



November 28, 2014

FOUNDATION INVESTIGATION REPORT

**HIGH FILL AREAS 1 TO 6
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE (IC) AND
ASSOCIATED MUNICIPAL ROADS, CITY OF HAMILTON
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2112-05-00**

Submitted to:

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REPORT

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PART A

**FOUNDATION INVESTIGATION REPORT
HIGH FILL AREAS 1 TO 6
FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE (IC) AND ASSOCIATED
MUNICIPAL ROADS, CITY OF HAMILTON
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2112-05-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the proposed high fill embankments associated with the construction of a new interchange structure at the Highway 5 and Highway 6 intersection, which is to replace the existing Highway 5 and Highway 6 at-grade crossing. The proposed work is part of the overall assignment for the future Highway 5 and Highway 6 Interchange (IC) and associated Municipal Roads in the City of Hamilton, Ontario, which includes: high fill embankments for the Highway 5 and Highway 6 re-alignments and interchange ramps; rock cut slope assessment; culvert extensions and replacements; retaining walls; high mast lights and overhead signs.

The Terms of Reference (TOR) and the Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated January 2010, which forms part of the Consultant's Assignment Number (Number 2008-E-0038) for this project. Golder's proposal for the foundation engineering services is contained in Section 6.8 of IBI's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated September 10, 2012.

This report addresses the foundation investigation carried out for the proposed high fill embankments required for the construction of the Highway 5 over Highway 6 Interchange structure and the associated interchange ramps only. The purpose of this investigation is to establish the subsurface conditions at the high fill locations along the proposed re-aligned Highway 5 and the new ramp alignments by borehole drilling, in situ testing and laboratory testing on selected soil samples. The investigation areas are shown in plan on Drawing 1.

2.0 SITE DESCRIPTION

The proposed high fill embankments are located in the vicinity of the existing Highway 5 and Highway 6 intersection, which is located west of Waterdown and approximately 3 km north of the Highway 403/Highway 6 Interchange at Clappison's Corners in the City of Hamilton, Ontario. There are six (6) high fill areas, designated as Areas 1 through 6, which are generally located in order of increasing chainage in the direction of proposed traffic flow along the proposed Highway 5 and associated interchange ramp alignment corridors as shown on Drawing 1, following the text of this report. High Fill Areas 1 and 2 are located along the re-aligned Highway 5, immediately west and east of the proposed Highway 5/Highway 6 Interchange structure, and High Fill Areas 3 to 6 are located along the proposed interchange ramp alignments connecting Highway 5 to Highway 6 in the four interchange quadrants.

The existing Highway 5 alignment in the project area is oriented generally in a west-east direction extending through the City of Brantford to the west and the City of Mississauga to the east. The existing Highway 6 alignment is oriented generally in a north-south direction connecting with Highway 403 to the south and Highway 401 to the north of Highway 5, and was last widened in 2005. The proposed high fill embankments will allow for the existing at grade crossing to be modified to an interchange with the Highway 5 structure crossing over Highway 6 thus accommodating future traffic forecast, and involves re-alignment of Highway 5 slightly to the north and Highway 6 slightly to the east of their present locations, in the vicinity of the present crossing.

The topography across the project site consists of relatively flat terrain which slopes downward further to the south of the intersection along Highway 6 down the Niagara Escarpment. Highway 6 generally traverses the escarpment in a cut up to 15 m deep through excavated bedrock as it approaches the intersection with



Highway 5. Vegetation at the site is sparse, consisting of grass, small shrubs and isolated treed areas. Surplus material from the Queen Elizabeth Way (QEW) construction sites are stockpiled on the northwest quadrant of the intersection. Commercial facilities are present along the Highway 5 and Highway 6 corridors and residential properties are located along Highway 5 further to the west of the intersection.

The high fill sections investigated generally extend through open fields with localized sparsely treed areas, and some isolated paved former parking lots adjacent to the present crossing. The original ground surface within these areas varies between about Elevations 220.0 m and 226.3 m, referenced to Geodetic datum; a detailed description of each high fill area is presented in Sections 4.4 to 4.9.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the detail foundation investigation of the high fill embankments was carried out between November 12 and 21, 2012 during which time a total of nineteen (19) sampled boreholes (designated as Boreholes H5-1 to H5-8, WS-1, WS-2, ES-1 to ES-3, WN-1, WN-2 and EN-1 to EN-4) were advanced at the locations of the high fill areas. As some of the proposed limits of the high fill areas are within the existing Highway 5 and Highway 6 right-of-ways, the boreholes were strategically located to cover the critical sections of the high fill areas while allowing for safe operation of the drill rigs. Two (2) boreholes (designated as Boreholes BH 1 and BH 5) advanced as part of the field investigation work carried out for the Highway 5 over Highway 6 Interchange Structure¹ were utilized to supplement the high fill investigation. The method of investigation of these supplemental boreholes are detailed in the above referenced report, however, the Record of Borehole sheets and the results of the laboratory testing for these boreholes are presented together with the boreholes and laboratory test results for the high fill areas in Appendix A to Appendix F.

The details of each high fill area and the locations of the boreholes advanced at each site are shown on Drawings 2 to 7 and are presented below.

Location / High Fill Area Designation	Reference Drawing	Station Limits	Boreholes Advanced	Reference Appendix
Highway 5 / High Fill Area 1	Drawing 2	29+850 to 29+960	6 Boreholes (BH 1 and H5-1 to H5-5)	A
Highway 5 / High Fill Area 2	Drawing 3	30+040 to 30+120	4 Boreholes (BH 5 and H5-6 to H5-8)	B
Ramp W-S / High Fill Area 3	Drawing 4	10+000 to 10+140	2 Boreholes (WS-1 and WS-2)	C
Ramp E-S / High Fill Area 4	Drawing 5	10+000 to 10+100	3 Boreholes (ES-1 to ES-3)	D
Ramp W-N / High Fill Area 5	Drawing 6	10+000 to 10+100	2 Boreholes (WN-1 and WN-2)	E
Ramp E-N / High Fill Area 6	Drawing 7	10+000 to 10+210	4 Boreholes (EN-1 to EN-4)	F

¹ Golder Associates Ltd. January 2014. *Foundation Investigation and Design Report, Highway 5 Over Highway 6 Interchange Structure, Future Highway5/Highway 6 Interchange (IC) and Associated Municipal Roads, City of Hamilton, Ministry of Transportation, Ontario. GWP 2112-05-00. GEOCREs No. 30M5-289.*



The borehole investigation was carried out using a track-mounted CME 55 drill rig and a truck-mounted CME 75 drill rig, supplied and operated by DBW Drilling Ltd. of Ajax, Ontario. The boreholes were advanced through the overburden using 102 mm outside diameter (O.D.) solid stem augers or 152 mm outside diameter (O.D.) hollow stem augers. Soil samples were obtained at ground surface where practical and at intervals of depth of 0.75 m, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)².

The boreholes drilled during this current investigation and the supplemental boreholes were advanced to depths ranging from 5.0 m to 6.6 m below existing ground surface, mostly to auger and/or split-spoon refusal (i.e. inferred bedrock).

The groundwater conditions and water levels in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in each of six (6) selected boreholes to permit monitoring of the water level at the high fill sites. Each installed piezometer consists of 19 mm diameter PVC pipe, with a 1.5 m slotted screen sealed within a filter sand pack at a select depth within the borehole. The boreholes and annulus surrounding the piezometer pipe above the screen and filter sand pack were backfilled to the ground surface with bentonite pellets. Piezometer installation details and water level readings are described on the Record of Borehole sheets included in Appendices A to F, which corresponds to High Fill Areas 1 to 6. All boreholes in which standpipe piezometer are not installed were backfilled to the ground surface with bentonite upon completion in accordance with Ontario Regulation 903, Wells (as amended). The boreholes advanced through the Highway 5 and Highway 6 asphalt were sealed at the surface with cold patch asphalt, up to approximately 0.3 m thick.

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes in the field, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples in accordance with MTO and/or ASTM Standards, as applicable. The results of the laboratory testing are presented on the Record of Borehole sheets and shown on the laboratory figures contained in Appendices A to F.

The borehole locations and the ground surface elevations were staked and surveyed by Callon Dietz, a licensed surveying company retained by Golder Associates. Where the location of a borehole was moved due to site constraints, the as-drilled borehole location and ground surface elevation were surveyed by a member of our technical staff, referenced to the original borehole (survey) stake put down by Callon Dietz. The as-drilled borehole locations (positioned relative to MTM NAD 83 northing and easting coordinates) and the ground surface elevations (referenced to Geodetic datum) summarized below are provided on the individual Record of Borehole sheets and are shown on Drawings 2 to 7.

² ASTM D1586 – *Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soil.*



FOUNDATION REPORT – HIGH FILL AREAS 1 TO 6, FUTURE HIGHWAY 5/HIGHWAY 6 INTERCHANGE (IC), GWP 2112-05-00

Location / High Fill Area Designation	Borehole Number	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
Highway 5 / High Fill Area 1	BH 1	4797035.5	270882.4	222.1	6.3
	H5-1	4796932.3	270815.2	222.5	5.0
	H5-2	4796952.4	270830.2	222.4	6.6
	H5-3	4796972.2	270845.4	222.1	6.6
	H5-4	4796992.2	270859.2	221.8	5.9
	H5-5	4797014.8	270871.0	221.6	5.7
Highway 5 / High Fill Area 2	BH 5	4797082.1	270915.5	222.7	5.2
	H5-6	4797086.5	270942.5	222.1	5.2
	H5-7	4797104.7	270959.6	222.6	5.3
	H5-8	4797122.7	270976.9	223.4	5.0
Ramp W-S / High Fill Area 3	WS-1	4796977.4	270880.3	222.1	6.3
	WS-2	4796968.4	270932.5	222.5	6.3
Ramp E-S / High Fill Area 4	ES-1	4797002.5	270841.8	220.0	6.2
	ES-2	4796989.6	270816.3	222.5	6.6
	ES-3	4796990.2	270798.5	226.3	6.6
Ramp W-N / High Fill Area 5	WN-1	4797099.2	270987.0	222.7	5.3
	WN-2	4797109.9	271008.8	223.1	5.0
Ramp E-N / High Fill Area 6	EN-1	4797131.6	270948.2	222.4	5.3
	EN-2	4797125.7	270923.8	222.2	5.3
	EN-3	4797126.1	270902.9	222.1	5.3
	EN-4	4797134.5	270875.4	222.2	5.4

3.2 Stockpiled Material Investigation

Surplus material from MTO Contract 2009-2015 for the Queen Elizabeth Way construction is currently stockpiled at the northwest quadrant of the existing Highway 5 and Highway 6 intersection. As part of the Pavement Engineering Scope of Work for this assignment, a field investigation and laboratory testing program was carried out on the stockpiled material to evaluate the suitability of the material for use as earth fill for this project. The results of the pavements field investigation, including the methodology and results of the laboratory testing are contained in the Pavement Investigation and Design Report³ for this project.

³ Golder Associates Ltd. 2014. *Pavement Investigation and Design Report*, Future Highway5/Highway 6 Interchange (IC) and Associated Municipal Roads, City of Hamilton, Ministry of Transportation, Ontario. GWP 2112-05-00. (In Progress)



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The study area is located on the Niagara Escarpment⁴, a topographic break that separates the two levels of the Niagara Peninsula, which is manifested in typically harder, resistant dolostone and limestone bedrock units forming vertical cliffs along the brow of the Escarpment, over the softer shale bedrock below. The Niagara Escarpment extends from the Niagara River to the northern tip of the Bruce Peninsula and is generally flanked by landscapes of glacial origin. Capping the Niagara Escarpment is the Lockport Formation consisting of white, grey and brown dolostone of Silurian Age (Karrow, 1987)⁵ at the crest underlain by the Rochester, Irondequoit, Reynales, Thorold, Grimsby and Cabot Head Formations consisting of grey to reddish brown shaley dolostone, limestone, siltstone and sandstone (Blair and McFarland, 1992)⁶.

Overburden within the study area is comprised primarily of glacial till mapped as the Halton Till which extends as a sheet in the Hamilton area, terminating in the Waterdown Moraines east of the Niagara Escarpment between the Lake Iroquois and the Trafalgar Moraine. The Halton Till is generally considered a fine-grained diamicton with minor fine-grained lacustrine sediments incorporated within the body of the unit, likely from glacial reworking of underlying lacustrine sediments. The Halton Till also contains cobbles and boulders and in some areas, “boulder pavements” (Watt, 1955)⁷ can be encountered where boulders are nested or concentrated within the till unit.

During the retreat of the last ice sheet, lakes were formed in depressions on the land surface in which were deposited sand, gravel, silt and clay materials. The last major meltwater system along the Escarpment occurred when the Waterdown Moraines were formed. Several channels among the Waterdown Moraines functioned at various times, feeding melt waters southwest toward glacial lakes to create lacustrine and outwash sand deposits.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes, including the results of the in situ tests and the results of the laboratory tests carried out on selected soil samples are presented on the Record of Borehole sheets and the geotechnical laboratory test figures, presented in Appendices A to F for High Fill Areas 1 to 6, respectively. The results of the in situ field tests (i.e. SPT ‘N’-values) as presented on the Record of Borehole sheets and in Sections 4.4 to 4.9 are uncorrected.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the high fill embankments centerline profiles on Drawings 2 to 7 are inferred from non-continuous sampling, observations of drilling

⁴ Chapman, L. J. and Putnam, D. F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000

⁵ Karrow, P.F. 1987. *Quaternary Geology of the Hamilton-Cambridge Area, Southern Ontario*, Ontario Geological Survey, Report 255. Ministry of Northern Development and Mines, Ontario.

⁶ Blair, R. and McFarland, S. 1993. *Regional Correlation of the Middle and Lower Silurian Stratigraphy of the Niagara Escarpment Area*, Proceedings of the 1992 Conference of the Canadian National Chapter, International Association of Hydrogeologists, Hamilton, Ontario, 659-696.

⁷ Watt, A.K. 1955. *Pleistocene Geology and Groundwater Resources of the Township of North York, York County*, Ontario Department of Mines, Sixty Fourth Annual report, Volume LXIV, Part 7.



progress, the results of Standard Penetration Tests and interpretation of the subsurface conditions. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected, however, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. The orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to the project north and the stations are referenced up-chainage along the proposed Highway 5 embankment and new interchange ramp alignments. In the project area, Highway 5 is oriented essentially west-east and Highway 6 is oriented north-south.

In general, the subsurface conditions encountered at the various borehole locations at the proposed high fill areas consist of a surficial layer of asphalt or topsoil over a deposit of fill associated with the construction of Highway 5 and Highway 6 pavement structures and associated ditches, underlain by a cohesive till deposit and underlain by inferred bedrock. The stratigraphy generally consists of:

- Surficial layers of asphalt or topsoil, underlain by deposits of grey to brown non-cohesive fill comprised of sandy silt, sand and silt, silty sand, silty sand and gravel, gravelly silty sand, gravelly sand and sand and gravel, in places containing trace organics, clayey silt seams/pockets, pieces of asphalt, bricks and concrete, which forms the granular base for the pavement structure. Underlying the non-cohesive fill deposits or topsoil/asphalt layers in some areas are deposits of cohesive fill comprised of dark brown to brown (to black at one location) clayey silt, clayey silt with sand and silty clay containing trace organics, topsoil, sand seams/pockets, pieces of asphalt.
- Cohesive till deposits of brown to grey clayey silt to clayey silt with sand and silty clay generally underlie the fill deposits and are in places underlain by inferred bedrock. The cohesive till deposits typically contain silt, sandy silt, silty sand and sand layers/seams, and cobbles and boulders (in places).

A general description of the stockpiled material and the detailed descriptions of the subsurface conditions at each investigated high fill area are provided in the following sections of this report.

4.3 Stockpiled Material

Based on the result of the pavement field investigation conducted on the stockpiled material, the soil generally consists of a layer of topsoil, underlain by an upper deposit of red to brown, firm, clayey silt trace to with sand and trace gravel, then underlain by a lower deposit of dark grey, firm, clayey silt with sand and trace to some gravel. Cobbles and boulders were noted within the stockpiled material and the samples obtained from the test pits were generally moist. The detailed description of the stockpile soil and the results of laboratory tests are provided in the Pavement Investigation and Design Report³ referenced in Section 3.2.

4.4 Highway 5: STA. 29+850 to STA. 29+960 (High Fill Area 1)

The plan and profile along the centerline of the proposed high fill embankment along Highway 5 west of Highway 6 showing the borehole locations and interpreted stratigraphy are presented on Drawing 2. The Record of Boreholes BH 1 and H5-1 to H5-5, and the laboratory test results completed for this high fill area are presented in Appendix A. The proposed embankment within this section of Highway 5 is generally about 8 m high, but could be up to 9 m high in places, relative to the existing ground surface which varies from about



Elevation 222.5 m at the western limit to about Elevation 220.5 m (within the ditch) at the eastern limit of this high fill area.

In summary, the subsurface conditions at this site as encountered in Boreholes BH 1 and H5-1 to HF-5 consist of asphalt or topsoil and fill underlain by a cohesive till deposit of stiff to hard clayey silt, as described below.

4.4.1 Asphalt

An approximately 200 mm thick layer of asphalt was encountered in Borehole BH 1 drilled through the pavement of the existing Highway 6 Southbound lane (SBL) shoulder, and an approximately 100 mm thick layer of prime surface treated asphalt was encountered in Boreholes H5-1, H5-2 and H5-4 advanced through the paved driveways adjacent to the existing Highway 5 Westbound lane (WBL) shoulder.

4.4.2 Topsoil

A layer of sand and silt topsoil about 0.7 m thick was encountered at the existing ground surface in Borehole H5-5 drilled near the ditch line of existing Highway 5. A Standard Penetration Test (SPT) “N”-value measured within the topsoil layer is 11 blows per 0.3 m of penetration, indicating a compact relative density.

4.4.3 Fill

A 0.7 m to 4.3 m thick deposit of fill associated with the construction of the highway and the adjacent ditches was encountered underlying either the asphalt/topsoil or at the ground surface in all the boreholes. The surface of the fill deposit ranges from about Elevations 222.4 m to 220.9 m. The upper layer of the fill as encountered in Boreholes BH 1, H5-1, H5-3 and H5-4 is generally non-cohesive, comprising of gravelly silty sand to gravelly sand some silt to sand and gravel trace silt; containing trace clay, trace organics and clayey silt pockets/seams. Underlying the non-cohesive fill and topsoil in all boreholes except Borehole H5-4 is a cohesive fill comprised of clayey silt trace sand to sandy, to clayey silt with sand; containing trace gravel to gravelly, trace organics, topsoil and pieces of asphalt.

The SPT “N”-values measured within the non-cohesive fill range from 4 blows to 29 blows per 0.3 m of penetration, indicating a loose to compact relative density. The SPT “N”-values recorded within the cohesive fill range from 6 blows to 56 blows per 0.3 m of penetration but typically less than 14 blows per 0.3 m of penetration, suggesting that the clayey silt to clayey silt with sand fill has a firm to hard (but typically firm to stiff) consistency.

The grain size distribution tests completed on three (3) samples of the gravelly silty sand to gravelly sand to sand and gravel fill, and on one (1) sample of the clayey silt fill are presented on Figure A1 and Figure A2, respectively, in Appendix A. Atterberg limits tests were carried out on two (2) samples of the cohesive fill and measured liquid limits of about 32 per cent and 34 per cent, plastic limits of about 16 per cent, and corresponding plasticity indices of about 16 per cent and 18 per cent. The results of the Atterberg limits tests are shown on a plasticity chart on Figure A3 in Appendix A and indicate that the cohesive fill consists of clayey silt of low plasticity. The natural moisture content measured on four (4) samples of the non-cohesive fill ranges from about 2 per cent to 9 per cent and the natural water content recorded on one (1) sample of the cohesive fill is about 15 per cent.



4.4.4 Clayey Silt Till

A cohesive till deposit comprised of predominantly clayey silt, sandy to some sand and trace gravel was encountered underlying the fill in all the boreholes. The deposit generally contains silt to sand seams and in Borehole H5-2, a localized layer of silty clay till was encountered overlying the clayey silt till deposit. The top of the till deposit ranges from about Elevations 221.4 m to 217.4 m and the thickness of the till deposit ranges from about 1.5 m to 5.9 m across the boreholes. Boreholes H5-1 and H5-2 were terminated within the cohesive till deposit whereas Boreholes BH 1 and H5-3 to H5-5 were terminated on refusal to further auger and/or split-spoon advancement.

The SPT “N”-values measured within the cohesive till range from 10 blows to 46 blows per 0.3 m of penetration, suggesting that the clayey silt to silty clay till has a stiff to hard consistency. SPT “N”-values of 12 blows per 0.05 m of penetration, 25 blows per 0.08 m of penetration and 20 blows per 0.1 m of penetration were recorded prior to termination of Boreholes BH 1, H5-3 and H5-5.

Grain size distribution tests were carried out on ten (10) samples of the clayey silt till deposit and the results are shown on Figures A4A and A4B in Appendix A. The result of grain size distribution test completed on one (1) sample of the silty clay till is presented on Figure A5. Atterberg limits tests were carried out on twelve (12) selected samples of the cohesive till deposit and measured liquid limits ranging from about 20 per cent to 36 per cent, plastic limits ranging from about 13 per cent to 19 per cent, and plasticity indices ranging from about 7 per cent to 18 per cent. These test results, which are plotted on a plasticity chart on Figure A6 in Appendix A, indicate that the cohesive till deposit consists of clayey silt of low plasticity to silty clay of intermediate plasticity. The natural moisture content measured on twenty one (21) selected samples of the till deposit ranges from about 11 per cent to 22 per cent.

4.4.5 Refusal

In Boreholes BH 1, H5-3 to H5-5, the bedrock surface is inferred by refusal to further split-spoon penetration and/or auger advancement at depths ranging from about 5.7 m to 6.6 m below ground surface, corresponding to between about Elevations 215.9 m and 215.5 m.

4.4.6 Groundwater Conditions

In general, the samples obtained from the boreholes were moist to wet. All open boreholes were observed to be dry upon completion of drilling operations except Borehole H5-2. A standpipe piezometer was installed in each of Boreholes H5-2 and H5-5 to permit monitoring of the groundwater level at this high fill site. Details of the piezometer installation and measured groundwater levels are shown on the Record of Borehole sheets in Appendix A. The groundwater levels measured in the open borehole and in the piezometers on February 13, 2013 are summarized below.



Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
H5-2	222.4	5.7	216.7	November 12, 2012	Open Borehole Piezometer
		3.7	218.7	February 13, 2013	
H5-5	221.6	1.7	219.9	February 13, 2013	Piezometer

The groundwater levels at this site are subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during any period of heavy precipitation.

4.5 Highway 5: STA. 30+040 to STA. 30+120 (High Fill Area 2)

The plan and profile along the centerline of the proposed high fill embankment along Highway 5 east of Highway 6 showing the borehole locations and interpreted stratigraphy are shown on Drawing 3. The Record of Boreholes BH 5 and H5-6 to H5-8, and the laboratory test results completed for this high fill area are presented in Appendix B. The proposed embankment within this section of Highway 5 is up to about 8 m high relative to the existing ground surface which varies from about Elevation 221.7 m at the western limit to about Elevation 223.4 m at the eastern limit of the high fill area.

The subsoils at this site, as encountered in Boreholes BH 5 and H5-6 to H5-8, consist of asphalt or topsoil and fill underlain by a cohesive till deposit of generally stiff to hard clayey silt, in places containing cobbles and silty sand seams as described below.

4.5.1 Asphalt

An approximately 100 mm thick layer of prime surface treated asphalt was encountered in Boreholes H5-6 to H5-8 advanced through the paved shoulders along the north side of Highway 5.

4.5.2 Topsoil

A 100 mm thick layer of topsoil was encountered in Borehole BH 5 advanced within the open field at the north-east corner of the existing Highway 5/Highway 6 intersection.

4.5.3 Fill

A fill deposit approximately 1.3 m thick was encountered underlying the asphalt or topsoil layers in all boreholes between about Elevations 223.3 m and 221.6 m. The fill material is variable in composition, comprising a layer of non-cohesive grey to brown silty sand, trace clay, trace gravel and trace organics, to silty sand and gravel, to sand and gravel trace to some silt, containing pieces of concrete. The non-cohesive fill is underlain by a deposit of cohesive fill comprised of clayey silt, some sand and trace to some gravel, to clayey silt with sand and some gravel. The fill encountered in Boreholes BH 5 and H5-8 contains trace organics.



The SPT “N”-values measured within the non-cohesive fill range from 11 blows to 42 blows per 0.3 m of penetration, indicating a compact to dense relative density. The SPT “N”-values recorded within the cohesive fill range from 8 blows to 18 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

A grain size distribution test was carried out on one (1) sample of the clayey silt with sand fill and the result is presented on Figure B1 in Appendix B. An Atterberg limits test was conducted on a sample of the cohesive fill and measured a liquid limit of about 29 per cent, a plastic limit of about 14 per cent and a corresponding plasticity index of about 15 per cent. The result of the Atterberg limits test is shown on a plasticity chart on Figure B2 in Appendix B, and indicates that this material is clayey silt of low plasticity. The natural water content measured on two (2) samples of the non-cohesive fill is about 2 per cent and 5 per cent; the natural water content measured on three (3) samples of the cohesive fill ranges between about 13 per cent and 19 per cent.

4.5.4 Clayey Silt Till

A cohesive till deposit was encountered underlying the fill deposit in all the boreholes. The surface of the till deposit varies between about Elevations 222.0 m and 220.3 m and the thickness of the deposit is between about 3.6 m and 3.9 m. The cohesive till deposit is predominantly comprised of clayey silt, some sand, and trace to some gravel; the lower portion of the till deposit (below Elevation 218 m) is generally coarser comprised of clayey silt, sandy to with sand and silty sand seams. Cobbles were present within the lower portion of the deposit in Borehole BH 5. Borehole H5-8 was terminated within the till deposit.

The SPT “N”-values measured within the cohesive till deposit range from 11 blows to 57 blows per 0.3 m of penetration (but typically greater than 20 blows per 0.3 m of penetration), suggesting a stiff to hard (but typically very stiff to hard) consistency.

The results of grain size distribution tests completed on seven (7) samples of the clayey silt till deposit are presented together on Figure B3 in Appendix B. Atterberg limits tests were carried out on seven (7) selected samples of the cohesive till deposit and measured liquid limits ranging from about 22 per cent to 32 per cent, plastic limits ranging from about 13 per cent to 16 per cent and plasticity indices ranging from about 9 per cent to 15 per cent. These test results, which are plotted on a plasticity chart on Figure B4 in Appendix B, indicate that the cohesive till deposit consists of clayey silt of low plasticity. The natural moisture content measured on eleven (11) selected samples of the cohesive till deposit ranges from about 11 per cent to 42 per cent.

4.5.5 Refusal

In Boreholes BH 5, H5-6 and H5-7, the bedrock surface is inferred by refusal to further auger advancement at depths between about 5.2 m and 5.3 m below ground surface, corresponding to between about Elevations 217.3 m and 216.5 m.

4.5.6 Groundwater Conditions

In general, the samples taken in the boreholes were dry to wet. The groundwater levels in the open boreholes were measured upon completion of drilling operations and a standpipe piezometer was installed in each of Borehole H5-6 and H5-8 to permit monitoring of the groundwater level at this site. Details of the piezometer installation and the measured groundwater levels are shown on the Record of Borehole sheets in Appendix B.



The groundwater levels recorded in the open boreholes and in the piezometers on February 13, 2013 are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
BH 5	221.7	4.9	216.8	November 15, 2012	Open Borehole
H5-6	222.1	3.8 1.8	218.3 220.3	November 15, 2012 February 13, 2013	Open Borehole Piezometer
H5-7	222.6	5.0	217.6	November 15, 2012	Open Borehole
H5-8	223.4	4.8 2.1	218.6 221.3	November 14, 2012 February 13, 2013	Open Borehole Piezometer

The groundwater levels are subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during any period of heavy precipitation.

4.6 Ramp W-S: STA. 10+000 to STA. 10+140 (High Fill Area 3)

The plan and profile along the centerline of the proposed interchange Ramp W-S embankment showing the borehole locations and interpreted stratigraphy are shown on Drawing 4. The Record of Boreholes WS-1 and WS-2, and the laboratory test results completed for this new high fill area are presented in Appendix C. The new interchange Ramp W-S is proposed to connect Highway 5 Eastbound lanes (EBL) to Highway 6 Southbound lanes (SBL) from STA. 10+000 to STA. 10+140, and is between about 4.5 m and 6.5 m high to about STA. 10+070. The existing ground surface along the proposed high fill embankment within the investigated portion of Ramp W-S varies from about Elevation 222.1 m at the western limit to about Elevation 222.5 m at the southern limit of the investigated area.

The subsurface soils encountered along the proposed interchange ramp consist of asphalt and fill underlain by a cohesive till deposit comprised of stiff to hard clayey silt, as described below.

