July 2012

DRAFT FOUNDATION INVESTIGATION AND DESIGN REPORT

High Fills at Crown Hill Overpass Highway 400 Northbound Rehabilitation Highway 11 to Highway 93 Simcoe County, Ontario, GWP. 2179-10-00

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DRAFT REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershefield Limited (MH) on behalf of the Ministry of Transportation (MTO) to provide foundation engineering services in support of the Highway 400 Northbound rehabilitation from Highway 11 to Highway 93 in Simcoe County, Ontario.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal (RFP) dated May 2008; in Section 6.8 of MH's *Technical Proposal* for this assignment and in Golder's scope change letter of May 10, 2011.

This report provides factual data on the subsurface conditions encountered at the site where high fills (embankments) are required to accommodate the realigned Highway 400 Northbound across Highway 11 via a new overpass structure (Crown Hill Overpass).

The following documents are referenced in the preparation of this report:

- Golder Associates Ltd., "Foundation Investigation and Design Report, Widening of Deep Cuts and High Fill Embankments, Highway 400 NBL Rehabilitation Between Highway 11 and Highway 93, Simcoe County, GWP. 2039-06-00", MTO GEOCRES No. 31D-509, March 2011.
- Golder Associates Ltd., "Draft Foundation Investigation and Design Report, Crown Hill Overpass Replacement, Highway 400 NBL, Simcoe County, GWP. 2179-10-00", June 2012.

2.0 SITE DESCRIPTION

The site is located at the Highway 400 and Highway 11 split where Highway 400 Northbound is a two lane freeway that rises up on an embankment and crosses above the Highway 11 freeway via a single span bridge. The existing embankments at this site vary in height and are up to 10 m high relative to the natural ground surface with a side slope geometry that is approximately 2 horizontal to 1 vertical (2H:1V).

The topography across the site adjacent to the Highway 400 and Highway 11 split slopes gently to the west towards Little Lake. Vegetation within the right of way is sparse consisting of grass and small shrubs with densely treed areas further beyond.

3.0 INVESTIGATION PROCEDURES

Golder completed a foundation investigation and design report titled "Widening of Deep Cuts and High Fill Embankments, Highway 400 NBL Rehabilitation Between Highway 11 and Highway 93, Simcoe County, GWP. 2039-06-00". Boreholes 09-F-01 to 09-F-10 from this investigation are applicable to this study and their locations are shown on Drawing 1. The subsurface investigations for this assignment were carried out between November 2009 and September 2010 using drilling equipment supplied and operated by Walker Drilling Ltd. of Utopia, Ontario, and Canadian Soil Drilling of Midhurst, Ontario.

Subsurface investigations for the proposed Crown Hill overpass structure were carried out between March 28 and April 18, 2012. Boreholes 12-01, 12-02, 12-08 and 12-09 from this investigation are applicable to this study and their locations are shown on Drawing 1. These boreholes were drilled with drilling equipment supplied and operated by Canadian Soil Drilling of Midhurst, Ontario.

The boreholes were drilled with conventional truck and track mounted drill rigs and samples of the overburden soils were obtained at intervals of depth ranging from 0.75 m to 1.5 m using a 50 mm outer diameter (O.D.) split-spoon sampler in conjunction with the Standard Penetration Test (SPT), as specified in ASTM D1586 (Standard Test Method for Standard Penetration Test).

In addition to the testing outlined above, Dynamic Cone Penetration Tests (DCPT) were conducted in Boreholes 09-F-1, 09-F-5, 09-F-6 and 09-F-7. This test consists of continuously driving into undisturbed ground a 50 mm diameter cone (60°vertex angle) attached to a drill rod, with a driving energy of 475 J per blow (63.5 kg hammer dropping freely a vertical distance of 0.76 m). The number of blows for each 300 mm of penetration is recorded and this provides an indication of the relative changes in the soil density/consistency with depth.

Groundwater conditions were observed in the open boreholes during and immediately following the drilling operations. To permit longer term groundwater level monitoring, Boreholes 12-02 and 12-08 were instrumented with a standpipe piezometer consisting of a 50 mm diameter PVC pipe with a slotted screen enclosed in sand. The piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A. The remaining boreholes were backfilled to ground surface using bentonite pellets in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by members of Golder's staff who staked out the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. Access to some preferred borehole locations was also difficult due to locally steep slopes and poor ground conditions and these boreholes were relocated to be as close as feasible to the originally staked location while allowing for safe drill rig operation.

The recovered soil samples were subjected to Visual Identification (VI) and select samples were also subjected to a laboratory testing programme consisting of natural moisture content, Atterberg limits testing and grain size distribution analyses in accordance with MTO and/or ASTM Standards as appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and the laboratory figures in Appendix B.

The borehole locations were staked in the field by Golder's personnel relative to the on-site features shown on the digital terrain model provided by MH. The ground surface elevations at the borehole locations were also determined from this digital terrain model. The borehole locations in MTM NAD83 northing and easting coordinates, the ground surface elevations referenced to geodetic datum and the depths drilled, are summarized in the following table.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
12-01	4,921,041.5	292,822.3	246.8	18.8
12-02	4,921,022.8	292,796.3	237.3	14.0
12-08	4,920,906.8	292,853.8	233.5	26.4
12-09	4,920,896.1	292,893.8	241.8	34.0
09-F-1	4,920,764.2	292,854.8	238.0	22.9
09-F-2	4,920,824.0	292,915.1	232.0	9.8
09-F-3	4,920,912.8	292,905.3	242.0	26.5
09-F-4	4,920,950.9	292,924.1	232.8	15.9
09-F-5	4,920,787.2	292,803.8	231.5	12.8
09-F-6	4,920,849.8	292,830.3	232.0	17.4
09-F-7	4,920,910.4	292,856.7	233.5	18.9
09-F-8	4,921,027.9	292,790.2	238.0	8.1
09-F-9	4,921,009.7	292,806.3	234.6	14.2
09-F-10	4,921,092.7	292,763.1	248.0	21.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 400 is located within the physiographic region known as the Simcoe Uplands (Chapman and Putnam 1984). The general topography within the Simcoe Uplands consists of broad, gently rolling till or moraine plains divided by deep valleys. The till within the Uplands is often overlain by glaciofluvial deposits consisting of sandy silt to sand and gravel. These deposits can present a wide range of grain sizes including large boulders, till lenses and silt.

Surficial deposits of glaciolacustrine materials formed by the wave action at the shores of glacial lakes or along glacial melt water streams are also commonly found within the site area overlaying the till. These deposits consist primarily of coarse-grained sediments of fine to medium grained sand or silt and minor clay deposits (Ontario Geological Survey, 1994). Surficial deposits of clayey silt to silty clay are also present adjacent to current and former streams.

4.2 Subsurface Conditions

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered subsurface conditions and the results of in-situ and laboratory tests are presented in this appendix. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous soil sampling and therefore represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will also vary between and beyond the borehole locations.

The stratigraphy is complex and soil conditions and stratification are very variable and can change over short distances making interpretation between boreholes difficult. In general, the ground surface at this site is underlain by topsoil, non-cohesive and cohesive fill soils and a buried peat layer in Borehole 09-F-4. These soils are generally underlain by granular deposits ranging in composition from sands and silts, to sand and gravel, to gravelly sand, to silty sand till. At some borehole locations the granular deposits are divided by cohesive clayey silt to silty clay strata.

4.2.1 Topsoil

Boreholes 09-F-2, 09-F-5 to 09-F-9, 12-02 and 12-08 encountered a surficial topsoil layer approximately 100 mm to 200 mm thick.

4.2.2 Fill

Fill material was encountered at this site. The borehole locations where the fill material was encountered, the fill thickness at the corresponding borehole location and its corresponding base elevation are tabulated below.

Location	Borehole No.	Fill Thickness (m)	Elevation of Base of Fill (m)
North High Fill Area	12-01	5.7	241.1
	09-F-10	7.6	240.4
South High Fill Area	12-08	1.9	231.4
	12-09	5.6	236.2
	09-F-1	7.1	230.9
	09-F-3*	8.6	233.3
	09-F-4	1.2	231.6
	09-F-7	1.0	232.4

* Fill overlain at ground surface by a 100 mm thick layer of asphalt.

The fill soils are generally cohesionless, varying in composition from sand to silty sand, sand and gravel and gravel. The results of grain size distribution tests completed on five selected samples of the sand to silty sand fill are shown on Figure B1 in Appendix B. These results show a grain size distribution consisting of 0 % to 3 % gravel, 57 % to 85 % sand, 7 % to 29 % silt and 5 % to 11 % clay sized particles.

In Borehole 09-F-3 the lower 3.1 m of fill extending from 5.6 m (Elevation 236.4 m) to 8.7 m (Elevation 233.3 m) below ground surface consists of clayey silt, some sand, trace to some gravel. An Atterberg limits test was carried out on a sample of the clayey silt fill and the results indicate a plastic limit of 12%, a liquid limit of 17%, and a plasticity index of 5% corresponding to a moisture content of 8%. These test results plotted on the plasticity chart on Figure B2 in Appendix B, confirm that the fill material is a cohesive clayey silt soil of low plasticity (CL).

The measured SPT "N" values within the cohesionless fill range from 7 to 48 blows per 0.3 m of penetration, indicating a loose to dense (but typically compact to dense) relative density. The natural water content of samples of this cohesionless fill varies from 2% to 14%.

The measured SPT "N" values within the clayey silt fill are 32 and 35 blows per 0.3 m of penetration, suggesting a hard consistency and the natural water content of a sample of the clayey silt fill is 8%.

4.2.3 Peat

In Borehole 09-F-4 the silty sand fill is underlain by an approximately 0.9 m thick layer of peat. The peat layer extends to a depth of 2.1 m below ground surface corresponding to Elevation 230.7 m.

4.2.4 Granular Deposits

Granular deposits of sands and silts, sand and gravel, gravelly sand and silty sand till were encountered at this site. These deposits generally contain trace to some gravel, trace to some silt and trace to some clay and in some boreholes cobbles were also encountered within the soil matrix. Summarized below are the borehole locations where these deposits were encountered, the depth and corresponding elevation to the top of the deposit; the deposit's thickness and its base elevation.

Location	Borehole No.	Depth to Top of Deposit (m)	Top of Deposit Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
North High Fill Area	12-01	5.7	241.1	3.1	238.0
		8.8*	238.0	1.5	236.5
		10.3	236.5	1.5	235.0
		11.8	235.0	>7.0	Below 228.0
	12-02	0.1	237.2	2.0	235.2
		2.1	235.2	0.8	234.4
		4.0	233.3	3.1	230.2
		7.1	230.2	>6.9	Below 223.3
	09-F-8	0.1	237.9	3.0	234.9
		3.7	234.3	>4.4	Below 229.9
	09-F-9	0.1	234.5	2.0	232.5
		2.1	232.5	1.3	231.2
		4.0	230.6	>10.2	Below 220.4
	09-F-10	7.6	240.4	3.3	237.1
		11.0	237.1	2.8	234.3
		16.8	231.2	>5.0	Below 226.3

Location	Borehole No.	Depth to Top of Deposit (m)	Top of Deposit Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
South High Fill Area	12-08	2.1	231.4	0.8	230.6
		5.6	227.9	2.3	225.6
		8.6	224.9	4.6	220.3
		17.8	215.7	3.0	212.7
		20.8	212.7	1.5	211.2
		22.3	211.2	>4.1	Below 207.1
	12-09	5.6	236.2	4.5	231.7
		10.1	231.7	3.1	228.6
		14.7	227.1	9.2	217.9
		26.9	214.9	3.1	211.8
		32.2	209.6	>1.8	Below 207.8
	09-F-1	7.1	230.9	1.9	229.0
		10.1	227.9	>8.7	Below 219.2
	09-F-2	0.2	231.8	0.8	231.0
		1.4	230.6	1.8	228.8
		3.9	228.1	>5.9	Below 222.2
	09-F-3	8.7	233.3	1.2	232.1
		10.2	231.8	2.0	229.8
		13.3	228.7	1.5	227.2
		15.4	226.6	4.1	222.5
		19.5	222.5	5.5	217.0
	09-F-4	2.1	230.7	0.5	230.2
		5.6	227.2	5.1	222.1
		14.8	218.0	>1.1	Below 216.9
	09-F-5	0.1	231.4	0.6	230.8
		1.5	230.0	1.4	228.6
		3.8	227.7	0.9	226.8
		5.6	225.9	>4.2	Below 221.7
	09-F-6	0.1	231.9	0.6	231.3
		2.9	229.1	1.1	228.0
		4.0	228.0	1.6	226.4
		5.6	226.4	3.1	223.3
		8.7	223.3	1.4	221.9
		10.1	221.9	>2.6	Below 219.3
	09-F-7	1.1	232.4	1.0	231.4
		8.6	224.9	4.7	220.2

* Silty sand till deposit

Twenty-five samples of the sand to silty sand deposits were subjected to grain size distribution tests and the results are shown on Figures B3 to B7 in Appendix B. The results show a grain size distribution consisting of 0% to 15% gravel, 53% to 91% sand, 6% to 30% silt and 2% to 17% clay sized particles.

Eleven samples of the sand and silt to sandy silt soils were subjected to grain size distribution tests and the results are illustrated on Figures B8 and B9 in Appendix B. These results show a grain size distribution consisting of 0% to 17% gravel, 27% to 62% sand, 30% to 61% silt and 4% to 12% clay sized particles. Atterberg limits tests were also performed on a sample of the sandy silt soil and the results are plotted on the plasticity chart on Figure B10 in Appendix B. These values indicate a non-plastic (ML) soil.

Grain size distribution tests were also performed on two samples of the gravelly sand to sand and gravel soils and the results are shown on Figure B11 in Appendix B. These results show a grain size distribution consisting of 24% and 31% gravel, 47% and 56% sand, 9% and 20% silt and 4% and 9% clay sized particles.

The measured SPT "N" values in these granular deposits range from Static Weight of Hammer to more than 100 blows per 0.3 m penetration but are typically greater than 10 blows per 0.3 m penetration. Based on these results the granular deposits have typically compact to very dense relative densities with zones of very loose soils. The natural water content of samples retrieved from these deposits generally varies from 4% to 26% and in Borehole 09-F-9; the presence of organics in a sample of the surficial silty sand deposit is inferred based on a natural water content of 35%.

4.2.5 Clayey Silt to Silty Clay

Clayey silt to silty clay soils were encountered at this site interlayered within the cohesionless deposits. Summarized below are the borehole locations where these deposits were encountered, the depth and corresponding elevation to the top of the deposit; the deposit's thickness and its base elevation.

Location	Borehole No.	Depth to Top of Deposit (m)	Top of Deposit Elevation (m)	Deposit Thickness (m)	Deposit Base Elevation (m)
North High Fill Area	12-02	2.9*	234.4	1.1	233.3
	09-F-8	3.1	234.9	0.6	234.3
	09-F-9	3.4	231.2	0.6	230.6
	09-F-10	13.7	234.3	3.1	231.2
South High Fill Area	12-08	2.9 7.9 13.2	230.6 225.6 220.3	2.7 0.7 4.6	227.9 224.9 215.8
	12-09	13.2 23.9 30.0*	228.6 217.9 211.8	1.5 3.0 2.2	227.1 214.9 209.6
	09-F-1	9.0	229.0	1.1	227.9
	09-F-2	1.0 3.2	231.0 228.8	0.4 0.7	230.6 228.1
	09-F-3	9.8 12.2 14.8 25.0	232.2 229.8 227.2 217.0	0.4 1.1 0.6 >1.5	231.8 228.7 226.6 Below 215.5
	09-F-4	2.6 10.7	230.2 222.1	3.0 4.1	227.2 218.0
	09-F-5	0.7 2.9 4.7	230.8 228.6 226.8	0.8 0.9 0.9	230.0 227.7 225.9
	09-F-6	0.7	231.3	2.2	229.1
	09-F-7	2.1 13.3	231.4 220.2	6.5 >3.5	224.9 Below 216.7

* Clayey Silt Till

These cohesive deposits vary in composition from clayey silt to silty clay with minor constituents that include trace sand to sand, trace gravel and in some boreholes cobbles. In Boreholes 12-02 and 12-09 clayey silt till units were also identified.

The results of grain size distribution tests carried out on ten (10) selected samples of the clayey silt to silty clay deposits are illustrated on Figures B12 and B13 in Appendix B. The results show a grain size distribution consisting of 0% to 1% gravel, 1% to 26% sand, 22% to 71% silt and 13% to 69% clay sized particles.

Atterberg limits tests were also carried out on twelve (12) samples of the clayey silt to silty clay deposits and the results are plotted on plasticity charts on Figures B14 and B15 in Appendix B. The results indicate plastic limits of 10% to 18%, liquid limits of 14% to 45% and plasticity indices of 4% to 27 % corresponding to natural water contents ranging from 12% to 45%. These test results indicate low to intermediate plasticity (CL to CI) cohesive clayey silt to silty clay soils.

Grain size distribution tests were carried out on two (2) samples of the clayey silt till and the results are shown on Figure B16 in Appendix B. The results show a grain size distribution consisting of 8% and 10% gravel, 44% and 48% sand, 24% and 25% silt and 18% and 23% clay sized particles. Random cobble and boulder inclusions can also be expected to occur within the matrix of till soils.

Atterberg limits tests were also carried out on two samples of the clayey silt till and the results are plotted on the plasticity chart on Figure 17 in Appendix B. The results yielded plastic limits of 9% and 11%, liquid limits of 15% and 19%, and plasticity indices of 6% and 8% corresponding to natural water contents of 11% and 18%. The results indicate that the till matrix is a cohesive soil of low plasticity (CL to CL-ML).

The measured SPT “N” values within the clayey silt to silty clay deposits range from 1 to 48 blows per 0.3 m of penetration. Where low SPT “N” values were measured, in situ shear vane testing was carried out and the measured undrained shear strengths range from approximately 22 kPa to 96 kPa. Based on these results the clayey silt to silt clay deposits are considered to have generally soft to very stiff consistencies with zones of hard silty clay soils. The natural water content of samples of the clayey silt to silty clay soils range from 11% to 45%.

Standard Penetration tests performed in the clayey silt till measured SPT “N” values of 14 blows and 22 blows per 0.3 m of penetration. Based on these values the clayey silt till is considered to have a stiff to very stiff consistency. The natural water content of two samples of the clayey silt till are 11% and 18%.

The remoulded shear strength of the clayey silt to silty clay deposits was also measured to assess the sensitivity of the clayey silt to silty clay deposits. The sensitivity varies from approximately 0.6 to 3.8 which indicates low sensitivity cohesive deposits according to the *Canadian Foundation Engineering Manual* (CFEM 2006).

4.3 Groundwater Conditions

The recorded depths to the groundwater level and corresponding elevations are summarized in the following table.

Location	Borehole No.	Date	Groundwater Levels	
			Depth (m)	Elevation (m)
North High Fill Area	12-01	March 28, 2012	10.7[1]	236.1
	12-02	April 17, 2012 May 28, 2012	4.6[1] 0.6[2]	232.7 236.7
	09-F-8	December 02, 2009	3.7[1]	234.3
	09-F-9	August 06, 2010	1.4[1]	233.2
	09-F-10	August 10, 2010	10.1[1]	237.9
South High Fill Area	12-08	April 18, 2012 May 28, 2012	4.6[1] 1.0[2,3]	228.9 234.5
	12-09	March 29, 2012	10.0[1]	231.8
	09-F-1	August 09, 2010	7.1[1]	230.9
	09-F-2	December 01, 2009	0.6[1]	231.4
	09-F-3	August 10, 2010	10.6[1]	231.4
	09-F-4	November 30, 2009	2.1[1]	230.7
	09-F-5	August 05, 2010	1.5[1]	230.0
	09-F-6	August 05, 2010	1.8[1]	230.2
	09-F-7	August 04, 2010	6.1[1]	227.4

1 Water level measured in borehole upon completion of drilling.
2 Water level measured in piezometer.
3 Measured water level above existing ground surface in piezometer.

In Borehole 12-08 the standpipe piezometer screen was installed in granular waterbearing deposits of sand and gravelly sand overlain by a relatively impermeable layer of clayey silt to silty clay. The measured water level in the standpipe piezometer installed in this borehole is 1.0 m above ground surface suggesting the presence of artesian conditions in these deposits.

The groundwater level has been estimated based on the measured water levels recorded in the standpipe piezomenters, unstabilized water levels observed during and following completion of drilling, soil moisture conditions, and changes in soil colour from brown to grey.

In the north high fill area the groundwater level generally follows the topography falling gradually to the south towards the watercourse at Sta. 18+910. At Sta. 19+000 the estimated groundwater level is Elevation 238.5 m falling to about Elevation 237 m at Sta. 18+950, and Elevation 236.5 m at Sta. 18+925 in the vicinity of the proposed north bridge abutment.

The groundwater level in the vicinity of the south bridge abutment (Sta. 18+800) is estimated at Elevation 232.5 m. The ground water level falls to the south along the proposed alignment and is estimated to be constant at Elevation 231.0 m between Sta. 18+725 and Sta. 18+650. The groundwater level along the existing Hwy. 400 NBL alignment is estimated to be higher than the levels along the proposed alignment. Along the existing alignment the groundwater level rises from Elevation 231.0 m at Sta. 18+650, to Elevation 231.5 m at Sta. 18+725, to Elevation 232.0 m at Sta. 18+775.

All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and in response to major weather events. Perched water can also be expected to occur where permeable sand and gravel soils are underlain by relatively impermeable clayey silt and silty clay soils.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Rehman Abdul, P.Eng. and Ms. Lisa Coyne, P.Eng., senior geotechnical engineers with Golder. Mr. Fintan J. Heffernan, P.Eng., Golder's MTO's Designated Contact for this project conducted an independent quality control review and audit of the report.

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PART B

DRAFT FOUNDATION DESIGN REPORT
HIGH FILLS AT CROWN HILL OVERPASS
HIGHWAY 400 NORTHBOUND REHABILITATION
HIGHWAY 11 TO HIGHWAY 93
SIMCOE COUNTY, ONTARIO, GWP. 2179-10-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report presents an interpretation of the factual geotechnical data and provides geotechnical design recommendations for the high fills associated with the Crown Hill overpass. The discussions and recommendations presented are based on our understanding of the project and our interpretation of the factual data obtained from the subsurface investigations.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided, as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

Highway 400 northbound will be realigned to the west and will cross Highway 11 via a new bridge, viz. Crown Hill Overpass. South of this new bridge the design grade of the realigned highway ranges from about Elevation 242.0 m at Sta. 18+775 decreasing to Elevation 232.0 m at Sta. 18+400. Immediately north of the new overpass the design grade is approximately Elevation 247.0 m at Sta. 18+925 increasing to about Elevation 249.5 m at Sta. 19+075.

The design cross-sections provided by MH indicate that between Sta. 18+400 and Sta. 18+650 the existing embankment geometry will be modified to accommodate the realigned highway since the realigned Highway 400 Northbound generally falls within the existing embankment footprint. The modifications include cutting and lowering the crest and side slopes of the existing embankment at select locations as well as embankment widening on the east side between Sta. 18+515 and Sta. 18+600. The approximate fill height in the widening areas will be less than 4.5 m. From Sta. 18+650 to the south bridge abutment new fill will be placed on the west side slope of the existing embankment at heights ranging from about 3.0 m at Sta. 18+675 increasing to about 9.0 m at Sta. 18+775.

The design cross-sections also show that north of the proposed bridge, the existing embankment will be widened on the west side between Sta. 18+925 to about Sta. 19+050. The fill height in this area ranges from about 10 m at Sta. 18+925 decreasing to about 2 m at Sta. 19+050.

6.2 Embankment Stability

The global, internal and surficial stability of the embankments will depend on the slope geometry and also to a large degree on the properties of the existing soils. For the purpose of global stability analyses, the commercially available slope stability program Slide 6.0 developed by Rocscience Inc. was used. The Janbu, Morgenstern-Price and Spencer methods for stability analysis were employed and a minimum target Factor of Safety of 1.3 was established.

Critical sections were selected where the embankment was highest and where the subsurface soils were the weakest. The design sections selected for analysis are Sta. 18+775, Sta. 18+925 and Sta. 19+000 and a 2 m wide mid-height bench was incorporated in the analysis where earth fill embankments are equal to or greater than 8 m in height.

The soil parameters used for the slope stability analyses and the factors of safety that were obtained are summarized below and the slope stability models depicting the corresponding factors of safety are provided in Appendix G, Figures 1 to 6.

Material Type	Undrained Analysis			Drained Analysis		
	ϕ (degrees)	c (kPa)	γ (kN/m^3)	ϕ' (degrees)	c' (kPa)	γ (kN/m^3)
New Embankment Fill (Local Earth Fill)	31	0	19	31	0	19
Existing Fill	31-32	0	20	31-32	0	20
Sand and Silt to Silty Sand	29-35	0	19-20	29-35	0	19-20
Clayey Silt to Silty Clay	0	25-200	19-20	28-30	3	19-20
Sand	29-35	0	19-20	29-35	0	19-20
Sand and Gravel to Gravelly Sand	30-35	0	20	30-35	0	20
Silty Sand Till	32	0	21	32	0	21
Clayey Silt Till	0	75-125	21	30	3	21
Design Factors of Safety (Sta. 18+775)	>1.3 for 2H:1V side slopes			>1.3 for 2H:1V side slopes		
Design Factors of Safety (Sta. 18+925)	>1.3 for 2H:1V side slopes			>1.3 for 2H:1V side slopes		
Design Factors of Safety (Sta. 19+000)	1.3 for 2H:1V side slopes			1.3 for 2H:1V side slopes		

The analysis indicates that embankments constructed at the recommended design side slopes of 2 horizontal to 1 vertical (2H:1V), will have acceptable factors of safety of 1.3 or greater with respect to global stability.

