REPORT

A world of capabilities delivered locally

February 22, 2011

FOUNDATION INVESTIGATION REPORT

BRULE CREEK BRIDGE REPLACEMENT
HIGHWAY 652, SITE NO. 39E-057
TOWNSHIPS OF LAMARCHE AND GLACKMEYER, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 133-88-00, AGREEMENT NO. 5008-E-0037

Submitted to:
LEA Consulting Ltd.
625 Cochrane Drive, Suite 900
Markham, Ontario
L3R 9R9

GEOCRES NO.: 42H-42

Report Number: 09-1191-0022-1
Distribution:

1 e-copy - Ministry of Transportation, Ontario, North Bay, ON (Northeastern Region)
1 e-copy - Ministry of Transportation, Ontario, Downsview, ON (Foundations Section)
1 e-copy - LEA Consulting Ltd., Markham, ON
1 Copy - Golder Associates Ltd., Sudbury, ON

Golder Associates

Table of Contents

APPENDICES

Appendix A Record of Boreholes and Drillholes

Appendix B Laboratory Test Results

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of Ministry of Transportation, Ontario (MTO) to provide preliminary and detail design services for the replacement of the Brule Creek Bridge, and associated detour bridge, located on Highway 652 (east of Cochrane) between the Townships of Lamarche and Glackmeyer. This report addresses the detail design services for the Brule Creek Bridge, Site No. 39E-057.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal (RFP) dated November 17, 2008. Golder's proposal P81-1685, dated December 2008, for foundation engineering services associated with the replacement and temporary detour bridges is contained in Sections 5.8 and 6.8 of LEA's Technical Proposal that forms part of the Consultant's Agreement Number 5008-E-0037 for this project. Subsequent to the award of the engineering services contract, the Preliminary and Detail Design investigation phases were combined to Detail Design level only. The work was carried out in accordance with Golder's Supplemental Specialty Quality Control Plan for this project dated September 16, 2009. The General Arrangement drawings for the replacement bridge and detour bridge structures were provided to Golder by LEA on May 19, 2010.

Subsurface information for the existing bridge is contained the Department of Highways report available on GEOCRES (DHO, 1967). The purpose of this investigation is to establish the subsurface conditions at the proposed replacement and detour structure locations by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The location of the investigated area is shown on the Contract Drawings.

2.0 SITE DESCRIPTION

The site is situated in the Townships of Lamarche and Glackmeyer on Highway 652 crossing the Brule Creek, approximately 7 km east of the junction with Highway 11. The surrounding land is generally flat-lying, mainly comprised of grass and tree covered terrain extending beyond the limits of the site and scattered residences. The creek banks adjacent to the existing bridge area are vegetated with landscaped grass and small shrubs. The creek flows in a northerly direction and is less than 6 m wide at the existing bridge location. During the field investigation in June 2010, a small beaver dam was observed immediately south of the bridge. On the return site visit on August 12, 2010, the beaver dam had been breached/broken.

We understand that the Brule Creek channel was relocated in 1968 approximately 30 m to the west of its original location and the existing bridge structure was then constructed. The existing bridge consists of a 27 m long by 8.5 m wide five-span structure founded on approximately 15 m long timber piles. The existing ground surface along the existing highway alignment ranges from Elevation 251.1 m to 251.4 m rising from west to east. The existing embankment front slopes are formed at about 2.5 horizontal to 1 vertical (2.5H:1V) and the side slopes are at about 2H:1V.

The water level in the creek was measured at Elevation 247.0 m upstream (south) and Elevation 246.4 m downstream (north) of the bridge in June 2010, when the beaver dam was still in place. The normal high water level is reported to be Elevation 247.1 m. The existing highway embankment grade is up to approximately 4 m above the creek water level, or about 2.5 m above the surrounding ground surface.

3.0 INVESTIGATION PROCEDURES

The fieldwork at the bridge site was carried out between June 22 and 28, 2010, at which time a total of eight (8) boreholes (BR10-01 to BR10-08) were advanced. Four boreholes (BR10-01 to BR10-04) were advanced for the proposed main bridge abutments and approaches and four (4) boreholes (BR10-05 to BR10-08) were advanced for the proposed detour bridge abutments and approaches. On August 12, 2010, a shallow borehole was drilled immediately adjacent to Borehole BR10-07 to obtain additional Shelby tube samples of the clay stratum for laboratory testing. The locations and elevations of the boreholes are shown on the Contract Drawings.

All boreholes were drilled using a CME 55 track-mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. (Downing) of Grenville-Sur-La-Rouge, Quebec. The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers and/or NW casing with wash boring. In general, soil samples were obtained at intervals of depth of about 0.75 m to 3.0 m, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Samples of the cohesive soils were obtained using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes. Rock core samples were obtained using an 'NQ' size core barrel in Boreholes BR10-03 and BR10-04. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended by Ontario Regulation 372).

The boreholes for the main and detour bridge approaches were advanced to a depth of 15.8 m below ground surface. The boreholes for the detour bridge abutments were advanced to a depth of 20.4 m below ground surface and the boreholes for the main bridge abutments were advanced to casing refusal at depths of 39.5 m and 46.9 m below ground surface. Bedrock core was obtained for lengths of 4.6 m and 3.4 m in Boreholes BR10-03 and BR10-04, respectively, at the main bridge abutments.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. Piezometers were installed in Boreholes BR10-01 and BR10-07 to allow monitoring of the stabilized groundwater level at these locations. The piezometers consist of 19 mm O.D. rigid PVC tubing with a 3.0 m long slotted screen sealed within the clayey silt deposit. A flush mounted cap was installed in Borehole BR10-01 which is located on the shoulder of the existing highway. A plastic cap was installed in Borehole BR10-07 which is located on the north shoulder of the proposed detour. Details of the piezometer installations and water level readings are presented on the attached Record of Borehole sheets in Appendix A. The piezometers were decommissioned on August 12, 2010.

Flowing artesian groundwater conditions were encountered in Boreholes BR10-03 and BR10-04 upon encountering the sand to sandy silt deposit underlying the clayey silt to clay deposit at depth. Details of the sealing of the artesian boreholes are given in Section 4.2.12.

Traffic protection was implemented for the boreholes drilled within the roadway in accordance with the Traffic Protection Plan for this project and the MTO Book 7, Temporary Conditions Manual of the Ontario Traffic Manual (2001).

The fieldwork was supervised throughout by a member of our technical staff, who located the boreholes, arranged for the clearance of underground service locations, supervised the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and rock core samples. The samples were identified

in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. One-dimensional consolidation (oedometer) tests were carried out on two Shelby tube samples of the cohesive soil. In addition, uniaxial compressive strength (UCS) testing was carried out on two selected specimens of the bedrock core recovered from the boreholes.

The locations of the boreholes for the proposed main bridge were laid out by Golder relative to the existing bridge features. The locations of the boreholes for the proposed detour bridge were laid out relative to the detour centreline stakes, which were surveyed by Trow Geomatics. Golder surveyed the geodetic ground surface elevation of the boreholes once completed, referencing an existing benchmark located approximately 14 m north and 42 m east of the existing bridge (MTO BM #818171). The northing and easting coordinates (MTM NAD 83) were determined by plotting the boreholes relative to the working points shown on the General Arrangement drawings. The northing and easting coordinates, ground surface elevations and borehole depth for each borehole are presented on the Record of Borehole sheets in Appendix A and summarised below.

Borehole	Borehole Location		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BR10-01	5435628.2	308645.3	250.8	15.8
BR10-02	5435619.6	308715.2	251.8	15.8
BR10-03	5435626.8	308694.4	251.4	45.0
BR10-04	5435621.1	308666.2	251.1	50.3
BR10-05	5435609.0	308640.0	249.9	15.8
BR10-06	5435606.3	308665.0	248.5	20.4
BR10-07	5435611.6	308695.4	249.6	20.4
BR10-08	5435608.9	308720.4	250.0	15.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the Western Abitibi Subprovince of the Superior Province (Geology of Ontario; OGS Special Volume 4)[1]. The bedrock of this domain consists of metavolcanic and minor metasedimentary rocks.

Based on terrain mapping by the Ontario Geological Survey[2], the subsurface soils in the vicinity of the site consist of glaciolacustrine plain deposits comprised of peat and clayey silts, overlying bedrock.

[1] Geology of Ontario, 1991. Ontario Geological Survey, Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

[2] Northern Ontario Engineering Geology Terrain Study, OGS Electronic Map

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and cuttings. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile and cross-section on the Contract Drawings.

The existing ground surface encountered at the boreholes along Highway 652 (BR10-01 to BR10-04) ranges from Elevation 250.8 m to 251.8 m sloping up from west to east. The existing ground surface encountered at the boreholes along the detour alignment (BR10-05 to BR10-08) ranges from Elevation 248.5 m to 250.0 m.

In general, the subsoils consist of fill overlying alluvium and a thick deposit of clayey silt to silty clay. Silt and sand to sandy silt deposits underlie the clayey deposit at depth and are in turn underlain by cobbles and boulders over metavolcanic bedrock. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

A 30 mm to 200 mm thick layer of topsoil was encountered from ground surface in Boreholes BR10-05 to BR10-08.

4.2.2 Asphalt

A 115 mm and 200 mm thick layer of asphalt was encountered from ground surface in Boreholes BR10-04 and BR10-03, respectively.

4.2.3 Fill

Boreholes BR10-01 to BR10-04, which were advanced within the shoulders or driving lanes of the existing highway, encountered embankment fill consisting of granular fill and/or clayey fill from the ground surface or underlying the asphalt pavement. Silty clay fill was also encountered in Boreholes BR10-07 and BR10-08, located on the east side of the creek (i.e. just west of the original creek location) underlying the topsoil.

Granular Fill

Granular fill consisting of moist, brown sand, sand and gravel or silty sand was encountered in Boreholes BR10-01 to BR10-04. The fill contains trace to some silt and/or trace gravel and/or trace clay. Trace organics was noted in Boreholes BR10-02 and BR10-03. Glass fragments were noted in the silty sand fill in Borehole BR10-03. Borehole BR10-04 encountered wood and cobbles and boulders within the sand fill.

The granular fill is between 1.5 m and 2.9 m thick and was encountered between Elevation 251.8 m and 250.8 m.

The SPT 'N'-values measured in the granular fill range from 10 blows to 38 blows per 0.3 m of penetration indicating a compact to dense relative density.

Grain size distribution tests were carried out on three samples of the granular fill and the results are shown on Figure B-1.

The natural water content measured on samples of the granular fill are between about 2 percent and 10 percent.

A hydrocarbon odour was noted in the sand fill at a depth of 0.8 m in Borehole BR10-03 and at a depth of 1.5 m in Borehole BR10-04.

Clayey Silt to Silty Clay Fill

A 1.4 m to 5.7 m thick layer of moist to wet, brown to grey clayey silt to silty clay fill was encountered below the granular fill in Boreholes BR10-02 and BR10-03 and below the topsoil in Boreholes BR10-07 and BR10-08. The surface of the cohesive fill was encountered between Elevation 250.3 and 248.4 m. The cohesive fill in Boreholes BR10-07 and BR10-08 and the upper 3.5 m in Borehole BR10-02 contains trace to some sand and gravel and trace organics. The cohesive fill in Borehole BR10-03 and the lower 2.2 m in Borehole BR10-02, located on the east side of the existing bridge, consists of brown to black clay, sand, wood, roots and trace to some organics.

SPT 'N'-values recorded in the cohesive fill range from 3 blows to 10 blows per 0.3 m of penetration suggesting a soft to stiff consistency.

Grain size distribution tests were carried out on three samples of the cohesive fill and the results are presented on Figure B-2. Atterberg limits tests were carried out on four samples of the cohesive fill and test results are presented on Figure B-3. The liquid limits range from 33 percent to 47 percent, plastic limits range from 17 percent to 26 percent and the plasticity indices range between 12 percent and 21 percent. These results indicate the deposit is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

One organic content test carried out on one sample of the cohesive fill indicates 8 percent organics.

The natural water content measured on samples of the cohesive fill ranges from about 15 percent to 46 percent.

A hydrocarbon odour was noted in the silty clay fill samples at a depth of 4.6 m in Borehole BR10-02.

4.2.4 Silty Clay (Alluvium)

A deposit of moist to wet, grey to black silty clay containing trace to some sand, trace gravel and trace to some organics (alluvium) was encountered below the fill materials in Boreholes BR10-01, BR10-04, BR10-07 and BR10-08 and below the topsoil in Borehole BR10-06. The surface of the alluvium deposit was encountered between Elevation 249.0 m and 247.2 m and the thickness ranges from 0.7 m to 1.9 m.

The SPT 'N'-values measured within the silty clay alluvium range from 6 blows to 25 blows per 0.3 m of penetration suggesting a firm to very stiff consistency. Typically, the 'N'-values were less than 14 blows per 0.3 m of penetration suggesting the deposit is firm to stiff.

Grain size distribution tests were carried out on three samples of the silty clay alluvium and the results are presented on Figure B-4. Atterberg limits tests were carried out on two samples of the alluvium deposit and the results are presented on Figure B-5. The liquid limits are 42 percent and 43 percent, the plastic limits are 22 percent and 25 percent and the plasticity indices are 18 percent and 21 percent. The results indicate the deposit is classified as a silty clay of intermediate plasticity.

The natural moisture content measured on several samples of the alluvium range from about 24 percent to 49 percent.

4.2.5 Silty Clay

A deposit of moist to wet, brown to grey, silty clay was encountered below the alluvium in Boreholes BR10-01 and BR10-04 on the west side of the creek, below the topsoil in Borehole BR10-05 and underlying the alluvium in BR10-06 to BR10-08 along the proposed detour. The deposit contains trace to some sand and gravel and trace organics and is considered to be the desiccated/weathered crust of the main clayey silt to clay deposit at the site. The surface of the silty clay deposit was encountered between Elevation 249.9 m and 245.4 m and the thickness ranges from 1.0 m to 2.6 m.

The SPT 'N'-values measured in the silty clay crust range from 4 blows to 20 blows per 0.3 m of penetration. One in situ field vane test carried out within the crust measured an undrained shear strength of 30 kPa. The SPT 'N'-values together with the in situ vane suggest the silty clay crust generally has a firm to very stiff consistency.

Grain size distribution tests were carried out on three samples of this deposit and the results are presented on Figure B-6. Atterberg limits tests were carried out on four samples of the silty clay crust and the test results are presented on Figure B-7. The liquid limits range from 38 percent to 41 percent, the plastic limits range from 17 percent to 19 percent and the plasticity indices range between 21 percent and 24 percent. The results indicate the crust material is classified as a silty clay of intermediate plasticity.

The natural moisture content measured on several samples of the silty clay crust range from 23 percent to 35 percent.

One organic content test was carried out on one sample of the crust material, taken below the alluvium, and indicates 6 percent organics.

4.2.6 Clayey Silt to Silty Clay

The upper portion of the main deposit of cohesive material consists of wet, grey clayey silt to silty clay containing trace to some sand and trace to some gravel. This deposit was encountered below the silty clay crust in Boreholes BR10-01 and BR10-04 to BR10-08 and below the fill material in Boreholes BR10-02 and BR10-03. The surface of this deposit was encountered between Elevation 247.6 m and 244.2 m. In Boreholes BR10-01,

BR10-02, BR10-05 and BR10-08, this deposit extends to the borehole termination depths indicating a thickness between 8.6 m and 13.5 m. In Boreholes BR10-03, BR10-04, BR10-06 and BR10-07, the deposit was proven for a thickness between 9.8 m and 10.8 m.