4.6.1 Asphalt

An approximately 200 mm thick layer of asphalt was encountered in Boreholes WS-1 and WS-2 drilled through the pavement, at the existing Highway 5 and Highway 6 intersection.

4.6.2 Fill

An approximately 1.9 m and 1.2 m thick deposit of fill was encountered below the asphalt at about Elevations 221.9 m and 222.3 m in Boreholes WS-1 and WS-2, respectively. The fill encountered in the boreholes is comprised of an upper layer of non-cohesive sand and gravel to sandy silt, trace gravel and trace clay containing clayey silt seams, underlain by cohesive fill comprised of clayey silt, sandy to trace sand, some gravel containing sand seams.



A SPT “N”-value of 12 blows per 0.3 m of penetration was recorded within the sandy silt portion of the fill, indicating a compact relative density. The measured SPT “N” values within the clayey silt fill are 6 blows and 9 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

The result of a grain size distribution test carried out on one (1) sample of the clayey silt fill is presented on Figure C1 in Appendix C. An Atterberg limits test was carried out on one (1) sample of the cohesive fill and measured a liquid limit of about 26 per cent, a plastic limit of about 13 per cent and a corresponding plasticity index of about 13 percent indicating that the fill is comprised of clayey silt of low plasticity. The measured moisture content on one (1) sample of the clayey silt fill is about 13 per cent.

4.6.3 Clayey Silt Till

A cohesive till deposit was encountered underlying the fill in Boreholes WS-1 and WS-2. The top of this cohesive till deposit was encountered at about Elevations 220.0 m and 221.1 m and the thickness of the deposit is about 4.2 m and 4.9 m in the respective boreholes. The cohesive till deposit is generally comprised of clayey silt some sand to sandy, trace to some gravel containing sand seams in places. In Borehole WS-2, the lower portion of the till deposit grades to a clayey silt with sand.

The SPT “N”-values recorded within the cohesive till deposit range from 11 blows to 33 blows per 0.3 m of penetration, suggesting that the till deposit has a stiff to hard consistency. A SPT “N” value of 7 blows per 0.03 m of penetration and 5 blows per 0.08 m of penetration was recorded prior to termination of Boreholes WS-1 and WS-2, respectively.

Grain size distribution tests were carried out on three (3) selected samples of the clayey silt till and the results are presented on Figure C3 in Appendix C. Atterberg limits tests were performed on four (4) samples of the cohesive till and measured liquid limits between about 22 per cent and 32 per cent, plastic limits between about 12 per cent and 17 per cent, and the plasticity indices between about 10 per cent and 14 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C4 in Appendix C and indicate this till deposit to consist of clayey silt of low plasticity. The measured water content on seven (7) selected samples of this till deposit ranges between about 12 per cent and 15 per cent.

4.6.4 Refusal

In Boreholes WS-1 and WS-2, the bedrock surface is inferred by refusal to further split-spoon penetration and auger advancement at a depth of about 6.3 m below ground surface, corresponding to about Elevations 215.8 m and 216.2 m at the respective boreholes.

4.6.5 Groundwater Conditions

The samples taken in the boreholes were generally moist to wet. Boreholes WS-1 and WS-2 were observed to be dry upon completion of drilling operations.

The groundwater levels at this site are subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during any period of heavy precipitation.



4.7 Ramp E-S: STA. 10+000 to STA. 10+100 (High Fill Area 4)

The plan and profile along the centerline of the proposed interchange Ramp E-S embankment showing the borehole locations and interpreted stratigraphy are shown on Drawing 5. The Record of Boreholes ES-1 to ES-3, and the laboratory test results completed for this new high fill area are presented in Appendix D. The new interchange Ramp E-S is proposed to connect Highway 5 Westbound lanes (WBL) to Highway 6 Southbound lanes (SBL) from STA. 10+000 to STA. 10+100, and is generally between 4.5 m and 8.5 m high to about STA. 10+050, but could be up to about 9 m in places. The existing ground surface along the proposed high fill embankment within the investigated portion of Ramp E-S varies from about Elevation 220.0 m near the eastern limit to about Elevation 226.3 m at the southern limit of the investigated area.

The subsurface soils encountered along the proposed interchange ramp consist of asphalt and fill underlain by a cohesive till deposit comprised of brown to grey stiff to hard clayey silt till, as described below.

4.7.1 Asphalt

An approximately 100 mm thick layer of prime surface treated asphalt was encountered in Borehole ES-1 and ES-2 advanced through the paved driveway adjacent to the Highway 5/Highway 6 intersection.

4.7.2 Fill

A fill deposit associated with the construction of the paved driveway adjacent to the Highway 5/Highway 6 intersection was encountered below the asphalt in Boreholes ES-1 and ES-2, and from ground surface in Borehole ES-3 associated with the stockpile soil located north-west of the intersection. The surface of the fill deposit varies between about Elevations 226.3 m and 219.9 m, and the thickness of the fill varies between about 1.3 m and 3.7 m. The upper portion of the fill underlying the asphalt is non-cohesive and comprised of sand and silt, some clay and some gravel containing sand pockets, to sand and gravel, some silt and trace clay. The lower portion of the fill under the asphalt and an upper layer of stockpiled material is generally cohesive, comprised of clayey silt to silty clay, trace to some sand, trace gravel, trace organics and containing wood pieces in places.

The SPT “N”-values measured within the non-cohesive fill range from 7 blows to 23 blows per 0.3 m of penetration, indicating a loose to compact relative density. The SPT “N”-values recorded within the cohesive fill range from 9 blows to 15 blows per 0.3 m of penetration, suggesting a stiff consistency.

A grain size distribution test was carried out on one (1) sample of the sand and gravel fill and one (1) sample of the sand and silt fill, and the results are presented on Figures D1A and D1B in Appendix D. An Atterberg limits test was conducted on one (1) sample of the sand and silt fill and measured a liquid limit of about 16 per cent, a plastic limit of about 13 per cent and a corresponding plasticity index of about 3 per cent. The result of the Atterberg limits test is shown on a plasticity chart on Figure D2 in Appendix D, indicating the fines material to be silt of slight plasticity. The natural water content measured on two (2) samples of the non-cohesive fill is about 3 per cent and 11 per cent. For the cohesive fill, the grain size distribution of one (1) sample of the silty clay is presented on Figure D3 in Appendix D and the result of an Atterberg limits test completed on this sample is presented on Figure D4 in Appendix D. The Atterberg limits test yielded a liquid limit of about 36 per cent, a plastic limit of about 19 per cent and a corresponding plasticity index of about 17 per cent, indicating that a



component of the cohesive fill consists of silty clay of intermediate plasticity. The natural water content measured on two (2) samples of the cohesive fill is about 14 per cent and 20 per cent.

4.7.3 Clayey Silt Till

A cohesive till deposit comprised of brown to grey clayey silt, sandy to some sand and trace to some gravel was encountered underlying the fill deposit in all the boreholes. Boulders were also inferred (from auger grinding and split-spoon sampling) to be present within this deposit in Borehole ES-2. The surface of the cohesive till deposit was encountered at depths ranging from about 1.4 m to 3.7 m below ground surface (Elevations 218.6 m to 222.6 m, respectively) and the thickness of the cohesive till ranges from about 2.9 m to 4.8 m. Boreholes ES-2 and ES-3 were terminated within the till deposit.

The SPT “N”-values recorded within the cohesive till deposit range from 14 blows to 39 blows per 0.3 m of penetration, suggesting that the clayey silt till has a stiff to hard consistency. A SPT “N”-value of 30 blows per 0.03 m of penetration was recorded upon refusal to further split-spoon and auger advancement in Borehole ES-1.

Grain size distribution tests were carried out on six (6) selected samples of the cohesive till deposit and the results are provided on Figure D5 in Appendix D. Atterberg limits tests were performed on six (6) samples of the cohesive till and measured liquid limits ranging from about 26 per cent to 31 per cent, plastic limits ranging from about 14 per cent to 19 per cent and plasticity indices ranging from about 12 per cent to 14 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure D6 in Appendix D and indicate the till deposit to consist of clayey silt of low plasticity. The natural water content on eleven (11) selected samples of the cohesive till deposit ranges from about 12 per cent to 22 per cent.

4.7.4 Refusal

In Boreholes ES-1, the bedrock surface is inferred by refusal to further split-spoon penetration and auger advancement at a depth of about 6.2 m below ground surface, corresponding to Elevation 213.8 m.

4.7.5 Groundwater Conditions

The samples taken in the boreholes were generally moist to wet. The groundwater levels in the open boreholes were measured upon completion of drilling operations and Boreholes ES-1 and ES-3 were noted to be dry. A standpipe piezometer was installed in Borehole ES-3 to permit monitoring of the groundwater level at this site. Details of the piezometer installation and the measured groundwater levels are shown on the Record of Borehole sheets in Appendix D. The groundwater levels recorded in the open boreholes and in the piezometer on February 13, 2013 are summarized below.



Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
ES-2	222.5	5.9	216.6	November 13, 2012	Open Borehole
ES-3	226.3	3.5	222.8	February 13, 2013	Piezometer

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

4.8 Ramp W-N: STA. 10+000 to STA. 10+100 (High Fill Area 5)

The plan and profile along the centerline of the proposed interchange Ramp W-N showing the borehole locations and interpreted stratigraphy are shown on Drawing 6. The Record of Boreholes WN-1 and WN-2, and the laboratory test results completed for this new high fill area are presented in Appendix E. The new interchange Ramp W-N is proposed to connect Highway 5 Eastbound lanes (EBL) to Highway 6 Northbound lanes (NBL) from STA. 10+000 to STA. 10+100, and is between about 4.5 m and 5 m high to about STA. 10+025. The existing ground surface along the proposed high fill embankment within the investigated portion of Ramp W-N varies between about Elevation 222.7 m at the western limit to about Elevation 223.1 m at the northern limit of the investigated area.

The subsurface conditions encountered along the proposed high fill embankment consist of asphalt and fill associated with the construction of the existing Highway 5, underlain by a cohesive till deposit of stiff to hard clayey silt, as described below.

4.8.1 Asphalt

An approximately 200 mm to 300 mm thick layer of asphalt, part of the Highway 5 pavement structure was encountered in the two boreholes.

4.8.2 Fill

A 0.5 m and a 0.6 m thick layer of fill comprised of sand and gravel trace silt was encountered below the asphalt in both boreholes. The top of the fill was encountered at about Elevation 222.5 m and 222.8 m in Boreholes WN-1 and WN-2, respectively.

4.8.3 Clayey Silt Till

A cohesive till deposit was encountered underlying the fill in both boreholes. The till deposit is comprised of clayey silt, some sand, trace gravel and grades to clayey silt, sandy to with sand, some gravel below about Elevation 219.0 m. The surface of the cohesive till deposit is at about Elevations 221.9 m and 222.3 m, and the thickness of the deposit is about 4.5 m and 4.2 m in Boreholes WN-1 and WN-2, respectively. Borehole WN-2 was terminated within this deposit.



The SPT “N”-values measured within the cohesive till deposit range from 11 blows to 44 blows per 0.3 m of penetration, suggesting that the till deposit has a stiff to hard consistency.

The results of grain size distribution tests carried out on four (4) samples of the clayey silt till are presented on Figure E1 in Appendix E. Atterberg limits tests were carried out on four (4) samples of this till deposit and measured liquid limits ranging from about 24 per cent to 32 per cent, plastic limits ranging from about 13 per cent to 16 per cent and plasticity indices ranging from about 12 per cent to 17 per cent. The results of the Atterberg limits tests are shown on a plasticity chart on Figure E2 in Appendix E, and indicate that the till deposit consists of clayey silt of low plasticity. The natural water content measured on six (6) samples of this till deposit ranges from about 12 per cent to 15 per cent.

4.8.4 Refusal

The bedrock surface is inferred by refusal to further auger advancement in Borehole WN-1 at a depth of about 5.3 m below ground surface, corresponding to about Elevation 217.4 m.

4.8.5 Groundwater Conditions

The samples taken in the boreholes were moist. The groundwater levels in the open boreholes were measured upon completion of drilling operations and the details are provided on the Record of Borehole sheets in Appendix E, and are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
WN-1	222.7	4.4	218.3	November 20, 2012	Open Borehole
WN-2	223.1	4.4	218.7	November 20, 2012	Open Borehole

The groundwater levels at this site are subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during any period of heavy precipitation.

4.9 Ramp E-N: STA. 10+000 to STA. 10+210 (High Fill Area 6)

The plan and profile along the centerline of the proposed interchange Ramp E-N embankment showing the borehole locations and interpreted stratigraphy are shown on Drawing 7. The Record of Boreholes EN-1 to EN-4 and the laboratory test results completed for this high fill area are presented in Appendix F. The new interchange Ramp E-N is proposed to connect the Highway 5 Westbound lanes (WBL) to the Highway 6 Northbound lanes (NBL) from STA. 10+000 to STA. 10+210, and is between about 4.5 m and 6.5 m high to about STA. 10+080. The existing ground surface along the proposed high fill embankment within the investigated portion of Ramp E-N varies from about Elevation 222.4 m near the eastern limit to about Elevation 222.1 m near the northern limit of the investigated area.



The subsurface conditions encountered along the proposed ramp alignment consist of a surficial layer of topsoil and fill underlain by a cohesive till deposit comprised of very stiff to hard clayey silt to clayey silt with sand, as described below.

4.9.1 Topsoil

A 200 mm to 300 mm thick layer of topsoil was encountered at the ground surface in all the boreholes.

4.9.2 Fill

An approximately 1.1 m to 1.9 m thick deposit of fill was encountered below the topsoil in all the boreholes and the surface of the fill deposit varies between about Elevations 222.1 m and 221.9 m. The fill deposit is generally cohesive, comprised of brown to dark brown clayey silt trace to some sand to clayey silt with sand, containing trace gravel, trace organics, sand pockets pieces of asphalt and topsoil. The upper 0.5 m of the fill in Borehole EN-3 consists of dark brown to brown sandy silt, trace clay, trace organics and contain pieces of brick.

The SPT “N”-values measured within the cohesive fill range from 5 blows to 12 blows per 0.3 m of penetration, suggesting a firm to stiff consistency. A SPT “N”-value of 9 blows per 0.3 m of penetration was recorded within the layer of sandy silt fill, indicating a loose relative density.

The grain size distribution test completed on two (2) samples of the clayey silt to clayey silt with sand fill are presented on Figure F1 in Appendix F. Atterberg limits tests were also performed on two (2) selected samples of the cohesive fill and measured liquid limits of about 30 per cent and 33 per cent, plastic limits of about 17 per cent and corresponding plasticity indices of about 13 per cent and 16 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure F2 in Appendix F, and indicate that the cohesive fill is a clayey silt of low plasticity. The natural water content measured on two (2) samples of the cohesive fill is about 14 per cent and 25 per cent.

4.9.3 Clayey Silt to Clayey Silt with Sand Till

A deposit of cohesive till comprised of clayey silt, with sand to trace sand trace to some gravel, sand seams and sand layers (in places) was encountered underlying the fill deposit in all the boreholes. The surface of the cohesive till deposit was encountered between about Elevations 221.0 m and 220.0 m, and the thickness of the till deposit varies between about 3.2 m and 3.9 m.

The SPT “N”-values recorded within the cohesive till deposit range from 16 blows to 48 blows per 0.3 m of penetration, suggesting that the cohesive till has a very stiff to hard consistency. A SPT “N”-value of 10 blows per 0.08 m of penetration was recorded upon refusal in Borehole EN-3.

The results of the grain size distribution tests completed on six (6) selected samples of the clayey silt to clayey silt with sand till are provided on Figure F3 in Appendix F. Atterberg limits tests were carried out on six (6) samples of the cohesive till deposit and measured liquid limits ranging from about 23 per cent to 32 per cent, plastic limits ranging from about 14 per cent to 17 per cent, and corresponding plasticity indices ranging from about 9 per cent to 16 percent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure F4 in Appendix F and indicate that the cohesive till deposit consist of clayey silt of low plasticity. The



natural water content measured on fourteen (14) samples of the cohesive till deposit ranges from about 13 per cent to 20 per cent.

4.9.4 Refusal

In the four boreholes, the bedrock surface is inferred by refusal to further split-spoon penetration and/or auger advancement at depths between about 5.3 m and 5.4 m below ground surface (between about Elevations 217.1 m and 216.8 m).

4.9.5 Groundwater Conditions

The samples taken in the boreholes were generally moist to wet. The groundwater levels in the open boreholes were measured upon completion of drilling operations and open Borehole EN-4 was dry. A standpipe piezometer was installed in Borehole EN-4 to permit monitoring of the groundwater level at this site. Details of the piezometer installation and measured groundwater levels are shown on the Record of Borehole sheets in Appendix F. The groundwater levels recorded in the open boreholes and in the piezometer on February 13, 2013 are summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
EN-1	222.4	4.7	217.7	November 14, 2012	Open Borehole
EN-2	222.2	4.8	217.4	November 14, 2012	Open Borehole
EN-3	222.1	4.1	218.0	November 19, 2012	Open Borehole
EN-4	222.2	2.4	219.8	February 13, 2013	Piezometer

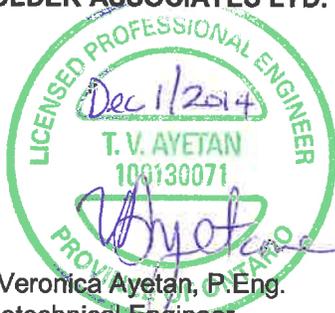
The groundwater levels at this site are subject to seasonal fluctuations and precipitation events and should be expected to be higher during the spring season or during any period of heavy precipitation.



5.0 CLOSURE

Mr. John Hagan, P.Eng., a pavement/geotechnical engineer with Golder supervised the field drilling program. This report was prepared by Ms. T. Veronica Ayetan, P.Eng., a geotechnical engineer with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted a technical review and quality control review of the report.

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LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° 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 cm² 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.

V. MINOR SOIL CONSTITUENTS

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	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

	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.



LIST OF SYMBOLS

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

I.	GENERAL	(a)	Index Properties (continued)
π	3.1416	w	water content
$\ln x$,	natural logarithm of x	w_l or LL	liquid limit
\log_{10}	x or log x, logarithm of x to base 10	w_p or PL	plastic limit
g	acceleration due to gravity	I_p or PI	plasticity index = $(w_l - w_p)$
t	time	w_s	shrinkage limit
FoS	factor of safety	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)
II.	STRESS AND STRAIN	(b)	Hydraulic Properties
γ	shear strain	h	hydraulic head or potential
Δ	change in, e.g. in stress: $\Delta \sigma$	q	rate of flow
ε	linear strain	v	velocity of flow
ε_v	volumetric strain	i	hydraulic gradient
η	coefficient of viscosity	k	hydraulic conductivity (coefficient of permeability)
ν	Poisson's ratio	j	seepage force per unit volume
σ	total stress	(c)	Consolidation (one-dimensional)
σ'	effective stress ($\sigma' = \sigma - u$)	C_c	compression index (normally consolidated range)
σ'_{vo}	initial effective overburden stress	C_r	recompression index (over-consolidated range)
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)	C_s	swelling index
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$	C_α	secondary compression index
τ	shear stress	m_v	coefficient of volume change
u	porewater pressure	C_v	coefficient of consolidation (vertical direction)
E	modulus of deformation	C_h	coefficient of consolidation (horizontal direction)
G	shear modulus of deformation	T_v	time factor (vertical direction)
K	bulk modulus of compressibility	U	degree of consolidation
		σ'_p	pre-consolidation stress
		OCR	over-consolidation ratio = σ'_p / σ'_{vo}
III.	SOIL PROPERTIES	(d)	Shear Strength
(a)	Index Properties	τ_p, τ_r	peak and residual shear strength
$\rho(\gamma)$	bulk density (bulk unit weight)*	ϕ'	effective angle of internal friction
$\rho_d(\gamma_d)$	dry density (dry unit weight)	δ	angle of interface friction
$\rho_w(\gamma_w)$	density (unit weight) of water	μ	coefficient of friction = $\tan \delta$
$\rho_s(\gamma_s)$	density (unit weight) of solid particles	c'	effective cohesion
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)	C_u, S_u	undrained shear strength ($\phi = 0$ analysis)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)	p	mean total stress $(\sigma_1 + \sigma_3)/2$
e	void ratio	p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
n	porosity	q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
S	degree of saturation	q_u	compressive strength $(\sigma_1 - \sigma_3)$
		S_t	sensitivity

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

Notes: 1
2

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



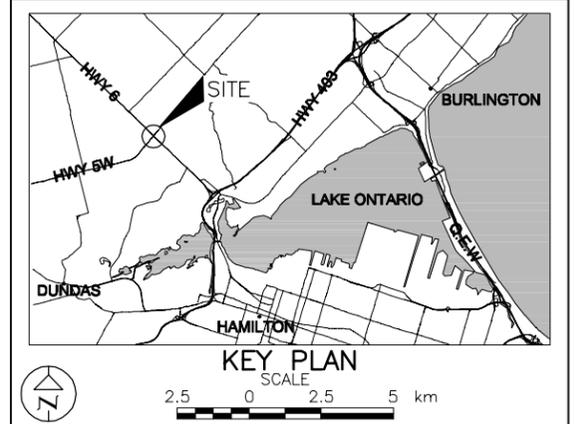
DRAWINGS

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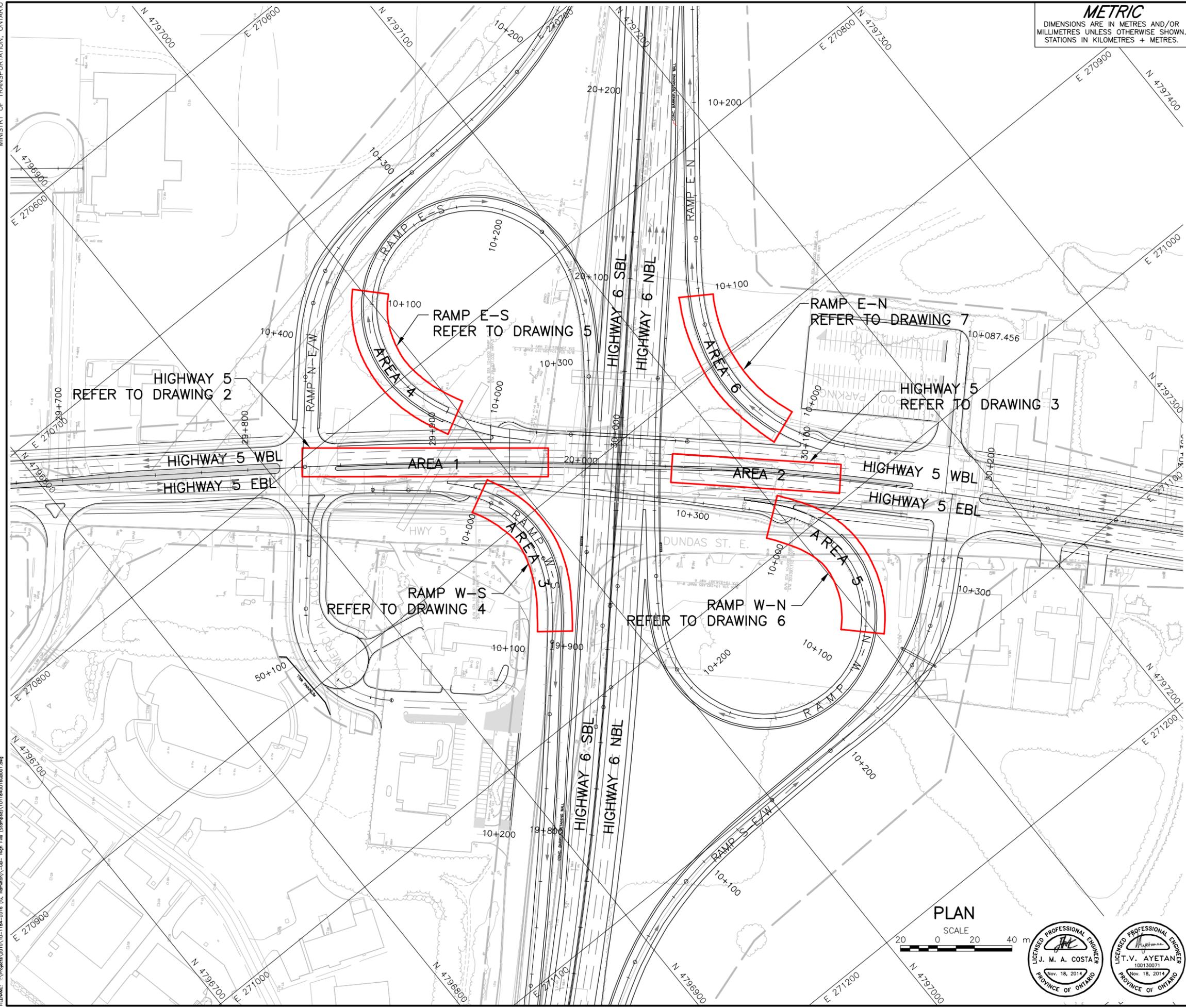
CONT No. GWP No. 2112-05-00
 HIGHWAY 5/HIGHWAY 6 INTERCHANGE
 HIGH FILL AREAS 1 TO 6
 INDEX PLAN



Golder Associates Ltd.
 MISSISSAUGA, ONTARIO, CANADA



LEGEND



PLAN
 SCALE 1:200
 0 20 40 m



NOTES
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REFERENCE
 Base plans provided in digital format by IBI, drawing file no. T5&6-MNC-Slanc-New STA.dwg, received June 24, 2013.