Where earth fill embankments are equal to or higher than 8 m, a mid-height bench should be incorporated in the design. The bench should:

- extend for the length through which the embankment height exceeds 8 m;
- be at least 2 m wide; and
- have 2% positive drainage to shed run-off water

6.3 Seismic Considerations

6.3.1 Stability

Under earthquake conditions, the stability of embankments can be 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.

The selection of an appropriate horizontal seismic coefficient (seismic coefficient) is the most important, and difficult, aspect of a pseudo static stability analysis. Because soil slopes are not rigid and the peak acceleration generated during an earthquake lasts for only a very short period of time, seismic coefficients used in practice generally correspond to acceleration values well below the predicted peak accelerations. There are no specific rules for the selection of an appropriate seismic coefficient for design but the general consensus is that the seismic coefficient should be based on the anticipated level of acceleration within the failure mass and should correspond to some fraction of the anticipated peak acceleration. For the purpose of this study, a seismic coefficient value of 50% of the Peak Horizontal Acceleration as recommended by Hynes-Griffin[1] was used for design.

The site is treated as lying in Seismic Zone 0. Reference to Annex A3.1, Table A3.1.1 of the *Canadian Highway Bridge Design Code 2006 (CHBDC 2006)* indicates that the following seismic parameters (Barrie) should be used for design:

- Velocity Related Seismic Zone 1
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05

For a 10 % probability of exceedance in 50 years the site-specific peak ground acceleration (PGA) is 0.018g based on the NRC website; however, the more conservative *CHBDC 2006* value of 0.05 g (derived from the zonal acceleration ratio) was used for this assessment. In accordance with Table 4.4 of the *CHBDC (2006)*, a Site Coefficient (S) of 1.2, consistent with Soil Profile Type II was used for design. Therefore, a 20 % ground motion amplification is recommended for design, resulting in an increase in the ground surface acceleration to approximately 0.06g and a design seismic coefficient value of 0.03 (50% of the PGA).

The pore water pressure in the subsurface soils will increase under earthquake conditions. In the granular, cohesionless deposits the pore water pressures are expected to dissipate very quickly due to the soils relatively high permeability and the effective stress parameters of these soils were used for the pseudo-static analyses. For clay soils however, total stress parameters were used for the pseudo-static analysis to account for excess pore water pressures generated during earthquake conditions.

Pseudo-static seismic slope stability analyses for a 2H:1V slope geometry indicates that the embankments will have a factor of safety greater than 1.0 with respect to global stability. The results of the seismic stability analyses are presented in Appendix C, Figures 7 to 9.

Some shallow sloughing and toe failure of these slopes could occur during seismic events. This sloughing and toe failure is expected to be limited, would not 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.

[1] Hynes-Griffin ME, Franklin AG. “Rationalizing the seismic coefficient method.” U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, 1984, Miscellaneous Paper GL-84-13.

6.3.2 Liquefaction Potential

The potential for liquefaction of the subsurface soils at this site was assessed using the Seed and Idriss (1971) method[2]. The assessment indicates that there is negligible potential for soil liquefaction of the soils immediately below the embankments. Some toe failure may occur but it is expected to be limited and easily repairable.

6.4 Embankment Settlement

The soils underlying the embankment footprint in the widening areas were analysed for settlement using elastic deformation moduli established from predictions and empirical correlations with Atterberg limits and SPT "N" values [Bowles, (1984), and CHBDC, (2006)], tempered with engineering judgement from our experience with similar soils in this region of Ontario.

The realigned Highway 400 northbound will generally require embankment widening on the west side of the existing alignment. Maximum settlement will occur below the centreline and the west portion of the new/widened embankment, reducing essentially to zero settlement where the new embankment ties into the existing embankment and the fill height is negligible.

North of the Crown Hill overpass the embankment fill height ranges from about 10 m at Sta. 18+925 decreasing to about 6.5 m at Sta. 19+000. The total settlement under the new/widened embankment due to these embankment fill heights is estimated to range from about 30 mm to 40 mm. Since the subsurface soils in this area are essentially cohesionless deposits, the total settlement will be elastic occurring during and immediately following placement of the embankment fill.

South of the Crown Hill overpass the embankment fill height ranges from about 9 m at Sta. 18+775 decreasing to about 4 m at Sta. 18+725. The total settlement under the new/widened 9 m high embankment is estimated to range from about 150 mm to 200 mm. About 80 mm to 90 mm of this settlement will represent longer term post-construction consolidation settlement in the clayey silt layers. Within the matrix of the firm to stiff cohesive soil deposits are sand layers that will provide drainage to the consolidating clayey silt deposits thus helping to increase the rate of consolidation. It is predicted that the majority of the consolidation settlement will be complete approximately three to four months after fill placement. The remainder of this settlement (70 mm to 110 mm) will be elastic occurring during and immediately following placement of the embankment fill.

The areas where settlement will be critical will be where the embankments are the highest i.e. within 20 m away from the Crown Hill bridge abutments. A maximum allowable post construction settlement of about 10 mm to 25 mm in these areas would be considered acceptable for this project. As noted above, most of the settlement of the soils below the new/widened approach embankments will be immediate, and the consolidation settlement is estimated to be complete in a relatively short time period of twelve to fifteen weeks. To minimize post-paving differential settlement between the approach embankments and the overpass abutments, it is recommended that the approach embankment areas be preloaded by placing engineered fill and the pavement Granular "B" subbase, and allowing the fill to sit for a twelve- to fifteen-week period prior to placing the pavement Granular "A" base course and final paving. Provided there is sufficient time in the construction schedule for this approach,

[2] Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" Journal of Soil Mechanics and Foundations Division, ASCE, Vol. 101, No. SM9, September, pp. 1249-1273

other means/methods of accelerating settlement such as surcharging or the use of light weight fill are not warranted.

Normal post-construction settlement of compacted granular embankment fill should be less than 25 mm and should occur instantaneously or shortly after embankment construction is complete. It is understood that the Crown Hill Overpass and the embankments will likely be constructed simultaneously. Therefore, to minimize long term post construction settlement of the embankment fill adjacent to the bridge abutment; it is recommended that embankments extending 30 m laterally from the bridge abutment be constructed with Select Subgrade Material (SSM) conforming to the requirements of OPSS 1010.

A settlement monitoring program is required to confirm that either most of the settlement is complete or, the remaining settlement prior to commencing paving, will be less than or equal to the acceptable maximum of 25 mm. Included in Appendix D is a non-standard special provision for the supply and installation of settlement instruments. Drawings depicting the proposed settlement instrumentation plan and instrument details are included in Appendix E.

6.5 Embankment Construction

Materials used for embankment construction should meet the requirements of OPSS 212 (Borrow Material) and should be placed in lifts not exceeding 300 mm. Each lift should be uniformly compacted to at least 95 percent of the material's Standard Proctor Maximum Dry Density (SPMDD). Embankment construction should be in accordance with OPSS 206 (Grading) and OPSS 501 (Compaction). Bonding between new and existing embankment fill is required by benching as per OPSD 208.010 (Benching). Transition treatments (earth fill to granular fill) should be undertaken in accordance with OPSD 205.040 (Transition Treatment).

It is recommended that any deleterious material and soft/loose and other unsuitable soils be removed within an envelope given by an imaginary slope not steeper than 1H:1V from the toe of the proposed embankment. The exposed subgrade should be inspected, approved, and properly compacted from the surface in accordance with OPSS 501.

To facilitate construction operations in inclement weather, surface water runoff should be diverted away from construction areas by gravity drainage and a system of interceptor trenches. In wet weather an approximately 200 mm thick free draining granular layer would also be required to minimize disturbance and maintain trafficability of construction equipment.

Proper erosion control measures should be implemented both during construction and permanently. Temporary erosion and sediment control must be provided in accordance with OPSS 805. Fill slopes should be provided with permanent erosion protection in accordance with OPSS 803 (sodding) and/or OPSS 804 (seed and cover).

It is also imperative that the designs include provisions for preventing the flow of surface water down the face of slopes. Consideration can be given to using a mountable curb and gutter arrangement to control and divert surface water away from the top of the slope. Surface water must be directed to armoured outfalls/outlets designed to drain into roadside ditches.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Rehman Abdul, P.Eng. a senior geotechnical engineer with Golder, with technical input from Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Fintan J. Heffernan, P.Eng., Golder's MTO's Designated Contact for this project conducted an independent quality control review and audit of the report.

GOLDER ASSOCIATES LTD.

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Senior Geotechnical Engineer

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Designated MTO Foundations Contact

RA/FJH/jl

n:\active\2009\1111\09-1111-0022 mh - hwy 400 nbl - vespra twp\6 - reports\8 - high fills at crown hill overpass\draft report\09-1111-0022 draft fidr 12july 20 high fills.docx

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

Hynes-Griffin ME, Franklin AG. Rationalizing the seismic coefficient method, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, 1984, Miscellaneous Paper GL-84-13.

Ontario Geological Survey, 1984. Aggregate Resources Inventory of Vespra Township, Simcoe County, Southern Ontario, Ministry of Natural Resources, Ontario.

Seed, H.B. and Idriss, I.M. 1971, Simplified Procedure for Evaluating Soil Liquefaction Potential, Journal of Soil Mechanics and Foundations Division, ASCE, Vol. 101, No. SM9, September, pp. 1249-1273.

Ontario Provincial Standard Specifications (OPSS)

OPSS 212 Construction Specification for Borrow.

OPSS 206 Construction Specification for Grading.

OPSS 501 Construction Specification for Compacting.

OPSS 803 Construction Specification for Sodding.

OPSS 804 Construction Specification for Seed and Cover.

OPSS 805 Construction Specification for Temporary Erosion and Sediment Control Measures.

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010 Benching of Earth Slopes

OPSD 205.040 Transition Treatment

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes:
1. $\tau = c' + \sigma' \tan\phi'$
2. shear strength = (compressive strength)/2

MINISTRY OF TRANSPORTATION, ONTARIO

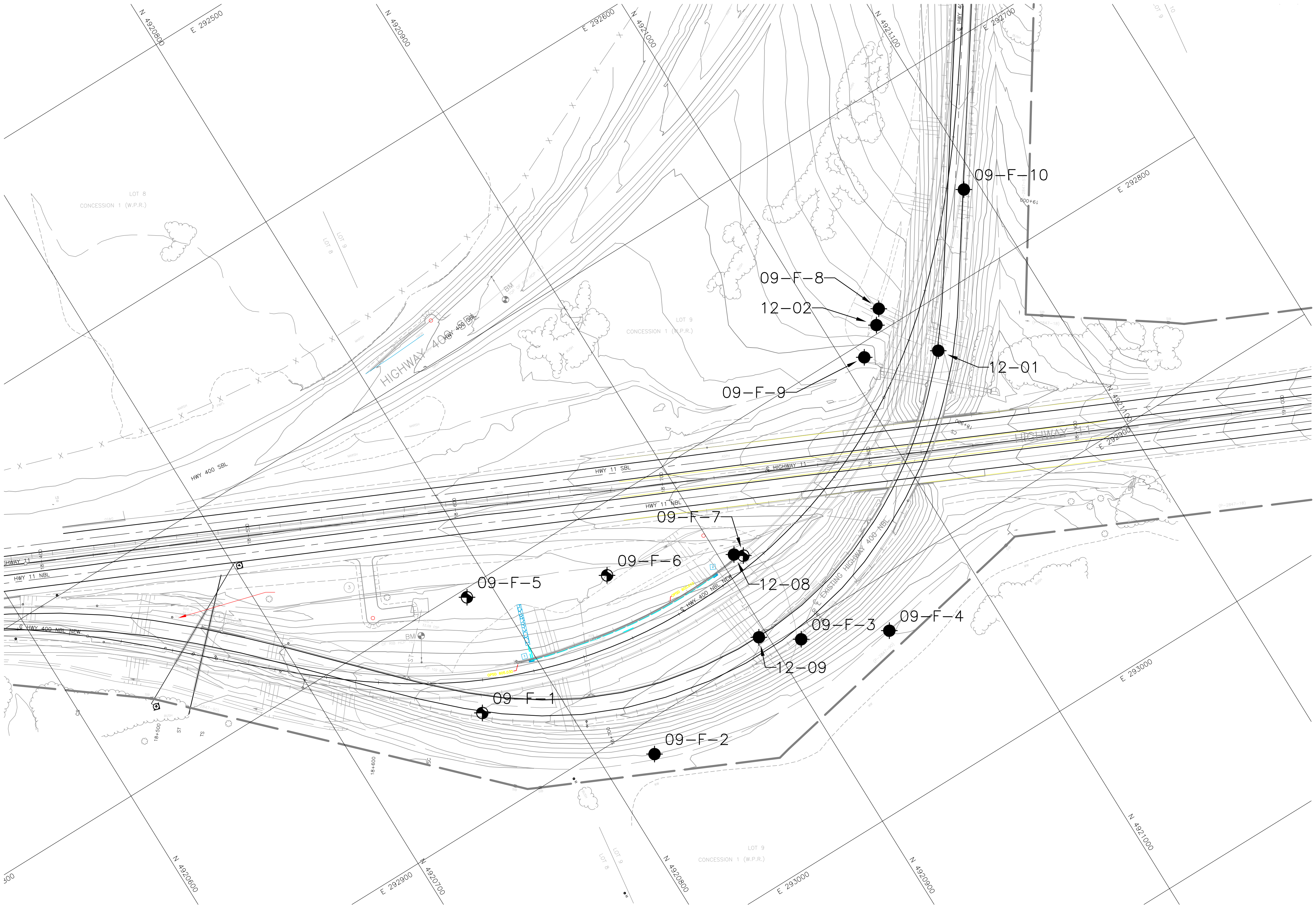
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2179-10-00

HIGHWAY 400 NBL REHAB.
HIGH FILLS AT CROWN HILL OVERPASS
BOREHOLE LOCATIONS

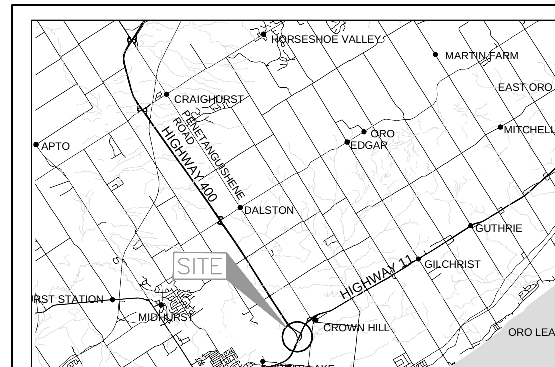
SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

SCALE 20 0 20 40 m



KEY PLAN
SCALE 5 0 5 10 km

LEGEND

- Borehole
- Borehole and DCPT

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
09-F-1	238.0	4920764.2	292854.8
09-F-2	232.0	4920824.0	292915.1
09-F-3	242.0	4920912.8	292905.3
09-F-4	232.8	4920950.9	292924.1
09-F-5	231.5	4920787.2	292803.8
09-F-6	232.0	4920849.8	292830.3
09-F-7	233.5	4920910.4	292856.7
09-F-8	238.0	4921027.9	292790.2
09-F-9	234.6	4921009.7	292806.3
09-F-10	248.0	4921092.7	292763.1
12-01	246.8	4921041.5	292822.3
12-02	237.3	4921022.8	292796.3
12-08	233.5	4920906.8	292853.8
12-09	241.8	4920896.1	292893.8

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 Morrison Hershfield (drawing file x84117Base.dwg, received January 29, 2010, and Crown Hill Option 2.dwg received May 03, 2011).

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400	PROJECT NO. 09-1111-0022		DIST. CENTRAL
SUBM'D. VA	CHKD. LCC	DATE: 7/12/2012	SITE:
DRAWN: JFC/DD	CHKD. RA	APPD. FJH	DWG. 1

PLOT DATE: July 12, 2012
FILENAME: T:\Projects\2009\09-1111-0022 (MH, Vespra)\-04- (Crown Hill Embankments)\091111002204001.dwg

APPENDIX A

Record of Borehole Sheets

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 12-01

 METRIC

PROJECT 09-1111-0022

G.W.P. 2179-10-00 | LOCATION N 4921041.5 ;E 292822.3 | ORIGINATED BY DD

DIST Central HWY 400 | BOREHOLE TYPE Truck Mount Power Auger | COMPILED BY NLP

DATUM Geodetic | DATE March 28, 2012 | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
246.8	GROUND SURFACE										
0.0	Sand, trace to some silt, trace clay, trace gravel (FILL) Loose to dense Brown Moist	1	SS	43							
		2	SS	28		246	○				
		3	SS	15		245					
		4	SS	21		244	○				
		5	SS	28		243					
		6	SS	7			○	2	85	7	6
		7	SS	31		242					
241.1 5.7	SAND, trace to some gravel, some silt, containing interlayers of silty sand at a depth of 7.6 m Dense to very dense Brown Moist					241					
		8A	SS	36			○				
		8B	SS	32		240					
		9	SS	59		239	○	8	70	15	7
238.0 8.8	Silty SAND, some gravel, trace to some clay (TILL) Dense Brown Moist					238					
		10	SS	42		237	○				
236.5 10.3	Silty SAND, some gravel, containing organics and wood fragments Very dense Grey Moist to wet Auger grinding noted from 10.7 m to 12.2 m	11	SS	60/0.15	∇	236					
235.0 11.8	SAND, trace to some silt, some gravel, trace clay, containing seams or lenses of clayey silt in Sample 13 Compact to dense Grey Wet					235					
		12	SS	20		234	○	15	65	15	5
	Auger grinding noted from 12.2 m to 15.2 m					233					
		13	SS	46							
231.9						232					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 12-01

 METRIC

PROJECT 09-1111-0022

G.W.P. 2179-10-00 LOCATION N 4921041.5 ;E 292822.3 ORIGINATED BY DD

DIST Central HWY 400 BOREHOLE TYPE Truck Mount Power Auger COMPILED BY NLP

DATUM Geodetic DATE March 28, 2012 CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
14.9	SAND, trace to some silt, trace clay Very dense Brown Wet	14	SS	137		~18	0	91	7	2
					231					
					230					
		15	SS	153						
					229					
228.0		16	SS	186		~16				
18.8	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 10.7 m (Elev. 236.1 m) upon completion of drilling.				228					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

Golder Associates

RECORD OF BOREHOLE No 12-02

 METRIC

PROJECT	09-1111-0022				
G.W.P.	2179-10-00	LOCATION	N 4921022.8 ;E 292796.3	ORIGINATED BY	DD
DIST	Central HWY 400	BOREHOLE TYPE	Track Mount Power Auger	COMPILED BY	NLP
DATUM	Geodetic	DATE	April 17, 2012	CHECKED BY	LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
237.3	GROUND SURFACE									
0.0	TOPSOIL									
0.1	SAND and SILT , some gravel, trace clay, containing clayey silt seams Compact to dense Grey Moist	1	SS	12	237					
		2	SS	14	236					
		3	SS	32		○	15	47	31	7
235.2 2.1	Gravelly SAND, trace silt Dense Brown Moist	4	SS	44	235					
234.4 2.9	CLAYEY SILT with sand, trace to some gravel (TILL) Stiff Brown Moist	5	SS	14	234	w_P–○–w_L	10	48	24	18
233.3 4.0	SAND, some gravel, trace to some silt, trace clay Very dense Brown Moist to wet Spoon bouncing on possible boulder at 4.7 m and 6.2 m, auger grinding noted from 4.6 m to 7.6 m	6	SS	50/0.08	233, 232					
		7	SS	100/0.08	231	○	13	72	9	6
230.2 7.1	SAND, trace to some silt Very dense Brown Moist Spoon bouncing at 7.7 m	8	SS	100/0.08	230, 229					
		9	SS	60	228	○				
		10	SS	132	227, 226					
		11	SS	125	225	○				
		12	SS	130/0.15	224					
223.3 14.0										

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

MIS-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/11/12 DD/SAC

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Foundation Design

RECORD OF BOREHOLE No 12-02

 METRIC

PROJECT	09-1111-0022				
G.W.P.	2179-10-00	LOCATION	N 4921022.8 ;E 292796.3	ORIGINATED BY	DD
DIST	Central HWY 400	BOREHOLE TYPE	Track Mount Power Auger	COMPILED BY	NLP
DATUM	Geodetic	DATE	April 17, 2012	CHECKED BY	LCC

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 4.6 m (Elev. 232.7 m) upon completion of drilling 2. Water level in piezometer at a depth of 0.6 m (Elev. 236.7 m) on May 28, 2012										

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

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

MIS-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/11/12 DD/SAC

RECORD OF BOREHOLE No 12-08

 METRIC

PROJECT 09-1111-0022
G.W.P. 2179-10-00
LOCATION N 4920906.8 ;E 292853.8
ORIGINATED BY DD
DIST Central HWY 400
BOREHOLE TYPE Track Mount Power Auger
COMPILED BY NLP
DATUM Geodetic
DATE April 18, 2012
CHECKED BY LCC

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
233.5	GROUND SURFACE
0.0	TOPSOIL
0.2	Sand, trace to some silt to silty sand, trace to some clay, (FILL) Compact Brown to grey Moist
231.4 / 2.1	Silty SAND, trace clay Loose Grey Moist
230.6 / 2.9	CLAYEY SILT, with to some sand, containing sand layers Firm to stiff Grey Moist to wet
227.9 / 5.6	SAND, trace to some silt, trace to some clay, containing clayey silt seams Loose to compact Grey Moist to wet
225.6 / 7.9	CLAYEY SILT with sand, containing sand layers Stiff Grey Moist to wet
224.9 / 8.6	SAND to SILT to SAND, trace to some silt, trace clay, trace gravel Loose to compact Brown Moist to wet
220.3 / 13.2	CLAYEY SILT to SILTY CLAY, trace to some sand, trace gravel Firm to stiff Grey Moist to wet

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	17				
2	SS	29				
3	SS	10	0	61	29	10
4	SS	8				
5	SS	10	0	22	63	15
6	SS	4	0	10	65	25
7	SS	5	0	75	14	11
8	SS	13				
9	SS	15	1	87	7	5
10	SS	6*				
11	SS	5*	0	59	30	11
12	SS	8	0	6	52	42

ELEVATION SCALE: 233, 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219

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 wP, NATURAL MOISTURE CONTENT w, LIQUID LIMIT wL — WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m3

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

Golder Associates

RECORD OF BOREHOLE No 12-08

 METRIC

PROJECT	09-1111-0022		
G.W.P.	2179-10-00	LOCATION	N 4920906.8 ;E 292853.8
DIST	Central	HWY	400
BOREHOLE TYPE	Track Mount Power Auger	DATUM	Geodetic
DATE	April 18, 2012		
ORIGINATED BY	DD	COMPILED BY	NLP
CHECKED BY	LCC		

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	CLAYEY SILT to SILTY CLAY, trace to some sand, trace gravel. Firm to stiff. Grey. Moist to wet	13	SS	8	0	9	22	69
		14	SS	6				
215.7 / 17.8	Silty SAND, trace gravel, trace clay. Dense to very dense. Brown to grey. Moist to wet	15	SS	38				
		16	SS	139	1	64	28	7
212.7 / 20.8	Gravelly SAND, trace silt, trace clay. Very dense. Grey. Wet	17	SS	125/0.15				
211.2 / 22.3	SAND, trace silt to silty SAND, trace clay. Very dense. Grey. Wet	18	SS	155				
		19	SS	157				
207.1 / 26.4	END OF BOREHOLE							

Elevation scale: 218, 217, 216, 215, 214, 213, 212, 211, 210, 209, 208

Sample 13 liquid limit annotation: 45, 42.4

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

NOTES:

1. Water level in open borehole at a depth of 4.6 m, (Elev. 228.9 m) upon completion of drilling

2. Water level in piezometer measured at 1.0 m above ground surface (Elev. 234.5 m) on May 28, 2012

* SPT "N" values considered to have been affected by sample disturbance due to groundwater inflow to borehole

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

Foundation Design

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RECORD OF BOREHOLE No 12-09

 METRIC

PROJECT 09-1111-0022

G.W.P. 2179-10-00 LOCATION N 4920896.1 ;E 292893.8 ORIGINATED BY DD

DIST Central HWY 400 BOREHOLE TYPE Track Mount Power Auger COMPILED BY NLP

DATUM Geodetic DATE March 29, 2012 CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
241.8	GROUND SURFACE									
0.0	Sand, some gravel, trace silt (FILL) Compact Brown Moist	1	SS	13						
241.1 / 0.7	Silty sand to sand, trace gravel, trace to some silt, trace clay (FILL) Compact to dense Brown Moist	2	SS	18		o				
		3	SS	24						
		4	SS	40		o	0	87	7	6
		5	SS	36						
		6	SS	28		o				
		7	SS	44						
236.2 / 5.6	SAND and SILT to SAND, trace to some silt, trace clay, trace to some gravel, containing clayey silt layers Compact to very dense Brown to grey Moist	8	SS	20		o				
		9	SS	62						
		10	SS	30		o				
231.7 / 10.1	SAND and SILT, trace gravel, trace to some clay, containing clayey silt layers Loose to compact Grey Moist to wet				▽ (approx. El. 232)					
		11	SS	8						
		12	SS	14		o	2	48	40	12
228.6 / 13.2	CLAYEY SILT, trace sand Stiff Grey Moist to wet	13	SS	9		w_P –o	0	1	71	28
227.1 / 14.7										

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%). ELEVATION SCALE 241 240 239 238 237 236 235 234 233 232 231 230 229 228 227.

