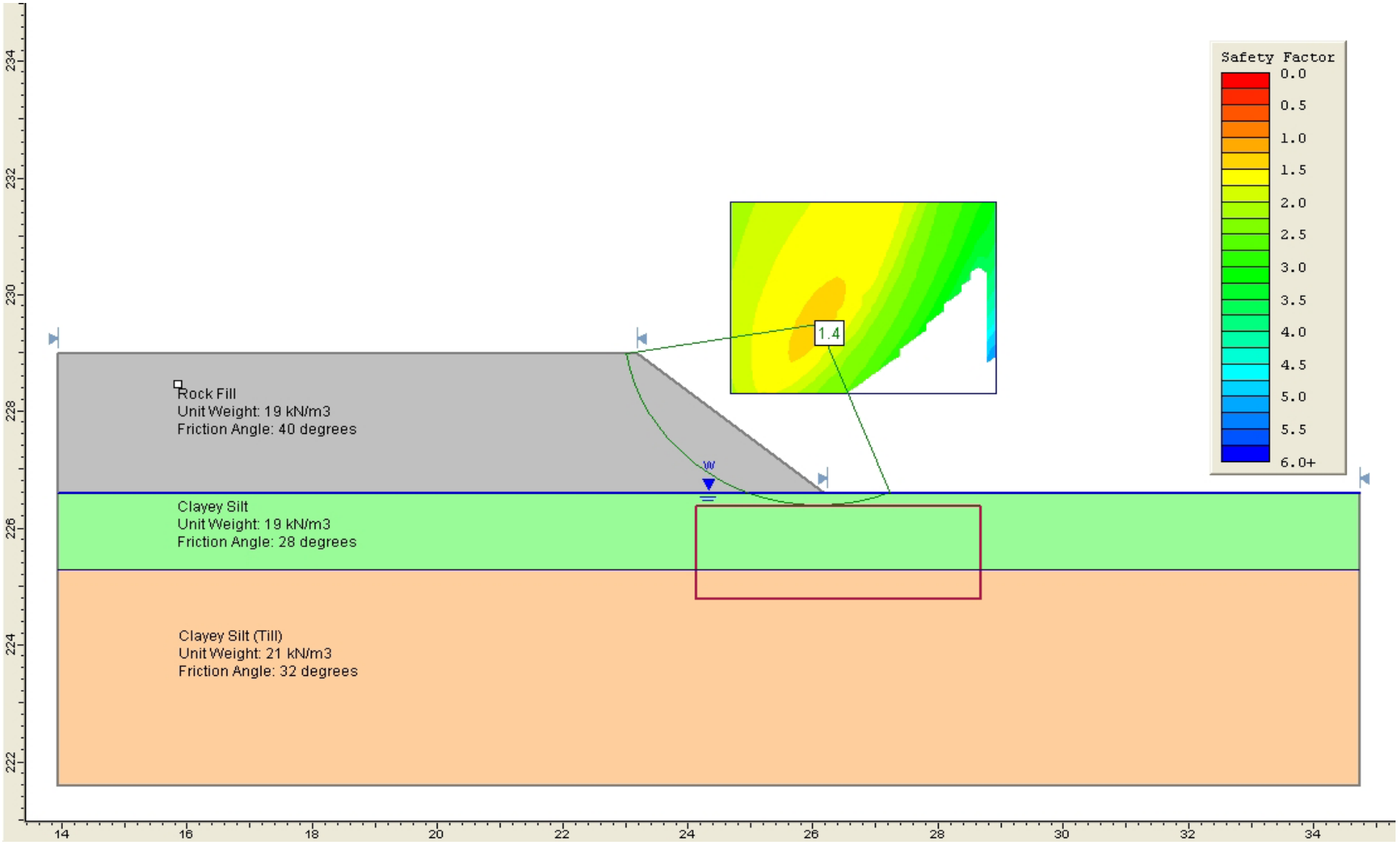
Date: January 2009
Project: 06-1111-044-3

Golder Associates

Drawn: TB
Checked: LCC

Static Global Stability Analysis Results
Highway 7 Embankment Widening, Station 15+800 to 15+900 (South)
1.25H : 1V Embankment Side Slope (Rock Fill)

Figure 19



Date: January 2009
Project: 06-1111-044-3

Golder Associates

Drawn: TB
Checked: LCC

APPENDIX A

OPERATIONAL CONSTRAINTS

Muskeg Excavation - Item No.

Operational Constraint

This special provision outlines the procedure to be used where muskeg excavation is required adjacent to or below the toe of the existing Highway 7 embankment, where such excavation extends to a depth of greater than 1 m below the original ground surface at the embankment toe.

Removal of the peat and/or organic soils shall be in accordance with OPSD 203.020 except as noted herein.

- Excavation of the embankment fill, organic deposits and peat within the embankment widening footprint shall be carried out in short sections perpendicular to the highway alignment with the excavation width (measured parallel to the highway direction) not more than 3 m at any time. Excavation and backfilling operations shall be carried out simultaneously in such a manner that the excavation is not left open for more than 3 m in width at any given time.
- Temporary excavation through the existing embankment fill shall be made, where required, with side slopes no steeper than 1H:1V from the crest of the existing highway embankment to the base of the excavation.
- Temporary excavation side slopes (i.e., back slopes) through the peat/organic soils shall be no steeper than 2H:1V.
- Some distress to the existing highway embankment may occur during swamp excavation; provisions for traffic control measures shall be included to maintain the safe operation of Highway 7 during excavation and backfilling operations.

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.