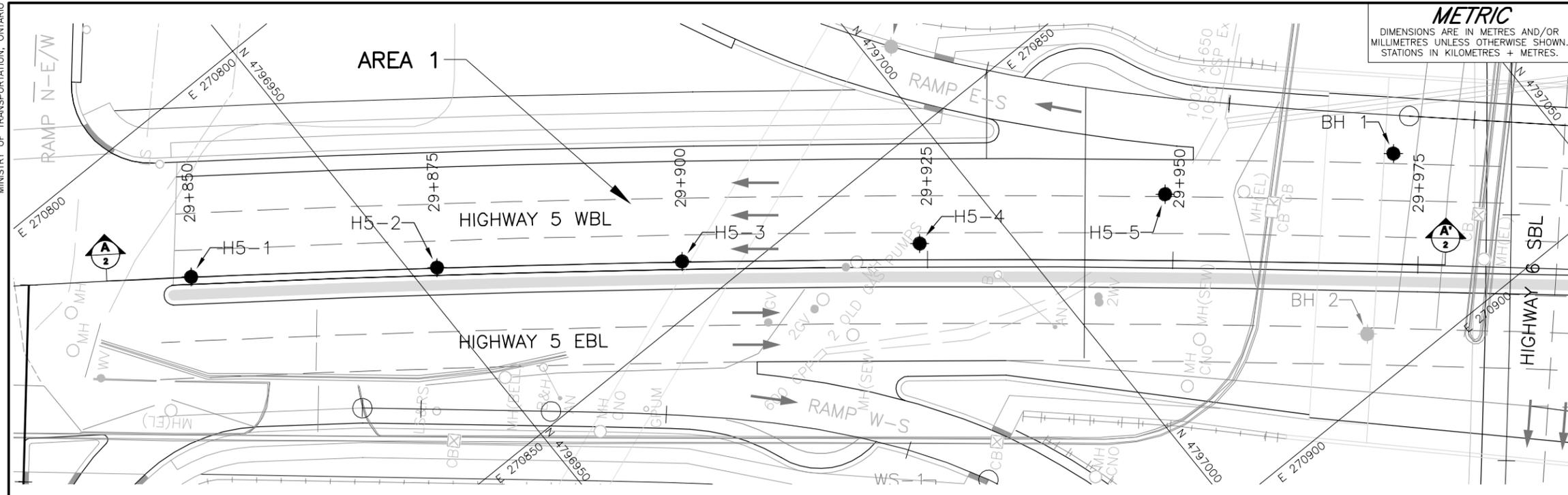
NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO. 10-1184-0016	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Jan. 2014	SITE:
DRAWN: DD/MR	CHKD.	APPD. JMAC	DWG. 1

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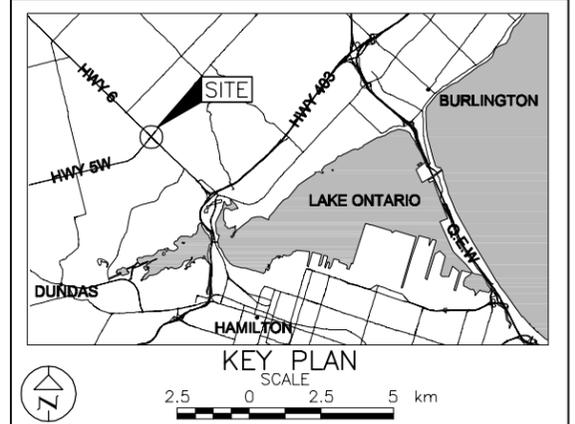
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HIGHWAY 5/HIGHWAY 6 INTERCHANGE
HIGHWAY 5: STA. 29+850 to STA. 29+960
(HIGH FILL AREA 1)
BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates Ltd.
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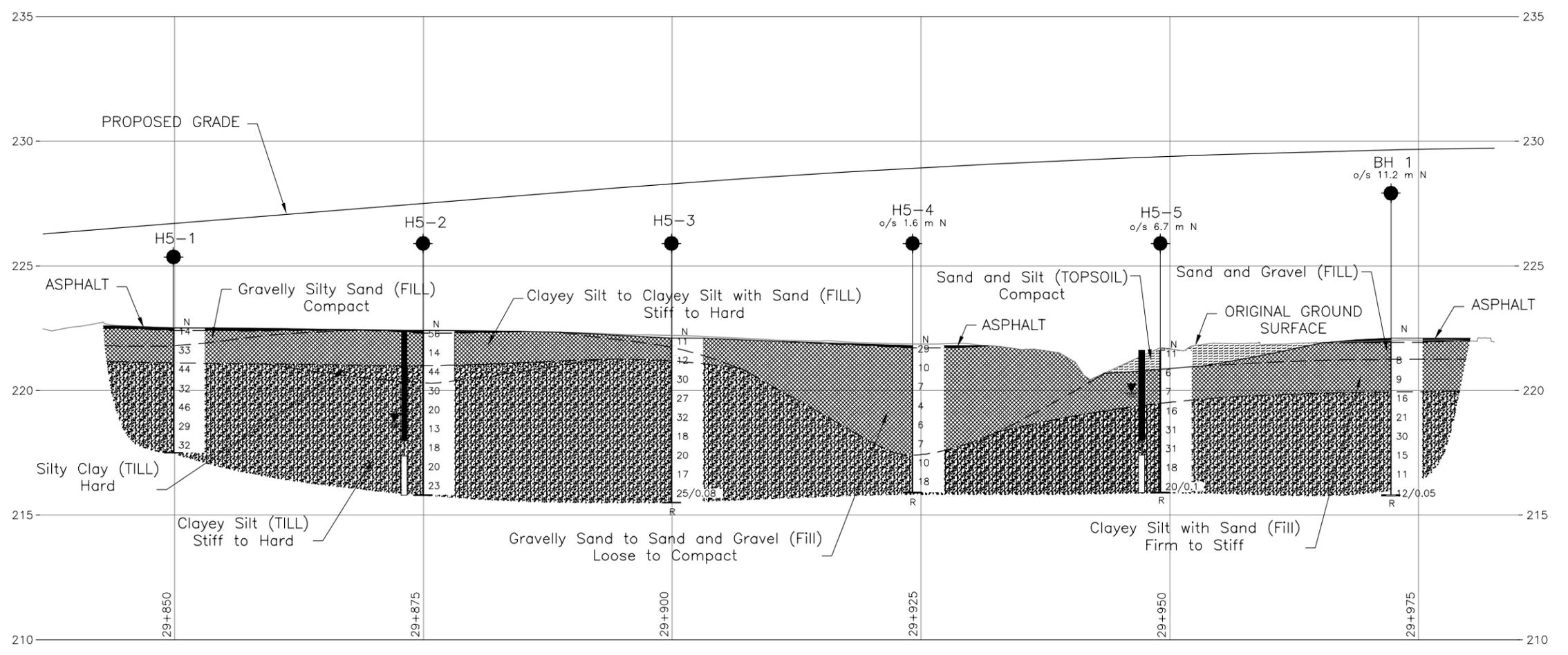


PLAN
SCALE
5 0 5 10 m



LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ▭ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ▭ WL in piezometer, measured on Feb. 13, 2013



A-A' 2
CENTRELINE PROFILE
HIGHWAY 5
HORIZONTAL SCALE
5 0 5 10 m
VERTICAL SCALE
2 0 2 4 m

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH 1	222.1	4797035.5	270882.4
H5-1	222.5	4796932.3	270815.2
H5-2	222.4	4796952.4	270830.2
H5-3	222.1	4796972.2	270845.4
H5-4	221.8	4796992.2	270859.2
H5-5	221.6	4797014.8	270871.0

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NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO. 10-1184-0016	
SUBM'D. TVA		CHKD. TVA	DATE: Jan. 2014
DRAWN: DD/MR		CHKD.	APPD. JMAC
		DIST. SITE: DWG. 2	

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

CONT No. GWP No. 2112-05-00

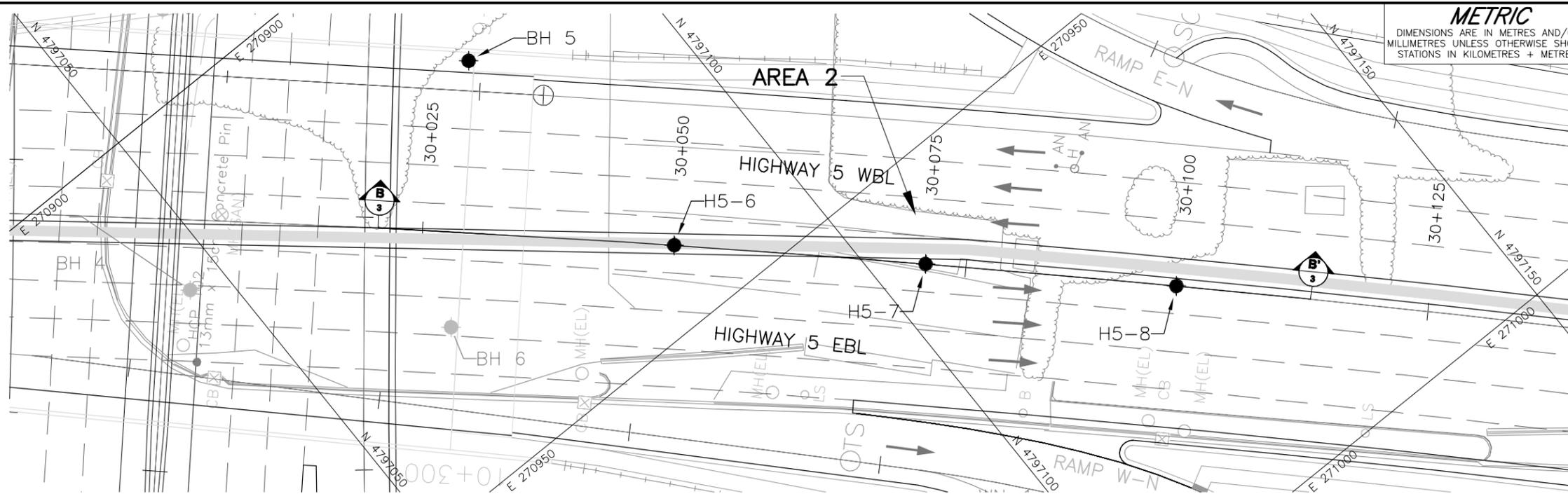


HIGHWAY 5/HIGHWAY 6 INTERCHANGE
 HIGHWAY 5: STA. 30+040 TO STA. 30+120
 (HIGH FILL AREA 2)
 BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



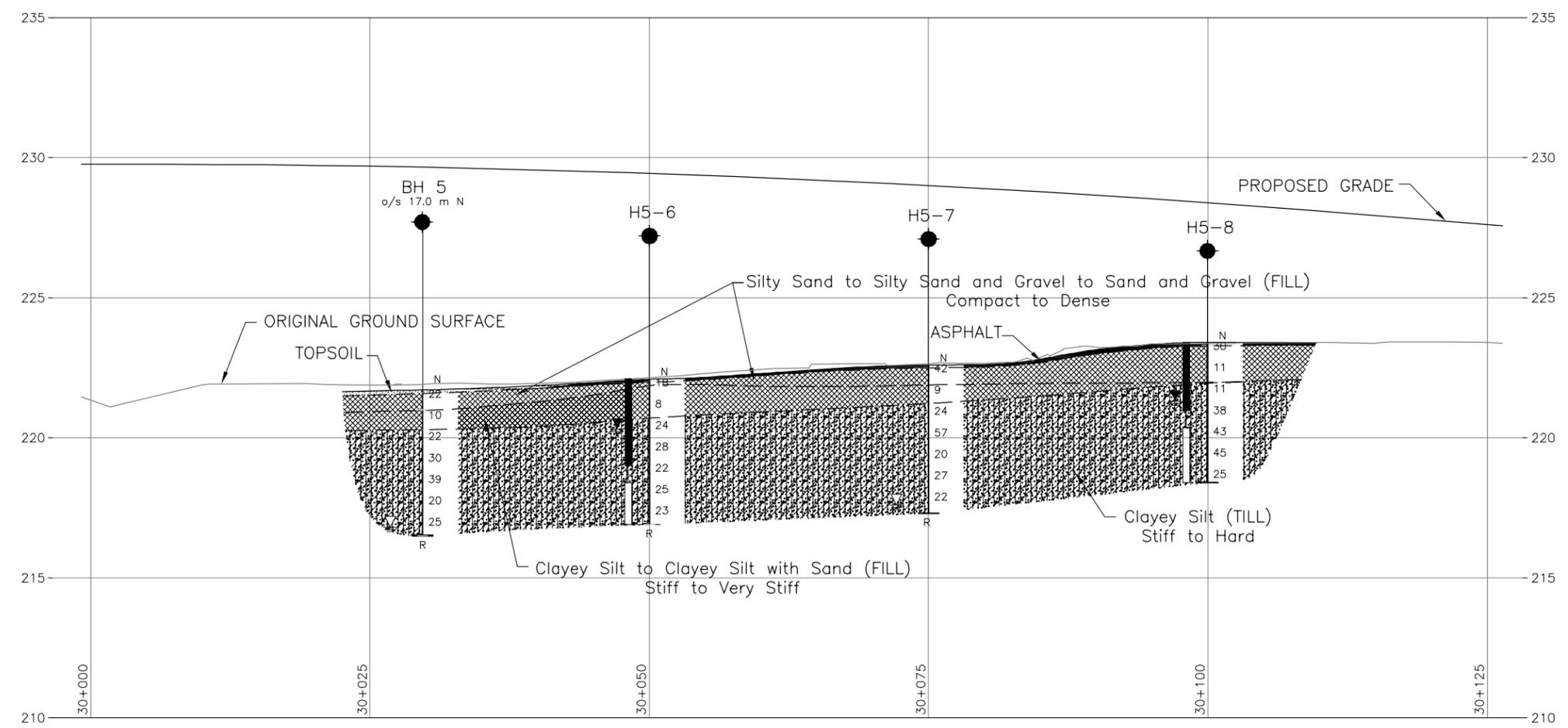
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 MISSISSAUGA, ONTARIO, CANADA



PLAN
 SCALE
 5 0 5 10 m



KEY PLAN
 SCALE
 2.5 0 2.5 5 km



B-B
3
CENTRELINE PROFILE
HIGHWAY 5
 HORIZONTAL SCALE
 5 0 5 10 m
 VERTICAL SCALE
 2 0 2 4 m

LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊏ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ▽ WL in piezometer, measured on Feb. 13, 2013
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH 5	221.7	4797082.1	270915.5
H5-6	222.1	4797086.5	270942.5
H5-7	222.6	4797104.7	270959.6
H5-8	223.4	4797122.7	270976.9

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REFERENCE

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NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO. 10-1184-0016	
SUBM'D. TVA		CHKD. TVA	DATE: Jan. 2014
DRAWN: DD/MR		CHKD.	APPD. JMAC
			DWG. 3

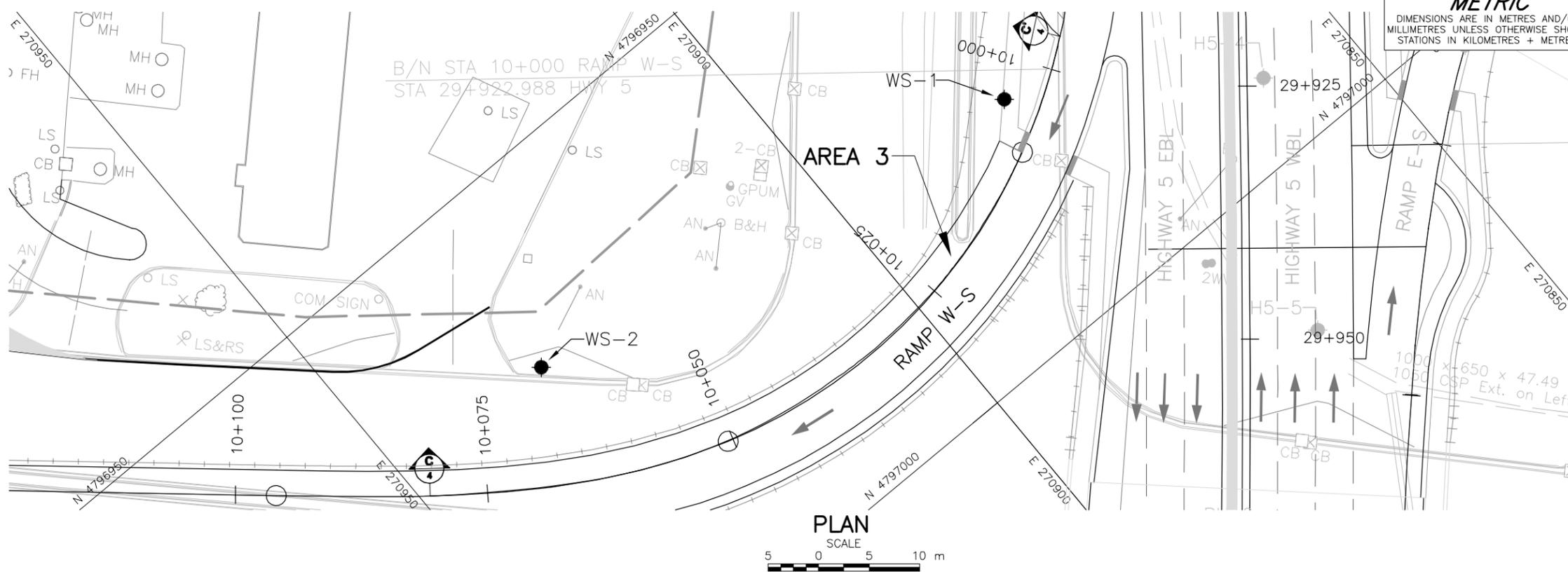


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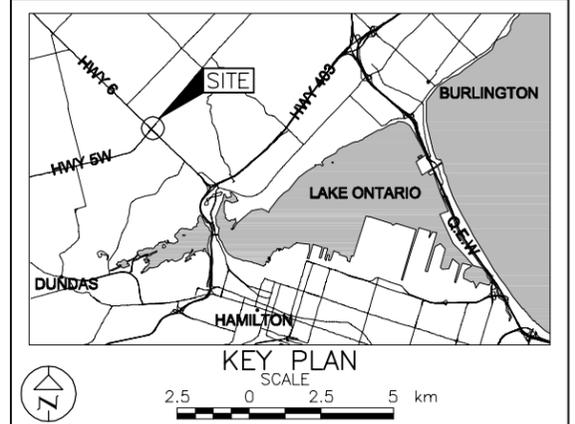
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 HIGHWAY 5/HIGHWAY 6 INTERCHANGE
 RAMP W-S: STA. 10+000 TO STA. 10+140
 (HIGH FILL AREA 3)
 BOREHOLE LOCATIONS AND SOIL STRATA



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PLAN
 SCALE
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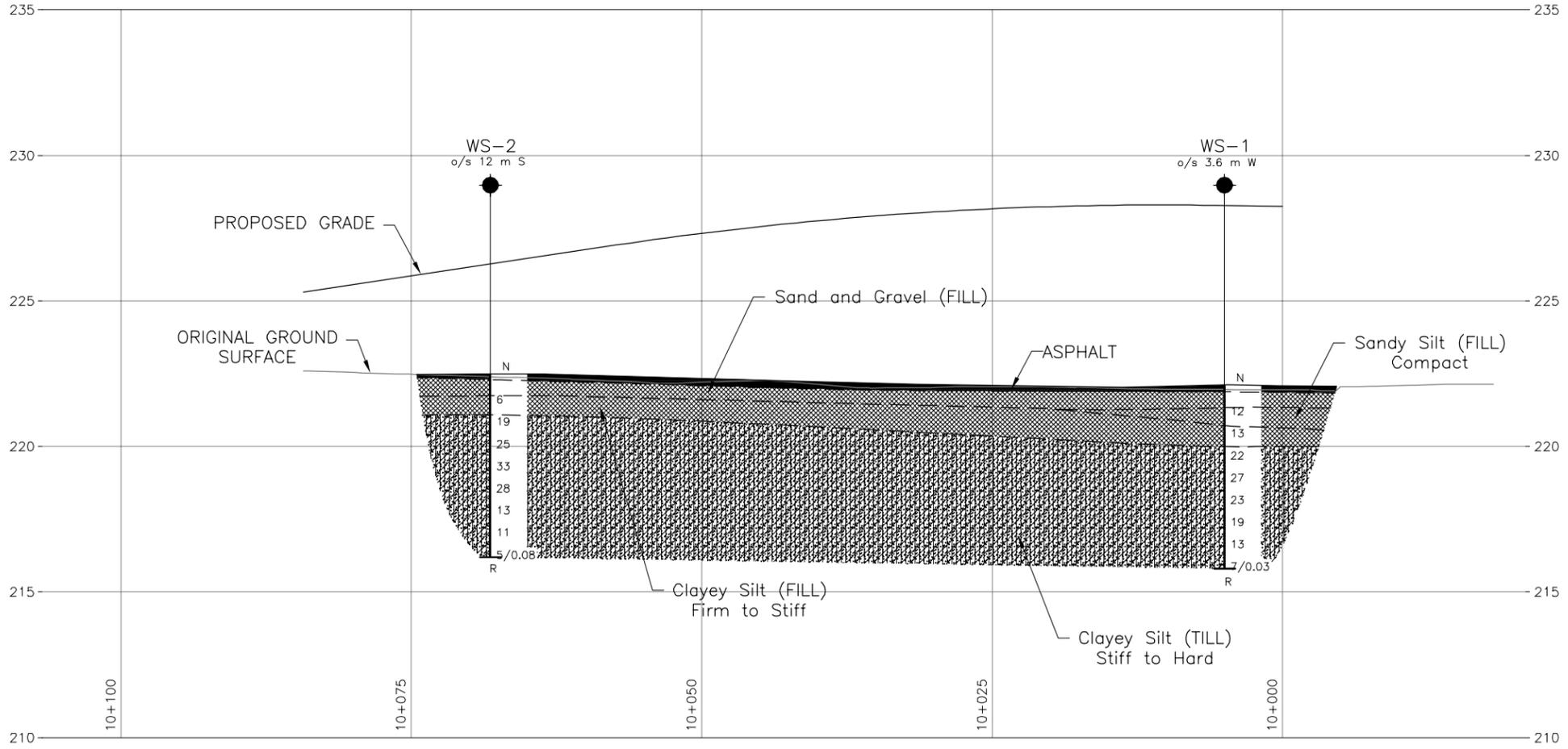


LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ▭ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
WS-1	222.1	4796977.4	270880.3
WS-2	222.5	4796968.4	270932.5



C-C
4
CENTRELINE PROFILE
RAMP W-S
 HORIZONTAL SCALE
 5 0 5 10 m
 VERTICAL SCALE
 2 0 2 4 m

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NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO.	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Jan. 2014	SITE:
DRAWN: DD/MR	CHKD.	APPD. JMAC	DWG. 4



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

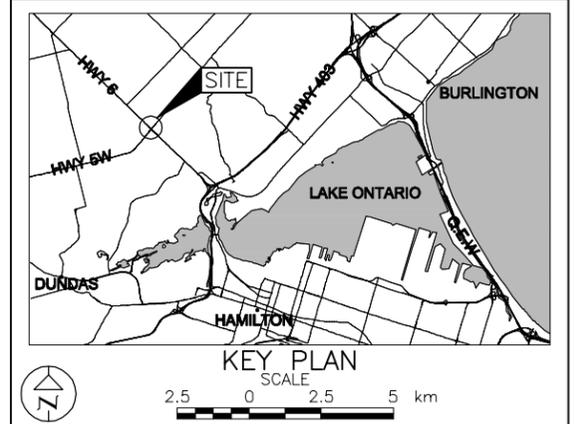
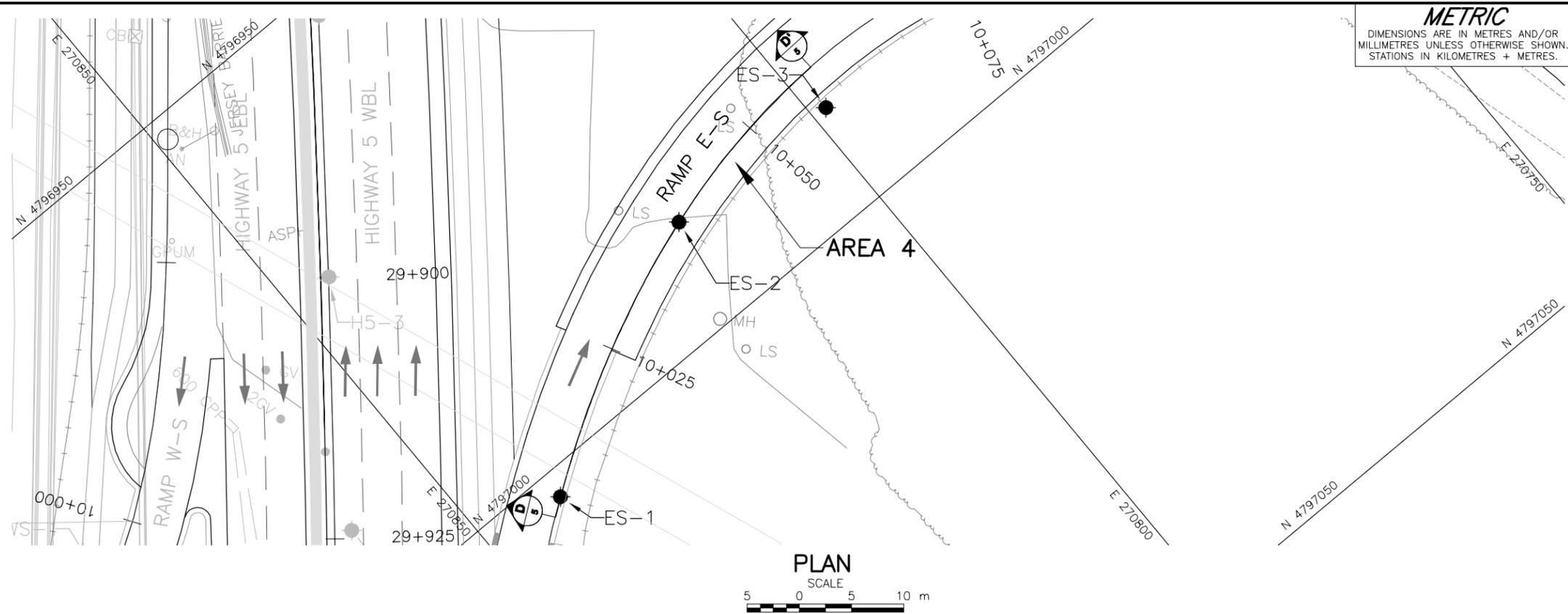
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GWP No. 2112-05-00

HIGHWAY 5/HIGHWAY 6 INTERCHANGE
RAMP E-S: STA. 10+000 TO STA. 10+100
(HIGH FILL AREA 4)

BOREHOLE LOCATIONS AND SOIL STRATA

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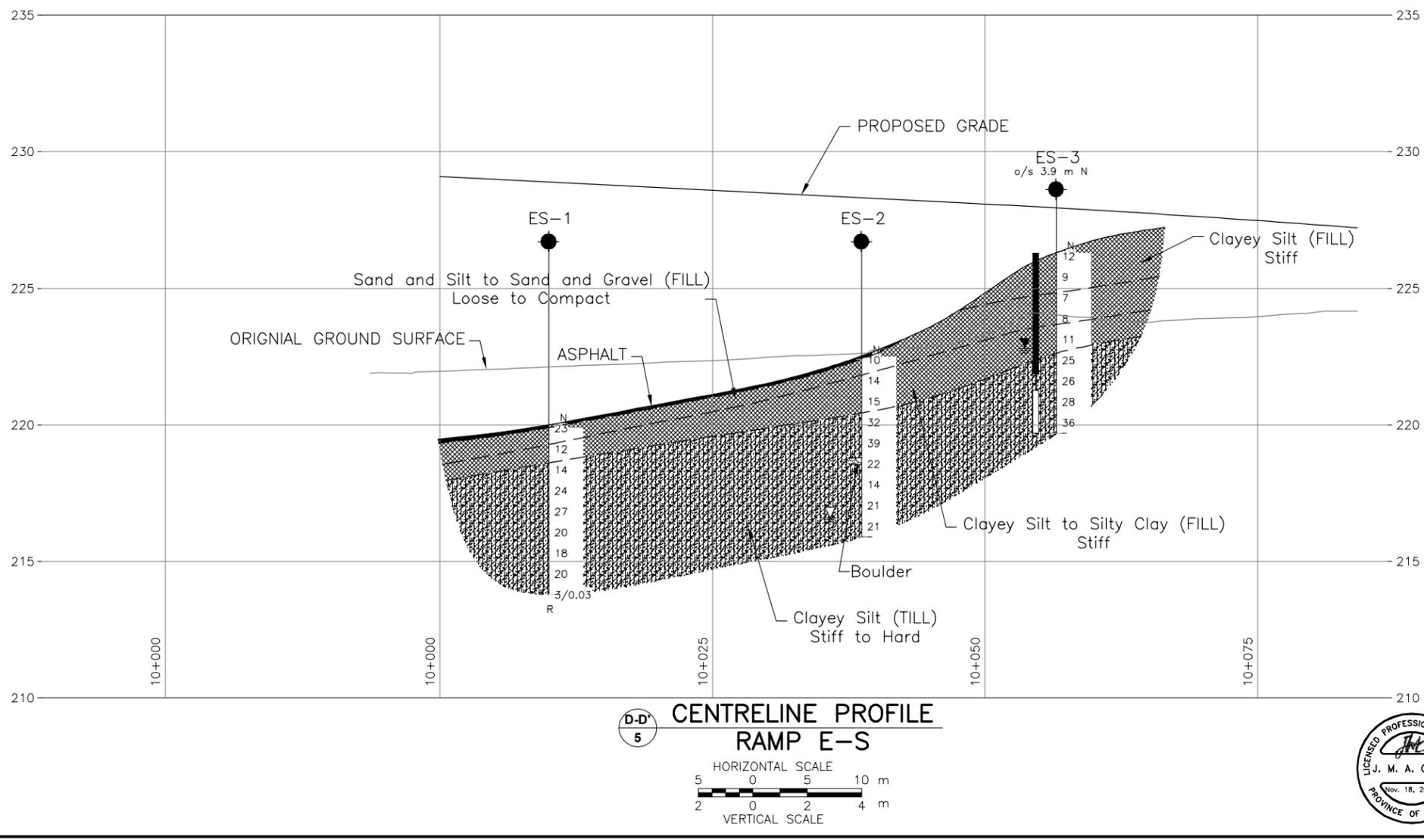


LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ▽ WL in piezometer, measured on Feb. 13, 2013
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
ES-1	220.0	4797002.5	270841.8
ES-2	222.5	4796989.6	270816.3
ES-3	226.3	4796990.2	270798.5



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REFERENCE

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NO.	DATE	BY	REVISION

Geocres No. 30M5-306

HWY. 5 and 6	PROJECT NO. 10-1184-0016	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Jan. 2014
DRAWN: DD/MR	CHKD.	APPD.

