



December 22, 2015

FOUNDATION INVESTIGATION AND DESIGN REPORT

**S-E/W RAMP EXTENSION, FILL EMBANKMENT, EARTH CUT, STORMWATER
STORAGE TANK AND ASSOCIATED STRUCTURES
NORMAN BETHUNE AVENUE AND HIGHWAY 404 S-E/W RAMP EXTENSION
FROM HIGHWAY 7 TO NORMAN BETHUNE AVENUE
YORK REGION TRANSPORTATION SERVICES, CONTRACT NO. T-14-53
CITY OF MARKHAM, ONTARIO**

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REPORT





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EARTH CUT, STORMWATER STORAGE TANK AND
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PART A

**FOUNDATION INVESTIGATION REPORT
S-E/W RAMP EXTENSION, FILL EMBANKMENT, CUT, STORMWATER
STORAGE TANK AND ASSOCIATED STRUCTURES
NORMAN BETHUNE AVENUE AND HIGHWAY 404 S-E/W RAMP
EXTENSION FROM HIGHWAY 7 TO NORMAN BETHUNE AVENUE
YORK REGION TRANSPORTATION SERVICES, CONTRACT NO. T-14-53
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of York Region to provide foundation engineering services in support of the design of the E-N Ramp, S-E/W Ramp extension and their associated structures, as well as a watermain replacement, at the northeast quadrant of the intersection of Highway 404 and Highway 7. This work is associated with the Midblock Crossing project in Markham, Ontario which was originally initiated by Coffey Geotechnics Inc. (Coffey Geotechnics).

This report addresses the S-E/W Ramp extension, underground stormwater storage tank, earth cuts and fills, retaining wall and concrete toe walls. Separate reports address the foundation investigations for the E-N Ramp and watermain components of the project. The scope of work for foundation engineering services associated with the Midblock Crossing project is contained in Golder's proposal dated June 26, 2015.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid.

2.0 SITE DESCRIPTION

The S-E/W Ramp extension, from the northbound lanes of Highway 404, is located east of Highway 404 and north of Highway 7. The site is located partially on Seneca College Markham Campus and partially on the City of Markham's property. The existing ramp off Highway 404 ends at Highway 7 and is located within a cut area. The extension of the ramp to the north of Highway 7 transitions from a cut at Highway 7 to a high fill embankment northerly towards Bethune Avenue.

The overall surface topography in the vicinity of the site is relatively flat with cut areas for the existing N-E/W Ramp, E-N Ramp and Highway 7. The area consists predominantly of commercial developments, an educational institution and a sports field on the Seneca College Markham Campus. The ground surface at the site ranges between approximately Elevations 195 m and 187 m.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Borehole Investigation

Five boreholes were advanced at this site as part of a previous geotechnical investigation carried out by Coffey Geotechnics for the retaining wall and cut section of the crossing of Highway 7 and the ramp extension associated with the Midblock Crossing. The investigation was carried out by Coffey Geotechnics in May 2011 during which time Boreholes B103, B104 and R1 to R3 were advanced along the alignment of the S-E/W Ramp, to depths between about 13 m and 26 m. The approximate locations of the boreholes advanced in the Highway 7 area associated with the various facilities are shown on Drawing 1 and the locations of the boreholes specific to the S-E/W Ramp extension cut/fill sections and the retaining wall are shown on Drawing 2.

The boreholes were advanced using hollow stem augers and washboring techniques, and soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 51 mm outer diameter split-spoon sampler



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driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The water level in the open boreholes was observed during and following the drilling operations and a piezometer was installed in Borehole B103 to allow monitoring of the groundwater level at the site.

3.2 Current Borehole Investigation

A geotechnical field investigation was also carried out by Golder at the site of the S-E/W Ramp between September 10 and 15, 2015, during which time a total of six boreholes (Boreholes GA-BR-01 to GA-BR-03, GA-WM-06, GA-ST-01 and GA-ST-02) were advanced to supplement the existing (Coffey Geotechnics) subsurface information. The locations of these specific boreholes are shown in plan on Drawings 1 and 2.

The borehole investigation was carried out using a track-mounted CME-75 drill rig and a track-mounted Acker Soil-Max drill rig supplied and operated by Lantech Drilling Service Inc. of Sharon, Ontario. The boreholes were advanced through the overburden using 210 mm outside diameter hollow stem augers and mud rotary drilling techniques. Soil samples were generally obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outside diameter split-spoon sampler driven by manual hammers in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). The boreholes were advanced to depths ranging from about 12.7 m to 18.7 m below existing ground surface.

The groundwater conditions and water level in the open boreholes were observed during and immediately following the completion of drilling operations. A piezometer was installed in each of Boreholes GA-BR-01, GA-BR-02, GA-WM-06 and GA-ST-02 to allow monitoring of the groundwater level at this site. The piezometers consist of a 50 mm diameter PVC pipe, with a slotted screen sealed within the silt and sand to sand deposit in Boreholes GA-BR-01, GA-BR-02, GA-WM-06 and GA-ST-02. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled with bentonite pellets to the ground surface. The piezometer installation details and water level readings are noted on the Record of Boreholes in Appendix A. All other boreholes were backfilled upon completion of drilling in accordance with Ontario Regulation 903 (as amended).

Samples of groundwater were collected from select wells after completion of the field investigation, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. The results of the analytical testing are provided in Table B1 in Appendix B.

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



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The proposed borehole locations and the ground surface elevations were surveyed and staked by J.D. Barnes Limited (J.D. Barnes), a professional surveying company, and the as-drilled borehole locations were surveyed by Golder relative to the staked locations. The borehole locations provided on the Records of Boreholes and shown on Drawings 1 and 2 are given using UTM NAD 83 northing and easting coordinates, and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including MTM NAD 83 coordinates, ground surface elevations and drilled depths are summarized below.

Borehole Number	Location in UTM NAD 83 (MTM NAD 83)		Ground Surface Elevation	Borehole Depth
	Northing	Easting		
GA-BR-01	4856282.4 m (4856454.6 m)	631119.8 m (315354.5 m)	189.8 m	17.2 m
GA-BR-02	4856302.6 m (4856475.4 m)	631090.9 m (315325.9 m)	190.4 m	18.7 m
GA-BR-03	4856328.0 m (4856501.2 m)	631066.7 m (315302.2 m)	190.7 m	14.2 m
GA-WM-06	4856308.3 m (4856480.8 m)	631109.3 m (315344.4 m)	190.5 m	12.7 m
GA-ST-01	4856369.2 m (4856542.6 m)	631056.7 m (315292.9 m)	190.8 m	15.7 m
GA-ST-02	4856390.0 m (4856563.6 m)	631042.3 m (315278.9 m)	191.1 m	12.7 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site at the intersection of Highway 404 and Highway 7 is located within the Peel Plain physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984). The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping down gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till typically consists of clayey silt to silty clay, with occasional sand to silt zones. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation, together with the results of in situ and laboratory testing, are presented on the Record of



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Borehole sheets and laboratory test summary figures provided in Appendices A and B, respectively. The Record of Borehole sheets and laboratory testing results from the previous (Coffey Geotechnics) investigation are presented in Appendix C. The interpreted stratigraphic profile is shown on Drawing 2.

The results of the in situ field tests (i.e. SPT 'N'-values) carried out during the current investigation as presented on the Record of Borehole sheets and in Section 4.3 are uncorrected. According to the Canadian Foundation Engineering Manual (*CFEM*, 2006), the energy delivered to the drill rod varies with the hammer release system, hammer type, anvil and operator characteristics. It should be noted that different hammer release systems were used during the previous and current investigations (i.e. automatic versus manual) and as such SPT 'N'-values measured during the previous investigation, and in the boreholes of the current investigation may vary within the same deposit.

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

In general, the subsurface conditions at the site consist of a layer of topsoil, underlain by an upper deposit of clayey silt to silty clay, which is in turn underlain by a sandy silt to sand deposit. The sandy silt to sand deposit is underlain by a lower deposit of clayey silt in.

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

It should be noted that the previous (Coffey Geotechnics) investigation describes portions of deposits as "till" units (i.e. sandy silt to sand till and clayey silt till), however, the current investigation did not encounter such similar units and the deposits are classified as silty sand to sand and clayey silt.

4.3 S-E/W Ramp Alignment

The plan and profile along the centerline of the S-E/W Ramp extension, showing the borehole locations and interpreted stratigraphy is shown on Drawing 2. A total of eleven boreholes (GA-BR-01 to GA-BR-03, GA-WM-06, GA-ST-01, GA-ST-02, B103, B104 and R1 to R3) were completed to investigate the subsurface conditions along the S-E/W Ramp extension alignment.

4.3.1 Topsoil

An approximately 100 mm to 300 mm thick layer of topsoil was encountered in all boreholes. The top of this layer ranges between about Elevations 190.7 m and 189.8 m.

4.3.2 Fill

An approximately 0.3 m and 0.6 m thick layer of sandy silt fill with clayey silt inclusions was encountered underlying the topsoil in Boreholes B104 and B103 at about Elevations 189.1 m and 190.4 m, respectively.



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The SPT 'N'-values measured within the fill are 5 blows and 7 blows per 0.3 m of penetration, indicating a loose relative density.

4.3.3 Clayey Silt to Silty Clay (Upper)

A 1.5 m to 3.8 m thick upper deposit of clayey silt to silty clay was encountered between Elevation 191.8 m and 190.3 m underlying the topsoil in Boreholes GA-BR-02, GA-BR-03, GA-WM-06, GA-ST-01, GA-ST-02 and R1 to R3 and below the fill in Borehole B103. Sandy silt and silty sand seams were encountered in Boreholes GA-WM-06 and R2. In Borehole GA-ST-01 cobbles were inferred from auger grinding at a depth of 3.1 m.

The SPT 'N'-values measured within the upper clayey silt to silty clay deposit range from 6 blows to 51 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

The natural water content measured on nine samples of the upper deposit of clayey silt from the current investigation ranges from about 9 per cent to 25 per cent. The natural water content measured on a sandy silt seam is about 13 per cent.

The results of grain size distribution tests completed on three samples of the upper deposit of clayey silt from the current investigation are shown on Figure B1 in Appendix B. The grain size distributions of four samples of the clayey silt to silty clay deposit from the previous investigation are shown on Figures C1 to C3 in Appendix C.

Atterberg limits test carried out on four samples of the cohesive upper deposit obtained during the current investigation measured liquid limits ranging from about 21 per cent to 28 per cent and plastic limits ranging from about 8 per cent to 14 per cent, corresponding to plasticity indices ranging from about 13 per cent to 14 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 in Appendix B and indicate that the material is classified as clayey silt of low plasticity. An Atterberg limits test carried out on one sample of the sandy silt seam in Borehole GA-WM-06 indicates that the material is non-plastic. Atterberg limits tests carried out on three samples of upper cohesive deposit obtained during the previous investigation measured liquid limits ranging from about 37 per cent to 46 per cent and plastic limits ranging from about 16 per cent to 21 per cent, corresponding to plasticity indices ranging from about 21 per cent to 25 per cent. The test results from the previous investigation are shown on the plasticity chart on Figures C4 and C5 in Appendix C, and indicate that the deposit also consists of silty clay of intermediate plasticity.

4.3.4 Sandy Silt to Sand

A 6.5 m to 16.6 m thick deposit of sandy silt to silt and sand to silty sand to sand was encountered between Elevations 189.7 m and 186.3 m below the topsoil in Boreholes GA-BR-01 and R1 to R3, below the fill layer in Borehole B104 and below the upper clayey silt to silty clay deposit in Boreholes GA-BR-02, GA-BR-03, GA-WM-06, B103 and R1 to R3. The sandy silt to sand deposit contains clayey silt interbeds, non-plastic silt interbeds in Boreholes GA-BR-02, GA-ST-02, B103 and R1 and a 3.4 m thick pocket of clayey silt in Borehole B103. Auger grinding or hard tricone advancement was noted on inferred cobbles at a depth of 4.1 m in Borehole GA-BR-01, 11.1 m in Borehole GA-ST-01, and at 3.7 m, 5.2 m and 11.4 m in Borehole GA-ST-02. Additionally, the presence of cobbles was inferred in Boreholes R1 and R2 from the previous investigation,



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below depths of 10.4 m and 10.8 m. Boreholes GA-BR-02, GA-BR-03, GA-WM-06, GA-ST-01, GA-ST-02, R1 and R2 were terminated within the sandy silt to sand deposit.

The SPT 'N'-values measured within the sandy silt to sand deposit generally range from 10 blows per 0.3 m of penetration to 100 blows per 0.05 m of penetration, indicating a generally compact to very dense relative density. SPT 'N'-values between 2 blows and 9 blows per 0.3 m of penetration were measured in the upper portion of the deposit in Boreholes B103, R1 and R2, indicating a very loose to loose relative density. The SPT 'N'-values measured within the clayey silt pocket in Borehole B103 range from 100 blows per 0.2 m of penetration to 100 blows per 0.13 m of penetration, suggesting a hard consistency. In general, the relative density of the deposit increases with depth.

The natural water content measured on 29 samples of the sandy silt to sand deposit from the current investigation range from about 5 per cent to 28 per cent.

The results of grain size distribution tests completed on twelve samples of the silt and sand to sand deposit obtained during the current investigation are shown on Figures B3A to B3C in Appendix B. The results of grain size distribution tests completed on eight samples of the sandy silt to sand deposit from the previous investigation are shown on Figures C6, C8 to C10 and C12 in Appendix C. The results of a grain size distribution test completed on one sample of a clayey silt interbed and one sample of a sand and gravel pocket within the sandy silt to sand deposit from the previous investigation are shown on Figures C13 and C7 in Appendix C, respectively.

The Atterberg limits tests carried out on eight samples of the sandy silt to sand deposit indicate that the material is non-plastic.

4.3.5 Gravelly Sand to Sand and Gravel (Interlayer)

A gravelly sand to sand and gravel interlayer was encountered in Boreholes R1, R2, GA-BR-03, GA-ST-01 and GA-ST-02. The top of the gravelly sand to sand and gravel interlayer ranges from about Elevations 184.3 m and 181.4 m and the thickness of the interlayer varies between about 0.3 m and 2.0 m. The presence of cobbles was inferred within the interlayer by auger grinding. A 750 mm boulder was inferred by hard tricone advancement at a depth of 7.8 m in Boreholes GA-ST-01.

The SPT 'N'-values measured within the gravelly sand to sand and gravel interlayer range from 62 blows per 0.3 m of penetration to 50 blows per 0.08 m of penetration, indicating a very dense relative density.

The natural water content measured on two samples of the sand and gravel deposit from the current investigation are about 8 per cent and 15 per cent.

The result of a grain size distribution test completed on one sample of the gravelly sand to sand and gravel interlayer for the current investigation is shown on Figure B4 in Appendix B.

The results of grain size distribution tests completed on two samples of the sandy gravel interlayer obtained during the previous investigation are shown on Figures C7 and C11 in Appendix C.



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4.3.6 Clayey Silt (Lower)

A 0.2 m to 7.8 m thick lower cohesive deposit comprised of clayey silt was encountered between Elevations 182.8 m and 176.8 m, underlying the sandy silt to sand deposit in Boreholes GA-BR-01, B103, B104 and R3. These boreholes were terminated within the lower clayey silt deposit. Sandy silt pockets were encountered in the lower clayey silt deposit in Borehole GA-BR-01.

The SPT 'N'-values measured within the lower clayey silt deposit range from 29 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, suggesting a very stiff to hard consistency.

The natural water content measured on two samples of the lower clayey silt deposit from the current investigation are about 14 per cent and 27 per cent.

The result of a grain size distribution test completed on one sample of the lower clayey silt obtained during the previous investigation is shown on Figure C14 in Appendix C.

An Atterberg limits test carried out on one sample of the lower deposit of clayey silt obtained during the current investigation measured a liquid limit of about 29 per cent and a plastic limit of about 17 per cent, corresponding to a plasticity index of about 12 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B5 in Appendix B and indicates that the material is classified as a clayey silt of low plasticity. An Atterberg limits test carried out on one sample of the clayey silt obtained during the previous investigation measured a liquid limit of about 27 per cent, a plastic limit of about 14 per cent, corresponding to a plasticity index of about 13 per cent. The result from the previous investigation is shown on the plasticity chart on Figure C15 in Appendix C and indicates that the material is classified as a clayey silt of low plasticity.

4.4 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. The water levels encountered upon completion of drilling during the current investigation were between Elevations 187.5 m and 187.0 m. However, the water level observed in the open boreholes during and/or on completion of drilling may not represent the longer-term, stabilized groundwater level at the site.

A standpipe piezometer was installed in each of Boreholes GA-BR-01, GA-BR-02, GA-WM-06, and GA-ST-02 as part of the current investigation, and a standpipe piezometer was installed in Borehole B103 during the previous investigation. The observed groundwater level in the standpipe piezometers is shown on the Record of Borehole sheets in Appendices A and C, and summarized below:

Borehole	Depth to Water Level	Groundwater Elevation	Date of Measurement
GA-BR-01	4.1 m	185.7 m	September 14, 2015
	3.9 m	185.9 m	September 15, 2015
	4.0 m	185.8 m	October 13, 2015
GA-BR-02	4.4 m	186.0 m	September 11, 2015
	4.8 m	185.6 m	September 11, 2015
	4.6 m	185.8 m	September 15, 2015
	4.8 m	185.6 m	October 13, 2015



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Borehole	Depth to Water Level	Groundwater Elevation	Date of Measurement
GA-WM-06	5.0 m	185.5 m	September 10, 2015
	4.9 m	185.6 m	September 11, 2015
	4.9 m	185.6 m	September 15, 2015
	4.9 m	185.6 m	October 13, 2015
GA-ST-02	5.3 m	185.8 m	September 15, 2015
	5.4 m	185.7 m	October 13, 2015
B103	4.3 m	186.3 m	May 27, 2011
	4.3 m	186.3 m	June 8, 2011
	4.4 m	186.2 m	June 21, 2011
	4.4 m	186.2 m	June 22, 2011
	4.3 m	186.3 m	June 30, 2011

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.



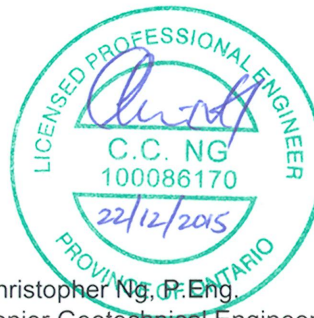
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5.0 CLOSURE

Ms. Madison Kennedy, B.A.Sc., and Mr. Oleg Skorik, E.I.T., supervised the borehole investigation program. This report was prepared by Mme. Caitlyn Cartwright, E.I.T., and Madison Kennedy, B.A.Sc., and was reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Principal of Golder and Designated MTO Foundations Contact, conducted an independent review of this report.

