REPORT

SEPTEMBER 2014

FOUNDATION INVESTIGATION REPORT

STILL RIVER NBL BRIDGE STRUCTURE, SITE NO. 44-458/1
HIGHWAY 69 FOUR-LANING FROM 1.7 KM NORTH OF HIGHWAY 529 NORTHERLY TO 3.9 KM NORTH OF HIGHWAY 522
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5404-05-00; WP 5139-08-01

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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the proposed Highway 69 northbound lanes (NBL) structure over the Still River (Site No. 44-458/1), which is within the Contract 2 limits of the new Highway 69 alignment to the north of the junction with Highway 529. The proposed work in Contract 2 is part of the four-laning of Highway 69 from 1.7 km north of Highway 529 northerly to 3.9 km north of Highway 522, for a total distance of 19.7 km. The foundation engineering components within the overall project limits include the engineering of: high fill embankments and embankments over swamps; the Canadian National Railway (CNR) re-alignment; the Bekanon Road and Highway 522 interchanges and structures; the Still River, Straight Lake and Key River structures; the Canadian Pacific Railway (CPR) and Canadian National Railway (CNR) structures; as well as culvert crossings. The Still River NBL Bridge structure is located approximately 1.2 km east of the existing Highway 69. The general location of this bridge along the new Highway 69 four-laning alignment is shown on the Site Location Plan on Drawing 1.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2009. Golder's proposal for foundation engineering services associated with the Contract 2 Still River NBL Bridge structure is contained in Section 6.8 of URS's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Quality Control Plan for foundation engineering services for this project, dated April 19, 2010. The General Arrangement (GA) Drawing for the proposed Still River NBL Bridge structure (two-span bridge option) was provided to Golder by URS on April 5, 2011. In addition, a preliminary GA Drawing for the one-span bridge option was provided to Golder by URS on October 1, 2010.

This report addresses the foundation investigation carried out for the Still River NBL Bridge structure and the associated approach embankments only. A two-span structure was proposed in the Environmental Assessment Report. During the initial stage of the detail design assignment one-span and two-span options were evaluated. In September 2011 Golder conducted field investigations and prepared a Technical Memorandum summarizing the findings and provided preliminary recommendations with respect to both a one-span and two-span alternative. Following discussions with the Ministry, a two-span option has been chosen for the Still River crossing. Since the feasibility of a one-span bridge option was evaluted during the initial design stage, this foundation investigation report has been prepared to address the two options. Separate reports address the foundation investigations for the related swamp crossings and high fill areas, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed bridge structure location, including the associated approach embankments, by borehole drilling, rock coring, in situ testing and laboratory testing on selected soil and rock core samples. The foundation units/limits for this investigation were located in the field by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by URS. The investigation area is shown in plan on Drawing 2.

2.0 SITE DESCRIPTION

The proposed Highway 69 alignment is oriented generally in a south-north direction spanning the Township of Wallbridge to the south, the Township of Henvey and the Township of Mowat to the north. The Contract 2 section of the new four-lane Highway 69 alignment is also oriented generally in a south-north direction within the overall project limits, spanning the Township of Wallbridge to the south and the Township of Henvey to the north

for a total distance of 4.8 km. The proposed Still River NBL bridge structure is located within the Contract 2 highway alignment and is located approximately 3.2 km from the southern limit of Contract 2, corresponding to approximately 1.5 km northeast of the junction between existing Highway 69 and Highway 526. The proposed new four-lane Highway 69 alignment is oriented generally in a south-north direction and parallel to the east side of the existing Highway 69 within the Contract 2 project limits.

In general, the topography of this section of the overall project limits consists of rolling terrain, including sparsely to densely populated tree covered areas and numerous bedrock outcrops separated by valleys, rivers and swamps containing areas of standing water and various types of vegetation and organic soils. The proposed bridge structure and associated approach embankments are to be situated on a relatively flat and low-lying open field area on the south side of the Still River and on the moderately to densely tree covered sloping ground and bedrock outcrop on the north side of the river. On the south side of the river, the ground surface within the limits of the proposed structure is relatively flat at about Elevation 181.0 m along the south approach embankment and at the south abutment. On the north side of the river, the ground surface ranges from about Elevation 178.7 m to 179.1 m at the centre pier to about Elevation 179.0 m to 181.3 m at the north abutment and along the north approach (for the one-span bridge option) and about Elevation 183.9 m to 187.3 m at the north abutment and along the north approach embankment (for the two-span bridge option). All elevations are referenced to Geodetic datum.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the proposed Still River NBL Bridge structure was carried out between February 10 and 27, and March 3 and 31, 2011 during which time a total of thirteen (13) boreholes, two (2) probeholes (defined as augered boreholes (without sampling) for the purpose of establishing probable bedrock surface), two (2) Dynamic Cone Penetration Tests (DCPTs) and two (2) hand excavations were advanced at the locations of the proposed structure foundation elements and approach embankments. A summary of the respective boreholes, probeholes, DCPTs and hand excavations advanced at each foundation element and approach embankment is presented below.

Foundation Element/ Approach Embankment	Investigation Type			
	Borehole No.	Probehole No.	DCPT No.	Hand Excavation
South Approach Embankment (One- or Two-Span Option)	S204-18 B202-01	--	--	--
South Abutment (One- or Two-Span Option)	B202-02 SP1[1]	--	--	--
Centre Pier	B202-03 B202-14 B202-15	B202-P01 B202-P02	--	--
North Abutment (One-Span Bridge	B202-04 B202-12 B202-13	--	B202-DC01 B202-DC02	--

Foundation Element/ Approach Embankment	Investigation Type			
	Borehole No.	Probehole No.	DCPT No.	Hand Excavation
North Approach Embankment (One-Span Option)	B202-05	--	--	--
North Abutment (Two-Span Option)	B202-06 B202-07 B202-08 B202-09	--	--	B202-10
North Approach Embankment (Two-Span Option)	--	--	--	B202-11

Note: 1. Borehole SP1 was advanced in the vicinity of the south abutment to install a pizometer for monitoring the groundwater level in the area.

In addition, one (1) borehole (Borehole S204-18) advanced within the immediately adjacent Swamp 204 as part of the field investigation work carried out by Golder for the Contract 2 swamp crossings and high fill areas[1] was utilized to supplement this investigation at the south approach embankment. The Record of Borehole sheets and the results of the laboratory testing for all of the boreholes/drillholes advanced for this bridge structure, including Borehole S204-18, are presented in Appendix A and Appendix B, respectively. The locations of the boreholes, probeholes and DCPTs are shown on Drawing 2.

The field investigation was carried out using a track-mounted Diedrich D-25 or D-50 Turbo drill rig supplied and operated by Walker Drilling Co. Ltd. of Utopia, Ontario and by portable equipment supplied and operated by OGS Inc. of Almonte, Ontario. Hand excavation methods were used as appropriate depending on the terrain to confirm refusal conditions at shallow borehole locations. The boreholes were advanced through the overburden using 127 mm or 213 mm outer diameter (O.D.) solid-stem augers, tricone and/or 'casing (BW, EW, NW or HW) with wash boring techniques. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm O.D. split-spoon sampler advanced by automatic hammers on the drill rigs, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). Boreholes advanced by portable equipment employed one-third ($^1/_3$) weight hammers lifted manually and dropped from the SPT height. The SPT 'N'-value obtained by the use of the lesser weight hammer were then adjusted down by a factor of 3 to correspond to the SPT 'N'-values that would be expected to be obtained had a full-weight hammer been used. Chunk samples were obtained in two (2) boreholes at locations of thin overburden over bedrock knobs. 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 assessment of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes and 'B' size vanes in smaller diameter boreholes advanced by portable equipment. Samples of the bedrock were obtained using 'NQ' or 'EQ' or 'BQ' size rock core barrel.

[1] Golder Associates Ltd. 2012. *Foundation Investigation and Design Report, Swamp Crossings and High Fill Areas – Contract 2, Highway 69 Four Laning from 1.7 km North of Highway 529 Northerly to 3.9 km North of Highway 522, Ministry of Transportation, Ontario, G.W.P. 5404 05 00; W.P. 5404 05 01. Geocres No. 41H-115.*

The boreholes, probeholes and DCPTs at the locations of the foundation elements were typically advanced to casing and/or split-spoon sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring in selected boreholes. The boreholes at the nort-east corner of the north abutment and at the north approach embankment associated with the two-span bridge option were located on bedrock outcrops and refusal condition was confirmed by hand excavation and exposure of bedrock. The boreholes, probeholes and DCPTs were advanced to depths of up to about 53.1 m below existing ground surface, including coring of bedrock. The bedrock was cored for lengths between about 1.6 m and 3.7 m in Boreholes B202-03 to B202-05, B202-07 to B202-09 and B202-12. Photographs of the recovered rock core samples are provided in Appendix B.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. Within the limits of the centre pier and the north abutment (associated with the two-span bridge option), a piezometer was installed in each of Boreholes B202-03 and B202-08 and in a pre-augered hole located near the proposed south abutment (designated as Borehole SP1) to monitor the ground water levels at these locations. The piezometers consist of 35 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the boreholes. The boreholes and annulus surrounding the piezometer pipe above the screen sand pack were backfilled to the surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. All boreholes in which standpipe piezometers were not installed were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903, Wells (as amended). The piezometer installed in Borehole SP1 was decommissioned once a final water level reading was taken ten (10) days after installation.

The field work was observed by members of our engineering and technical 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 and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. 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. A consolidation (oedometer) test was also carried out on a sample of the cohesive deposit. Strength testing, such as uniaxial (unconfined) compression and point load index, was carried out on selected specimens of the rock core. The results of the laboratory testing are included in Appendix B.

Classification of the rock mass quality of the bedrock with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)[2]. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2) and the strength classification of the intact rock mass based on field identification (i.e. strong to extremely strong – R4 to R6) are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM[3]) standard classification system.

The perimeter limits of each foundation unit were located in the field by Callon Dietz prior to drilling. The as-drilled borehole, probehole and DCPT locations and ground surface elevations were surveyed by a member of our technical staff, referenced to the survey stakes put down by Callon Dietz. The locations given in the

[2]Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

[3] International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

Record of Borehole/Drillhole sheets, Record of Probehole sheets and Record of DCPT sheets and shown on Drawings 2 and 3 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole, probehole and DCPT locations and ground surface elevations are summarized below.

Borehole / Probehole / DCPT No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole / Probehole / DCPT Depth (m)
	Northing	Easting		
B202-01	5074802.7	225185.9	181.1	16.6
B202-02	5074821.3	225178.6	181.0	53.1
B202-03	5074861.3	225162.8	178.8	27.3
B202-04	5074872.5	225158.4	179.4	13.0
B202-05	5074886.4	225152.9	181.3	6.2
B202-06	5074898.6	225140.9	183.9	0.9
B202-07	5074902.4	225139.5	184.3	4.2
B202-08	5074901.3	225146.9	184.2	6.6
B202-09	5074900.3	225154.9	186.4	3.7
B202-10[1]	5074904.1	225153.3	187.1	0.1
B202-11[1]	5074919.8	225139.4	187.3	0.1
B202-12	5074873.6	225151.0	179.5	7.5
B202-13	5074871.4	225166.4	179.4	15.3
B202-14	5074860.2	225170.8	179.0	28.1
B202-15	5074862.4	225155.3	178.7	23.1
S204-18	5074795.1	225189.0	181.1	42.8
SP1	5074819.8	225159.0	181.1	6.1
B202-P01	5074858.6	225156.8	178.9	25.6
B202-P02	5074864.1	225169.3	179.1	25.7
B202-DC01	5074869.7	225152.4	179.0	13.4
B202-DC02	5074875.3	225164.9	180.2	12.8

Note: 1. B202-10 and B202-11 refers to a shovel excavation carried out at the north-east corner of the north abutment (two-span option) and at the north embankment approach, respectively, to expose the bedrock surface.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in The Physiography of Southern Ontario[4], this section of the new Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

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

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of shallow deposits of sand, silt and clay underlain by metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils, underlain by soft/loose native soils, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of crystalline gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4[5]. Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation (including excavations carried out by a hand shovel), together with the results of the laboratory tests carried out on selected soil and bedrock core samples, are presented on the attached Record of Borehole and Drillhole sheets and the laboratory test figures provided in Appendix A and Appendix B, respectively. The results of the in situ field tests (i.e. SPT 'N'-values and undrained shear strengths from the field vanes) as presented on the Record of Borehole sheets and in Section 4.0 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs and in situ testing. The stratigraphic boundaries are shown on Borehole SP1, augered for a piezometer installation, are interpreted based on cuttings and auger samples and are approximate only. 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 thickness of the overburden/depth to refusal as inferred from the resistance to auger, casing and DCPT advancement are shown on Record of Probehole sheets and Record of Penetration Test sheets in Appendix A. It should be noted that the interpreted stratigraphy shown on Drawings 2 and 3 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the south approach and south abutment (to the south of Still River) consist of a surficial layer of topsoil, underlain by alternating deposits of cohesive and non-cohesive soils, underlain by inferred cobbles and boulders. Bedrock was not encountered within the maximum depth of investigation (53.1 m). In the areas of the centre pier, north abutment and north approach (to the north of Still River) the subsurface conditions consist of bedrock outcrops and surficial layers of topsoil underlain by deposits of sand to silt and clay, underlain by bedrock at relatively shallow depth. The overburden thickness is variable across the proposed bridge structure, ranging from no cover at the north approach embankment (i.e. bedrock outcrops exposed at ground surface) to 53.1 m or greater at the south abutment.