Continued Next Page

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

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RECORD OF BOREHOLE No 12-09

 METRIC

PROJECT 09-1111-0022

G.W.P. 2179-10-00 | LOCATION N 4920896.1 ;E 292893.8 | ORIGINATED BY DD

DIST Central HWY 400 | BOREHOLE TYPE Track Mount Power Auger | COMPILED BY NLP

DATUM Geodetic | DATE March 29, 2012 | CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND to SAND, trace to some silt, trace clay, trace gravel, containing silty clay layers from 15.2 m to 15.7 m; Compact to dense; Brown to grey; Moist to wet	14	SS	14	226		
		15	SS	30	225	○	
		16	SS	24	224	○	0 83 10 7
		17	SS	17	222		
		18	SS	21	220	○	
		19	SS	34	219		
217.9 / 23.9	CLAYEY SILT with to some sand; Stiff; Grey; Moist to wet	20	SS	12	217	w_P ├─┤ w_L, ○	0 26 42 32
		21	SS	9	216		
214.9 / 26.9	Gravelly SAND, some silt, trace clay; Loose; Grey; Wet	22	SS	2*	214	○	
		23	SS	WH*	213		
211.8					212		

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

Golder Associates

RECORD OF BOREHOLE No 12-09

 METRIC

PROJECT 09-1111-0022			
G.W.P. 2179-10-00	LOCATION N 4920896.1 ;E 292893.8	ORIGINATED BY DD
DIST Central HWY 400	BOREHOLE TYPE Track Mount Power Auger	COMPILED BY NLP
DATUM Geodetic	DATE March 29, 2012	CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
30.0	CLAYEY SILT with sand, trace to some gravel, (TILL) Very stiff Grey Moist	24	SS	22	211	8	44	25	23
					210				
209.6 / 32.2	SAND and GRAVEL, trace to some silt, trace clay Very dense Grey Wet				209				
		25	SS	52	208	31	56	9	4
207.8 / 34.0	END OF BOREHOLE								

NOTE:

1. Water level in open borehole at a depth of 10.0 m, (Elev. 231.8 m) upon completion of drilling

* SPT "N" values considered to have been affected by sample disturbance due to groundwater inflow to borehole

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; GROUND WATER CONDITIONS; STRAT PLOT

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

Foundation Design

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RECORD OF BOREHOLE No 09-F-1

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00
LOCATION N 4920764.2 ;E 292854.8
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers
COMPILED BY NK
DATUM Geodetic
DATE August 9, 2010
CHECKED BY LCC

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
238.0	GROUND SURFACE
0.0	Sand and graveL, trace to some silt (FILL) Dense Brown Moist
237.3 / 0.7	Silty sand, trace to some gravel, trace clay (FILL) Compact to dense Brown Moist
234.0 / 4.0	Gravel, trace sand, trace silt, trace clay, containing cobbles (FILL) Dense Brown Dry to most
230.9 / 7.1	SAND and SILT, trace clay, containing clayey silt seams Compact Grey Wet
229.0 / 9.0	CLAYEY SILT, trace sand Soft to firm Grey Moist
227.9 / 10.1	SAND and SILT, trace gravel, trace clay, containing clayey silt layers Loose to dense Brown becoming grey at 13.2 m Wet

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	35				
2	SS	26				
3	SS	48	3	71	21	5
4	SS	31				
5	SS	48				
6	SS	37				
7	SS	35				
8	SS	27	0	49	44	7
9	SS	10				
10	SS	2				
11	SS	31				
12	SS	7*	0	62	34	4
13	SS	5*				
14	SS	16				

GROUND WATER CONDITIONS: water level shown at elevation approx. 231.0 (∇)

ELEVATION SCALE: 237, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

MIS-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/11/12 DD/SAC

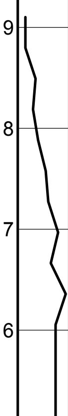
Golder Associates

RECORD OF BOREHOLE No 09-F-1

 METRIC

PROJECT 09-1111-0022			
G.W.P. 2039-06-00	LOCATION N 4920764.2 ;E 292854.8	ORIGINATED BY AB
DIST Central HWY 400	BOREHOLE TYPE CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers	COMPILED BY NK
DATUM Geodetic	DATE August 9, 2010	CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND and SILT, trace gravel, trace clay, containing clayey silt layers Loose to dense Brown becoming grey at 13.2 m Wet		15	SS	5*						
							222				
			16	SS	8*		221		○ (w ≈ 20)		1 52 43 4
							220				
219.2			17	SS	3*						
18.8	END OF BOREHOLE Dynamic Cone Penetration Test						219				
							218				
							217				
							216				
215.1 / 22.9	END OF DCPT Notes: *SPT"N" value considered to be affected by sample disturbance due to groundwater inflow to borehole. 1. Water level in open borehole at a depth of 7.1 m (Elevation 230.9 m) on completion of drilling.										



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

Golder Associates

RECORD OF BOREHOLE No 09-F-2

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4920824.0 ;E 292915.1
BOREHOLE TYPE D-50 Track-Mount, 200 mm Diameter Hollow Stem Augers
DATE December 1, 2009
ORIGINATED BY AB
COMPILED BY NLP/NK
CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ (kN/m³)	GR	SA	SI	CL
232.0	GROUND SURFACE												
0.0	TOPSOIL												
0.2	Sandy SILT, trace clay, Loose, Brown, Wet	1	SS	6	∇								
231.0 / 1.0	SILTY CLAY, trace sand, Stiff, Grey, Moist	2	SS	2		231	+ 3.8	○					
230.6 / 1.4	Sandy SILT, trace clay, containing silty clay layers/lenses, Compact, Grey, Wet	3	SS	23		230							
		4	SS	13				○		0	27	61	12
228.8 / 3.2	SILTY CLAY, trace sand, Firm, Grey, Moist	5	SS	4		229							
228.1 / 3.9	SAND, trace silt, trace clay, containing clayey silt seams/layers, Compact, Brown to grey, Wet	6	SS	19		228		○	NP				
		7	SS	11*		227							
						226							
		8	SS	19		225		○		0	89	6	5
		9	SS	27		224							
						223							
		10	SS	16				○					
222.2 / 9.8	END OF BOREHOLE												

NOTES:

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

1. In situ vane testing performed in shallow borehole drilled 2 m south of Borehole 09-F-2.

2. Water level in open borehole at a depth of 0.6 m (Elevation 231.4 m) on completion of drilling.

Legend: 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); REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Foundation Design

Golder Associates

RECORD OF BOREHOLE No 09-F-3

 METRIC

PROJECT	09-1111-0022		
G.W.P.	2039-06-00	LOCATION	N 4920912.8 ;E 292905.3
DIST	Central HWY 400	BOREHOLE TYPE	D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger
DATUM	Geodetic	DATE	August 10, 2010
ORIGINATED BY	MS	COMPILED BY	NK
CHECKED BY	LCC		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
242.0	GROUND SURFACE
0.0	Asphalt
0.1	Sand and gravel, trace silt (FILL) Compact Brown Moist
240.9 / 1.1	Sand, trace to some gravel, trace to some silt, trace clay (FILL) Dense Brown Moist
236.4 / 5.6	Clayey silt, some sand, trace to some gravel (FILL) Hard Brown Moist
233.3 / 8.7	SAND and SILT, trace clay Compact Grey Wet
232.1	CLAY, trace to some silt, trace sand Innferred firm Grey Moist
231.8 / 10.2	SILT and SAND, trace clay and gravel, containing clayey silt layers Compact to loose Grey Wet
229.8 / 12.2	CLAYEY SILT, trace sand Stiff Grey Moist
228.7 / 13.3	SAND, trace silt, containing silty clay layers Compact Brown Wet
227.2 / 14.8	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	28	
2	SS	33	
3	SS	39	
4	SS	47	
5	SS	32	
6	SS	35	
7	SS	29	0 48 44 8
8	SS	13	
9	SS	15	0 34 56 10
10	SS	7	
11	SS	5	
12	SS	28	

GROUND WATER CONDITIONS: water level symbol at approx. elev. 231.5

ELEVATION SCALE: 241, 240, 239, 238, 237, 236, 235, 234, 233, 232, 231, 230, 229, 228

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100

Field vane + at approx. elev. 228.8: 2.7

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 09-F-3

 METRIC

PROJECT 09-1111-0022

G.W.P. 2039-06-00 LOCATION N 4920912.8 ;E 292905.3 ORIGINATED BY MS

DIST Central HWY 400 BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger COMPILED BY NK

DATUM Geodetic DATE August 10, 2010 CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE --- CLAYEY SILT, trace to some sand, Inferred firm, Grey, Moist							
226.6 / 15.4	SAND, trace to some silt, trace clay and gravel, containing silty clay layers, Dense to compact, Brown to grey, Wet	13	SS	37				
		14	SS	15	2	82	9	7
		15	SS	23				
222.5 / 19.5	SAND and SILT, trace clay and gravel, Loose to compact, Grey, Wet	16	SS	17	1	61	33	5
		17	SS	9				
		18	SS	11	0	50	45	5
217.0 / 25.0	CLAYEY SILT, trace sand, Stiff, Grey, Moist	19	SS	8				
215.5 / 26.5	END OF BOREHOLE							

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (226, 225, 224, 223, 222, 221, 220, 219, 218, 217, 216); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Note:

1. Water level in open borehole at a depth of 10.6 m (Elevation 231.4 m) on completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 09-F-4

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00
LOCATION N 4920950.9 ;E 292924.1
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE D-50 Track-Mount, 200 mm Diameter Hollow Stem Augers
COMPILED BY NLP/NK
DATUM Geodetic
DATE November 30, 2009
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT	GR	SA	SI	CL
232.8	GROUND SURFACE									
0.0	Silty sand, trace to some clay, trace gravel (FILL) Compact Brown to grey Moist	1	SS	10						
		2	SS	11		o	3	57	29	11
231.6 / 1.2	PEAT, containing silt layers	3	SS	12	∇					
230.7 / 2.1	SILT, trace to some sand Loose Grey Wet									
230.2 / 2.6	CLAYEY SILT, trace to some sand, containing sand seams/layers from 4.6 m to 5.6 m depth Stiff to very stiff Grey Wet	4	SS	6		o				
		5	SS	14						
		6	SS	18		wP—w—wL	0	10	67	23
		7	SS	9						
227.2 / 5.6	Silty SAND, some clay, trace gravel, contains cobbles Compact to dense Brown Wet	8	SS	15		o				
		9	SS	31		o	0	53	30	17
		10	SS	14*		o				
222.1	Cobbles inferred at 10.4 m depth due to grinding of augers									
10.7	CLAYEY SILT with sand Stiff Grey Wet	11	SS	8						
221.2 / 11.6	SILTY CLAY, trace to some sand, trace gravel, containing cobbles Firm Grey Wet	12	SS	3		o				
		13	SS	7						
218.0 / 14.8										

Chart headers: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%). Elevation scale: 232, 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218.

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 09-F-4

 METRIC

PROJECT 09-1111-0022

G.W.P. 2039-06-00 | LOCATION N 4920950.9 ;E 292924.1 | ORIGINATED BY AB

DIST Central HWY 400 | BOREHOLE TYPE D-50 Track-Mount, 200 mm Diameter Hollow Stem Augers | COMPILED BY NLP/NK

DATUM Geodetic | DATE November 30, 2009 | CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND, trace silt, trace gravel Compact Grey Moist		14	SS	27				o (~18)		
216.9 / 15.9	END OF BOREHOLE						217				

NOTES:

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

1. Water level in open borehole at a depth of 2.1 m (Elevation 230.7 m) on completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 09-F-5

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00
LOCATION N 4920787.2 ;E 292803.8
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger
COMPILED BY MS/NK
DATUM Geodetic
DATE August 5, 2010
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	FIELD VANE (sensitivity)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
231.5	GROUND SURFACE						
0.0 / 0.1	TOPSOIL						
	Silty SAND, Very loose, Brown, Moist	1	SS	2			
230.8 / 0.7	SILTY CLAY, trace to some sand, Firm to stiff, Brown, Moist	2	V	-		2.3, 2.5	
230.0 / 1.5	SAND and SILT, containing clayey silt layers, Compact, Grey, Wet	3	SS	16	▽ (Elev. 230.0)		
		4	SS	18			0 43 50 7
228.6 / 2.9	CLAYEY SILT, trace sand, Soft, Grey, Moist	5	SS	1		3	
227.7 / 3.8	Silty SAND, trace clay, Loose, Grey, Wet						
226.8 / 4.7	CLAYEY SILT, Very soft to soft, Brown, Wet	6	SS	2			
225.9 / 5.6	SAND, some silt to Silty SAND, trace clay, containing clayey silt layers, Loose to compact, Brown, Wet	7	SS	3*			0 80 16 4
		8	SS	3*			
		9	SS	10			0 68 27 5
221.7 / 9.8	END OF BOREHOLE Dynamic Cone Penetration Test						
218.7 / 12.8	END OF DCPT						

Elevation scale: 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30
UNIT WEIGHT γ kN/m³

Notes:

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

1. Water level in open borehole at a depth of 1.5 m (Elevation 230.0 m) on completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 09-F-6

 METRIC

PROJECT 09-1111-0022			
G.W.P. 2179-10-00	LOCATION N 4920849.8 ;E 292830.3		ORIGINATED BY AB
DIST Central HWY 400	BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger		COMPILED BY MS/NK
DATUM Geodetic	DATE August 5, 2010		CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
232.0	GROUND SURFACE					
0.0	TOPSOIL					
0.1	SAND, some silt Loose Brown Moist	1	SS	7		
231.3 / 0.7	CLAYEY SILT, trace to some sand, containing silty sand seams and layers Firm to stiff Brown Moist to wet	2	SS	2		0 22 63 15
		3	SS	9	∇ (water level approx. El. 230.3); field vane + 3.2	
		4	SS	5		
229.1 / 2.9	SILT, some sand Very loose Grey Wet	5	SS	2		
228.0 / 4.0	Sandy SILT, trace to some clay, containing silt seams Compact Brown Wet	6	SS	11		
226.4 / 5.6	SAND, trace silt, clay and gravel, containing clayey silt layers Very loose to loose Brown Wet	7	SS	9		
		8	SS	2*		6 79 8 7
223.3 / 8.7	SAND and GRAVEL, trace silt, containing clayey silt layers Compact Grey Wet	9	SS	13*		
221.9 / 10.1	SAND, some silt, trace clay, containing clayey silt layers Compact Brown Wet	10	SS	16		0 82 14 4
		11	SS	3*		
219.3 / 12.7	END OF BOREHOLE Dynamic Cone Penetration Test					

ELEVATION SCALE: 231, 230, 229, 228, 227, 226, 225, 224, 223, 222, 221, 220, 219, 218

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

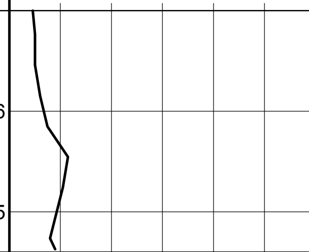
+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 09-F-6

 METRIC

PROJECT	09-1111-0022		
G.W.P.	2179-10-00	LOCATION	N 4920849.8 ;E 292830.3
ORIGINATED BY	AB		
DIST	Central	HWY	400
BOREHOLE TYPE	CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger	COMPILED BY	MS/NK
DATUM	Geodetic	DATE	August 5, 2010
CHECKED BY	LCC		

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE Dynamic Cone Penetration Test						216 215				
214.6 17.4	END OF DCPT Notes: *SPT "N" value considered to be affected by sample disturbance due to groundwater inflow to borehole. 1. Water level in open borehole at a depth of 1.8 m (Elevation 230.2 m) on completion of drilling.										

MIS-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/11/12 DD/SAC

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

Golder Associates

RECORD OF BOREHOLE No 09-F-7

 METRIC

PROJECT 09-1111-0022			
G.W.P. 2039-06-00	LOCATION N 4920910.4 ;E 292856.7	ORIGINATED BY AB	
DIST Central HWY 400	BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger	COMPILED BY MS/NK	
DATUM Geodetic	DATE August 4, 2010	CHECKED BY LCC	

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa (+ FIELD VANE, sensitivity)	WATER CONTENT (%)	UNIT WEIGHT kN/m³	GR	SA	SI	CL
233.5	GROUND SURFACE												
0.0	TOPSOIL												
0.1	Sand and gravel, trace to some silt, containing clayey silt lenses (FILL) Loose to dense Brown Moist	1	SS	9		233							
		2	SS	32				w ≈ 13					
232.4 / 1.1	Silty SAND, trace gravel, trace clay Loose to dense Grey Moist	3	SS	9		232				1	66	25	8
231.4 / 2.1	CLAYEY SILT with sand to some sand, containing sand layers Firm to very stiff Brown Moist	4	SS	5		231	+ 2.3; +	w ≈ 21					
		5	SS	18		230				0	24	63	13
		6	SS	7				w ≈ 19					
						229	+ 1.2						
					▽	228	+ 2.9						
		7	SS	3		227	+ 0.6						
		8	SS	15		226		w_P–w					
224.9 / 8.6	Silty SAND to SAND, trace clay and gravel, containing clayey silt layers Loose to compact Brown Wet					225							
		9	SS	14		224							
		10	SS	8		223		w ≈ 20		1	62	23	14
		11	SS	7		222 / 221							
220.2 / 13.3	CLAYEY SILT, trace to some sand, containing some gravel below 16 m Firm to stiff Grey Moist	12	SS	4		220 / 219		w ≈ 27					

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 09-F-7

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00
LOCATION N 4920910.4 ;E 292856.7
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger
COMPILED BY MS/NK
DATUM Geodetic
DATE August 4, 2010
CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAYEY SILT, trace to some sand, containing some gravel below 16 m Firm to stiff Grey Moist	13	SS	4	218			1 12 38 49
216.7 / 16.8		14	SS	6	217	+ 2.8 (field vane)	plastic/natural/liquid limits plotted	
	END OF BOREHOLE Dynamic Cone Penetration Test				216, 215			
214.6 / 18.9	END OF DCPT							

NOTES:

1. Vane shear testing at depths of 2.6 m and 2.9 m completed in shallow borehole adjacent to borehole 09-F-7.

2. Wet soils encountered at a depth of 6.1 m (Elevation 227.4 m)

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 09-F-8

 METRIC

PROJECT 09-1111-0022
G.W.P. 2039-06-00 LOCATION N 4921027.9 ;E 292790.2 ORIGINATED BY AB
DIST Central HWY 400 BOREHOLE TYPE D-50 Track-Mount, 200 mm Diameter Hollow Stem Augers COMPILED BY NLP/NK
DATUM Geodetic DATE December 2, 2009 CHECKED BY LCC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
238.0	GROUND SURFACE											
0.0	TOPSOIL											
0.1	Silty SAND, trace clay, trace gravel, containing clayey silt layers, and organics Loose Brown Moist	1	SS	4								
		2	SS	5		237	~10		5	58	23	14
		3	SS	7		236	~9					
	Cobbles inferred at 2.3 m and 3.1 m depths due to grinding of augers	4	SS	8		235						
234.9 3.1	CLAYEY SILT, some sand, trace gravel Stiff Brown Moist	5	SS	12			~10					
234.3 3.7	Silty SAND, trace clay, trace to some gravel, containing clayey silt layers Compact to very dense Brown Wet	6	SS	16	▽	234						
		7	SS	17		233	~9	NP	14	54	23	9
		8	SS	57		232						
						231						
229.9 8.1	END OF BOREHOLE	9	SS	49		230	~17					

NOTE:

1. Water level in open borehole at a depth of 3.7 m (Elevation 234.3 m) on completion of drilling.

Chart legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Golder Associates

RECORD OF BOREHOLE No 09-F-9

 METRIC

PROJECT 09-111100-22
G.W.P. 2039-06-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4921009.7 ;E 292806.3
BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger
DATE August 6, 2010
ORIGINATED BY AB
COMPILED BY MS/NK
CHECKED BY LCC

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT w (%)	GR	SA	SI	CL
234.6	GROUND SURFACE										
0.0	TOPSOIL										
0.1	SAND and SILT, some gravel, trace clay, containing organics. Loose to compact. Brown, grey and black. Moist becoming wet below 1.4 m	1	SS	7		234					
		2	SS	8	▽ (water level approx. elev. 233.4)		approx. 26				
		3	SS	20		233	approx. 13	17	46	30	7
232.5 / 2.1	SAND and GRAVEL, trace to some silt, trace clay. Compact to dense. Grey. Wet	4	SS	32		232					
		5	SS	14*							
231.2 / 3.4	CLAYEY SILT, some sand, trace gravel. Stiff. Grey. Wet					231					
230.6 / 4.0	SAND, trace to some silt, trace clay and gravel. Very dense. Grey-brown. Wet	6	SS	51		230	approx. 19				
		7	SS	68		229, 228					
		8	SS	160		227	approx. 17	1	82	14	3
		9	SS	95		226, 225					
		10	SS	92		224	approx. 17				
		11	SS	89		223, 222					
		12	SS	112		221	approx. 17	0	88	9	3
220.4 / 14.2											

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 09-F-9

 METRIC

PROJECT	09-111100-22				
G.W.P.	2039-06-00	LOCATION	N 4921009.7 ;E 292806.3	ORIGINATED BY	AB
DIST	Central HWY 400	BOREHOLE TYPE	CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger	COMPILED BY	MS/NK
DATUM	Geodetic	DATE	August 6, 2010	CHECKED BY	LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE Notes: * SPT "N" values considered to be affected by sample disturbance due to ground water inflow to borehole. 1. Water level in open borehole at a depth of 1.4 m (Elevation 233.2 m) on completion of drilling.										

MIS-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/11/12 DD/SAC

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

Golder Associates

RECORD OF BOREHOLE No 09-F-10

 METRIC

PROJECT 09-1111-0022
G.W.P. 2179-10-00
DIST Central HWY 400
DATUM Geodetic
LOCATION N 4921092.7 ;E 292763.1
BOREHOLE TYPE CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers
DATE August 10, 2010
ORIGINATED BY AB
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.0	GROUND SURFACE					
0.0	Sand and gravel, trace to some silt (FILL) Dense Brown Moist	1	SS	42		
247.4 / 0.6	Sand, some silt, some gravel (FILL) Dense to compact Brown Moist	2	SS	42		
		3	SS	29		
		4	SS	15		
241.9 / 6.1	Sand and gravel, some silt (FILL) Compact Brown Moist	5	SS	15		
240.4 / 7.6	SAND, some silt, trace to some gravel, containing clayey silt lenses Very dense to compact Brown Moist to wet	6	SS	53		11 66 19 4
		7	SS	23		
237.1 / 11.0	Gravelly SAND, trace to some silt, trace clay, containing clayey silt lenses Loose to very dense Brown Moist to wet	8	SS	7		
		9	SS	12		24 47 20 9
		10	SS	34		
		11	SS	59		
234.3 / 13.7	SILTY CLAY, trace sand and gravel, containing cobbles Hard Grey Moist	12	SS	35	45	

Ground water level symbol at elevation approx. 238.