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**FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT,
EARTH CUT, STORMWATER STORAGE TANK AND
ASSOCIATED STRUCTURES**

PART B

**FOUNDATION DESIGN REPORT
S-E/W RAMP EXTENSION, FILL EMBANKMENT, CUT, STORMWATER
STORAGE TANK AND ASSOCIATED STRUCTURES
NORMAN BETHUNE AVENUE AND HIGHWAY 404 S-E/W RAMP
EXTENSION FROM HIGHWAY 7 TO NORMAN BETHUNE AVENUE
YORK REGION TRANSPORTATION SERVICES, CONTRACT NO. T-14-53
CITY OF MARKHAM, ONTARIO**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides engineering design recommendations for the proposed S-E/W Ramp extension associated with the Highway 404/Highway 7 interchange rehabilitation from Highway 7 to Bethune Avenue in Markham, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the design of the structure foundations and approach embankments.

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

6.1 General

Golder Associates Ltd. (Golder) has been retained by AECOM (formerly URS Canada Inc.) on behalf of York Region (York) to provide recommendations on foundation aspects for the detail design of the proposed S-E/W Ramp extension associated with the Highway 404/Highway 7 interchange in Markham, Ontario. The proposed work includes an underground stormwater storage tank, earth cut and fill embankment, a retaining wall and concrete toe walls.

Based on the General Arrangement (GA) drawing provided by AECOM on October 6, 2015, the proposed underground stormwater storage tank is about 49 m long by 3 m wide by 2.1 m high and is located between about STA 10+118 and 10+167. The earth cut is located between STA 10+025 and 10+130 where the N-E Ramp crosses over the S-E/W Ramp and is up to about 3 m deep. The fill embankment extends from about STA 10+130 to STA 10+640 and is up to 5.8 m high. The retained soil system (RSS) wall (Wall No. 2R) extending along the S-E/W ramp extension from about STA 10+130 to STA 10+296 is up to about 5.8 m high and the concrete toe walls No. 6 and No. 7 extending from about STA 10+130 to STA 10+210 and STA 10+170 to STA 10+277, respectively, are between about 1 m and 1.3 m high.

6.2 Lateral Earth Pressures

The lateral earth pressures acting on the walls of the underground stormwater storage tank and on the retaining walls will depend on the type and method of placement of the backfill material, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

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



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- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II, but with less than 5 per cent passing the No. 200 sieve, should be used as backfill behind the walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting). Other aspects of the granular backfill and frost taper requirements for the stormwater storage tank should be in accordance with OPSD 803.010 (Backfill and Cover for Concrete Culverts) and granular backfill requirements with respect to sub-drains and frost taper for the retaining walls should be in accordance with OPSD 3121.150 (Retaining Walls, Backfill, Minimum Granular Requirement).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem of the retaining walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Other surcharge loadings should be accounted for in the design as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.2 m behind the back of the wall (in accordance with Figure C6.20(a) of the *Commentary* to the CHBDC). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing/wall (in accordance with Figure C6.20(b) of the *Commentary* to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

Fill Type	Soil Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22 kN/m ³	0.43	0.27
Granular 'B' Type II	21 kN/m ³	0.43	0.27

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

6.3 Stormwater Storage Tank

Based on the profile drawing for the S-E/W Ramp Extension provided by AECOM on October 6, 2015, an approximately 49 m long by 3 m wide by 2.1 m high underground stormwater storage tank is located between about STA 10+118 and 10+167. It is further understood that the tank will be essentially a closed bottom, box-type structure founded on the native soils. The proposed founding elevation for the storage tank is Elevation 186.8 m and as such, the storage tank will be founded on the native compact to dense sandy silt to silty sand deposit.



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6.3.1 Geotechnical Axial Resistance

The following factored geotechnical axial resistance at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS, for 25 mm of settlement) may be used for design:

Foundation Condition	Factored Geotechnical Axial Resistance at ULS	Geotechnical Reaction at SLS for 25 mm of Settlement
Base on properly prepared compact to dense sandy silt to silty sand deposit	900 kPa	150 kPa

The geotechnical resistances provided herein are given for loads will that be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the footing, inclination of the load should be taken into account in accordance with Section 6.7.2 of the *CHBDC (2006)*. Further, the geotechnical resistance given above should be reviewed and adjusted as may be necessary if the plan area of the tank, the foundation type or the founding elevations change from those presently proposed.

6.3.2 Frost Protection

The stormwater storage tank should be founded at and provided with a minimum depth of 1.2 m or equivalent soil cover for frost protection as per OPSS 3090.101 (Frost Penetration Depths for Southern Ontario), as measured vertically and perpendicular from the face of the abutment slope to the edge of the underside of the footing.

6.3.3 Bedding and Backfill

The bedding and backfill requirements for the proposed precast stormwater storage tank should be in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts). The storage tank should be provided with at least 300 mm of OPSS.PROV 1010 (Aggregates) Granular 'A' for bedding purposes. The bedding should be placed in lifts not exceeding 200 mm in loose thickness, and compacted to at least 98 per cent of the Standard Proctor Maximum Dry Density of the material as specified in OPSS.PROV 501 (Compacting). In addition, a minimum 75 mm thick uncompacted levelling pad consisting of OPSS.PROV 1010 Granular 'A' or concrete fine aggregate meeting the gradation requirements specified in the OPSS.PROV 1002 (Aggregates – Concrete), should be provided as shown on OPSS 803.010 (Backfill and Cover Concrete Culverts) for culvert construction in dry conditions.

Backfill around the storage tank should consist of granular fill meeting the specification for OPSS.PROV 1010 (Aggregates) Granular 'A', but with less than 5 per cent passing the No. 200 (0.075 mm) sieve. The fill should be placed concurrently on both sides of the storage tank walls, ensuring that the depth of backfill on one side does not exceed the other side by more than 400 mm.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.



6.4 Earth Cut and High Fill Embankments

Based on the profile drawing provided by AECOM on October 6, 2015, the proposed grade for the S-E/W Ramp will require an earth cut up to about 3 m deep between about STA 10+025 and 10+130 and placement of up to about 5.8 m of embankment granular fill between about STA 10+130 and STA 10+640.

In general, the excavation for the earth cut will be carried out through the deposits of firm to hard clayey silt to silty clay and compact to dense sandy silt to sand while the high fill embankment will be founded on the firm to hard clayey silt to silty clay.

It should be noted that retaining walls will be constructed in the earth cut area and that the stability and settlement analysis for the cut retaining walls (East RSS Wall and West RSS Walls) have been addressed in the report associated with the E-N Ramp embankment and bridge structure. As such, the following sections present the results of the stability and settlement of the high fill embankment portion of the S-E/W Ramp only.

6.4.1 Stability

6.4.1.1 Methodology

Limit equilibrium slope stability analyses for the high fill embankment were carried out using the commercially available program Slide (version 6.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factors of Safety (FoS) of numerous potential failure surfaces were computed for the highest embankment cross-section in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum FoS of 1.3 is considered appropriate for the design of embankment slopes under static conditions. For stability analysis involving retaining walls, a target minimum FoS of 1.5 is considered appropriate for design under static conditions.

6.4.1.2 Parameter Selection

For the non-cohesive soils present at this site, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of the in situ Standard Penetration Tests (SPT). The correlations proposed by Peck et al (1974) and U.S. Navy (1986) were employed and the results were adjusted by engineering judgment based on precedent experience in similar soils.

For the purpose of the stability analysis, the groundwater level was assumed to be at Elevation 186.5 m, which is based on the average piezometric groundwater level measured on site.

The following presents the simplified stratigraphy and the associated strengths and unit weights employed for the existing and new fill material as well as the native overburden deposits encountered at the embankment areas:



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Embankment	Soil Type	Unit Weight, γ	Cohesion, c'	Effective Friction Angle, ϕ'
S-E/W Ramp High Fill Embankment	New Granular Embankment Fill	21 kN/m ³	0 kPa	34°
	Firm to Hard Clayey Silt to Silty Clay	18 kN/m ³	100 kPa	-
	Compact to Dense Sandy Silt to Sand	19 kN/m ³	0 kPa	30°
	Very Stiff to Hard Clayey Silt	18 kN/m ³	200 kPa	-

6.4.1.3 Results of Analysis

The results of the stability analyses for the high fill embankment are summarized below. The minimum FoS is based on a deep-seated, global trial failure surface that would impact the operation of the highway.

Embankment	Analysis	Slope Profile	Embankment Height at Critical Section	Minimum Factor of Safety
S-E/W Ramp High Fill Embankment	West Side Slope	2H:1V	5.8 m	≥ 1.3
	RSS Wall (Wall No. 2R)	Up to 5.8 m high RSS Wall	5.8 m	≥ 1.5

Note: The width of the reinforced soil mass is assumed to be 0.8 times the wall height.

6.4.2 Settlement

6.4.2.1 Methodology

To estimate the magnitude of expected settlement of the embankment, analyses were carried out at the critical section of the embankment corresponding to the highest grade above existing ground surface. Settlement analyses were carried out using the commercially available program Settle^{3D} (version 3.0), developed by Rocscience Inc.

6.4.2.2 Parameter Selection

The following presents the simplified stratigraphy and the associated unit weights and strengths employed for the estimation of settlement of the foundation soils at the approach embankment areas are presented below. The immediate compression of the non-cohesive overburden soils were modelled by estimating an elastic modulus of deformation based on the SPT 'N'-values and using correlations proposed by Bowles (1984) and Kulhawy and Mayne (1990). These estimated values were compared with the typical range of expected values for similar soil types, as outlined in CHBDC (2006) and adjusted, as appropriate. The consolidation settlement parameters of the cohesive deposits was assessed using empirical correlations proposed in literature by Koppula (1986), Terzaghi and Peck (1967), Kulhawy and Mayne (1990) and Azzouz et al. (1976). The



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coefficient of consolidation, c_v , required in the time-rate analysis was estimated from the U.S. Navy (1986) correlation with liquid limits assuming over-consolidated soils.

Embankment	Soil Type	Thickness at Critical Section	Unit Weight, γ	Deformation Parameter(s)
S-E/W Ramp High Fill Embankment	Firm to Hard Clayey Silt to Silty Clay	~ 2.5 m	18 kN/m ³	$e_o = 0.7$ $C_c = 0.28$ $C_r = 0.06$ $c_v = 1.34 \times 10^{-2} \text{ cm}^2/\text{s}$
	Compact to Dense Sandy Silt to Sand	~ 6.5 m	18 kN/m ³	$E' = 20 \text{ MPa}$
	Very Stiff to Hard Clayey Silt	~ 6.7 m	19 kN/m ³	$E' = 50 \text{ MPa}$

For the purpose of the settlement analysis, the groundwater level was assumed to be at Elevation 186.5 m, which is based on the average piezometric groundwater level measured on site.

6.4.2.3 Settlement of Foundation Soils

The results of the analyses of the estimated settlement of the foundation soils at the critical section are presented below.

Embankment	Estimated Immediate Settlement of Foundation Soils	Estimated Consolidation Settlement of Foundation Soils	Estimated Total Settlement of Foundation Soils
S-E/W Ramp High Fill Embankment	50 mm	80 mm	130 mm

The immediate settlement is expected to occur relatively quickly (i.e. during construction) in response to the embankment construction. Based on the estimated coefficient of consolidation (c_v about $1.34 \times 10^{-2} \text{ cm}^2/\text{s}$) for the cohesive deposit, it is estimated that 90 per cent consolidation settlement will be completed in about 15 days. As such, it is recommended that a preload period of 30 days be included in the construction schedule to reduce the post-construction settlement to less than 25 mm. Taking into consideration that the native cohesive deposit is highly over-consolidated and the recommended duration of the preload period of 30 days (as compared to the estimated time for 90 per cent consolidation of 15 days), instrumentation and settlement monitoring is not considered necessary.

6.5 Retained Soil System (RSS) Wall (Wall No. 2R)

6.5.1 Founding Elevations

Based on the drawing provided by AECOM on October 6, 2015, a retaining wall up to about 5.8 m high is to be constructed along the east side of the future S-E/W Ramp Extension extending from about STA 10+110 to STA 10+296. Based on the subsurface conditions encountered at the side a retained soil system (RSS) wall is considered to be a suitable option for the required retaining wall.



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The highest founding elevation for the front facing panels and the reinforced soil mass of the RSS walls recommended for design are presented below.

Retaining Wall	Elevation of the Finished Ground Surface in Front of Retaining Wall	Highest Wall Founding Elevation ¹	Founding Soil
Wall No. 2R STA 10+110 to 10+296	190.5 m to 191.8 m	189.3 m to 190.6 m	Stiff to Very Stiff Clayey Silt to Silty Clay

Note: 1. The highest founding elevation is 1.2 m below the base of the retaining wall due to depth of frost penetration at this site.

The front facing panels should be supported on a footing constructed on a granular pad. The granular pad should consist of a minimum thickness of 0.3 m of compacted Granular 'A' material, which should extend at least 0.5 m beyond the outside edge of both sides of the facing footing, then outward/downward at a slope of 1H:1V.

6.5.2 Geotechnical Axial Resistance

For the RSS facing panels supported on a 0.3 m wide footing constructed on a compacted granular pad as described in Section 6.5, the following factored geotechnical axial resistances at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS, for 25 mm of settlement) may be used for design:

Foundation	Factored Geotechnical Axial Resistance at ULS	Geotechnical Resistance at SLS for 25 mm of Settlement
Footing on a stiff to very stiff clayey silt to silty clay	225 kPa	N/A ¹

Note: 1. The geotechnical resistance at SLS for 25 mm of settlement will be greater than the factored axial resistance at ULS and as such, the SLS condition does not apply.

Assuming that the RSS walls acts as a unit and uses the full width of the reinforced soil mass (which can be taken as approximately 0.8 times the wall height) and is founded on the native stiff to very stiff clayey silt, the following factored geotechnical axial resistances at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS, for 25 mm of settlement) may be used for design:

Foundation Location	Estimated Approximate Wall Height	Reference Borehole	Founding Elevation on Granular Pad	Factored Geotechnical Axial Resistance at ULS	Geotechnical Resistance at SLS for 25 mm of Settlement
STA 10+120	1.0 m	Borehole R1	189.8 m	225 kPa	150 kPa
STA 10+160	2.2 m	Borehole ST-01	190.2 m	350 kPa	150 kPa
STA 10+180	2.9 m	Borehole ST-02	190.4 m	350 kPa	125 kPa
STA 10+200	3.7 m	Borehole R2	190.6 m	250 kPa	125 kPa
STA 10+280	5.8 m	Borehole R3	191.1 m	400 kPa	125 kPa



6.5.3 Frost Protection

The footing for the RSS facing panels should be provided with a minimum 1.2 m of soil cover for frost protection as per OPSD 3090.101 (Frost Penetration Depths for Southern Ontario), as measured vertically and perpendicular from the face of the embankment/ground surface to the edge of the underside of the footing.

If adequate soil cover cannot be provided for the footing, rigid styrofoam insulation could be installed to compensate for the lack of soil cover and provide protection from frost penetration.

6.5.4 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the compacted fill of the RSS wall mass and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC* (2006). The coefficient of friction ($\tan \delta$) between the compacted granular fill of the RSS wall and the properly prepared native subgrade may be taken as 0.30.

6.5.5 Global Stability

The static global stability analyses for an RSS wall were completed using the parameters outlined in Section 6.4.1.2, and assume that all organics and other deleterious materials are removed prior to constructing the RSS walls. As discussed in Section 6.4.1.1, a target minimum FoS of 1.5 is consider appropriate for design of the RSS walls for global stability. The results of the stability analyses indicate that a FoS for the RSS wall equal to or greater than 1.5 is achieved (refer to Section 6.4.1.3). It should be noted, however, that the internal stability of a reinforced earth structure is to be designed and assessed by the proprietary product designer/manufacture to ensure that the internal stability of the wall is adequate.

6.5.6 Settlement

The estimated settlement along the RSS walls is presented below.

Retaining Wall	Estimated Settlement of Foundation Soils ¹
Wall No. 2R	Less than 25 mm

Note: 1. Assumes that that retaining wall footing and front facing is constructed after the preload period of 30 days(refer to Section 6.4.2.3).

6.5.7 Performance and Appearance

Given that the RSS wall along to the S-E/W Ramp Extension is associated with a 400-series highway, a high site performance rating and a high appearance rating is required in accordance with the MTO RSS Design Guidelines (2008).



6.6 Concrete Toe Walls

6.6.1 Concrete Toe Wall No. 6

Based on the drawings provided by AECOM on October 6, 2015, an up to about 1 m high concrete toe wall will be required between STA 10+030 and 10+210 along the east side of the S-E/W Ramp Extension. The concrete toe wall will be founded on the native very stiff clayey silt and compact to dense sandy silt to sand deposits between STA 10+030 and 10+130 and on granular embankment fill (i.e. Granular 'A' or Granular 'B') between STA 10+130 and 10+210. Given the founding conditions encountered in the boreholes drilled along the toe wall and the adjacent embankment constructed of compact granular fill, a factored geotechnical axial resistance at ULS of 300 kPa may be used for design. A coefficient of friction ($\tan \delta$) of 0.30, 0.45 and 0.55 may be used for design of the toe wall for horizontal sliding resistance along the base of the toe wall founded on the native clayey silt, dense sand and compact Granular 'A', respectively.

The concrete toe wall should be constructed in accordance with OPSD 3120.100 (Concrete Toe Wall) Type III.

6.6.2 Concrete Toe Wall No. 7

Based on the drawings provided by AECOM on October 6, 2015, an up to about 1.3 m high concrete toe wall will be required between STA 10+170 and 10+277 along the west side of the S-E/W Ramp Extension. The native stiff clayey silt over compact to dense sandy silt to sand would not provide adequate geotechnical axial resistance for the toe wall, as required by OPSD 3120.100 (Concrete Toe Wall). As such, it is recommended that a 1 m thick granular pad be placed over the native subgrade prior to the construction of Concrete Toe Wall No. 7. For a toe wall founded on a 1 m thick compacted Granular 'A' pad, a factored geotechnical axial resistance at ULS of 300 kPa and a coefficient of friction ($\tan \delta$) of 0.55 may be used for design for horizontal sliding resistance along the base of the toe wall. It is noted that the 2H:1V slope behind the toe wall is higher than 4 m for the section of wall between STA 10+240 and 10+277 (i.e. it is up to about 5 m high) and as such, the concrete toe wall must be designed such that there is adequate resistance against sliding and overturning.

The concrete toe wall should be constructed in accordance with OPSD 3120.100 (Concrete Toe Wall) Type II.

6.7 Construction Considerations

6.7.1 Overburden Excavation

The native overburden soils are considered Type 3 soils according to the Occupational Health and Safety Act and Regulation for Construction Projects (OHSA). Temporary open-cut excavations above the groundwater level, or above the lowered groundwater level with proper groundwater control in place, should be carried out with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V).

All excavations must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended).

The native sandy silt to sand deposits are highly erodible and as such consideration should be given to either placing of erosion protection on the exposed slope or cutting into the slope, in the areas where the sandy silt to sand deposit is exposed and backfilling to the final slope configuration using Granular 'B' Type II.



6.7.2 Subgrade Preparation

The existing native firm to hard clayey silt and silty clay and loose to very dense sandy silt to sand deposits are considered to be appropriate subgrade for the support of the proposed stormwater storage tank, RSS wall and embankment; however, prior to any construction or the placement of any fill, any organic materials and softened soil should be stripped from the plan limits of the proposed works and the subgrade soils should be proof-rolled, especially in areas of loose/loosened soil.