DWG. 5

LICENSED PROFESSIONAL ENGINEER
J. M. A. COSTA
Nov. 18, 2014
PROVINCE OF ONTARIO

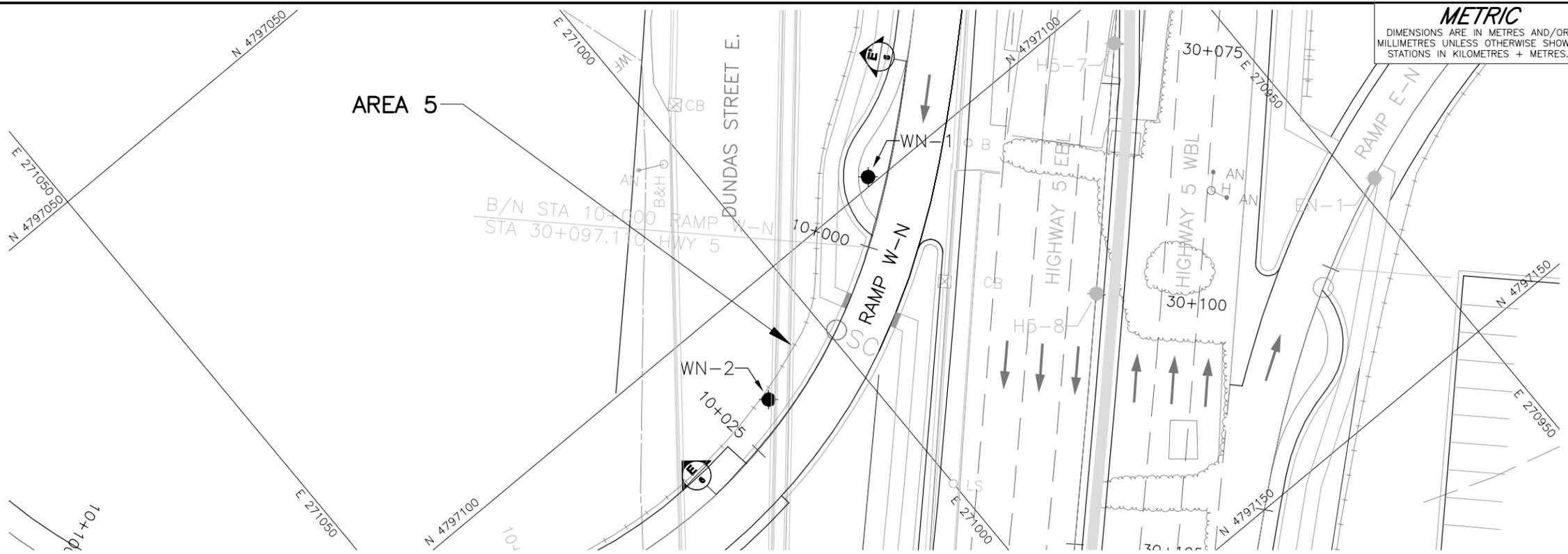
LICENSED PROFESSIONAL ENGINEER
T. V. AYETAN
100130071
Nov. 18, 2014
PROVINCE OF ONTARIO

METRIC
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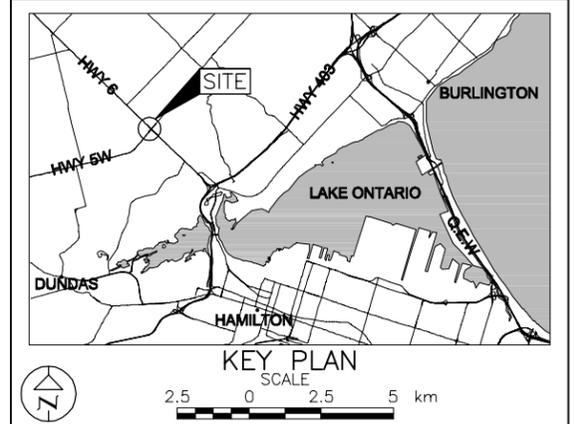
CONT No. GWP No. 2112-05-00
HIGHWAY 5/HIGHWAY 6 INTERCHANGE
RAMP W-N: STA. 10+000 to STA. 10+100
(HIGH FILL AREA 5)
BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates
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MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
5 0 5 10 m

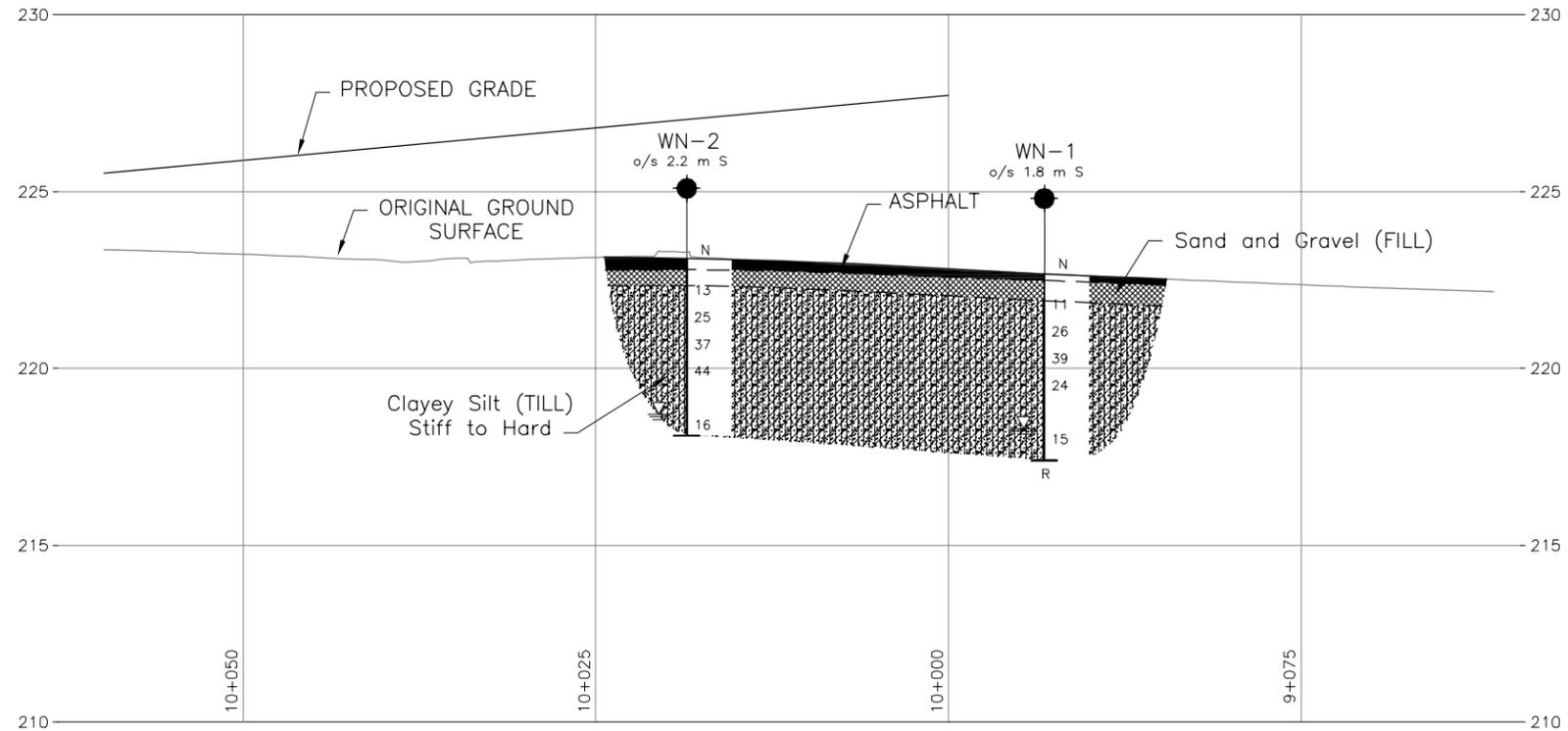


LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
WN-1	222.7	4797099.2	270987.0
WN-2	223.1	4797109.9	271008.8



E-E' CENTRELINE PROFILE RAMP W-N
6
HORIZONTAL SCALE
5 0 5 10 m
VERTICAL SCALE
2 0 2 4 m

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NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO. 10-1184-0016	
SUBM'D. TVA	CHKD. TVA	DATE: Jan. 2014	DIST.
DRAWN: DD/MR	CHKD.	APPD. JMAC	DWG. 6

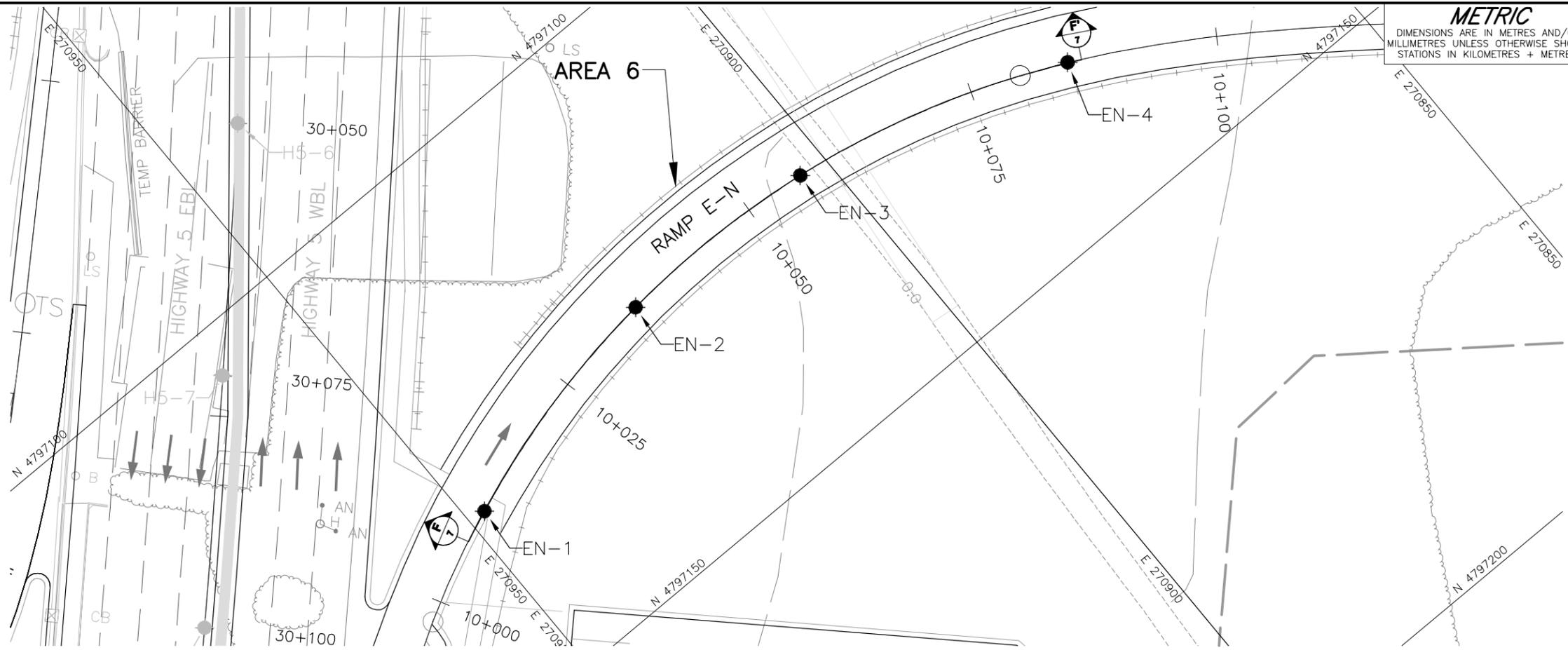
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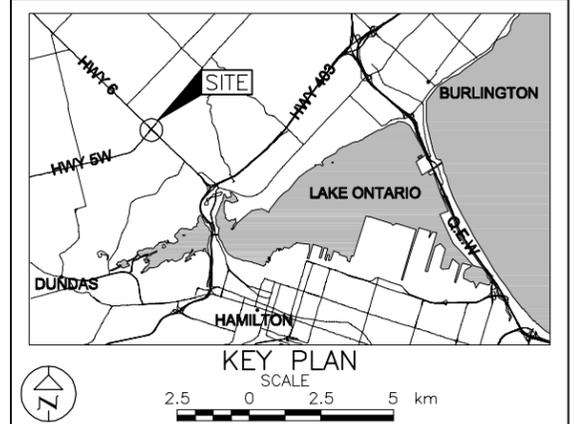


HIGHWAY 5/HIGHWAY 6 INTERCHANGE
RAMP E-N: STA. 10+000 TO STA. 10+210
(HIGH FILL AREA 6)
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



PLAN
SCALE
5 0 5 10 m

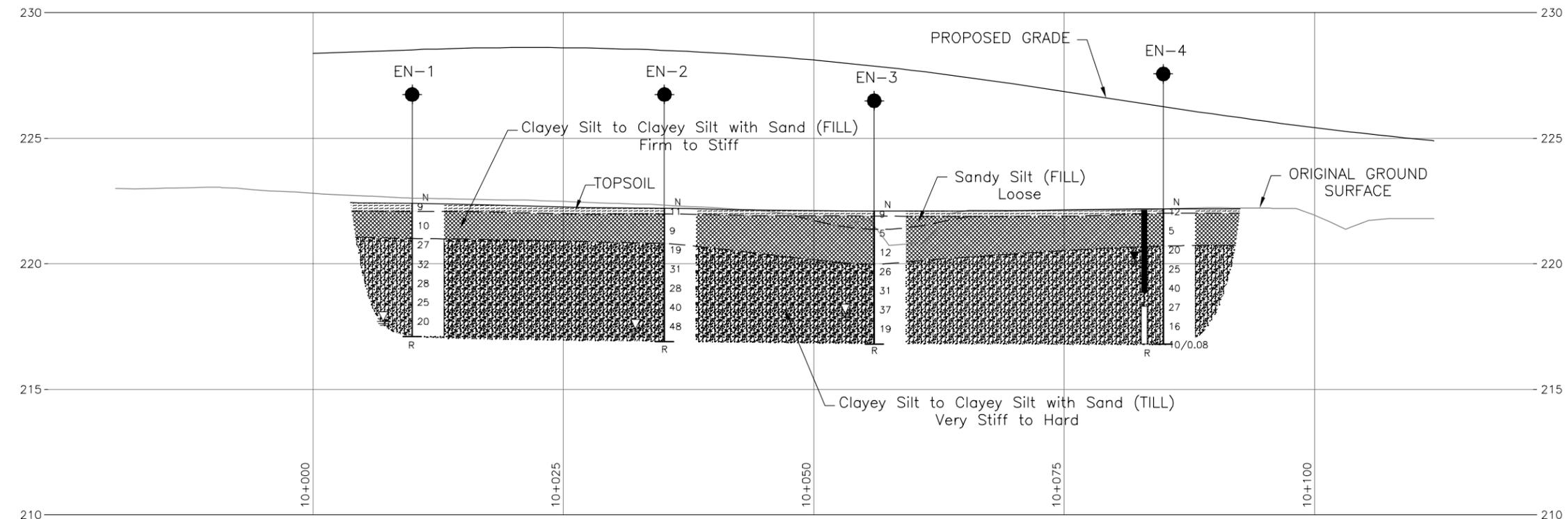


LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- R Refusal
- ≡ WL in piezometer, measured on Feb. 13, 2013
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
EN-1	222.4	4797131.6	270948.2
EN-2	222.2	4797125.7	270923.8
EN-3	222.1	4797126.1	270902.9
EN-4	222.2	4797134.5	270875.4



F-7 CENTRELINE PROFILE RAMP E-N
HORIZONTAL SCALE
5 0 5 10 m
VERTICAL SCALE
2 0 2 4 m

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

REFERENCE

Base plans provided in digital format by IBI, drawing file no. T5&6-MNC-Slone-New STA.dwg, received June 24, 2013 and Profile file no. T5&6_MPROF.dwg, received February 20, 2013.

NO.	DATE	BY	REVISION
Geocres No. 30M5-306			
HWY. 5 and 6		PROJECT NO. 10-1184-0016	DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Jan. 2014	SITE:
DRAWN: DD/MR	CHKD.	APPD. JMAC	DWG. 7





APPENDIX A

Highway 5: STA. 29+850 to STA. 29+960 (High Fill Area 1) Record of Boreholes and Laboratory Test Results

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No BH 1	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797035.5 ; E 270882.4</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 21, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
222.1	GROUND SURFACE																
0.0	ASPHALT						222										
0.2	Sand and gravel, trace silt, cobbles at 0.5 m depth (FILL)																
221.3	Brown Moist																
0.8	Clayey silt, sandy, some gravel, trace organics and topsoil (FILL)		1	SS	8		221										21 29 34 16
	Stiff Brown to black Moist		2	SS	9												
220.0							220										
2.1	CLAYEY SILT, sandy, trace gravel, sand seams to a depth of 2.7 m (TILL)		3	SS	16												1 25 49 25
	Stiff to very stiff Brown to grey Moist		4	SS	21		219										
			5	SS	30		218										
			6	SS	15		217										
			7	SS	11												
215.8			8	SS	12/0.05		216										
6.3	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK																
	NOTE: 1. Borehole dry upon completion of drilling																

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PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No H5-1	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4796932.3; E 270815.2</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 12, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
								20	40	60	80	100	10	20	30		
222.5	GROUND SURFACE																
0.0	ASPHALT																
0.1	Gravelly silty sand, trace clay, clayey silt pockets and pieces of asphalt (FILL)		1	SS	14		222						○				21 44 28 7
221.8	Compact Brown Moist		2	SS	33												
0.7	Clayey silt with sand, gravelly, pieces of asphalt (FILL)						221										
221.1	Hard Brown Moist		3	SS	44								○				
1.4	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff to hard Brown to red Moist to wet		4	SS	32		220										
	----- sand seams Wet -----		5	SS	46		219										1 19 59 21
			6	SS	29								○				
			7	SS	32		218										
217.5	END OF BOREHOLE																
5.0	NOTE: 1. Borehole dry upon completion of drilling.																

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PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No H5-2	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4796952.4 ; E 270830.2</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 12, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40					
222.4	GROUND SURFACE													
0.0	ASPHALT													
0.1	Clayey silt, trace gravel, trace to some sand (FILL) Stiff to hard Brown Moist		1	SS	56									
			2	SS	14									
221.0														
1.4	SILTY CLAY, trace to some sand (TILL) Hard Brown Moist		3	SS	44								0 9 52 39	
220.3														
2.1	CLAYEY SILT, sandy to some sand, trace gravel, silty sand and sandy silt seams to a depth of 3.5 m (TILL) Stiff to hard Brown Moist to wet		4	SS	30									
			5	SS	20								4 24 55 17	
			6	SS	13									
			7	SS	18								2 20 50 28	
			8	SS	20									
			9	SS	23								7 19 47 27	
215.8	END OF BOREHOLE													
6.6	NOTES: 1. Water level in open borehole measured at a depth of 5.7 m below ground surface (Elev. 216.7 m) upon completion of drilling. 2. WATER LEVEL READINGS: Date Depth (mm) Elev. (m) 11/23/12 3.4 219.0 01/22/13 3.4 219.0 02/07/13 3.7 218.7 02/13/13 3.7 218.7													

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PROJECT 10-1184-0016 **RECORD OF BOREHOLE No H5-3** **SHEET 1 OF 1** **METRIC**
G.W.P. 2112-05-00 **LOCATION** N 4796972.2 ; E 270845.4 **ORIGINATED BY** JBH
DIST HWY 5 & 6 **BOREHOLE TYPE** 102 mm O.D. Continuous Flight Solid Stem Augers **COMPILED BY** BM
DATUM Geodetic **DATE** November 12, 2012 **CHECKED BY** TVA

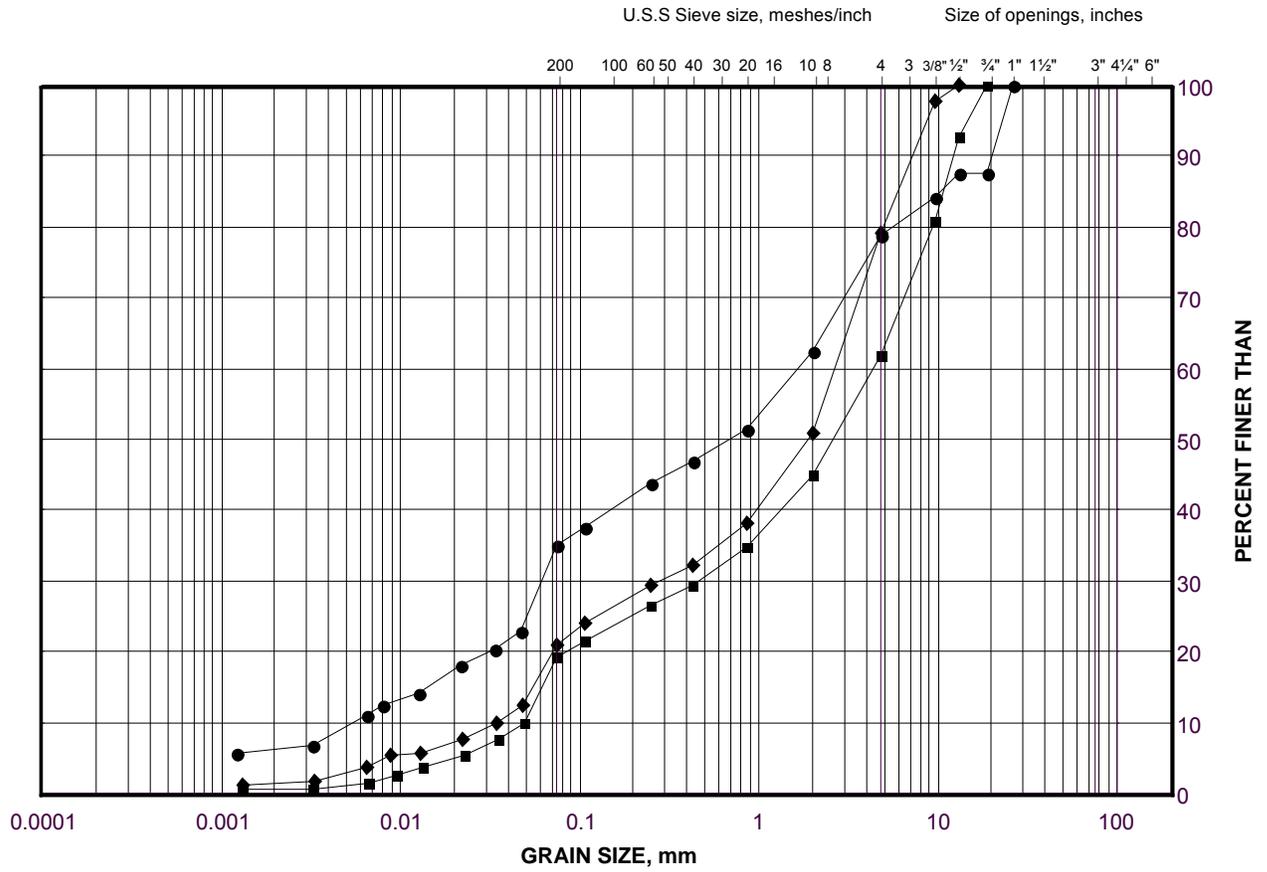
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	SHEAR STRENGTH kPa			WATER CONTENT (%)
											○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×	REMOULDED	GR	SA	SI	CL	
222.1	GROUND SURFACE																				
0.0	Sand and gravel, some silt, trace clay (FILL) Compact Brown Moist		1A	SS	11																
221.8			1B																		
221.4	Clayey silt with sand, trace gravel, trace organics (FILL) Stiff Brown Moist		2	SS	12																
0.7																					
	CLAYEY SILT, sandy, trace gravel (TILL) Stiff to hard Brown to grey Moist		3	SS	30																
			4	SS	27																
			5	SS	32																
	----- silt seams -----		6	SS	18																
			7	SS	20																
			8	SS	17																
			9	SS	25/0.08																
215.5	END OF BOREHOLE SPOON BOUNCING / REFUSAL																				
6.6	NOTE: 1. Borehole dry upon completion of drilling.																				

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GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand to Gravelly Sand to Sand and Gravel (FILL)

FIGURE A1



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

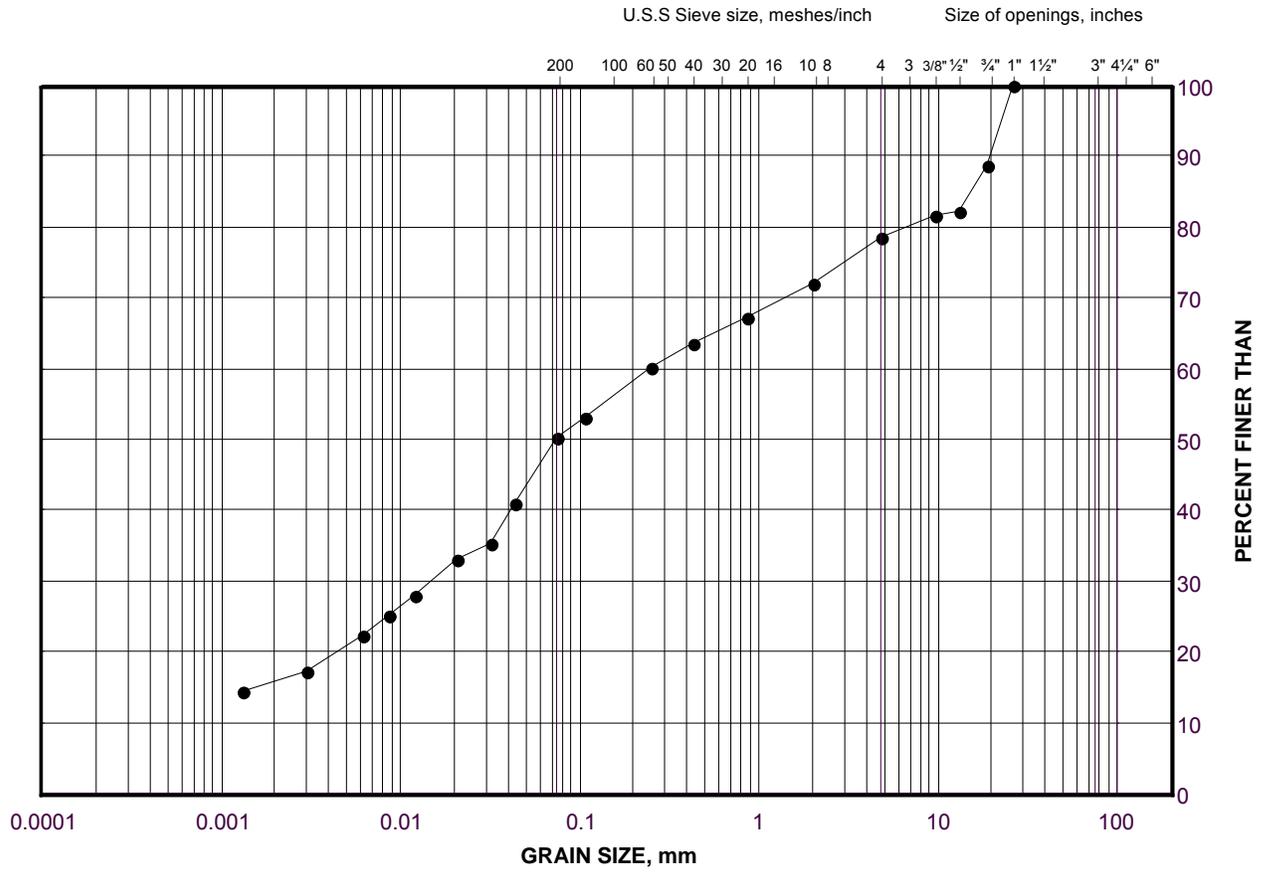
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	H5-1	1	222.2
■	H5-3	1A	221.8
◆	H5-4	2	220.8

GRAIN SIZE DISTRIBUTION

Clayey Silt (FILL)

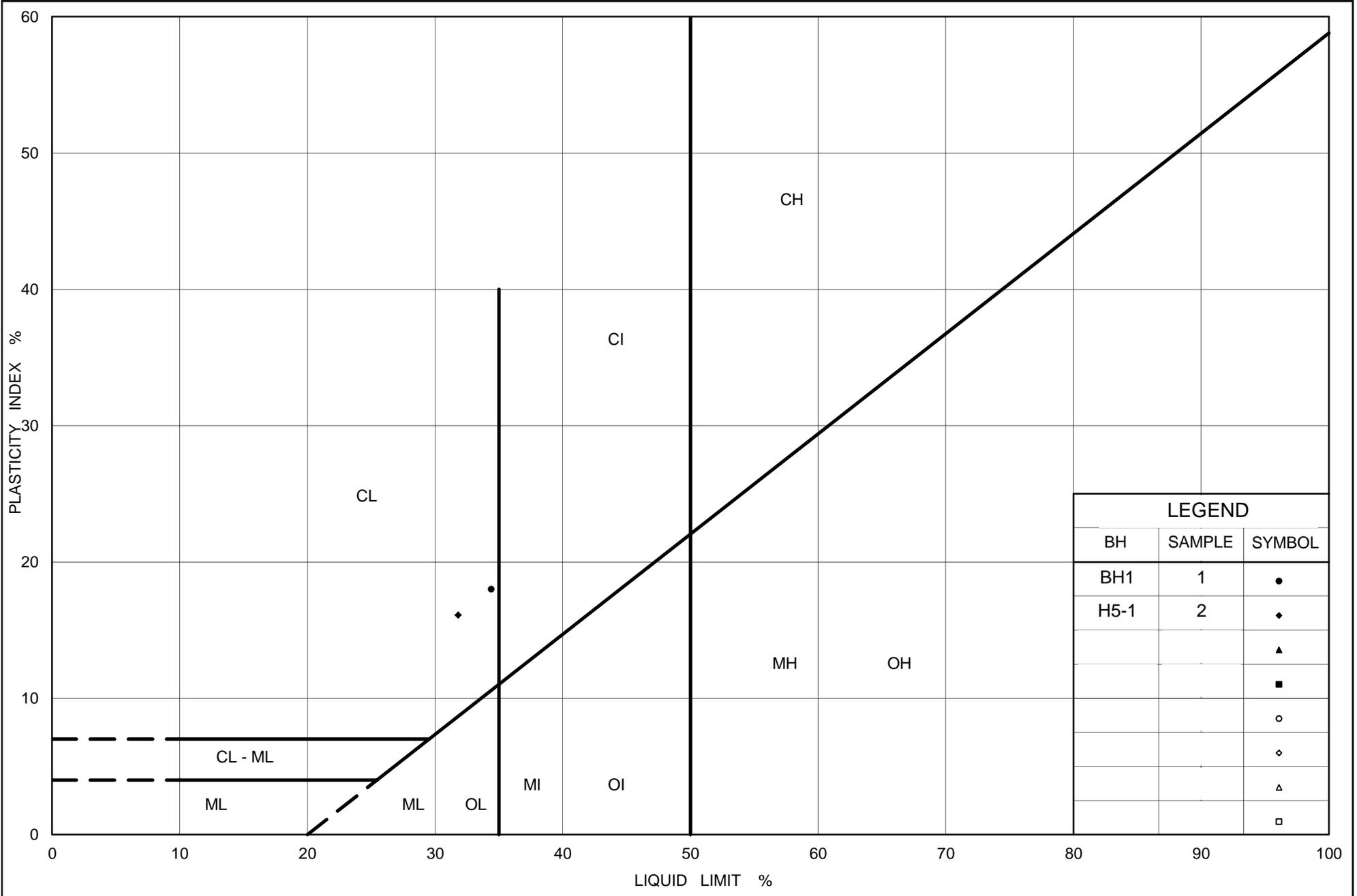
FIGURE A2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	BH1	1	221.1