Elevation scale: 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235, 234

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 09-F-10

 METRIC

PROJECT 09-1111-0022

G.W.P. 2179-10-00 | LOCATION N 4921092.7 ;E 292763.1 | ORIGINATED BY AB

DIST Central HWY 400 | BOREHOLE TYPE CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers | COMPILED BY NK

DATUM Geodetic | DATE August 10, 2010 | CHECKED BY LCC

--- CONTINUED FROM PREVIOUS PAGE ---

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILTY CLAY, trace sand and gravel, containing cobbles Hard Grey Moist	13	SS	48	232					
231.2 16.8	SAND, trace to some silt, trace gravel, trace clay Compact to very dense Brown Wet	14	SS	19	231	~22	0	78	20	2
		15	SS	141	230	~18				
		16	SS	59*	228					
		17	SS	172/0.23	227	~14	3	89	6	2
226.3 21.7	END OF BOREHOLE									

Notes:

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

1. Water level in open borehole at a depth of 10.1 m (Elevation 237.9 m) on completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

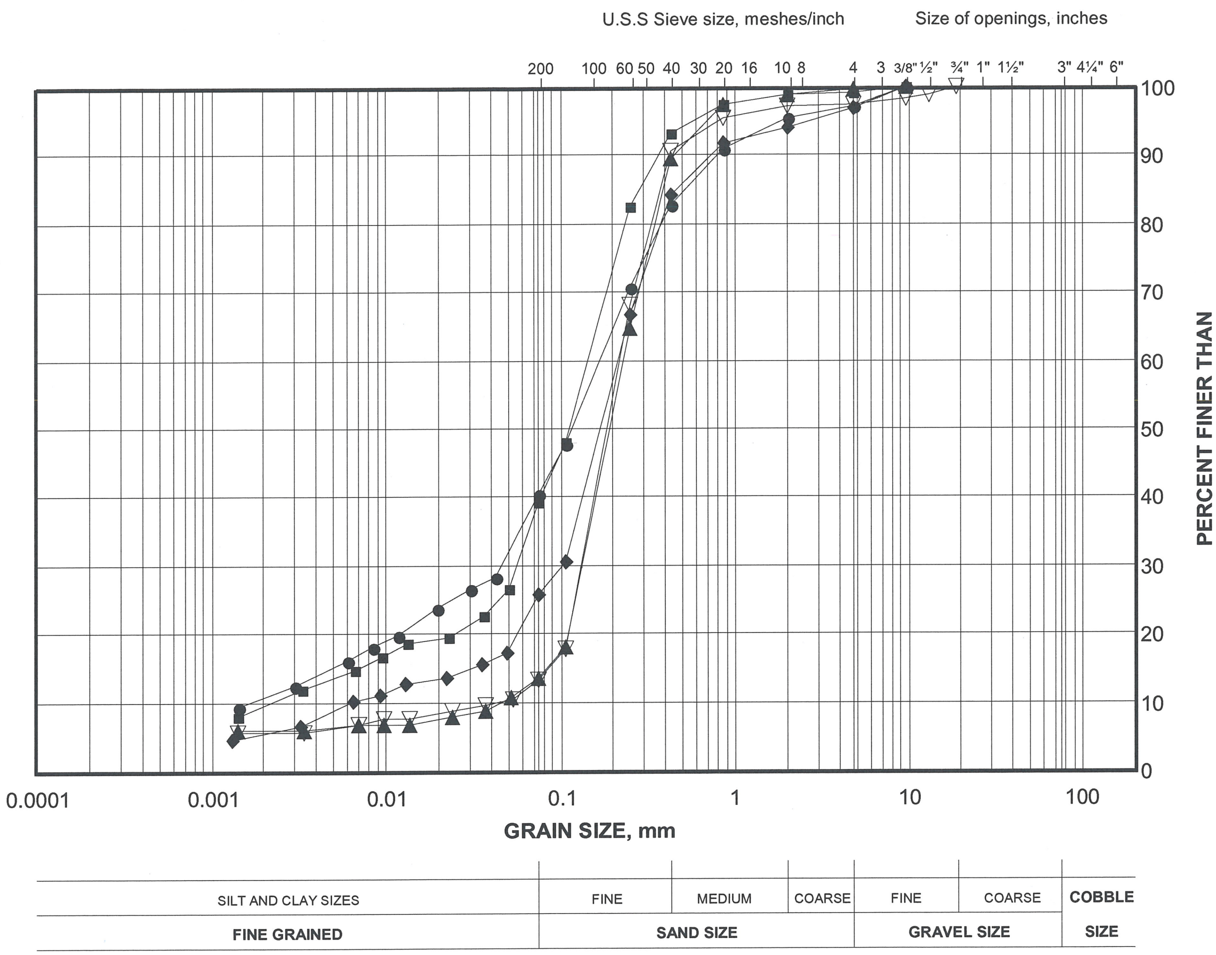
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Fill - Sand to Silty Sand

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-4	2	231.8
■	12-08	3	231.7
◆	09-F-1	3	236.2
▲	12-09	4	239.3
▽	12-01	6	242.8

Project Number: 09-1111-0022

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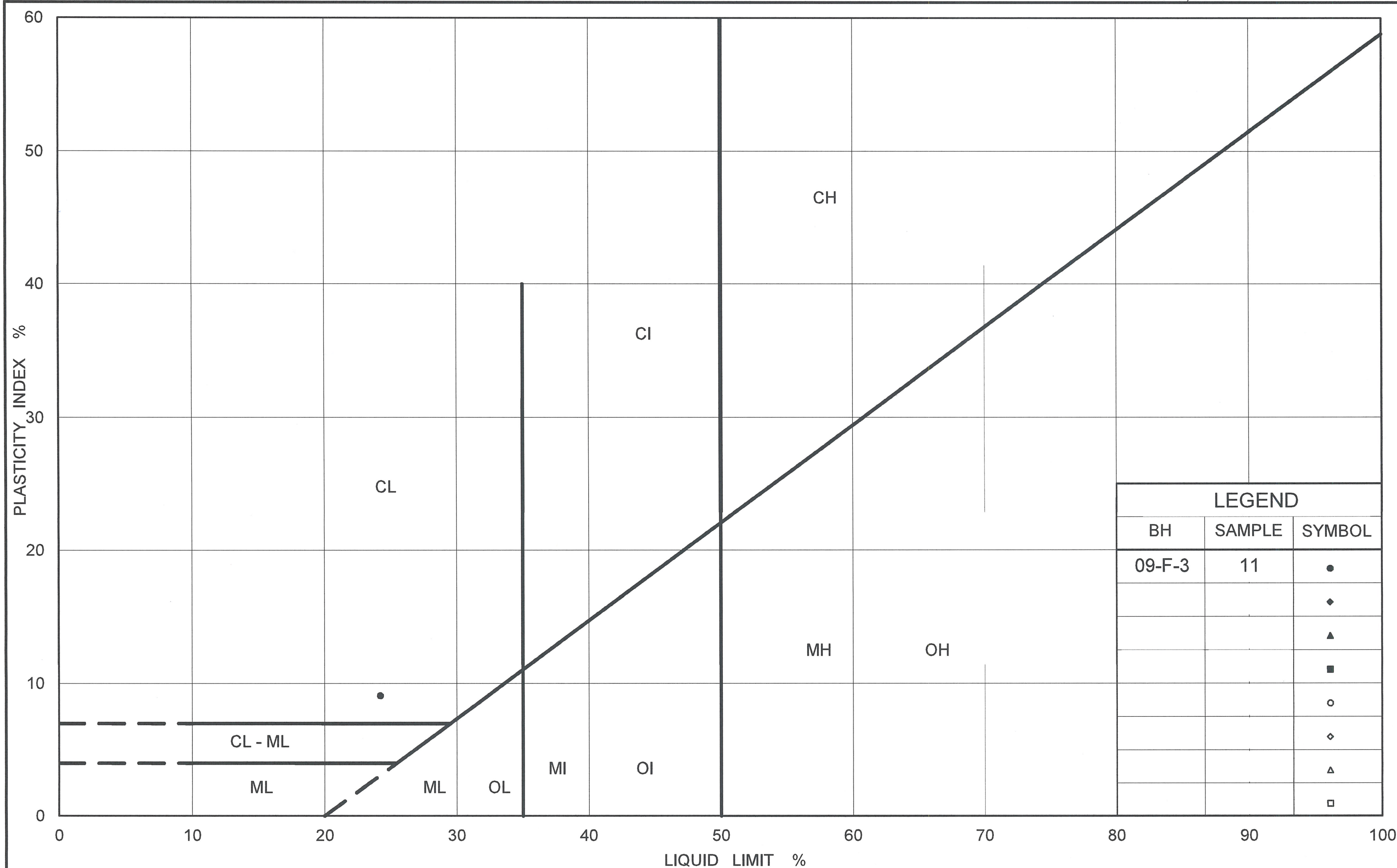
Golder Associates

Date: 17-Jul-12

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Fill - Clayey Silt

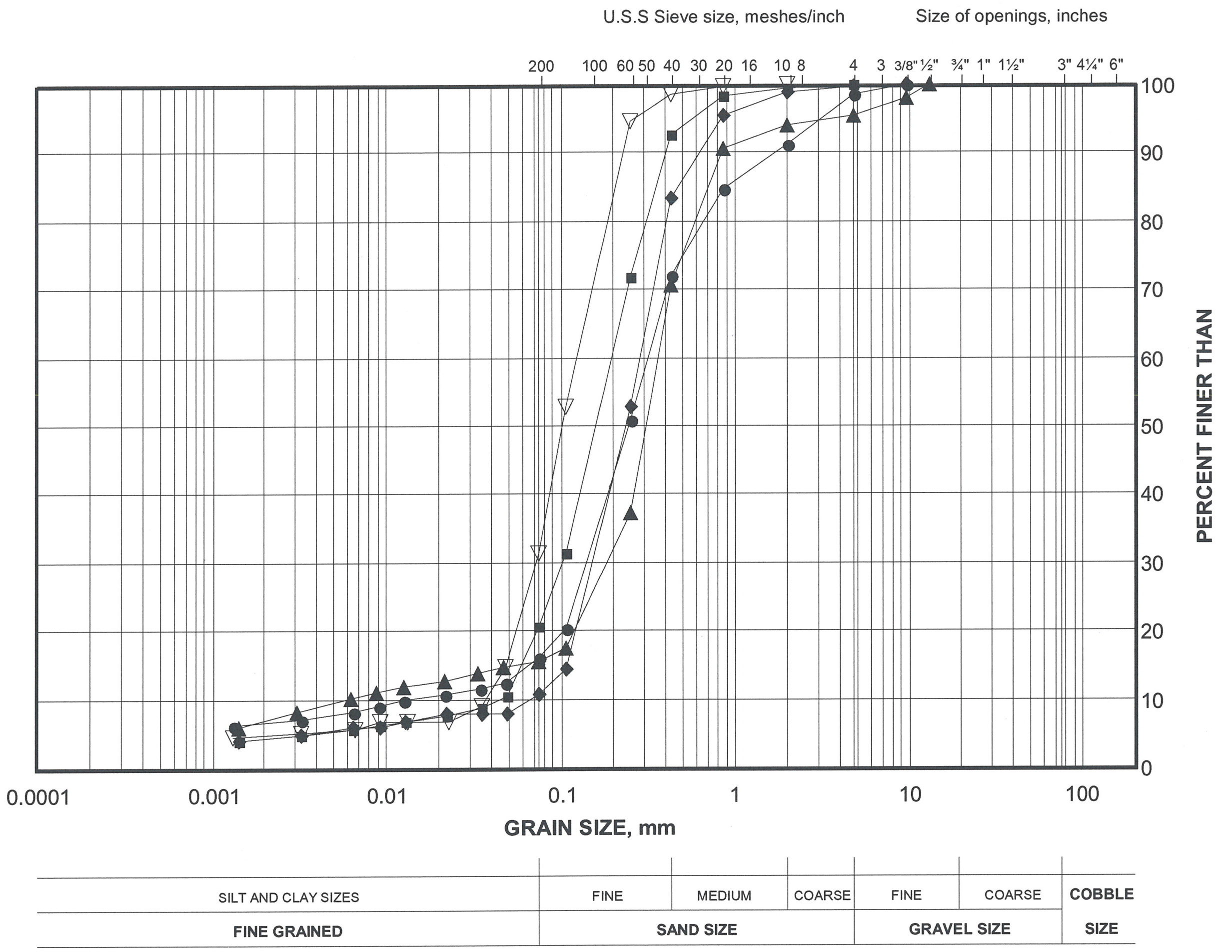
Figure No. B2

Project No. 09-1111-0022

Checked By: [signature]

GRAIN SIZE DISTRIBUTION
Sand to Silty Sand

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-3	14	224.9
■	09-F-5	7	225.1
◆	09-F-2	8	224.9
▲	09-F-6	8	224.1
▽	09-F-5	9	222.1

Project Number: 09-1111-0022

Checked By: [signature]

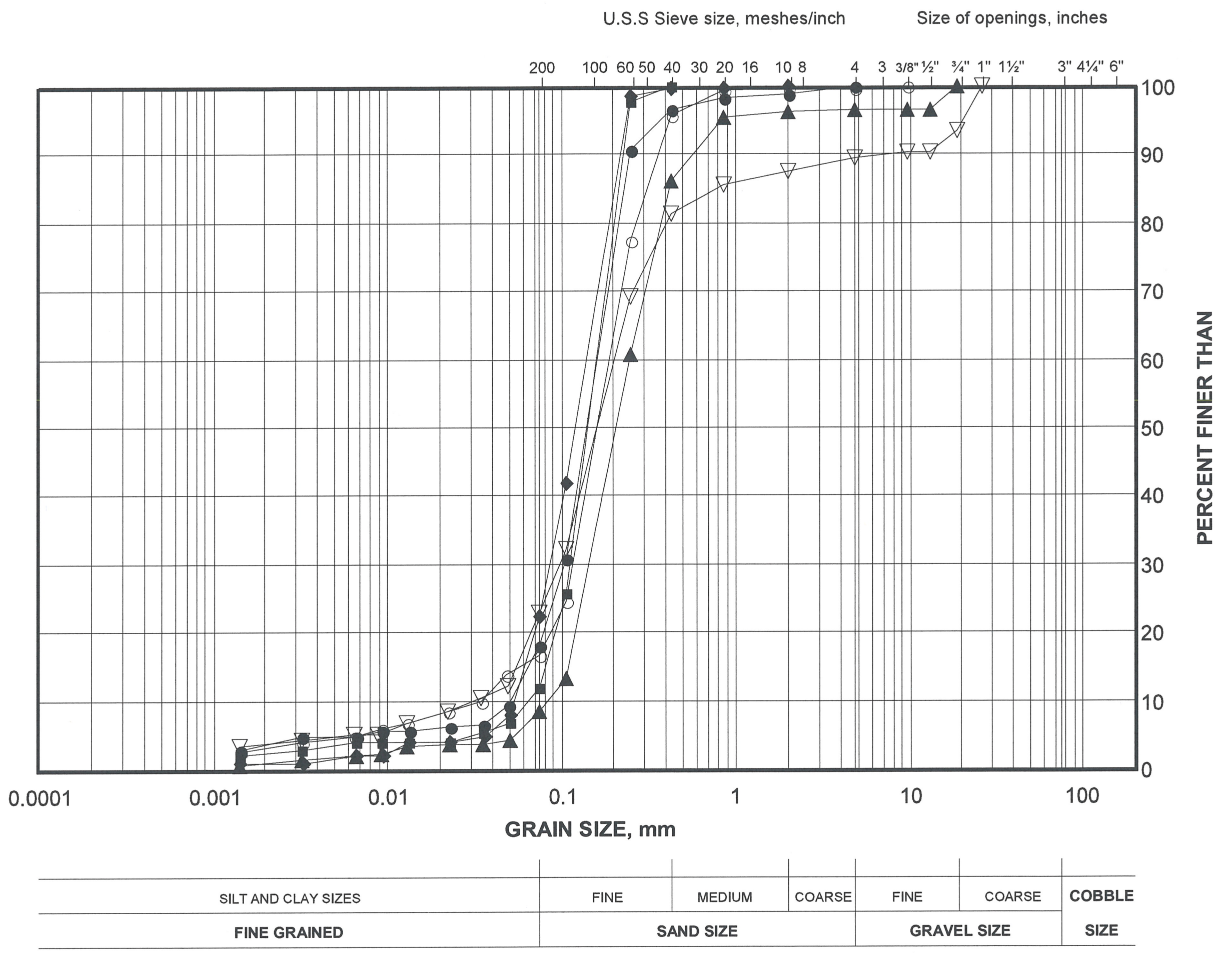
Golder Associates

Date: 16-Jul-12

GRAIN SIZE DISTRIBUTION

Sand to Silty Sand

FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-6	10	221.1
■	09-F-9	12	220.7
◆	09-F-10	14	231.0
▲	09-F-10	17	226.5
▽	09-F-10	6	240.1
○	09-F-9	8	226.8

Project Number: 09-1111-0022

Checked By: [signature]

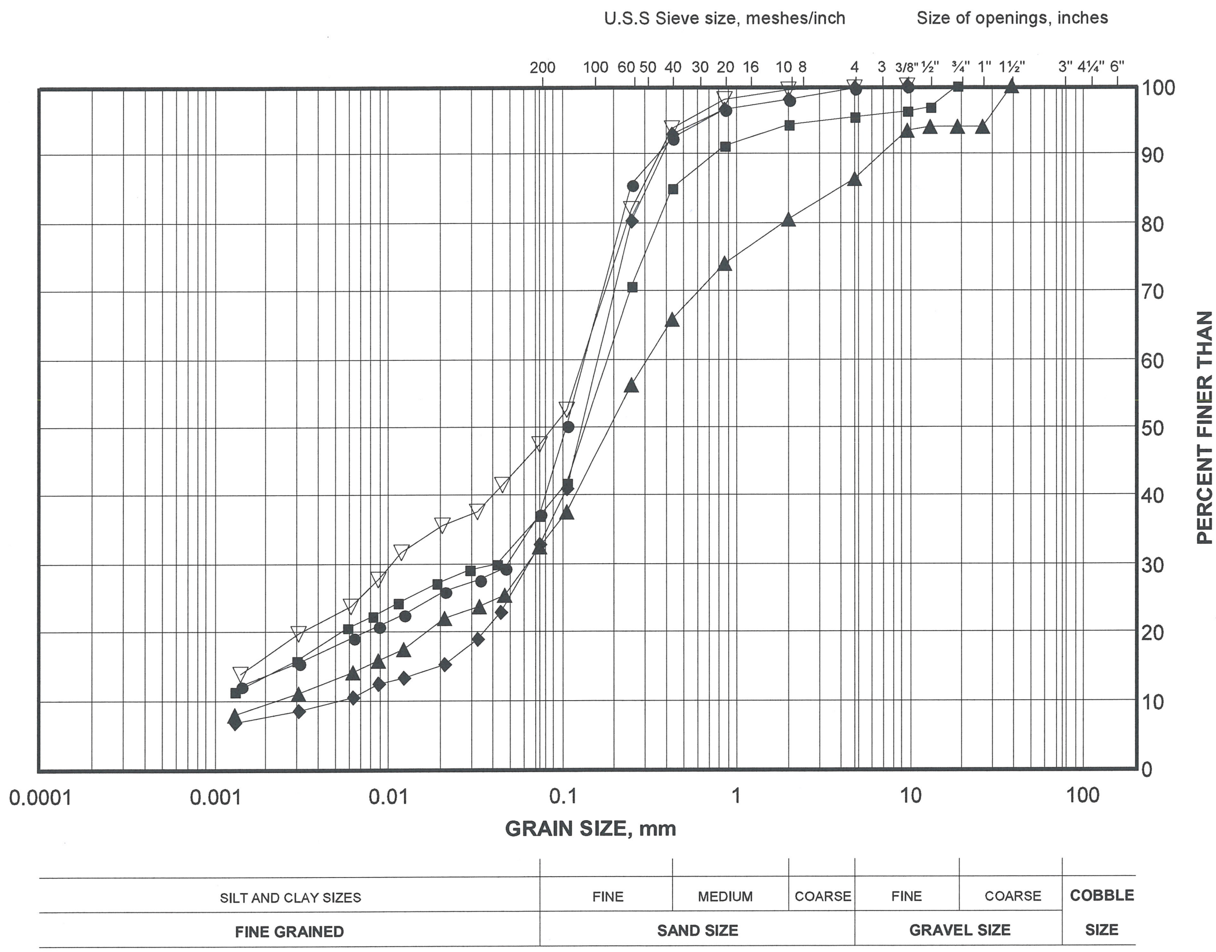
Golder Associates

Date: 16-Jul-12

GRAIN SIZE DISTRIBUTION

Sand to Silty Sand

FIGURE B5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-7	10	222.7
■	09-F-8	2	236.9
◆	09-F-7	3	232.4
▲	09-F-8	7	233.2
▽	09-F-4	9	225.0

Project Number: 09-1111-0022

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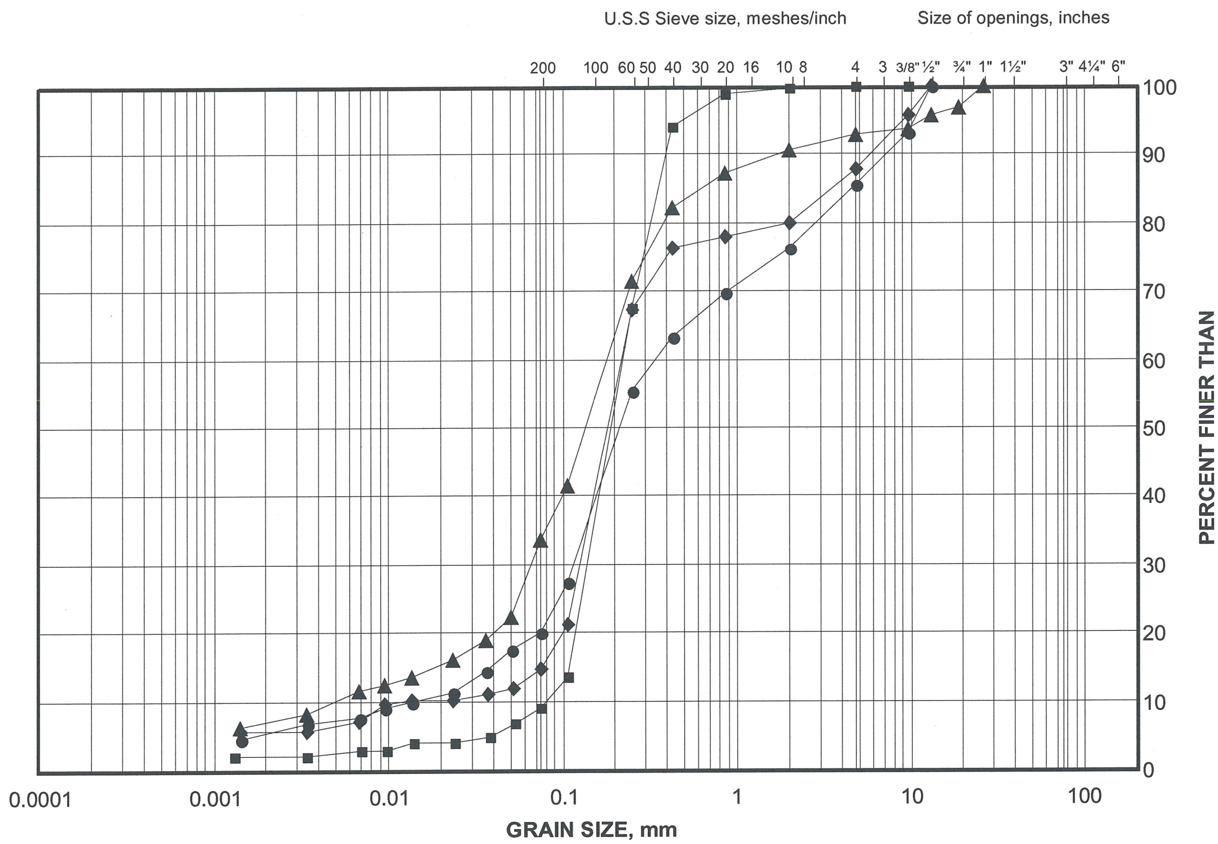
Date: 16-Jul-12

GRAIN SIZE DISTRIBUTION Sand to Silty Sand	FIGURE B6



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-01	12	234.4
■	12-01	14	231.3
◆	12-02	7	231.2
▲	12-01	9	238.9

Project Number: 09-1111-0022

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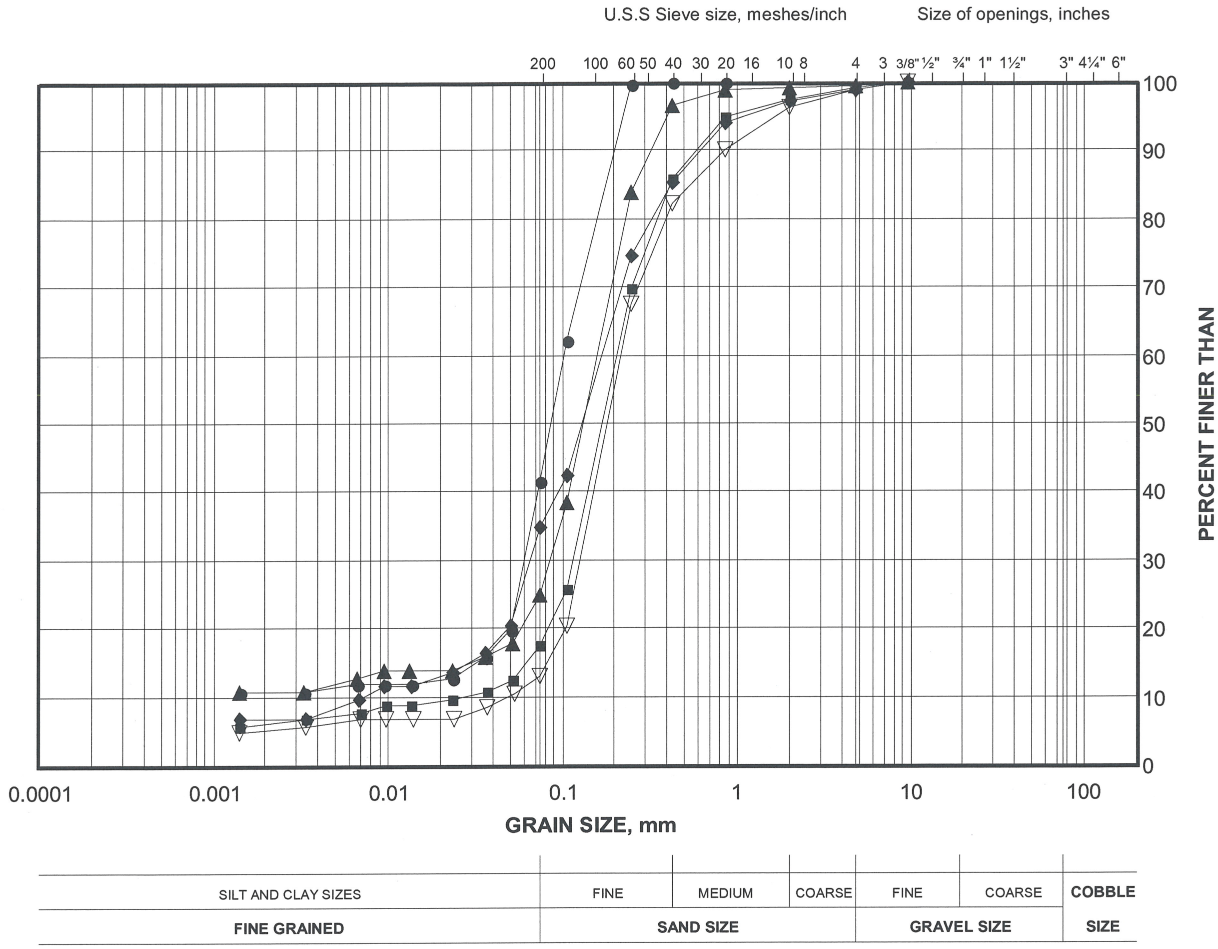
Date: 17-Jul-12