6.7.3 Placement of Embankment Fill

Upon completion of stripping of all organics and other deleterious materials from the plan limits of the proposed works, placement of granular fill for the construction of the fill embankments should be carried out in accordance with OPSS.PROV 501 (Compacting). Materials use for the construction of the embankment should meet the specification of OPSS.PROV 1010 Granular 'B'. The granular fill should be compacted in lifts not exceeding 300 mm thick to a minimum 95 per cent of Standard Proctor Maximum Dry Density (SPMDD). In areas where the fill embankment is formed by the retained soil system (wall) the soil mass should be comprised of granular material as specified by the supplier/manufacturer of the wall system.

Where granular fill is used to widen or tie-in to existing earth slopes, benching of the existing earth slopes should be carried out in accordance with OPSD 208.010 (Benching of Earth Slopes).

6.7.4 Erosion Protection

To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod should be carried out on the embankment slope(s) as soon as practicable after construction of the embankment. In the short term, if placement of cover material cannot be carried out soon after the construction of the embankments, erosion control blankets should be installed to minimize erosion of the embankment slopes. The erosion protection should be in accordance with OPSS.PROV 804 (Seed and Cover).

6.7.5 Control of Groundwater and Surface Water

The soils at the base of the excavation along the RSS wall and the stormwater storage tank consist of water-bearing, relatively permeable sandy silt, silt and sand, silty sand and sand. The groundwater level measured in the standpipe piezometers installed in the previous and current investigations range from Elevation 186.3 m to 185.5 m and as such, control of groundwater may be required during wet periods of the year. Where required, it is considered that pumping from within trenches/ditching with adequately size and properly filtered sumps will be sufficient to control the groundwater inflow.

Surface water should be directed away from the excavation at all times.

6.7.6 Obstructions

It should be noted that obstructions (inferred as cobbles and boulders, from auger grinding and split-spoon sampling) were encountered within the sandy silt to sand deposit and the gravelly sand to sand and gravel



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interlayer. The presence of such obstructions could affect excavation works. The Contractor should be made aware of the potential presence of cobbles and/or boulders within the overburden soils as noted in the NSSP for Obstructions included in Appendix D. The borehole drilling method does not permit accurate measurement of the cobbles or boulders; nor can an estimate to be made of the quantity (overall volume) of these materials.

6.7.7 Protection of Subgrade

The non-cohesive soils that will be exposed within the excavations at the RSS wall and the stormwater storage tank locations will be susceptible to disturbance from construction traffic and/or precipitation and ponded water. To limit the effects of this disturbance, a concrete working slab should be placed on the prepared subgrade if concrete or compact Granular 'A' is not placed within four hours after preparation, inspection and approval of the subgrade. The minimum thickness of the concrete working slab should be 100 mm and the concrete should have a minimum 28-day compressive strength of 20 MPa.

6.7.1 Analytical Testing for Construction Materials

The results of analytical tests carried out on two samples of groundwater taken from Boreholes GA-WM-06 and GA-ST-02 are presented in Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel elements.



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7.0 CLOSURE

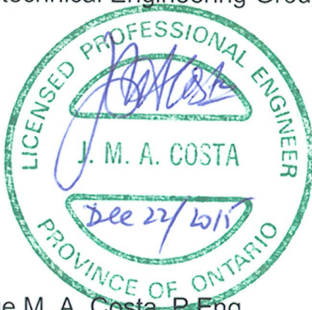
This Foundation Design Report was prepared by Ms. Madison C. Kennedy, B.A.Sc., a member of the geotechnical engineering group, and reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., a Principal with Golder and Designated MTO Foundations Contact, conducted an independent review of this report.

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\\golder.gds\gal\mississauga\active\2015\3 proj\1533525 aecom_midblock crossing_york region\foundation engineering\6-reporting\02 - s-ew ramp\final\1533525-2 - 15dec22 drpt
midblock crossing s-ew ramp & stormtank.docx



FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT, EARTH CUT, STORMWATER STORAGE TANK AND ASSOCIATED STRUCTURES

REFERENCES

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ASTM International:

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

Commercial Software:

Settle3D (Version 3.0) by Rocscience Inc.

Slide (Version 6.0) by Rocscience Inc.



FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT, EARTH CUT, STORMWATER STORAGE TANK AND ASSOCIATED STRUCTURES

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provincial Standard Specifications (OPSS)

OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 1002	Material Specification for Aggregates - Concrete
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal To 3.0 m
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSD 3120.100	Walls, Retaining, Concrete Toe Wall
OPSD 3121.150	Walls, Retaining, Backfill, Minimum Granular Requirement

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)



FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT, EARTH CUT, STORMWATER STORAGE TANK AND ASSOCIATED STRUCTURES

DRAWINGS



PLAN
SCALE
20 0 20 40 m

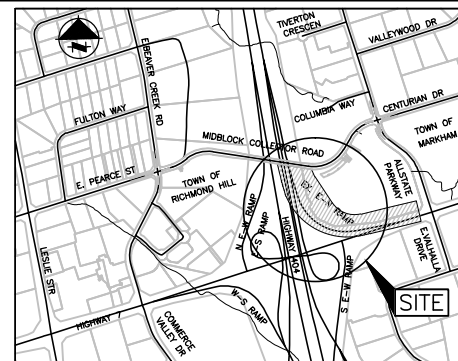


CONT No.
WP No.

HIGHWAY 7 TO HIGHWAY 404 E-N RAMP S-E/W
RAMP AND WATERMAIN
S-E/W RAMP EXTENSION
BOREHOLE LOCATIONS INDEX PLAN



SHEET



KEY PLAN

NOT TO SCALE

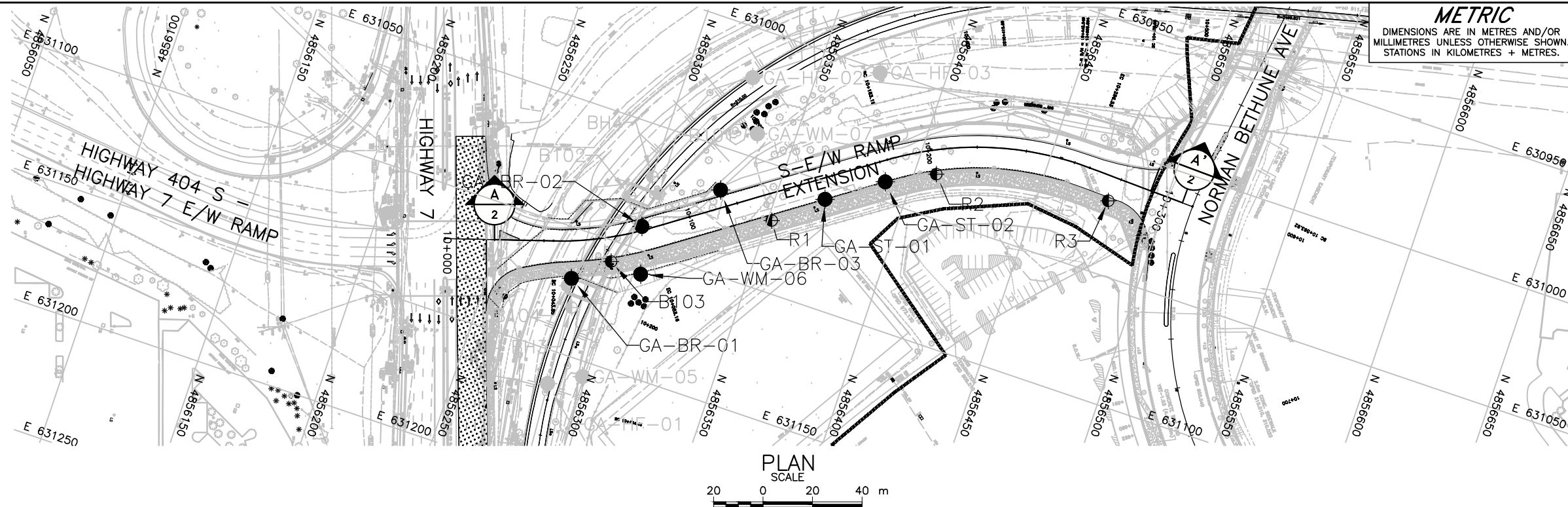
LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation

REFERENCES

Base plans provided in digital format by AECOM, drawing file nos. Bgd-2015.dwg, Mdbk_Ramp_Pln.dwg, Ramp_Aln.dwg, Ramp_Pln.dwg and received October 13, 2015.

NO.	DATE	BY	REVISION
Geocres No. 30M14-426			
HWY. 404		PROJECT NO. 1533525	
SUBM'D. MCK		DATE: Nov. 2015	
DRAWN: JFC		APPD. JMAC	
CHKD. MCK		SITE:	
CHKD. CN		DWG. 1	



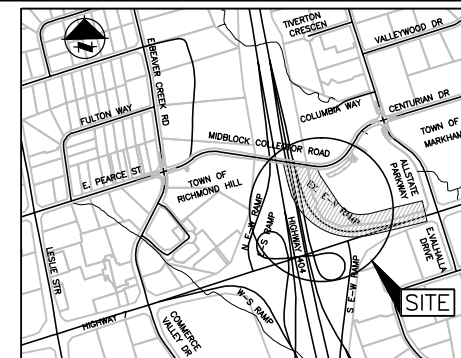
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.

HIGHWAY 7 TO HIGHWAY 404
S-E/W RAMP EXTENSION
BOREHOLE LOCATIONS AND
SOIL STRATA



SHEET
ST20



KEY PLAN
NOT TO SCALE

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL in piezometer (Refer to report text)
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B103	190.6	4856295.4	631108.3
GA-BR-01	189.8	4856282.4	631119.8
GA-BR-02	190.4	4856302.6	631090.9
GA-BR-03	190.7	4856328.0	631066.7
GA-ST-01	190.8	4856369.2	631056.7
GA-ST-02	191.1	4856390.0	631042.3
GA-WM-06	190.5	4856308.3	631109.3
R1	190.6	4856351.6	631071.8
R2	191.4	4856408.6	631032.7
R3	192.0	4856477.9	631020.6

NOTES

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

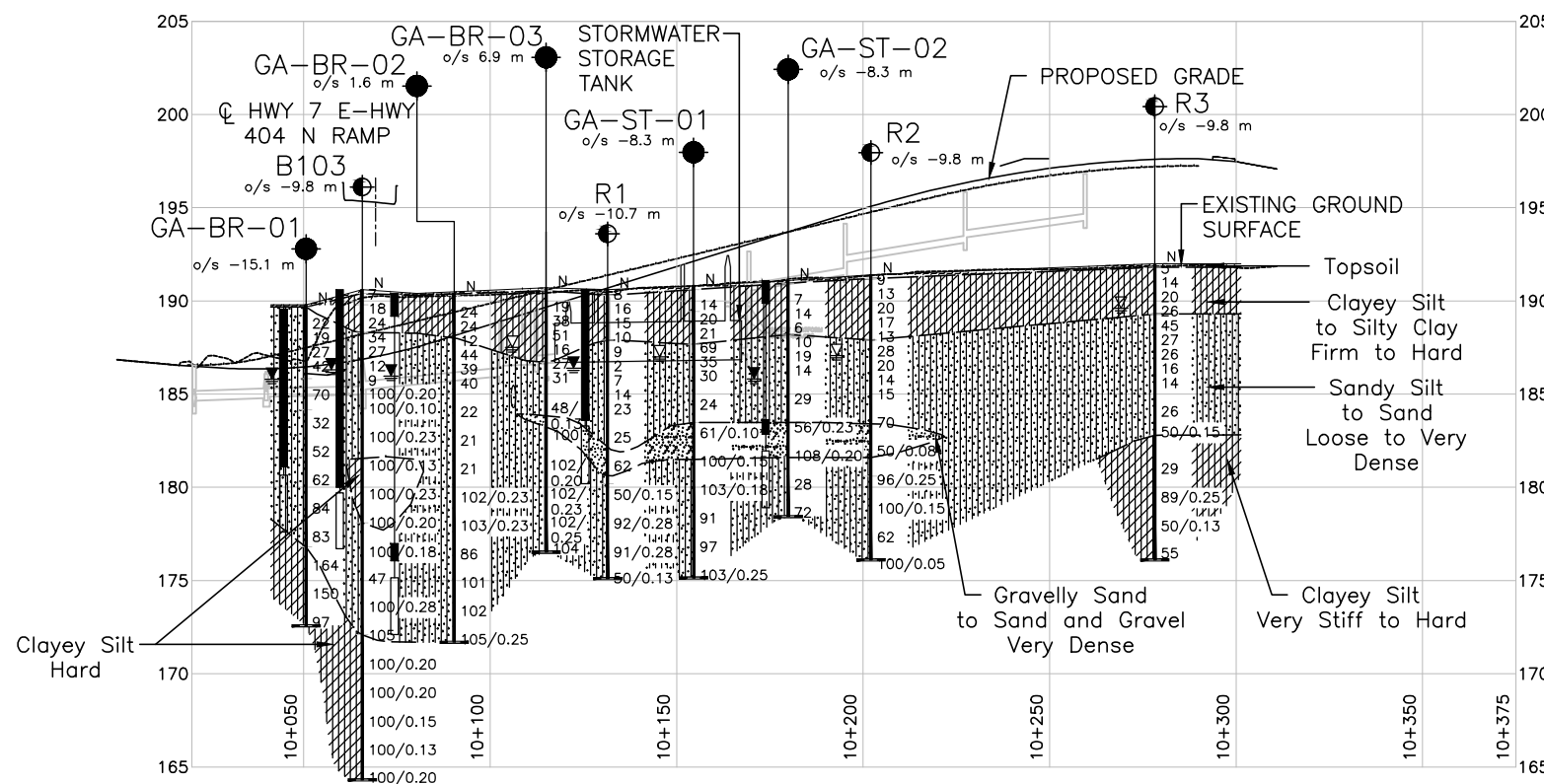
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

REFERENCES

Base plans provided in digital format by AECOM, drawing file nos. Bgd-2015.dwg, Mdbk_Ramp_Pln.dwg, Ramp_Aln.dwg, Ramp_Pln.dwg and Ramp_Prf.dwg, received October 13, 2015.

NO.	DATE	BY	REVISION
1			
Geocres No. 30M14-426			
HWY. 404	PROJECT NO. 1533525		DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: Oct. 2015	SITE: .
DRAWN: JFC	CHKD. CN	APPD. JMAC	DWG. 2



PROFILE OF S-E/W RAMP EXTENSION

HORIZONTAL SCALE
20 0 20 40 m

VERTICAL SCALE
4 0 4 8 m





APPENDIX A

Record of Boreholes – Golder 2015 Investigation



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1
2

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

III. SOIL DESCRIPTION

(a) Non-Cohesive 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

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.)

(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

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.

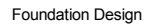
IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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



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

PROJECT 1533525		RECORD OF BOREHOLE No GA-BR-01				SHEET 2 OF 2		METRIC								
W.P. _____		LOCATION N 4856282.4 ; E 631119.8				ORIGINATED BY OS										
DIST _____ HWY _____		BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Augers				COMPILED BY JM										
DATUM Geodetic		DATE September 14, 2015				CHECKED BY CN										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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					WATER CONTENT (%)			
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100					
			12	SS	150											
						174										
			13	SS	97	173										
172.6	CLAYEY SILT, trace sand, sandy silt pockets Hard Grey Moist to wet															
17.2	END OF BOREHOLE															
	NOTE: 1. Water level measurements in piezometer: <div style="display: flex; justify-content: space-between;"> <div>Date</div> <div>Depth (m)</div> <div>Elev. (m)</div> </div> <div style="display: flex; justify-content: space-between;"> <div>09/14/15</div> <div>4.1</div> <div>185.7</div> </div> <div style="display: flex; justify-content: space-between;"> <div>09/15/15</div> <div>3.9</div> <div>185.9</div> </div> <div style="display: flex; justify-content: space-between;"> <div>10/13/15</div> <div>4.0</div> <div>185.8</div> </div>															

GTA-MTO 001 S:\CLIENTS\REGION OF YORK\MIDBLOCK_CROSSING\02_DATA\GINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM

PROJECT 1533525		RECORD OF BOREHOLE No GA-BR-02		SHEET 1 OF 2		METRIC	
W.P. _____		LOCATION N 4856302.6 ; E 631090.9		ORIGINATED BY MCK			
DIST _____ HWY _____		BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone		COMPILED BY JM			
DATUM Geodectic		DATE September 10 and 11, 2015		CHECKED BY CN			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _p	W	W _L
190.4	GROUND SURFACE																
0.0	TOPSOIL																
0.1	CLAYEY SILT, trace to some sand, trace gravel Very stiff Brown Dry to moist		1	SS	24												
			2	SS	24												
188.3																	
2.1	SAND, trace to some silt, trace clay, trace to some gravel Compact to very dense Brown to grey Wet		3	SS	12												
			4	SS	44												
			5	SS	39												
			6	SS	40												
			7	SS	22												
			8	SS	21												
			9	SS	21												
			10A 10B	SS	102/0.23												
	- 28 cm silt layer encountered at 10.8 m																
			11	SS	103/0.23												
	- 10 cm silt layer encountered at 12.3 m																
			12	SS	86												
								</									

Continued Next Page

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

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PROJECT <u>1533525</u>		RECORD OF BOREHOLE No GA-BR-02		SHEET 2 OF 2		METRIC	
W.P. _____		LOCATION <u>N 4856302.6 ; E 631090.9</u>		ORIGINATED BY <u>MCK</u>			
DIST _____ HWY _____		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodectic</u>		DATE <u>September 10 and 11, 2015</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	w _p	w	w _L					
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	SAND, trace to some silt, trace clay, trace to some gravel Compact to very dense Brown to grey Wet		13	SS	101															
			14	SS	102															
171.7			15	SS	105/0.25															
18.7	END OF BOREHOLE NOTE: 1. Water level measurements in piezometer: Date Depth (m) Elev. (m) 09/11/15 4.4 186.0 09/11/15 4.8 185.6 09/15/15 4.6 185.8 10/13/15 4.8 185.6																			

GTA-MTO 001 S:\CLIENTS\REGION OF YORK\MIDBLOCK_CROSSING\02_DATA\GINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM

PROJECT <u>1533525</u>		RECORD OF BOREHOLE No GA-BR-03		SHEET 1 OF 2		METRIC	
W.P. _____		LOCATION <u>N 4856328.0 ; E 631066.7</u>		ORIGINATED BY <u>MCK</u>			
DIST _____ HWY _____		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodectic</u>		DATE <u>September 11, 2015</u>		CHECKED BY <u>CN</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										WATER CONTENT (%)		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED											
190.7	GROUND SURFACE																			
0.0	TOPSOIL																			
0.2	CLAYEY SILT, trace to some sand, trace gravel Very stiff to hard Brown Dry																			
			1	SS	19															
			2	SS	38															
			3	SS	51															
			4A	SS	16															
			4B																	
186.7	SILT and SAND to Silty SAND, trace clay Compact to very dense Brown to grey Wet		5A	SS	27															
4.0			5B																	
			6	SS	31															
			7	SS	48/0.13															
			8	SS	100															
			9	SS	102/0.20															
			10	SS	102/0.23															
			11	SS	102/0.25															