The SPT 'N'-values measured in the clayey silt to silty clay range from weight of hammer (i.e. 0 blows) to 25 blows per 0.3 m of penetration. Typically, the 'N'-values are between 1 blow and 4 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths between 27 kPa and 42 kPa. The SPT 'N'-values together with the in situ vanes suggest the deposit generally has a very soft to firm consistency, with a stiff consistency near the surface of the stratum where it is closer to the overlying crust in some boreholes. An undrained shear strength of 72 kPa was measured in Borehole BR10-05 in a suspected silt seam.

Grain size distribution tests were carried out on several samples of this stratum, including one sample which contained a fine sand seam, and the results are presented on Figure B-8. Atterberg limits tests were carried out on several samples of the clayey silt to silty clay deposit and the test results are presented on Figure B-9. The liquid limits range from 19 percent to 38 percent, the plastic limits range from 10 percent to 17 percent and the plasticity indices range from 8 percent to 22 percent. The results indicate the deposit is classified as a clayey silt of low plasticity to a silty clay of intermediate plasticity.

The natural moisture content measured on several samples of the main clay deposit range from 19 percent to 50 percent.

Two laboratory consolidation (oedometer) tests were carried out on specimens of the clayey silt to silty clay obtained from Boreholes BR10-04 (existing highway alignment) and BR10-07 (detour alignment) and the test results are shown on Figures B-10 and B-11, respectively. The preconsolidation stresses were estimated from the Void Ratio versus logarithmic Pressure plots using the Casagrande method as well as from the Total Work versus Pressure plots. The relevant consolidation test results are summarized below:

Borehole/ Sample Number	Elevation (m)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	e_o	C_r	C_c	c_v^* (cm^2/s)
BR10-04/8	243.2	95	135	40	1.4	0.713	0.03	0.17	$6.7x10^{-4}$
BR10-07/8	243.2	65	130	65	2.0	0.775	0.02	0.12	$4.7x10^{-3}$

Note: *For approximate stress range of 70 ≤ σv′ ≤ 280 kPa
where: σ_{vo}' effective overburden stress in kPa
σ_p' preconsolidation stress in kPa
OCR overconsolidation ratio
e_o initial void ratio
C_c compression index (based on void ratio)
C_r recompression index (based on void ratio)
c_v coefficient of consolidation in cm2/s in the normally consolidated range

4.2.7 Silty Clay to Clay

The lower portion of the main deposit of cohesive soil consists of wet, grey silty clay to clay containing trace sand and was encountered below the upper portion of the clayey silt to silty clay stratum in the deepest boreholes, namely BR10-03 and BR10-04 (main bridge abutments) and BR10-06 and BR10-07 (detour bridge abutments). The surface of this deposit was encountered between Elevation 236.0 m and 234.1 m. In

Boreholes BR10-06 and BR10-07, this cohesive stratum was drilled for a thickness of 4.9 m and 7.9 m and extended to the borehole termination depths. In Boreholes BR10-03 and BR10-04, this lower portion of the cohesive deposit was fully penetrated for a thickness of 12.3 m and 15.3 m, respectively.

The SPT 'N'-values measured in the lower portion of the silty clay to clay deposit range from 1 blow to 5 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths between 23 kPa and 50 kPa. The SPT 'N'-values together with the in situ vanes suggest the deposit generally has a very soft to firm consistency.

Grain size distribution tests were carried out on two samples of the lower portion of the cohesive deposit and the results are presented on Figure B-12. Atterberg limits tests were carried out on four samples of the silty clay to clay deposit and the results are presented on Figure B-13. The liquid limits range from 47 percent to 59 percent, the plastic limits range from 20 percent to 22 percent and the plasticity indices range from 27 percent to 36 percent. The results indicate that this portion of the deposit is classified as a silty clay of intermediate plasticity to a clay of high plasticity.

The natural moisture content measured on several samples of the main clay deposit range from 40 percent to 50 percent.

4.2.8 Silt

A deposit of wet, grey silt containing trace clay to clayey silt and trace sand was encountered below the silty clay to clay deposit in Boreholes BR10-03 and BR10-04. The surface of the silt deposit was encountered at Elevation 222.1 m and 220.3 m and the thickness of the deposit in both boreholes is 3.0 m.

The SPT 'N'-values measured in the silt deposit range from 11 blows to 17 blows per 0.3 m of penetration indicating a compact relative density.

Grain size distribution tests were carried out on two samples of the silt and the results are shown on Figure B-14.

The natural moisture content measured on two samples of the silt is 24 percent and 28 percent.

4.2.9 Sand to Sandy Silt

A deposit of wet, brown to grey sand to sandy silt containing trace to some clay was encountered below the silt deposit in Boreholes BR10-03 and BR10-04. The surface of the sand to sandy silt deposit in these two boreholes was encountered at Elevation 219.1 m and 217.3 m and the thickness of the deposit is 4.6 m to 12.2 m, respectively.

The SPT 'N'-values measured in the sand to sandy silt range from 11 blows to 35 blows per 0.3 m of penetration indicating a compact to dense relative density.

Grain size distribution tests were carried out on two samples of the sand to sandy silt and the results are shown on Figure B-15.

The natural moisture content measured on two samples of the sand to sandy silt is 23 percent and 24 percent.

4.2.10 Cobbles and Boulders

A 3.7 m and 0.9 m thick deposit of cobbles and boulders was encountered underlying the sand to sandy silt deposit in Boreholes BR10-03 and BR10-04, respectively. The surface of the cobbles and boulders deposit was encountered at Elevation 214.5 m (BR10-03) and 204.2 m (BR10-04). Bedrock coring techniques (in NQ size) were used to advance the boreholes through this deposit.

4.2.11 Bedrock

Bedrock was encountered at Elevation 210.8 m and 204.2 m (i.e. at depths of 40.6 m and 46.9 m below existing grade) in Boreholes BR10-03 and BR10-04 and was cored for 4.4 m and 3.4 m lengths, respectively. The retrieved bedrock core is described as massive, fine grained, dark grey, mafic metavolcanic bedrock with granitic veins and healed and partially healed joints, as presented in the Record of Drillhole sheets in Appendix A.

The Rock Quality Designation (RQD) measured on the core samples ranges from 61 percent to 100 percent, which indicates rock mass of fair to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006). The Total Core Recovery (TCR) during bedrock coring was 100 percent.

Laboratory UCS testing was carried out on two core samples of the bedrock. The UCS values are presented below and the test results indicate the bedrock is very strong as per Table 3.5 of the CFEM (2006).

Borehole	Elevation (m)	UCS (MPa)
BR10-03	207.3	175
BR10-04	203.1	121

4.2.12 Groundwater Conditions

Groundwater levels were measured in the open boreholes during and upon completion of drilling. Piezometers were installed in Boreholes BR10-01 and BR10-07 and sealed within the clayey silt to silty clay deposit to monitor the groundwater levels over time. The measured groundwater levels in the open boreholes and piezometers are presented below.

Borehole	Installation	Time and/or Date	Groundwater Depth* (m)	Groundwater Elevation (m)
BR10-01	Open borehole	Upon completion of drilling	4.9	245.9
	Piezometer	June 29, 2010 August 12, 2010	5.9 3.4	244.9 247.4
BR10-02	Open borehole	Upon completion of drilling	6.1	245.7
BR10-03	Open borehole	Upon completion of drilling	2.0 m above ground surface (7.0 m above creek water level)	253.4
BR10-04	Open borehole	Upon completion of drilling	0.9 m above ground surface (5.6 m above creek water level)	252.0
BR10-05	Open borehole	Upon completion of drilling	14.4	235.5
BR10-06	Open borehole	Upon completion of drilling	16.0	232.5
BR10-07	Piezometer	June 29, 2010 August 12, 2010	4.8 0.4	244.8 249.2
BR10-08	Open borehole	Upon completion of drilling	Dry to bottom of boreholes at 5.8 m depth	--

*Depth unless otherwise indicated.

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Further, surface water was noted to be ponded at the toe of the existing highway embankment near Borehole BR10-07 at the time of the groundwater level measurements, which may have resulted in an artificially high groundwater level in Borehole BR10-07 on August 12, 2010.

The water level in Brule Creek was measured at Elevation 247.0 m upstream (south) and 246.4 m downstream (north) of the bridge at the time of the investigation in June 2010. The normal high water level is reported to be Elevation 247.1 m. A beaver dam located on the south side of the bridge resulted in the 0.6 m elevation difference between the upstream and downstream water level measurements.

Groundwater and creek water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt. Although perched water was not encountered within the embankment fill during the investigation, it is possible that water is perched within the cohesionless and/or cohesive fill.

Artesian groundwater conditions were encountered in Boreholes BR10-03 and BR10-04 upon penetrating into the sand to sandy silt deposit. The groundwater levels were measured at Elevation 253.4 m and 252.0 m in Boreholes BR10-03 and BR10-04, respectively (corresponding to 7.0 m and 5.6 m above the creek level). The boreholes were sealed at the source as follows, consistent with Ontario Regulation 903 Wells (as amended by Ontario Regulation 372):

- Borehole BR10-03 was sealed using geotextile socks filled with bentonite pellets and pushed down into the borehole to a depth of 39.6 m (Elevation 211.8 m) after removing the core barrel and NW casing from the hole. The bentonite filled geotextile socks were temporarily held down with the drill rods to prevent heaving. Subsequently, alternating layers of bentonite pellets and clay cuttings were dropped into the borehole as the casing was removed followed by a bentonite seal placed in the borehole to the ground surface. Cold patch asphalt was used to restore the ground surface.
- Bentonite slurry drilling mud was used during drilling of Borehole BR10-04 to reduce the uplift effect of the artesian flows so as to facilitate borehole advancement and bedrock coring. Borehole BR10-04 was sealed using bentonite pellets initially from the bottom of the borehole at a depth of 50.3 m (Elevation 200.8 m) followed by the placement of additional bentonite pellets to a depth of 28.0 m (Elevation 243.5 m) after removing the core barrel and NW casing from inside the hollow stem augers. The borehole was then backfilled with alternating layers of clay cuttings and bentonite pellets followed by a near surface seal of bentonite. Cold patch asphalt was used to restore the ground surface.

On August 12, 2010, during the return visit to site to obtain water level readings and decommission the piezometers, it was confirmed visually that Boreholes BR10-03 and BR10-04 did not show artesian flow groundwater conditions.

5.0 CLOSURE

The field drilling program was supervised by Mr. Indulis Dumpis. This report was prepared by Mr. David Muldowney and the technical aspects were reviewed by Ms. Sarah E.M. Coyne, P.Eng., Associate. A quality control review of the report was provided by Mr. Jorge M.A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project.

Report Signature Page

GOLDER ASSOCIATES LTD.

David Muldowney, B.Eng.
Geotechnical Group

Sarah E.M. Coyne, P.Eng.
Senior Geotechnical Engineer, Associate

Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal

DAM/SEMC/JMAC/lb

n:\active\2009\1190 sudbury\1191\09-1191-0022 lea brule and wicklows\7000 reporting\brule\part a\09-1191-0022 rpt 11feb22 brule creek fir.docx

APPENDIX A

Record of Boreholes and Drillholes

LIST OF SYMBOLS

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

1. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

* 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	liquid limit
w_p	plastic limit
I_p	plasticity index – $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p)/I_p$
I_c	consistency index = $(w_l - w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes:
1 $\tau = c' + \sigma' \tan\phi'$
2 Shear strength = (Compressive strength)/2

LIST OF ABBREVIATIONS

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

1. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance, N_d:

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

Piezocone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of Major discontinuities

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock Mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	< 50 mm

GRAIN SIZE

Terms	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

* Note: Grains > 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separation) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole, a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separation such as fractures, bedding planes and foliation planes or mechanically induced fractures caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

B	- Bedding	⊾	- Perpendicular To
FO	- Foliation / Schistosity	ıı	- Parallel To
CL	- Cleavage	P	- Polished
SH	- Shear Plane / Zone	K	- Slickensided
VN	- Vein	SM	- Smooth
F	- Fault	R	- Rough
CO	- Contact	ST	- Stepped
J	- Joint	PL	- Planar
FR	- Fracture	U	- Undulating
MF	- Mechanical Fracture	C	- Curved

Golder Associates

RECORD OF BOREHOLE No BR10-01

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435628.2; E 308645.3 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL

DATUM Geodetic | DATE June 22, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.8	GROUND SURFACE										
0.0	Sand and gravel (FILL)										
0.2	Brown Moist										
	Sand, trace gravel, trace silt (FILL) Compact Brown Moist		1	SS	10		250		○		
249.0											
1.8	SILTY CLAY, some sand, trace gravel, trace organics (ALLUVIUM) Firm to stiff Dark brown Moist		2	SS	12		249				
			3	SS	8		248		○		3 14 35 48
247.8											
3.0	SILTY CLAY, trace to some sand, trace organics Firm Brown to grey Moist to wet		4	SS	7	▼					
			5	SS	4		247		○		
			6	SS	4		246				
245.2								+ 5, 5			
5.6	CLAYEY SILT, trace to with sand Very soft to firm Grey Wet						245				
			7	SS	3		244		○		
								+ 4, 3			
							243				
			8	SS	WH		242		○		
							241				
							240	+ 2, 2			
							239				
			9	SS	1		238		○		
	Clayey silt with sand seam at 13.7 m depth.		10	SS	1		237		○		0 54 18 28
							236				

Continued Next Page

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

Golder Associates

PROJECT 09-1191-0022

RECORD OF BOREHOLE No BR10-01

2 OF 2 **METRIC**

W.P. 133-88-00 LOCATION N 5435628.2; E 308645.3 ORIGINATED BY ID

DIST HWY 652 BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers COMPILED BY JJL

DATUM Geodetic DATE June 22, 2010 CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
235.0	CLAYEY SILT, trace to with sand Very soft to firm Grey Wet		11	SS	3		235				
15.8	End of Borehole										
	Note: 1. Water level at a depth of 4.9 m below ground surface (Elev. 245.9 m) upon completion of drilling. 2. Water level in piezometer at 5.9 m depth (Elev. 244.9 m) and 3.4 m depth (Elev. 247.4 m) on June 29, 2010 and August 12, 2010 respectively.										

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

Golder Associates

RECORD OF BOREHOLE No BR10-02

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435619.6; E 308715.2 | ORIGINATED BY ID
DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL
DATUM Geodetic | DATE June 22, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.8	GROUND SURFACE										
0.0	Sand, trace to some gravel, trace to some silt, trace organics (FILL) Compact Brown Moist		1	SS	10		251		○		10 79 (11)
250.3			2	SS	10						
1.5	Clayey silt with sand, trace to some gravel (FILL) Soft to firm Brown to grey Wet		3	SS	7		250		⊢○⊣		10 40 22 28
			4	SS	3		249				
			5	SS	3						
			6	SS	6		248		○		
246.8	Spoon bouncing at 5.0 m depth.		7	SS	58		247				
5.0	Wood with sand cuttings (FILL) Loose Brown Wet					▽	246				
			8	SS	5		245				
244.6											
7.2	CLAYEY SILT, trace to some sand, trace gravel Very soft to firm Grey Wet		9	SS	3		244		⊢○⊣		2 17 33 48
							243	+ 2			
							242	+ 2			
	SAND and GRAVEL layer between 10.8 m and 11.1 m depth.		10	SS	9		241		○		
							240				
							239	+ 2			
								+ 2			
			11	SS	1		238		○		
							237				

Continued Next Page

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

Golder Associates

PROJECT 09-1191-0022

RECORD OF BOREHOLE No BR10-02

2 OF 2 **METRIC**

W.P. 133-88-00 LOCATION N 5435619.6; E 308715.2 ORIGINATED BY ID

DIST HWY 652 BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers COMPILED BY JJL

DATUM Geodetic DATE June 22, 2010 CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
236.0			12	SS	3		236				
15.8	End of Borehole Note: 1. Water level at a depth of 6.1 m below ground surface (Elev. 245.7 m) upon completion of drilling. 2. Limited sample recovery (50 mm) in Sample 8. Small amount of sand, gravel and wood.										