A detailed description of the subsurface conditions encountered in the boreholes at the abutments, centre pier and approach embankments is provided in the following sections.

[5] Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.

4.3 South Abutment and Approach Embankment

One (1) borehole (Borehole B202-02) was advanced at the location of the proposed south abutment and one (1) borehole (Boreholes B202 01) was advanced on the alignment centreline of the proposed south approach embankment. In addition, one (1) borehole (Borehole S20418) advanced within Swamp 204, adjacent to the proposed south approach embankment, as part of the field investigation for the Contract 2 swamp crossings and high fill areas has been utilized to describe the subsurface conditions in this area.

In general, the subsurface conditions consist of topsoil underlain by alternating deposits of cohesive and non-cohesive soils with pockets and interlayers at varying depths. The alternating deposits are generally comprised of clayey silt to silty clay, sand to silt, silty clay to clay, silt to silty sand, silty clay to clay, and silt to sand, underlain by inferred cobbles and boulders.

4.3.1 Topsoil

An approximately 0.3 m and 0.2 m thick layer of topsoil was encountered at the ground surface in Boreholes B202-01/S204-18 and B202-02, respectively.

A natural water content measured on one (1) sample of the topsoil is about 24 per cent.

4.3.2 Sandy Silt

A deposit of brownish grey sandy silt, trace clay was encountered underlying the topsoil in Borehole B202-02. The top of this deposit is at about Elevation 180.8 m and the thickness of the layer is about 0.5 m.

The SPT ‘N’-value measured within the sandy silt deposit is 5 blows per 0.3 m of penetration, indicating a loose relative density.

The natural water content measured on a sample of this deposit is about 20 per cent.

4.3.3 Clayey Silt to Silty Clay (Near Surface)

A deposit of brownish grey to brown to grey clayey silt to silty clay, trace to some sand was encountered underlying the topsoil or near surface sandy silt in all boreholes. Sand lenses were encountered within the clayey silt in Borehole B202-02 and rootlets and silty sand layers were encountered in Borehole S204-18. The top of this deposit ranges from about Elevation 180.8 m to 180.3 m and the thickness of the cohesive deposit varies between about 1.7 m and 1.8 m.

The SPT ‘N’-values measured within the clayey silt to silty clay deposit range from 2 blows to 6 blows per 0.3 m of penetration, suggesting a soft to firm consistency. It should be noted that in situ field vanes carried within the near surface cohesive deposit in Swamp 204, adjacent to the south abutment and south approach embankment, measured undrained shear strengths as low as about 25 kPa.

The natural water content measured on three (3) samples of the silty clay portion of the cohesive deposit are about 19 per cent and 39 per cent.

A grain size distribution of one (1) sample of the silty clay portion of this cohesive deposit is shown on Figure B1 in Appendix B.

An Atterberg limits test was carried out on one (1) specimen of the cohesive deposit and indicates a liquid limit of about 37 per cent, a plastic limit of about 18 per cent, and a corresponding plasticity index of about 19 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure B2 in Appendix B and indicate the material to be a silty clay of intermediate plasticity.

4.3.4 Sand to Silt (Upper)

A deposit of non-cohesive soil comprised of brown to grey sand, silty sand, and silt, trace to some clay, interlayered in places, was encountered underlying the clayey silt to silty clay deposit in all boreholes. The top of this deposit ranges from about Elevation 179.0 m to 178.6 m and the thickness of the deposit varies between about 5.8 m and 7.6 m.

The SPT 'N'-values measured within this deposit range from 4 blows to 17 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on seven (7) samples of this deposit range from about 22 per cent to 29 per cent, while he natural water content measured on two (2) samples of the upper portion of the sand and silty sand deposit is 8 per cent and 11 per cent.

The grain size distributions of four (4) samples of the sand and the silt portions of this deposit are shown on Figure B3 in Appendix B. An Atterberg limits test on one (1) sample of the silt deposit indicates this material to be non-plastic.

4.3.5 Silty Clay to Clay (Upper)

A deposit of brown to grey silty clay to clay, containing sand lenses in the upper portion of the silty clay in Borehole B202-02, was encountered underlying the upper deposit of sand to silt in all boreholes. The top of the silty clay to clay deposit ranges from about Elevation 172.8 m to 171.4 m and the thickness of the deposit varies between about 7.9 m and 11.6 m. Borehole B202-01 was terminated within this deposit. In Borehole B202-02 a silt interlayer (or pocket) was encountered within the clayey silt to clay deposit, as discussed in Section 4.3.6.

The SPT 'N'-values recorded within the silty clay to clay deposit range from 0 blows (weight of hammer) to 3 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 39 kPa to 76 kPa with an average of about 55 kPa and the sensitivity is calculated to range from about 3 to 4. The field vane tests results indicate that the upper silty clay to clay deposit has a firm to stiff consistency.

The natural water content measured on eight (8) specimens of this deposit ranges from about 40 per cent to 74 per cent, but are generally greater than 50 per cent.

The grain size distributions of four (4) samples of the silty clay to clay deposit are shown on Figure B4 in Appendix B.

Atterberg limits tests were carried out on four (4) specimens of the silty clay to clay deposit and indicate liquid limits between about 44 per cent and 64 per cent, plastic limits between about 17 per cent and 21 per cent and

corresponding plasticity indices between about 27 per cent and 45 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B5 in Appendix B and indicate the material to be silty clay of intermediate plasticity to clay of high plasticity.

A laboratory consolidation test was carried out on one (1) specimen of the silty clay deposit obtained from a Shelby tube sample in Borehole B202-01. A preconsolidation stress of about 155 kPa was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of about 16.6 kN/m^3 and a specific gravity of about 2.77 were measured on the consolidation test specimen. Details of the test results are shown on Figure B6 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm^2/s)
Borehole B202-01 Sample 12	13.9 m / 167.2 m	135	155	20	1.1	0.91	0.10	1.54	1.81 x 10^{-3}

Note: * For stress range of between effective overburden stress and final stress due to 7.5 m high approach embankment, that is 135 kPa ≤ σ_v' ≤ 275 kPa

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
σ_p' is the preconsolidation stress in kPa
σ_v' is the vertical effective stress in kPa
OCR is overconsolidation ratio
e_o is initial void ratio
C_c is the compression index
C_r is the recompression index
c_v is the coefficient of consolidation in cm^2/s

4.3.6 Silt Interlayer

An approximately 2.7 m thick interlayer of grey silt, trace to some sand, trace to some clay and containing an approximately 0.6 m thick pocket of brownish grey silty clay was encountered within the upper silty clay to clay deposit in Borehole B202-02 at about Elevation 170.9 m.

Two (2) SPT 'N'-values measured within the silt interlayer and silty clay pocket are 14 blows and 3 blows per 0.3 m of penetration, respectively, indicating a very loose and compact relative density in the silt and suggesting a soft consistency in the silty clay, respectively.

The natural water content measured on two (2) specimens of the silt interlayer is about 26 per cent and 27 per cent.

A grain size distribution of one (1) sample of this interlayer is shown on Figure B7 in Appendix B.

4.3.7 Silt to Silty Sand Interlayer

A non-cohesive interlayer comprised of grey silt, trace to some sand, trace clay to silty sand was encountered underlying the upper silty clay to clay deposit in Boreholes B202-02 and S204-18. The top of this interlayer is at about Elevation 161.2 m and 161.3 m and the thickness of the interlayer is about 5.8 m and 3.1 m in the respective boreholes.

The SPT 'N'-values measured within the silt portion of the non-cohesive interlayer are 7 blows and 9 blows per 0.3 m of penetration, indicating a loose relative density. One (1) SPT 'N'-value measured within the silty sand portion of the non-cohesive interlayer is 45 blows per 0.3 m of penetration, indicating a dense relative density.

The natural water content measured on two (2) samples of this silt to silty sand interlayer is 20 per cent and 24 per cent.

A grain size distribution of one (1) sample of the silt portion of this non-cohesive interlayer is shown on Figure B7 in Appendix B.

4.3.8 Silty Clay to Clay (Lower)

A deposit of grey silty clay to clay was encountered underlying the silt to silty sand interlayer in Boreholes B202-02 and S204-18. Silt interlayers were encountered within this deposit in Borehole S204-18 below a depth of 36.1 m. The top of the silty clay to clay deposit is at about Elevation 155.4 m and 158.2 m and the thickness of this deposit is about 16.9 m and 15.0 m in the respective boreholes.

The SPT 'N'-values recorded within the silty clay to clay deposit generally range from 5 blows to 12 blows per 0.3 m of penetration. One (1) SPT 'N'-value measured within the bottom portion of the clay deposit in Borehole B202-02 is 26 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 71 kPa to greater than 120 kPa and the sensitivity is calculated to range from about 1 to 4. The field vane tests results indicate that the lower silty clay to clay deposit has a stiff to very stiff consistency.

The natural water content measured on four (4) specimens of this deposit ranges from about 31 per cent to 46 per cent.

The grain size distributions of two (2) samples of the silty clay to clay deposit are shown on Figure B8 in Appendix B

Atterberg limits tests were carried out on two (2) specimens of the silty clay to clay deposit and indicate liquid limits of about 35 per cent and 56 per cent, plastic limits of about 14 per cent and 21 per cent and corresponding plasticity indices of about 21 per cent and 35 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B9 in Appendix B and indicate the material to be silty clay of intermediate plasticity to clay of high plasticity.

4.3.9 Silt to Sand (Lower)

Underlying the lower deposit of silty clay to clay, an interlayered non-cohesive deposit comprised of sand to silty sand to sand and silt to silt was encountered in Boreholes B202-02 and S204-18. The top of the silt to sand deposit is at about Elevation 138.5 m and 143.2 m and the deposit was penetrated for about 6.3 m and 4.9 m in the respective boreholes. Borehole S204-18 was terminated within the sand silt portion of this deposit, while Borehole B202-02 was extended deeper by driving a DCPT to refusal at a depth of about 53.1 m below ground surface (Elevation 127.9 m).

The SPT 'N'-values recorded within this interlayered deposit range from 12 blows to 52 blows per 0.3 m of penetration, generally indicating a compact to very dense relative density.

The natural water content measured on four (4) samples of this deposit range from about 19 per cent to 25 per cent.

A grain size distribution of one (1) sample from the sand and silt portion of this deposit is shown on Figure B10 in Appendix B.

4.3.10 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. Artesian conditions were encountered in Borehole B202-02 during drilling at a depth of 45.1 m below the ground surface (Elevation 135.9 m) and the groundwater level recorded in the casing on February 16, 2011 was at about Elevation 182 m, measured at 1 m above ground surface. In Boreholes B202-01 and S204-18, the water level observed upon completion of drilling was at about Elevation 177.3 m (measured at a depth of about 3.8 m below ground surface) and 177.4 m (measured at a depth of about 3.7 m below ground surface), respectively.

A standpipe piezometer was installed in Borehole SP1 located on the centreline and to the west of the south abutment to permit monitoring of the groundwater level in this area. The details of the piezometer installations are shown on the Record of Borehole sheets in Appendix A. The groundwater level measured in the piezometer installation is summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
South Abutment	SP1	181.1	177.1 177.1	February 17, 2011 February 27, 2011

It should be noted that groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.4 Centre Pier (Two-Span Option)

A total of three (3) boreholes (Boreholes B202-03, B202-14 and B202-15) and two (2) probeholes (B202-P01 and B202-P02) were advanced at the location of the proposed centre pier. In general, the subsurface conditions consist of topsoil underlain by a deposit of silty sand to silt, underlain by a deposit of clayey silt to clay and bedrock.