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

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

PROJECT		1533525		RECORD OF BOREHOLE No GA-WM-06				SHEET 1 OF 1		METRIC																					
W.P.				LOCATION		N 4856308.3 ; E 631109.3		ORIGINATED BY		MCK																					
DIST		HWY		BOREHOLE TYPE		108 mm I.D. Hollow Stem Power Augers		COMPILED BY		JM																					
DATUM		Geodetic		DATE		September 10, 2015		CHECKED BY		CN																					
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 (%)														
190.5	GROUND SURFACE																														
0.9	TOPSOIL																														
	CLAYEY SILT, trace to some sand, trace to some gravel Very stiff Brown Moist		1	SS	28																										
			2	SS	30																										
	- 8 cm sandy silt layer encountered at a depth of 4.0 m		3A	SS	17																										
			3B	SS																											
187.4			4	SS	21																										
3.1	SILT and SAND to SAND, trace clay, trace to some silt, trace gravel to gravelly, inferred cobbles at depths of 3.8 m, 5.3 m and 8.5 m to Compact to very dense Brown to grey Dry to wet		5A	SS	23																										
			5B	SS																											
	- 6 cm clayey silt layer encountered at a depth of 4.0 m		6	SS	50																										
			7	SS	74																										
			8	SS	71																										
			9	SS	101/0.15																										
			10A	SS	80																										
			10B	SS																											
			11A	SS	73																										
177.8			11B	SS																											
12.7	END OF BOREHOLE																														
NOTE: 1. Water level measurements in piezometer: <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev. (m)</th> </tr> </thead> <tbody> <tr> <td>09/10/15</td> <td>5.0</td> <td>185.5</td> </tr> <tr> <td>09/11/15</td> <td>4.9</td> <td>185.6</td> </tr> <tr> <td>09/15/15</td> <td>4.9</td> <td>185.6</td> </tr> <tr> <td>10/13/15</td> <td>4.9</td> <td>185.6</td> </tr> </tbody> </table>																	Date	Depth (m)	Elev. (m)	09/10/15	5.0	185.5	09/11/15	4.9	185.6	09/15/15	4.9	185.6	10/13/15	4.9	185.6
Date	Depth (m)	Elev. (m)																													
09/10/15	5.0	185.5																													
09/11/15	4.9	185.6																													
09/15/15	4.9	185.6																													
10/13/15	4.9	185.6																													

GTA-MTO 001 S:\CLIENTS\REGION OF YORK\MIDBLOCK_CROSSING\02_DATA\GINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM



PROJECT <u>1533525</u>		RECORD OF BOREHOLE		No GA-ST-01	SHEET 1 OF 2	METRIC
W.P. _____		LOCATION <u>N 4856369.2 ;E 631056.7</u>		ORIGINATED BY <u>MCK</u>		
DIST _____ HWY _____		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone</u>		COMPILED BY <u>JM</u>		
DATUM <u>Geodectic</u>		DATE <u>September 14, 2015</u>		CHECKED BY <u>CN</u>		

[illegible]

Continued Next Page

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

PROJECT		RECORD OF BOREHOLE				No GA-ST-01		SHEET 2 OF 2		METRIC							
W.P. _____		LOCATION				N 4856369.2 ; E 631056.7		ORIGINATED BY		MCK							
DIST _____ HWY _____		BOREHOLE TYPE				108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone		COMPILED BY		JM							
DATUM Geodectic		DATE				September 14, 2015		CHECKED BY		CN							
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									
	--- CONTINUED FROM PREVIOUS PAGE ---																
175.1			13	SS	103/0.25												
15.7	END OF BOREHOLE * Hammer bouncing NOTE: 1. Water level in open borehole measured at a depth of 3.8 m below ground surface (Elev. 187.0 m) upon completion of drilling.																

GTA-MTO 001 S:\CLIENTS\REGION OF YORK\MIDBLOCK_CROSSING\02_DATA\GINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM

PROJECT 1533525		RECORD OF BOREHOLE No GA-ST-02				SHEET 1 OF 2		METRIC						
W.P. _____		LOCATION N 4856390.0 ; E 631042.3				ORIGINATED BY MCK								
DIST _____ HWY _____		BOREHOLE TYPE 108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone				COMPILED BY JM								
DATUM Geodetic		DATE September 14 and 15, 2015				CHECKED BY CN								
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						
191.1	GROUND SURFACE													
0.0	TOPSOIL													
0.2	CLAYEY SILT, some sand to sandy, trace gravel Firm to stiff Brown Moist		1	SS	7									
			2	SS	14									
			3	SS	6									
188.2	Sandy SILT to SAND, trace clay, trace gravel Compact Brown Moist - Auger grinding at a depth of 3.7 m		4	SS	10									
2.9			5	SS	19									
			6	SS	14									
	- Auger grinding at a depth of 5.2 m		7	SS	29									
183.5	SAND and GRAVEL, some silt, trace clay, containing cobbles Very dense Brown Moist - Inferred cobble (approximately 23 cm) encountered at a depth of 8.0 m		8	SS	56/0.23									
7.6			9	SS	108/0.20									
181.6	SAND, some silt, some gravel, containing clayey silt lenses Compact to very dense Brown to grey Wet		10	SS	28									
9.5			11	SS	72									
	- Auger grinding at a depth of 11.4 m													
178.4	END OF BOREHOLE													
12.7														

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\REGION_OF_YORK\MIDBLOCK_CROSSING\02_DATAGINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM

PROJECT <u>1533525</u>	RECORD OF BOREHOLE No GA-ST-02		SHEET 2 OF 2	METRIC
W.P. _____	LOCATION <u>N 4856390.0 ; E 631042.3</u>	ORIGINATED BY <u>MCK</u>		
DIST _____ HWY _____	BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Power Augers / 98 mm Open Hole Mud Rotary/Tricone</u>	COMPILED BY <u>JM</u>		
DATUM <u>Geodetic</u>	DATE <u>September 14 and 15, 2015</u>	CHECKED BY <u>CN</u>		

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		GR	SA	SI	CL
--- CONTINUED FROM PREVIOUS PAGE ---					○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)										
								20	40	60	80	100	10	20	30					
	NOTES: 1. Water level measurements in piezometer: Date Depth (m) Elev. (m) 09/15/15 5.3 185.8 10/13/15 5.4 185.7 2. Borehole abandoned at a depth of 9.1 m due to A-rods breaking during drilling. Borehole backfilled with approximately 5.5 m of drilling rods in the hole between depths 3.6 m (Elev. 187.0 m) and 9.1 m (Elev. 182.0 m). An additional borehole was advanced about 1.8 m North of the original borehole to delineate the subsurface conditions between a depth of 10.7 m (Elev. 180.4 m) and 12.7 m (Elev. 178.4 m).																			

GTA-MTO 001 S:\CLIENTS\REGION OF YORK\MIDBLOCK_CROSSING\02_DATA\GINT\MIDBLOCK_CROSSING.GPJ GAL-GTA.GDT 12/15/15 JM



**FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT,
EARTH CUT, STORMWATER STORAGE TANK AND
ASSOCIATED STRUCTURES**

APPENDIX B

Laboratory Test Results



FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT, EARTH CUT, STORMWATER STORAGE TANK AND ASSOCIATED STRUCTURES

Table B1 – Summary of Analytical Testing of Groundwater

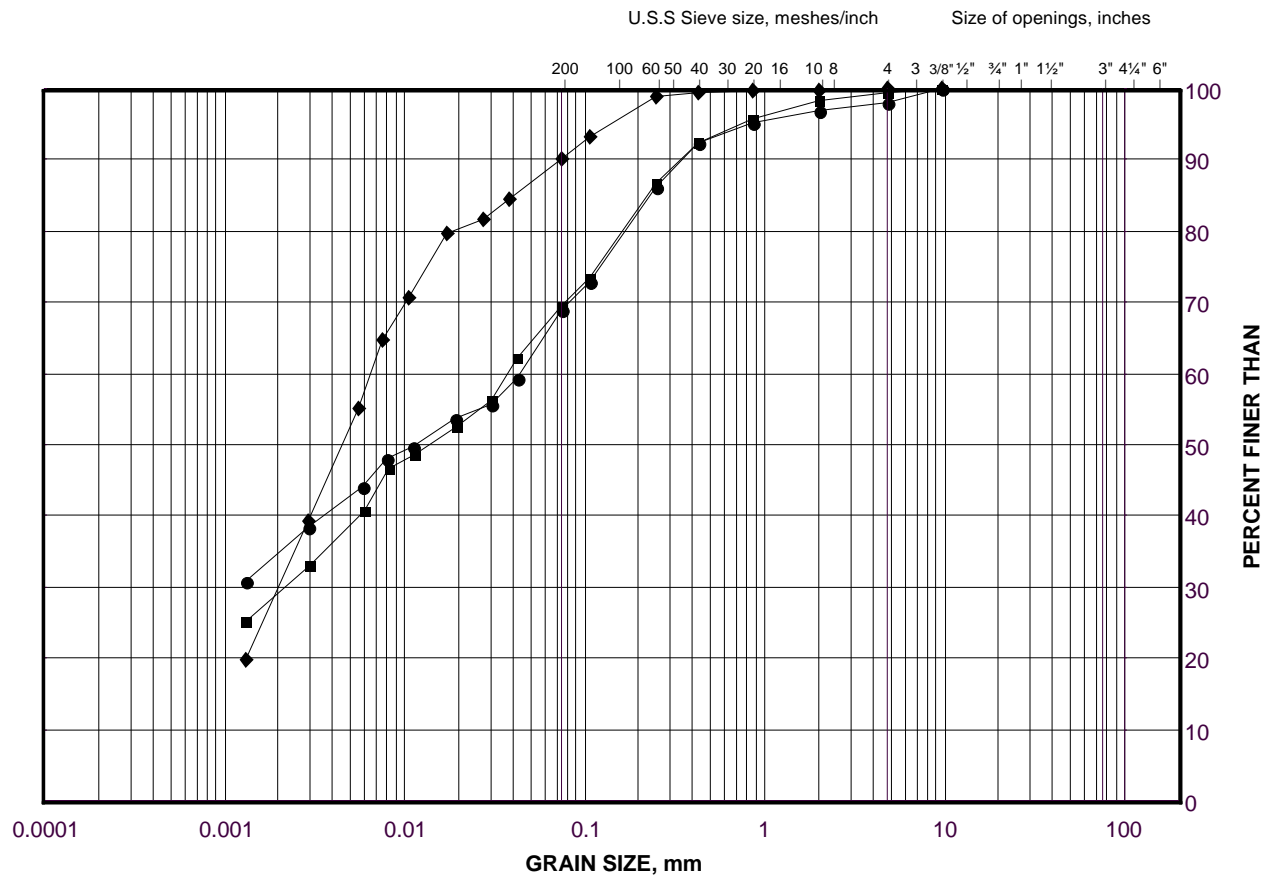
Borehole Number	Parameter (Units / Detection Limit)				
	Dissolved Chloride (mg/L / 0.5)	Dissolved Sulfate (mg/L / 0.5)	Conductivity (uS/cm / 2)	Resistivity (ohm-cm)	pH
GA-WM-06	143 / 0.5	59.2 / 0.5	1190 / 2	840	7.88
GA-ST-02	970 / 2	124 / 2	3620 / 2	276	7.78

Notes: 1. Samples obtained October 13, 2015.
2. Analytical testing carried out by Agat Laboratories.

Prepared by: MCK
Checked by: CN

Clayey Silt (Upper)
S-E/W Ramp Extension

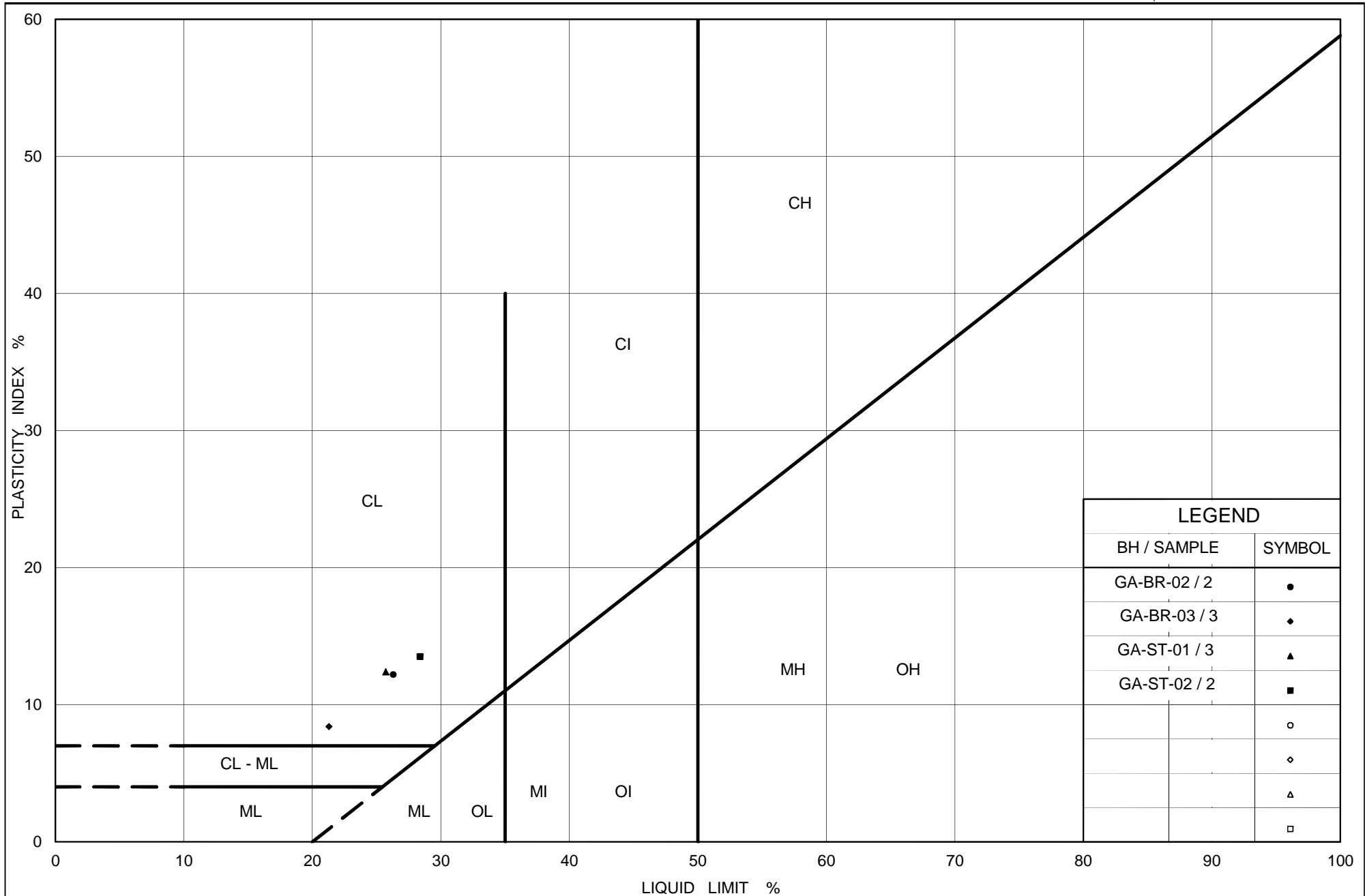
FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	GA-ST-02	2	189.4
■	GA-ST-01	3	188.3
◆	GA-BR-03	4B	189.0



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt (Upper) S-E/W Ramp Extension

Figure No. B2

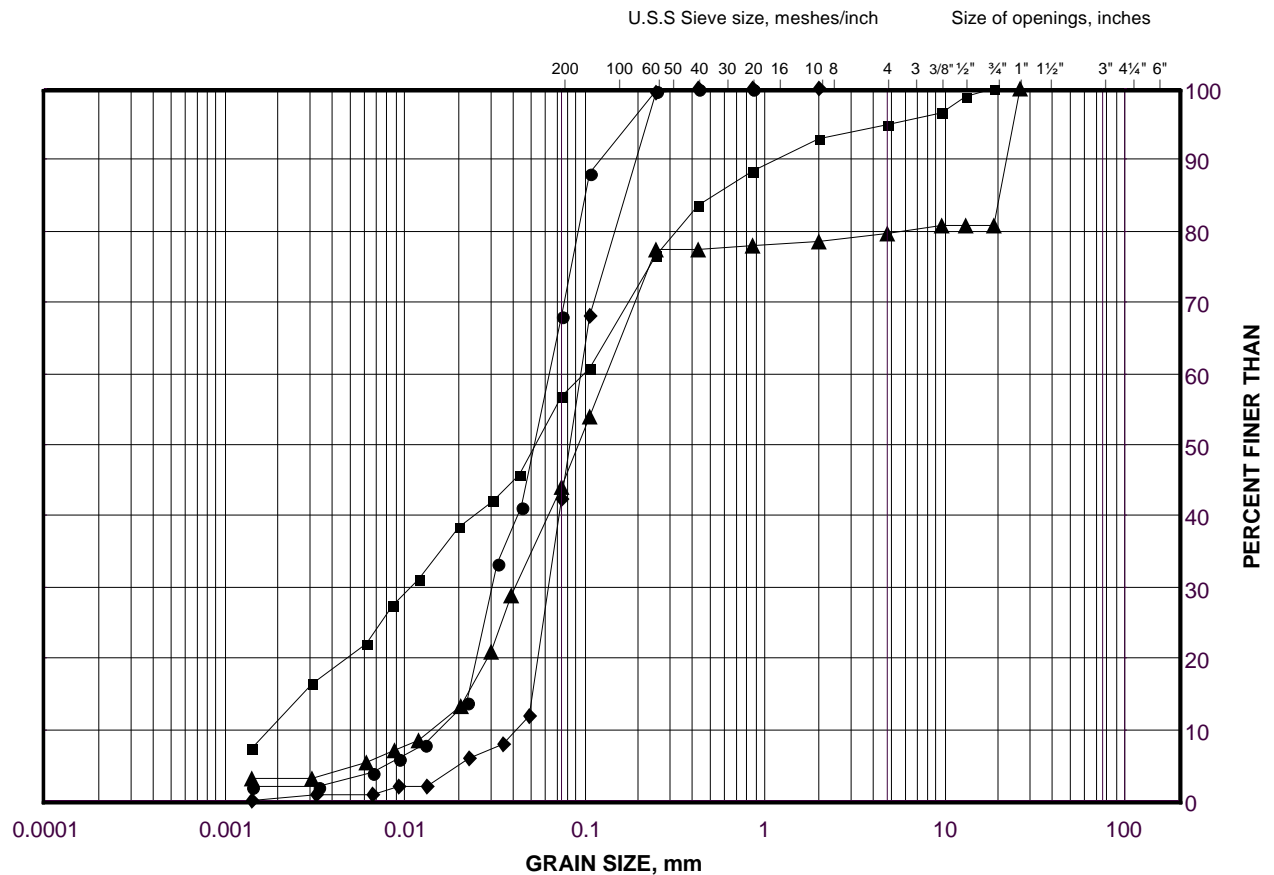
Project No. 1533525

Checked By: CN

GRAIN SIZE DISTRIBUTION

Silt and Sand
S-E/W Ramp Extension

FIGURE B3A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	GA-ST-02	5	187.1
■	GA-BR-01	5	185.0
◆	GA-BR-03	6	185.9
▲	GA-WM-06	7	184.2