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

Golder Associates

RECORD OF BOREHOLE No BR10-03

1 OF 4 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435626.8; E 308694.4 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring | COMPILED BY JJL

DATUM Geodetic | DATE June 23 and 24, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.4	GROUND SURFACE						
0.0	ASPHALT						
0.2	Sand and gravel, trace silt, trace clay (FILL) Compact Brown Moist		1	SS	20		
			2	SS	14		44 51 3 2
249.1							
2.3	Silty sand, trace gravel, trace glass fragments (FILL) Dense Brown		3	SS	38		
248.4	Moist to wet						
3.0	Silty clay, with sand, trace organics (FILL) Stiff to very stiff Brown Moist		4	SS	12		
			5	SS	16		
247.1							
4.3	Sand and gravel layer between 3.4 m and 3.5 m depth. Clayey silt to silty clay, trace to with sand, trace gravel, wood / roots, trace to some organics (FILL) Firm to stiff Brown to black Moist to wet		6	SS	9		OC=8.1%
			7	SS	6		6 42 32 20
244.2							
7.2	CLAYEY SILT, trace to some sand Very soft to firm Grey Wet		8	SS	3		
	Switched to NW casing at 8.2 m depth.		9	SS	1		
			10	SS	3		
			11	SS	1		

ELEVATION SCALE: 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

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

Continued Next Page

Golder Associates

PROJECT 09-1191-0022

RECORD OF BOREHOLE No BR10-03

 METRIC

W.P. 133-88-00 LOCATION N 5435626.8; E 308694.4 ORIGINATED BY ID

DIST HWY 652 BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY JJL

DATUM Geodetic DATE June 23 and 24, 2010 CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace to some sand Very soft to firm Grey Wet		12	TO	PH		236				
							235				
234.4											
17.0	SILTY CLAY to CLAY Very soft to firm Grey Wet						234	4 4			
			13	SS	1		233				0 0 15 85
							232				
							231	3 3			
			14	TO	PH		230				
							229				
							228				
			15	SS	3		227				
							226				
							225				
							224				
			16	SS	4		223	3 3			
222.1											
29.3	SILT, some to with clay Compact Grey Wet						222				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BR10-03

 METRIC

PROJECT 09-1191-0022 | W.P. 133-88-00 | DIST | HWY 652 | DATUM Geodetic

LOCATION N 5435626.8; E 308694.4 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring | DATE June 23 and 24, 2010

ORIGINATED BY ID | COMPILED BY JJL | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILT, some to with clay Compact Grey Wet						221				
			17	SS	11				○		0 0 77 23
219.1							220				
32.3	SAND, some silt to Sandy SILT, trace to some clay Dense Brown to grey Wet Artesian conditions noted below 33.0 m depth.						219				
			18	SS	32		218		○		0 82 13 5
							217				
							216				
214.5							215				
36.9	COBBLES and BOULDERS, with gravel		19	SS	35		214				
							213				
	Artesian conditions (water flowing out of casing) between 38.9 m and 39.5 m depth. Switched to NQ coring at 39.5 m depth.						212				
210.8							211				
40.6	MAFIC METAVOLCANIC (BEDROCK) Bedrock cored from 40.6 m to 45.0 m depth. For details of bedrock coring refer to Record of Drillhole BR10-03.		1	RC	REC 100%		210				RQD = 61%
			2	RC	REC 100%		209				RQD = 73%
							208				
			3	RC	REC 100%		207				RQD = 92%
206.4											

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BR10-03

4 OF 4 **METRIC**

PROJECT 09-1191-0022
W.P. 133-88-00
LOCATION N 5435626.8; E 308694.4
ORIGINATED BY ID
DIST HWY 652
BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring
COMPILED BY JJL
DATUM Geodetic
DATE June 23 and 24, 2010
CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
45.0	End of Borehole Note: 1. Water level at 2.0 m above ground surface (Elev. 253.4 m), coresponds to approximately 7.0 m above the creek level, upon completion of drilling. 2. On August 12, 2010, visual inspection at the ground surface indicated no artesian flow condition.										

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

PROJECT: 09-1191-0022

RECORD OF DRILLHOLE: BR10-03

SHEET 1 OF 1

LOCATION: N 5435626.8 ;E 308694.4

DRILLING DATE: June 23 and 24, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		Refer To Previous Page		210.8																
41	June 24, 2010 NW NQ Coring	MAFIC METAVOLCANIC, with granitic veins Fine grained Healed to partially healed joints Massive Dark Grey		40.6	1	Grey / 100%							JIR JIR JIR JIR JIR JIR							
42													BR JIR							
43					2	Grey / 100%							JIR JIR JIR JIR							
44					3	Grey / 100%							JIRx4 BR JIR JIR JIR JIR JIR							UCS=175 MPa
45				206.4									JIR JIR JIR							
		End Of Drillhole		45.0																
46																				
47																				
48																				
49																				
50																				

SUD-RCK 09-1191-0022 BRULE WICKLOW.GPJ GAL-MISS.GDT 02/02/11 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ID

CHECKED: DAM

Golder Associates

RECORD OF BOREHOLE No BR10-04

1 OF 4 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435621.1; E 308666.2 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing | COMPILED BY JJL

DATUM Geodetic | DATE June 25 and 26, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.1	GROUND SURFACE								
0.0	ASPHALT								
0.3	Sand and gravel (FILL)								
	Sand, some gravel, trace to some silt (FILL) Compact to very dense Brown Moist		1	SS	15				
	50 mm thick layer of WOOD at 1.5 m depth.		2	SS	11				
	Cobbles and boulders between 2.4 m and 3.0 m depth.		3	SS	103				20 70 (10)
248.1									
3.0	SILTY CLAY with peat layers and organics (ALLUVIUM) Very stiff Grey to black and brown Moist		4	SS	25				
247.4									
3.7	SILTY CLAY, trace sand Stiff Brown Moist		5	SS	11				0 3 51 46
			6	SS	13				
245.5									
5.6	CLAYEY SILT, trace sand Soft to firm Grey Wet		7	SS	4				
			8	TO	PH			19.4	
	Switched to NW casing at 8.2 m depth.								
			9	SS	3				
			10	TO	PH				
			11	SS	3				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

ELEVATION SCALE: 251 250 249 248 247 246 245 244 243 242 241 240 239 238 237

+4, +4, +3, +3, +3, +3 (Numbers refer to Sensitivity)

○ 3% STRAIN AT FAILURE

Continued Next Page

Golder Associates

RECORD OF BOREHOLE No BR10-04

2 OF 4 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | DIST | HWY 652 | DATUM Geodetic

LOCATION N 5435621.1; E 308666.2 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing | DATE June 25 and 26, 2010

ORIGINATED BY ID | COMPILED BY JJL | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
235.6 / 15.5	SILTY CLAY to CLAY Soft to firm Grey Wet						236	+ 3, 4			
			12	SS	3		234		○		
							233	+ 4, 4			
			13	SS	3		231				
							230				
							229				
							228	+ 3, 4			
			14	SS	3		225		○		
							224	+ 3, 3			
			15	SS	5		222	+ 3			

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BR10-04

3 OF 4 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | DIST | HWY 652 | DATUM Geodetic

LOCATION N 5435621.1; E 308666.2 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing | DATE June 25 and 26, 2010

ORIGINATED BY ID | COMPILED BY JJL | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
220.3	SILTY CLAY to CLAY Soft to firm Grey Wet						221	+ 3			
30.8	SILT, trace to some sand, trace to some clay Compact Grey Wet		16	SS	17		220				0 6 86 8
217.3							219		○		
33.8	SAND to SAND and SILT, trace clay Compact Grey Wet Artesian condition noted below 33.8 m depth.		17	SS	19		218				
							217				
			18	SS	15		216		○		0 63 33 4
							215				
			19	SS	21		214				
							213				
			20	SS	11		212				
							211				
							210				
							209				
							208				
							207				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No BR10-04

4 OF 4 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435621.1; E 308666.2 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing | COMPILED BY JJL

DATUM Geodetic | DATE June 25 and 26, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						206			
205.1										
46.0	COBBLES and BOULDERS						205			
204.2										
46.9	MAFIC METAVOLCANIC (BEDROCK) Bedrock cored from 46.9 m to 50.3 m depth. For details of bedrock coring refer to Record of Drillhole BR10-04.		1	RC	REC 100%		204			RQD = 68%
			2	RC	REC 100%		203			RQD = 19%
			3	RC	REC 100%		202			RQD = 100%
200.8							201			
50.3	End of Borehole Note: 1. Water level at 0.9 m above ground surface (Elev. 252.0 m) coresponds to approximately 5.5 m above the creek level, upon completion of drilling. 2. Bentonite powder added to wash water to advance borehole below 32 m. 3. On August 12, 2010 visual inspection at the ground surface indicated no artesian flow condition.									

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

PROJECT: 09-1191-0022

RECORD OF DRILLHOLE: BR10-04

SHEET 1 OF 1

LOCATION: N 5435621.1 ;E 308666.2

DRILLING DATE: June 25 and 26, 2010

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		Refer To Previous Page		204.2																
47	NW	MAFIC METAVOLCANIC with granitic veins Fine grained Healed to partially healed joints Massive Dark Grey		46.9	1	Grey / 100%							BR JIR JIR JIR							
48													JIR							UCS=121 MPa
49	June 26, 2010 NQ Coring				2	Grey / 100%							JIR BR							
50					3	Grey / 100%							JIR JIR							
				200.8																
		End of Drillhole		50.3																
51																				
52																				
53																				
54																				
55																				
56																				

SUD-RCK 09-1191-0022 BRULE WICKLOW.GPJ GAL-MISS.GDT 02/02/11 DATA INPUT:

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ID

CHECKED: DAM

Golder Associates

RECORD OF BOREHOLE No BR10-05

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435609.0; E 308640.0 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL

DATUM Geodetic | DATE June 27, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.9	GROUND SURFACE							
0.0 / 0.1	ORGANICS (TOPSOIL)							
	SILTY CLAY, trace to some sand, trace organics Very stiff Brown Wet		1	SS	15			
			2	SS	29		249	0 5 46 49
			3	SS	17		248	
247.6 / 2.3	CLAYEY SILT to SILTY CLAY, trace to some sand, trace gravel Very soft to firm Grey Wet		4	SS	7			1 6 46 47
			5	SS	4		247	
			6	SS	2		246	1 20 34 45
			7	SS	2		245	
			8	SS	3		244	
			9	SS	3		243	
	SILT layer 300 mm thick at 13.7 m depth.					▽	242	
							241	
							240	
							239	
							238	
							237	
							236	
							235	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

+4, +4, +3, +3, +3, +3, +13

MIS-MTO 001 09-1191-0022 BRULE WICKLOW.GPJ GAL-MISS.GDT 02/02/11 DATA INPUT:

Continued Next Page

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

Golder Associates

PROJECT 09-1191-0022

RECORD OF BOREHOLE No BR10-05

2 OF 2 **METRIC**

W.P. 133-88-00 LOCATION N 5435609.0; E 308640.0 ORIGINATED BY ID

DIST HWY 652 BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers COMPILED BY JJL

DATUM Geodetic DATE June 27, 2010 CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
234.1			10	SS	1				○		
15.8	End of Borehole						234				
	Note:										
	1. Water level at a depth of 14.4 m below ground surface (Elev. 235.5 m) and rising, upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BR10-06

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | DIST | HWY 652 | DATUM Geodetic

LOCATION N 5435606.3; E 308665.0 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | DATE June 27, 2010

ORIGINATED BY ID | COMPILED BY JJL | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.5	GROUND SURFACE							
0.0	ORGANICS (TOPSOIL)							
0.2	SILTY CLAY, some sand, trace gravel, trace to some organics (ALLUVIUM) Stiff Dark brown	1	SS	10		248		3 13 41 43
247.4	Moist	2	SS	12				
1.1	SILTY CLAY trace to some sand, trace gravel Stiff Brown Moist to wet	3	SS	9		247		
246.2								
2.3	CLAYEY SILT to SILTY CLAY Very soft to firm Grey Wet	4	SS	4		246		
		5	SS	4		245		0 17 38 45
		6	SS	1				
		7	TO	PH		244		
						243		
						242		
		8	SS	1		241		
						240		
						239		
		9	TO	PH		238		
						237		
236.0								
12.5	CLAY some silt, trace sand Very soft to firm Grey Wet					236		
		10	SS	1		235		0 1 18 81
						234		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

Continued Next Page

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

Golder Associates

PROJECT 09-1191-0022

RECORD OF BOREHOLE No BR10-06

2 OF 2 **METRIC**

W.P. 133-88-00 LOCATION N 5435606.3; E 308665.0 ORIGINATED BY ID

DIST HWY 652 BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers COMPILED BY JJL

DATUM Geodetic DATE June 27, 2010 CHECKED BY DAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAY some silt, trace sand Very soft to firm Grey Wet					▽	233	+ 4 + 4			
							232				
			11	SS	1						
							231				
			12	SS	1		230		○		
							229				
228.1			13	SS	1						
20.4	End of Borehole Note: 1. Water level at a depth of 16.0 m below ground surface (Elev. 232.5 m) and rising, upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No BR10-07

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435611.6; E 308695.4 | ORIGINATED BY ID
DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL
DATUM Geodetic | DATE June 28, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.6	GROUND SURFACE										
0.0	ORGANICS (TOPSOIL)										
0.1	SILTY CLAY, trace to some sand, trace gravel, trace organics (FILL) Firm Brown Wet		1	SS	8		249				
			2	SS	7						
248.1											
1.5	SILTY CLAY, some sand, trace gravel, trace to some organics (ALLUVIUM) Firm to stiff Grey to black Wet		3	SS	7		248				1 14 48 37
			4	SS	14		247				
246.6											
3.0	SILTY CLAY, trace to some sand Very stiff to firm Grey Wet		5	SS	20		246				OC=6.0% 0 7 51 42
			6	SS	7						
244.9	SAND and GRAVEL layer between 4.3 m and 4.7 m depth.						245				
4.7	CLAYEY SILT to SILTY CLAY, trace to some sand Soft to firm Grey Wet		7	SS	25						
			8	TO	PH		244			19.1	
							243				
							242	3 3			
							241				
			9	TO	PH		240				
							239				
			10	SS	3		238				
							237	3 3			
							236				
			11	SS	2		235				

Continued Next Page

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

MIS-MTO 001 09-1191-0022 BRULE WICKLOW.GPJ GAL-MISS.GDT 02/02/11 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No BR10-07

2 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | DIST | HWY 652 | DATUM Geodetic

LOCATION N 5435611.6; E 308695.4 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | DATE June 28, 2010

ORIGINATED BY ID | COMPILED BY JJL | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
234.1											
15.5	CLAY, some silt, trace sand Soft to firm						234	6 6			
							233		○		
			12	SS	2		232				
							231	3 3			
							230				
229.2			13	SS	4						
20.4	End of Borehole Note: 1. Water level in piezometer at 4.8 m depth (Elev. 244.8 m) and 0.4 m (Elev. 249.2 m) depth on June 29, 2010 and August 12, 2010 respectively 2. On August 12, 2010, additional borehole advanced 1.5 m south and shelby tube samples obtained at 4.6 m, 6.1 m, and 7.6 m depths.										