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PLASTICITY CHART

Clayey Silt to Clayey Silt with Sand (FILL)

Figure No. A3

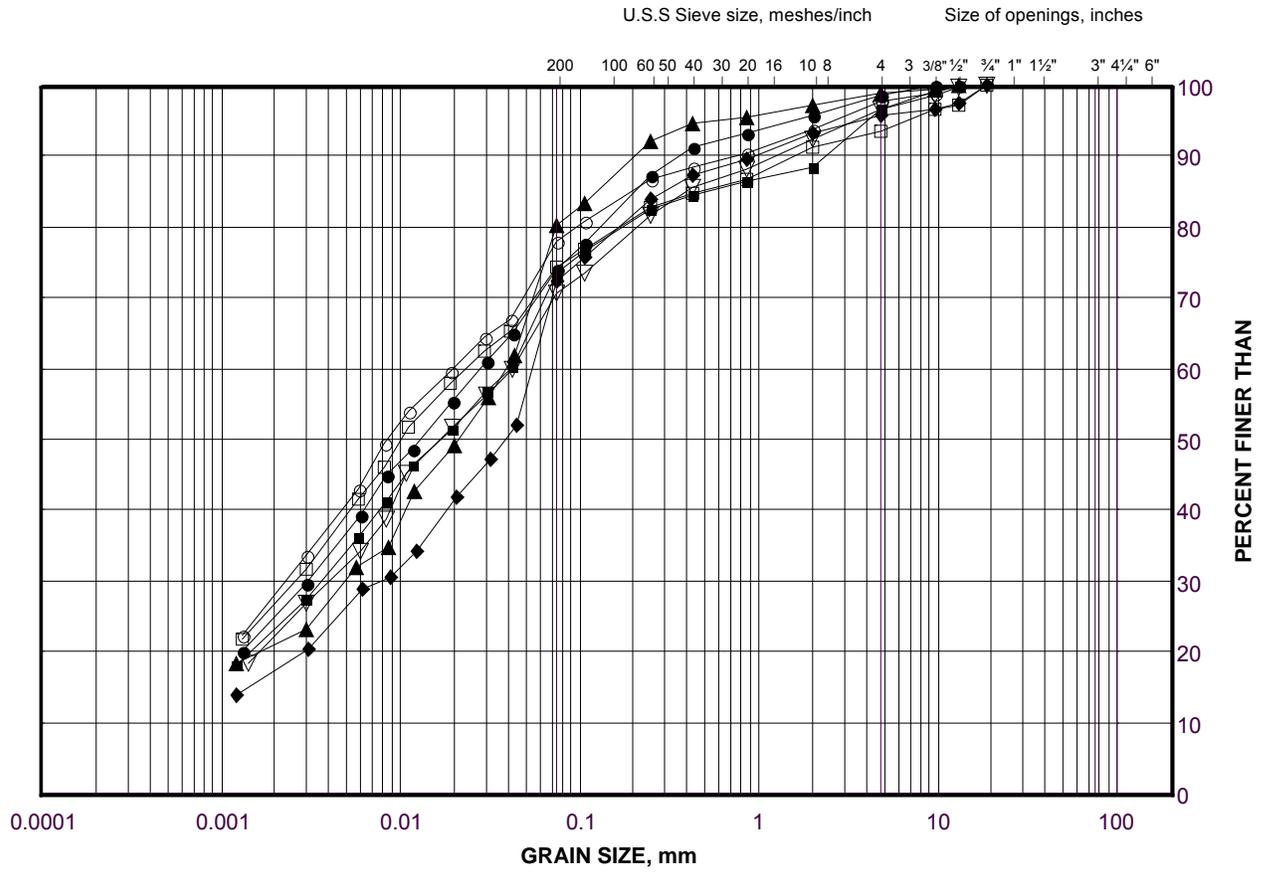
Project No. 10-1184-0016

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Clayey Silt (TILL)

FIGURE A4A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	BH1	3	219.6
■	H5-3	4	219.6
◆	H5-2	5	219.2
▲	H5-1	5	219.3
▽	H5-3	5	218.8
○	H5-2	7	217.7
□	H5-2	9	216.1

Project Number: 10-1184-0016

Checked By: TVA

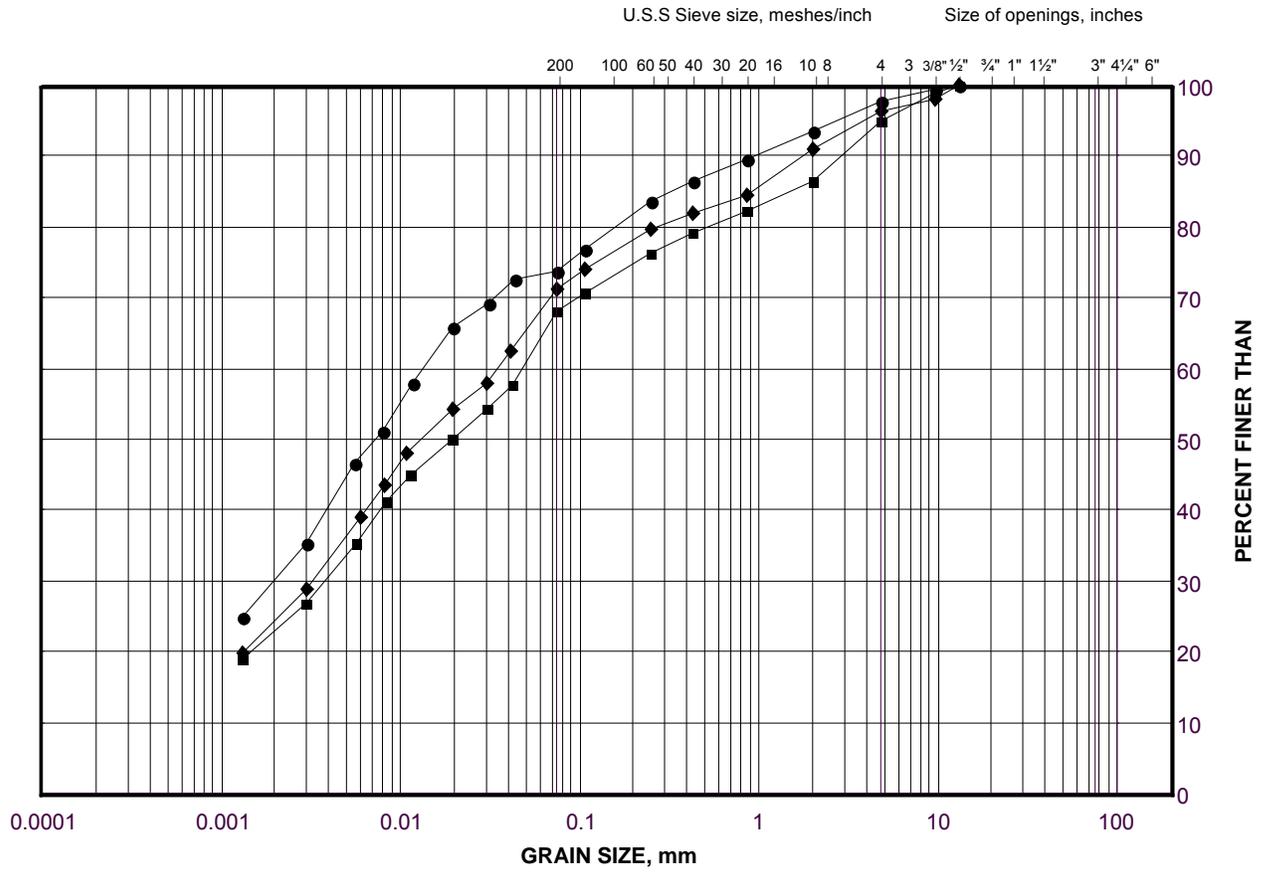
Golder Associates

Date: 11-Feb-14

GRAIN SIZE DISTRIBUTION

Clayey Silt (TILL)

FIGURE A4B



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

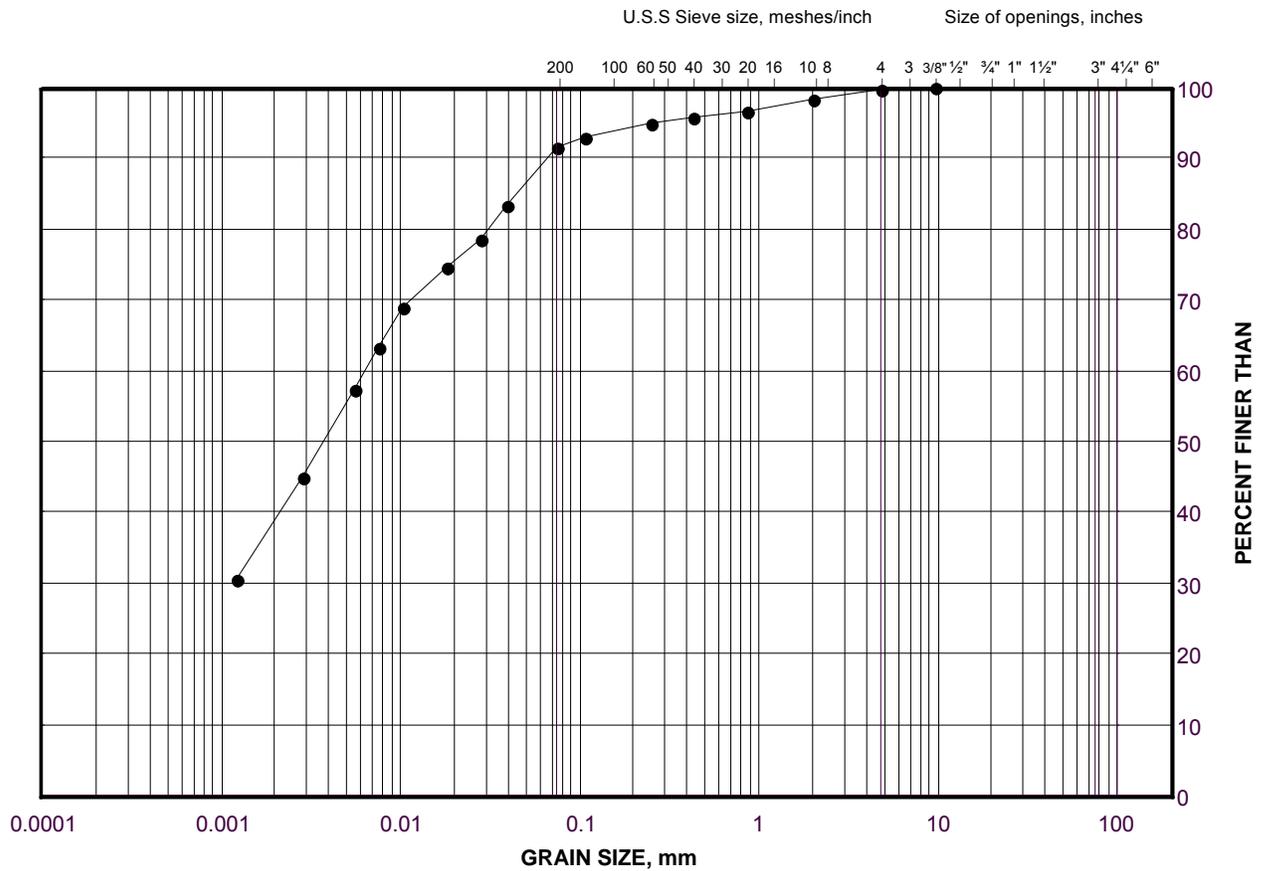
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	H5-5	5	218.3
■	H5-5	7	216.8
◆	H5-4	8	216.3

GRAIN SIZE DISTRIBUTION

Silty Clay (TILL)

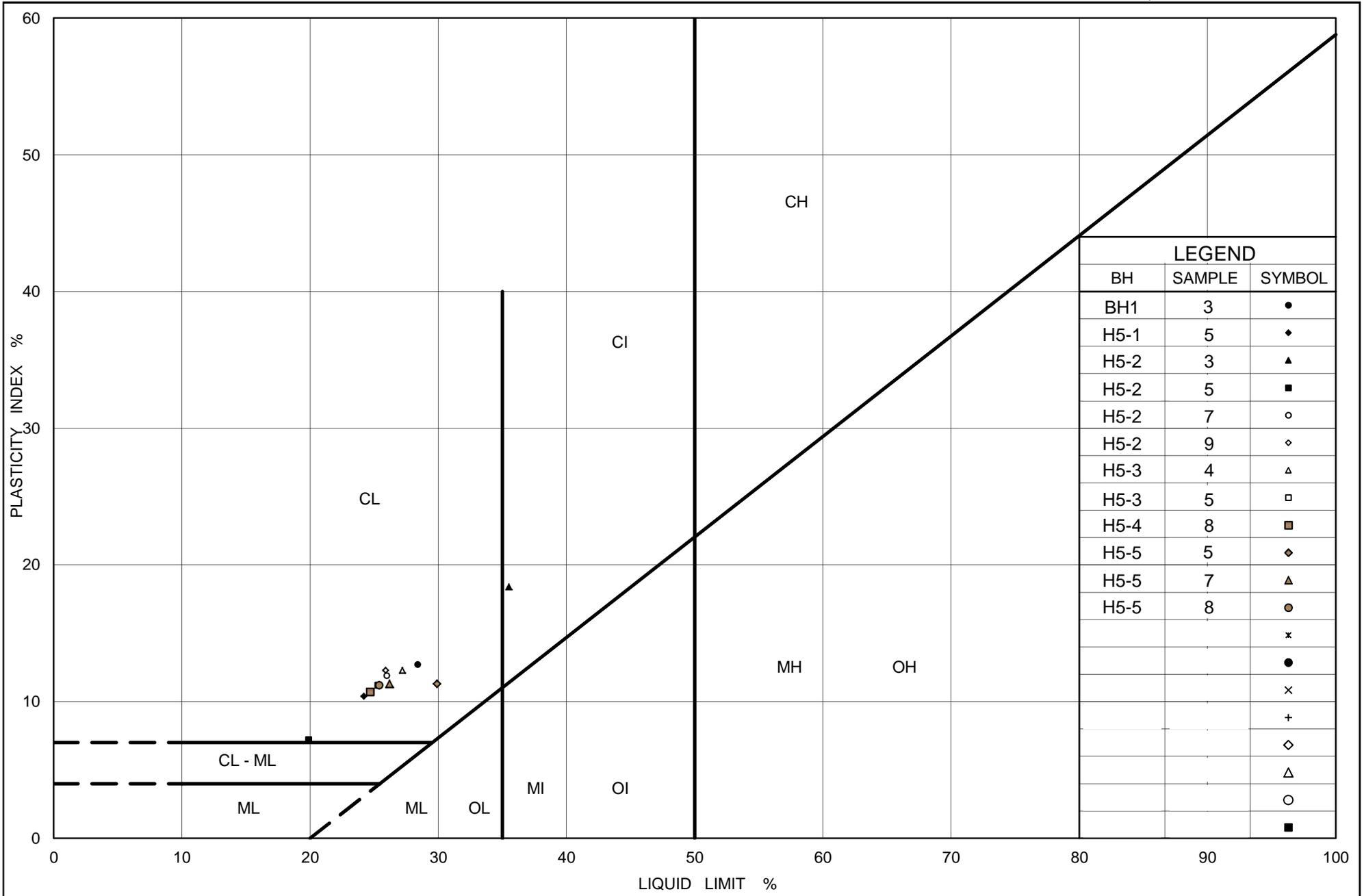
FIGURE A5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	H5-2	3	220.7



PLASTICITY CHART
Clayey Silt to Silty Clay (TILL)



Figure No. A6
Project No. 10-1184-0016
Checked By: TVA



APPENDIX B

Highway 5: STA. 30+040 to STA. 30+120 (High Fill Area 2) Record of Boreholes and Laboratory Test Results

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No BH 5	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797082.1 ; E 270915.5</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 15, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
								20	40	60	80	100	10	20	30		
221.7	GROUND SURFACE																
0.0	TOPSOIL																
0.1	Silty sand and gravel (FILL)		1	SS	22												
221.0	Compact Brown Dry																
0.7	Clayey silt, some sand, trace gravel, trace organics (FILL)		2	SS	10												
220.3	Stiff Brown Moist																
1.4	CLAYEY SILT, some sand, trace gravel (TILL)		3	SS	22												2 16 52 30
	Very stiff to hard Brown to grey Moist		4	SS	30												
			5	SS	39												
			6	SS	20												4 27 45 24
	Sandy, cobbles at 4.0 m depth		7	SS	25												
216.5	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK																
5.2	NOTE: 1. Water level in open borehole measured at a depth of 4.9 m below ground surface (Elev. 216.8 m) upon completion of drilling.																

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PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No H5-6	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797086.5 ; E 270942.5</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 15, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
222.1	GROUND SURFACE																
0.0	ASPHALT																
0.2	Sand and gravel, trace silt (FILL) Brown Moist		1	SS	18												
	Clayey silt with sand, some gravel (FILL) Stiff to very stiff Brown Moist		2	SS	8												19 34 36 11
220.7																	
1.4	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Brown to grey Moist		3	SS	24												
			4	SS	28												1 16 56 27
	Silty sand seams		5A 5B	SS	22												
			6	SS	25												
			7	SS	23												
216.9	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK																
5.2	NOTES: 1. Water level in open borehole measured at a depth of 3.8 m below ground surface (Elev. 218.3 m) upon completion of drilling. 2. WATER LEVEL READINGS: Date Depth (mm) Elev. (m) 11/16/12 5.1 217.0 11/23/12 4.3 217.8 01/22/13 1.7 220.4 02/07/13 1.8 220.3 02/13/13 1.8 220.3																

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

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No H5-7	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797104.7 ; E 270959.6</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 15, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
								20	40	60	80	100	10	20	30		
222.6	GROUND SURFACE																
0.0	ASPHALT																
0.1	Sand and gravel, trace to some silt, pieces of concrete (FILL) Dense		1	SS	42												
221.9	Grey to brown Moist		2	SS	9												
0.7	Clayey silt, some sand, trace to some gravel (FILL) Stiff																
221.2	Brown Moist		3	SS	24												2 18 54 26
1.4	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff to hard																
	Brown to grey Moist to wet		4	SS	57												
			5	SS	20												
			6	SS	27												
			7	SS	22												6 23 48 23
217.3	Sandy, trace to some gravel Wet																
5.3	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK																
	NOTE: 1. Water level in open borehole measured at a depth of 5.0 m below ground surface (Elev. 217.6 m) upon completion of drilling.																

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

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No H5-8	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797122.7; E 270976.9</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 14, 2012</u>	CHECKED BY <u>TVA</u>	

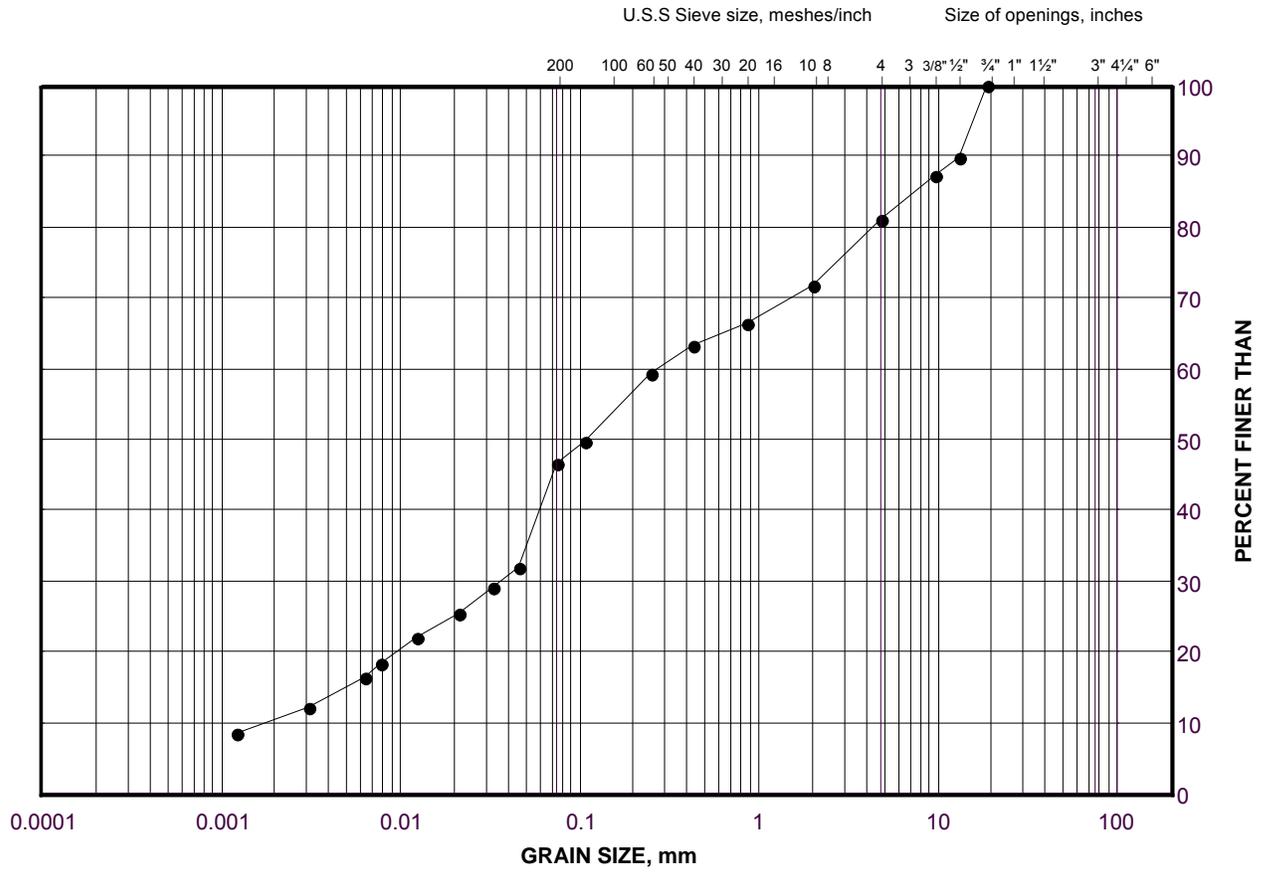
ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)																				
			NUMBER	TYPE	"N" VALUES			20	40						60	80	100																	
223.4	GROUND SURFACE																																	
0.0	ASPHALT																																	
0.1	Silty sand, trace clay, trace gravel, trace organics (FILL) Compact Brown Moist		1	SS	30		223																											
			2	SS	11																													
222.0	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Brown Moist to wet						222																											
1.4			3	SS	11																													
			4	SS	38		221																											
			5	SS	43		220						4	19 50 27																				
			6	SS	45																													
218.4	with SAND Wet						219																											
5.0	END OF BOREHOLE		7	SS	25								5	32 45 18																				
NOTES: 1. Water level in open borehole measured at a depth of 4.8 m below ground surface (Elev. 218.6 m) upon completion of drilling. 2. WATER LEVEL READINGS: <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Date</th> <th>Depth (mm)</th> <th>Elev. (m)</th> </tr> </thead> <tbody> <tr><td>11/15/12</td><td>2.7</td><td>220.7</td></tr> <tr><td>11/16/12</td><td>4.6</td><td>218.8</td></tr> <tr><td>11/23/12</td><td>4.5</td><td>218.9</td></tr> <tr><td>01/22/13</td><td>2.2</td><td>221.2</td></tr> <tr><td>02/07/13</td><td>2.3</td><td>221.1</td></tr> <tr><td>02/13/13</td><td>2.1</td><td>221.3</td></tr> </tbody> </table>														Date	Depth (mm)	Elev. (m)	11/15/12	2.7	220.7	11/16/12	4.6	218.8	11/23/12	4.5	218.9	01/22/13	2.2	221.2	02/07/13	2.3	221.1	02/13/13	2.1	221.3
Date	Depth (mm)	Elev. (m)																																
11/15/12	2.7	220.7																																
11/16/12	4.6	218.8																																
11/23/12	4.5	218.9																																
01/22/13	2.2	221.2																																
02/07/13	2.3	221.1																																
02/13/13	2.1	221.3																																

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GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (FILL)

FIGURE B1



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

LEGEND

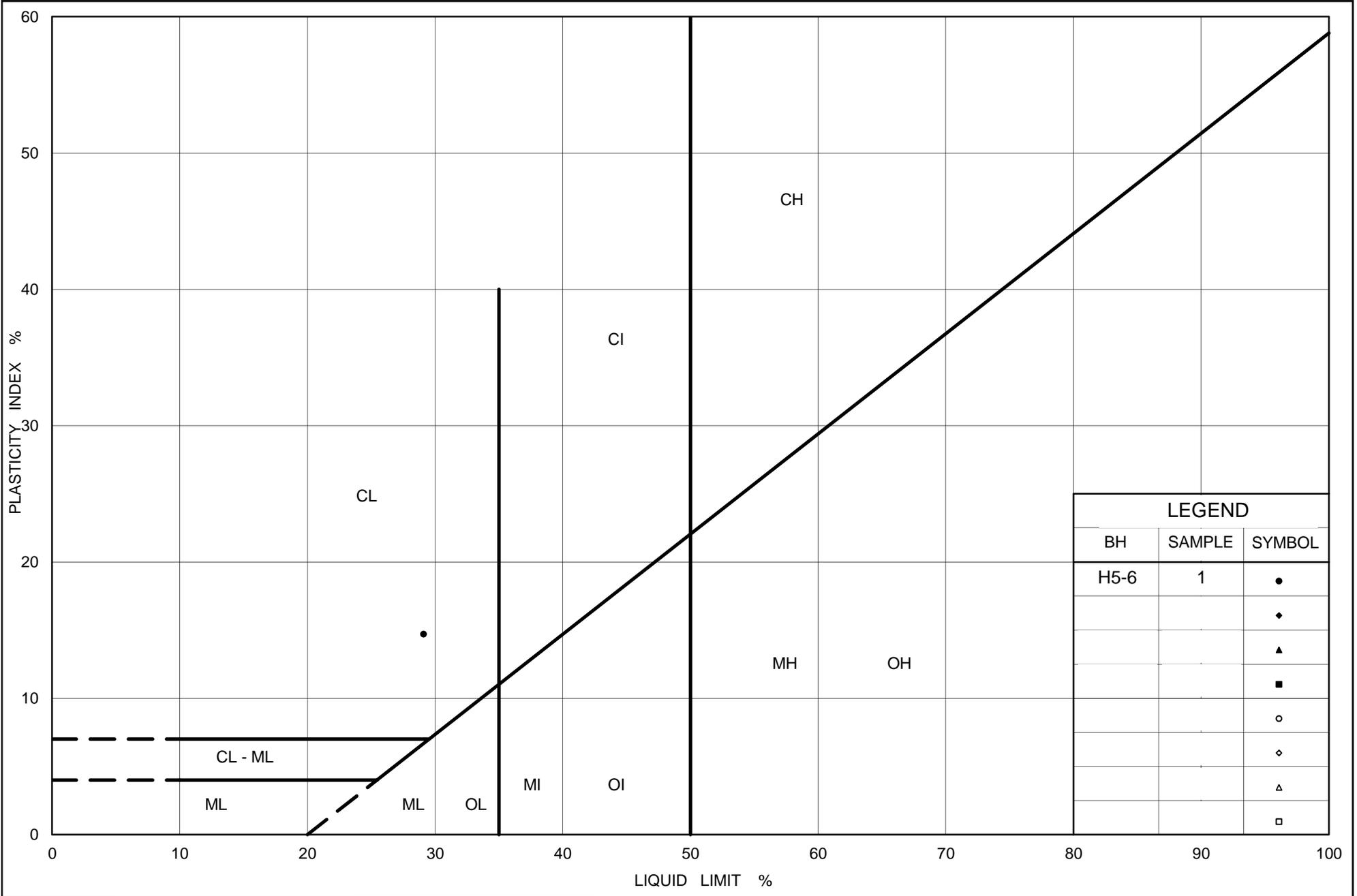
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	H5-6	2	221.1