4.4.1 Topsoil

An approximately 0.2 m thick layer of topsoil was encountered at the ground surface at all borehole locations. The surface of the topsoil ranges from about Elevation 179 m to 178.7 m.

4.4.2 Sand to Silt

A brown to grey non-cohesive deposit varying in composition from sand trace to some silt, to silty sand, to sand and silt trace clay, to silt some clay was encountered below the topsoil in all the boreholes. In general, the upper

portion of the deposit contains rootlets and organics and clay lenses in places. The top of the silty sand to silt deposit ranges from about Elevation 178.8 m to 178.5 m and the thickness of this deposit varies between about 5.0 m and 7.9 m.

The SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 6 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on twelve (12) samples of this deposit ranges from about 23 per cent to 35 per cent.

The grain size distributions of four (4) samples of the sand and silt to silt portion of this deposit are shown on Figure B11 in Appendix B.

An Atterberg limits test was carried out on one (1) sample of the silt portion of this deposit and measured a liquid limit of about 21 per cent, a plastic limit of about 18 per cent and a corresponding plasticity index of about 3 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B12 in Appendix B and indicates that the material is classified as silt of slight plasticity.

4.4.3 Clayey Silt and Clay

A deposit of grey clay was encountered underlying the sand to silt deposit at all borehole locations. In Borehole B202-03 the upper 1.5 m portion of the deposit is described as a clayey silt and in Boreholes B202-14 and B202-15 the deposit contains silt interlayers. The top of the clayey silt to clay deposit ranges from about Elevation 173.5 m to 170.9 m and the thickness of the deposit ranges from about 17.2 m to 20.0 m. The bottom of the deposit was defined by refusal to further split-spoon advancement and bedrock coring in Borehole S202-03. Borehole B202-15 was extended deeper by driving a dynamic cone to refusal at a depth of about 23.1 m below ground surface (Elevation 155.6 m), while Borehole B202-14 was extended deeper by first driving a dynamic cone to a depth of about 27.4 m below the ground surface (Elevation 151.6 m) and then advancing a tricone to refusal at a depth of 28.1 m below the ground surface (Elevation 150.9 m).

SPT 'N'-values measured within the clay deposit range from 1 blow to 3 blows per 0.3 m of penetration. In situ field vane tests carried out within the deposit measured undrained shear strengths typically ranging from about 38 kPa to 55 kPa, with one (1) undrained shear strength which is greater than 96 kPa. The sensitivity is calculated to be about 3 and 4. The field vane tests results indicate that the clay deposit generally has a firm to stiff consistency.

The natural water content measured on five (5) samples of this deposit ranges from about 36 per cent to 76 per cent, with the lower water content value being measured in the clayey silt portion of the deposit.

The grain size distributions of four (4) samples of this deposit are shown on Figure B13 in Appendix B.

Atterberg limits tests carried out on five (5) specimens of this deposit indicate a liquid limit of about 28 per cent and a plastic limit of about 18 per cent and a corresponding plasticity index of about 10 per cent for the clayey silt portion of the deposit; and liquid limits between about 51 per cent and 77 per cent, plastic limits between about 18 per cent and 24 per cent and plasticity indices between about 31 per cent and 53 per cent for the main clay deposit The results of the Atterberg limits tests are shown on the plasticity chart on Figure B14 in Appendix B and indicate the material to be clayey silt of low plasticity to clay of high plasticity.

4.4.4 Bedrock / Refusal

Bedrock was encountered below the clay deposit and core samples were recovered in Borehole B202-03. The bedrock surface was inferred from refusal to casing advancement in Probeholes B202-P01 and B202-P02, refusal to tricone advancement in Borehole B202-14, and refusal to dynamic cone penetration in Borehole B202-15. These refusal depths, while they do not confirm bedrock elevations, may be inferred to indicate potential proximity to the bedrock interface. The depth to bedrock below ground surface and corresponding bedrock surface elevation (inferred or actual) is summarized below.

Foundation Element	Borehole No. / Probehole No.	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
Centre Pier	B202-03	24.1	154.7	Bedrock Cored
	B202-14	28.1	150.9	Tricone Refusal
	B202-15	23.1	155.6	DCPT Refusal
	B202-P01	25.6	153.3	Casing Refusal
	B202-P02	25.7	153.4	Casing Refusal

In general, the bedrock surface slopes downwards to the south-east towards the river across the proposed centre pier footprint (up to approximately 3.3H:1V slope or a dip of approximately 17° from the horizontal). Across the proposed centre pier, the bedrock drops in elevation by as much as about 2.5 m over a distance of about 4 m (from northeast corner to southeast corner), which is equal to a slope of about 1.6H:1V or a dip of approximately 32° from the horizontal).

Based on the review of the cored bedrock samples, the bedrock consists of granite gneiss. The bedrock samples are described as fresh, foliated, medium crystalline, slightly porous, strong, pink, grey and black, as presented on the Record of Drillhole sheets in Appendix A. A photograph of the recovered samples is shown on Figure B15 in Appendix B. The degree of weathering of the bedrock samples (i.e. fresh – W1) and the strength classification of the rock mass based on field identification is medium strong to strong (i.e. R2 to R4) are described in accordance with the International Society for Rock Mechanics (ISRM) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples is between 48 per cent and 84 per cent, indicating a rock mass of poor to good quality. The RQD measured on one core sample (only 0.31 m in length) is 48 per cent, indicating a rock mass of poor quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of all samples recovered is 100 per cent and between 75 per cent and 90 per cent, respectively.

Point load tests were carried out on selected samples of the rock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. An axial test carried out on one (1) core sample of the granite gneiss bedrock measured an Is_{50} value of about 1.7 MPa and the diametral test carried out on one (1) core sample of the granite gneiss bedrock measured an Is_{50} value of 2.7 MPa.

One (1) Unconfined Compression (UC) test (ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) was carried out on a selected core sample of granite gneiss bedrock obtained from Borehole B202-03 and measured a compressive strength of about 69 MPa, as summarized in Table B2-1 and detailed in Table B2-2 in Appendix B.

Also presented in Table B1 are the estimated Uniaxial Compressive Strength (UCS) values for each sample tested for point load strength based on a relationship between Is_{50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731 (Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification) which varies depending on the size of the core sample and the strength of the rock. For this site, the UCS values are based on an estimated average correlation factor (K) of 19.

Based on the laboratory UC test and the point load test results, in accordance with Table 3.5 in CFEM (2006) the granite gneiss bedrock is classified as medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa).

4.4.5 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. Water levels observed in Boreholes B202-14 and B202-15 and Probehole B202-P01 upon completion of drilling range from about Elevation 178.1 m to 177.8 m, measured between about 0.8 m and 1.1 m below ground surface. Artesian conditions were observed in Probehole B202-P02 during drilling and the groundwater level recorded in the casing on March 31, 2011 was at about Elevation 181.4 m, measured at 2.3 m above ground surface.

A standpipe piezometer was installed in Borehole B202-03 to permit monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the Record of Borehole sheet in Appendix A. The groundwater level measured in the piezometer installation is summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
Centre Pier	B202-03	178.8	178.6	March 26, 2011

It should be noted that groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.5 North Abutment and Approach Embankment (One-Span Bridge)

A total of three (3) boreholes (Boreholes B202-04, B202-12 and B202-13) and two (2) Dynamic Cone Penetration Tests (DCPTs B202-DC01 and B202-DC02) were advanced at the location of the proposed north abutment and one (1) borehole (Borehole B202-05) was advanced on the alignment centerline at the north approach embankment. In general, the subsurface conditions encountered at the north abutment consist of topsoil underlain by a deposit of sand to silt and a deposit of clayey silt to clay which in turn is underlain by bedrock. The subsurface conditions encountered at the north embankment approach are comprised of a deposit of clayey silt to clay with a sandy silt interlayer underlain by bedrock

4.5.1 Topsoil

A 0.2 m to 0.3 m thick layer of topsoil was encountered at the ground surface at all borehole locations.

4.5.2 Sand to Silt

A non-cohesive deposit comprised of brown to grey sand trace gravel to silty sand trace to some clay to sandy silt to silt trace to some clay was encountered below the topsoil in Boreholes B202-04, B202-12 and B202-13. The upper portion of the silty sand to sandy silt deposit in Boreholes B202-12 and B202-13 contains rootlets and organics. The silt portion of the non-cohesive deposit encountered in Boreholes B202-04 and B202-13 contains silty clay lenses. The top of this deposit is at about Elevation 179.2 m and the thickness of this deposit ranges between about 2.3 m and 5 m.

The SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 8 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on nine (9) samples of this deposit ranges from about 20 per cent to 34 per cent.

The grain size distributions of four (4) samples of the silty sand to silt portion of this deposit are shown on Figure B20 in Appendix B.

An Atterberg limits test carried out on a sample of the silt portion of the deposit indicates a liquid limit of about 20 per cent, a plastic limit of about 18 per cent and a plasticity index of 2 per cent, The results of the Atterberg limits test is shown on the plasticity chart on Figure B21 in Appendix B and indicates that the material is classified as silt of slight plasticity.

4.5.3 Clayey Silt to Clay

A deposit of cohesive soil comprised of brown to grey clayey silt with sand, silty clay trace sand and clay was encountered underlying the sand to silt deposit or topsoil at all borehole locations. In Boreholes B202-05 the cohesive deposit contains an approximately 0.7 m thick sandy silt interlayer, as discussed in Section 4.5.4. The top of the cohesive deposit ranges from about Elevation 181.1 m to 174.2 m and the thickness of the cohesive deposit ranges from about 3.3 m to 10.1 m. Borehole B202-13 was extended deeper by driving a dynamic cone to refusal at a depth of about 15.3 m below ground surface (Elevation 164.1 m).

The SPT 'N'-values recorded within the clayey silt to clay deposit generally range from 0 blows (weight of hammer) to 8 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 24 kPa to 62 kPa and sensitivity is calculated to range from about 3 to 5. The field vane tests results indicate that the clayey silt to clay deposit has a soft to stiff consistency.

The natural water content measured on seven (7) samples of this deposit ranges from about 37 per cent to 74 per cent, but is generally greater than 50 per cent.

The grain size distributions of three (3) samples of the silty clay to clay portion of this deposit are shown on Figure B22 in Appendix B.

Atterberg limits tests were carried out on four (4) specimens of the clayey silt to clay portion of this deposit and indicate liquid limits ranging from about 32 per cent to 63 per cent, plastic limits ranging from about 16 per cent to 21 per cent and plasticity indices ranging from about 16 per cent to 45 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B23 in Appendix B and indicate the material to be clayey silt of low plasticity to clay of high plasticity.

A laboratory consolidation test was carried out on one (1) specimen of the clay deposit obtained from a Shelby tube sample in Borehole B202-04. A preconsolidation stress of about 155 kPa was estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. A bulk unit weight of about 16.5 kN/m^3 and a specific gravity of about 2.77 were measured on the consolidation test specimen. Details of the test results are shown on Figure B24 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm^2/s)
Borehole B202-04 Sample 9	7.5 m / 171.9 m	75	155	80	2.1	0.95	0.11	1.56	1.97 x 10^{-3}

Note: * For stress range of between effective overburden stress and final stress due to 9.5 m high approach embankment, that is 75 kPa ≤ σ_v' ≤ 255 kPa

where:
- σ_{vo}' is the in situ vertical effective overburden stress in kPa
- σ_p' is the preconsolidation stress in kPa
- σ_v' is the vertical effective stress in kPa
- OCR is overconsolidation ratio
- e_o is initial void ratio
- C_c is the compression index
- C_r is the recompression index
- c_v is the coefficient of consolidation in cm^2/s

4.5.4 Sandy Silt Interlayer

An approximately 0.7 m thick interlayer of grey sandy silt was encountered within the clayey silt to silty clay deposit in Borehole B202-05 at about Elevation 179.9 m.

One (1) SPT 'N'-value measured within the sandy silt interlayer is 28 blows per 0.3 m of penetration, indicating a compact relative density.

4.5.5 Bedrock / Refusal

Bedrock was encountered below the clayey silt to clay deposit and core samples were recovered in Boreholes B202-04, B202-05 and B202-12. The bedrock surface was inferred from refusal to dynamic cone penetration in Borehole B202-13 and in DCPTs B202-DC01 and B202-DC02. These refusal depths, while they do not confirm bedrock elevations, may be inferred to indicate potential proximity to the bedrock interface. The depth to bedrock below ground surface and corresponding bedrock surface elevation (inferred or actual) is summarized below.