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

Golder Associates

RECORD OF BOREHOLE No BR10-08

1 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435608.9; E 308720.4 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL

DATUM Geodetic | DATE June 28, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.0	GROUND SURFACE										
0.0	ORGANICS (TOPSOIL)										
0.2	Silty clay, trace to some sand, trace to some gravel, trace organics (FILL) Very stiff to soft Brown to dark brown Wet		1	SS	28						
			2	SS	10		249		○		
			3	SS	3		248		⊢○⊣		9 11 40 40
247.2			4	SS	5						
2.8	SILTY CLAY, trace sand, trace to some organics (ALLUVIUM) Firm Grey Wet		5	SS	6		247		○		
			6	SS	7		246		○		
245.4											
4.6	SILTY CLAY, trace to some sand, trace gravel Stiff Grey Wet		7	SS	10		245		○		
244.4											
5.6	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Firm Grey Wet		8	SS	4		244		⊢○⊣		3 16 34 47
			9	SS	4		243				
			10	SS	4		242				
							241		⊢○⊣		
							240	2			
			11	SS	3		239	2			
							238		○		
							237	2			
							236	2			

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No BR10-08

2 OF 2 **METRIC**

PROJECT 09-1191-0022 | W.P. 133-88-00 | LOCATION N 5435608.9; E 308720.4 | ORIGINATED BY ID

DIST | HWY 652 | BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers | COMPILED BY JJL

DATUM Geodetic | DATE June 28, 2010 | CHECKED BY DAM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60		
234.2			12	SS	3						
15.8	End of Borehole Note: 1. Borehole dry upon completion of drilling.										

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

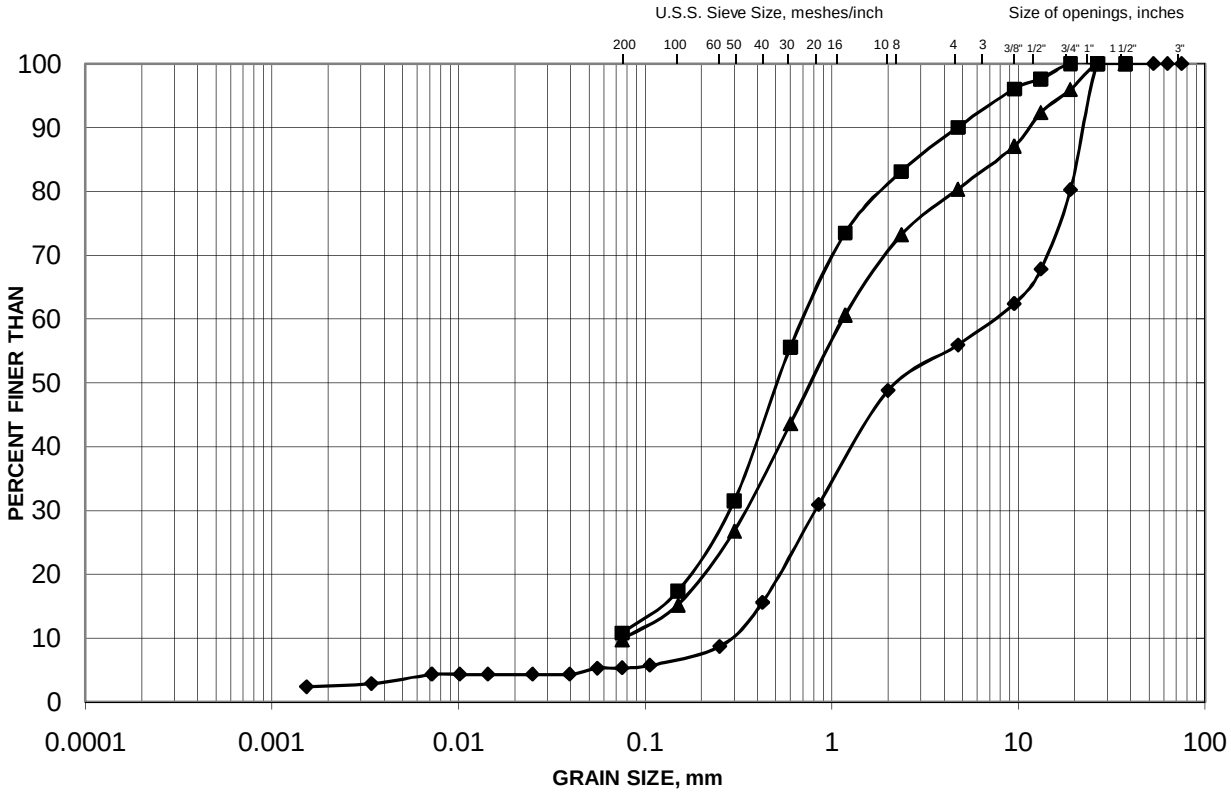
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel (Fill)

FIGURE B-1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	BR10-02	1	251.5
◆	BR10-03	2	249.6
▲	BR10-04	3	248.5

Project Number: 09-1191-0022-1

Checked By: SEMC

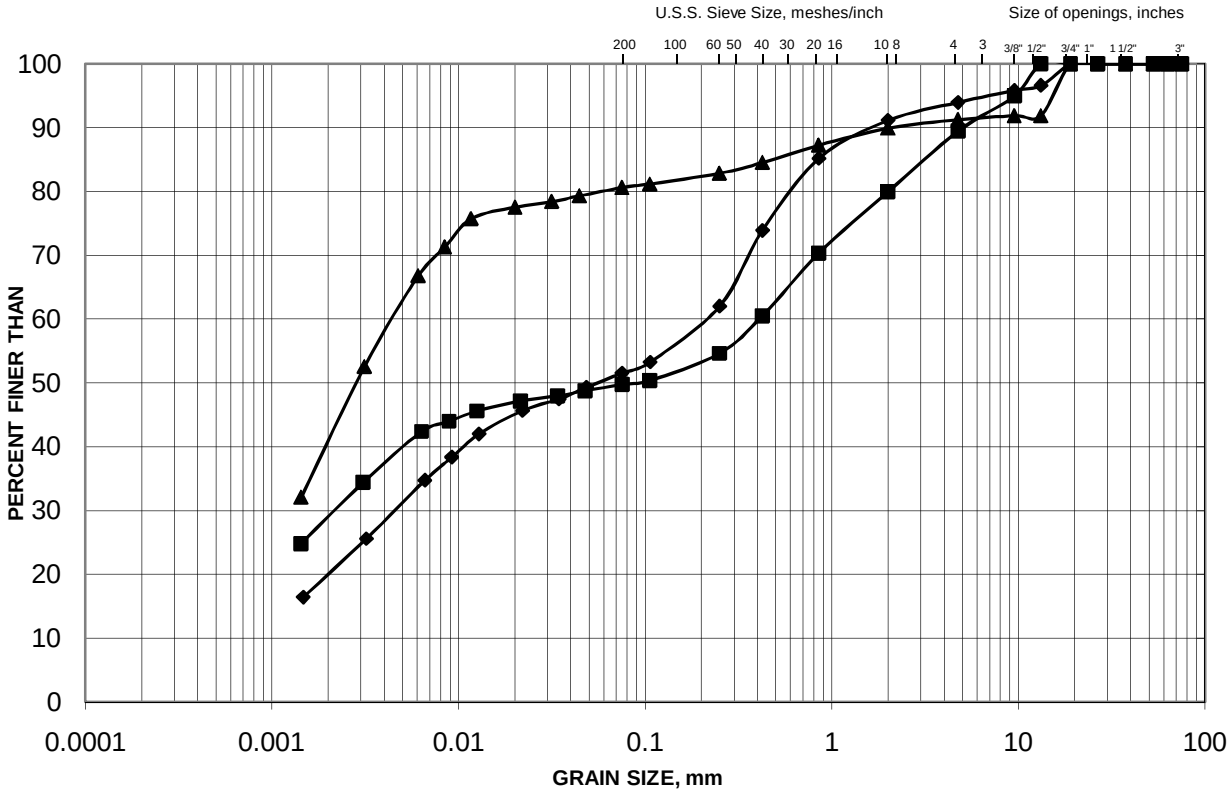
Golder Associates

Date: February 2011

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay (Fill)

FIGURE B-2



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
	BR10-02	3	250.0
	BR10-03	7	245.0
	BR10-08	3	248.2

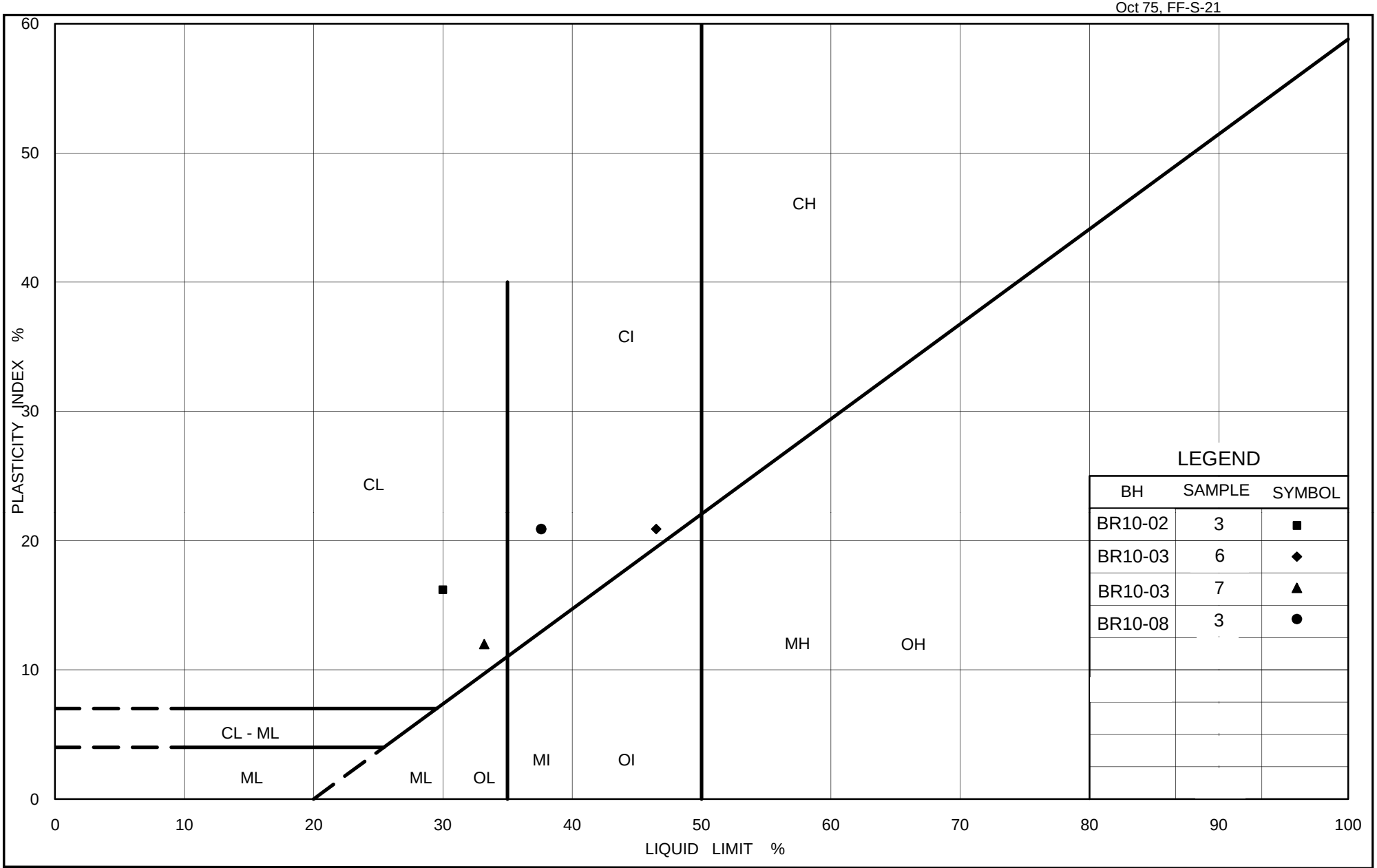
Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

Clayey Silt to Silty Clay (Fill)

Figure B-3

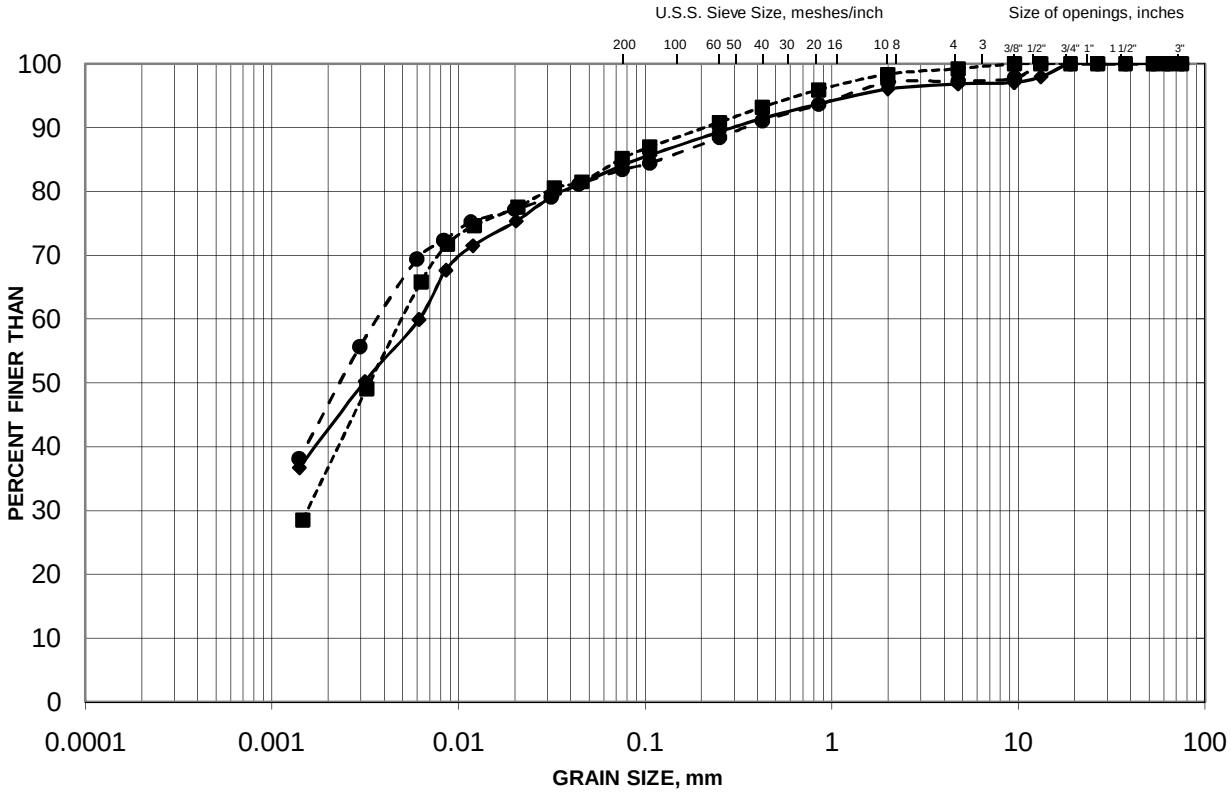
Project No. 09-1191-0022-1

Checked By: SEMC

GRAIN SIZE DISTRIBUTION

Silty Clay (Alluvium)

FIGURE B-4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
	BR10-01	3	248.2
	BR10-06	1	248.2
	BR10-07	3	247.8