Project Number: 1533525

Checked By: CN

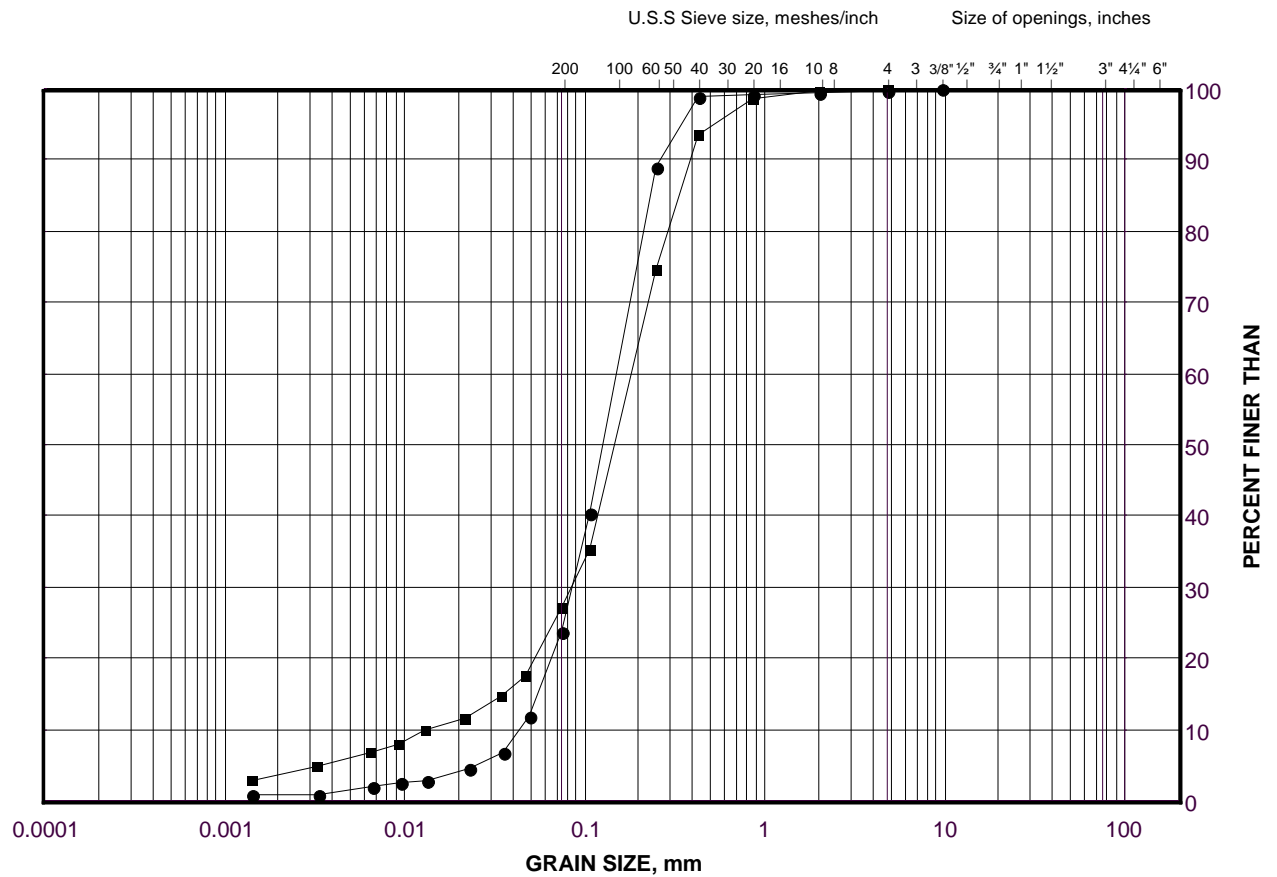
Golder Associates

Date: 22-Dec-15

GRAIN SIZE DISTRIBUTION

Silty Sand
S-E/W Ramp Extension

FIGURE B3B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	GA-BR-01	3	187.3
■	GA-BR-03	8	182.9

Project Number: 1533525

Checked By: CN

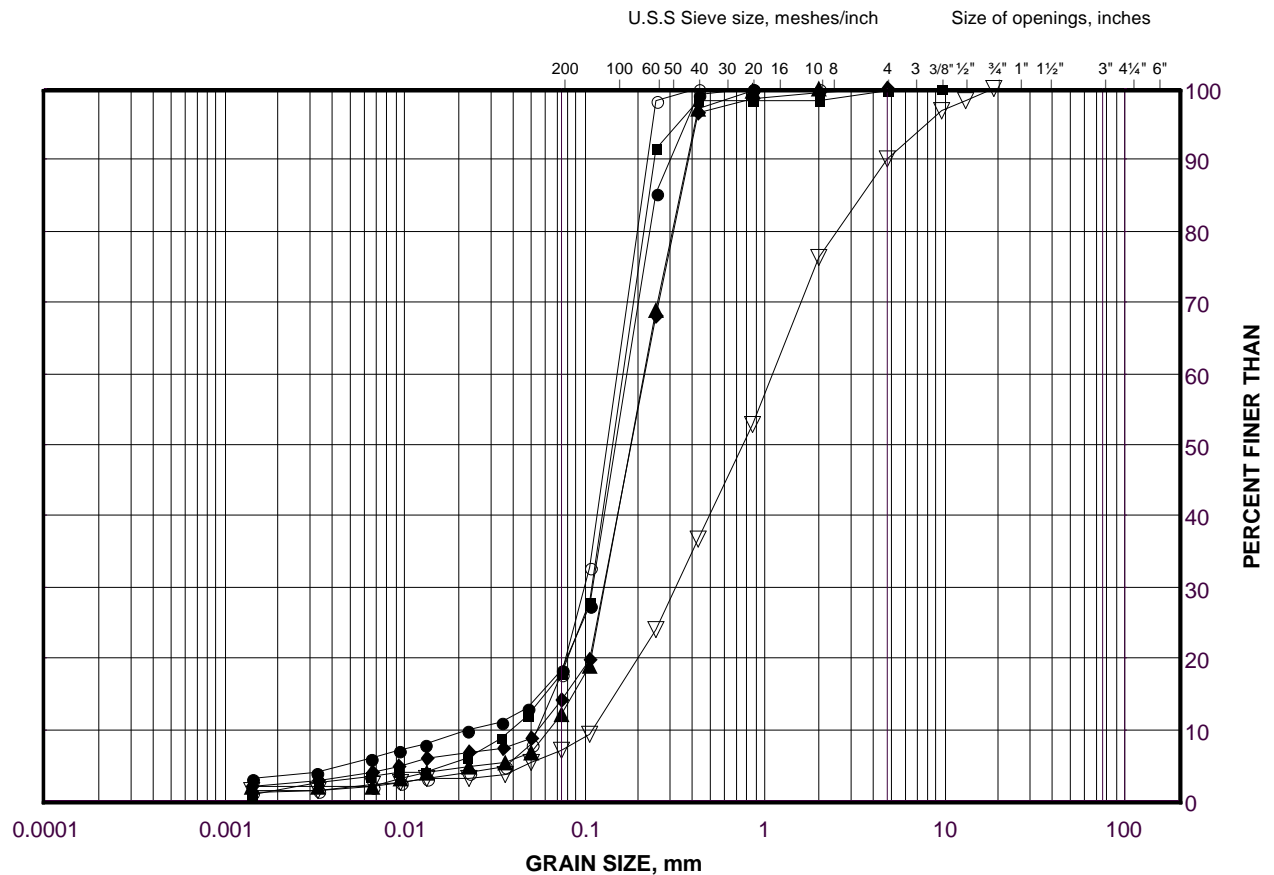
Golder Associates

Date: 22-Dec-15

GRAIN SIZE DISTRIBUTION

Sand
S-E/W Ramp Extension

FIGURE B3C



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	GA-WM-06	11B	184.2
■	GA-ST-01	12	176.9
◆	GA-BR-02	14	173.4
▲	GA-BR-02	6	185.6
▽	GA-BR-02	9	181.0
○	GA-BR-01	9	178.9

Project Number: 1533525

Checked By: CN

Golder Associates

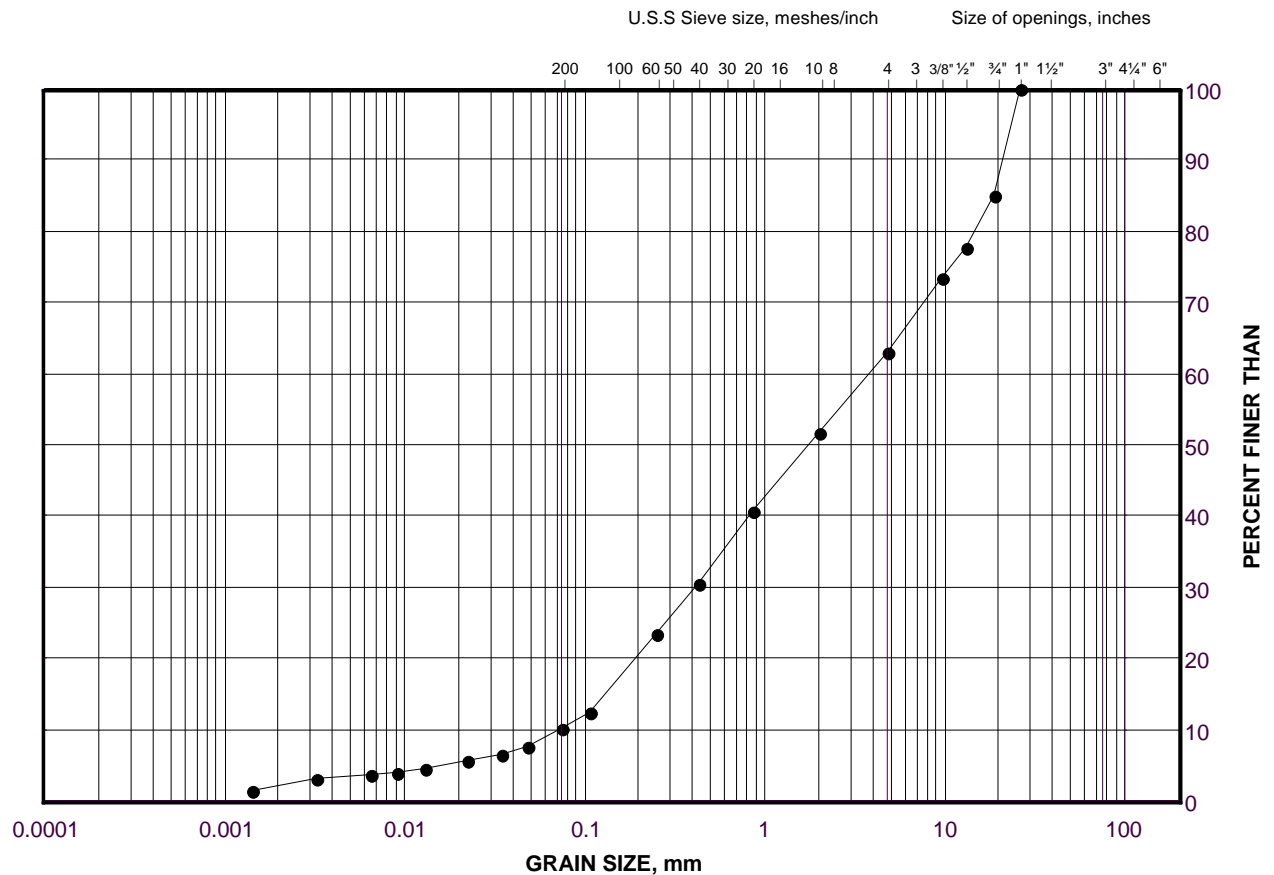
Date: 22-Dec-15

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Interlayer)

S-E/W Ramp Extension

FIGURE B4



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

LEGEND

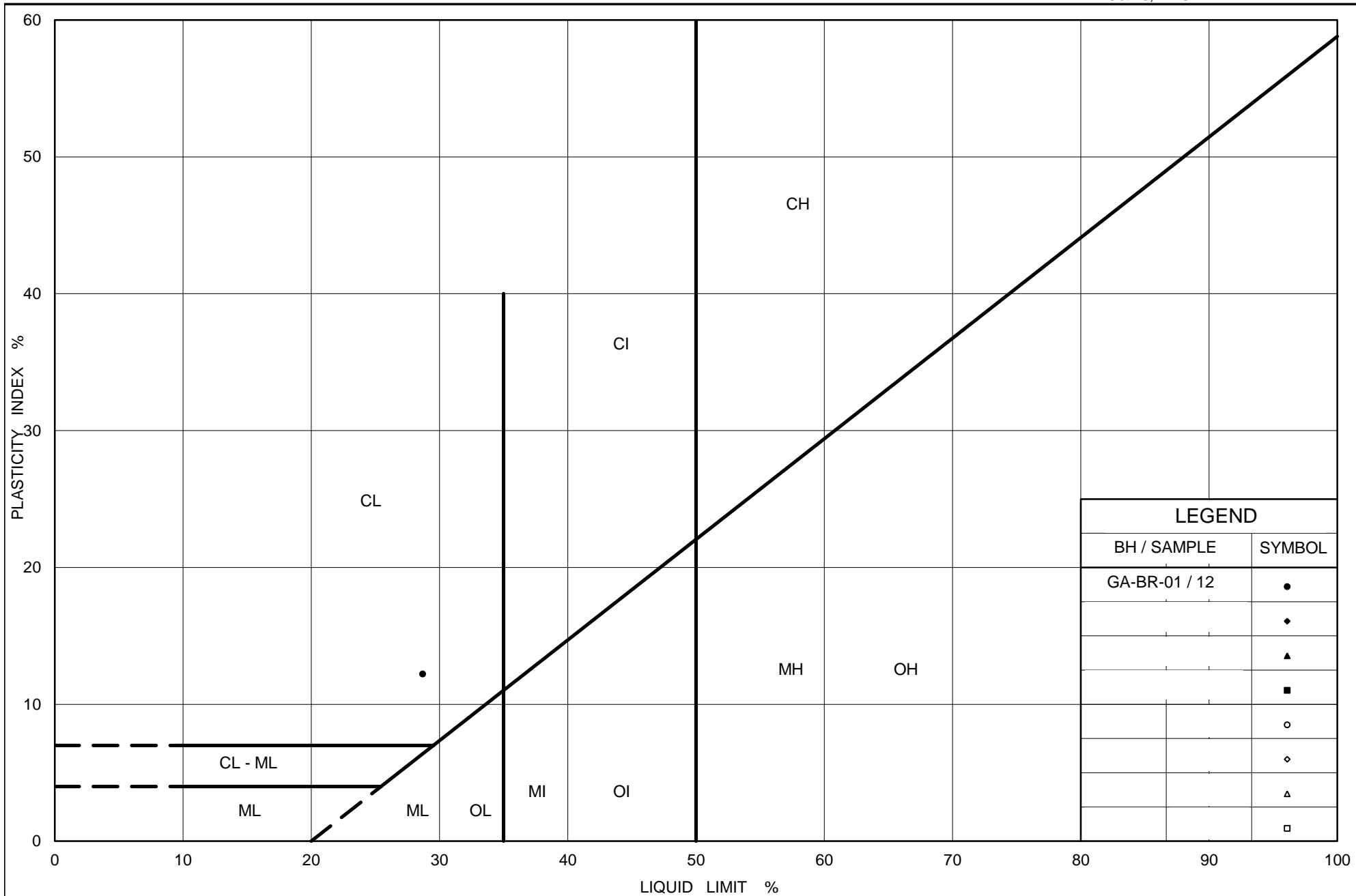
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	GA-ST-02	9	181.8

Project Number: 1533525

Checked By: CN

Golder Associates

Date: 19-Oct-15



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt (Lower) S-E/W Ramp Extension

Figure No. B5

Project No. 1533525

Checked By: CN



APPENDIX C

Previous Investigation – Record of Boreholes and Laboratory Test Results

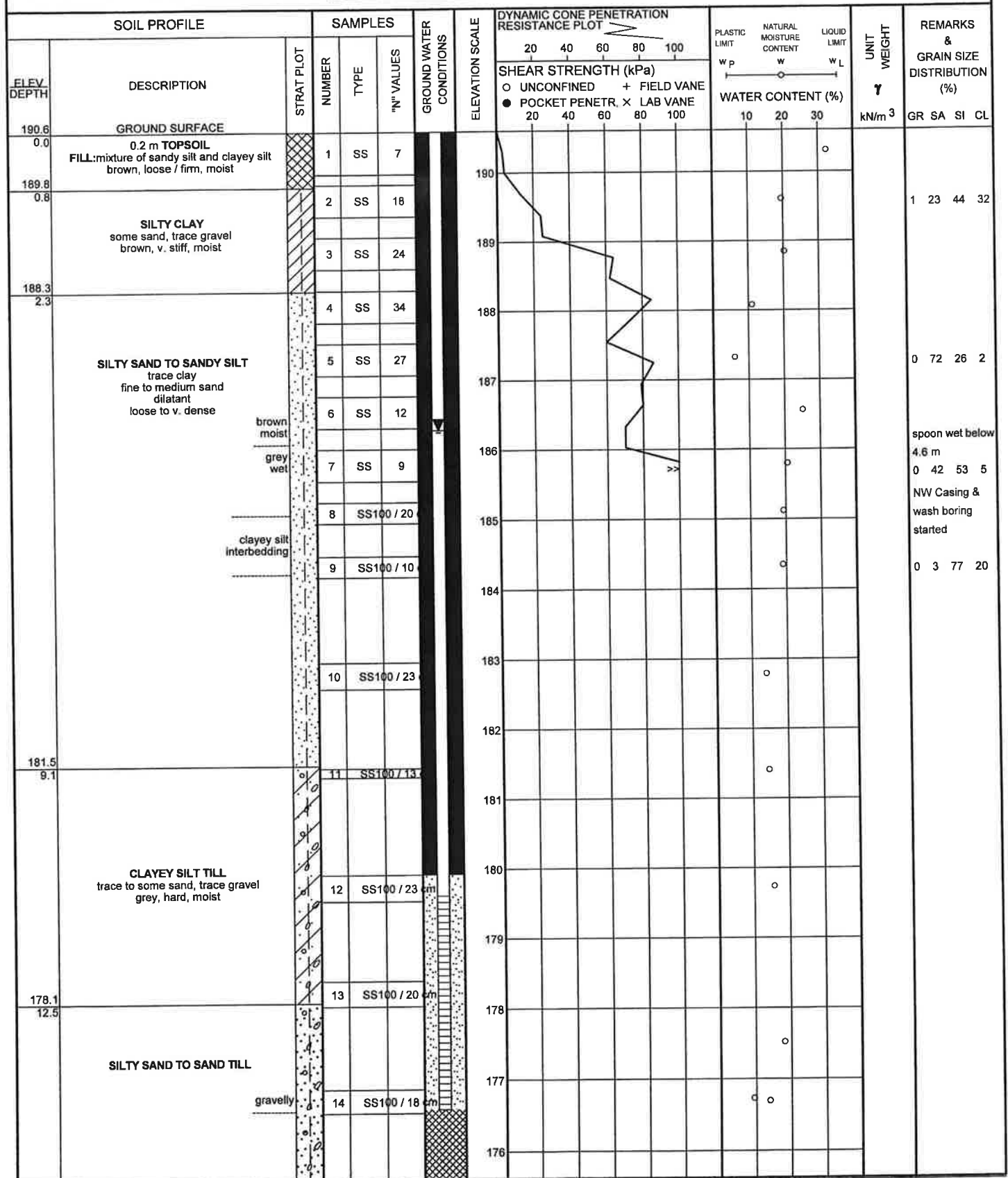
TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No B103