Foundation Element / Approach Embankment	Borehole No. / DCPT No.	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
North Abutment (One-Span Bridge)	B202-04	9.8	169.6	Bedrock Cored
	B202-12	5.9	173.6	Bedrock Cored
	B202-13	15.3	164.1	DCPT Refusal
	B202-DC01	13.4	165.6	DCPT Refusal
	B202-DC02	12.8	167.4	DCPT Refusal
North Approach Embankment	B202-05	4.6	176.7	Bedrock Cored

In general, the bedrock surface slopes down to the south-east towards the river from the borehole advanced at the centreline of the north approach embankment and across the proposed north abutment footprint. Across the proposed one-span north abutment, the bedrock drops in elevation by as much as about 8 m over a distance of about 4 m (from northwest corner to southwest corner), which is equal to a slope of about 0.5H:1V or a dip of approximately 63° from the horizontal).

Based on the review of the bedrock core samples, the bedrock consists of granite gneiss. The bedrock samples are described as fresh, foliated, medium crystalline, slightly porous, strong, pink, grey and black, as presented in the Record of Drillhole sheets in Appendix A. Photographs of the recovered samples are shown on Figures B25 to B27. The degree of weathering of the bedrock samples is fresh (i.e. W1) and the strength classification of the rock mass based on field identification is strong (i.e. R4).

The Rock Quality Designation (RQD) measured on the core samples ranges from 85 per cent to 100 per cent, indicating a rock mass of good to excellent quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are 100 per cent and between 63 per cent and 100 per cent, respectively.

Point load tests were carried out on selected samples of the rock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial test carried out on two (2) core samples of the granite gneiss bedrock measured Is_{50} values of about 5.2 MPa and 10.7 MPa and the diametral test carried out on two (2) core samples of the granite gneiss bedrock measured Is_{50} value of about 9.3 MPa and 10.6 MPa.

One (1) Unconfined Compression (UC) test (ASTM D7012-10 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) was carried out on a selected core sample of granite gneiss bedrock obtained in Borehole B202-04 and measured a compressive strength of about 193 MPa, as summarized in Table B2-1 and detailed in Table B2-4 in Appendix B.

Also presented in Table B1 are the estimated Uniaxial Compressive Strength (UCS) values for each sample tested for point load strength based on a relationship between Is_{50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731-08 – Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification, which varies depending on the size of the core sample and the strength of the rock. For this site, the UCS values are based on an estimated average correlation factor (K) of 19.

Based on the laboratory UC test and the point load test results, in accordance with Table 3.5 in *CFEM* (2006), the granite gneiss bedrock is classified as strong (R4, 50 MPa < UCS < 100 MPa) to very strong (R5, 100 MPa < UCS < 250 MPa).

4.5.6 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. The water level observed in the boreholes upon completion of drilling ranges between about Elevation 179.5 m and 178.0 m, measured between about 1.3 m and 1.8 m below ground surface.

It should be noted that groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.6 North Abutment and Approach Embankment (Two-Span Bridge)

A total of four (4) boreholes (Boreholes B202-06 to B202-09) and one hand shovel excavation (B202-10) were advanced at the location of the proposed north abutment and one (1) hand shovel excavation (B202-11) was advanced on the alignment centerline of the north approach embankment. In general, the subsurface conditions consist of peat/topsoil and/or cobbles and boulders over bedrock.

4.6.1 Peat / Topsoil

An approximately 0.2 to 0.6 m thick layer of black amorphous peat was encountered at the ground surface in Boreholes B202-06 to B202-09.

Two (2) SPT 'N'-values measured within the peat are 10 blows and 39 blows per 0.3 m of penetration, suggesting a stiff and hard consistency, respectively. It should be noted that the high 'N'-value (39 blows) can be attributed to increased resistance during split-spoon advacment into frozen ground.

The natural water content measured on two (2) specimens of the peat are about 520 per cent and 890 per cent, while the natural content measured on one (1) specimen of the hard consistency peat is about 33 per cent.

A layer of topsoil, about 0.1 m thick, was encountered at the ground surface in the hand shovel excavations, Boreholes B202-10 and B202-11.

4.6.2 Cobbles and Boulders

A deposit of cobbles and boulders was encountered below the peat in Boreholes B202-07 and B202-08, interlayered with seams of clayey silt, sand and gravel in Borehole B202-08. The top of the deposit is at Elevation 183.7 m and 183.9 m and the thicknesses of the deposit is about 0.5 m and 2.6 m in the respective boreholes. Photographs of the recovered core of the cobbles and boulders layer are presented on Figures B17 and B18 in Appendix B.

4.6.3 Sand to Gravel

A deposit of brown gravelly sand was encountered below the topsoil in Borehole B202-06 and interlayers of brown clayey silt, brown sand and grey gravel were encountered within the deposit of cobbles and boulders in Borehole B202-08. The top of the gravelly sand deposit is at about Elevation 183.7 m and the thickness of the deposit is about 0.7 m. Borehole B202-06 was terminated within this deposit. The top of the clayey silt and sand and gravel interlayers is at about Elevation 183.3 m and the thickness of the interlayers is about 0.1 m.

One (1) SPT 'N'-value measured within the gravelly sand is 10 blows per 0.3 m of penetration, indicating a compact relative density. SPT 'N'-values measured within the sand and gravel interlayers are 100 blows per 0.08 m and 100 blows per 0.1 m, respectively, as a result of driving the split-spoon into the cobbles and boulders.

The natural water content measured on one (1) sample of gravelly sand is about 13 per cent.

A grain size distribution of one (1) sample of the gravelly sand is shown on Figure B16 in Appendix B.

4.6.4 Bedrock / Refusal

Bedrock was encountered in Borehole B202-07 to B202-09 below the peat/topsoil and underlying the cobbles and boulders deposit; and core samples were recovered. The bedrock surface was inferred from split-spoon refusal in Borehole B202-06, and exposed by shovel (hand) excavation to confirm refusal at the bottom of the topsoil layer in Boreholes B202-10 and B202-11. The depth to bedrock below ground surface and corresponding bedrock surface elevation (inferred or actual) is summarized below.

Foundation Element / Approach Embankment	Borehole No.	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
North Abutment (Two-Span Bridge)	B202-06	0.9	183.0	Spoon Refusal
	B202-07	1.1	183.2	Bedrock Cored
	B202-08	2.9	181.3	Bedrock Cored
	B202-09	0.2	186.2	Bedrock Cored
	B202-10[1]	0.1	187.0	Shovel Refusal
North Approach Embankment	B202-11[1]	0.1	187.2	Shovel Refusal

Note: 1. Boreholes B202-10 and B202-11 refer to a shovel excavation carried out at the north-east corner of the north abutment (two-span bridge) and at the north approach embankment, respectively, to expose the bedrock surface.

In general, the bedrock surface in the area of the north abutment footprint and north approach embankment slopes down to the south-west towards the river, but locally within the abutment footprint the bedrock is at a lower elevation and forms a trough in the centre of the abutment footprint varying by about 5.7 m (approximately 1.4. Therefore, near the proposed north abutment and its approach embankment, the bedrock elevation varies by about 5.9 m over a distance of about 20 m (approximately 3.4H:1V slope or a dip of approximately 16º from the horizontal).

Based on the review of the cored bedrock samples, the bedrock consists of gneiss to granite gneiss with occasional zones of schist. In general the gneiss to granite gneiss bedrock samples are described as predominantly fresh (a slightly weathered zone was encountered in Borehole B202-07 from the bedrock surface to a depth of 3.3 m), generally foliated, medium to coarsely crystalline, slightly porous, strong, pink, grey and black and containing a mafic dyke between a depth of 5.86 m and 5.94 m in Borehole B202-08, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the recovered bedrock core samples are shown on Figures B17 to B19 in Appendix B. Occasional zones of schist were encountered in Borehole B202-09 at depths of 0.2 m and 1.3 m, corresponding to Elevation 186.2 m and 185.1 m, respectively. The schist bedrock samples are generally described as fresh (a highly weathered zone was encountered from a depth of 1.3 m to 1.4 m and contained rootlets), coarsely crystalline, slightly porous, strong, brown and black. The degree of

weathering of the bedrock samples is slightly weathered to fresh (i.e. W2 to W1) and the strength classification of the rock mass based on field identification strongto extremely strong (i.e. R4 to R6).

The Rock Quality Designation (RQD) measured on the core samples generally ranges between 62 per cent and 100 per cent, indicating a rock mass of fair to excellent quality. However, the RQD measured on a core sample recovered betwen a depth of about 2.9 m and 3.6 m from Borehole B202-08 was 0 per cent, indicating a rock mass of very poor quality. The Total Core Recovery (TCR) of samples recovered is typically between 94 per cent and 100 per cent. Solid Core Recovery (SCR) of samples recovered varies between 25 per cent and 100 per cent.

Point load tests were carried out on selected samples of the rock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table B1 in Appendix B. The axial tests carried out on two (2) core samples of the granite gneiss bedrock measured Is_{50} values of about 5.3 MPa and 8.3 MPa and the diametral tests carried out on three (3) core samples of the gneiss to granite gneiss bedrock measured Is_{50} values ranging from about 8.1 MPa to 14.1 MPa. An axial test carried out on one (1) core sample of the schist bedrock measured an Is_{50} value of 1.4 MPa.

One (1) Unconfined Compression (UC) test (ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens) was carried out on a selected core sample of granite gneiss bedrock obtained in the area of the proposed north abutment and measured a compressive strength of about 175 MPa, as summarized in Table B2-1 and detailed in Table B2-4 in Appendix B.

Also presented in Table B1 are the estimated Uniaxial Compressive Strength (UCS) values for each sample tested for point load strength based on a relationship between Is_{50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731 (Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification) which varies depending on the size of the core sample and the strength of the rock. For this site, the UCS values are based on an estimated average correlation factor (K) of 19.

Based on the laboratory UC test and the point load test results, in accordance with Table 3.5 in CFEM (2006) the gneiss to granite gneiss bedrock is generally classified as very strong (R5, 100 MPa < UCS < 250 MPa) to extremely strong (R6, UCS > 250 MPa), and the schist bedrock (based on one (1) point load test) is classified as medium strong (R3, 25 MPa < UCS < 50 MPa).

4.6.5 Groundwater Conditions

In general, the overburden samples taken in the boreholes were moist to wet. Borehole B202-06 was dry upon completion of drilling and the water level observed in Boreholes B202-07 and B202-09 upon completion of drilling was at Elevation 183.9 m to 184.6 m, measured at 0.4 m and 1.8 m below ground surface, respectively.

A standpipe piezometer was installed in Borehole B202-08 to permit monitoring of the groundwater level at the site. Details of the piezometer installation are shown on the Record of Borehole sheet in Appendix A. The groundwater level measured in the piezometer installation is summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
North Abutment	B202-08	184.2	183.4 183.5	February 28, 2011 March 31, 2011

It should be noted that groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

Mr. Matt Rhody, a senior technician with Golder and Messrs. Tony Tomory, E.I.T. and Alexander Mayot, E.I.T., directed the drilling program. This report was prepared by Mr. Tomasz Zalucki, P.Eng., a geotechnical engineer, and was reviewed by Mr. J. Paul Dittrich, Ph.D., P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

Tomasz Zalucki, P. Eng.
Geotechnical Engineer

J. Paul Dittrich, Ph.D., P. Eng.
Senior Geotechnical Engineer, Principal

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

TZ/CN/JPD/JMAC/sm

Http://capws/sites/0911116014highway69FourLaning/Contract 2/Reporting/Final/Still River NBL Bridge/09-1111-6014-2522 RPT 14Sep11 Highway 69 Still River NBL Bridge - Part A.docx

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No.
GWP No. 5404-05-00

SHEET

HIGHWAY 69
SITE LOCATION PLAN

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA

KEY PLAN
NOT TO SCALE

N 5090000
N 5080000
N 5070000
E 210000
E 220000
E 230000

HIGHWAY 522 INTERCHANGE UNDERPASS (WP 5151-08-01)
CNR OVERPASS BRIDGE AT HIGHWAY 522 (WP 5152-08-01)
CNR OVERPASS BRIDGE NBL & SBL (WP 5149-08-01 & WP 5150-08-01)
KEY RIVER BRIDGE NBL & SBL (WP 5147-08-01 & WP 5148-08-01)
STRAIGHT LAKE BRIDGE NBL & SBL (WP 5145-08-01 & WP 5146-08-01)
CPR OVERPASS NBL & SBL (WP 5143-08-01 & WP 5144-08-01)
BEKANON ROAD INTERCHANGE BRIDGE NBL & SBL (WP 5141-08-01 & WP 5142-08-01)
STILL RIVER BRIDGE NBL & SBL (WP 5139-08-01 & WP 5140-08-01)