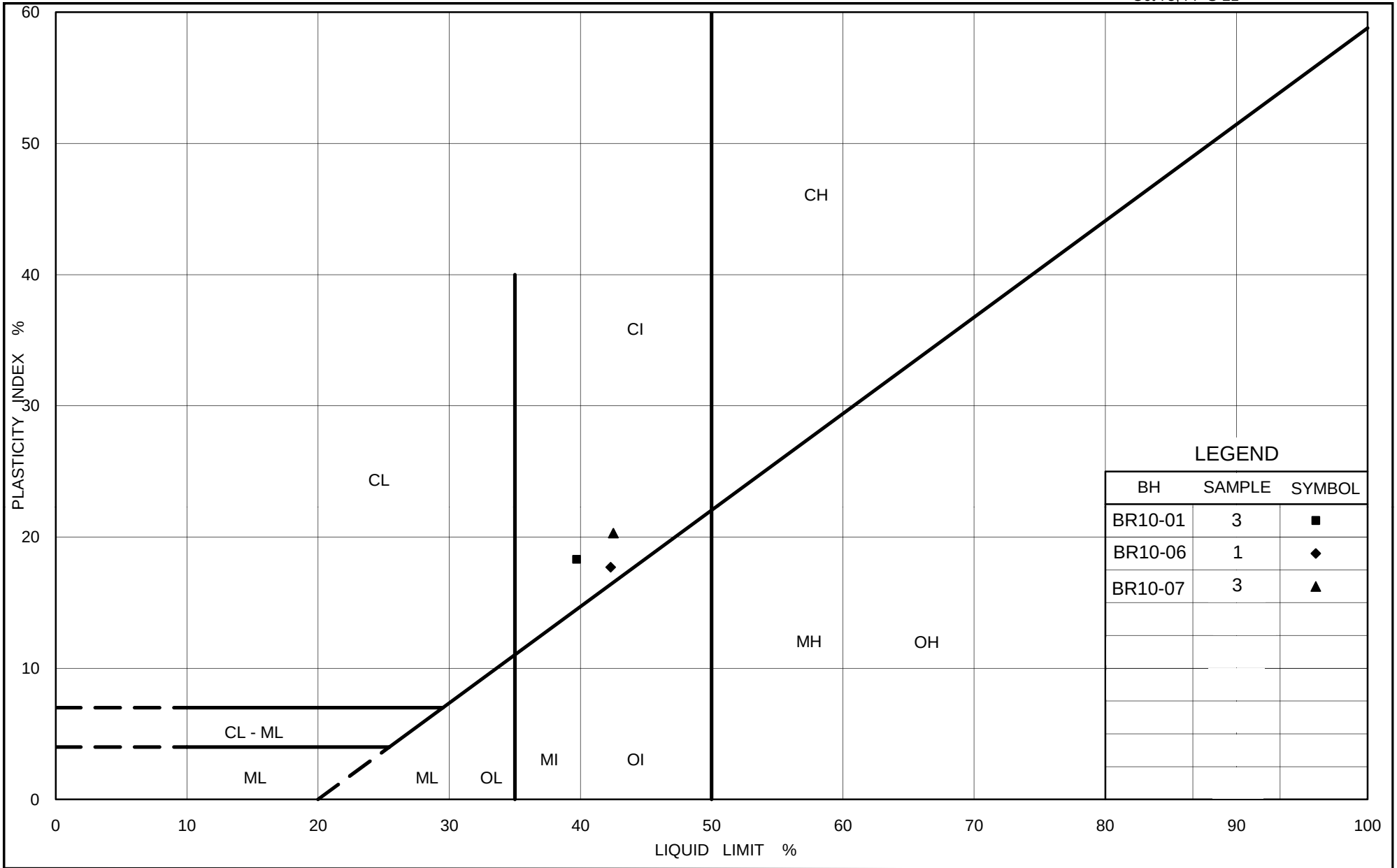
Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay (Alluvium)

Figure B-5

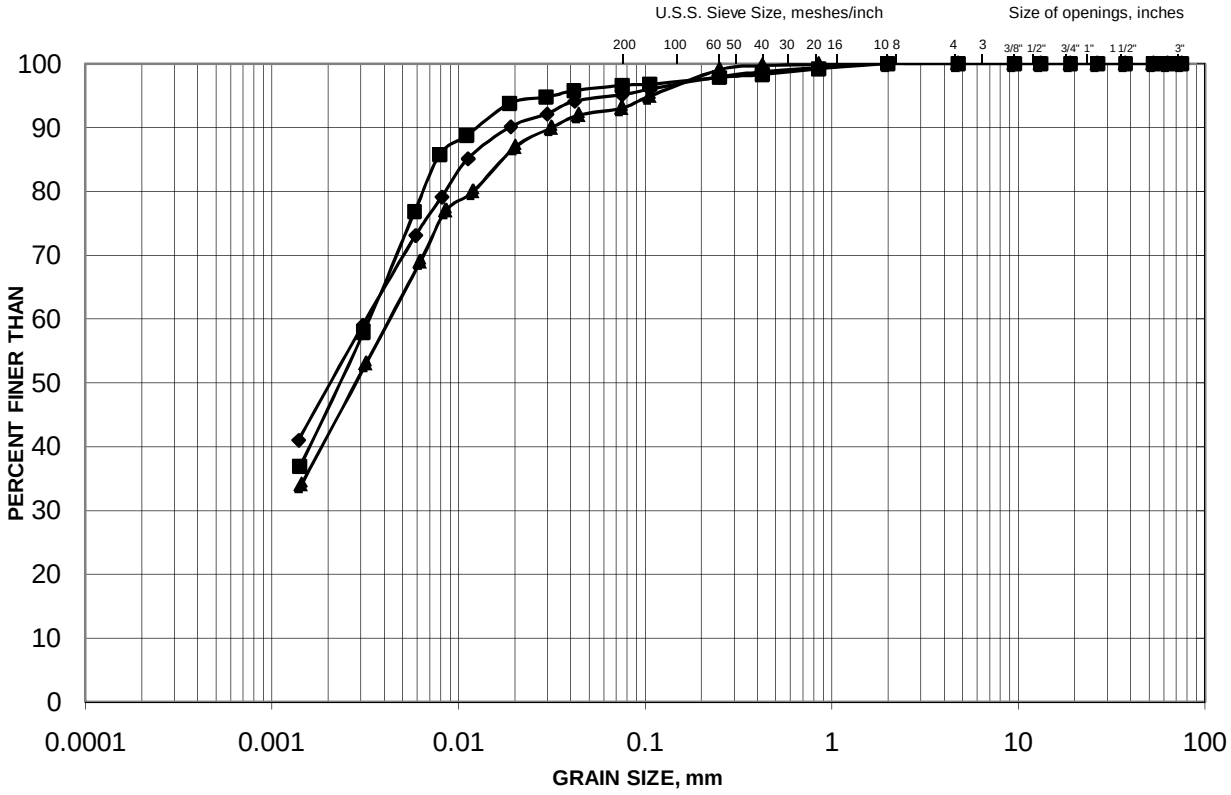
Project No. 09-1191-0022-1

Checked By: SEMC

GRAIN SIZE DISTRIBUTION

Silty Clay

FIGURE B-6



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	BR10-04	5	246.9
◆	BR10-05	2	248.8
▲	BR10-07	5	246.3

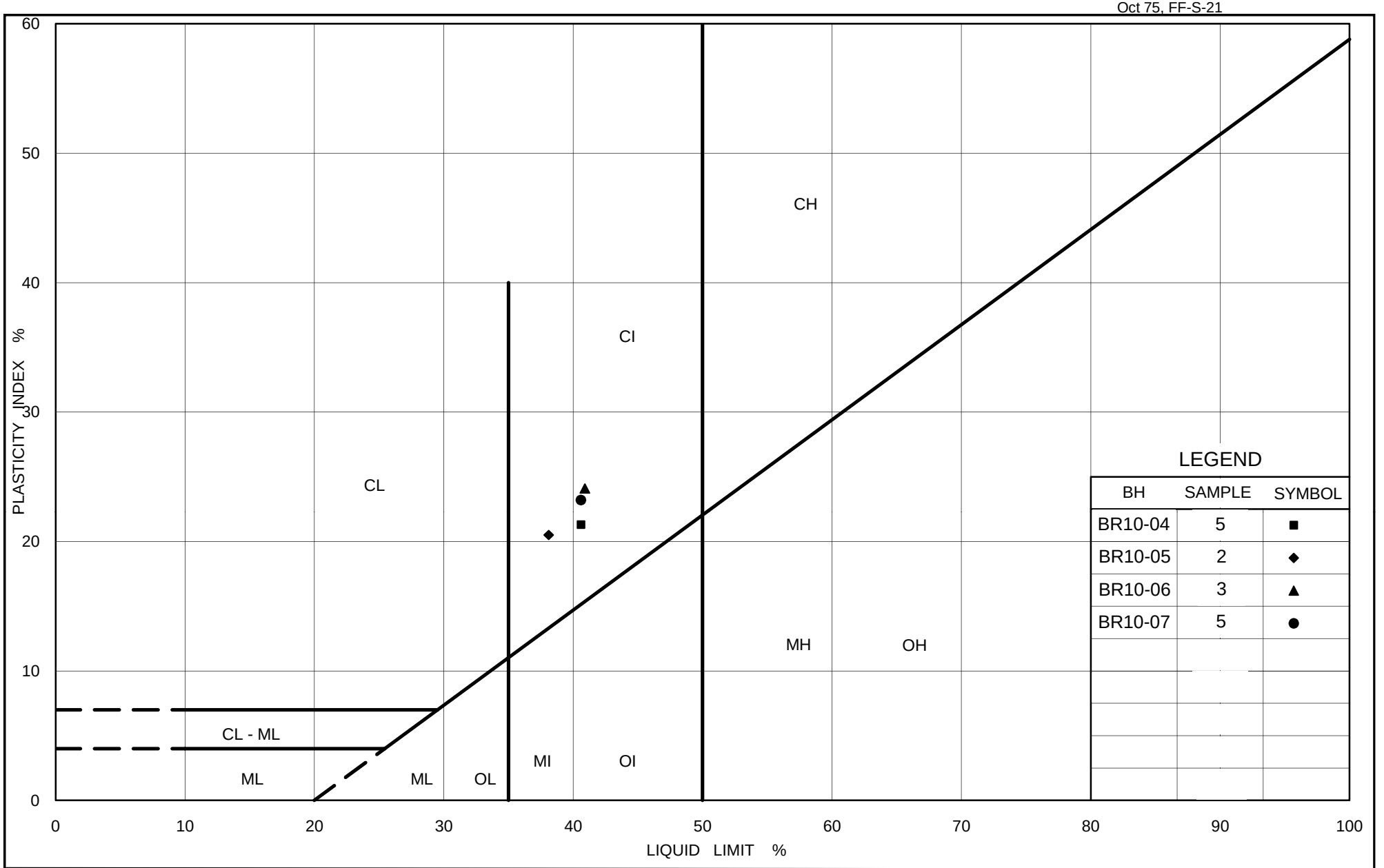
Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay

Figure B-7

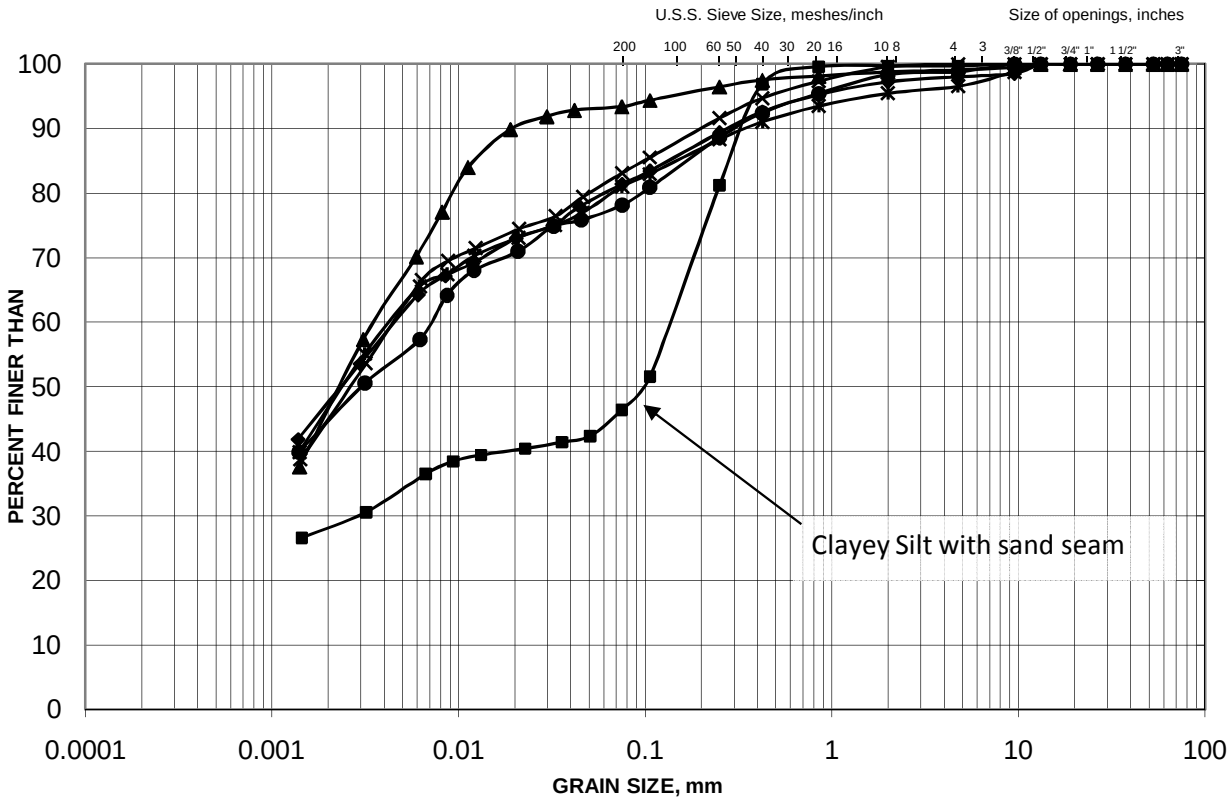
Project No. 09-1191-0022-1

Checked By: SEMC

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B-8



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
	BR10-01	10	236.8
	BR10-02	9	243.9
	BR10-05	4	247.3
	BR10-05	6	245.0
	BR10-06	5	245.1
	BR10-08	8	243.6

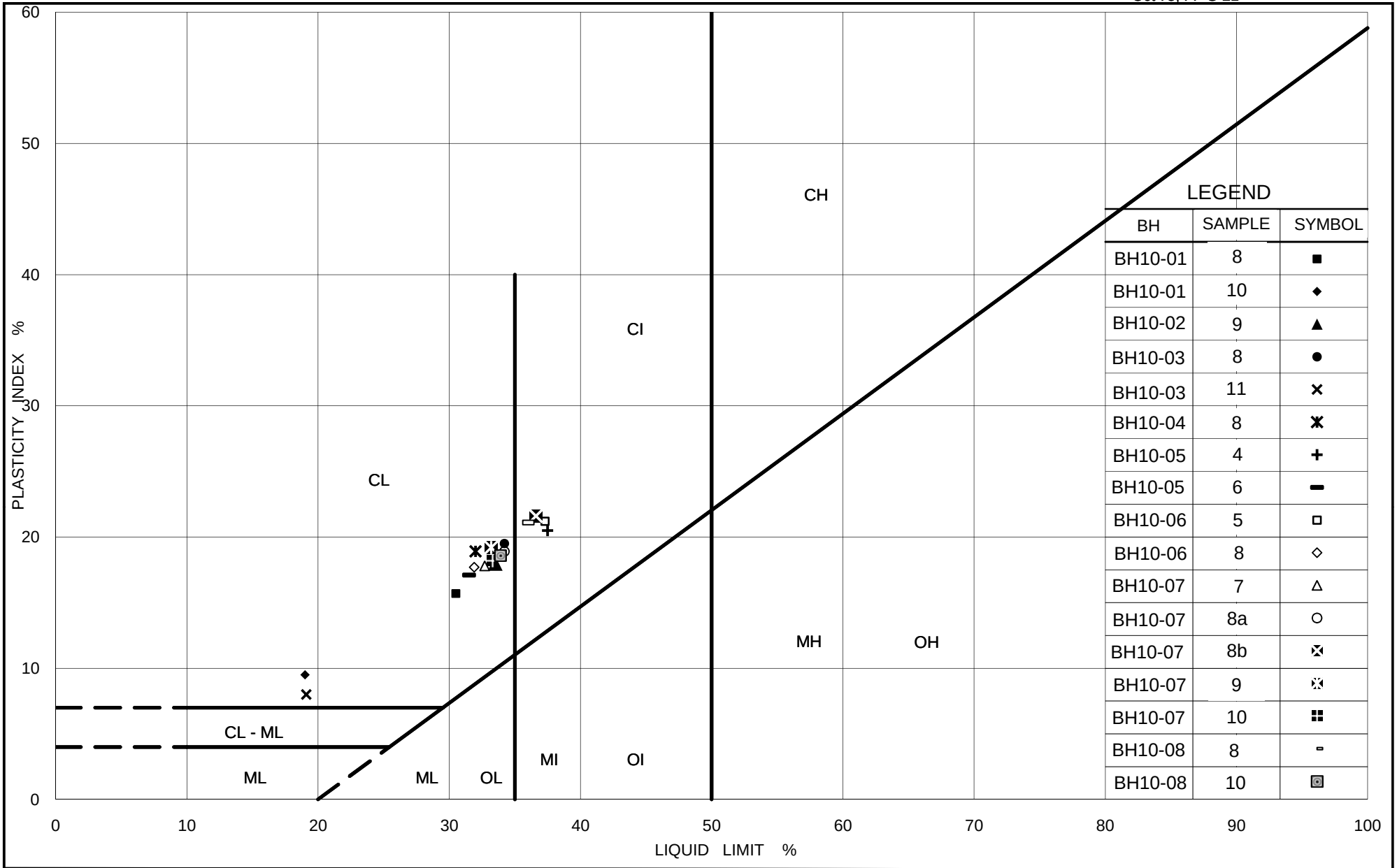
Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