GRAIN SIZE DISTRIBUTION

Sand to Silty Sand

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-08	11	221.1
■	12-09	16	223.3
◆	12-08	16	213.5
▲	12-08	7	227.2
▽	12-08	9	224.1

Project Number: 09-1111-0022

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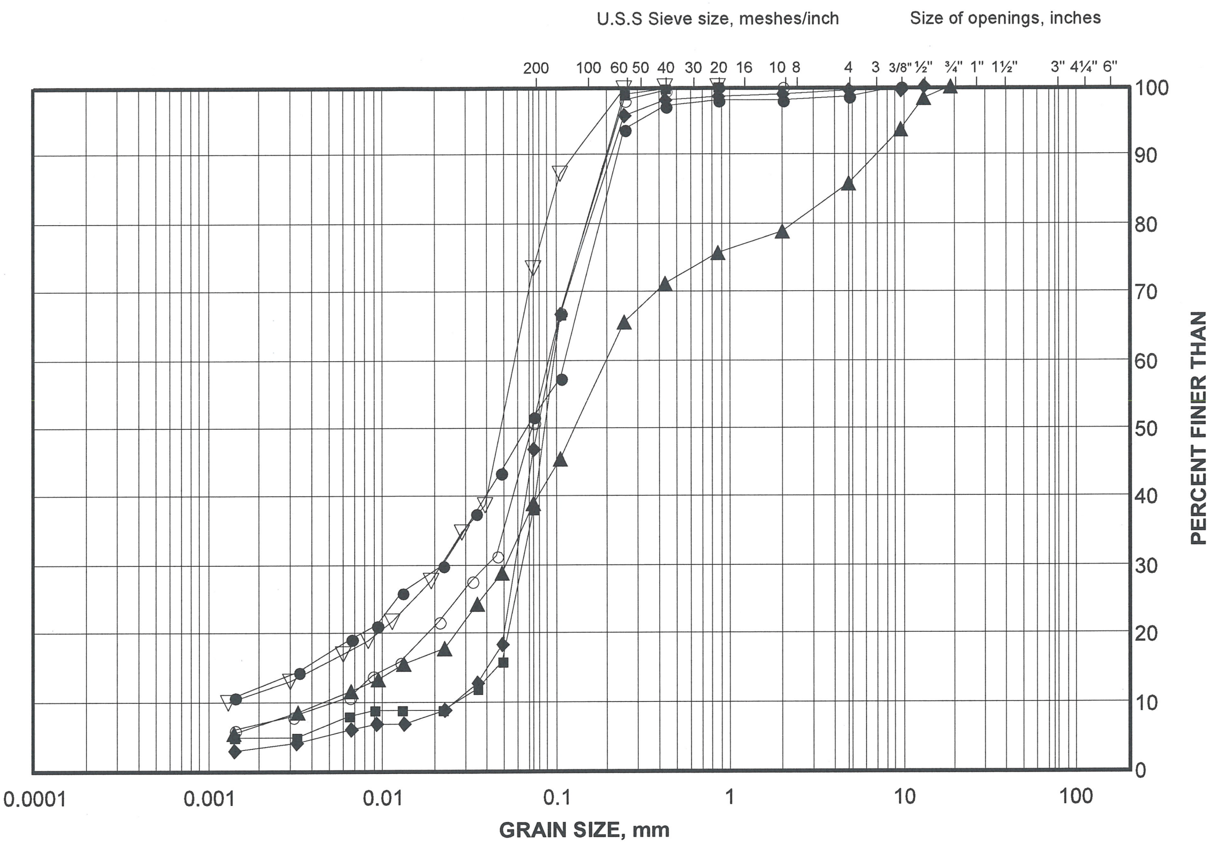
Golder Associates

Date: 17-Jul-12

GRAIN SIZE DISTRIBUTION

Sand and Silt to Sandy Silt

FIGURE B8



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-09	12	229.4
■	09-F-1	12	227.0
◆	09-F-1	16	220.9
▲	12-02	3	235.5
▽	09-F-2	4	229.5
○	09-F-1	8	230.1

Project Number: 09-1111-0022

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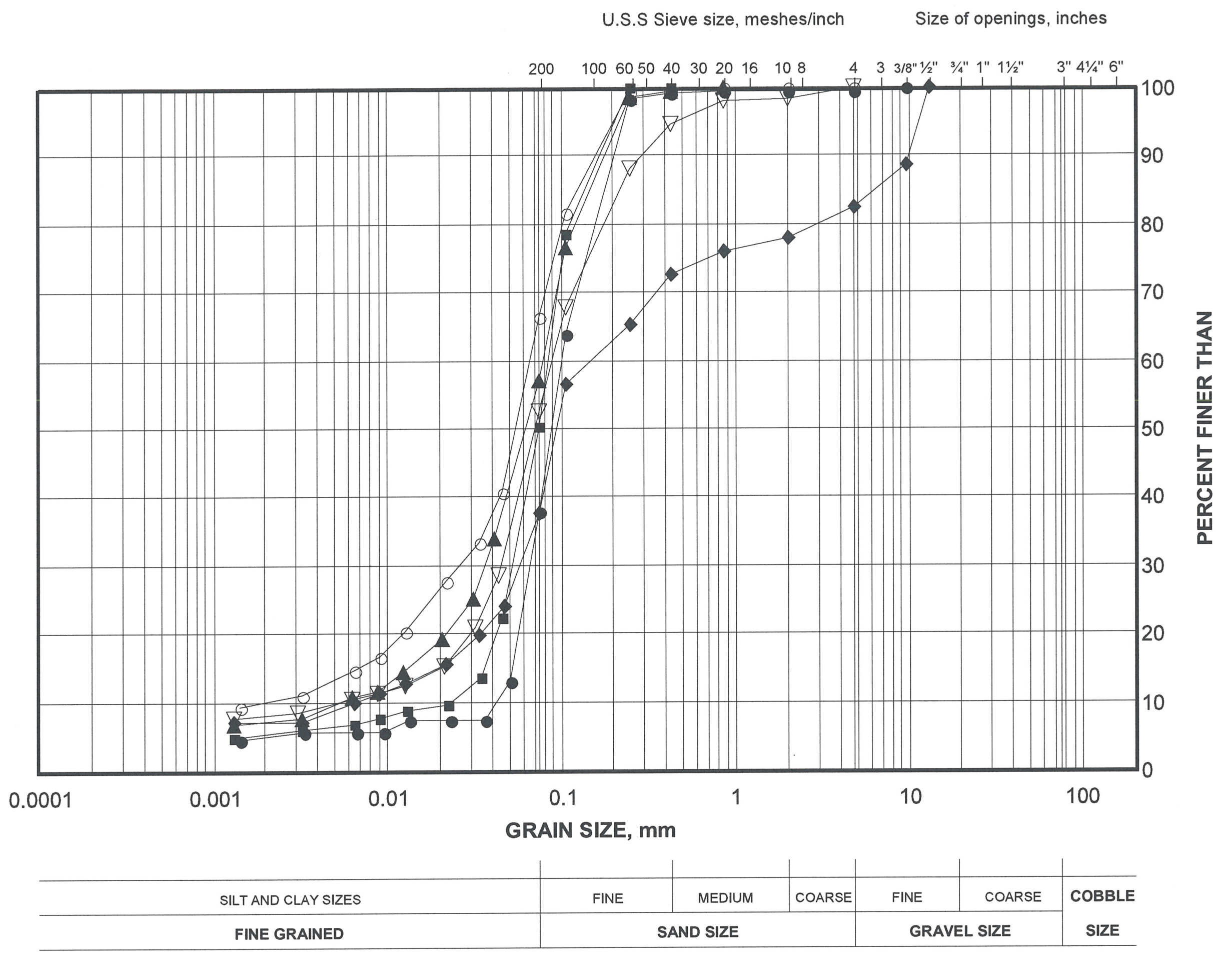
Golder Associates

Date: 13-Jul-12

GRAIN SIZE DISTRIBUTION
Sand and Silt to Sandy Silt

FIGURE B9



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-3	16	221.9
■	09-F-3	18	218.8
◆	09-F-9	3	232.9
▲	09-F-5	4	229.0
▽	09-F-3	7	232.6
○	09-F-3	9	231.0

Project Number: 09-1111-0022

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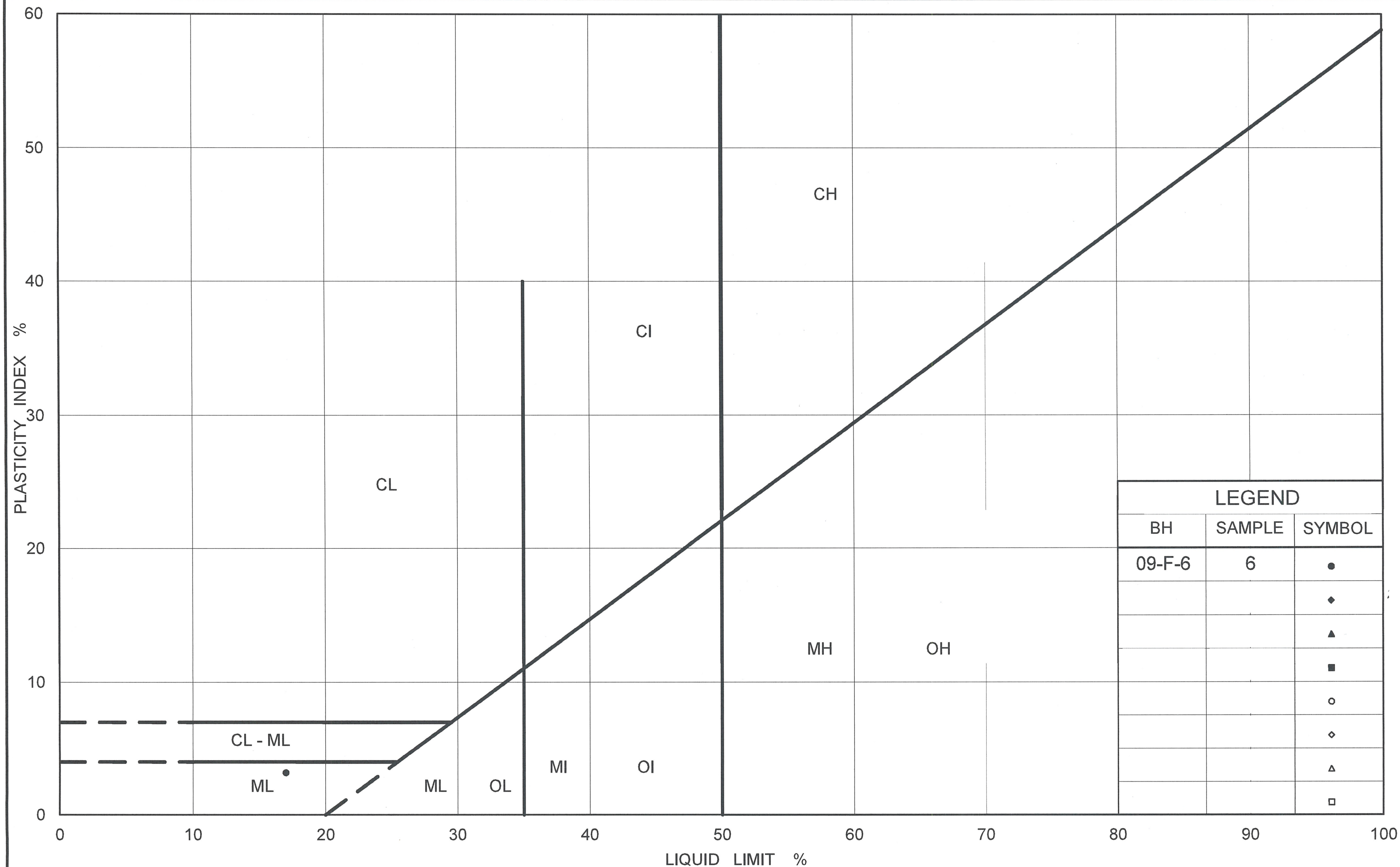
Date: 16-Jul-12

Oct 75, FF-S-21



Ministry of Transportation

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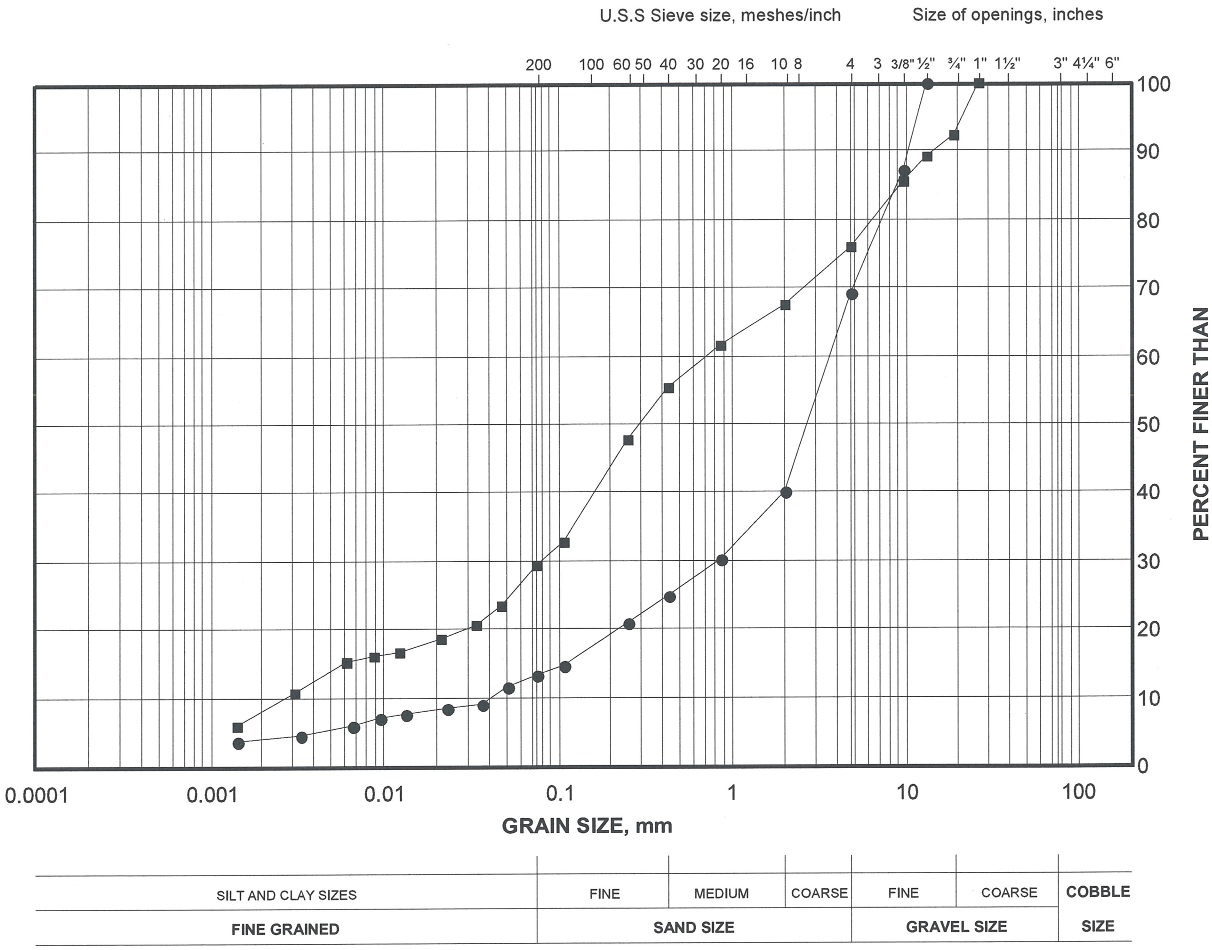
PLASTICITY CHART
Sandy Silt

Figure No.	B10
Project No.	09-1111-0022
Checked By:	[signature]

GRAIN SIZE DISTRIBUTION
Gravelly Sand to Sand and Gravel

FIGURE B11



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-09	25	208.0
■	09-F-10	9	236.3

Project Number: 09-1111-0022

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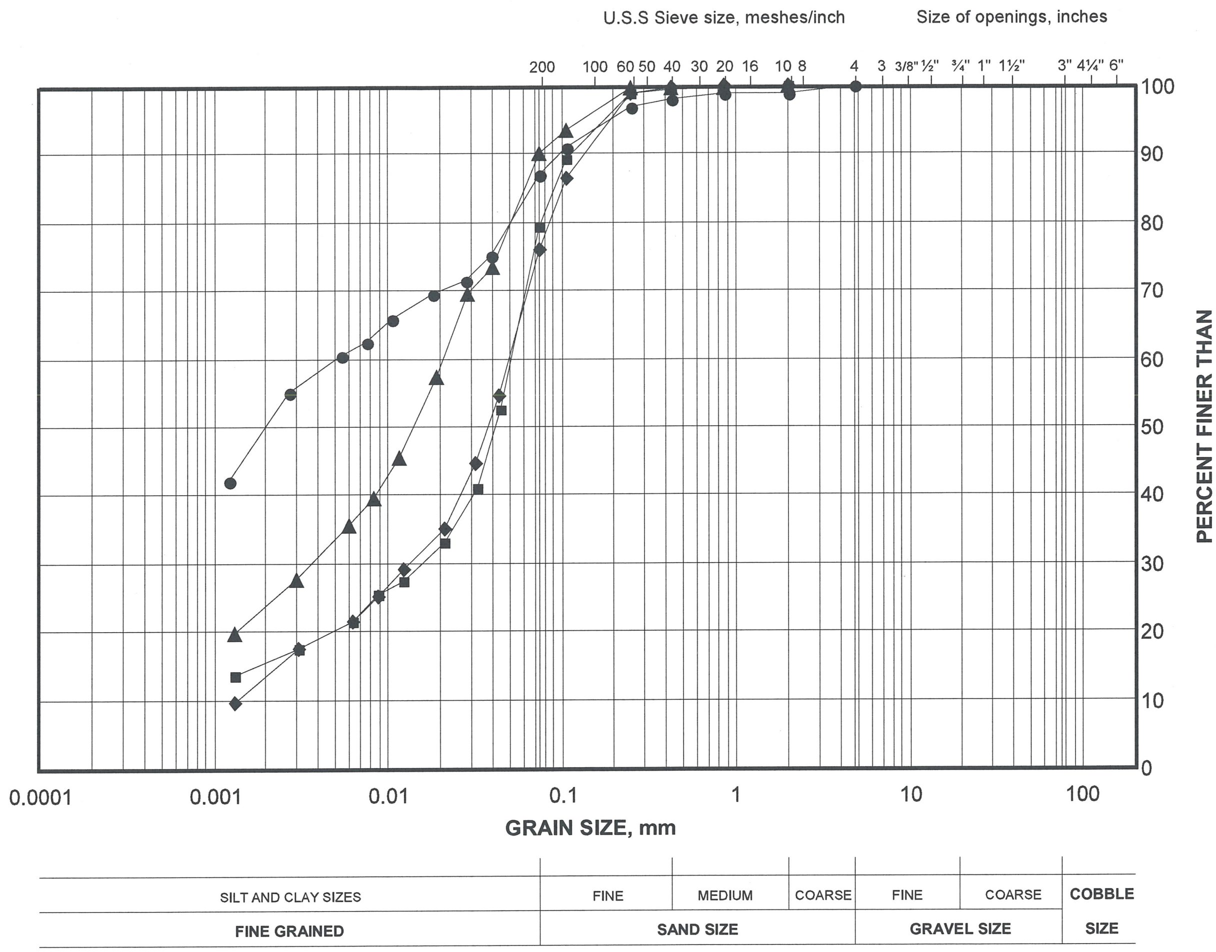
Date: 13-Jul-12

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B12



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	09-F-7	13	217.9
■	09-F-6	2	231.0
◆	09-F-7	5	230.2
▲	09-F-4	6	228.8

Project Number: 09-1111-0022

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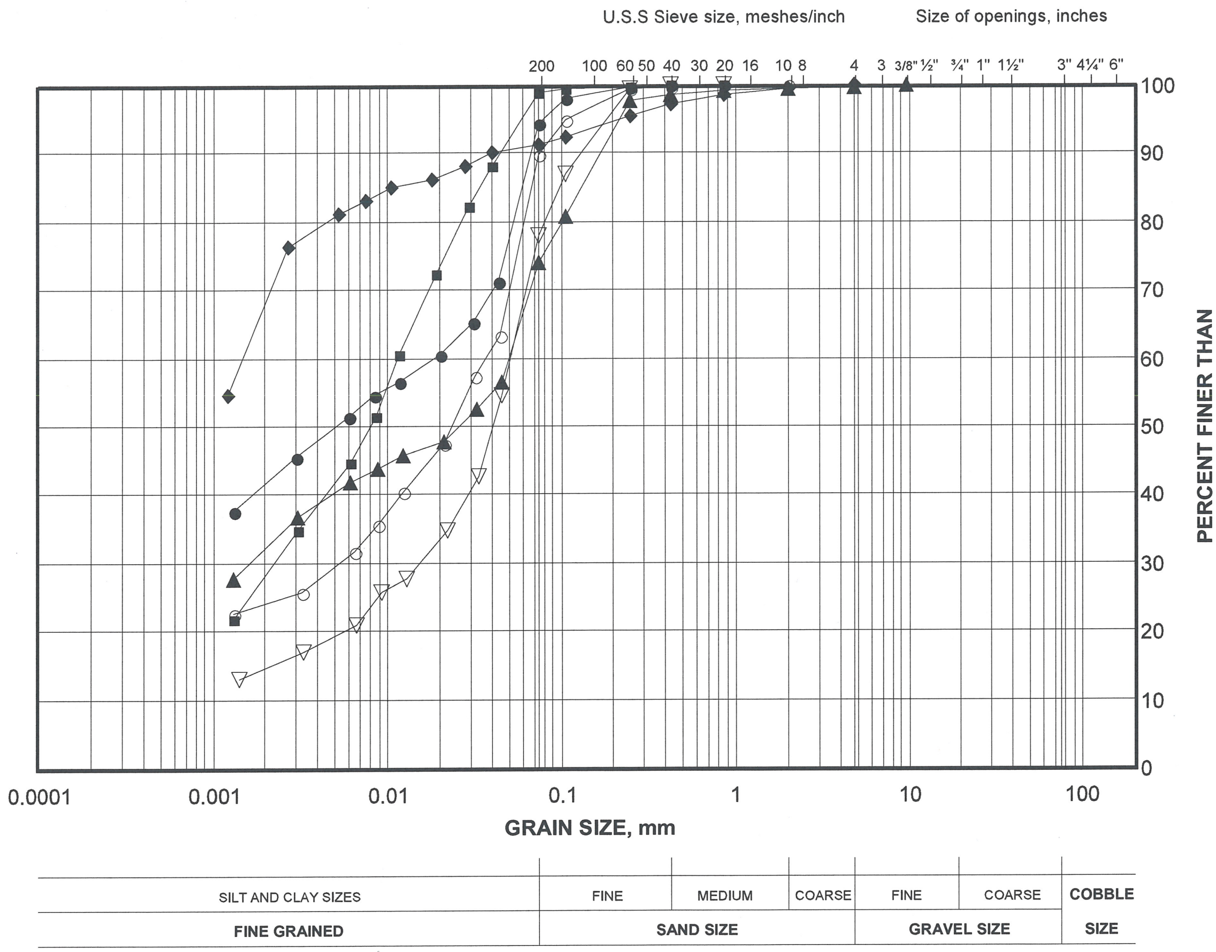
Date: 16-Jul-12

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B13



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-08	12	219.5
■	12-09	13	227.8
◆	12-08	13	218.0
▲	12-09	20	217.2
▽	12-08	5	230.2
○	12-08	6	228.7

Project Number: 09-1111-0022

Checked By: [signature]