CONTRACT 1 WP 5344-08-00 WP 5344-08-01
CONTRACT 4 WP 5347-08-01
GWP 5347-08-00
CONTRACT 5 WP 5404-05-01
CONTRACT 3 WP 5404-05-01
GWP 5404-05-00
CONTRACT 2 WP 5404-05-01

PROPOSED HIGHWAY 69
EXISTING HIGHWAY 69

HIGHWAY 522
HIGHWAY 526
HIGHWAY 529

CANADIAN NATIONAL RAILWAY
CANADIAN PACIFIC RAILWAY

MOWAT
HENVEY
HENVEY INLET
WALLBRIDGE
BRITT
KEY RIVER
GEORGIAN BAY

PLAN
SCALE
1 0 1 2 km

REFERENCE
Base Data – MNR NRVIS, obtained 2004, CANMAP v2008
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2008
Datum : NAD 83 Projection : MTM Zone 10

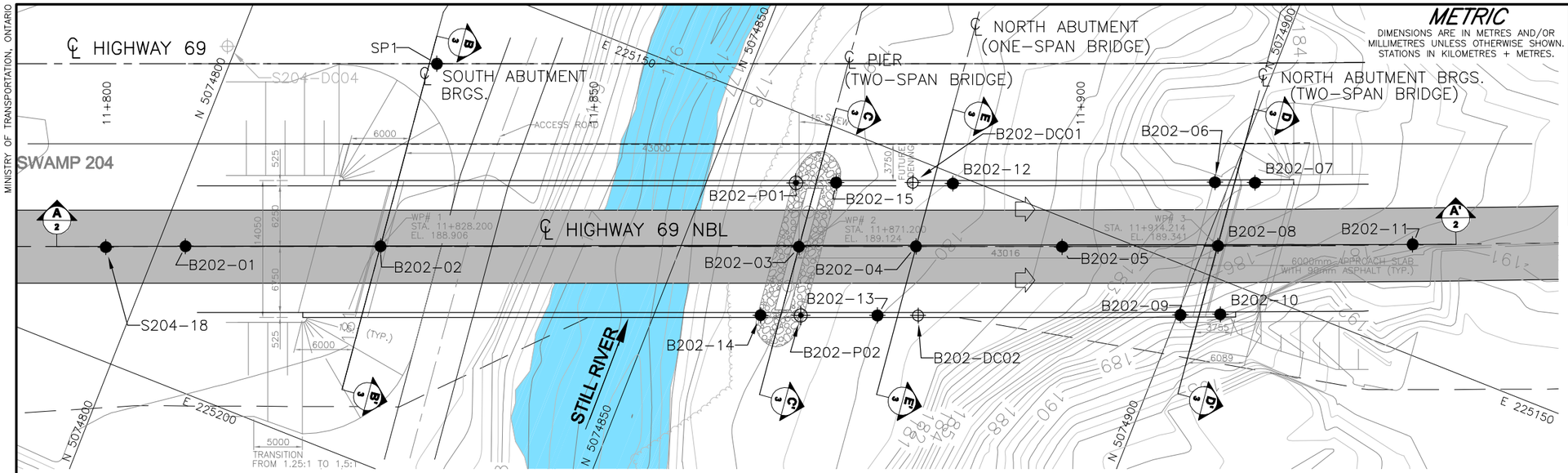
NO.	DATE	BY	REVISION

Geocres No. 41H-121

HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: June 2011	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 1

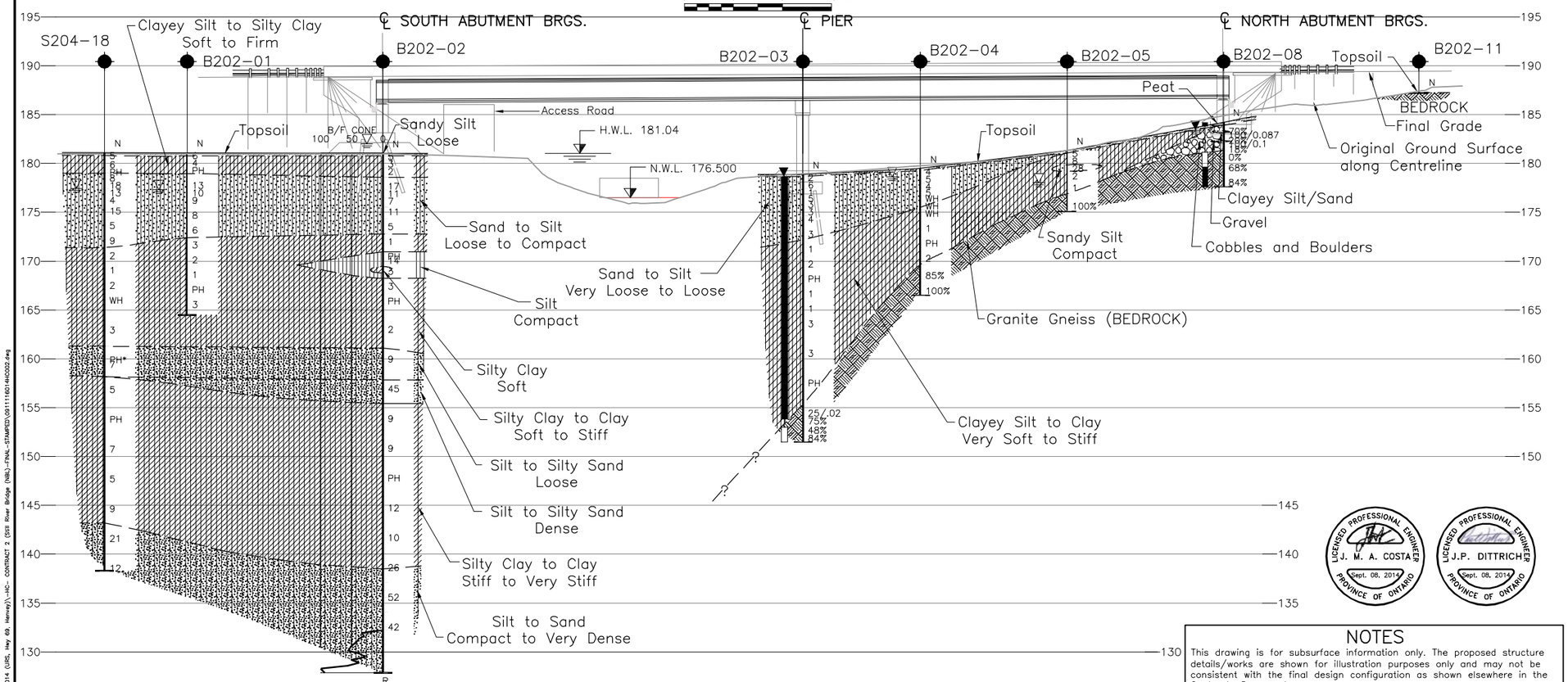
PLOT DATE: September 26, 2014
FILENAME: T:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-HC- CONTRACT 2 (SBI River Bridge (NBL)-FINAL-STAMPED)\09111601-HHC001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE 5 0 5 10 m



REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009, StillRiver_NBL_ga.dwg, received April 5, 2011 and Hwy69_Contour-Plan_C2_C3.dwg, received July 14, 2011.

A-A' / 2

CENTRELINE PROFILE HIGHWAY 69 (NBL)

SCALE 5 0 5 10 m

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 and beyond 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.

METRIC

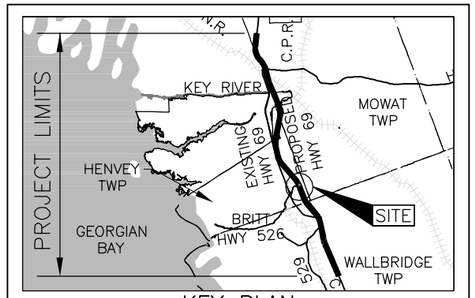
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5139-08-01

SHEET

HIGHWAY 69
STILL RIVER NBL BRIDGE STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE 6 0 6 12 km

LEGEND

- Borehole
- Dynamic Cone Penetration Test
- Probehole
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer, measured on February 28, 2011
- WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B202-01	181.1	5074802.7	225185.9
B202-02	181.0	5074821.3	225178.6
B202-03	178.8	5074861.3	225162.8
B202-04	179.4	5074872.5	225158.4
B202-05	181.3	5074886.4	225152.9
B202-06	183.9	5074898.6	225140.9
B202-07	184.3	5074902.4	225139.5
B202-08	184.2	5074901.3	225146.9
B202-09	186.4	5074900.3	225154.9
B202-10	187.1	5074904.1	225153.3
B202-11	187.3	5074919.8	225139.4
B202-12	179.5	5074873.6	225151.0
B202-13	179.4	5074871.4	225166.4
B202-14	179.0	5074860.2	225170.8
B202-15	178.7	5074862.4	225155.3
B202-DC01	179.0	5074869.7	225152.4
B202-DC02	180.2	5074875.3	225164.9
B202-P01	178.9	5074858.6	225156.8
B202-P02	179.1	5074864.1	225169.3
S204-18	181.1	5074795.1	225189.0
SP1	181.1	5074819.8	225159.0

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Sept. 08, 2014 PROVINCE OF ONTARIO

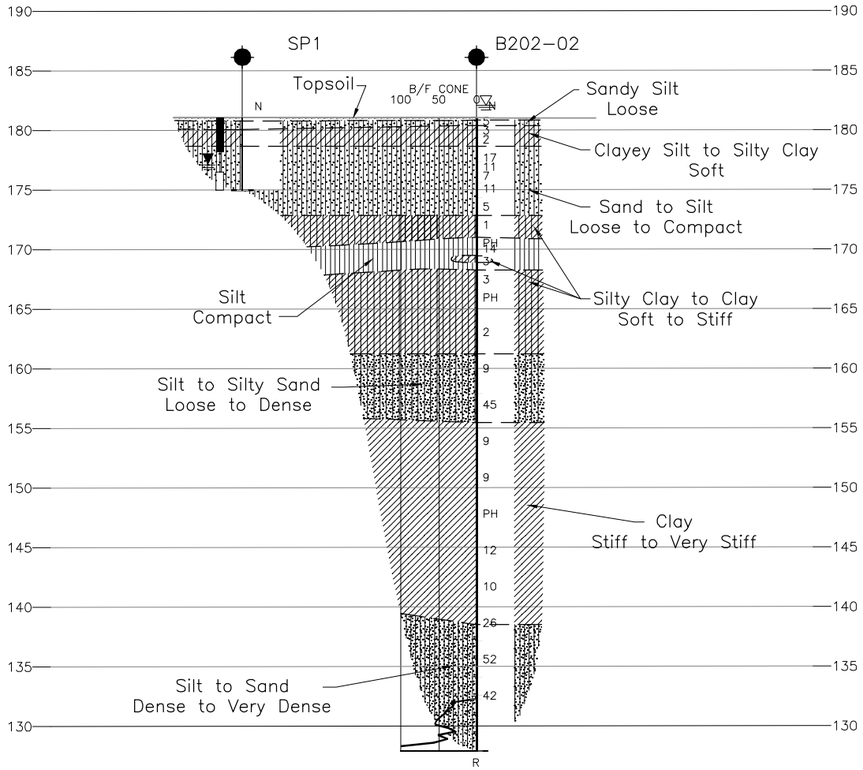
LICENSED PROFESSIONAL ENGINEER J.P. DITTRICH Sept. 08, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-121

HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA/TZ	DATE: Oct. 2012	SITE: 44-458/1
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 2