1 OF 2

METRIC

GWP G.W.P LOCATION 404 E-N On Ramp-Station 0+207, 5 m Rt of C/L (631108.3 E, 4856295.4 N) ORIGINATED BY LG
DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing, Wash Boring, DCPT COMPILED BY SH
DATUM Geodetic DATE 5/24/2011 5/27/2011 CHECKED BY ZO



Continued Next Page

+ 3, × 3 Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No B103

2 OF 2

METRIC

+ 3, × 3: Numbers refer to Sensitivity

TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No B104

1 of 1

METRIC

GWP G.W.P. LOCATION 404 E-N On Ramp-Station 0+192, 6.4 m Lt of C/L (631123.2 E, 4856281.7 N) ORIGINATED BY LG
DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing, Wash boring, DCPT COMPILED BY AS
DATUM Geodetic DATE 5/24/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)
								20	40	60			
189.3	GROUND SURFACE												
0.0	0.2 m TOPSOIL		1	SS	5		189						
188.8	FILL: mixture of clayey silt, topsoil and sandy silt, firm		2	SS	15		188						
0.5			3	SS	23		187						
	SILTY SAND TO SANDY SILT		4	SS	33		186						
	trace to some gravel		5	SS	25		185						
	brown		6	SS	55		184						
	moist		7	SS	66		183						
	wet, compact		8	SS	53		182						
	gravelly		9	SS	35		181						
	dense to v. dense		10	SS	65		180						
182.7			11	SS	43		179						
6.6			12	SS	91		178						
	SILTY SAND TO SAND TILL		13	SS	26		177						
	trace gravel, trace clay												
	grey, dense to v. dense, wet												
	brown												
	grey												
176.8													
12.5													
176.7	CLAYEY SILT TILL												
12.7	trace to some sand, trace gravel												
	grey, v. stiff, moist												
End of borehole @ 12.7 m Water level and caved-in @ 3.5 m (not stabilized)* upon completion DCPT performed from bottom of borehole to 13.3 m													

+ ³ × ³ Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETO10757AA: Highway 404/7

RECORD OF BOREHOLE No R1

1 OF 2

METRIC

GWP G.W.P. LOCATION 404 S-EW Off Ramp-Station 10+130, 10 m Rt of C/L (631071.8 E, 4856351.6 N) ORIGINATED BY LG
 DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing and Wash boring COMPILED BY SH
 DATUM Geodetic DATE 5/19/2011 CHECKED BY ZO

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 (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
190.6 0.0	GROUND SURFACE													
	0.3 m TOPSOIL dk. brown, tr. org.		1	SS	8		190							
			2	SS	16									10 18 35 37
	CLAYEY SILT TO SILTY CLAY trace to some sand, trace gravel stiff to v. stiff, moist		3	SS	15		189							
			4	SS	10		188							
187.9 2.7	sandy silt seams		5	SS	9		187							
			6	SS	2									
	SILTY SAND TO SANDY SILT trace clay pockets brown, v. loose to compact		7	SS	7		186							0 62 32 6
			8	SS	14		185							spoon wet below 5.3 m
			9	SS	23		184							
			10	SS	25		183							start of wash boring and NW casing
			11	SS	62		181							43 29 (28)
180.2 10.4			12	SS 50 / 15 c			180							
	SILTY SAND TO SAND TILL fine to medium trace gravel, trace clay occ. cobbles brownish grey, v. dense, wet		13	SS 92 / 28 c			178							
			14	SS 91 / 28 c			177							
							176							

Continued Next Page

+ 3, × 3: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No R1

2 OF 2

METRIC

GWP G.W.P. LOCATION 404 S-EW Off Ramp-Station 10+130, 10 m Rt of C/L (631071.8 E, 4856351.6 N) ORIGINATED BY LG
 DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing and Wash boring COMPILED BY SH
 DATUM Geodetic DATE 5/19/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	10 20 30					
175.6															
175.1 15.5	SILTY SAND TO SAND TILL with clayey silt seams		15	SS 50 / 13			175								
	End of borehole Hole caved-in @ 14.1 m upon completion Monitoring well installed to 10.4 m Water Level Records : May 19, 2011 4.9 m June 8, 2011 4.3 m June 21, 2011 4.2 m June 22, 2011 4.2 m June 30, 2011 4.2 m														

+ 3, X 3, 20
Sensitivity 15 5
10 (%) STRAIN AT FAILURE

METRIC

(%) STRAIN AT FAILURE

TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No R2

2 OF 2

METRIC

GWP G.W.P LOCATION 404 S-EW Off Ramp-Station 10+201, 9.4 m Rt of C/L (631032.7 E, 4856408.8 N) ORIGINATED BY LG
 DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing and Wash boring COMPILED BY SH
 DATUM Geodetic DATE 5/12/2011 5/16/2011 CHECKED BY ZO

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		20	40	60	80	100					
176.4																
176.1	SILTY SAND TO SAND TILL		15	SS	100 / 5 cm											no recovery
15.3	End of borehole Water level @ 4.3 m (not stabilized)* upon completion					176										

+ ³ × ³ Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No R3

1 OF 2

METRIC

GWP G.W.P. LOCATION 404 S-EW Off Ramp-Station 10+277, 10 m Rt of C/L (631020.6 E, 4856477.9 N) ORIGINATED BY LG
 DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing and Wash boring COMPILED BY AS/SH
 DATUM Geodetic DATE 5/16/2011 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE				
192.0 0.0	GROUND SURFACE						192					
	0.2 m TOPSOIL	dk. brown brown	1	SS	5							
	CLAYEY SILT TO SILTY CLAY trace to some sand, trace gravel firm to v. stiff, moist		2	SS	14		191				43.7	2 16 35 47
			3	SS	20		190					5 24 41 30
			4	SS	26		189					
189.3 2.7			5	SS	45		188					0 24 71 5
	SILTY SAND TO SANDY SILT trace clay brown, dense to compact		6	SS	27		187					
			7	SS	26		186					0 73 22 5
			8	SS	16		185					spoon wet below 6.1 m
			9	SS	14		184					start of wash boring and NW casing
			10	SS	26		183					
			11	SS	50 / 15 cm		182					
	CLAYEY SILT TILL trace to some sand grey to dk. grey, moist	hard	12	SS	29		181					
			13	SS	69 / 25 cm		180					0 8 43 49
			14	SS	50 / 13 cm		179					
182.8 9.2							178					

Continued Next Page

+ 3 x 3

Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

TRANETOB10757AA: Highway 404/7

RECORD OF BOREHOLE No R3

2 OF 2

METRIC

GWP G.W.P LOCATION 404 S-EW Off Ramp-Station 10+277, 10 m Rt of C/L (631020.6 E, 4856477.9 N) ORIGINATED BY LG
 DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger, NW Casing and Wash boring COMPILED BY AS/SH
 DATUM Geodetic DATE 5/16/2011 CHECKED BY ZO

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) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE									
						20	40	60	80	100							
177.0																	
176.1	CLAYEY SILT TILL trace to some sand		15	SS	55												
15.9	End of borehole Borehole dry (not stabilized)* upon completion Hole caved-in @ 2.2 m upon completion																

+ 3, × 3:

Numbers refer to
Sensitivity

20
15
10

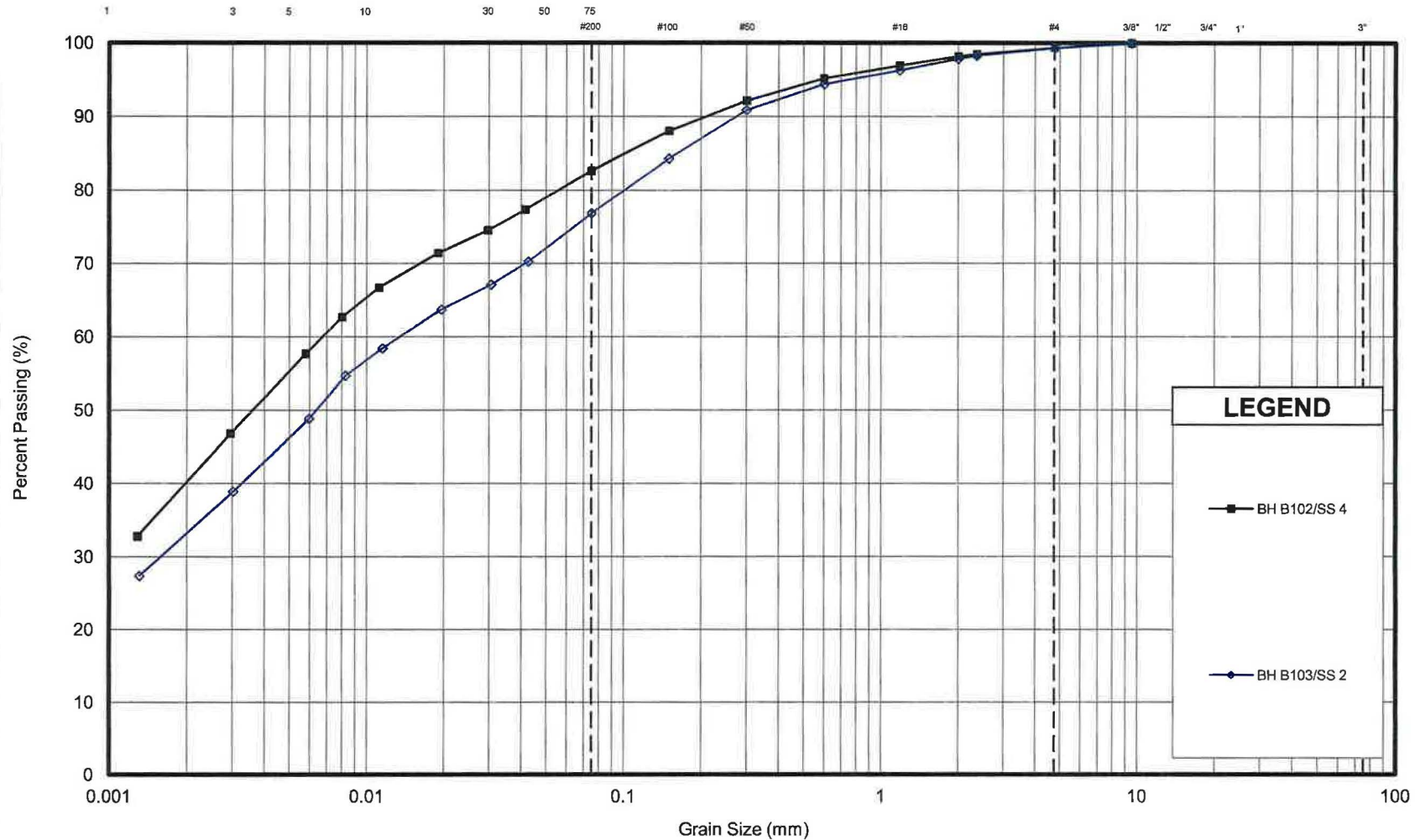
(%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (IMPERIAL)



LEGEND

—■— BH B102/SS 4

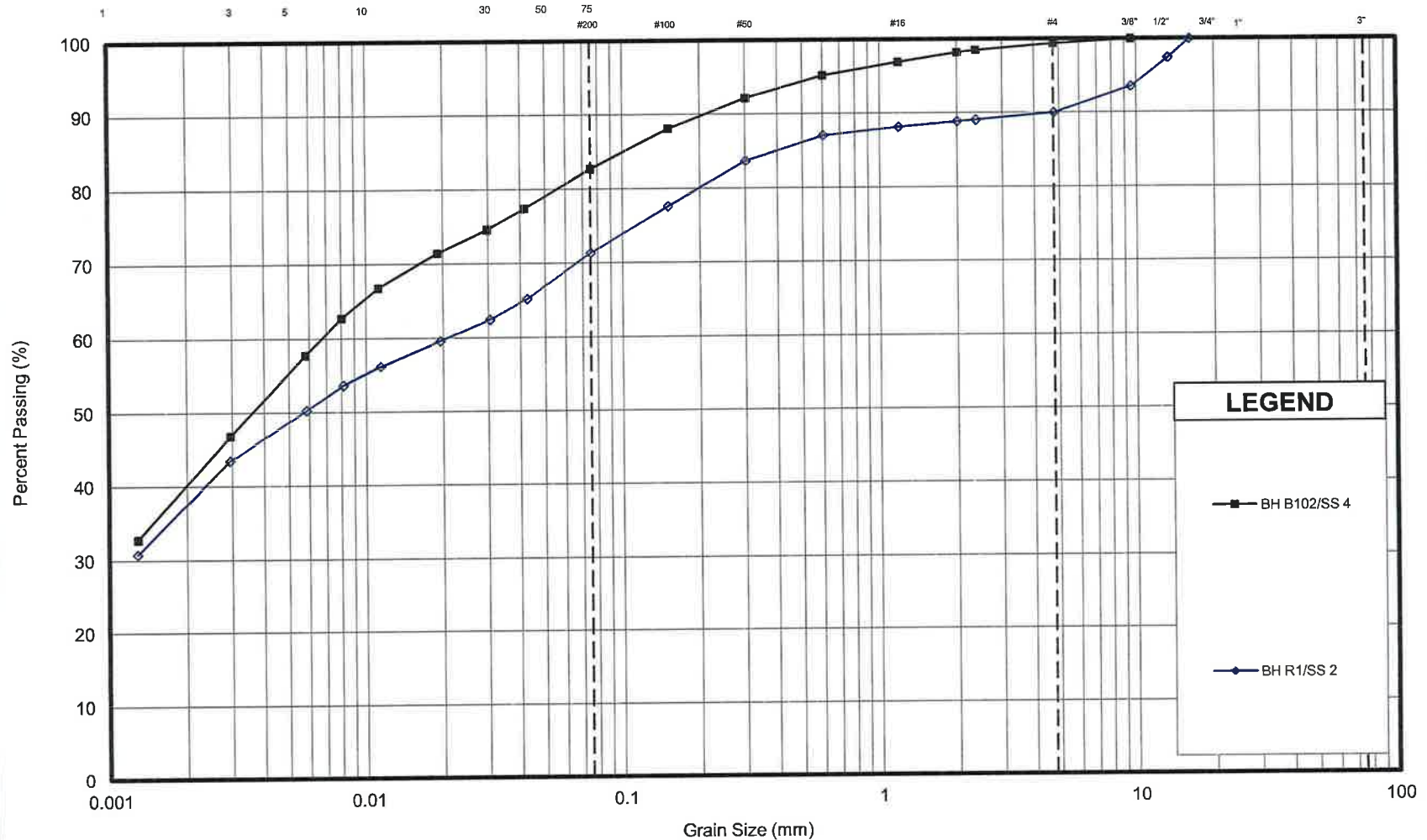
—◆— BH B103/SS 2

UNIFIED SOIL CLASSIFICATION SYSTEM

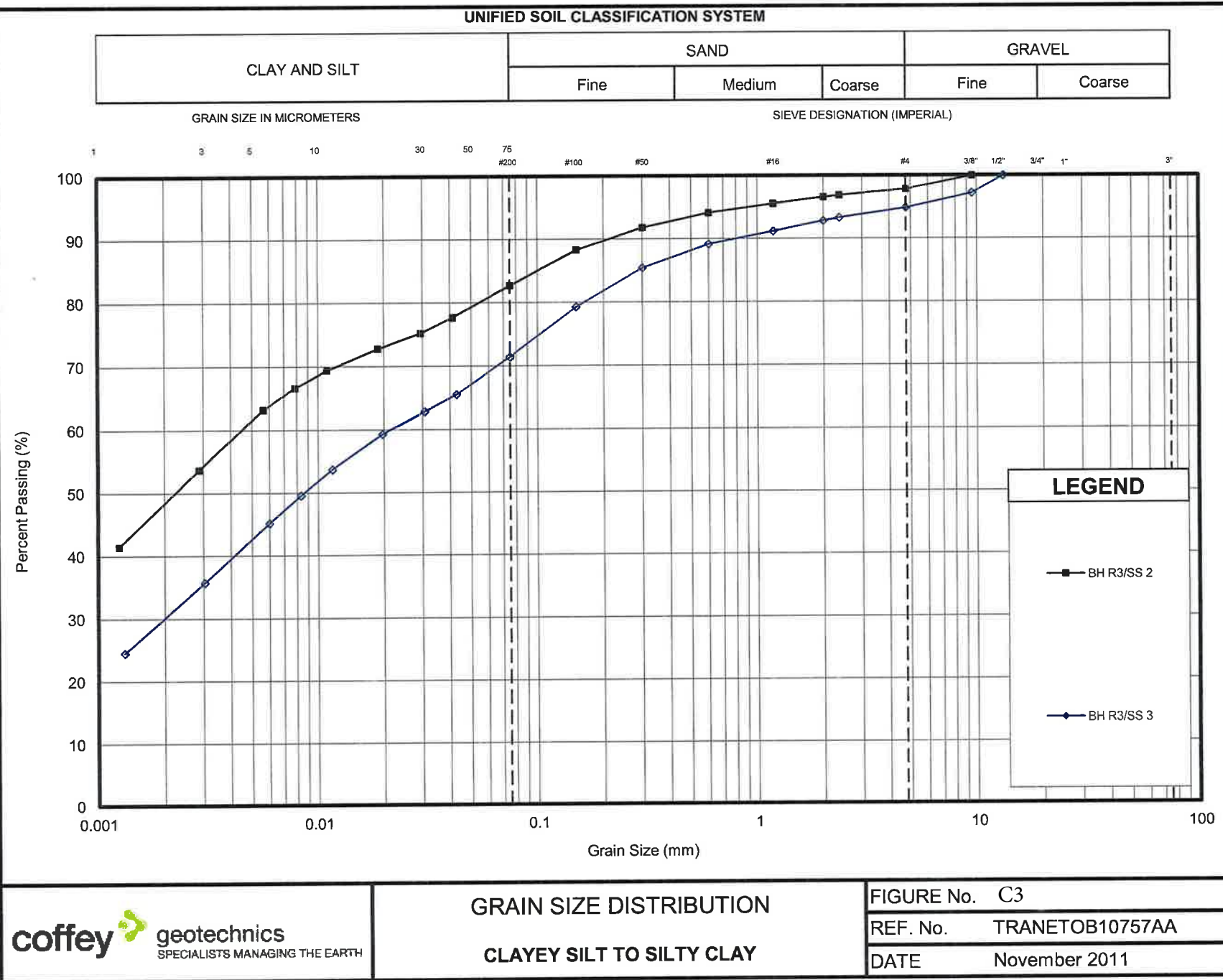
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GRAIN SIZE IN MICROMETERS