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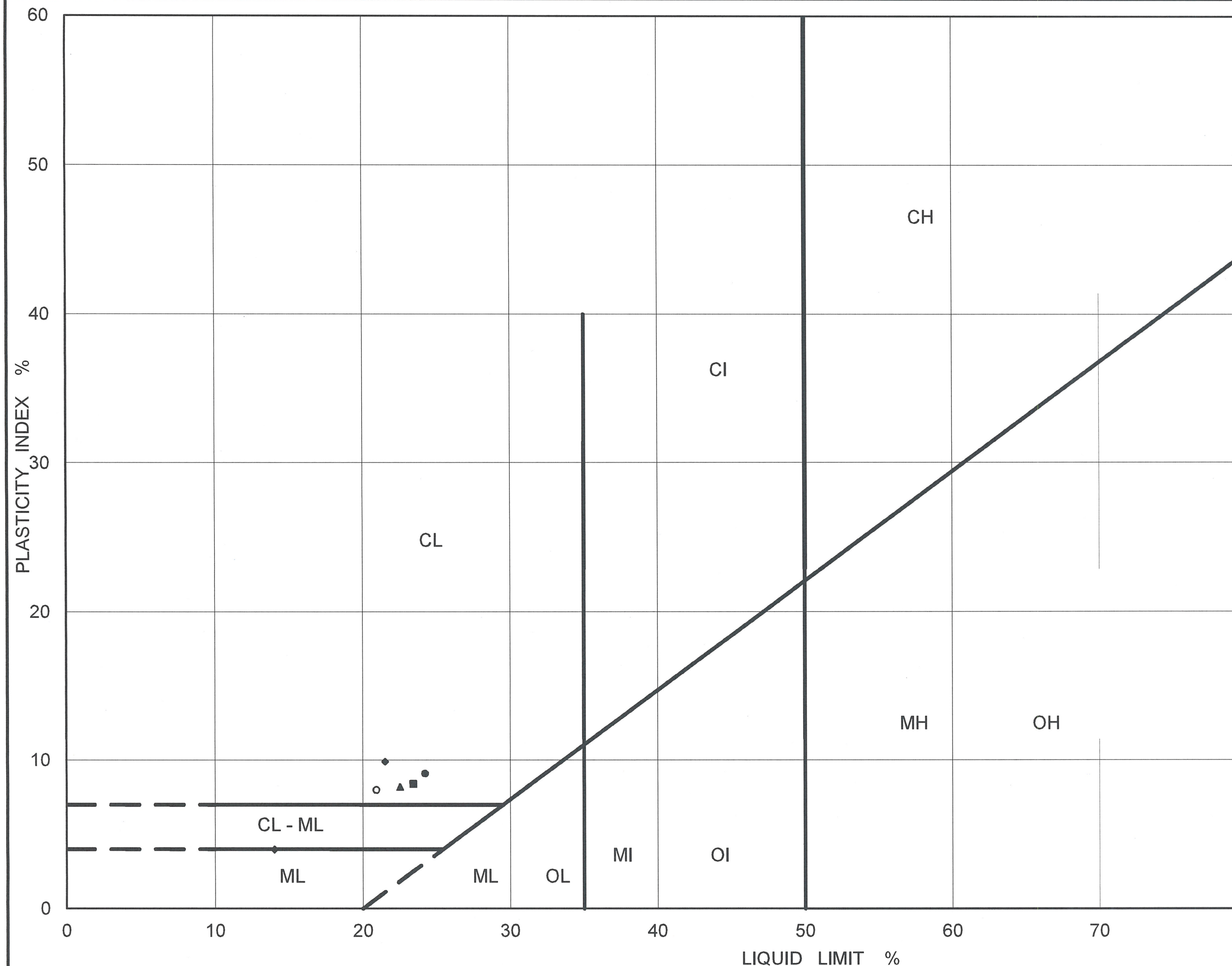
Date: 17-Jul-12

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
09-F-3	11	●
09-F-3	19	◆
09-F-4	6	▲
09-F-5	5	■
09-F-7	8	○
09-F-7	14	◇
		△
		□

Ministry of Transportation

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PLASTICITY CHART
Clayey Silt

Figure No. B14

Project No. 09-1111-0022

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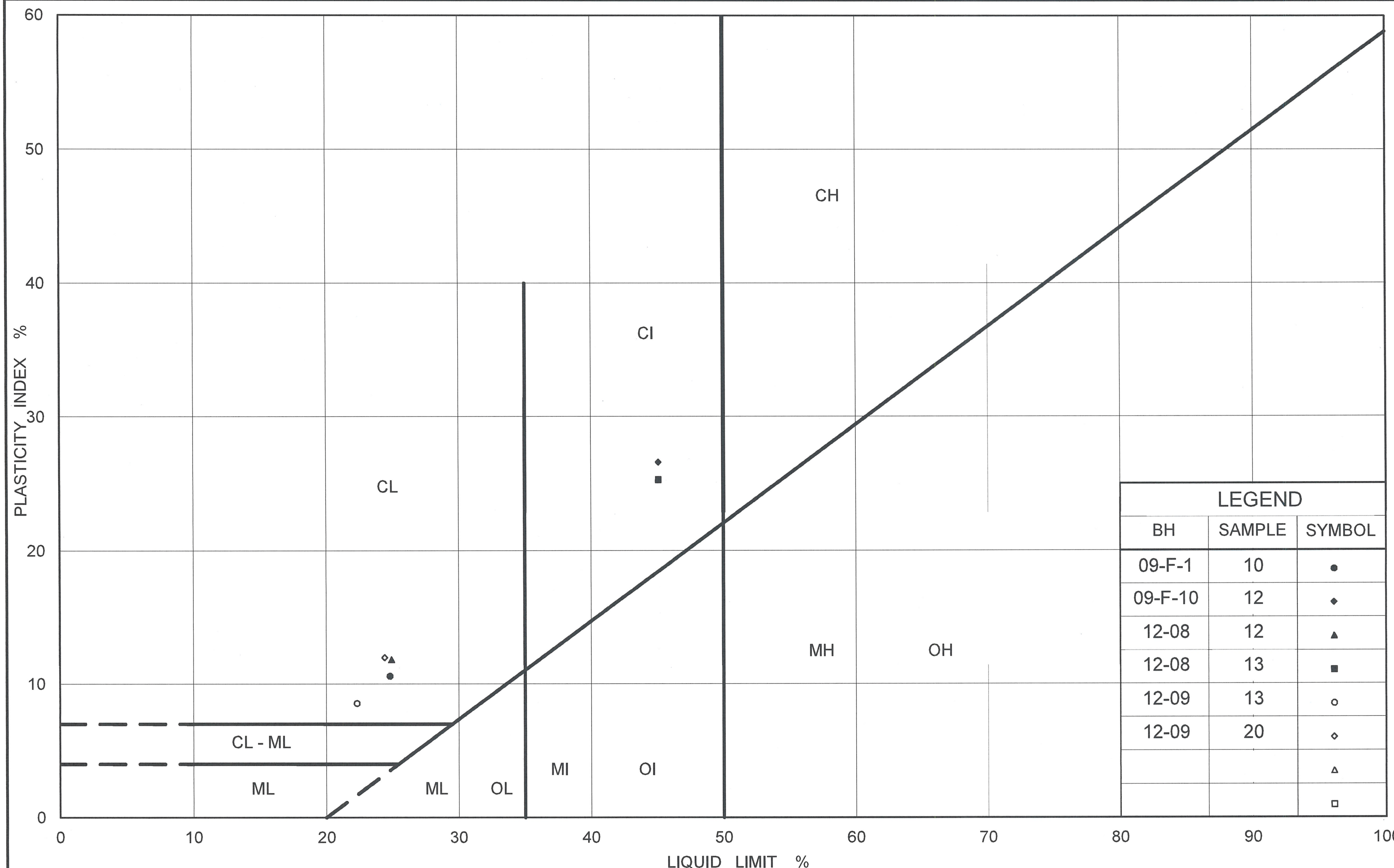
Oct 75, FF-S-21



Ministry of Transportation

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PLASTICITY CHART
Clayey Silt to Silty Clay

Figure No. B15

Project No. 09-1111-0022

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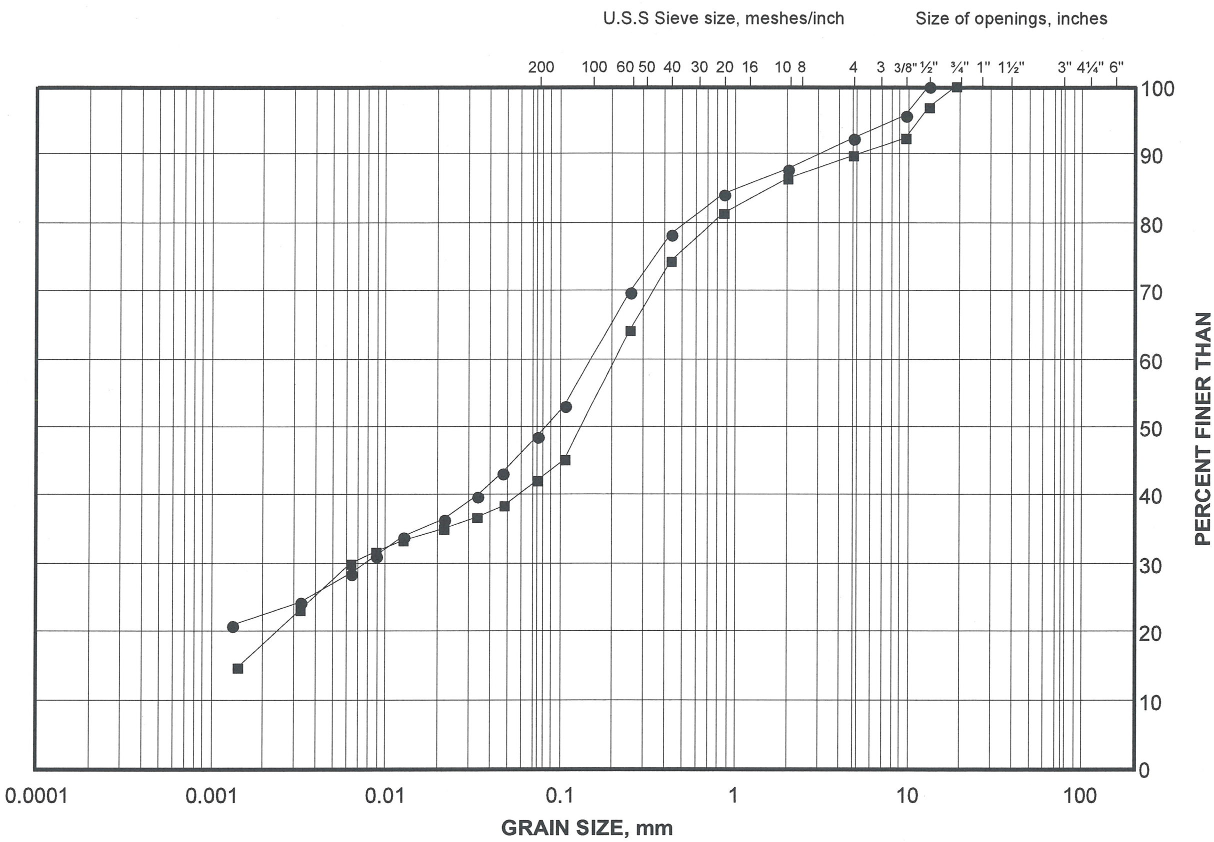
GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B16



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-09	24	211.1
■	12-02	5	234.0

Project Number: 09-1111-0022

Checked By: [signature]

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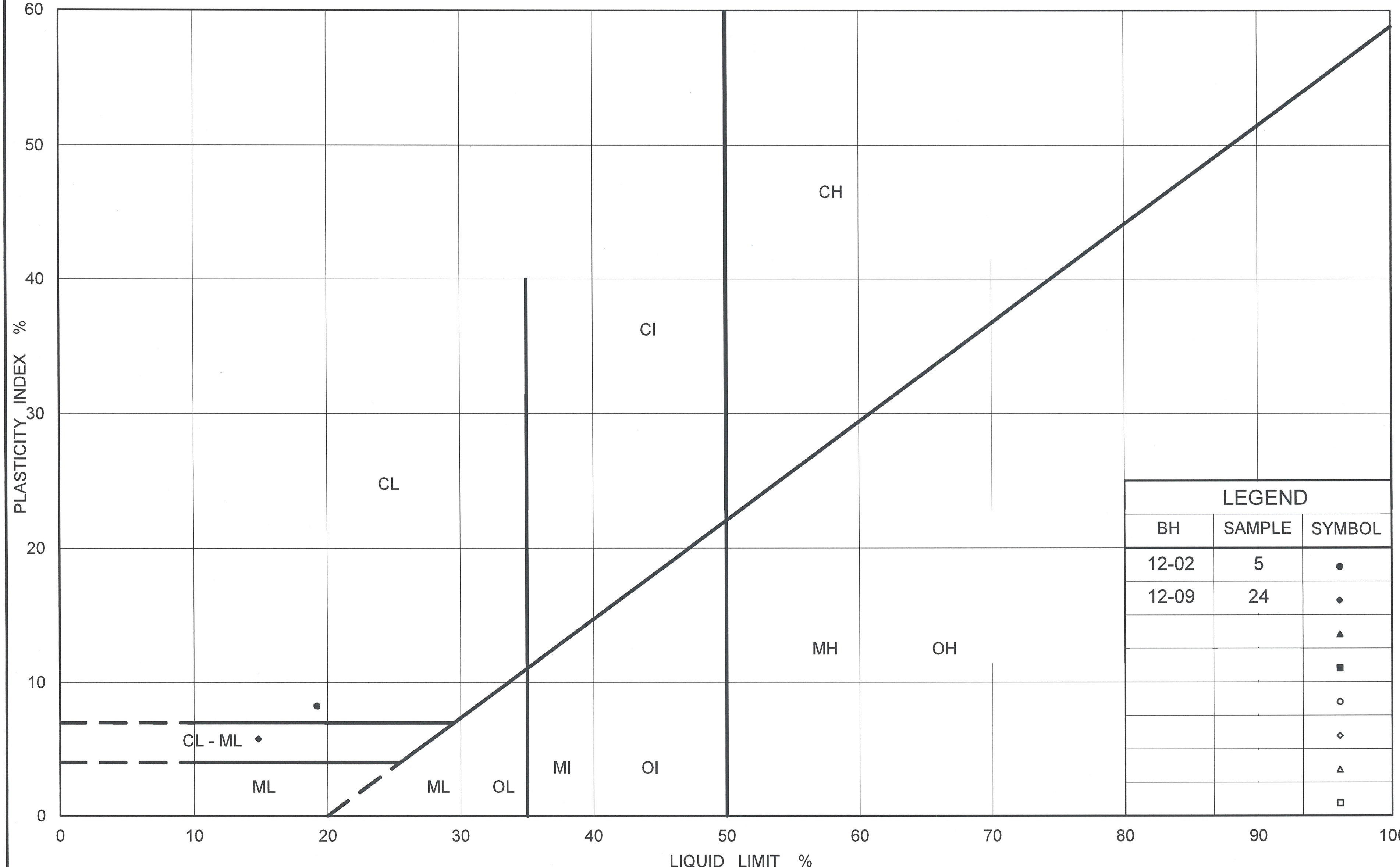
Date: 13-Jul-12

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
12-02	5	●
12-09	24	◆
		▲
		■
		○
		◇
		△
		□

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PLASTICITY CHART
Clayey Silt Till

Figure No. B17

Project No. 09-1111-0022

Checked By: [signature]

APPENDIX C

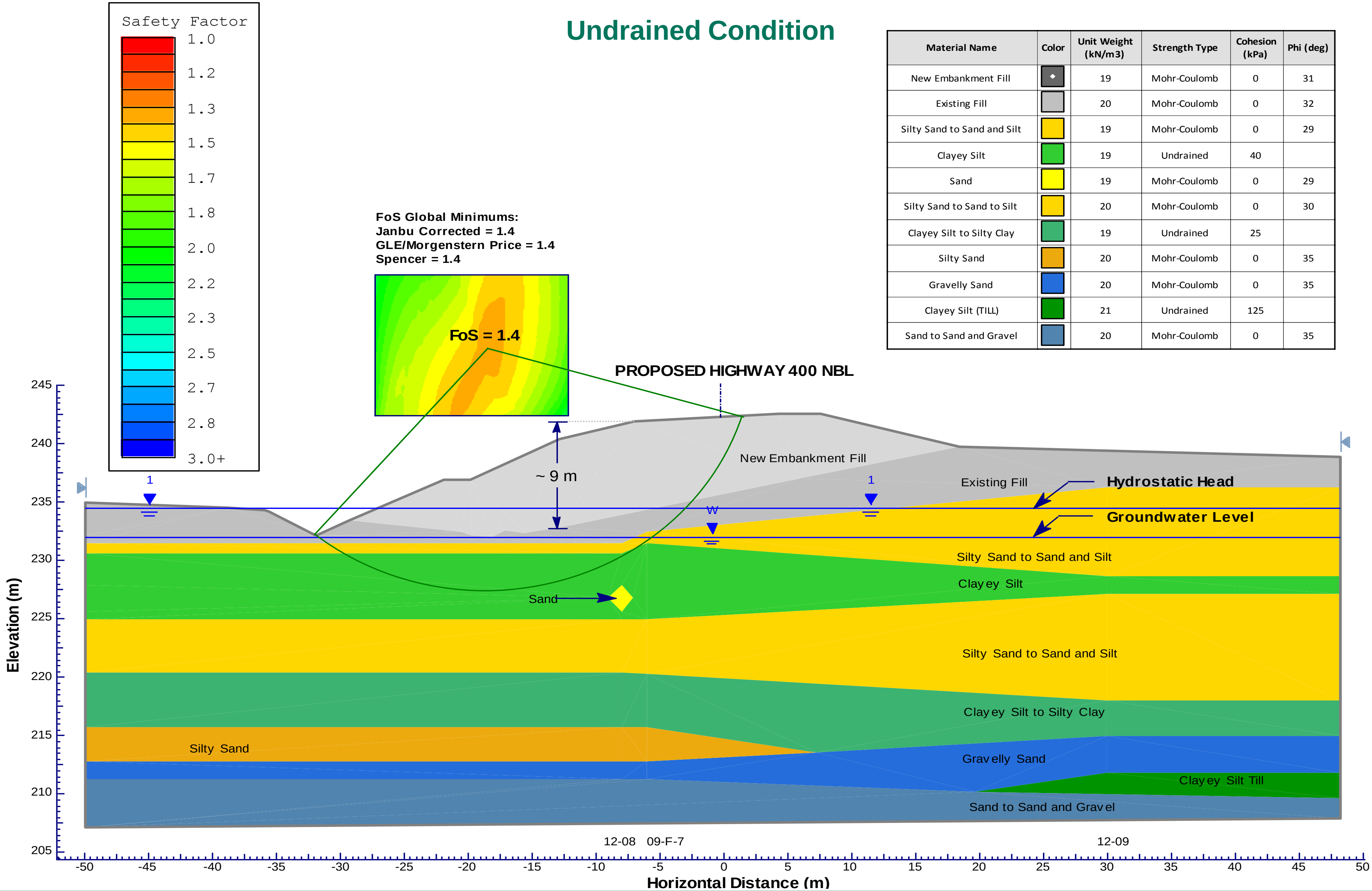
Slope Stability Analysis

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation Station 18+775 Static Global Stability

Figure 1

Undrained Condition

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Silty Sand to Sand and Silt		19	Mohr-Coulomb	0	29
Clayey Silt		19	Undrained	40	
Sand		19	Mohr-Coulomb	0	29
Silty Sand to Sand to Silt		20	Mohr-Coulomb	0	30
Clayey Silt to Silty Clay		19	Undrained	25	
Silty Sand		20	Mohr-Coulomb	0	35
Gravelly Sand		20	Mohr-Coulomb	0	35
Clayey Silt (TILL)		21	Undrained	125	
Sand to Sand and Gravel		20	Mohr-Coulomb	0	35



Date: July 2012
Project No: 09-1111-0022-7

Analysis By: TVA **Reviewed By:** RA

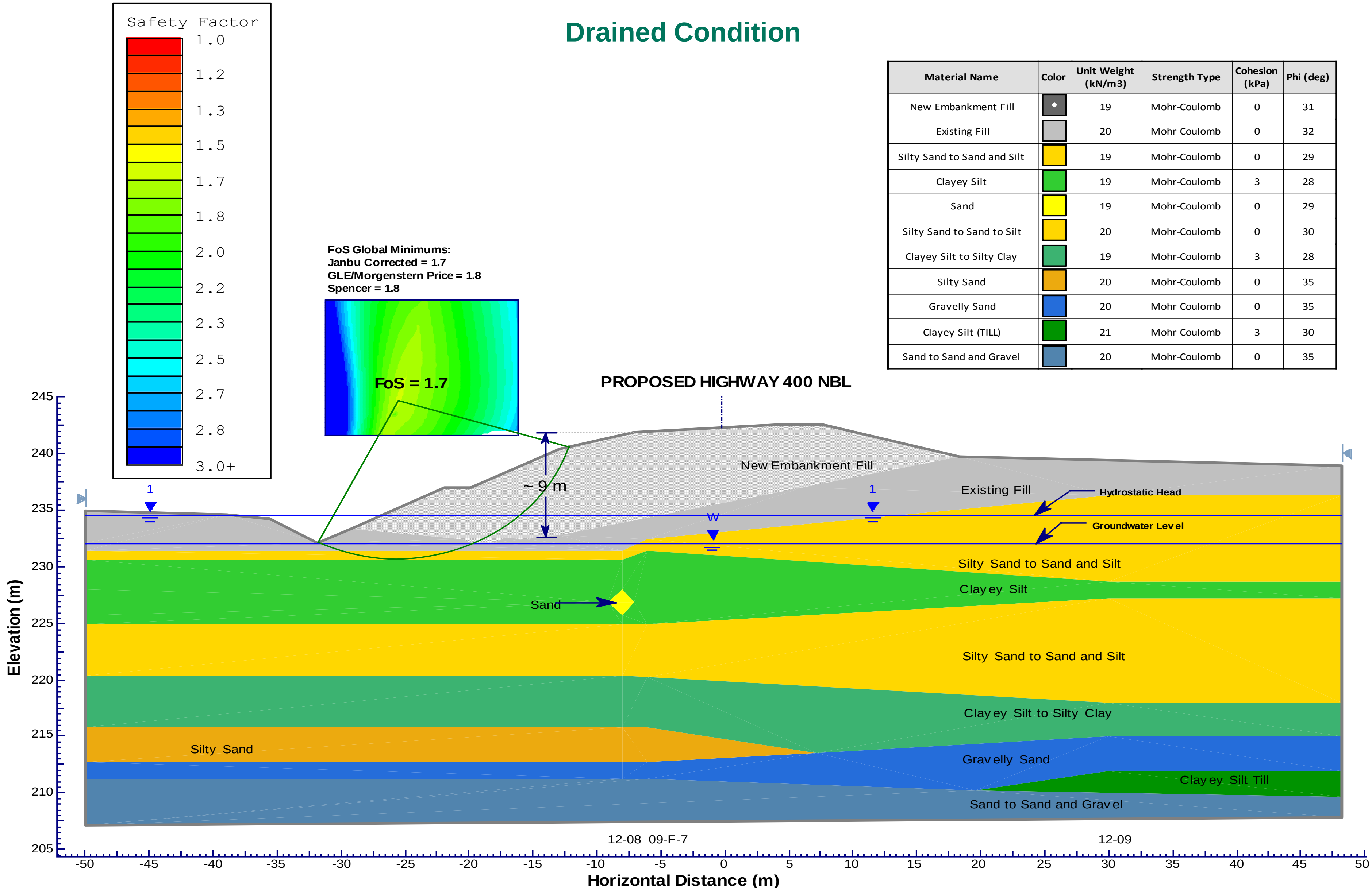
Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 18+775 Static Global Stability

Figure 2

Drained Condition

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Silty Sand to Sand and Silt		19	Mohr-Coulomb	0	29
Clayey Silt		19	Mohr-Coulomb	3	28
Sand		19	Mohr-Coulomb	0	29
Silty Sand to Sand to Silt		20	Mohr-Coulomb	0	30
Clayey Silt to Silty Clay		19	Mohr-Coulomb	3	28
Silty Sand		20	Mohr-Coulomb	0	35
Gravelly Sand		20	Mohr-Coulomb	0	35
Clayey Silt (TILL)		21	Mohr-Coulomb	3	30
Sand to Sand and Gravel		20	Mohr-Coulomb	0	35