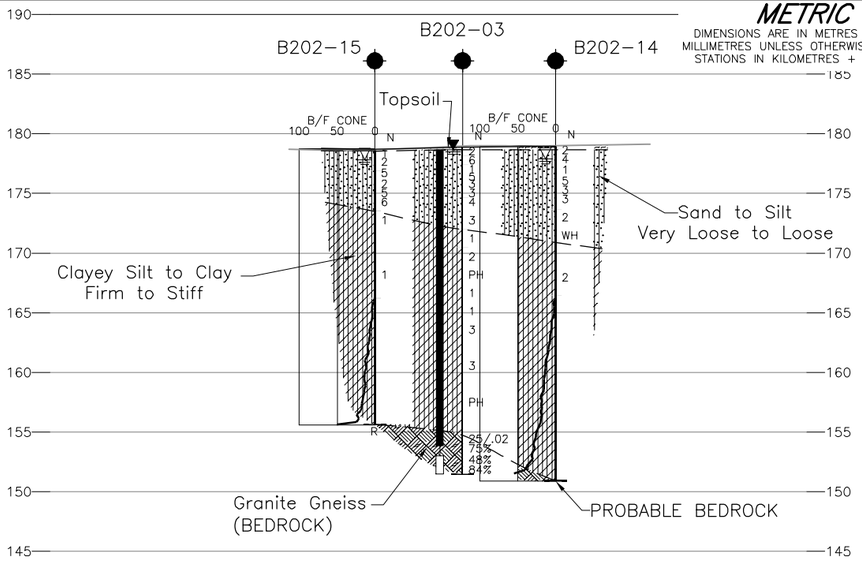
PLOT DATE: September 11, 2014
FILENAME: I:\Projects\2009\09-1111-6014 (URS, Hwy 69, Hanvey)\-HC- CONTRACT 2 (Still River Bridge (NBL)-FINAL-STAMPED\09111160140C002.dwg



B-B' / 2

SOUTH ABUTMENT
HIGHWAY 69 (NBL)

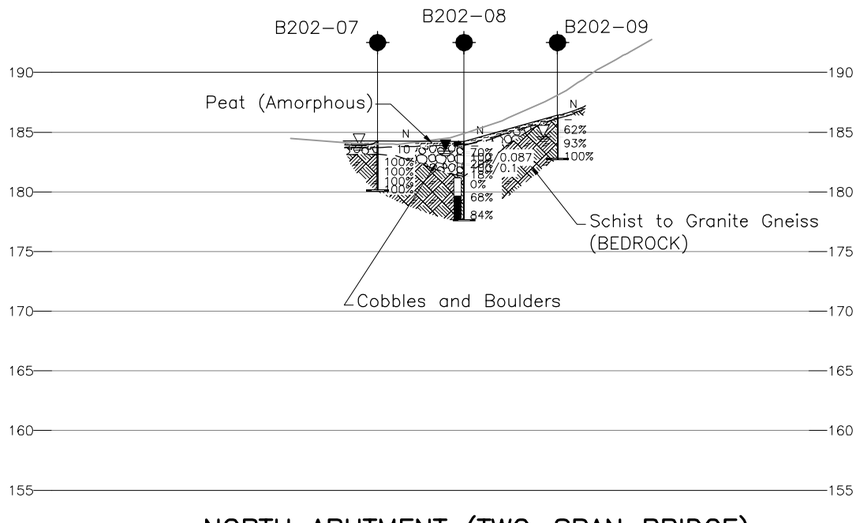
SCALE 5 0 5 10 m



C-C' / 2

CENTRE PIER (TWO-SPAN BRIDGE)
HIGHWAY 69 (NBL)

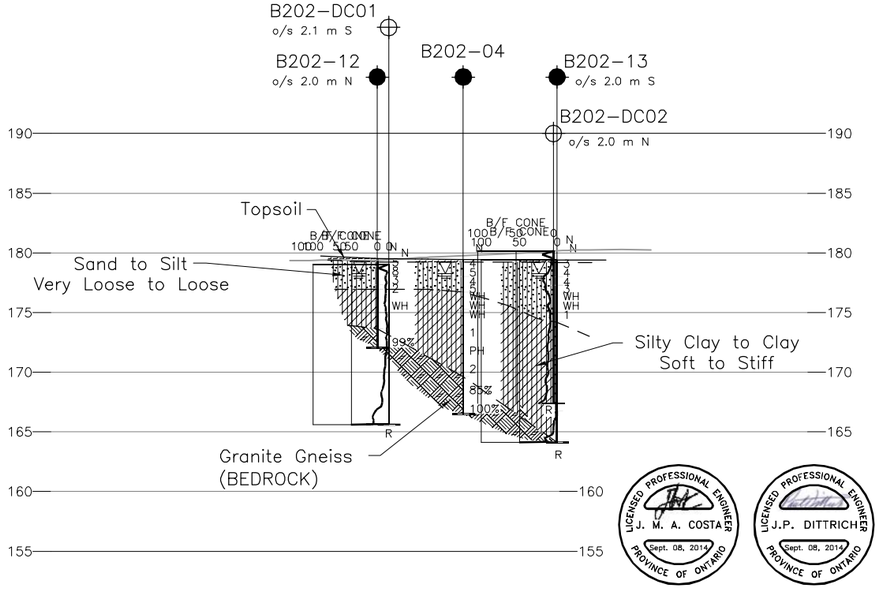
SCALE 5 0 5 10 m



D-D' / 2

NORTH ABUTMENT (TWO-SPAN BRIDGE)
HIGHWAY 69 (NBL)

SCALE 5 0 5 10 m



E-E' / 2

NORTH ABUTMENT (ONE-SPAN BRIDGE)
HIGHWAY 69 (NBL)

SCALE 5 0 5 10 m

REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69_base.dwg, Hwy69_plan.dwg, received December 16, 2009, StillRiver_NBL_ga.dwg, received April 5, 2011 and OG-Survey-Contours C2-3.dwg, received May 30, 2011.

METRIC

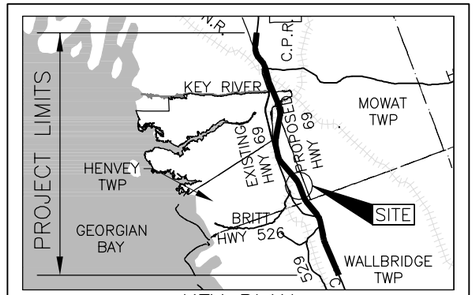
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5139-08-01

HIGHWAY 69
STILL RIVER NBL BRIDGE STRUCTURE
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE 6 0 6 12 km

LEGEND

- Borehole
- Dynamic Cone Penetration Test
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on February 28, 2011
- WL upon completion of drilling
- R — Refusal

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B202-13	179.4	5074871.4	225166.4
B202-14	179.0	5074860.2	225170.8
B202-15	178.7	5074862.4	225155.3
B202-DC01	179.0	5074869.7	225152.4
B202-DC02	180.2	5074875.3	225164.9
SP1	181.1	5074819.8	225159.0

NOTES

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LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Sept. 08, 2014 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.P. DITTRICH Sept. 08, 2014 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 41H-121

HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: Oct. 2012	SITE: 44-458/1
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 3

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: September 8, 2014
FILENAME: I:\Projects\2009\09-1111-6014 (URS, Hwy 69, Henvey)\-HC- CONTRACT 2 (Still River Bridge (NBL))-FINAL-STAMPED\091111601440C003.dwg

APPENDIX A

Record of Boreholes, Drillholes, Probeholes and Dynamic Cone Penetration Tests

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
υ	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 δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

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

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

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

Piezo-Cone Penetration Test (CPT)
A electronic cone penetrometer with a 60° conical tip and a project end area of 10 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) Non-Cohesive Soils

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

(b) Cohesive Soils
Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS 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 and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 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	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 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 varied 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 separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to 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 abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features 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

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

Golder Associates

RECORD OF BOREHOLE No B202-01

SHEET 1 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074802.7 ;E 225185.9
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Hollow Stem Auger
COMPILED BY MAS
DATUM Geodetic
DATE February 17, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.1	GROUND SURFACE										
0.0 / 180.8	TOPSOIL		1	SS	6		181				
0.3	SILTY CLAY, trace sand Firm Brownish grey to grey Moist		2	SS	4		180		○		
179.0			3	TO	PH		179				
2.1	SAND, trace gravel, trace silt, trace clay Loose to compact Brown to grey Moist to wet		4	SS	13	▽	178		○		1 94 4 1
	Becoming wet below a depth of 3.7 m		5	SS	10		177				
	Becoming grey at a depth of 4.5 m		6	SS	9		176				
			7	SS	8		175		○		
			8	SS	6		174				
172.4							173				
8.7	SILTY CLAY to CLAY, trace sand Firm to stiff Grey to brownish grey Moist		9	SS	3		172		⊢○		0 4 49 47
			10	SS	2		171	+ 3 3 3	○		
			11	SS	1		170	+ 3 3	○		
			12	SS	PH		169	+ 3 3 3	⊢○	16.6	
							168	+ 3 3 3			
							167				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B202-01

SHEET 2 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074802.7 ;E 225185.9
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Hollow Stem Auger
COMPILED BY MAS
DATUM Geodetic
DATE February 17, 2011
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	25 50 75		
	SILTY CLAY to CLAY, trace sand Firm to stiff Grey to brownish grey Moist		13	SS	3		166				0 1 45 54
164.5							165	3 3			
16.6	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 3.8 m below ground surface (Elev. 177.3 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No B202-02

SHEET 1 OF 4

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074821.3 ;E 225178.6
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 213 mm O.D. Cont. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE February 10,14,15 and 16, 2011
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0	GROUND SURFACE								
0.0	TOPSOIL		1A	SS	5				
0.2 / 180.3	Sandy SILT, trace clay Loose Brownish grey Moist		1B						
0.7 / 179.6	CLAYEY SILT, some sand, containing sand lenses Soft Brownish grey Wet		2	SS	3				
1.4 / 178.6	SILTY CLAY, trace sand Soft Brown and grey Moist		3	SS	2				0 3 53 44
2.4 / 177.3	SAND, trace silt, trace clay Compact Brown Moist		4	SS	17				
3.7 / 175.5	SILT, some sand, trace to some clay Loose to compact Brown Wet		5	SS	11				
			6	SS	7				0 18 75 7
5.5 / 174.3	SAND, trace silt Compact Grey Wet		7	SS	11				
6.7 / 172.8	SILT, some sand, trace clay Loose Grey Wet		8	SS	5			Non-plastic	0 15 83 2
8.2 / 170.9	SILTY CLAY, containing sand lenses Stiff Grey Moist		9	SS	1				
10.1 / 169.4	SILT, some sand, trace to some clay Compact Grey Wet		10	TO	PH*				
			11	SS	14				0 17 77 6
11.6 / 168.8	SILTY CLAY, trace sand Soft Brownish grey Moist		12A 12B	SS	3				
12.2 / 168.2	SILT, trace sand, trace clay Grey Wet								
12.8	CLAY Stiff Brown Wet		13	SS	3				
	Becoming grey at a depth of 14.3 m								

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 (%): 25 50 75

ELEVATION SCALE: 180 179 178 177 176 175 174 173 172 171 170 169 168 167

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

Continued Next Page

Golder Associates

RECORD OF BOREHOLE No B202-02 SHEET 2 OF 4 METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
DIST HWY 69
DATUM Geodetic

LOCATION N 5074821.3 ;E 225178.6
BOREHOLE TYPE 213 mm O.D. Cont. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
DATE February 10,14,15 and 16, 2011

ORIGINATED BY MR
COMPILED BY MAS
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAY Stiff Brown Wet		14	TO	PH						
161.2							165				
19.8	SILT, trace sand, trace clay Loose Grey Wet		15	SS	2		164				0 1 44 55
			16	SS	9		163				
157.8							162				
23.2	Silty SAND Dense Grey Wet		17	SS	45		161				
155.4							160				
25.6	CLAY Stiff to very stiff Grey Moist		18	SS	9		159				
							158				
							157				
							156				
							155				
							154				
							153				
							152				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No B202-02

SHEET 3 OF 4

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074821.3 ;E 225178.6
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 213 mm O.D. Cont. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE February 10,14,15 and 16, 2011
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAY Stiff to very stiff Grey Moist		19	SS	9						
			20	TO	PH						
			21	SS	12						0 1 34 65
			22	SS	10						
138.5			23A 23B 23C	SS	26						
42.5	SILT, trace sand Grey Wet										
137.1											
43.9	SAND Very dense Grey Wet										

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B202-02

SHEET 4 OF 4

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074821.3 ;E 225178.6
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 213 mm O.D. Cont. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE February 10,14,15 and 16, 2011
CHECKED BY TVA

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	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 ---										
135.6											
45.4	Silty SAND Very dense Grey Wet		24A 24B	SS	52						
134.1											
46.9	SAND Dense Grey Wet										
132.5			25A 25B	SS	42						
132.2	SILT, trace to some sand Dense Grey Wet										
48.8	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)										
127.9											
53.1	END OF DCPT Refusal to Further Penetration (100 Blows / 0.1 m)										

NOTES:

* Unable to recover a Shelby tube sample between depths of 10.2 m and 10.7 m below ground surface (Elev. 170.8 m and 170.3 m).