Clayey Silt to Silty Clay

Figure B-9

Project No. 09-1191-0022-1

Checked By: SEMC

CONSOLIDATION TEST SUMMARY

FIGURE B-10

SAMPLE IDENTIFICATION

Project Number	09-1191-022-1	Sample Number	8
Borehole Number	BR10-04	Sample Depth, m	7.9

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Date Started	7/22/10		
Date Completed	8/6/10		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.55	Unit Weight, kN/m^3	19.39
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m^3	15.21
Area, cm^2	31.77	Specific Gravity, measured	2.66
Volume, cm^3	80.95	Solids Height, cm	1.487
Water Content, %	27.54	Volume of Solids, cm^3	47.26
Wet Mass, g	160.08	Volume of Voids, cm^3	33.69
Dry Mass, g	125.51	Degree of Saturation, %	102.6

TEST COMPUTATIONS

Pressure	Primary Consolidation	Corr. Height	Void	Average Height	t_{90}	cv.	mv	k	Total Work
kPa	mm	cm	Ratio	cm	sec	cm^2/s	m^2/kN	cm/s	kJ/m3
0.0	0.00	2.548	0.713	2.548					
8.9	0.04	2.544	0.710	2.546	960	0.0014	1.64E-04	2.31E-08	0.007
17.9	0.04	2.540	0.708	2.542	900	0.0015	1.76E-04	2.62E-08	0.028
35.1	0.09	2.531	0.702	2.536	1560	0.0009	2.01E-04	1.72E-08	0.119
69.2	0.14	2.517	0.692	2.524	1320	0.0010	1.66E-04	1.66E-08	0.416
142.6	0.31	2.487	0.672	2.502	2520	0.0005	1.63E-04	8.41E-09	1.699
284.9	0.75	2.412	0.621	2.449	2700	0.0005	2.06E-04	9.52E-09	8.129
570.5	0.78	2.334	0.569	2.373	1920	0.0006	1.07E-04	6.54E-09	21.979
1139.7	0.75	2.259	0.518	2.296	1680	0.0007	5.17E-05	3.37E-09	49.460
2279.0	0.56	2.203	0.481	2.231	1200	0.0009	1.93E-05	1.66E-09	91.916
570.5	-0.15	2.217	0.491	2.210					
142.6	-0.21	2.238	0.505	2.228					
35.1	-0.34	2.272	0.527	2.255					
8.9	-0.36	2.308	0.552	2.290					

Note:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

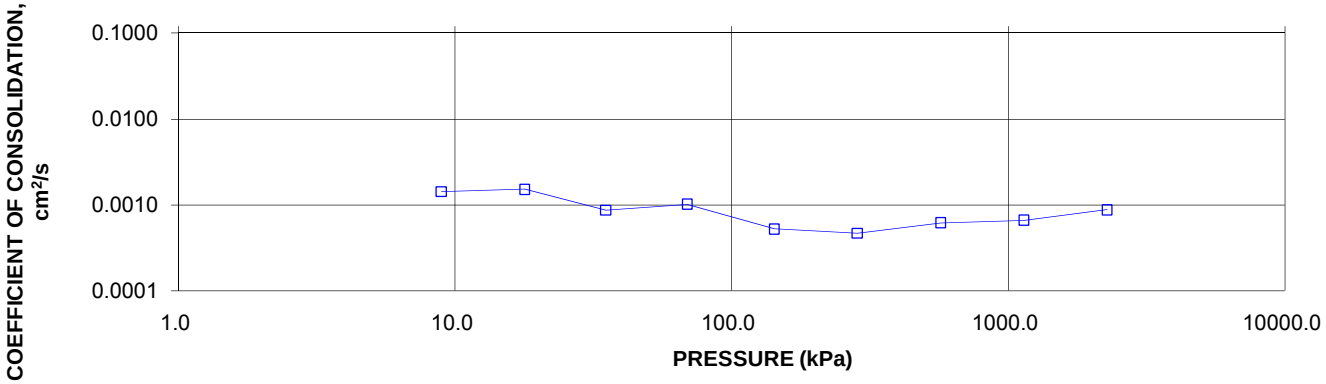
Sample Height, cm	2.31	Unit Weight, kN/m^3	19.96
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m^3	16.79
Area, cm^2	31.77	Specific Gravity, measured	2.66
Volume, cm^3	73.33	Solids Height, cm	1.487
Water Content, %	18.90	Volume of Solids, cm^3	47.26
Wet Mass, g	149.23	Volume of Voids, cm^3	26.07
Dry Mass, g	125.51		

Prepared By: TG

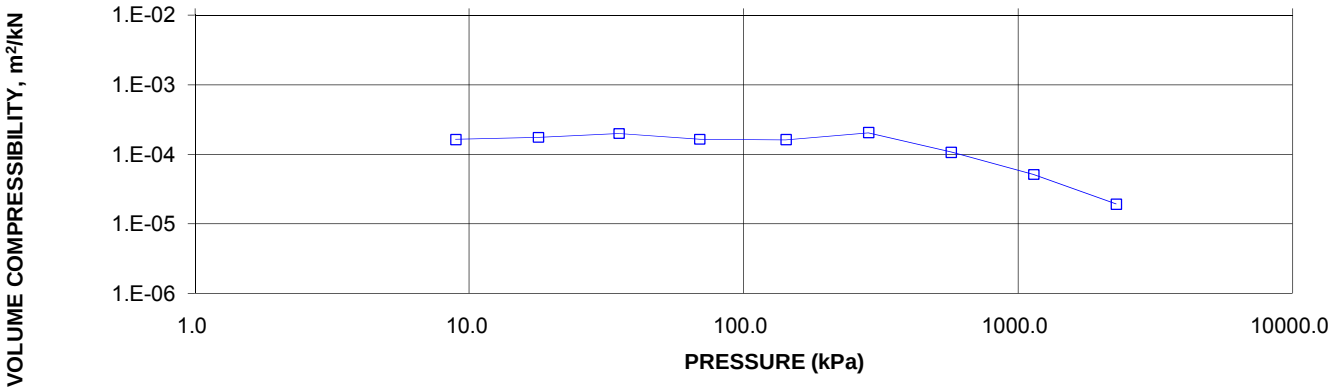
Golder Associates

Checked By: AB

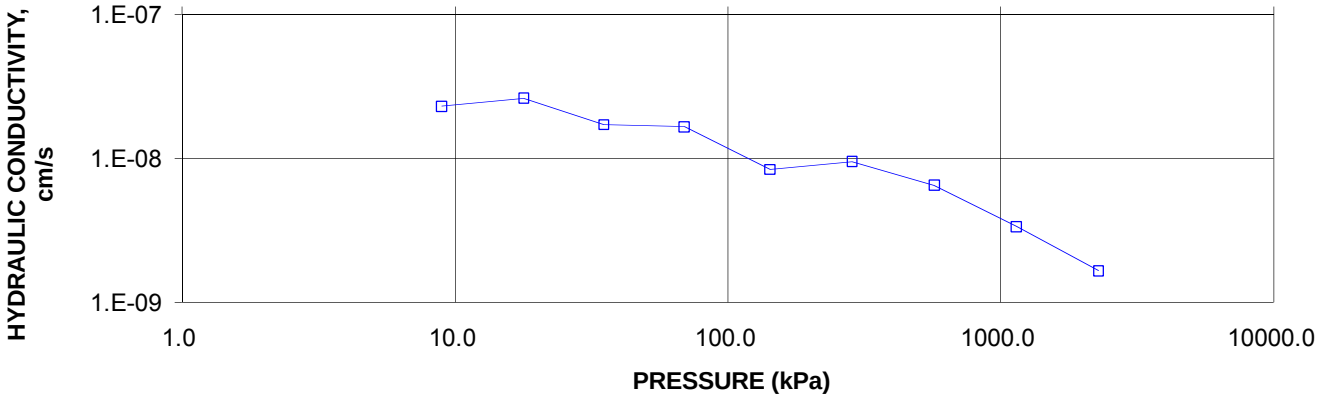
CONSOLIDATION TEST
CV cm^2/s VS PRESSURE (kPa)
BR10-04 SA 8



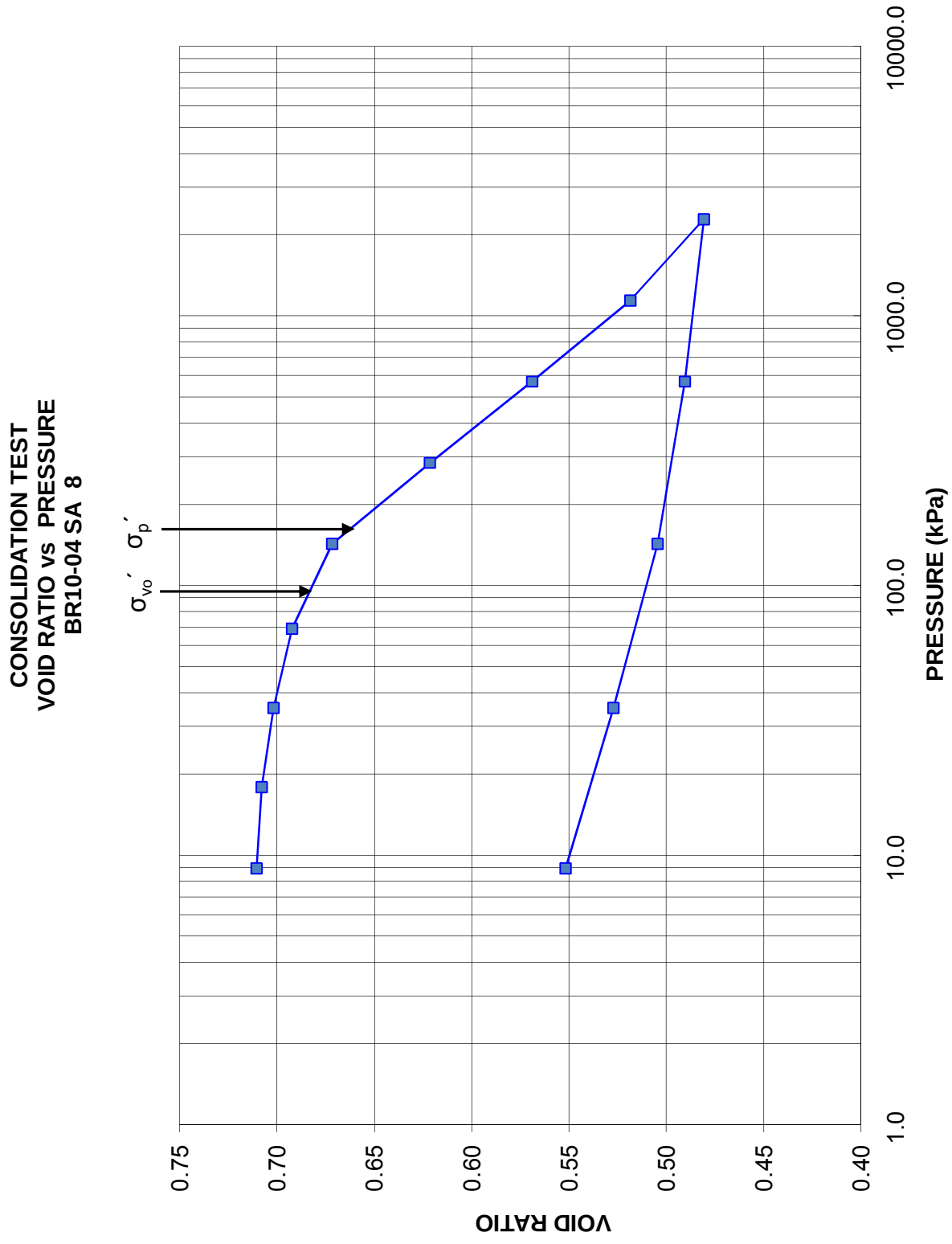
CONSOLIDATION TEST
MV m^2/kN vs PRESSURE (kPa)
BR10-04 SA 8