Date: July 2012 **Analysis By:** TVA **Reviewed By:** RA

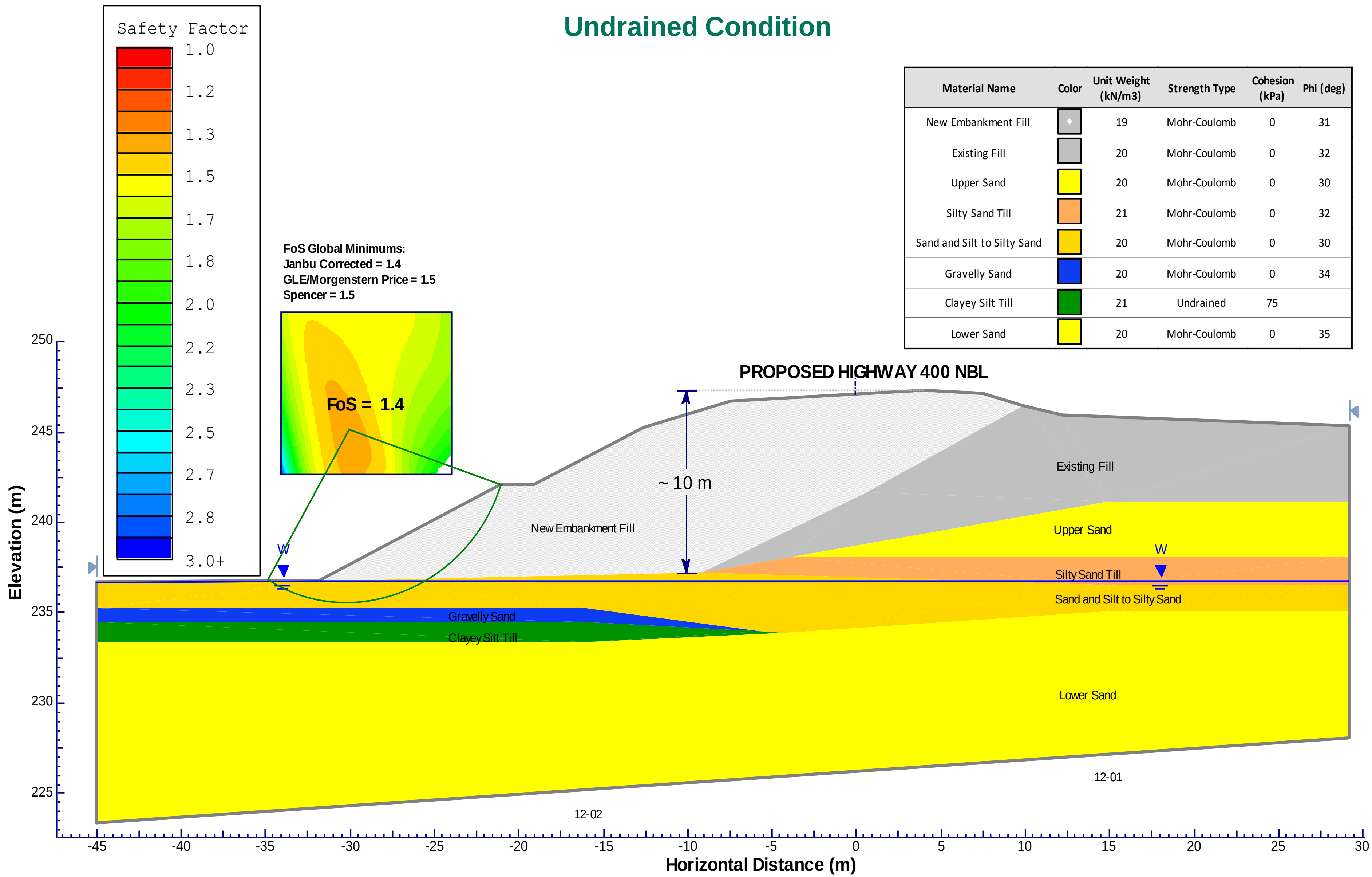
Project No: 09-1111-0022-7

Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 18+925 Static Global Stability

Figure 3

Undrained Condition



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Upper Sand		20	Mohr-Coulomb	0	30
Silty Sand Till		21	Mohr-Coulomb	0	32
Sand and Silt to Silty Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	34
Clayey Silt Till		21	Undrained	75	
Lower Sand		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

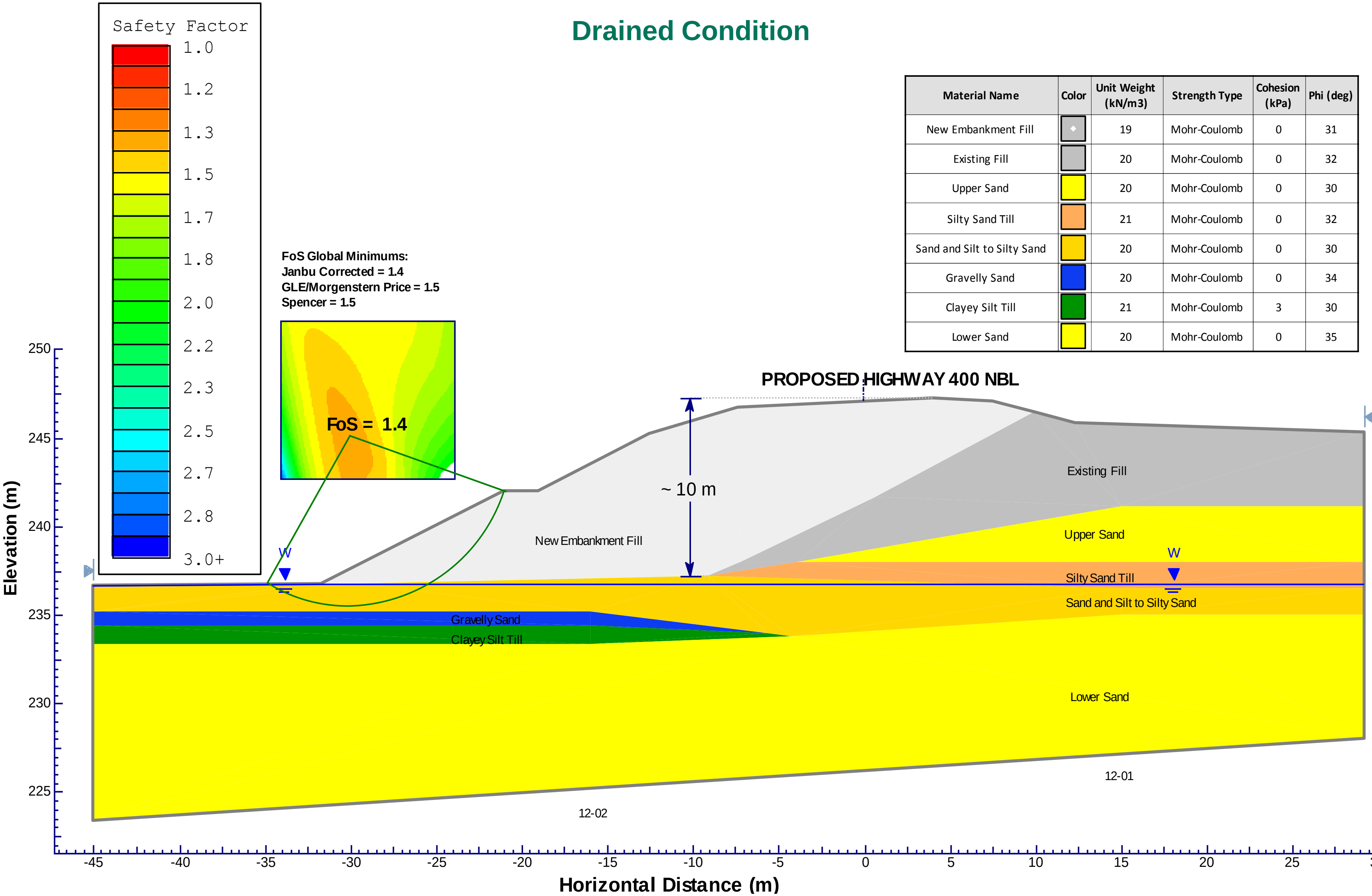
Analysis By: TVA **Reviewed By:** RA

Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 18+925 Static Global Stability

Figure 4

Drained Condition



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Upper Sand		20	Mohr-Coulomb	0	30
Silty Sand Till		21	Mohr-Coulomb	0	32
Sand and Silt to Silty Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	34
Clayey Silt Till		21	Mohr-Coulomb	3	30
Lower Sand		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

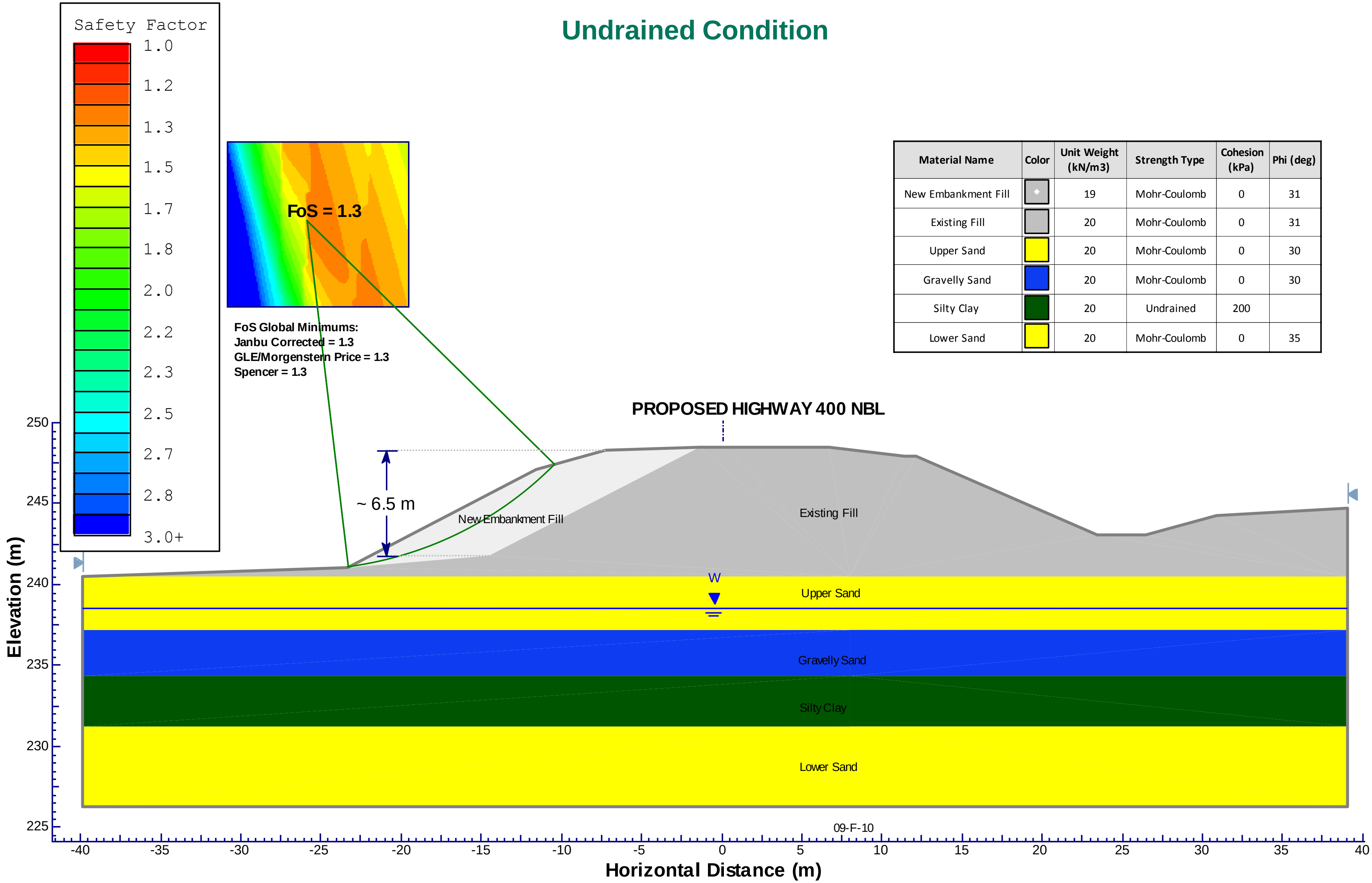
Analysis By: TVA **Reviewed By:** RA

Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 19+000 Static Global Stability

Figure 5

Undrained Condition



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	31
Upper Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	30
Silty Clay		20	Undrained	200	
Lower Sand		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

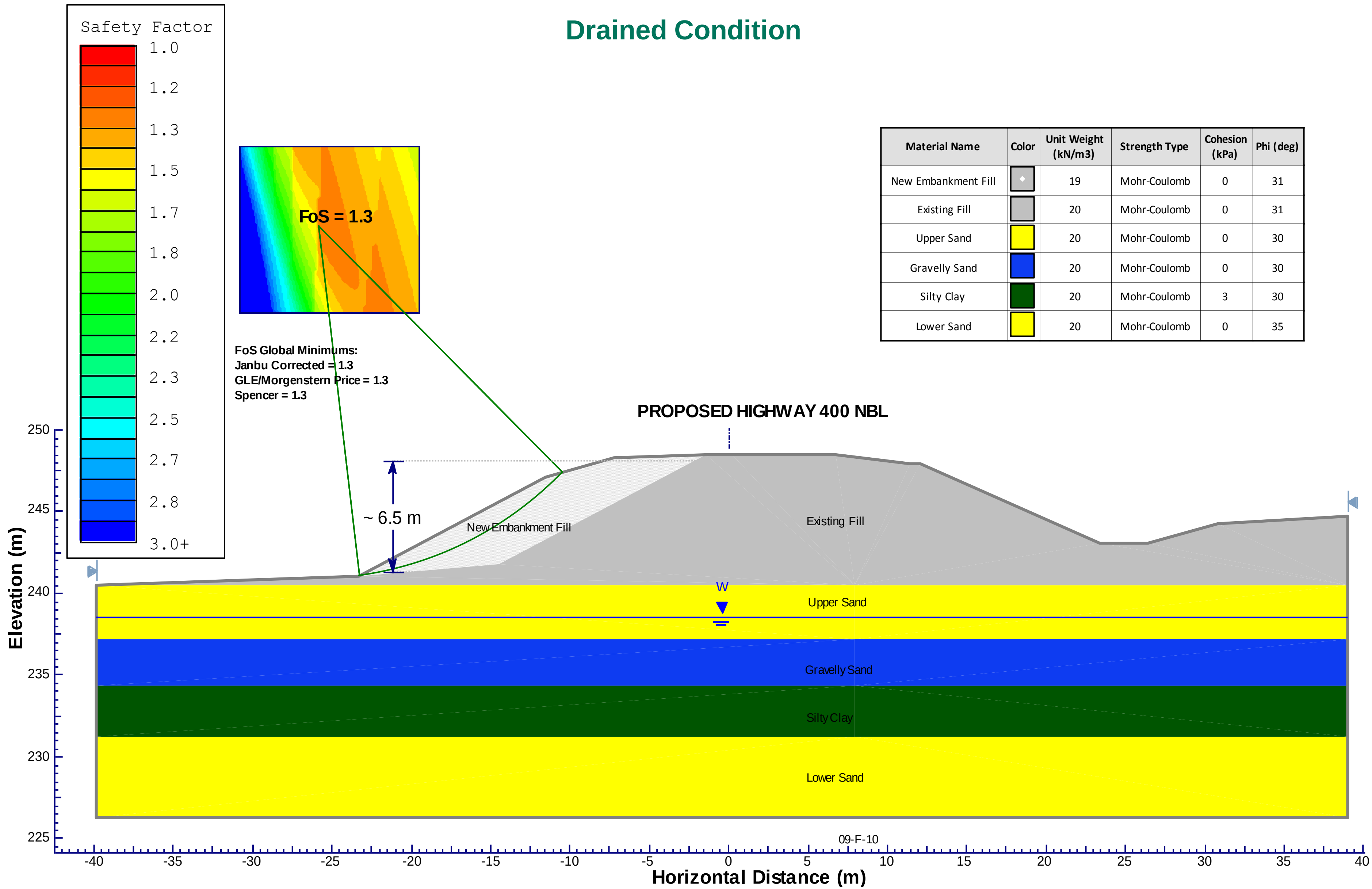
Analysis By: TVA **Reviewed By:** RA

Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation Station 19+000 Static Global Stability

Figure 6

Drained Condition



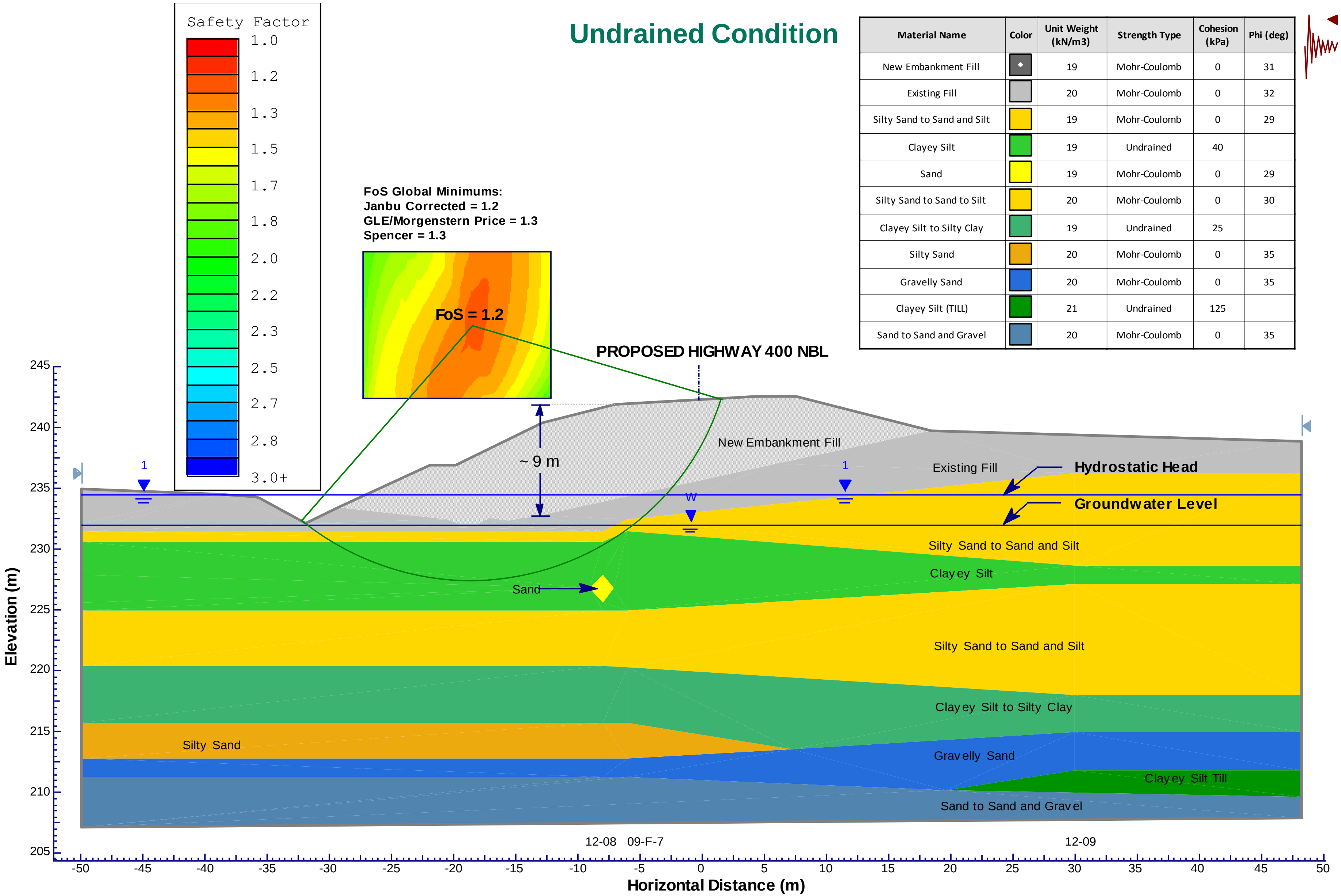
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	31
Upper Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	30
Silty Clay		20	Mohr-Coulomb	3	30
Lower Sand		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

Analysis By: TVA **Reviewed By:** RA

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 18+775 Seismic Global Stability

Figure 7



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Silty Sand to Sand and Silt		19	Mohr-Coulomb	0	29
Clayey Silt		19	Undrained	40	
Sand		19	Mohr-Coulomb	0	29
Silty Sand to Sand to Silt		20	Mohr-Coulomb	0	30
Clayey Silt to Silty Clay		19	Undrained	25	
Silty Sand		20	Mohr-Coulomb	0	35
Gravelly Sand		20	Mohr-Coulomb	0	35
Clayey Silt (TILL)		21	Undrained	125	
Sand to Sand and Gravel		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

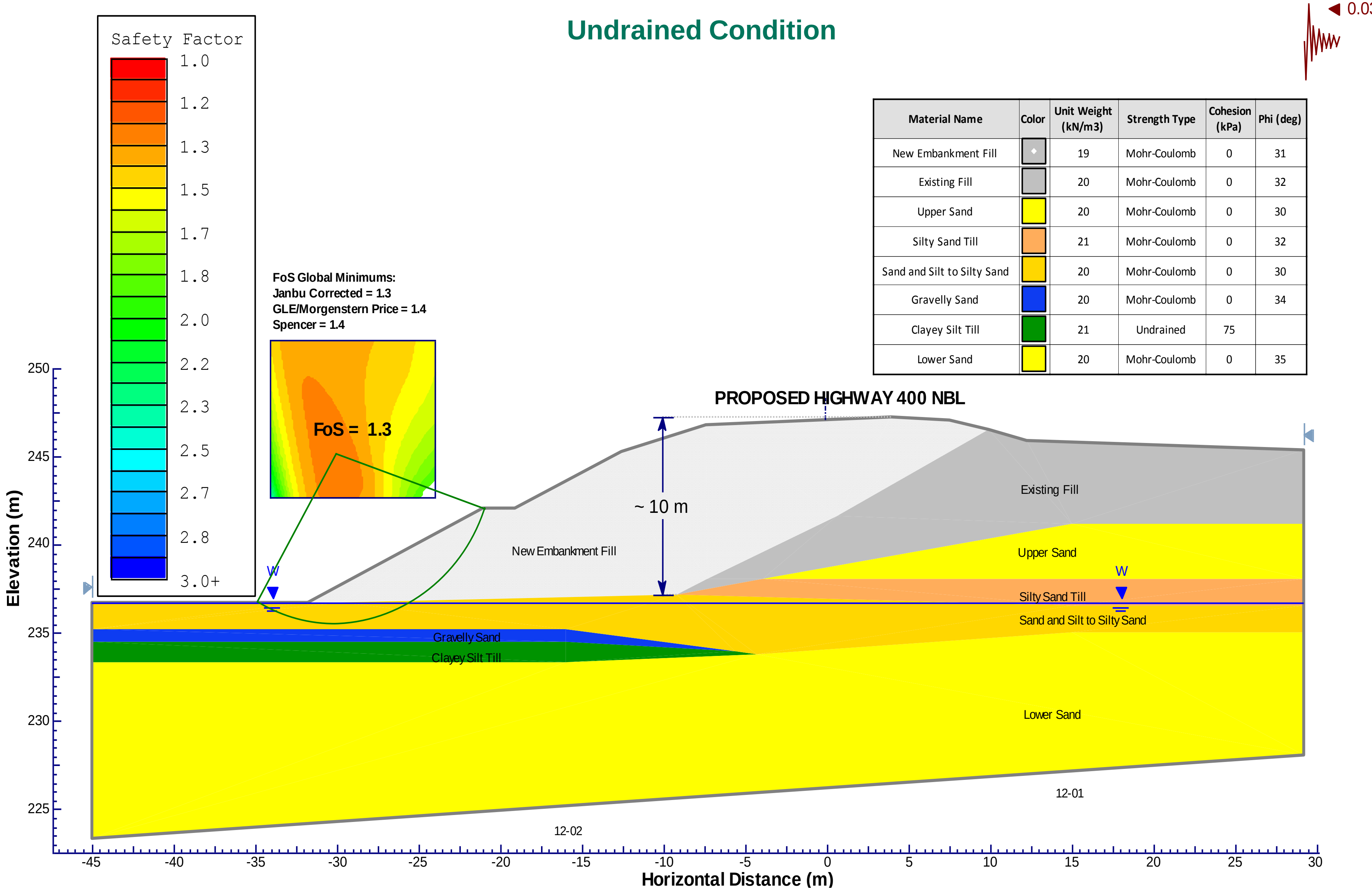
Analysis By: TVA **Reviewed By:** RA

Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 18+925 Seismic Global Stability

Figure 8

Undrained Condition



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	32
Upper Sand		20	Mohr-Coulomb	0	30
Silty Sand Till		21	Mohr-Coulomb	0	32
Sand and Silt to Silty Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	34
Clayey Silt Till		21	Undrained	75	
Lower Sand		20	Mohr-Coulomb	0	35

Date: July 2012
Project No: 09-1111-0022-7

Analysis By: TVA **Reviewed By:** RA

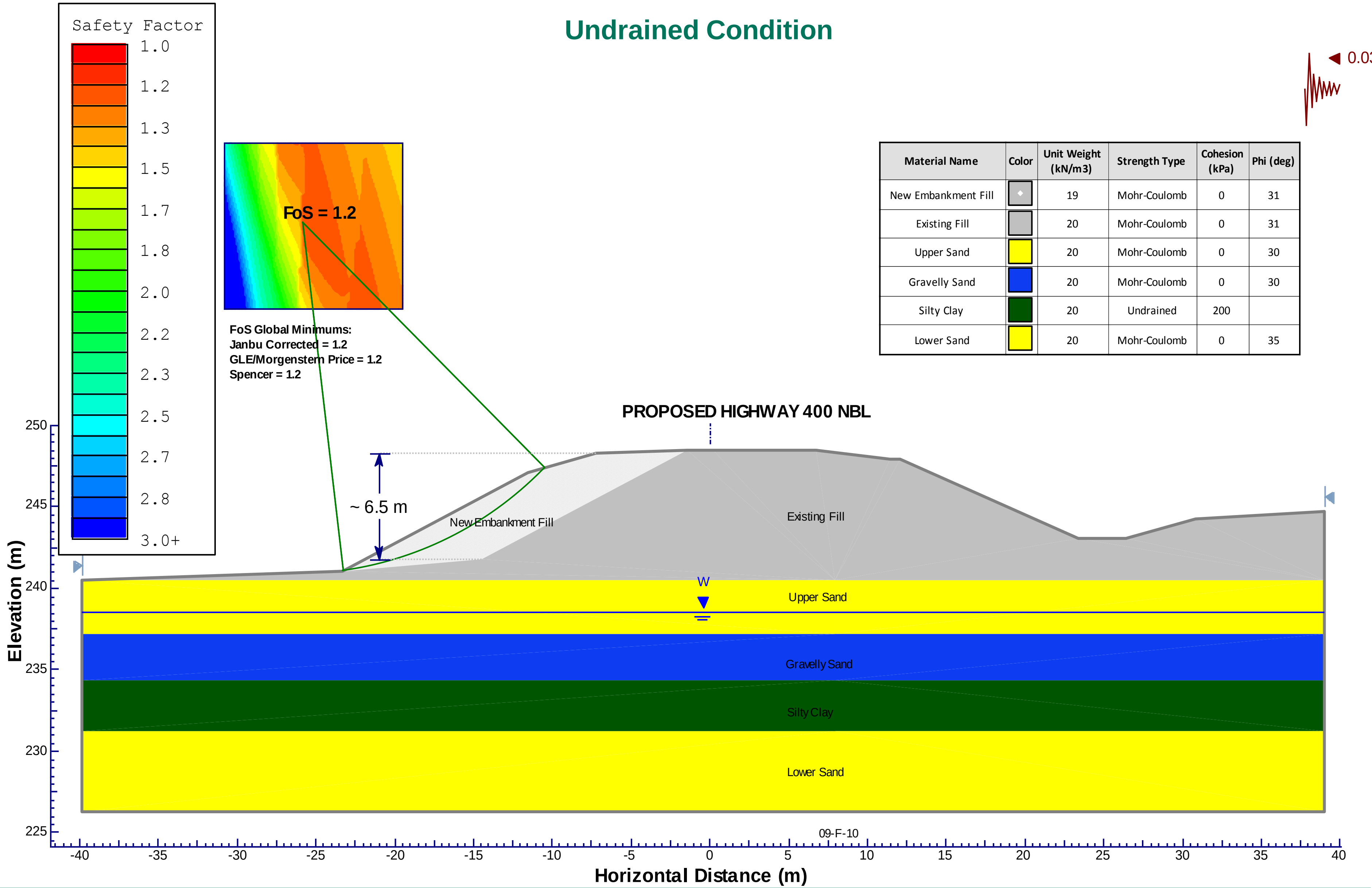
Golder Associates

High Fills at Crown Hill Overpass – Hwy 400 NBL Rehabilitation
Station 19+000 Static Global Stability

Figure 9

Undrained Condition

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankment Fill		19	Mohr-Coulomb	0	31
Existing Fill		20	Mohr-Coulomb	0	31
Upper Sand		20	Mohr-Coulomb	0	30
Gravelly Sand		20	Mohr-Coulomb	0	30
Silty Clay		20	Undrained	200	
Lower Sand		20	Mohr-Coulomb	0	35



Date: July 2012
Project No: 09-1111-0022-7

Analysis By: TVA **Reviewed By:** RA

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APPENDIX D

Non-Standard Special Provisions
Supply and Installation of Embankment Monitoring Equipment

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT – Item No.