1. Water level in open borehole rose to 1.0 m above ground surface (Elev. 182.0 m) at a depth of 45.1 m below ground surface (Elev. 135.9 m) during drilling - Artesian Condition.

2. A Dynamic Cone Penetration Test was carried out below a depth of 48.8 m; refusal encountered at a depth of 53.1 m below ground surface (Elev. 127.9 m).

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 / NATURAL MOISTURE CONTENT / LIQUID LIMIT
WATER CONTENT (%): 25 50 75
ELEVATION SCALE: 135 134 133 132 131 130 129 128
124

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

Golder Associates

RECORD OF BOREHOLE No B202-03

SHEET 1 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074861.3 ;E 225162.8
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Conti. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 26, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.8	GROUND SURFACE										
0.0	TOPSOIL		1A								
0.2	Silty SAND, containing rootlets Very loose Brown		1B	SS	2						
178.1							178				
0.7	Wet SAND, trace to some silt Loose Brown		2	SS	6						
177.4							177				
1.4	Wet Silty SAND, containing rootlets near surface Very loose to loose Brown to grey Wet		3	SS	1						
			4	SS	5						
	Becoming grey below a depth of 2.1 m		5	SS	3		176				
			6	SS	3		175				
174.6											
4.2	SAND and SILT, trace clay Very loose Grey Wet		7	SS	4						0 31 66 3
			8	SS	3		174				
171.9							173				
6.9	CLAYEY SILT, trace sand Firm Grey Moist		9	SS	1		172				0 2 73 25
170.4							171				
8.4	CLAY Firm to stiff Grey Moist		10	SS	2		170				
			11	TO	PH		169				
			12	SS	1		168				
			13	SS	1		167				0 1 49 50
							166				
							165				
							164				

Continued Next Page

+ 3 , × 3 : Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B202-03 SHEET 2 OF 2 METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074861.3 ;E 225162.8
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Conti. Flight Hollow Stem Auger Augers, HW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 26, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAY Firm to stiff Grey Moist		14	SS	3		163	3, 3	○		
							162				
			15	SS	3		161		○		0 1 40 59
							160	3, 3			
							159				
			16	TO	PH		158				
154.7							157	3, 3			
			17	SS	25/.02		156				
24.1	Granite Gneiss (BEDROCK) Bedrock cored from depths of 24.1 m to 27.3 m For Bedrock coring details refer to Record of Drillhole B203-03		1	RC	REC 100%		155				RQD = 75%
			2	RC	REC 100%		154				RQD = 48%
			3	RC	REC 100%		153				RQD = 84%
151.5							152				
27.3	END OF BOREHOLE NOTE: 1. Water level measurement in Piezometer: Date Depth (m) Elev. (m) 26/03/11 0.2 178.6										

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 2/6/13 SAC/DD

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-03

SHEET 1 OF 1

LOCATION: N 5074861.3 ;E 225162.8

DRILLING DATE: March 26, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: Walker Drilling

JN - Joint; FLT - Fault; SH - 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; VR - Very 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/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-03		154.75																	
	NW Casing March 26, 2011	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, medium strong to strong, pink, grey and black		24.10										JN,PL,SM Fe	1	1					
														JN,PL,SM Fe	1	1					
					1									JN,CU,SM Fe	2	1	6				
25																					
														JN,PL,SM Fe	1	1					
														JN,PL,SM Fe	1	1					
	NQRC March 26, 2011				2									JN,UN,SM Fe	2	1	3				
26														JN,CU,RO Fe	3	1					
														JN,PL,RO He	1.5	2					
					3									JN,PL,SM He	1	2	3				
27																					(Axial) UC = 69 MPa
				151.51																	
		END OF DRILLHOLE		27.34																	
28																					
29																					
30																					
31																					
32																					
33																					
34																					

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: MAS/TVA

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-04

SHEET 1 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074872.5 ;E 225158.4
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 27, 2011
CHECKED BY TVA

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 (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.4	GROUND SURFACE										
0.0	TOPSOIL		1A	SS	4		179				
0.2	Silty SAND Loose Brown Wet		1B								
178.0			2	SS	5		178				
1.4	SAND, trace gravel Loose Brown Wet		3	SS	4						
176.7			4	SS	5		177				
2.7	SILT, trace to some clay, trace sand, containing silty clay lenses Very loose Grey Wet		5	SS	WH						0 1 91 8
175.2			6	SS	WH		176				
4.2	CLAY Firm Grey Moist		7	SS	WH		175	3 3			
			8	SS	1		174				0 1 45 54
							173	4 4			
			9	TO	PH		172				16.5
							171	4 4			
			10	SS	2		170	4			
169.6											
9.8	Granite Gneiss (BEDROCK) Bedrock cored from depths of 9.8 m to 13.0 m For bedrock coring details refer to Record of Drillhole B202-04		1	RC	REC 100%		169				RQD = 85%
			2	RC	REC 100%		168				RQD = 100%
166.4							167				
13.0	END OF BOREHOLE										

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B202-04

SHEET 2 OF 2

METRIC

PROJECT 09-1111-6014

W.P. 5139-08-01 LOCATION N 5074872.5 ;E 225158.4 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY MAS

DATUM Geodetic DATE March 27, 2011 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L	γ kN/m^3	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	25 50 75		
	NOTE:										
	1. An additional borehole was drilled 1.0 m North of Borehole B202-04 to carry out installation of piezometer to a depth of 2.3 m below ground surface (Elev. 177.1 m).										
	2. Water level measurement in Piezometer:										
	Date Depth (m) Elev. (m) 10/03/12 1.4 178.1										

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-04

SHEET 1 OF 1

LOCATION: N 5074872.5 ;E 225158.4

DRILLING DATE: March 27, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: Walker Drilling

JN - Joint; FLT - Fault; SH - 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; VR - Very 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/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-04		169.63																
10	NW Cashg March 27, 2011	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, very strong, pink, grey and black Near vertical fracture with silt infilling between depths of 10.7 m and 11.3 m		9.81	1								JN,PL,SM He	1	1					10.7 MPa (Axial)
													JN,PL,RO	1.5	1					
11	NQRC March 27, 2011												JN,PL,SM Fe JN,PL,SM Cl JN,W,SM Cl JN,PL,SM Fe JN,PL,RO Fe	1 1 1.5 1 1.5	1 2 2 2 1					
12					2															10.6 MPa UC = 193 MPa
13				166.44																
		END OF DRILLHOLE Note: 1. Near vertical fracture with silty build up was observed within the recovered bedrock between depths of 10.7 m and 11.3 m, indicating possible water flow into bedrock.		13.00																
14																				
15																				
16																				
17																				
18																				
19																				

DEPTH SCALE

1 : 50

LOGGED: MR

CHECKED: MAS/TVA

Golder Associates

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-05

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074886.4 ;E 225152.9
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 28, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3	GROUND SURFACE										
0.0	TOPSOIL		1A	SS	5		181				
0.2	CLAYEY SILT with SAND, containing wood fragments		1B								
180.6	Firm										
0.7	Brown		2	SS	8		180				
	Moist										
	SILTY CLAY										
179.9	Stiff										
1.4	Brown and grey		3	SS	28	▽	179				
	Moist										
179.2	Sandy SILT										
2.1	Compact										
	Grey		4	SS	2			5			0 2 75 23
	Wet						178				
	CLAYEY SILT, trace sand, containing silt interlayers										
	Firm		5	SS	1						
	Grey						177	5			
	Moist										
176.7											
4.6	Granite Gneiss (BEDROCK)		1	RC	REC 100%		176				RQD = 100%
	Bedrock cored from a depth of 4.6 m to 6.2 m										
	For bedrock coring details refer to Record of Drillhole B202-05										
175.1											
6.2	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 1.8 m (Elev. 179.5 m) upon completion of drilling.

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

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-05

SHEET 1 OF 1

LOCATION: N 5074886.4 ;E 225152.9

DRILLING DATE: March 28, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: Walker Drilling

JN - Joint; FLT - Fault; SH - 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; VR - Very 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/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-05		176.74																
5	NW Casing March 28, 2011	GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong, pink, grey, and black		4.57								•	JN,PL,RO	1.5	1					
6	NQRC March 28, 2011				1											1		•		(Axial)
		END OF DRILLHOLE		175.12 6.19																
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MR
CHECKED: MAS/TVA

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-06

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5139-08-01 LOCATION N 5074898.6 ;E 225140.9 ORIGINATED BY TT

DIST HWY 69 BOREHOLE TYPE Portable Equipment COMPILED BY MAS

DATUM Geodetic DATE February 26, 2011 CHECKED BY TVA

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 (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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.9	GROUND SURFACE										
0.0	PEAT, trace sand (Amorphous)		1A								
0.2	Black Wet		1B	SS	10				○		24 57 16 3
183.0	Gravelly SAND, some silt, trace clay, containing organics										
0.9	Compact Brown Moist										
	END OF BOREHOLE SPOON REFUSAL										
	NOTE: 1. Borehole dry upon completion of drilling.										

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 2/6/13 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-07

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5139-08-01 LOCATION N 5074902.4 ;E 225139.5 ORIGINATED BY TT
DIST HWY 69 BOREHOLE TYPE Portable Equipment, BW Casing COMPILED BY MAS
DATUM Geodetic DATE February 27, 2011 CHECKED BY TVA

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 (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.3	GROUND SURFACE										
0.0 / 183.7	PEAT (Amorphous) Hard (Frozen) Black		1	SS	39	▽	184				
0.6 / 183.2	Cobbles and Boulders		1	RC	REC 50%						
1.1	Granite Gneiss (BEDROCK) Bedrock cored from depths of 1.1 m to 4.2 m For bedrock coring details refer to Record of Drillhole B202-07		2	RC	REC 100%		183				RQD = 100%
			3	RC	REC 100%		182				RQD = 100%
			4	RC	REC 100%						RQD = 100%
180.1			5	RC	REC 100%		181				RQD = 100%
4.2	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.4 m below ground surface (Elev. 183.9 m) upon completion of drilling.										

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-07

SHEET 1 OF 1

LOCATION: N 5074902.4 ;E 225139.5

DRILLING DATE: February 27, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc

JN - Joint; FLT - Fault; SH - 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; VR - Very 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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-07		183.68																
1	BQRC February 27, 2011	COBBLES AND BOULDERS		0.60 / 183.15	1															
2		GRANITE GNEISS Fresh, foliated, medium to coarsely crystalline, slightly porous, strong to very strong, pink and black		1.13	2															9.5 MPa
3					3															(Axial)
4					4								JN,PL,SM . Fe	1	2	3				
													JN,PL,RO	1.5	1					
					5								JN,PL,RO	1.5	1	2				
				180.11																
		END OF DRILLHOLE		4.17																

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TT

CHECKED: AM/TVA

Golder Associates

RECORD OF BOREHOLE No B202-08

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074901.3 ;E 225146.9
ORIGINATED BY TT
DIST HWY 69
BOREHOLE TYPE Portable Equipment, BW Casing and EW Casing
COMPILED BY MAS
DATUM Geodetic
DATE February 24 to 26, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.2	GROUND SURFACE										
0.0 / 183.9	Peat (Amorphous)		1	CS	-		184				
0.3 / 183.3	Cobbles and Boulders		1	RC	REC 94%						
	CLAYEY SILT, some sand, trace gravel, containing rootlets		2A	CS	-						
			2B	SS	100/0.08?						
1.2 / 182.3	Brown Moist SAND, some gravel, trace silt Brown Moist		2	RC	REC 53%		183				
			3	SS	100/0.1						
2.0 / 181.3	Cobbles and Boulders GRAVEL, some sand Grey Moist		3	RC	REC 59%		182				
2.9	Cobbles and Boulders Granite Gneiss (BEDROCK)		4	RC	REC 94%		181				RQD = 0%
	Bedrock cored from depths of 2.9 m to 6.6 m For bedrock coring details refer to Record of Drillhole B202-08		5	RC	REC 97%		180				RQD = 68%
			6	RC	REC 95%		179				RQD = 84%
177.6							178				
6.6	END OF BOREHOLE										

NOTE:

1. Water level measurement in Piezometer:

Date	Depth (m)	Elev. (m)
28/02/11	0.8	183.4
31/03/11	0.7	183.5
03/10/12	0.8	183.4

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

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-08

SHEET 1 OF 1

LOCATION: N 5074901.3 ;E 225146.9

DRILLING DATE: February 24 to 26, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc