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BR10-04 SA 8



CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE	FIGURE B-10 Page 3 of 4



Project No. 09-1191-0022-1

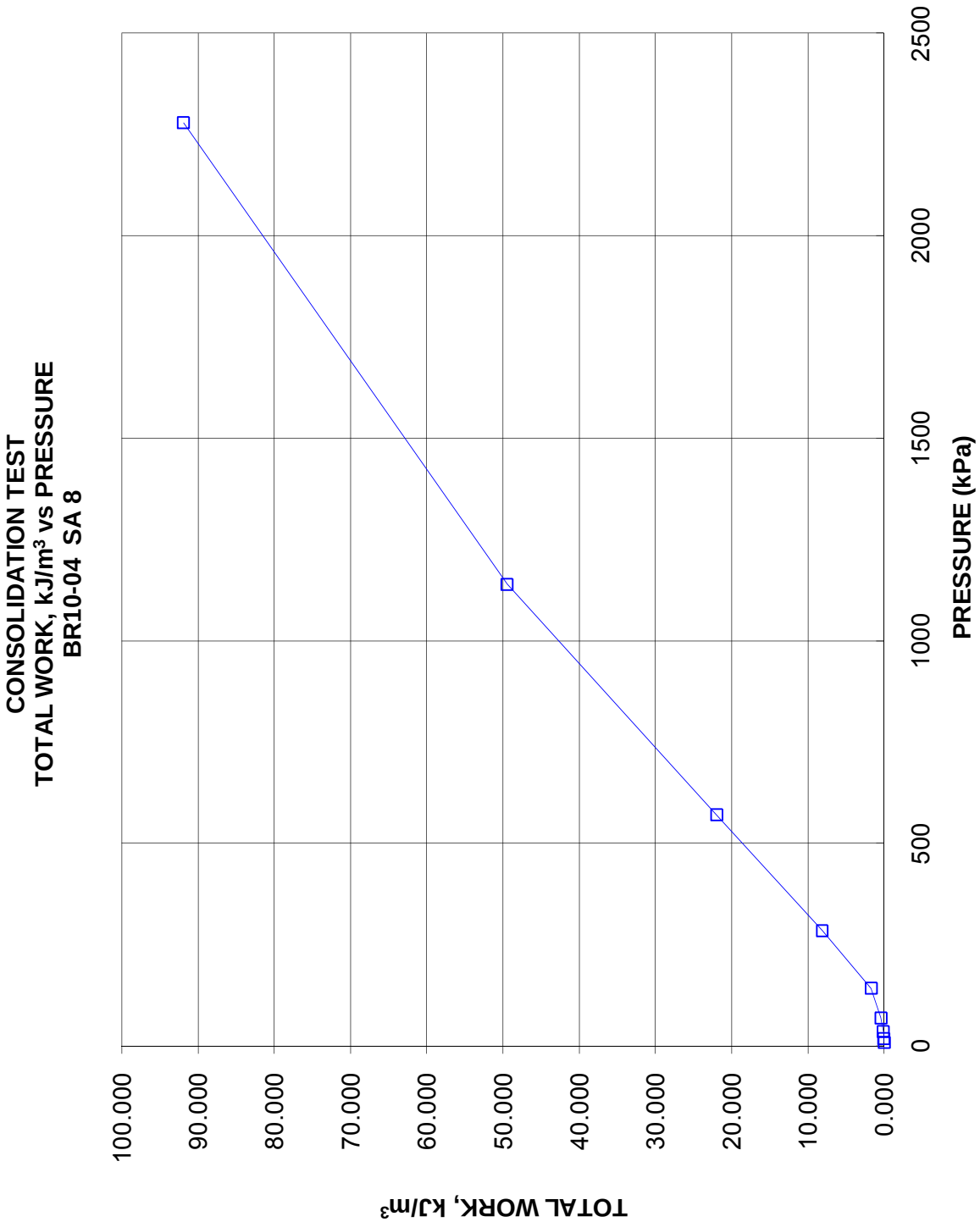
Prepared By: TG

Golder Associates

Checked By: AB

CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B-10
Page 4 of 4



Project No 09-1191-0022-1

Prepared By: TG

Golder Associates

Checked By: AB

CONSOLIDATION TEST SUMMARY

FIGURE B-11

SAMPLE IDENTIFICATION

Project Number	09-1191-022-1	Sample Number	8
Borehole Number	BR10-07	Sample Depth, m	6.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Date Started	8/16/10		
Date Completed	8/30/10		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.55	Unit Weight, kN/m^3	19.13
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m^3	14.86
Area, cm^2	31.77	Specific Gravity, measured	2.69
Volume, cm^3	80.95	Solids Height, cm	1.436
Water Content, %	28.69	Volume of Solids, cm^3	45.61
Wet Mass, g	157.89	Volume of Voids, cm^3	35.34
Dry Mass, g	122.69	Degree of Saturation, %	99.6

TEST COMPUTATIONS

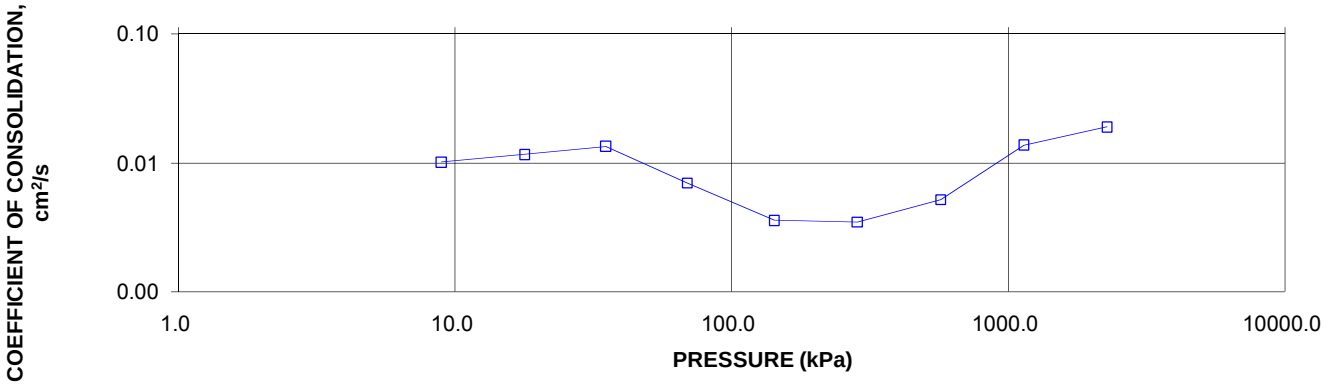
Pressure	Primary Consolidation	Corr. Height	Void	Average Height	t_{90}	cv.	mv	k	Total Work
kPa	mm	cm	Ratio	cm	sec	cm^2/s	m^2/kN	cm/s	kJ/m3
0.0	0.00	2.548	0.775	2.548					
8.9	0.03	2.545	0.773	2.547	135	0.0102	1.26E-04	1.25E-07	0.005
17.9	0.03	2.543	0.771	2.544	118	0.0117	1.11E-04	1.27E-07	0.018
35.1	0.05	2.538	0.768	2.540	101	0.0135	1.08E-04	1.43E-07	0.068
69.2	0.08	2.530	0.762	2.534	194	0.0070	9.37E-05	6.43E-08	0.235
142.6	0.15	2.515	0.751	2.522	375	0.0036	8.11E-05	2.86E-08	0.870
284.9	0.63	2.452	0.708	2.483	375	0.0035	1.73E-04	5.91E-08	6.200
570.5	0.55	2.397	0.670	2.424	240	0.0052	7.56E-05	3.85E-08	15.794
1139.7	0.50	2.347	0.635	2.372	86	0.0138	3.41E-05	4.62E-08	33.453
2279.0	0.50	2.298	0.601	2.323	60	0.0191	1.71E-05	3.19E-08	69.499
570.5	-0.16	2.314	0.612	2.306					
142.6	-0.28	2.343	0.632	2.328					
35.1	-0.36	2.379	0.657	2.361					
8.9	-0.32	2.410	0.679	2.395					

Note:
k calculated using cv based on t_{90} values.

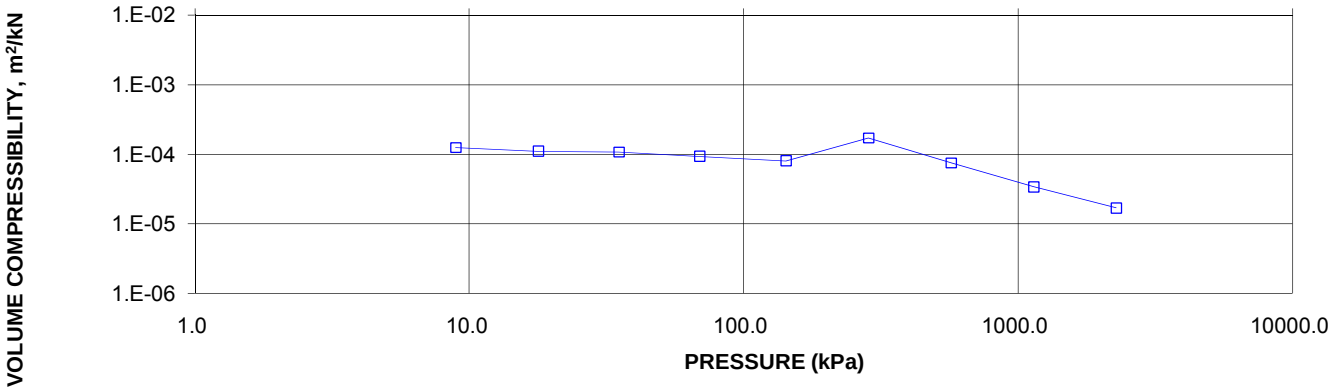
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.41	Unit Weight, kN/m^3	18.90
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m^3	15.71
Area, cm^2	31.77	Specific Gravity, measured	2.69
Volume, cm^3	76.58	Solids Height, cm	1.436
Water Content, %	20.28	Volume of Solids, cm^3	45.61
Wet Mass, g	147.57	Volume of Voids, cm^3	30.97
Dry Mass, g	122.69		

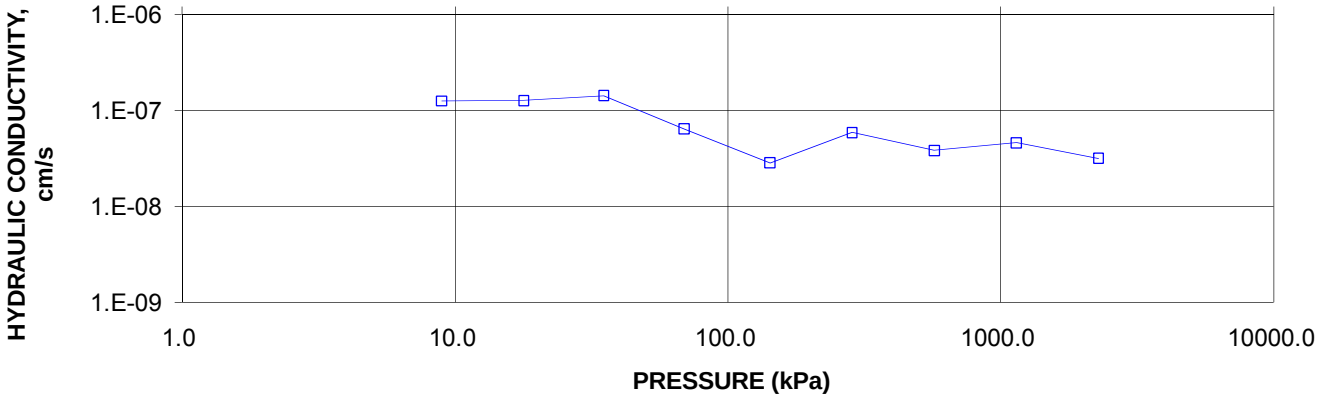
CONSOLIDATION TEST
CV cm^2/s VS PRESSURE (kPa)
BR10-07 SA 8