Project Number: 10-1184-0016

Checked By: TVA

Golder Associates

Date: 11-Feb-14



LEGEND		
BH	SAMPLE	SYMBOL
H5-6	1	•
		◊
		▲
		■
		○
		◇
		△
		□



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PLASTICITY CHART

Clayey Silt with Sand (FILL)

Figure No. B2

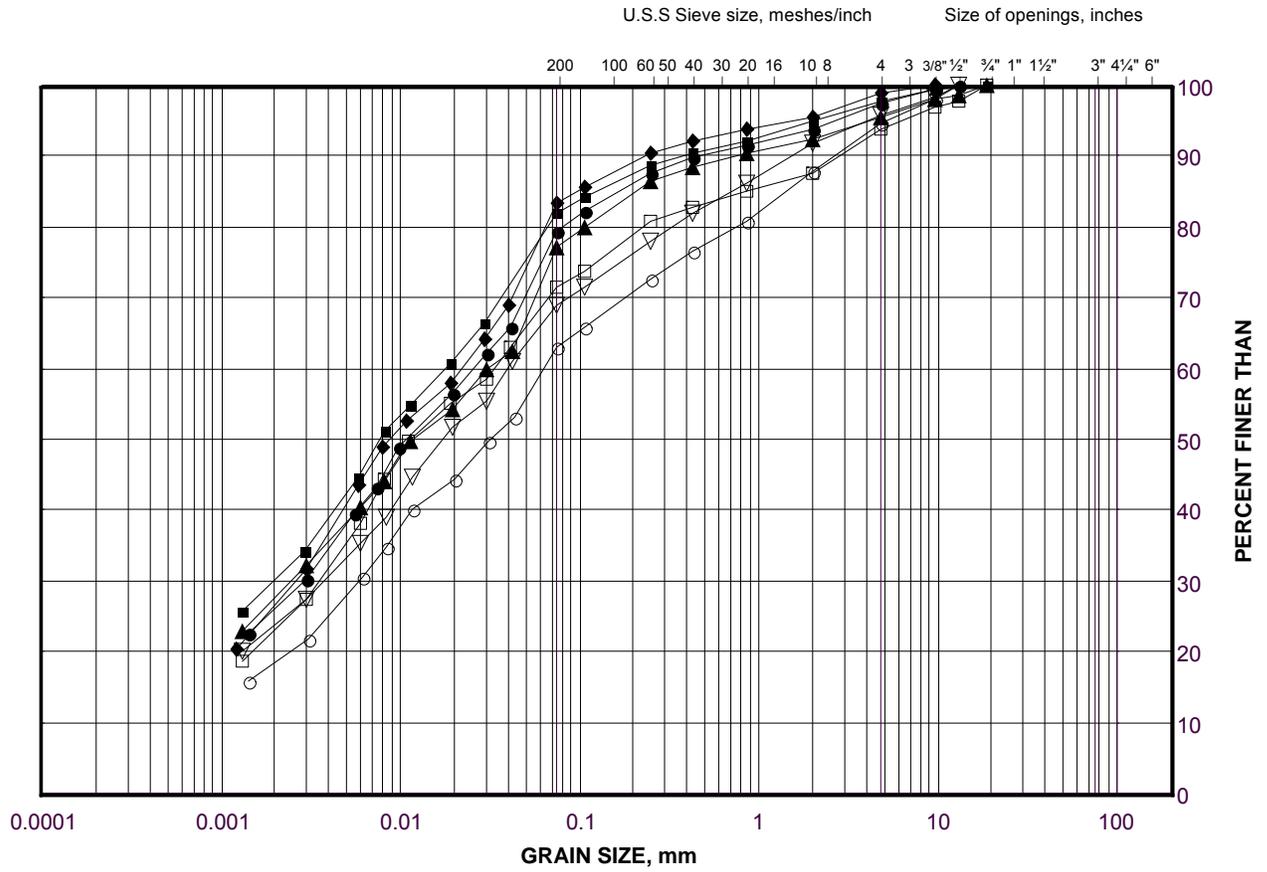
Project No. 10-1184-0016

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (TILL)

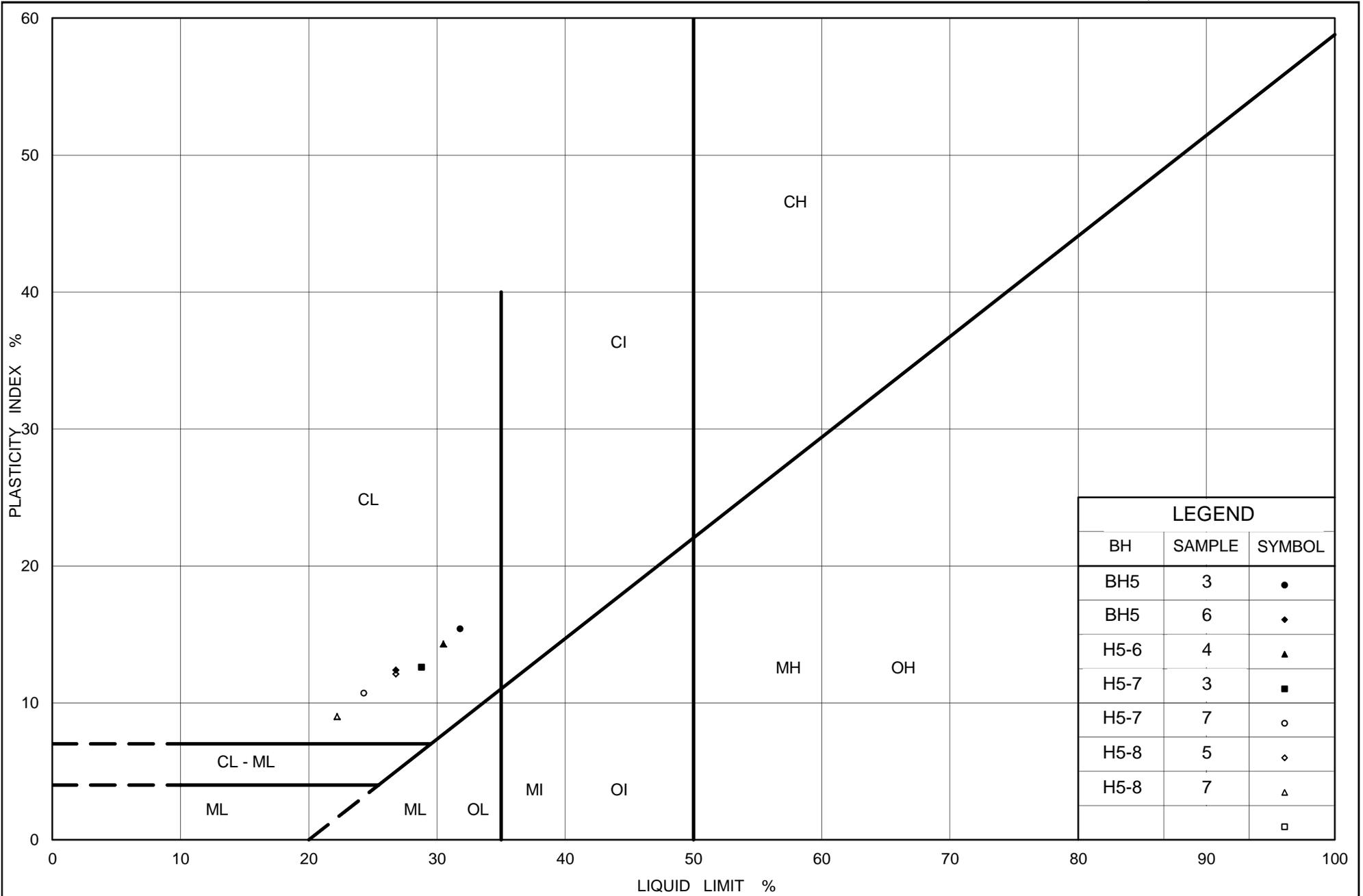
FIGURE B3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	H5-7	3	220.8
■	BH5	3	219.9
◆	H5-6	4	219.6
▲	H5-8	5	220.1
▽	BH5	6	217.6
○	H5-8	7	218.6
□	H5-7	7	217.8



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PLASTICITY CHART Clayey Silt (TILL)

Figure No. B4

Project No. 10-1184-0016

Checked By: TVA



APPENDIX C

Ramp W-S: STA. 10+000 to STA. 10+140 (High Fill Area 3) Record of Boreholes and Laboratory Test Results

PROJECT 10-1184-0016 **RECORD OF BOREHOLE No WS-1** **SHEET 1 OF 1** **METRIC**
G.W.P. 2112-05-00 **LOCATION** N 4796977.4 ; E 270880.3 **ORIGINATED BY** JBH
DIST HWY 5 & 6 **BOREHOLE TYPE** 102 mm O.D. Continuous Flight Solid Stem Augers **COMPILED BY** BM
DATUM Geodetic **DATE** November 21, 2012 **CHECKED BY** TVA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80	100	10	20
222.1	GROUND SURFACE																							
0.0	ASPHALT																							
0.2	Sand and gravel, trace silt (FILL)																							
221.3	Brown Moist																							
0.8	Sandy silt, trace gravel, trace clay, clayey silt seams (FILL)		1	SS	12																			
220.7	Compact Dark brown Moist																							
1.4	Clayey silt, sandy, some gravel, sand seams (FILL)		2	SS	13																			14 25 40 21
220.0	Stiff Brown Moist																							
2.1	CLAYEY SILT, some sand, trace gravel (TILL)		3	SS	22																			
	Stiff to very stiff Brown to grey Moist		4	SS	27																			2 14 52 32
			5	SS	23																			
			6	SS	19																			
			7	SS	13																			
			8	SS	7/0.03																			
215.8	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK																							
6.3	NOTE: 1. Borehole dry upon completion of drilling.																							

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PROJECT 10-1184-0016 **RECORD OF BOREHOLE No WS-2** **SHEET 1 OF 1** **METRIC**
G.W.P. 2112-05-00 **LOCATION** N 4796968.4 ; E 270932.5 **ORIGINATED BY** JBH
DIST HWY 5 & 6 **BOREHOLE TYPE** 102 mm O.D. Continuous Flight Solid Stem Augers **COMPILED BY** BM
DATUM Geodetic **DATE** November 21, 2012 **CHECKED BY** TVA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80	100	10	20
222.5	GROUND SURFACE																							
0.0	ASPHALT																							
0.2	Sand and gravel, trace silt (FILL)																							
221.7	Brown Moist																							
0.8	Clayey silt, trace sand (FILL)		1	SS	6																			
221.1	Firm Brown Moist																							
1.4	CLAYEY SILT, sandy, trace gravel, sand seams to a depth of 2.7 m (TILL)		2	SS	19																			
	Stiff to hard Brown Moist		3	SS	25																			
			4	SS	33																			
			5	SS	28																			
			6	SS	13																			
			7	SS	11																			
			8	SS	5/0.08																			
216.2	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK																							
6.3	NOTE: 1. Borehole dry upon completion of drilling.																							

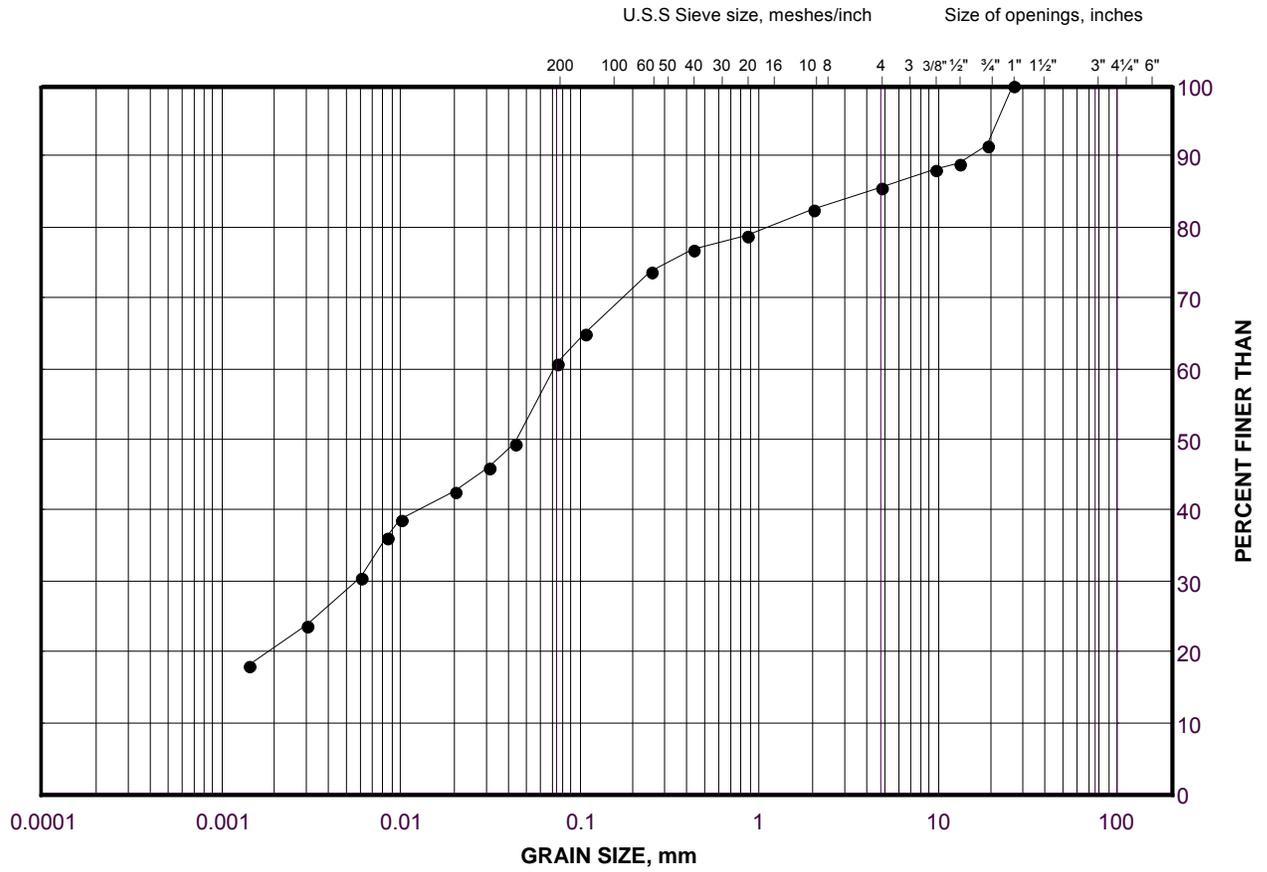
GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 11/18/14 DD

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

GRAIN SIZE DISTRIBUTION

Clayey Silt (FILL)

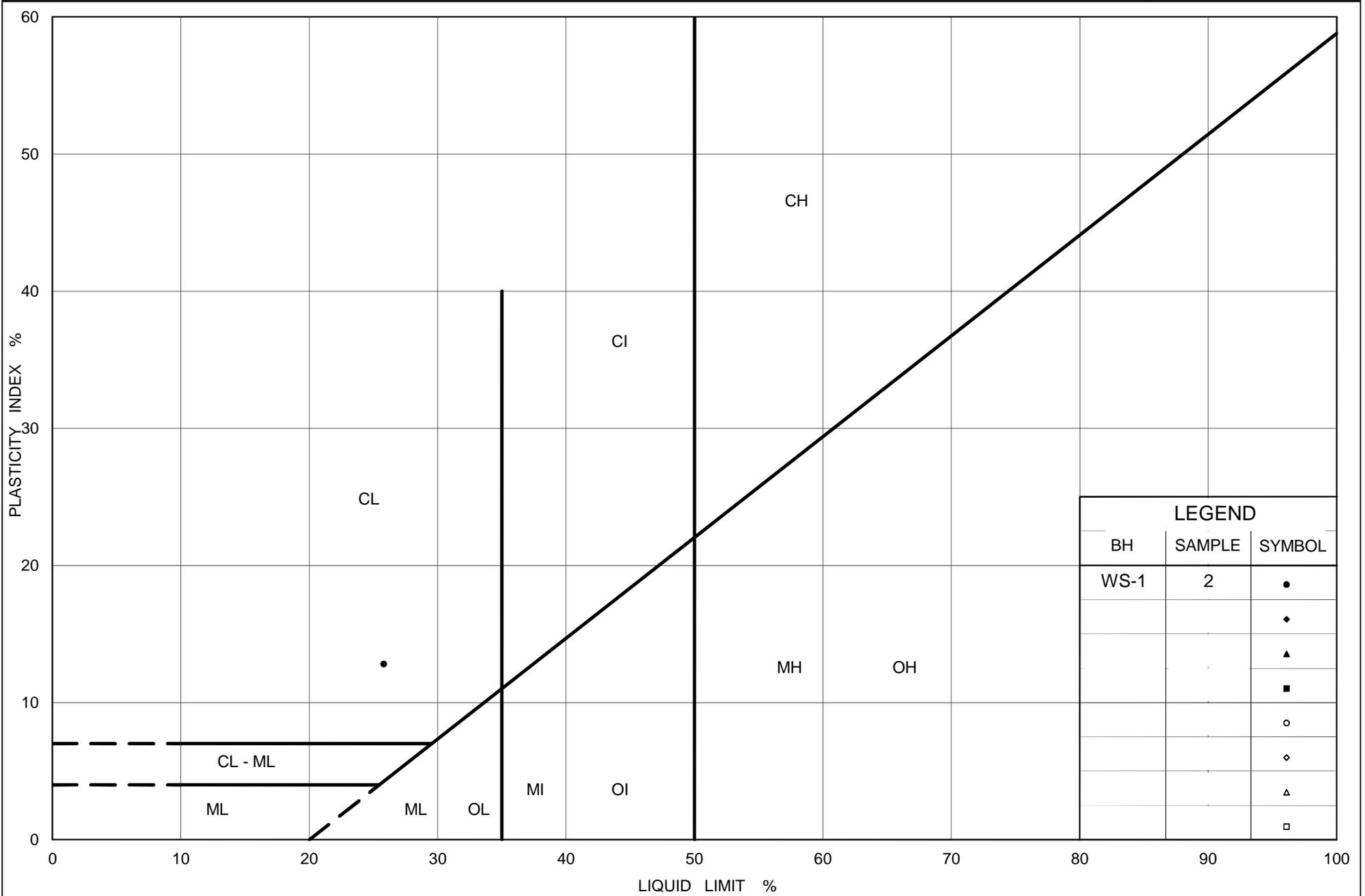
FIGURE C1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	WS-1	2	220.4



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PLASTICITY CHART

Clayey Silt (FILL)

Figure No. C2

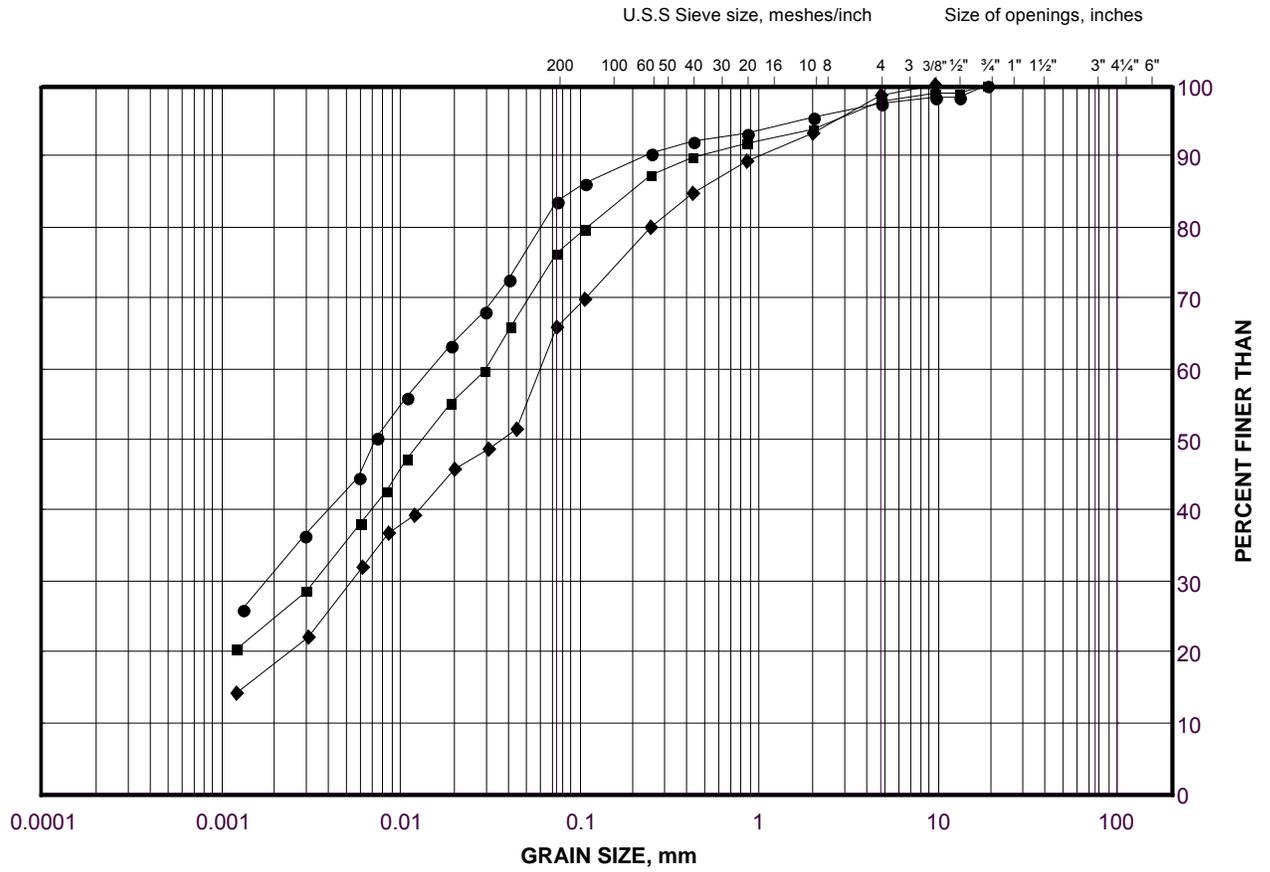
Project No. 10-1184-0016

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (TILL)

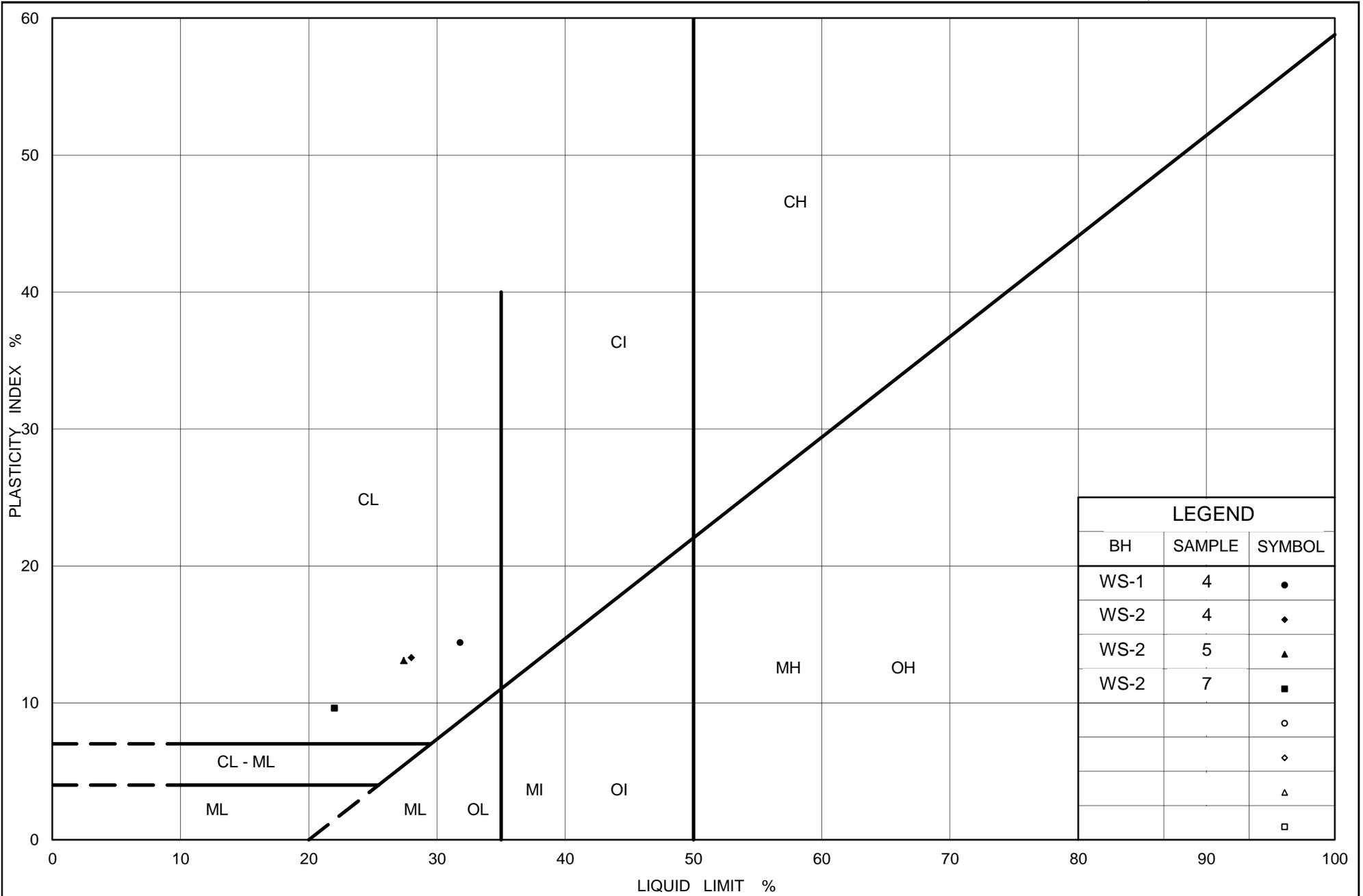
FIGURE C3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WS-1	4	218.8
■	WS-2	5	218.5
◆	WS-2	7	216.9



LEGEND		
BH	SAMPLE	SYMBOL
WS-1	4	●
WS-2	4	◆
WS-2	5	▲
WS-2	7	■
		○
		◇
		△
		□



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PLASTICITY CHART Clayey Silt (TILL)

Figure No. C4

Project No. 10-1184-0016

Checked By: TVA



APPENDIX D

Ramp E-S: STA. 10+000 to STA. 10+100 (High Fill Area 4) Record of Boreholes and Laboratory Test Results

PROJECT 10-1184-0016 **RECORD OF BOREHOLE No ES-1** **SHEET 1 OF 1** **METRIC**
G.W.P. 2112-05-00 **LOCATION** N 4797002.5;E 270841.8 **ORIGINATED BY** JBH
DIST HWY 5 & 6 **BOREHOLE TYPE** 102 mm O.D. Continuous Flight Solid Stem Augers **COMPILED BY** BM
DATUM Geodetic **DATE** November 13, 2012 **CHECKED BY** TVA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
220.0	GROUND SURFACE																
0.0	ASPHALT																
0.1	Sand and gravel, some silt, trace clay (FILL)		1	SS	23												53 32 13 2
219.3	Compact Brown Moist		2	SS	12												
0.7	Clayey silt, trace sand, trace organics (FILL)						219										
218.6	Stiff Brown Moist to wet		3	SS	14												
1.4	CLAYEY SILT, sandy to some sand, trace gravel (TILL)						218										1 18 52 29
	Stiff to hard Brown to grey Moist		4	SS	24												
			5	SS	27												
			6	SS	20												3 22 50 25
			7	SS	18												
			8	SS	20												
			9	SS	37/03												
213.8	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK						214										
6.2	NOTE: 1. Borehole dry upon completion of drilling.																

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

RECORD OF BOREHOLE No ES-2 SHEET 1 OF 1 **METRIC**

PROJECT 10-1184-0016

G.W.P. 2112-05-00 LOCATION N 4796989.6; E 270816.3 ORIGINATED BY JBH

DIST _____ HWY 5 & 6 BOREHOLE TYPE 102 mm O.D. Continuous Flight Solid Stem Augers COMPILED BY BM

DATUM Geodetic DATE November 13, 2012 CHECKED BY TVA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)						
						20	40	60	80	100	20	40	60	80	100	10	20	30	GR	SA	SI	CL	
222.5	GROUND SURFACE																						
0.0	ASPHALT																						
0.1	Sand and silt, some gravel (FILL)		1	SS	10																		
221.8	Compact Brown Moist																						
0.7	Silty clay, some sand, trace gravel, wood pieces (FILL)		2	SS	14																		
	Stiff Brown Moist to wet																						
220.4			3	SS	15																		
2.1	CLAYEY SILT, sandy, trace gravel																						
	Stiff to hard Brown to grey Moist to wet		4	SS	32																		
			5	SS	39																		
	Inferred boulder at a depth of 3.7 m		6	SS	22																		
			7	SS	14																		
			8	SS	21																		
			9	SS	21																		
215.9	END OF BOREHOLE																						
6.6	NOTE: 1. Water level in open borehole measured at a depth of 5.9 m below ground surface (Elev. 216.6 m) upon completion of drilling.																						