Non-Standard Special Provision

1.0 GENERAL

1.1 Scope

This non-standard special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Survey Benchmarks (BM)
- Settlement Rods (SR)

1.2 Purpose

The purpose of these instruments is to monitor settlements in the foundation soils in the High Fill areas at the Crown Hill Overpass.

The data will be used for construction planning, including the timing for final paving operations. These activities shall be controlled by the instrument readings.

1.3 Personnel

The Contractor shall retain a Geotechnical Consultant with MTO classification of "Geotechnical (Structures and Embankments) – Medium Complexity", to undertake the supply and installation of geotechnical instruments.

The Contractor (as referenced herein) shall be understood to refer to the Contractor and their Geotechnical Consultant.

1.4 Or equal

The term "or equal" shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

1.5 Notification

The Contract Administrator shall be notified a minimum of 15 working days in advance of commencing the installation of instruments.

1.6 Submission Requirements

The Contractor shall submit details of proposed installations including:

- Design and construction drawings, including equipment layout;
- Installation methodology and timing;

- Equipment and material specifications, data sheets;
- Location and types of survey benchmarks; and
- Installation schedule.

Submittals shall be made to the Contract Administrator a minimum of 15 days before the start of the instrument installation.

1.7 Drawings

Reference shall be made to the following drawings that are contained elsewhere in the Contract:

- Monitoring Points Location Plan;
- Typical Instrument Installation Details.

1.8 Subsurface Conditions

The subsurface conditions at the site are described in the following report:

- Foundation Investigation Report – High Fills at Crown Hill Overpass, Highway 400 Northbound Rehabilitation, Highway 11 to Highway 93, Simcoe County, Ontario. GWP 2039-06-00, dated July 18, 2012, by Golder Associates.

The owner warrants that the information provided in the report can be relied upon with the following exceptions.

1. Any interpretations of the data or opinions expressed in the report are not warranted; and
2. Although the raw measured data presented is warranted, the Contractor must satisfy himself as to the sufficiency of the information presented and obtain any updated or additional information, and perform any studies, analysis or investigations the Contractor deems necessary in order to prepare his design, at no additional cost to the Owner.

1.9 Equipment Operation and Weather Conditions

All installations and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the required accuracy throughout the temperature range. Monitoring shall be conducted year round and the Contractor is advised that the equipment should be accessible for monitoring throughout the duration of the Contract.

2.0 INSTALLATION

A summary of instrumentation requirements at the High Fills at Crown Hill Overpass site are given below in Table 2.0. Details and specific material requirements are presented elsewhere in this special provision.

Table 2.0 – High Fills at Crown Hill Overpass
Instrument Quantities and Locations

INSTRUMENT I.D.	STATION	OFFSET FROM CENTRELINE (m)	NO. OF INSTRUMENTS	
			SP	BM
BM1	Hwy 400 NBL Sta. 18+750	25 m East		1
BM2	Hwy 400 NBL Sta. 18+925	35 m West		1
SR1	Hwy 400 NBL Sta. 18+775	10 m West	1	
SR2	Hwy 400 NBL Sta. 18+750	10 m West	1	
SR3	Hwy 400 NBL Sta. 18+925	10 m West	1	
Total Instruments			**3**	**2**

2.1 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground surface elevation at each instrument location.

2.2 Survey Benchmarks (BM)

The Contractor shall provide as a minimum a non-yielding deep seated survey benchmark (BM) as specified herein. Alternatively the contractor may select stable non-settling points on the existing bridge subject to approval by the contract administrator. The geodetic elevation of all benchmarks shall be established by the Contractor.

The number and locations(s) of benchmark(s) shall be such that direct sighting is possible from all settlement rods to at least one benchmark.

2.3 Accuracy of Surveying for Elevations

Elevations shall be surveyed referenced to Geodetic datum to an accuracy of ± 2 mm or better.

2.4 Monitoring Instrument Location

All monitoring instruments shall be located in MTM NAD83 northing and easting coordinates.

2.5 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

2.6 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor, at no cost to the Ministry.

2.7 Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for at least 1 year.

2.8 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at no cost to the Ministry.

2.9 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled. In situ or laboratory testing is not required.

Boreholes shall be advanced using conventional drilling methods and shall be as straight and vertical as practical.

2.10 Installation Program

Instrument installation shall be completed in accordance with Table 2.1 which provides a summary of the installation schedule requirements at the High Fills at Crown Hill Overpass site.

Table 2.1 – High Fills at Crown Hill Overpass
Installation Program

TYPE	START INSTALLATION	FINISH INSTALLATION
BM	Before commencement of embankment construction	Before commencement of embankment construction
SR	Prior to placing embankment fill.	On completion of embankment construction

3.0 BENCHMARK (BM) – SUPPLY & INSTALLATION

3.1 GENERAL

3.1.1 Scope

This Section contains the requirements for the supply and installation of benchmarks (BM).

The purpose of the benchmark is to provide non-settling references for the surveying of settlement rods.

3.1.2 General Procedure

The benchmark consists of a steel rod anchored to the bottom of a borehole. The benchmark shall be installed prior to embankment construction. The number and locations of benchmarks shall be such that direct sighting is possible from all settlement rods to at least one benchmark. Elevations shall be surveyed to an accuracy of ± 2mm or better.

Prior to the installation of instruments, the Contractor shall accurately survey and stake the locations of each instrument and obtain a ground elevation at each instrument location.

3.1.3 Location

Benchmarks shall be located and installed outside of the area of construction activity. Notwithstanding the installation details provided herein the contractor may select stable non-settling points on the existing bridge subject to approval by the contract administrator.

Table 3.0 – High Fills at Crown Hill Overpass
Approximate Bench Mark Locations

Location	Offset from Centreline (m)	No. of BM	Estimated Rod Anchor Elevation (m)
North High Fills Area			
Sta. 18+750	25 m East	BM1	233.0
South High Fills Area			
Sta. 18+925	35 m West	BM2	225.0

3.2 MATERIALS

3.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the benchmark.

3.2.2 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4 mm (1"), supplied in lengths as required to complete the installation as described.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

3.2.3 Sand

The Contractor shall supply clean washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

3.2.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 – OPSS 1301).

3.2.5 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 – OPSS 1301).

3.2.6 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 – 50.8 mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

3.3 INSTALLATION

3.3.1 General

The Contractor shall install benchmarks (BM) as per the drawings provided in accordance with the information below.

3.3.2 Borehole Installation

The borehole shall be advanced to the rod anchor elevation provided in Table 3 using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

3.3.3 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

3.3.4 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the Contractor shall pour 0.5 m of clean sand in the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

3.3.5 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod above the rod anchor and sand.

3.3.6 Installation Details

The elevation, easting and northing of the top of the benchmark rod shall be surveyed.

3.4 COORDINATION WITH MONITORING

3.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a benchmark. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Location of the rod anchor and elevation top of rod;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the benchmark, including drilling method notes;
- Installation notes/sketches; and
- Description of benchmarks, sleeve and rod anchor.

3.4.2 Monitoring

Monitoring of settlements with reference to the benchmark shall be done by others. Monitoring shall be conducted during and following the embankment construction. The Contractor shall provide installation information as specified above and provide access to the benchmark for monitoring including, but not limited to snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed.

3.5 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Benchmark Northings and Eastings in MTM NAD83 coordinates;
- Elevation of the bottom of the rod anchor and top of rod relative to Geodetic datum;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the benchmarks, including drilling method notes;
- Installation notes/sketches; and
- Description of benchmark, sleeve and rod anchor.

4.0 SETTLEMENT RODS (SR) – SUPPLY & INSTALLATION

4.1 GENERAL

4.1.1 Scope

This Section contains the requirements for the supply and installation of settlement rods.

The purpose of the settlement rods is to monitor settlements of the foundation soils below the embankment base. The settlement readings shall help to establish the timing for bridge construction and final paving operations. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

4.1.2 General Procedure

The settlement rods shall be attached to a plate at the existing ground surface. As embankment construction proceeds the rods shall be extended above the new top of embankment.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment construction proceeds.

4.1.3 Location

The locations of the settlement rods are shown on the Contract Drawings and are given below in Table 4.0.

Table 4.0 – High Fills at Crown Hill Overpass
Approximate Settlement Rod Locations

Instrument I.D.	Station	Offset from Centreline (m)	No. of Settlement Rod (s)	Estimated Thickness of Embankment (m)*
SR1	Hwy. 400 NBL Sta. 18+775	10 m West	1	8.0
SR2	Hwy. 400 NBL Sta. 18+750	10 m West	1	6.5
SR3	Hwy. 400 NBL Sta. 18+925	10 m West	1	9.0

Notes:* Embankment thickness is equivalent to the distance between the proposed top of embankment design grade and the existing ground surface elevation at the settlement rod location.

4.2 MATERIALS

4.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement rods.

4.2.2 Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm (1/4"). The plate shall be at least 0.5 m by 0.5 m.

4.2.3 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4 mm (1"), supplied in lengths as required to complete the installation as described in Section 4.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

4.2.4 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 – 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

4.2.5 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP – OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reduction Sleeve (PVC pipe) shall be filled with medium to coarse sand.

4.3 INSTALLATION

4.3.1 General

The Contractor shall install settlement rods as per the Contract Drawings provided in addition to what is stated or emphasized below.

4.3.2 Settlement Plate

The settlement plate shall be installed horizontally on undisturbed native soil just below the existing ground surface.

The elevation of the base of the plate shall be surveyed before backfilling.

4.3.3 Rod

The rod shall be fixed to the center of the plate and shall be perpendicular to the plate.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

4.3.4 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the settlement rod shall extend 25 mm above the top of the friction sleeve at all times.

4.4 EXTENSION OF ROD

The settlement rods shall be extended upwards as the embankment is constructed so that the top of the rod is always at least 0.3 m but not more than 2 m above the surrounding fill.

4.4.1 Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended with the rods.

The settlement rod shall be in the center of the CSP and friction-reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

4.4.2 Installation Details

The elevation, easting and northing of the center of the base of the plate shall be surveyed.

The elevation, easting and northing of the top of the rod shall be surveyed.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

4.5 COORDINATION WITH MONITORING

4.5.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement rod. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Settlement plate and rod Northings and Eastings in MTM NAD 83 coordinates;
- Elevation of plate and rod referenced to Geodetic datum;
- Dates of installation;
- Installation notes/sketches; and
- Description of settlement rods, sleeve and plate.

Adjustments in the length of any settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

4.5.2 Monitoring

Monitoring of the settlement rods shall be done by others. Monitoring shall be conducted during and after the embankment construction.

The target settlements are outlined below:

North Embankment – A target settlement of 40 mm is specified.

South Embankment – A target settlement of 175 mm is specified.

The Contractor shall provide installation information as specified above and provide access to the settlement rods for monitoring including, but not limited to a level scaffolding platform and ladder, if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

4.6 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Settlement rod Northings and Eastings referenced to MTM NAD83 coordinates;
- Elevation of the plate and the top of the rod referenced to Geodetic datum;
- Distance between base of plate and top of rod;
- Dates of installation; and
- Installation notes/sketches.

5.0 DECOMMISSIONING OF INSTRUMENTS

5.1 General

The Contractor shall decommission all the Settlement Rods (SR) and Benchmarks (BM) at the end of the monitoring program following construction unless advised otherwise by the Contract Administrator. Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources act, R.R.O. 1990, Regulation 903 (as amended).

6.0 PAYMENT

6.1 Basis of Payment

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, monitoring equipment and material to do the work.

APPENDIX E

Monitoring Instrument Drawings

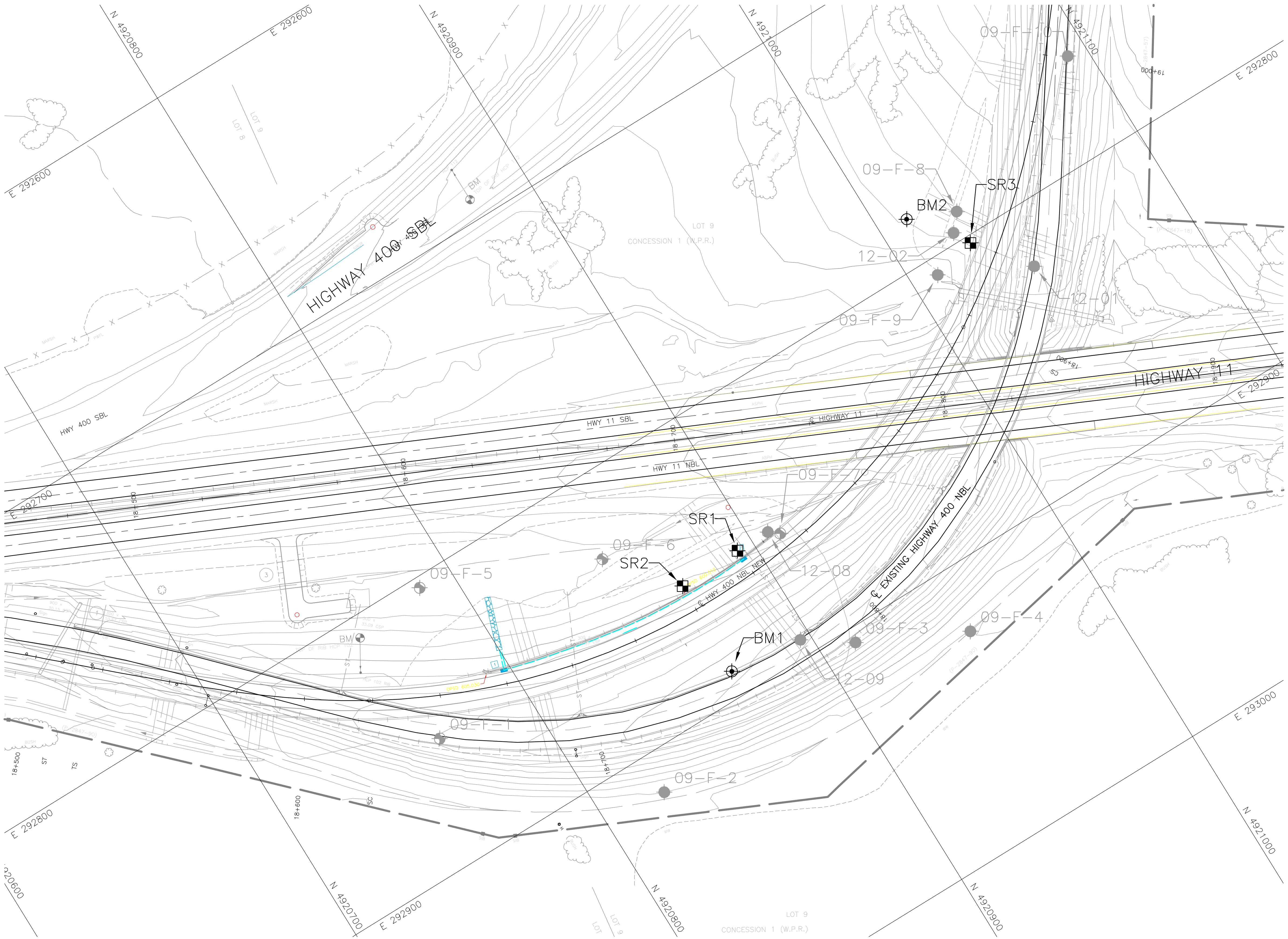
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2179–10–00

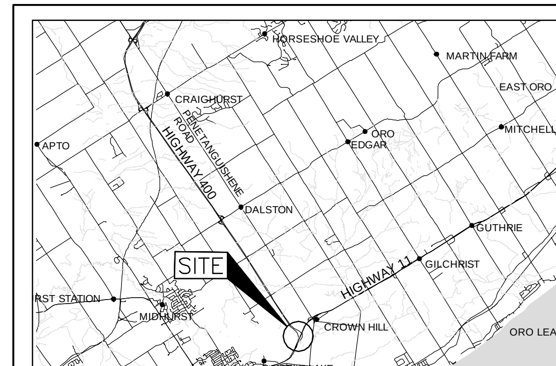
SHEET

HIGHWAY 400 NBL REHAB.
HIGH FILLS AT CROWN HILL OVERPASS
MONITORING POINTS LOCATION PLAN

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
15 0 15 30 m



KEY PLAN
SCALE
5 0 5 10 km

LEGEND

- Borehole
- Borehole and DCPT
- Benchmark (BM)
- Settlement Rod (SR)

BENCHMARK AND SETTLEMENT ROD COORDINATES

No.	NORTHING	EASTING
BM1	4920868.5	292890.4
BM2	4921010.8	292782.9
SR1	4920893.7	292853.8
SR2	4920869.7	292854.2
SR3	4921026.1	292802.7

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.

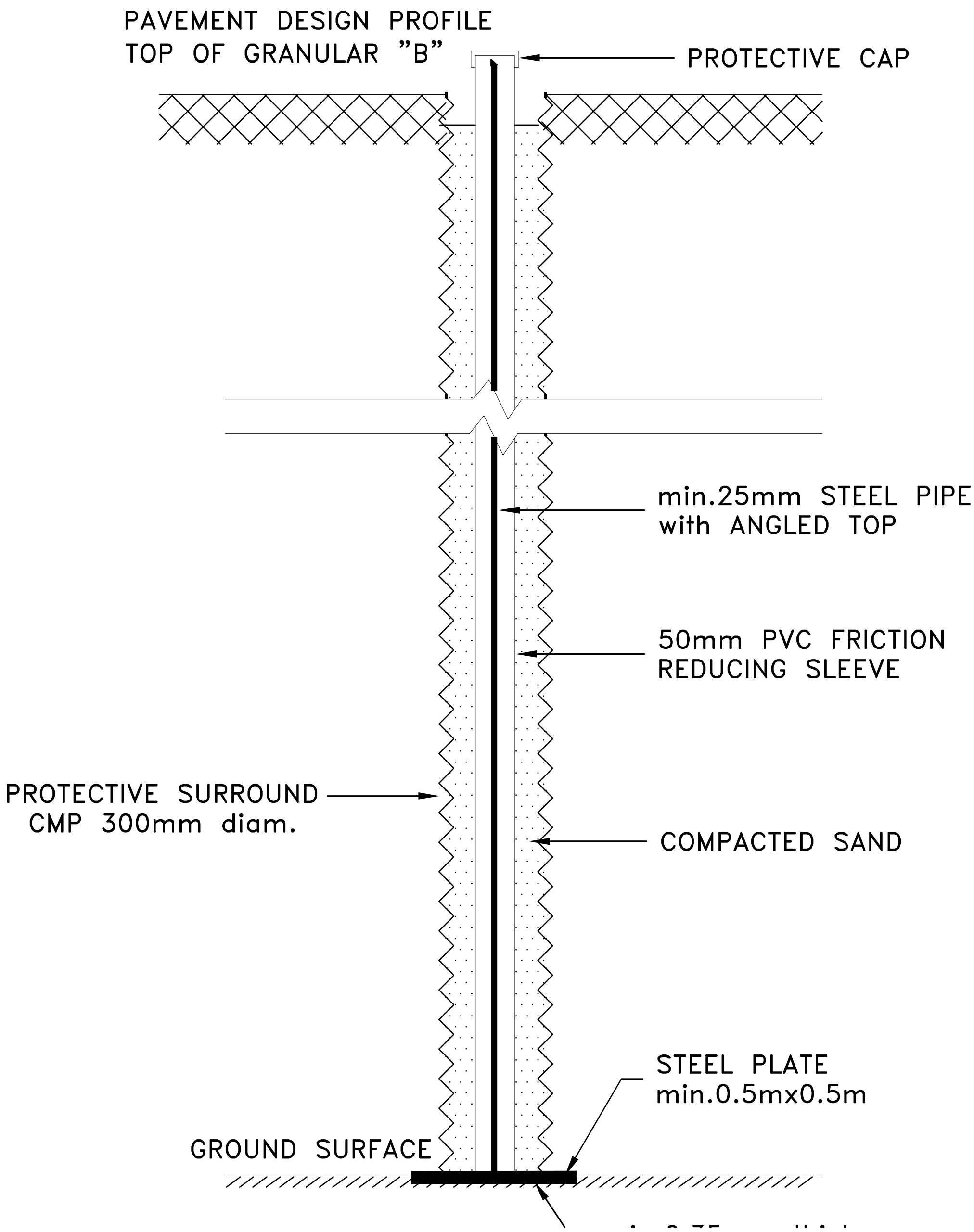
REFERENCE

Base plan provided in digital format by Morrison Hershfield (drawing file x84117Base.dwg, received January 29, 2010, and Crown Hill Option 2.dwg received May 03, 2011).

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400	PROJECT NO. 09–1111–0022		DIST. CENTRAL
SUBM'D. VA	CHKD. LCC	DATE: 7/12/2012	SITE:
DRAWN: JFC/DD	CHKD. RA	APPD. FJH	DWG. E1



NOT TO SCALE

PROJECT

HIGHWAY 400 NBL CROWN HILL INTERCHANGE
MONITORING LOCATION PLAN

TITLE

SETTLEMENT ROD DETAILS

Golder Associates
Mississauga, Ontario, Canada

PROJECT No.		09-1111-0022	FILE No. 0911110022OA0E2.dwg	
DESIGN			SCALE N.T.S.	REV.
CAD	DD	7/12/2012	DRAWING No.	
CHECK	RA	7/12/2012		
REVIEW	FJH	7/12/2012	E2	

PLOT DATE: July 12, 2012
FILENAME: T:\Projects\2009\09-1111-0022 (MH, Vespra)\-OA- (Crown Hill Embankments)\0911110022OA0E2.dwg

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