CONSOLIDATION TEST
MV m^2/kN vs PRESSURE (kPa)
BR10-07 SA 8



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BR10-07 SA 8

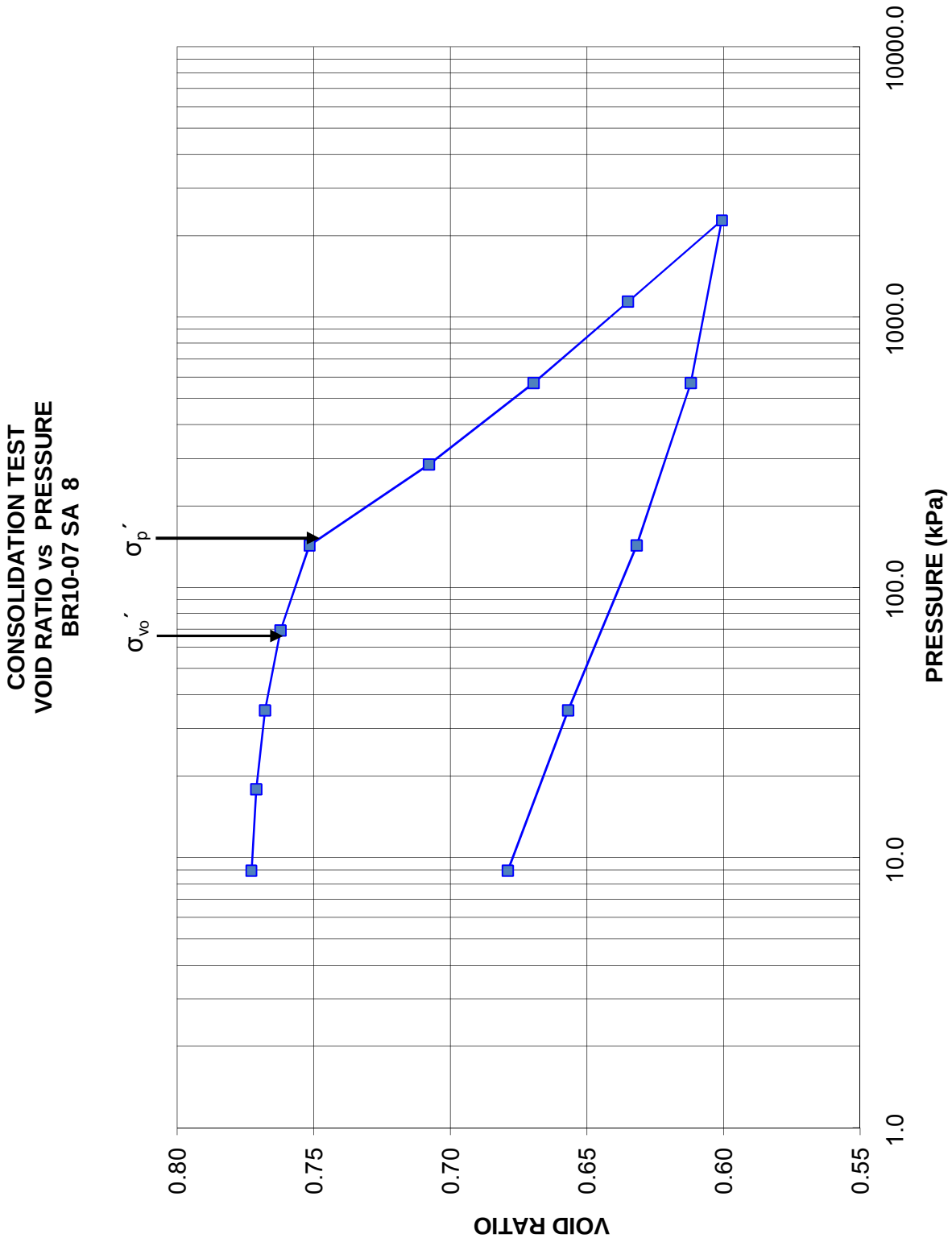


Project No. 09-1191-0022-1
Prepared By: TG

Golder Associates

Checked By: AB

CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE	FIGURE B-11 Page 3 of 4



Project No. 09-1191-0022-1

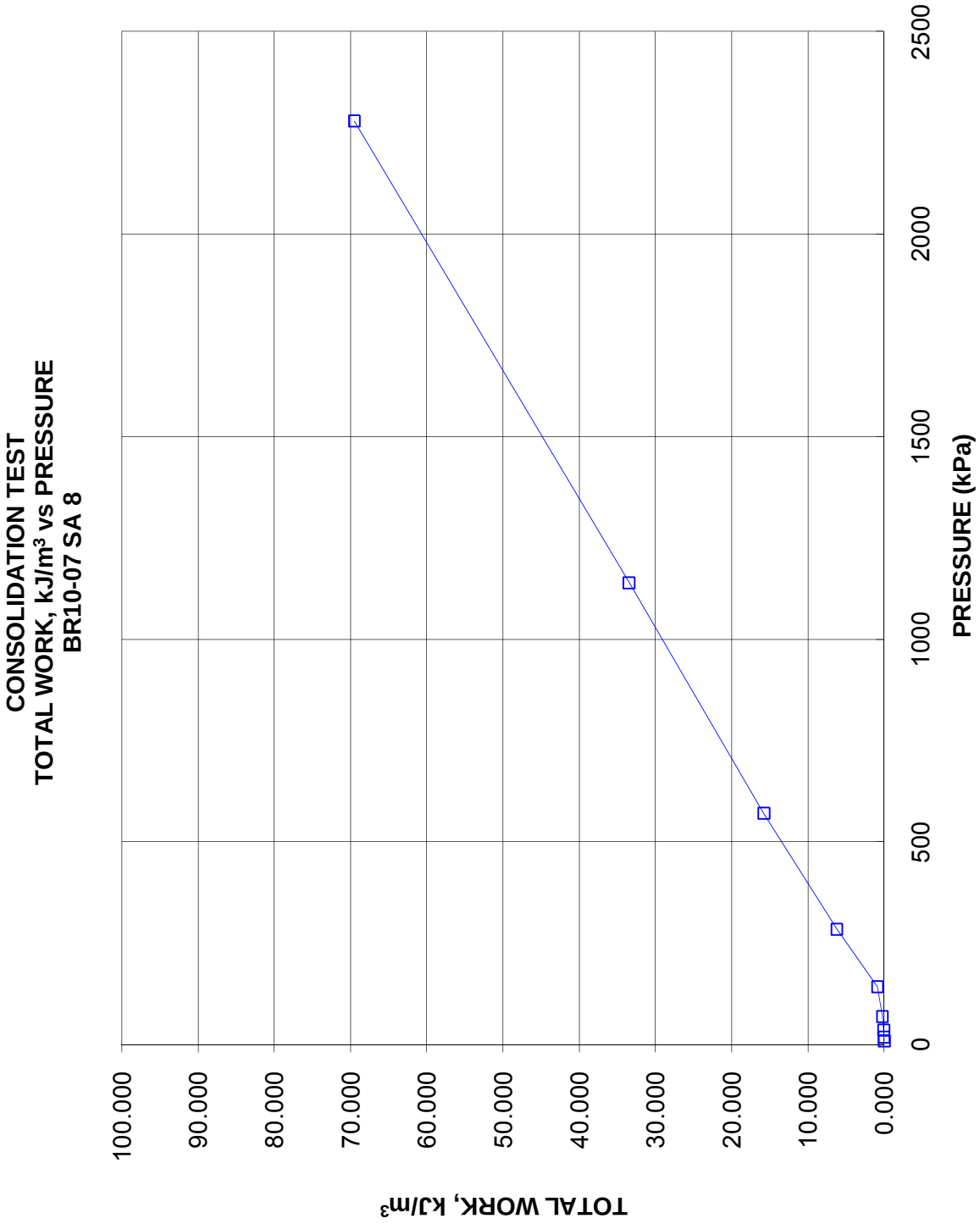
Prepared By: TG

Golder Associates

Checked By: AB

CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B-11
Page 4 of 4



Project No 09-1191-0022-1

Prepared By: TG

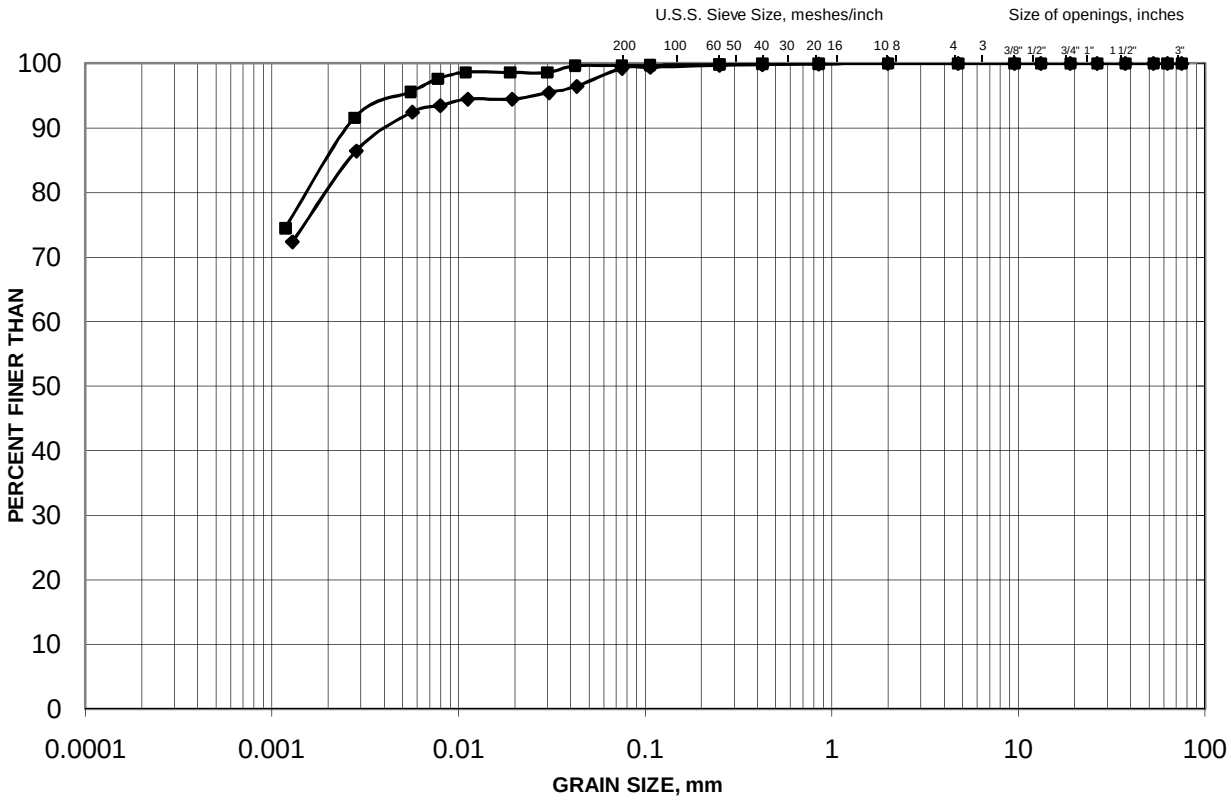
Golder Associates

Checked By: AB

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE B-12



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	BR10-03	13	232.8
◆	BR10-06	10	234.5

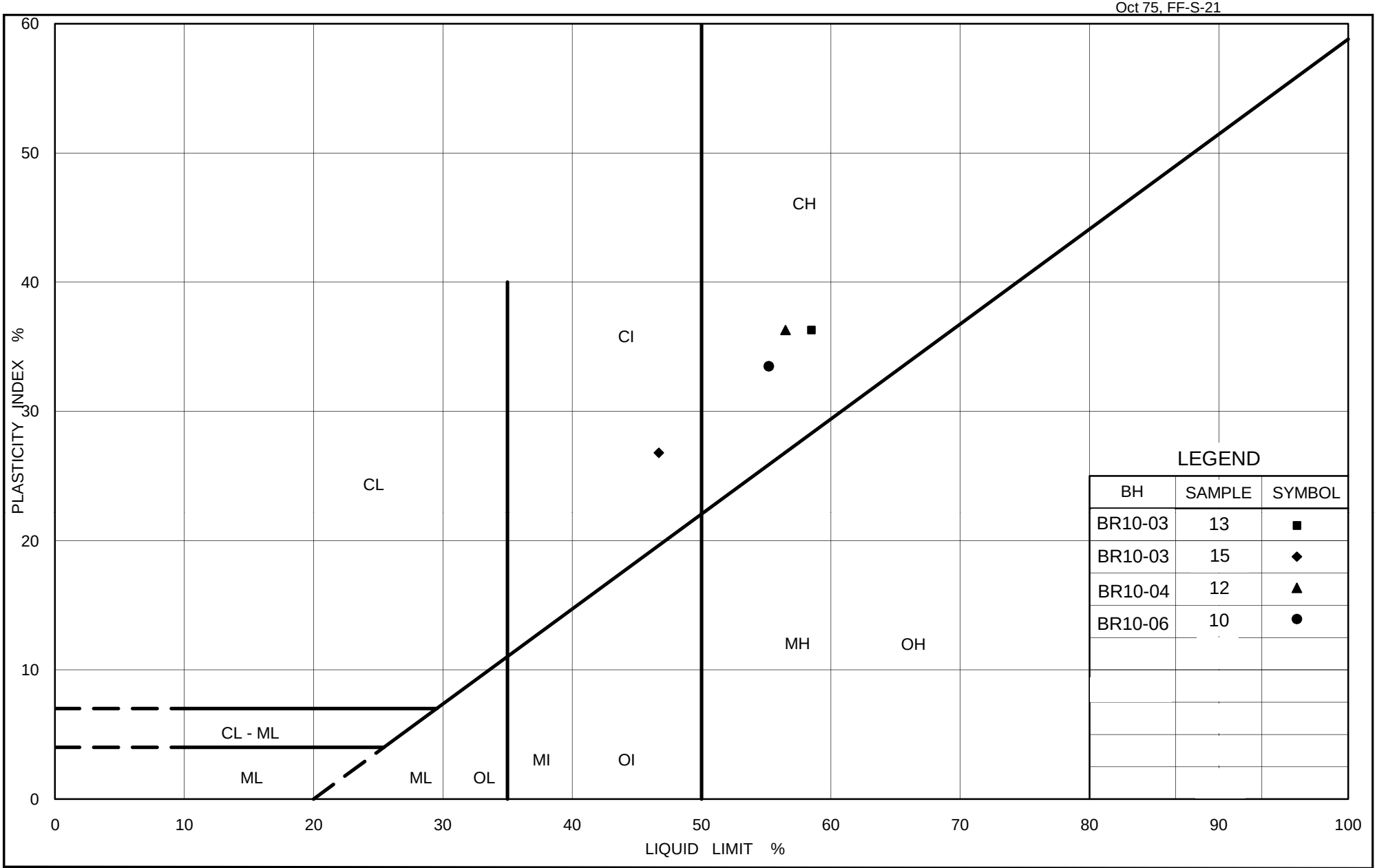
Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay to Clay

Figure B-13

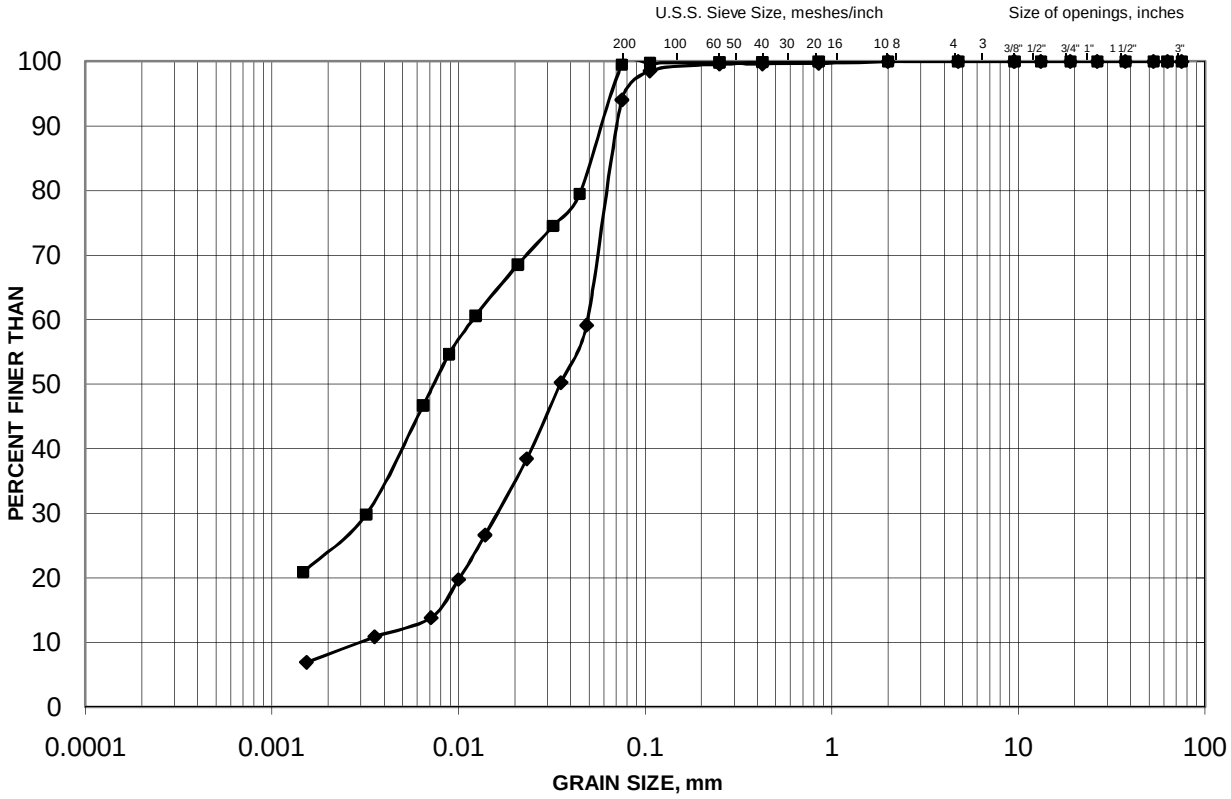
Project No. 09-1191-0022-1

Checked By: SEMC

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B-14



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	BR10-03	17	220.7
◆	BR10-04	16	218.8

Project Number: 09-1191-0022-1

Checked By: SEMC

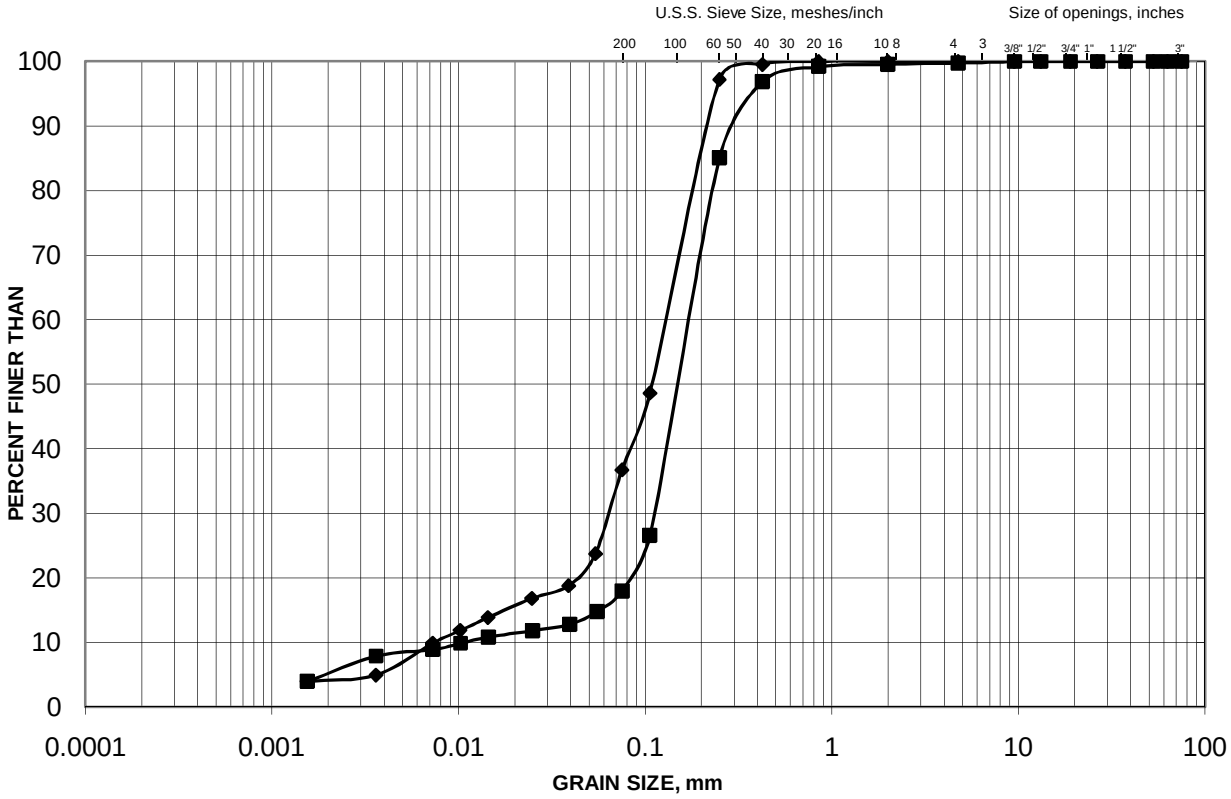
Golder Associates

Date: February 2011

GRAIN SIZE DISTRIBUTION

Sand to Sandy Silt

FIGURE B-15



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
■	BR10-03	18	217.6
◆	BR10-04	18	212.7

Project Number: 09-1191-0022-1

Checked By: SEMC

Golder Associates

Date: February 2011

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

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

Golder Associates