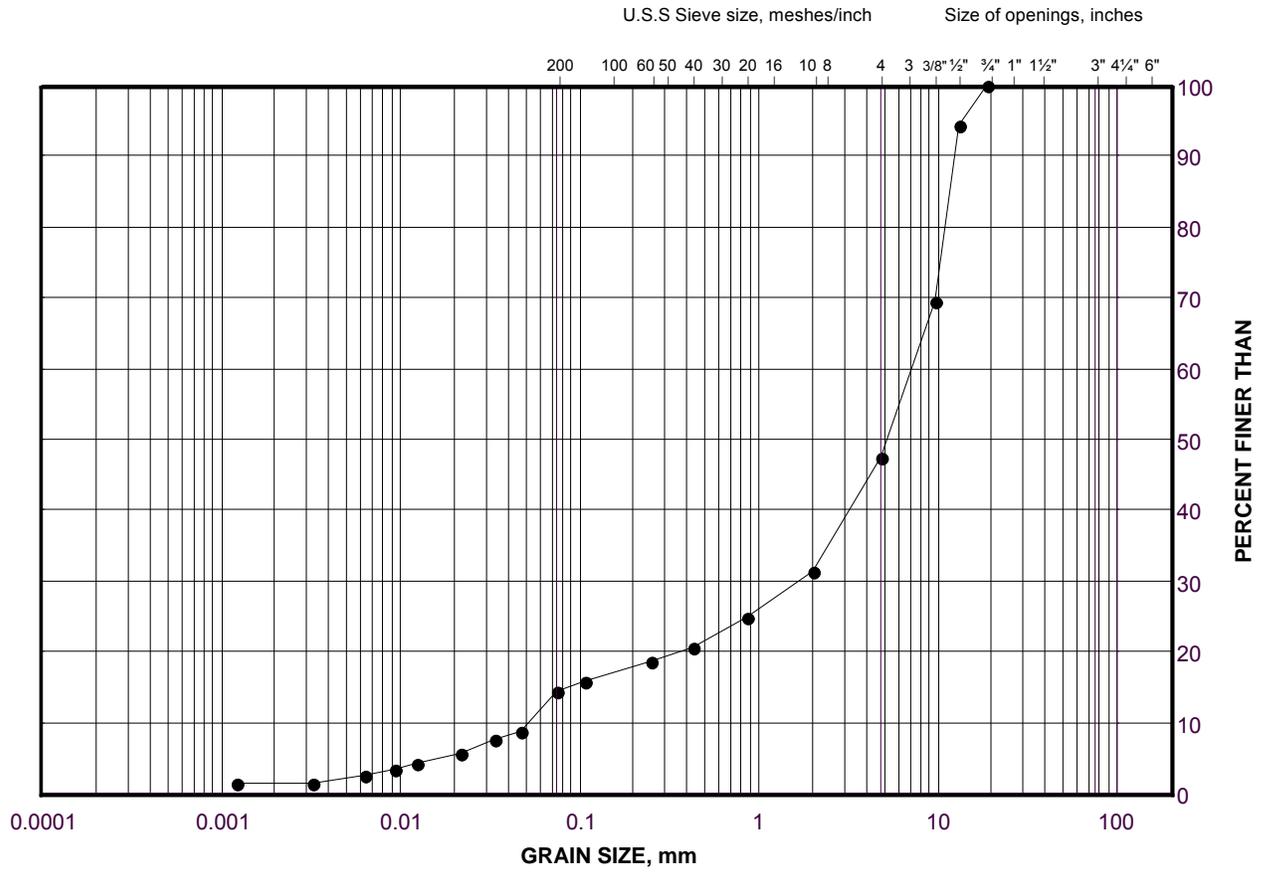
GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 11/18/14 DD

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

GRAIN SIZE DISTRIBUTION

Sand and Gravel (FILL)

FIGURE D1A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	ES-1	1	219.7

Project Number: 10-1184-0016

Checked By: TVA

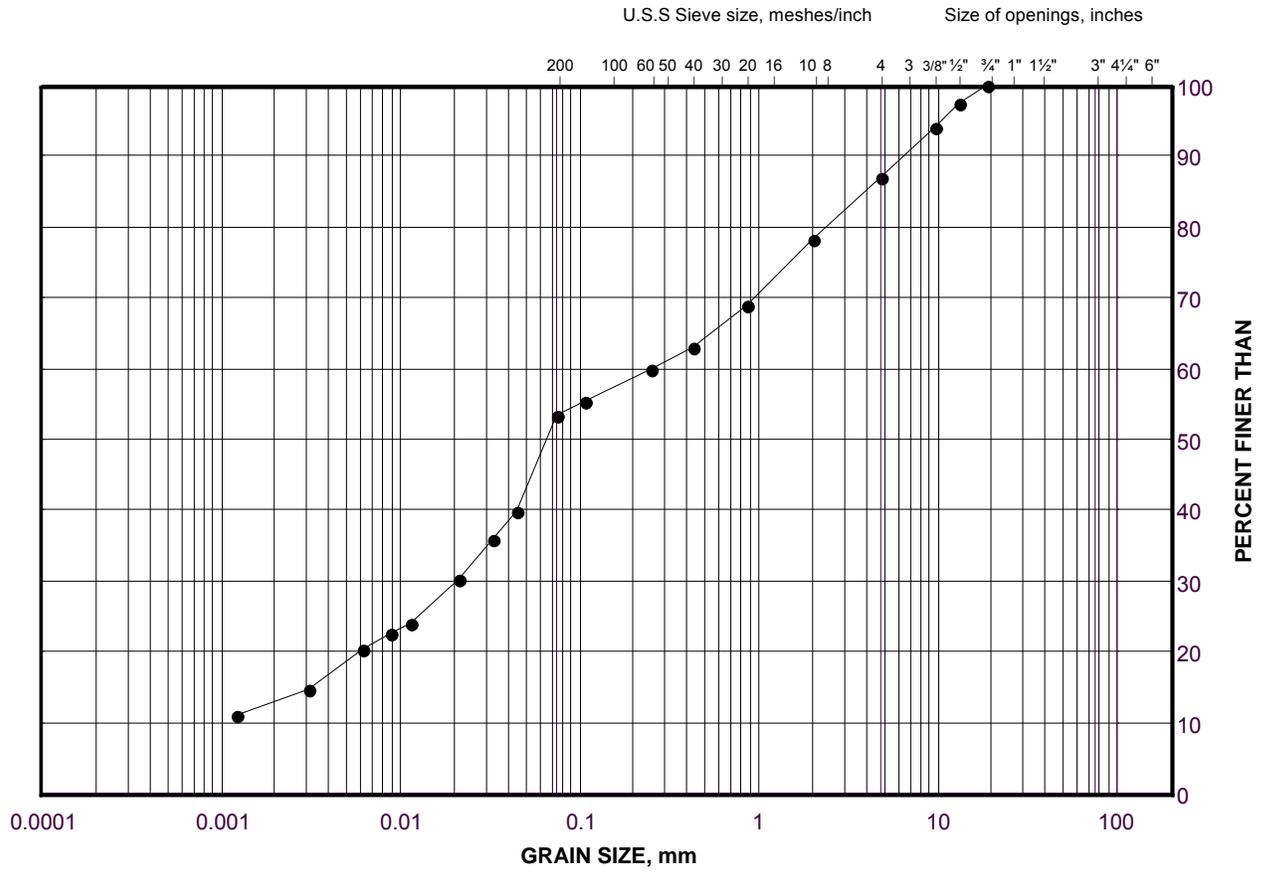
Golder Associates

Date: 11-Feb-14

GRAIN SIZE DISTRIBUTION

Sand and Silt (FILL)

FIGURE D1B



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

LEGEND

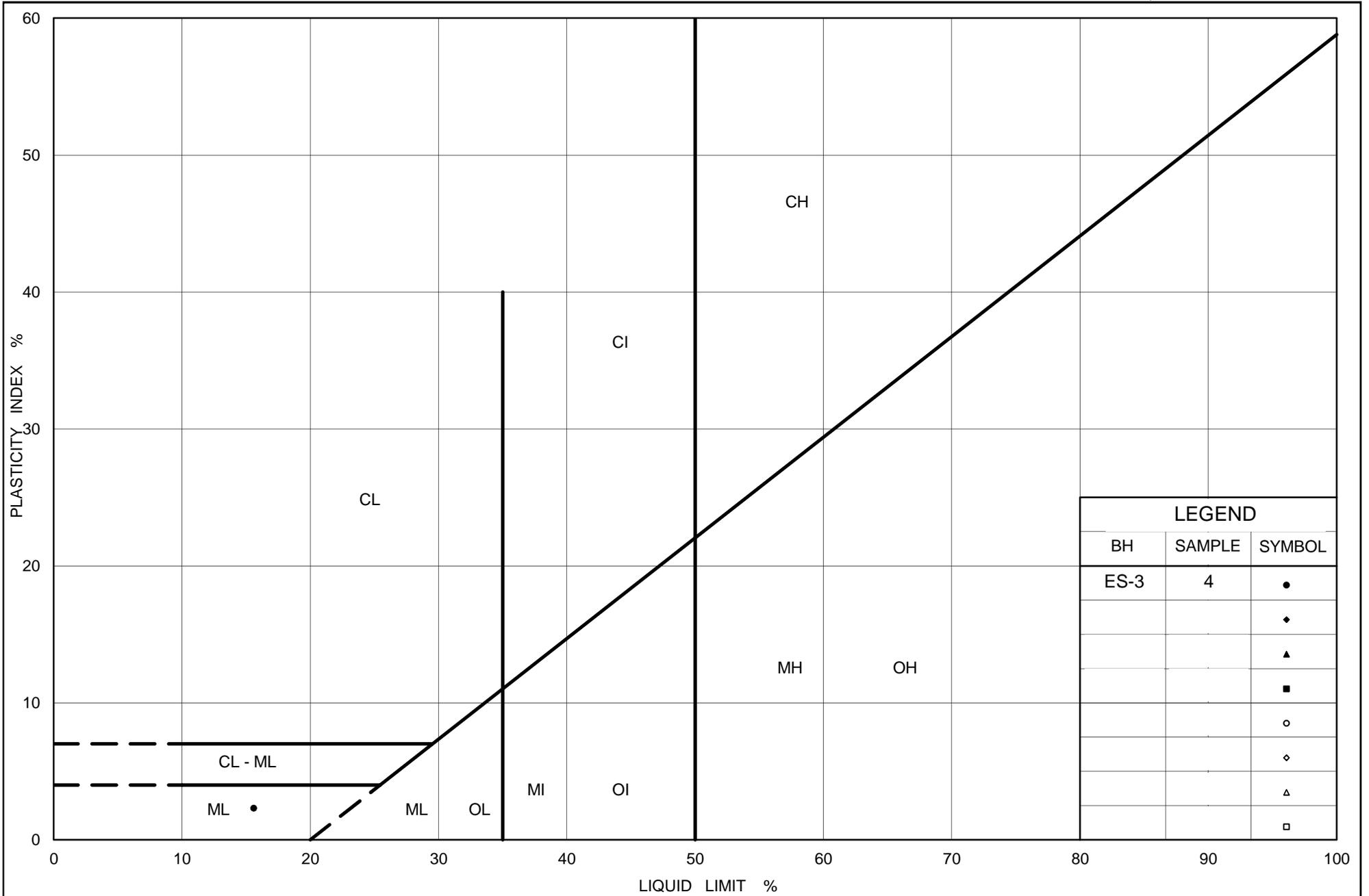
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	ES-3	3	224.6

Project Number: 10-1184-0016

Checked By: TVA

Golder Associates

Date: 11-Feb-14



LEGEND		
BH	SAMPLE	SYMBOL
ES-3	4	•
		◊
		▲
		■
		○
		◊
		▲
		□



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PLASTICITY CHART

Sand and Silt (FILL)

Figure No. D2

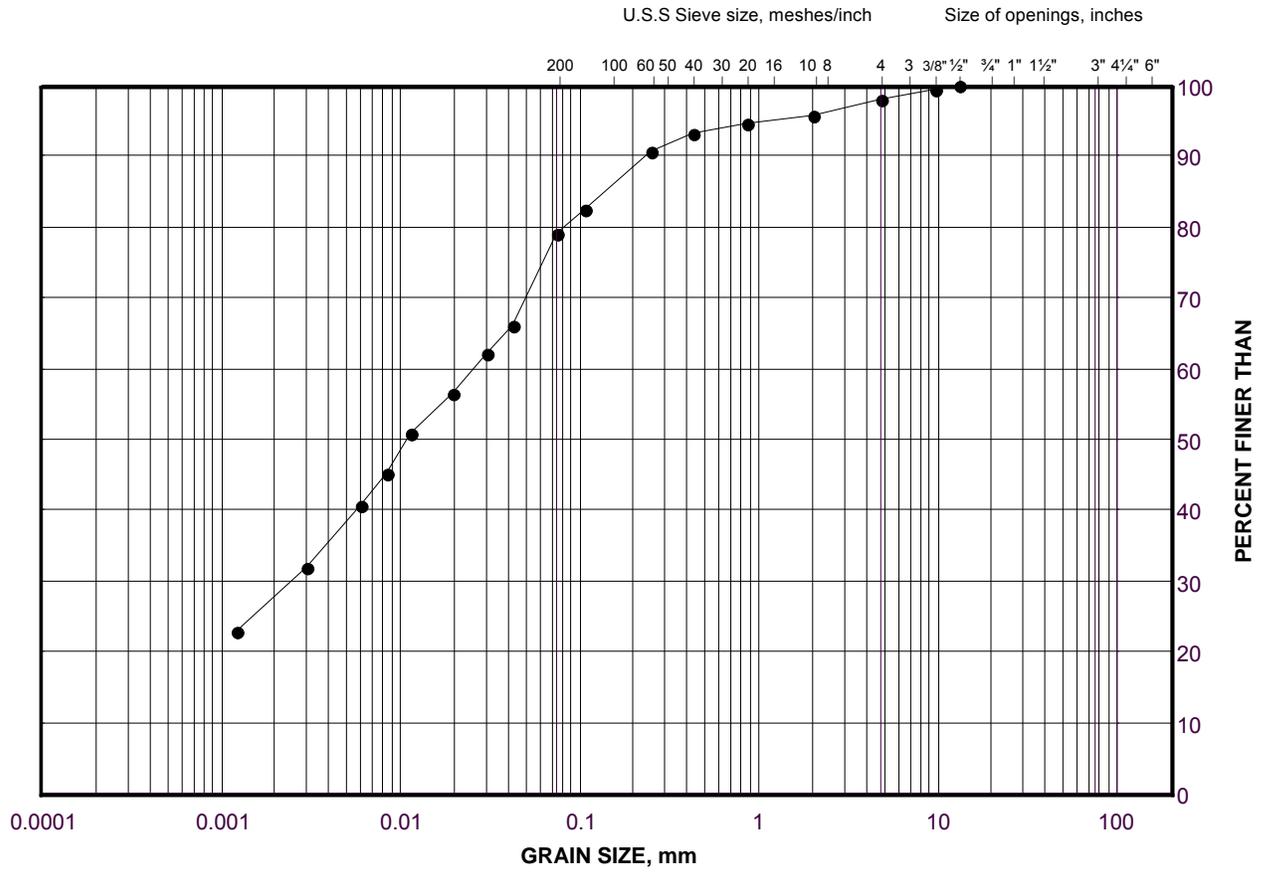
Project No. 10-1184-0016

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Silty Clay (FILL)

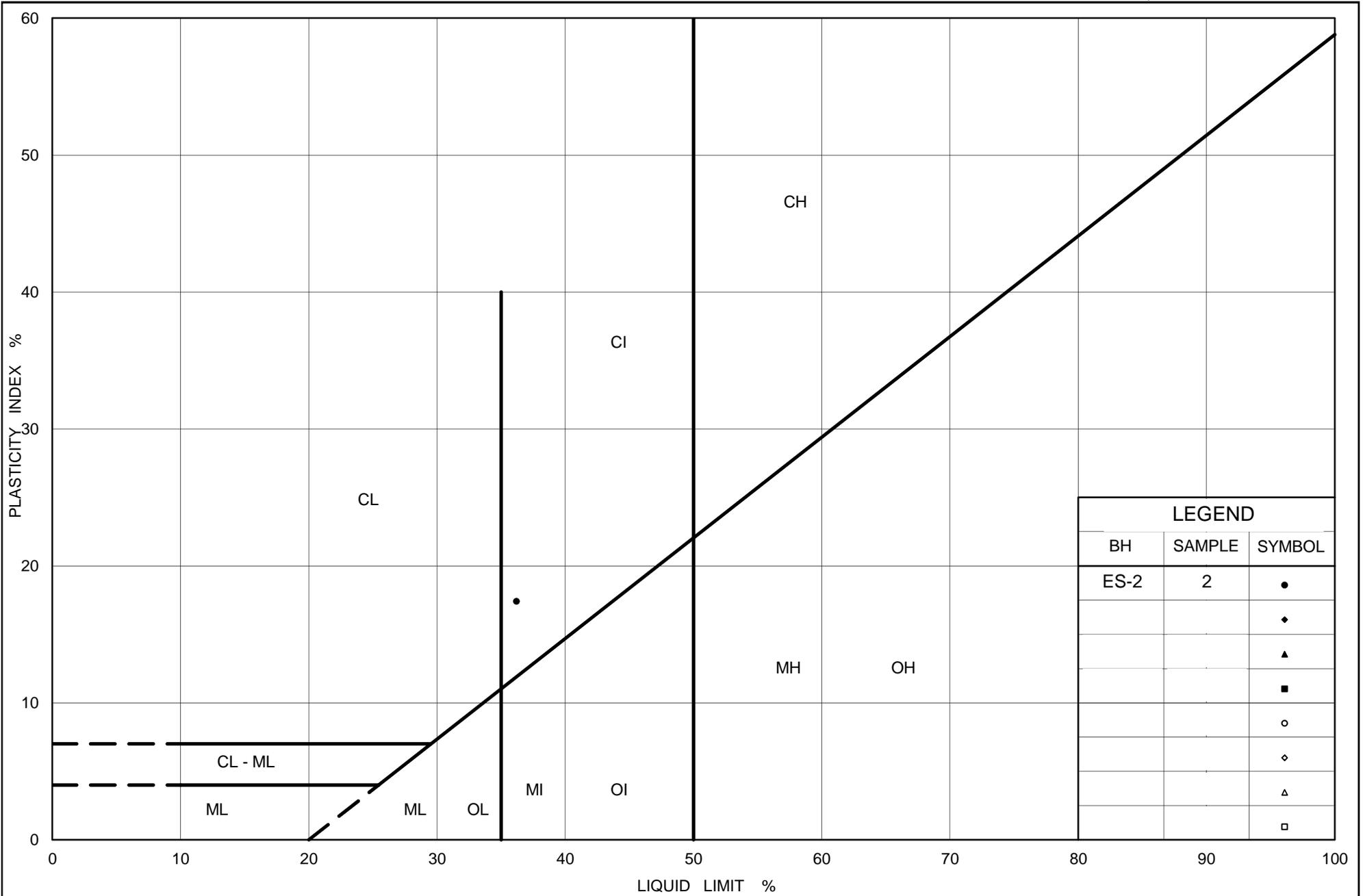
FIGURE D3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	ES-2	2	221.5



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PLASTICITY CHART

Silty Clay (FILL)

Figure No. D4

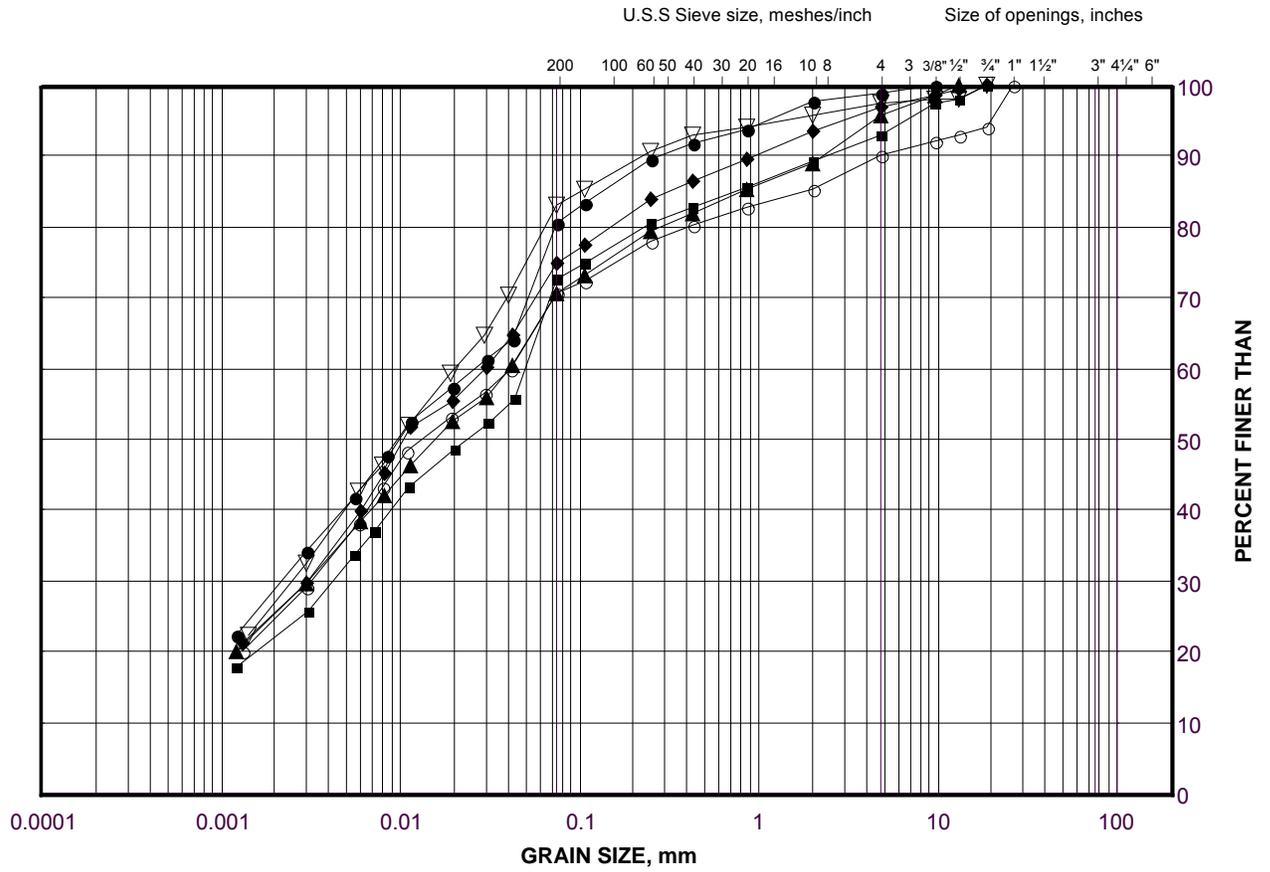
Project No. 10-1184-0016

Checked By: TVA

GRAIN SIZE DISTRIBUTION

Clayey Silt (TILL)

FIGURE D5



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

LEGEND

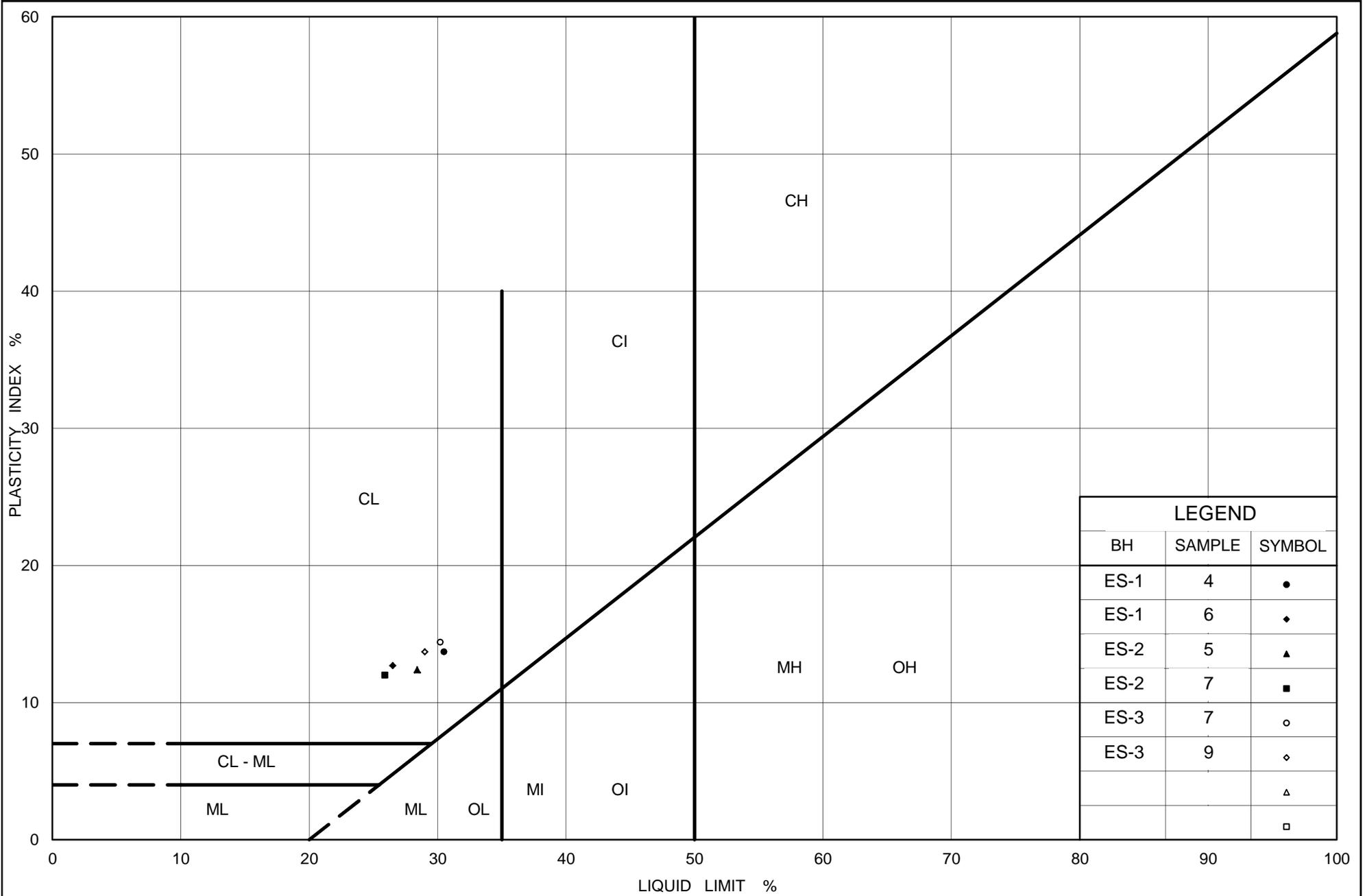
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	ES-1	4	217.5
■	ES-2	5	219.2
◆	ES-1	6	215.9
▲	ES-2	7	217.7
▽	ES-3	7	221.5
○	ES-3	9	219.9

Project Number: 10-1184-0016

Checked By: TVA

Golder Associates

Date: 11-Feb-14



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PLASTICITY CHART

Clayey Silt (TILL)

Figure No. D6

Project No. 10-1184-0016

Checked By: TVA



APPENDIX E

Ramp W-N: STA. 10+000 to STA. 10+100 (High Fill Area 5) Record of Boreholes and Laboratory Test Results

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No WN-1	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797099.2; E 270987.0</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 20, 2012</u>	CHECKED BY <u>TVA</u>	

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40
222.7	GROUND SURFACE																		
0.0	ASPHALT																		
0.2	Sand and gravel, trace silt (FILL) Brown Moist																		
221.9	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Brown Moist		1	SS	11														
0.8			2	SS	26												2 17 53 28		
			3	SS	39														
			4	SS	24														
			5	SS	15												12 26 44 18		
217.4	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK																		
5.3	NOTE: 1. Water level in open borehole measured at a depth of 4.4 m below ground surface (Elev. 218.3 m) upon completion of drilling.																		