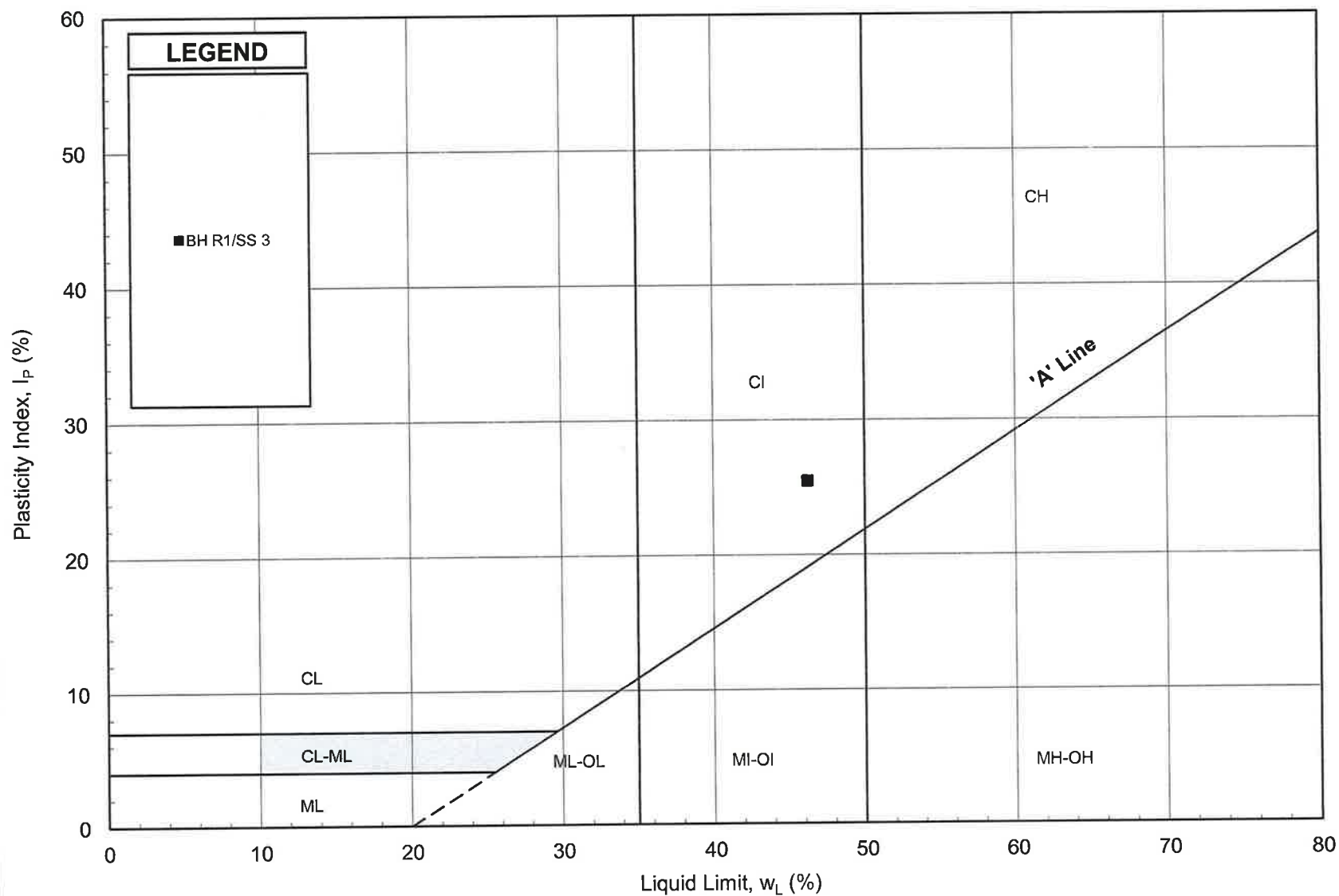
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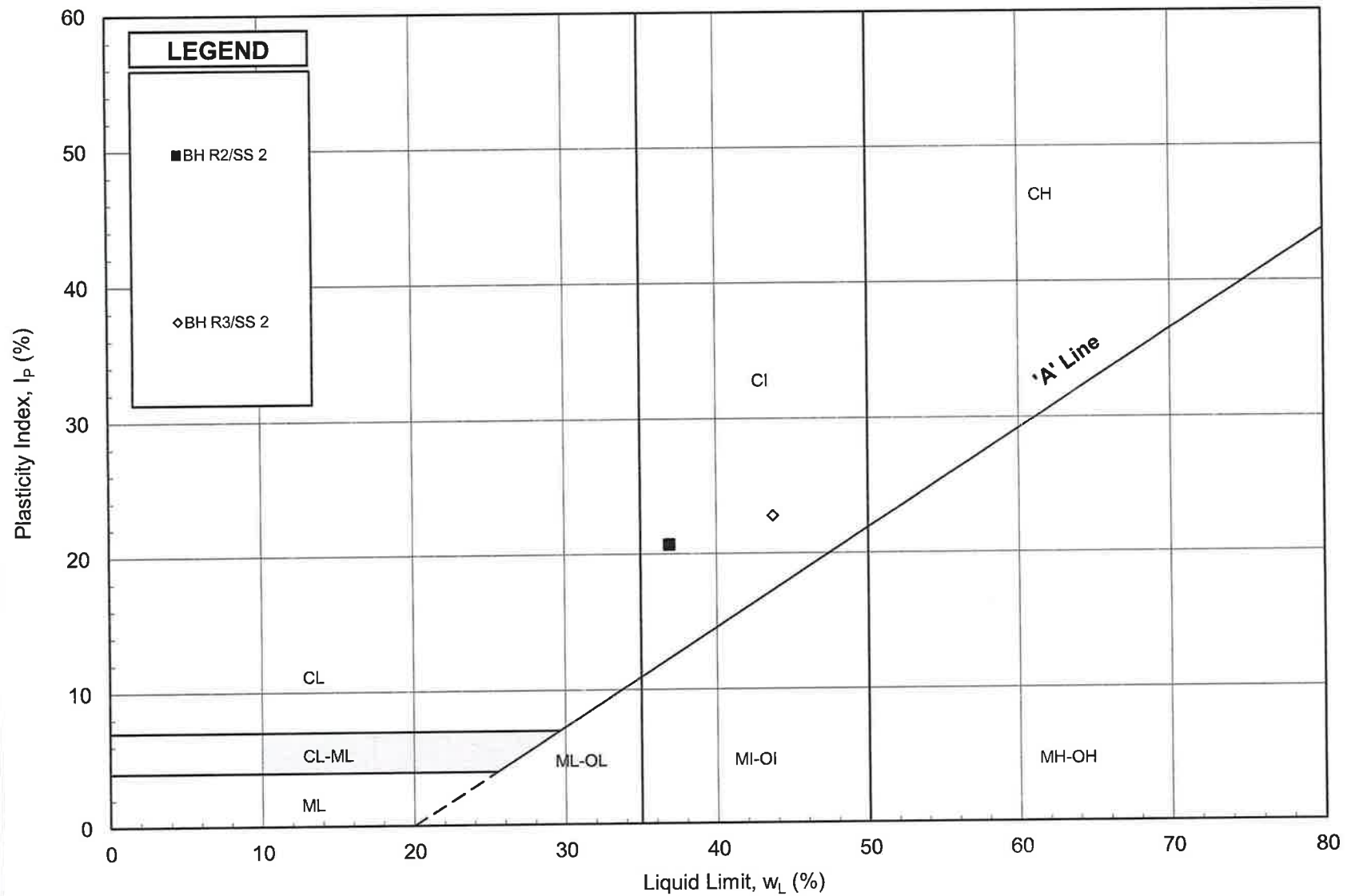
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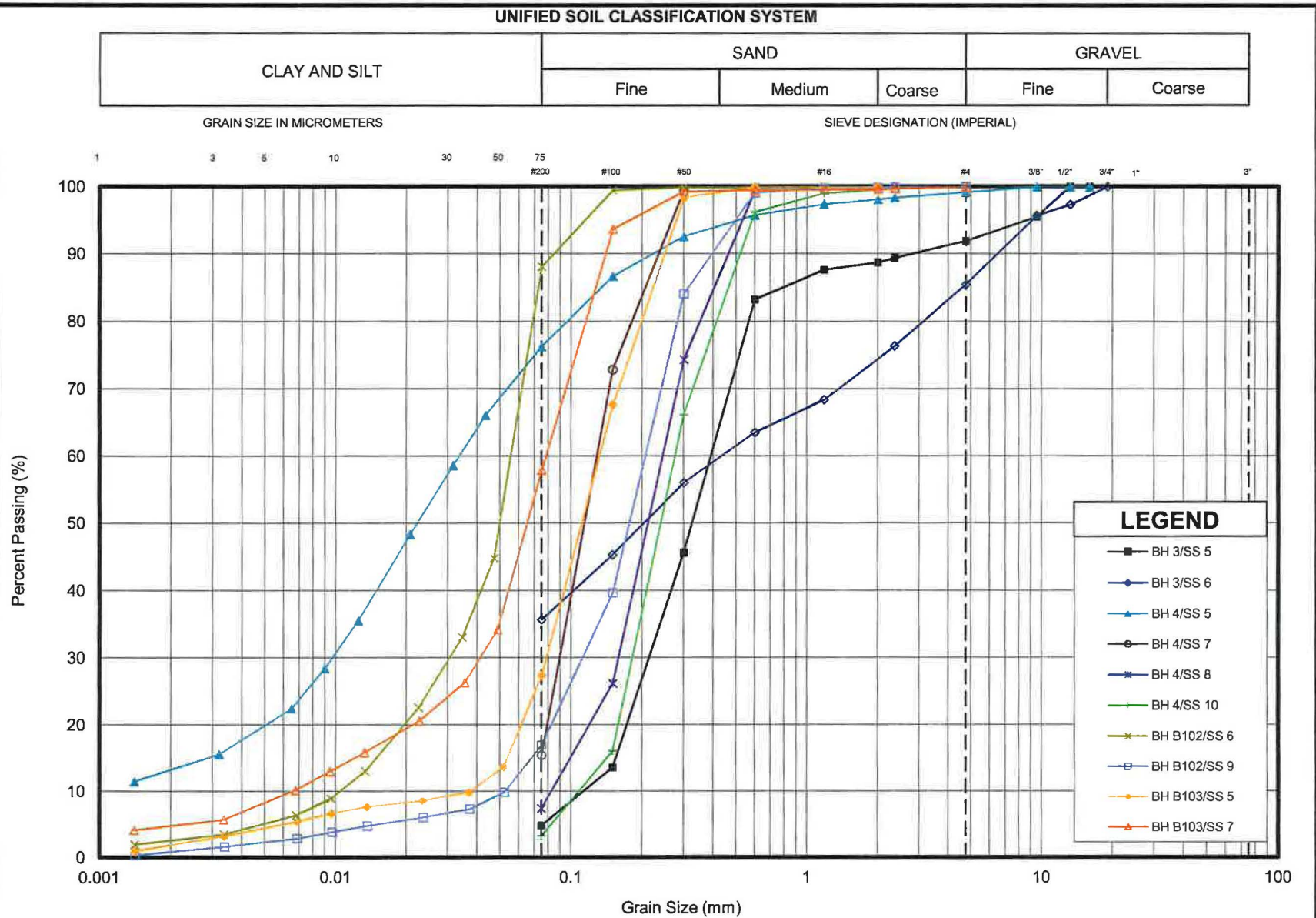
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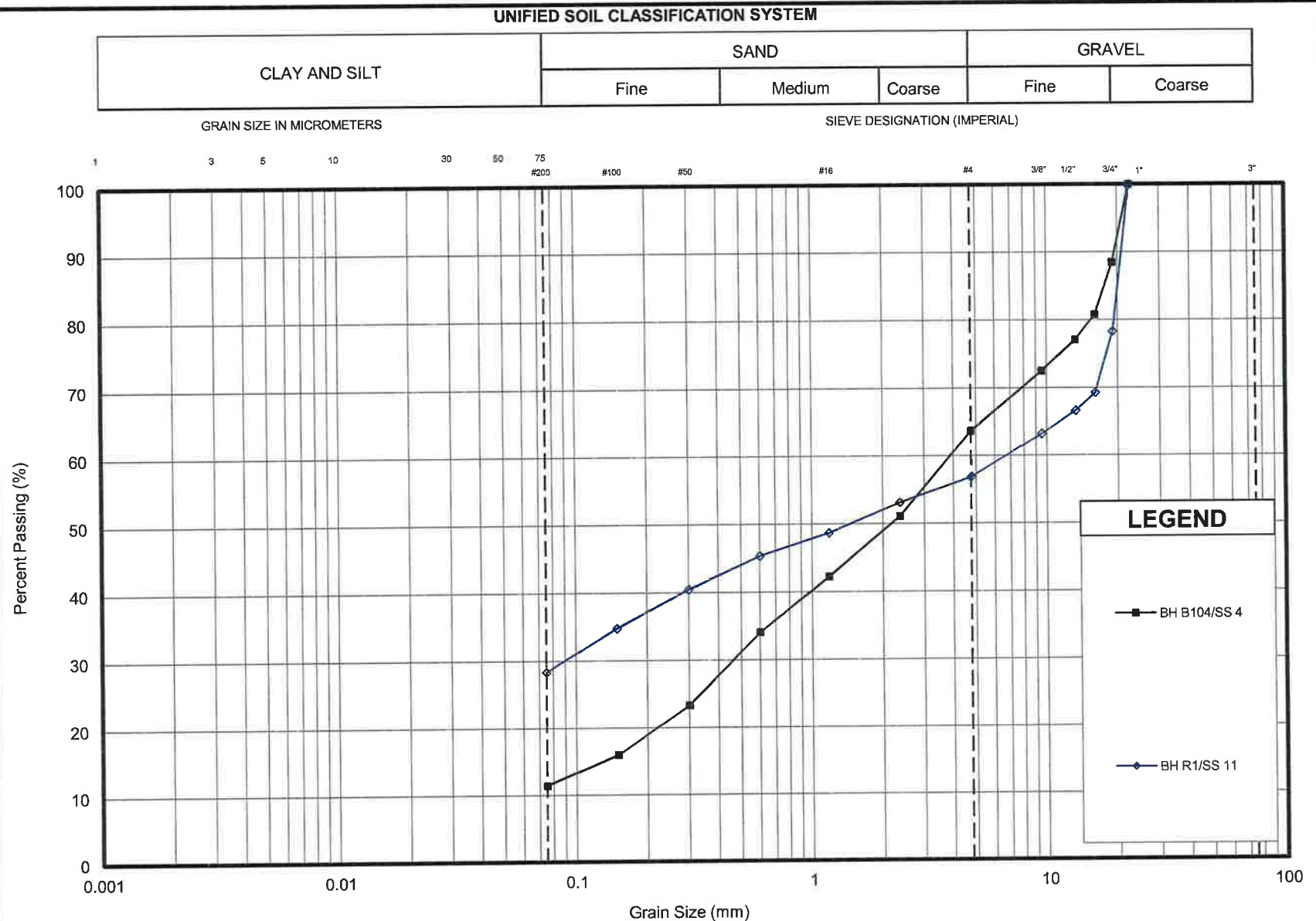
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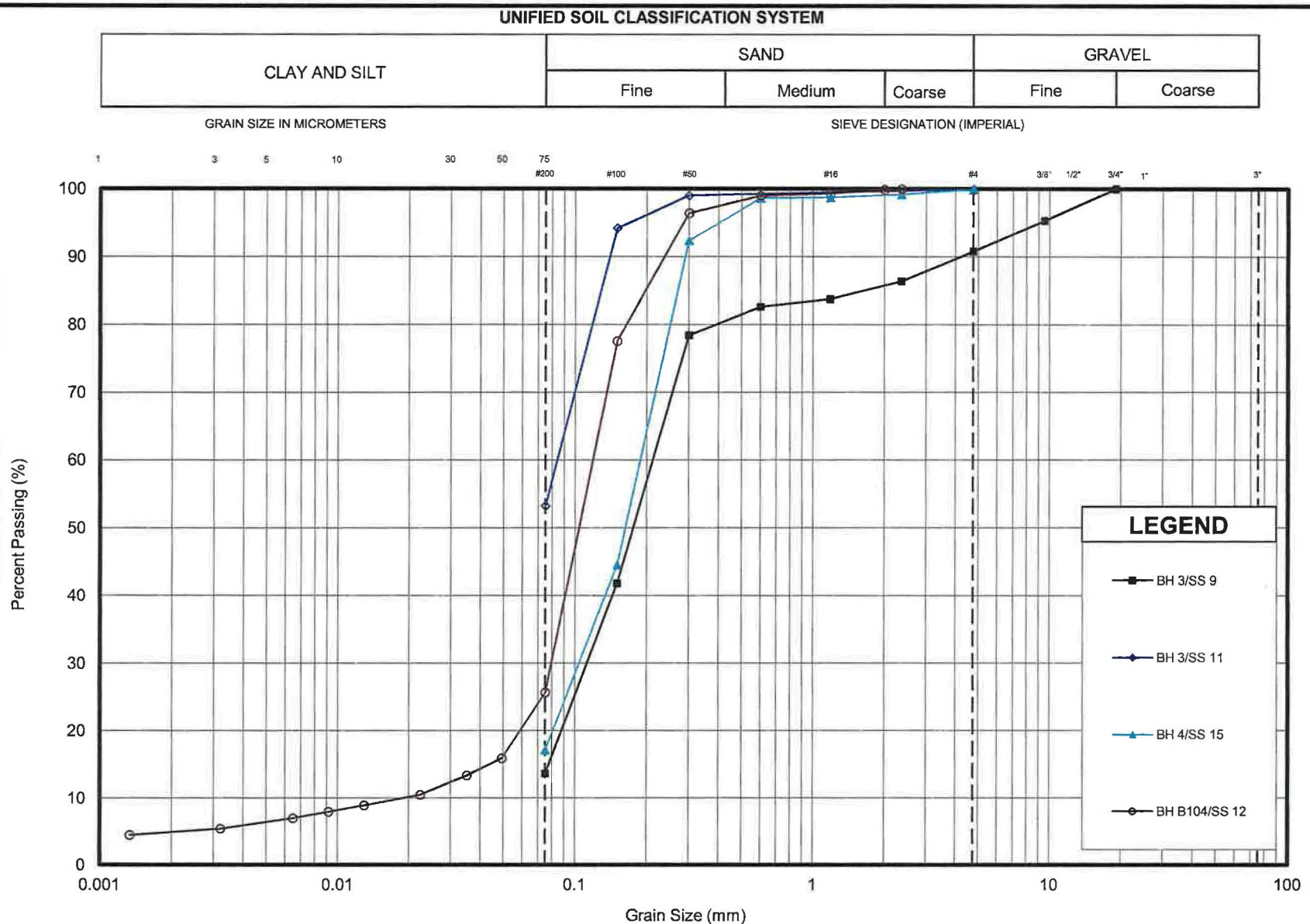