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

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No WN-2	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797109.9; E 271008.8</u>	ORIGINATED BY <u>JBH</u>	
DIST <u>HWY 5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 20, 2012</u>	CHECKED BY <u>TVA</u>	

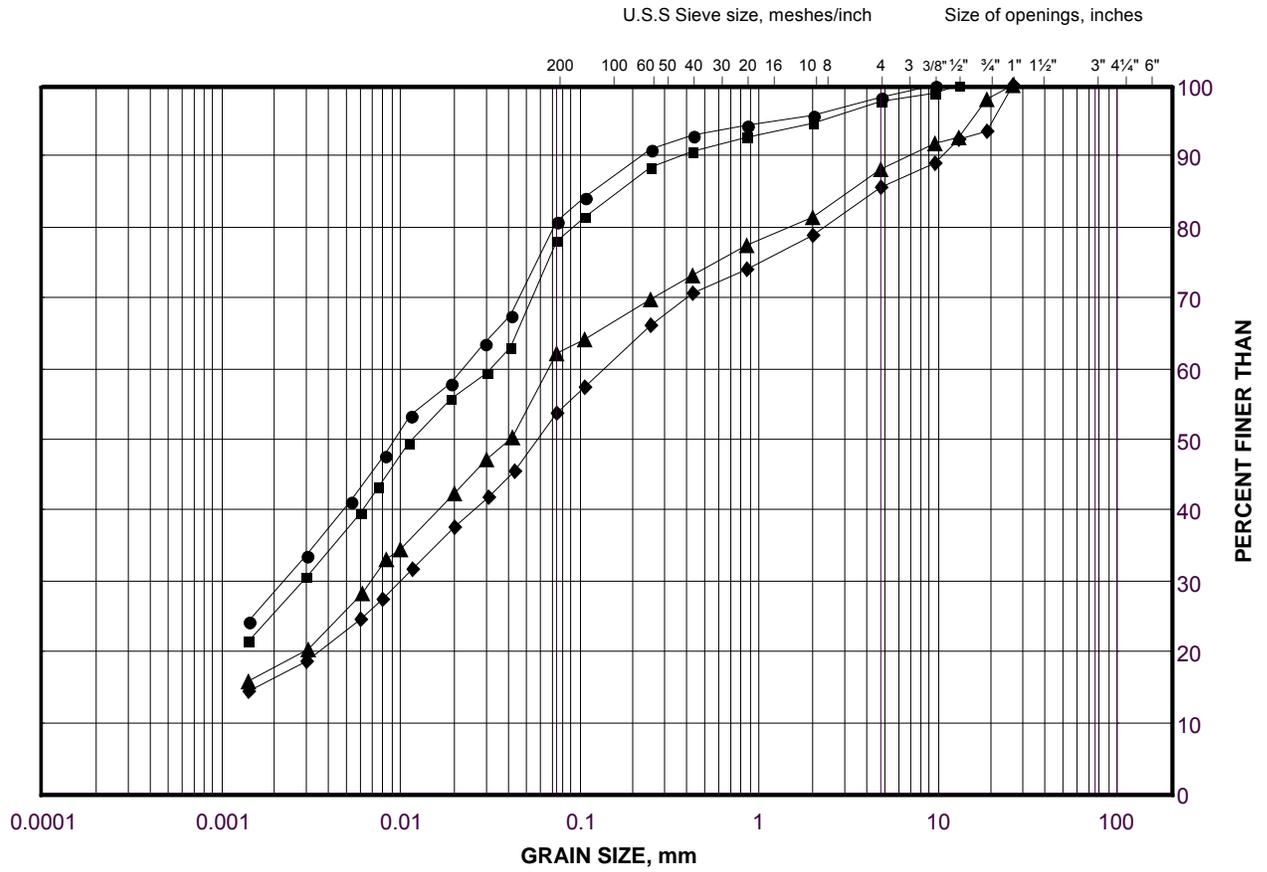
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	10 20 30	10 20 30	10 20 30		
223.1	GROUND SURFACE															
0.0	ASPHALT						223									
222.8																
0.3	Sand and gravel, trace silt (FILL) Brown Moist															
222.3																
0.8	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Brown Moist		1	SS	13		222									
			2	SS	25							o				
			3	SS	37		221									
			4	SS	44		220					d			2 20 52 26	
	with SAND, some gravel					▽	219									
218.1	END OF BOREHOLE		5	SS	16							d			15 31 38 16	
5.0	NOTE: 1. Water level in open borehole measured at a depth of 4.4 m below ground surface (Elev. 218.7 m) upon completion of drilling.															

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 11/18/14 DD

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (TILL)

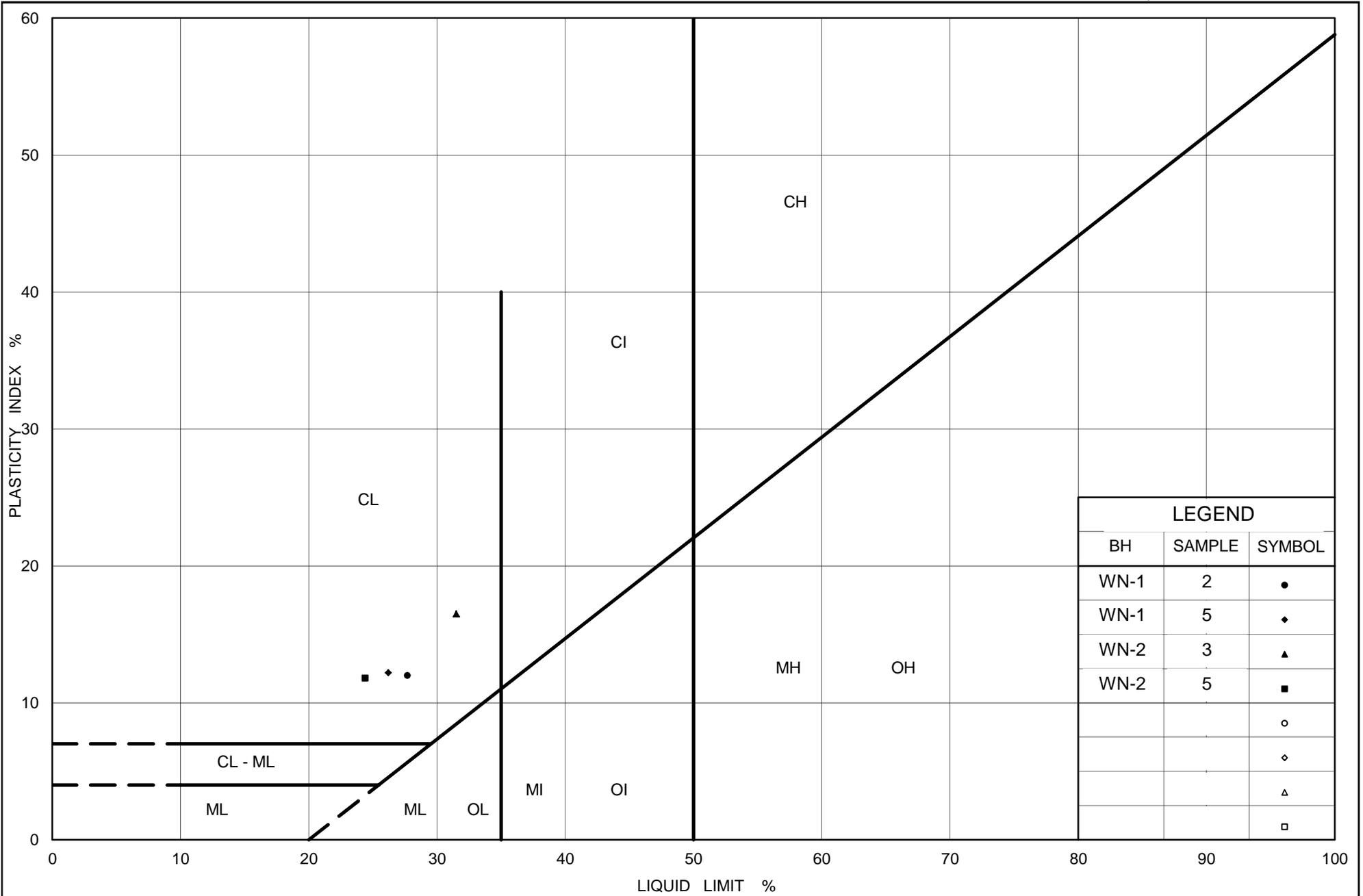
FIGURE E1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	WN-1	2	220.9
■	WN-2	3	220.6
◆	WN-2	5	218.4
▲	WN-1	5	218.9



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PLASTICITY CHART

Clayey Silt (TILL)

Figure No. E2

Project No. 10-1184-0016

Checked By: TVA



APPENDIX F

Ramp E-N: STA. 10+000 to STA. 10+210 (High Fill Area 6) Record of Boreholes and Laboratory Test Results

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No EN-1	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797131.6; E 270948.2</u>	ORIGINATED BY <u>JBH</u>	
DIST <u> </u> HWY <u>5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 14, 2012</u>	CHECKED BY <u>TVA</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
222.4	GROUND SURFACE						20	40	60	80	100					
0.0	TOPSOIL	[diagonal lines]	1	SS	9											
222.1	Clayey silt, sandy, trace gravel (FILL)	[cross-hatch]	2	SS	10							○	-----		1	23 59 17
0.3	Stiff Brown Moist															
221.0	CLAYEY SILT with SAND, sand layers between depths of 2.3 m and 3.5 m (TILL)	[cross-hatch]	3	SS	27							○				
1.4	Very stiff to hard Brown Moist															
220		[cross-hatch]	4	SS	32							-----○-----		0	34 46 20	
219		[cross-hatch]	5	SS	28											
218		[cross-hatch]	6	SS	25	▽						○				
217.1	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK		7	SS	20											
5.3	NOTE: 1. Water level in open borehole measured at a depth of 4.7 m below ground surface (Elev. 217.7 m) upon completion of drilling.															

GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 11/18/14 DD

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

PROJECT 10-1184-0016 **RECORD OF BOREHOLE No EN-2** **SHEET 1 OF 1** **METRIC**
G.W.P. 2112-05-00 **LOCATION** N 4797125.7 ; E 270923.8 **ORIGINATED BY** JBH
DIST HWY 5 & 6 **BOREHOLE TYPE** 102 mm O.D. Continuous Flight Solid Stem Augers **COMPILED BY** BM
DATUM Geodetic **DATE** November 14, 2012 **CHECKED BY** TVA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	SHEAR STRENGTH kPa
222.2	GROUND SURFACE																	
0.0	TOPSOIL																	
0.2	Clayey silt with sand, trace gravel (FILL) Stiff Brown Moist		1	SS	11													
			2	SS	9													
220.8	CLAYEY SILT, trace to some sand, trace gravel (TILL) Very stiff to hard Brown Moist																	
1.4			3	SS	19													
			4	SS	31													
			5	SS	28													
			6	SS	40													
			7A 7B	SS	48													
216.9	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK																	
5.3	NOTE: 1. Water level in open borehole measured at a depth of 4.8 m below ground surface (Elev. 217.4 m) upon completion of drilling.																	

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

PROJECT <u>10-1184-0016</u>	RECORD OF BOREHOLE No EN-3	SHEET 1 OF 1	METRIC
G.W.P. <u>2112-05-00</u>	LOCATION <u>N 4797126.1 ; E 270902.9</u>	ORIGINATED BY <u>JBH</u>	
DIST <u> </u> HWY <u>5 & 6</u>	BOREHOLE TYPE <u>102 mm O.D. Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>BM</u>	
DATUM <u>Geodetic</u>	DATE <u>November 19, 2012</u>	CHECKED BY <u>TVA</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20 40 60 80 100	○ UNCONFINED	+ FIELD VANE								
						20 40 60 80 100	● QUICK TRIAXIAL	× REMOULDED								
222.1	GROUND SURFACE															
0.0	TOPSOIL															
0.2	Sandy silt, trace clay, trace organics and pieces of brick (FILL)	1	SS	9												
221.4	Loose Dark brown to brown Moist	2	SS	5												
0.7	Clayey silt, trace to with sand, trace gravel, trace organics, sand pockets and topsoil between depths of 1.0 m and 1.1 m (FILL)	3	SS	12												
220.0	Firm to stiff Brown Moist	4	SS	26							○				3	20 51 26
2.1	CLAYEY SILT, sandy to some sand, trace to some gravel (TILL) Very stiff to hard Brown Moist	5	SS	31							○					
		6	SS	37							○				6	24 51 19
	Wet	7A 7B	SS	19							○					
216.8	END OF BOREHOLE AUGER REFUSAL INFERRED BEDROCK															
5.3	NOTE: 1. Water level in open borehole measured at a depth of 4.1 m below ground surface (Elev. 218.0 m) upon completion of drilling.															

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

RECORD OF BOREHOLE No EN-4 SHEET 1 OF 1 **METRIC**

PROJECT 10-1184-0016

G.W.P. 2112-05-00 LOCATION N 4797134.5; E 270875.4 ORIGINATED BY JBH

DIST _____ HWY 5 & 6 BOREHOLE TYPE 102 mm O.D. Continuous Flight Solid Stem Augers COMPILED BY BM

DATUM Geodetic DATE November 19, 2012 CHECKED BY TVA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)										
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20	40	60	80	100	10	20	30	GR
222.2	GROUND SURFACE																									
0.0	TOPSOIL																									
0.2	Clayey silt with sand, trace gravel, asphalt pieces (FILL) Firm to stiff Brown to dark brown Moist		1	SS	12																					
			2	SS	5																					3 38 40 19
220.7	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff to hard Brown to grey Moist		3	SS	20																					
			4	SS	25																					
			5	SS	40																					
			6	SS	27																					3 19 51 27
			7	SS	16																					
216.8	END OF BOREHOLE SPOON BOUNCING AND AUGER REFUSAL INFERRED BEDROCK		8	SS	10/0.08																					
5.4																										

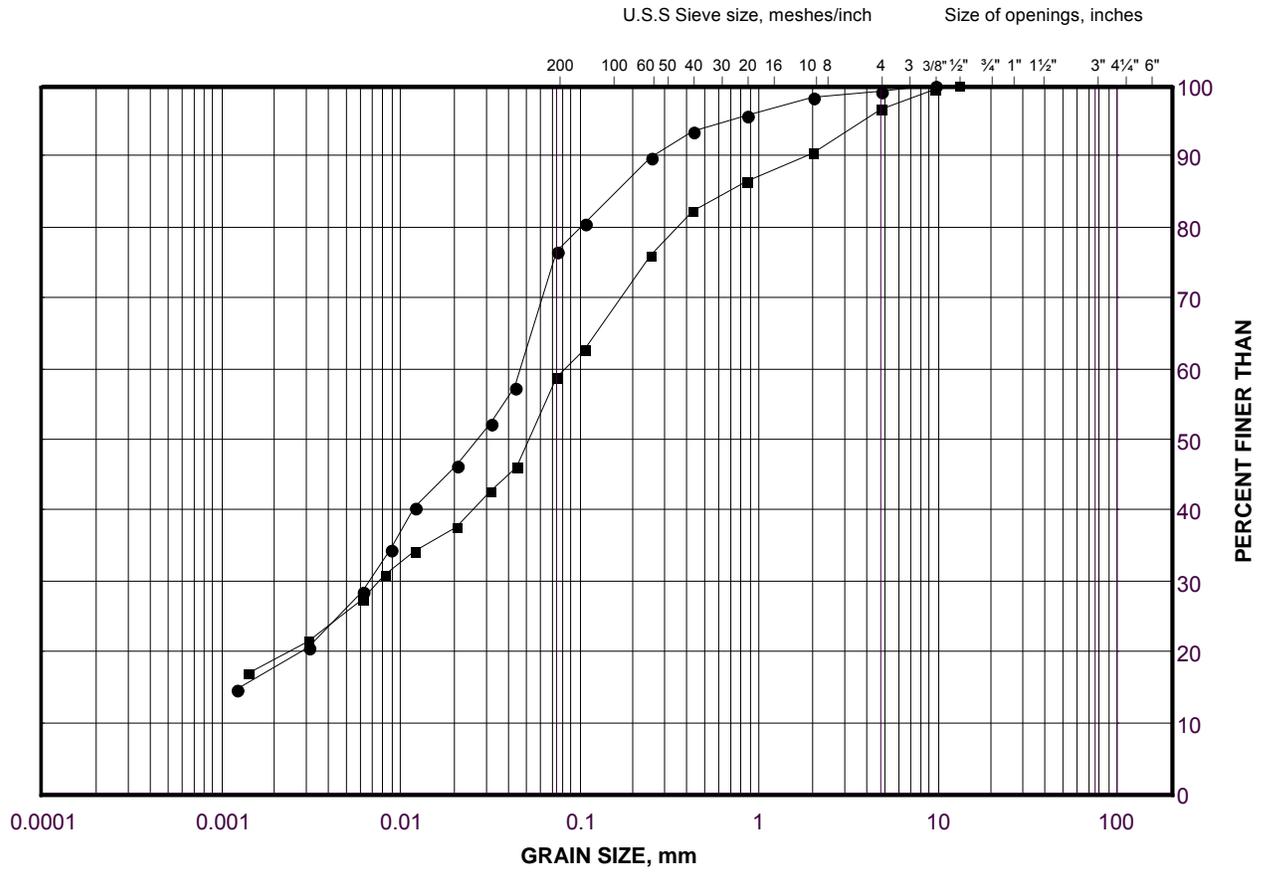
GTA-MTO 001 T:\PROJECTS\2010\10-1184-0016 (IG, HAMILTON)\LOG\10-1184-0016.GPJ GAL-GTA.GDT 11/18/14 DD

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

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (FILL)

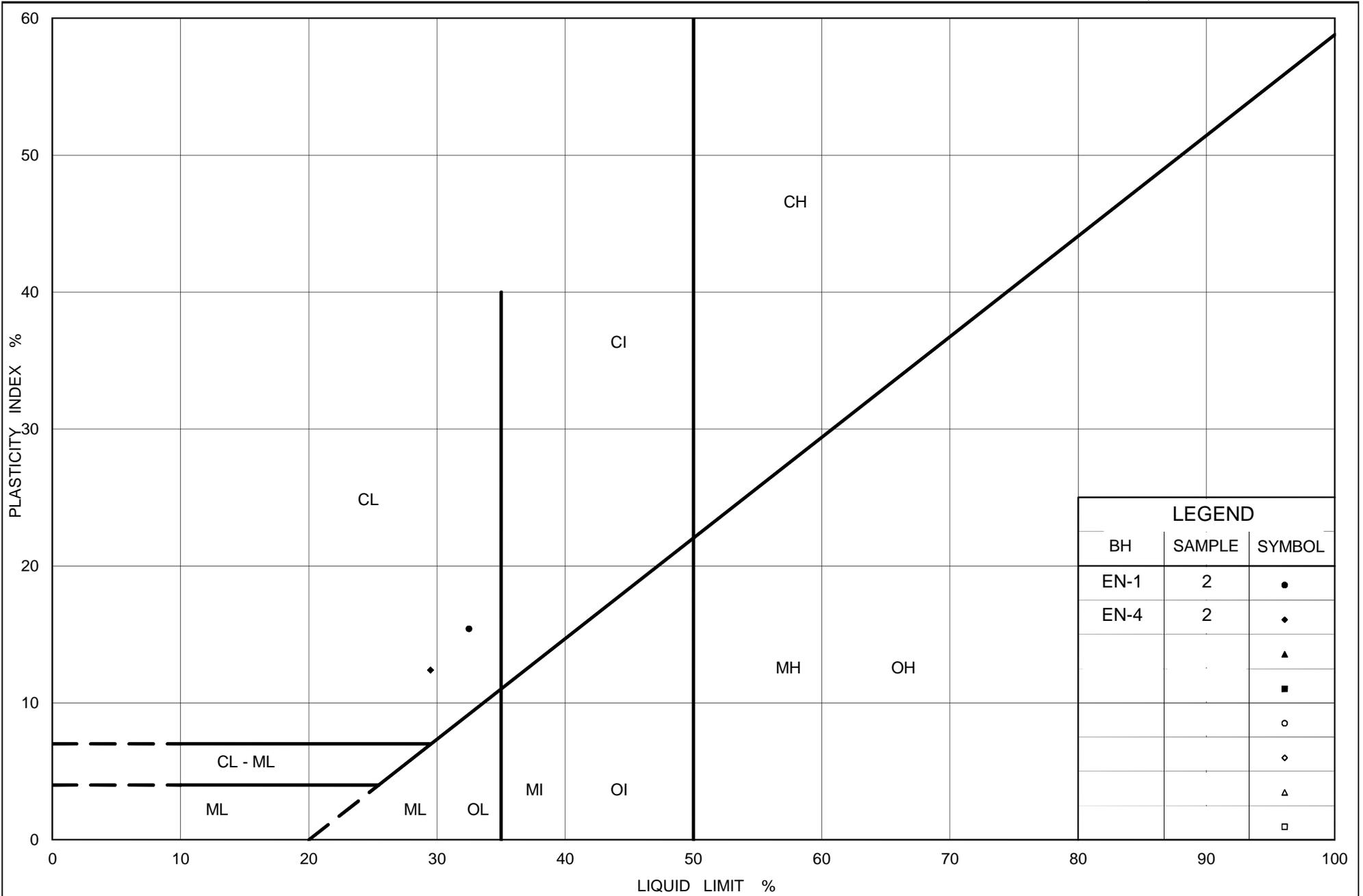
FIGURE F1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	EN-1	2	221.4
■	EN-4	2	221.3



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PLASTICITY CHART

Clayey Silt to Clayey Silt with Sand (FILL)

Figure No. F2

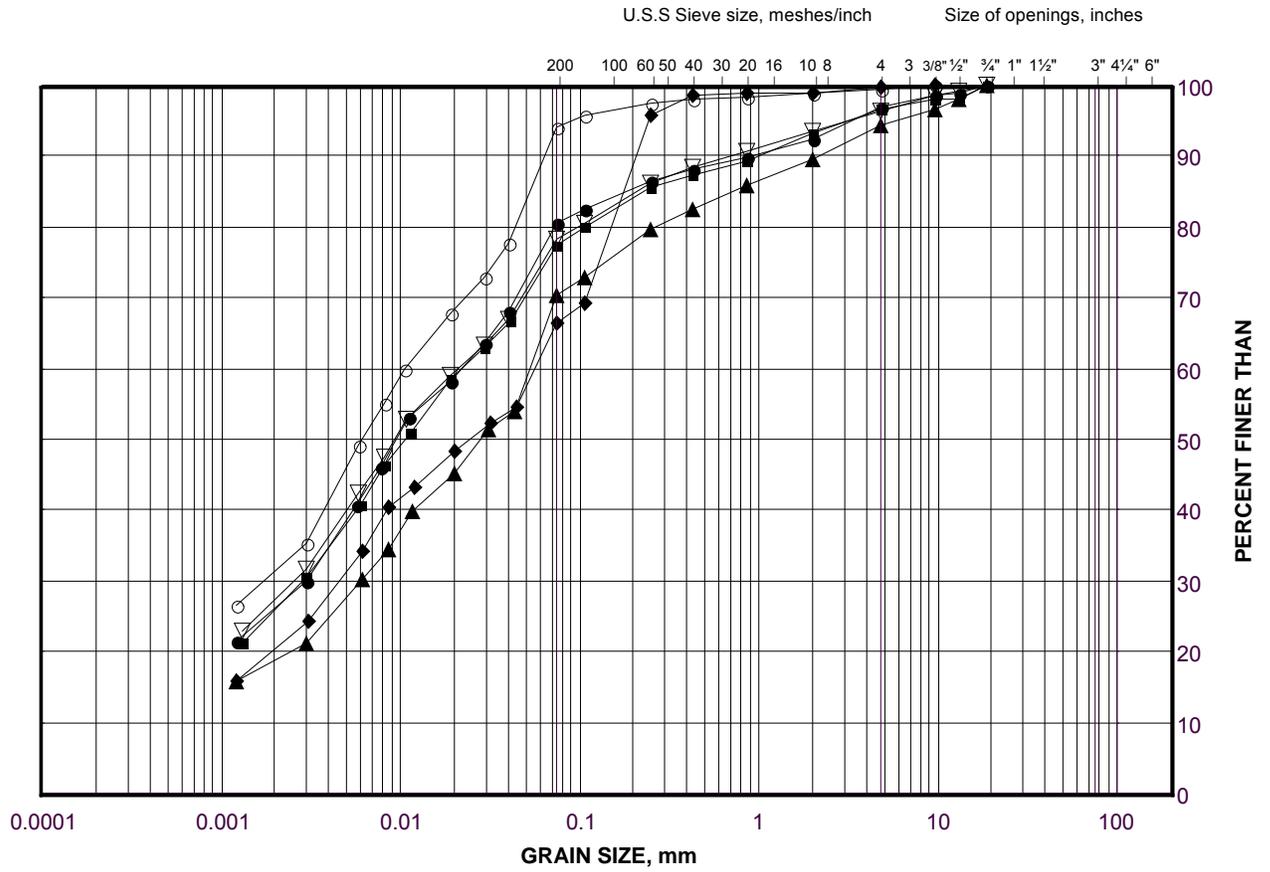
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GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand (TILL)

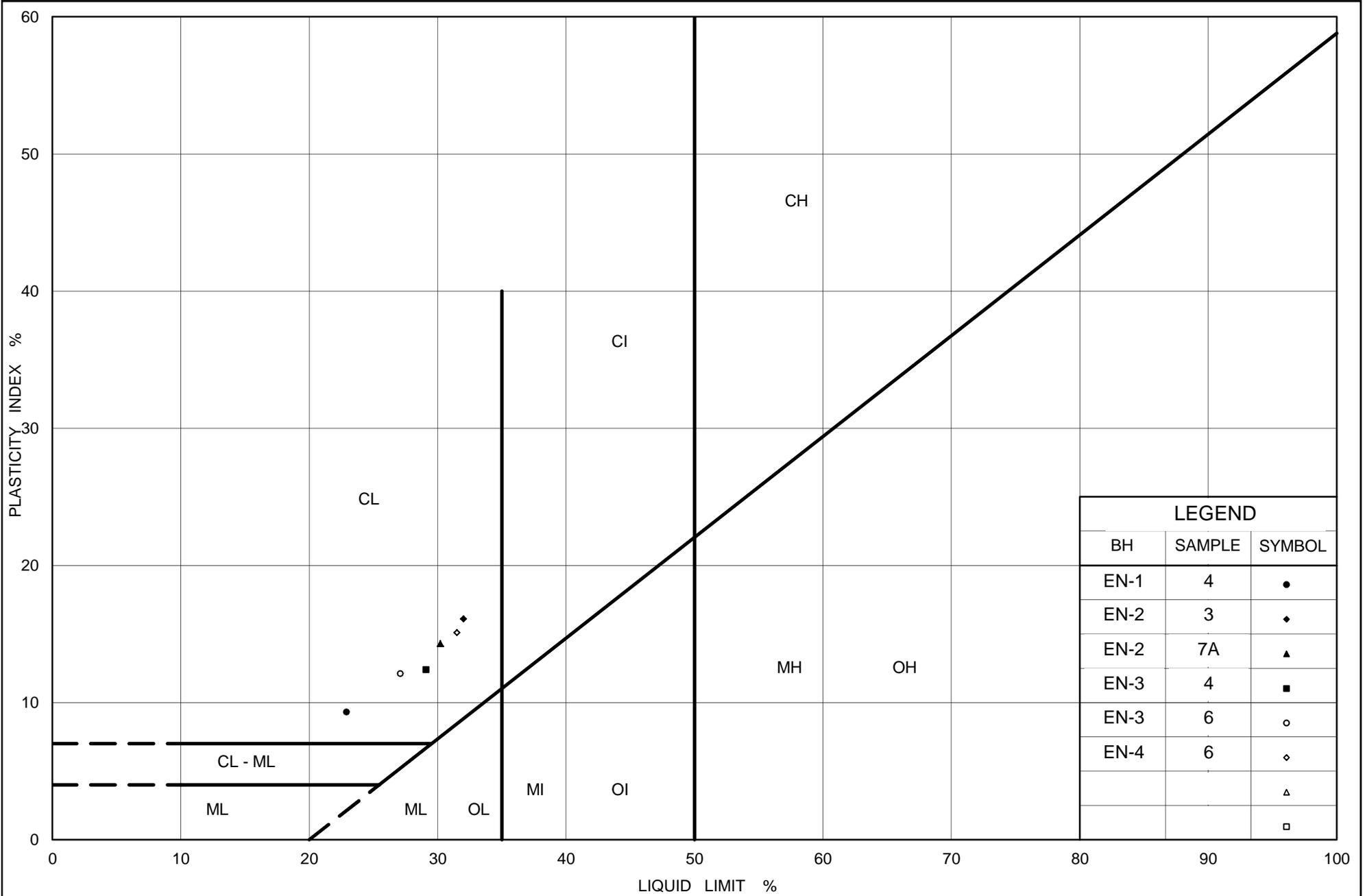
FIGURE F3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	EN-2	3	220.5
■	EN-3	4	219.6
◆	EN-1	4	219.8
▲	EN-3	6	218.1
▽	EN-4	6	218.2
○	EN-2	7A	217.5



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PLASTICITY CHART

Clayey Silt to Clayey Silt with Sand (TILL)

Figure No. F4

Project No. 10-1184-0016

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At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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