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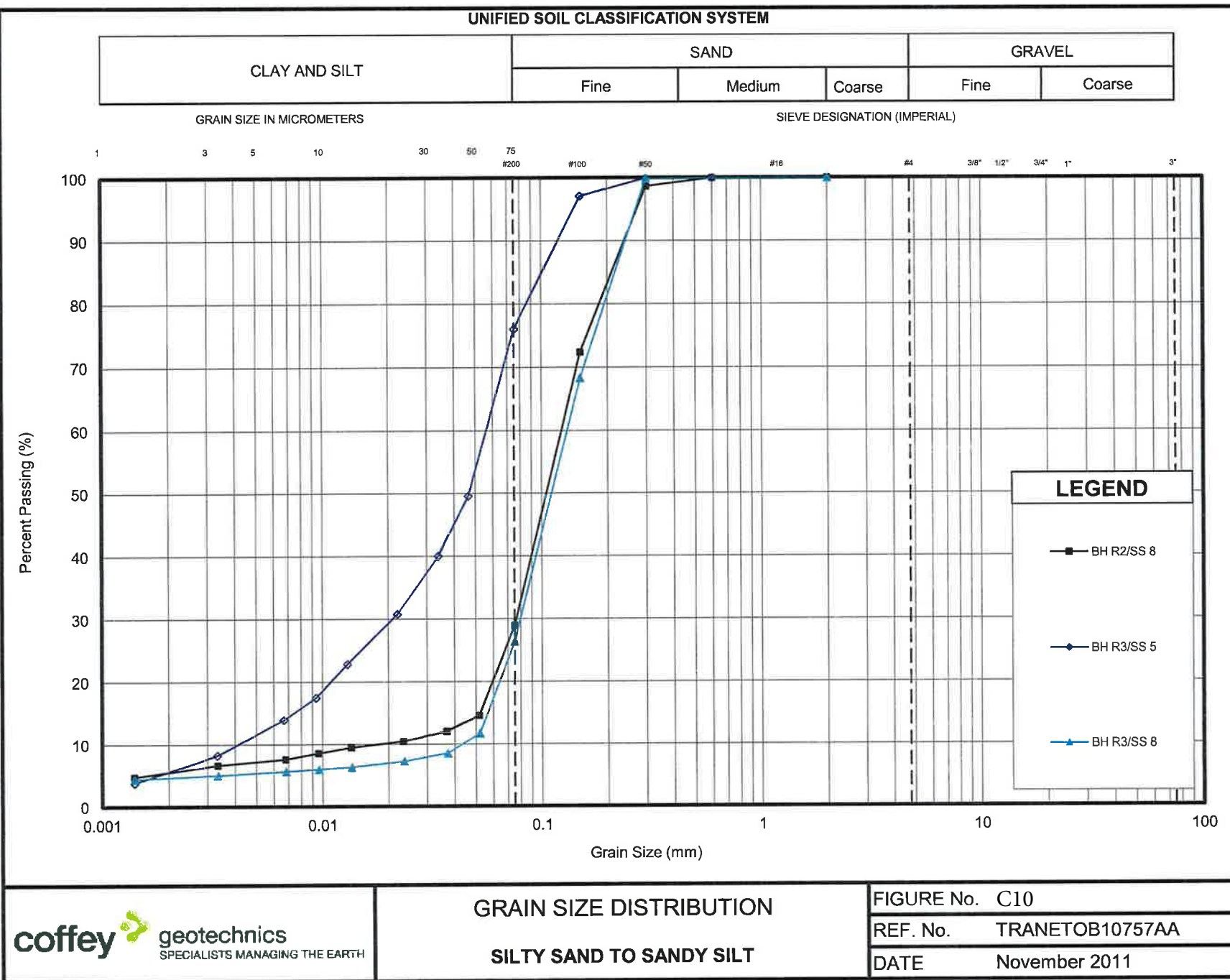


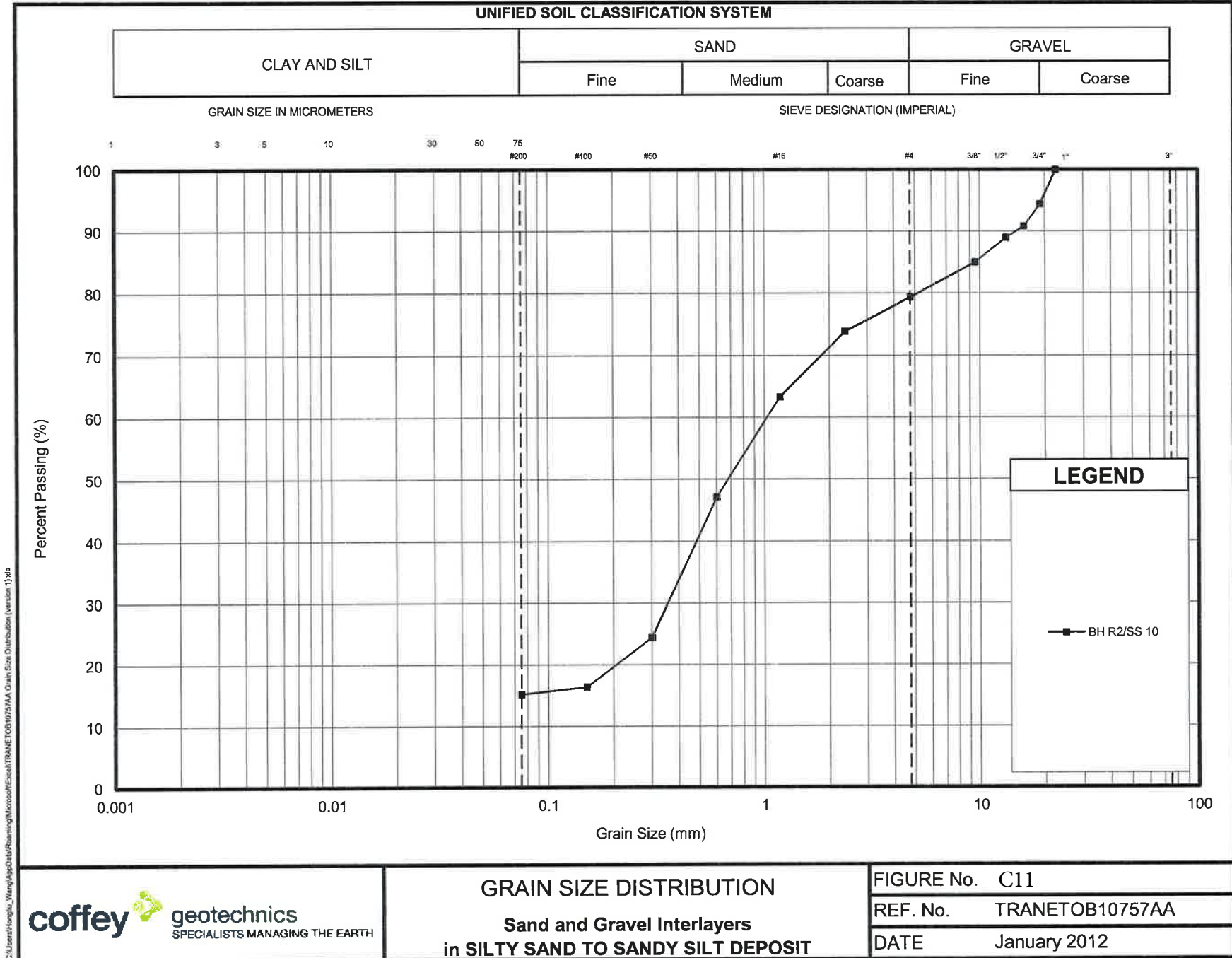
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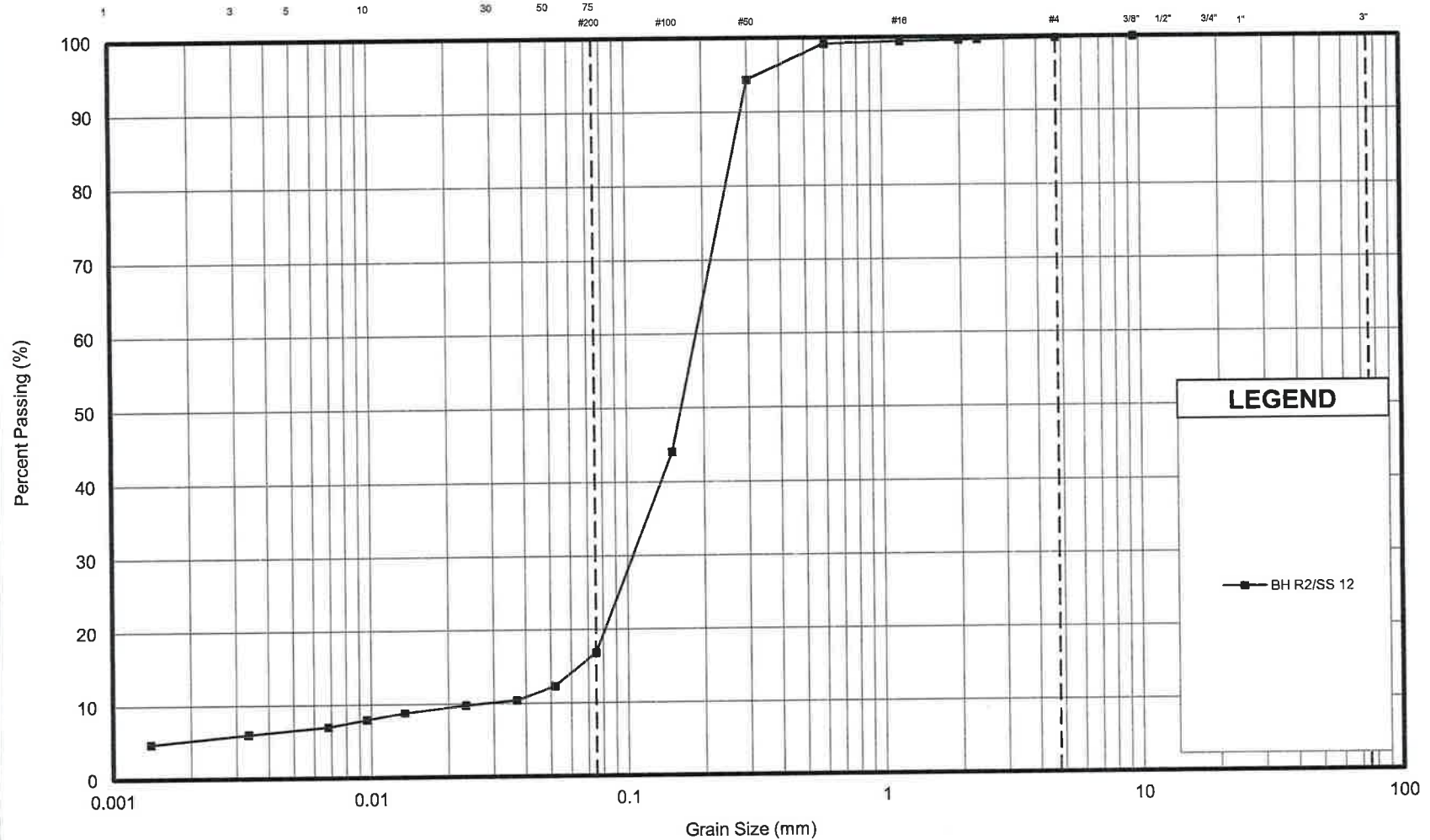
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UNIFIED SOIL CLASSIFICATION SYSTEM

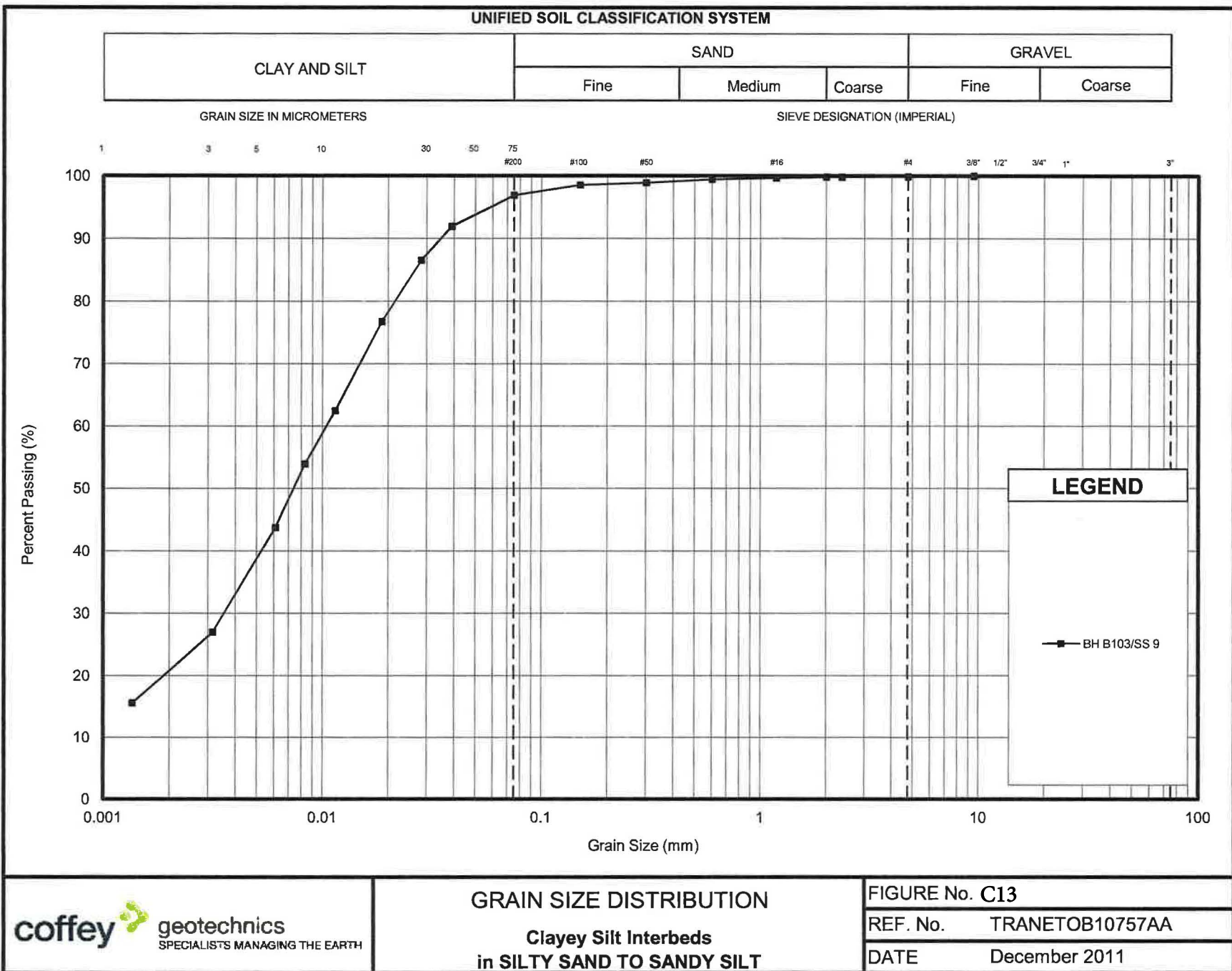
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	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

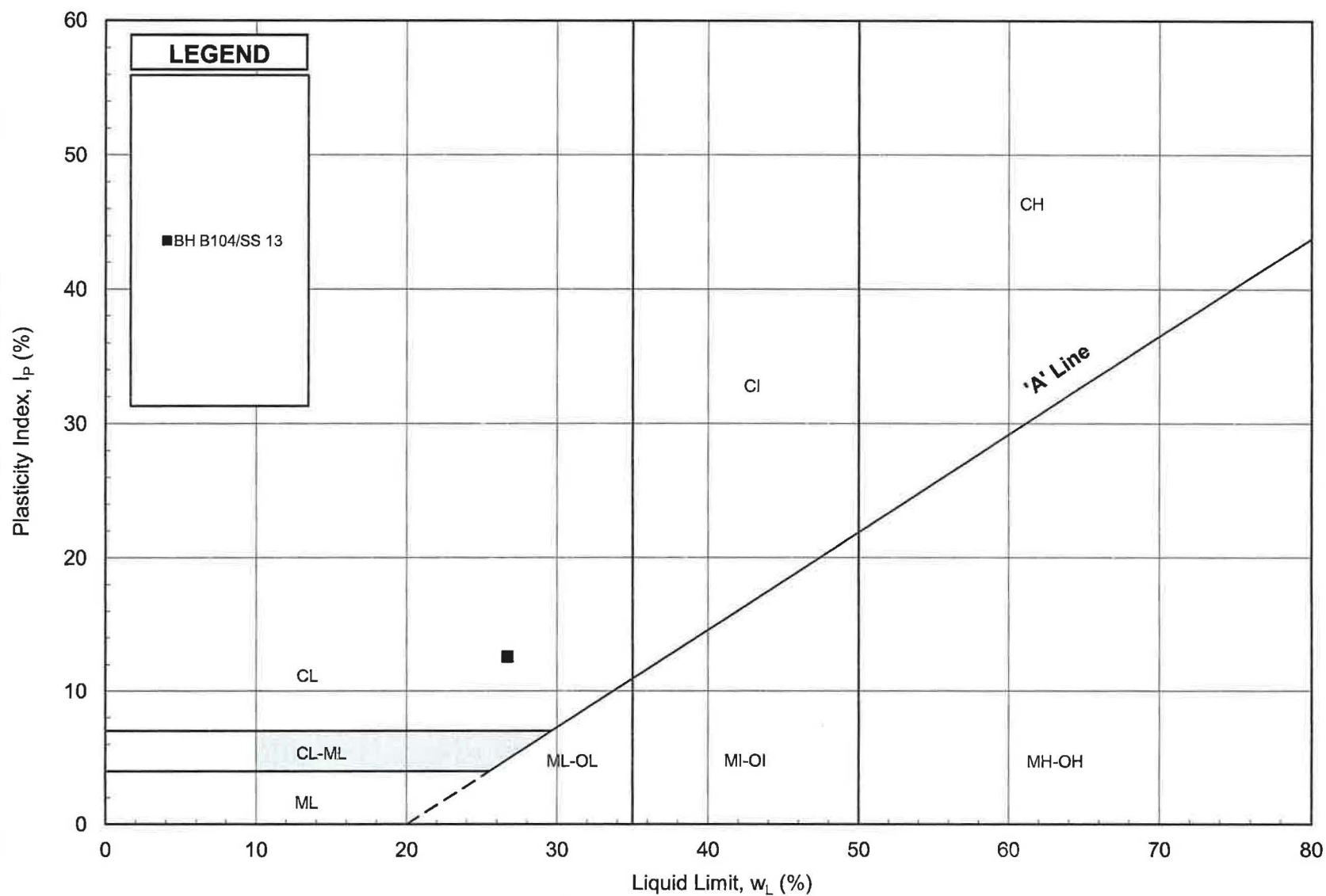
SIEVE DESIGNATION (IMPERIAL)



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**FOUNDATION REPORT - S-E/W RAMP, FILL EMBANKMENT,
EARTH CUT, STORMWATER STORAGE TANK AND
ASSOCIATED STRUCTURES**

APPENDIX D

Non-Standard Special Provision (NSSP)

OBSTRUCTIONS - Item No.

Non-Standard Special Provision

The presence of cobbles and boulders within the sandy silt to sand deposit is inferred from auger grinding and resistance to split-spoon driving encountered during the subsurface investigation at the project site. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for sub-excavation through this material for earth cuts and the underground stormwater storage tank construction.

Basis of Payment

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

END OF SECTION

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. 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 who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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