JN - Joint; FLT - Fault; SH - 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; VR - Very 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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-08		183.89																
		COBBLES AND BOULDERS		0.33	1															
				183.32																
1				0.90																
				183.03																
		COBBLES AND BOULDERS		1.19	2															
				182.33																
2				1.89																
		COBBLES AND BOULDERS		2.03	3															
				181.31																
3	BQRC and EQRC February 24 to 26, 2011	GRANITE GNEISS Slightly weathered, foliated, finely crystalline, slightly porous, strong, grey, pink and black		2.91	4								JN,PL,RO	1.5	2					
				180.91									JN,PL,RO	1.5	1					
				3.31									JN,PL,RO	2	1	6				
		GRANITE GNEISS Fresh, foliated, medium crystalline, slightly porous, strong to very strong, grey, pink and black											JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
4													JN,PL,RO							
													JN,PL,RO							
					5								JN,PL,RO	1.5	1	6				
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					8.3 MPa (Axial)
													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
5													JN,PL,RO	1.5	1					
													JN,PL,RO	1.5	1					
					6											6				
6		Mafic dyke between depths of 5.86 m and 5.94 m																		
				177.62																
		END OF DRILLHOLE		6.60																
7																				
8																				
9																				
10																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TT

CHECKED: MAS/TVA

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-09

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074900.3 ;E 225154.9
ORIGINATED BY TT
DIST HWY 69
BOREHOLE TYPE Portable Equipment, BW Casing
COMPILED BY MAS
DATUM Geodetic
DATE February 27, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.4	GROUND SURFACE										
0.0 / 186.1	Peat (Amorphous)		1	CS	-		186				
0.3	Schist (BEDROCK) / Gneiss (BEDROCK)		1	RC	REC 99%						RQD = 62%
185.1							185				
1.3 / 184.6	Schist (BEDROCK)		2	RC	REC 100%	▽					RQD = 93%
1.8	Granite Gneiss (BEDROCK) Bedrock cored from depths of 0.3 m to 3.7 m For bedrock coring details refer to Record of Drillhole B202-09		3	RC	REC 100%		184				RQD = 100%
182.7							183				
3.7	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev 184.6 m) upon completion of drilling										

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

GTA-MTO 001 09-1111-6014.GPJ GAL-GTA.GDT 2/6/13 SAC/DD

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-09

SHEET 1 OF 1

LOCATION: N 5074900.3 ;E 225154.9

DRILLING DATE: February 27, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc

JN - Joint; FLT - Fault; SH - 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; VR - Very 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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-09		186.15																
	BQRC February 27, 2011	SCHIST Fresh, coarsely crystalline, slightly porous, medium strong, brown and black		0.32									JN,PL,RO Fe JN,PL,RO Fe JN,UN,RO	1.5 1.5 3	1 1 1					
1		GNEISS Fresh, medium to coarsely crystalline, slightly porous, strong to very strong, containing pegmatitic crystal, pink, grey and black			1								JN,UN,RO JN,UN,SM	3 2	1 1	12				8.1 MPa
				185.10									JN,PL,RO	1.5	1					
		SCHIST Highly weathered, containing rootlets		1.32 1.40									JN,PL,RO JN,PL,RO JN,PL,RO Fe	1.5 1.5 1.5	1 1 1					(Axial)
		SCHIST Fresh, coarsely crystalline, slightly porous, medium strong, brown and black		184.59 1.83									JN,PL,RO Fe JN,PL,RO Fe	1.5 1.5	1 1					
2		GRANITE GNEISS Fresh, foliated, medium to coarsely crystalline, slightly porous, strong to extremely strong, grey, pink and black			2								JN,PL,RO JN,PL,RO	1.5 1.5	1 1					
3					3															14.1 MPa UC = 175 MPa
				182.72																
		END OF DRILLHOLE		3.70																
4																				
5																				
6																				
7																				
8																				
9																				
10																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: TT

CHECKED: MAS/TVA

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-10

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5139-08-01 LOCATION N 5074904.1 ;E 225153.3 ORIGINATED BY TT

DIST HWY 69 BOREHOLE TYPE Hand Excavation COMPILED BY MAS

DATUM Geodetic DATE February 26, 2011 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
187.1	GROUND SURFACE										
0.0	TOPSOIL										
0.1	END OF EXCAVATION - Bedrock										
	NOTE:										
	1. Hand digging carried out at proposed borehole location to expose bedrock.										

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

Golder Associates

RECORD OF BOREHOLE No B202-11

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

W.P. 5139-08-01 LOCATION N 5074919.8 ;E 225139.4 ORIGINATED BY TT

DIST HWY 69 BOREHOLE TYPE Hand Excavation COMPILED BY MAS

DATUM Geodetic DATE March 3, 2011 CHECKED BY TVA

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 (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.3	GROUND SURFACE										
0.0	TOPSOIL										
0.1	END OF EXCAVATION - Bedrock										
	NOTE:										
	1. Hand digging carried out at proposed borehole location to expose bedrock.										

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

Golder Associates

RECORD OF BOREHOLE No B202-12

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074873.6 ;E 225151.0
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 28, 2011
CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.5	GROUND SURFACE										
0.0 / 179.2	TOPSOIL		1A, 1B	SS	5						
178.8	Sandy SILT, containing rootlets Loose Grey Moist										
0.7	Silty SAND, trace to some clay, containing organics Very loose to loose Brown Moist to Wet		2	SS	8	▽					
177.3			3	SS	3						0 71 21 8
176.9	Sandy SILT Very loose Grey Wet		4A, 4B	SS	2						
2.6	CLAY, containing silt interlayers to a depth of 3.4 m Soft to firm Grey Moist		5	SS	WH						0 1 43 56
173.6											
5.9	Granite Gneiss (BEDROCK) Bedrock cored from depths of 5.9 m to 7.5 m For bedrock coring details refer to Record of Drillhole B202-12		1	RC	REC 100%						RQD = 99%
172.0											
7.5	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 1.3 m below ground surface (Elev. 178.2 m) upon completion of drilling.										

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

PROJECT: 09-1111-6014

RECORD OF DRILLHOLE: B202-12

SHEET 1 OF 1

LOCATION: N 5074873.6 ;E 225151.0

DRILLING DATE: March 28, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: OGS Inc

JN - Joint; FLT - Fault; SH - 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; VR - Very 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	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	DISCONTINUITY DATA: Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		Continued from Record of Borehole B202-12		173.65																
6	NQRC March 26, 2011	GRANITE GNEISS Fresh, medium crystalline, slightly porous, strong to very strong, pink, grey and black		5.90																
7	NW Casing March 26, 2011				1								JN,PL,SM He	1	2	1			9.3 MPa	
		END OF DRILLHOLE		172.05 7.50																
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: MR

CHECKED: MAS/TVA

GTA-RCK 018 09-1111-6014.GPJ GAL-MISS.GDT 11/21/12 SAC/DD

Golder Associates

RECORD OF BOREHOLE No B202-13

SHEET 1 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074871.4 ;E 225166.4
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 29, 2011
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
179.4	GROUND SURFACE					
0.0	TOPSOIL		1A	SS	3	
0.2	Silty SAND, containing organics and rootlets to a depth of 0.8 m Very loose to loose Brown and grey Wet		1B			
178.0			2	SS	4	▽
1.4	SAND, some gravel Loose Brown		3	SS	4	
177.3	Wet					
2.1	SILT, trace clay, trace sand Very loose Grey Wet		4	SS	3	
			5	SS	WH	
	Containing silty clay lenses between depths of 3.5 m and 4.1 m		6	SS	WH	
			7	SS	1	
174.2						
5.2	SILTY CLAY to CLAY, trace sand Firm to stiff Grey Moist					
166.7						
12.7	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)					

ELEVATION SCALE: 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165

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 (%)
25 50 75

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

	GR	SA	SI	CL
5139-08-01	0	5	90	5
6	0	3	81	16

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

Continued Next Page

Golder Associates

RECORD OF BOREHOLE No B202-13

SHEET 2 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074871.4 ;E 225166.4
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 29, 2011
CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)		
	--- CONTINUED FROM PREVIOUS PAGE ---							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	w_P w w_L	γ kN/m³	GR SA SI CL
164.1								20 40 60 80 100	25 50 75		
15.3	END OF DCPT Refusal to Further Penetration (Hammer Bouncing) NOTES: 1. Water level in open borehole at a depth of 1.4 m below ground surface (Elev. 178.0 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was carried out below a depth of 12.7 m; refusal encountered at a depth of 15.3 m (Elev. 164.1 m) below ground surface.										

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

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

Golder Associates

RECORD OF BOREHOLE No B202-14

SHEET 1 OF 3

METRIC

PROJECT 09-1111-6014 | W.P. 5139-08-01 | LOCATION N 5074860.2 ;E 225170.8 | ORIGINATED BY MR

DIST | HWY 69 | BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | COMPILED BY MAS

DATUM Geodetic | DATE March 29 and 30, 2011 | CHECKED BY TVA

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
179.0	GROUND SURFACE								
0.0	TOPSOIL								
0.2	SAND and SILT, trace clay, containing rootlets to a depth of 0.6 m Very loose to loose Brown to grey Moist to Wet		1	SS	2				
			2	SS	4	▽			
			3	SS	1				
			4	SS	5				0 59 38 3
			5	SS	3				
	Becoming grey below a depth of 4.1 m		6	SS	3				
173.7									
5.3	SILT, some clay, trace sand, containing clay lenses Very loose Grey Wet		7	SS	2				
			8	SS	WH				0 1 81 18
170.9									
8.1	CLAY, containing silt interlayers Firm to stiff Grey Moist		9	SS	2				
166.5									
12.5	Dynamic Cone Penetration Test (DCPT) END OF BOREHOLE								

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 (%): 25 50 75

ELEVATION SCALE: 178 177 176 175 174 173 172 171 170 169 168 167 166 165

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Continued Next Page

Golder Associates

RECORD OF BOREHOLE No B202-14 SHEET 2 OF 3 METRIC

PROJECT 09-1111-6014 | W.P. 5139-08-01 | LOCATION N 5074860.2 ;E 225170.8 | ORIGINATED BY MR

DIST | HWY 69 | BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | COMPILED BY MAS

DATUM Geodetic | DATE March 29 and 30, 2011 | CHECKED BY TVA

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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Dynamic Cone Penetration Test (DCPT)						163				
							162				
							161				
							160				
							159				
							158				
							157				
							156				
							155				
							154				
							153				
							152				
151.6											
27.4	END OF DCPT										
150.9							151				
28.1	END OF TRICONE BOREHOLE (PROBABLE BEDROCK)										

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No B202-14

SHEET 3 OF 3

METRIC

PROJECT 09-1111-6014

W.P. 5139-08-01 LOCATION N 5074860.2 ;E 225170.8 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY MAS

DATUM Geodetic DATE March 29 and 30, 2011 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	w_P w w_L	γ kN/m^3	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	WATER CONTENT (%) 25 50 75		
	NOTES: 1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 177.9 m) upon completion of drilling. 2. A Dynamic Cone Penetration Test was carried out between depths of 12.5 m and 27.4 m below ground surface (Elev. 166.5 m and 151.6 m) . 3. Tricone advanced below a depth of 27.4 m; refusal encountered at a depth of 28.1 m below ground surface (Elev. 150.9 m) on probable bedrock.										

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

Golder Associates

RECORD OF BOREHOLE No B202-15

SHEET 1 OF 2

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074862.4 ;E 225155.3
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
COMPILED BY MAS
DATUM Geodetic
DATE March 30, 2011
CHECKED BY TVA

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 (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 (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
178.7	GROUND SURFACE						178				
0.0	TOPSOIL										
0.2	SAND, some silt, containing rootlets and organics Very loose Grey to brown Wet		1	SS	1	▽					
			2	SS	2		177				
176.9											
1.8	SAND and SILT, trace clay Very loose to loose Brown to grey Wet		3A 3B	SS	5		176				
			4	SS	2						
			5	SS	5		175				0 67 31 2
			6	SS	6		174				
173.5											
5.2	CLAY, containing silt interlayers Firm Grey Moist		7	SS	1		173				
							172	3 3			
							171	4 3			
							170	3 3			
			8	SS	1		169				0 1 25 74
							168				
							167	3 3			
166.2	END OF BOREHOLE							3 3			
12.5	Dynamic Cone Penetration Test (DCPT)						166				
							165				
							164				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B202-15

SHEET 2 OF 2

METRIC

PROJECT 09-1111-6014 | W.P. 5139-08-01 | LOCATION N 5074862.4 ;E 225155.3 | ORIGINATED BY MR

DIST | HWY 69 | BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring | COMPILED BY MAS

DATUM Geodetic | DATE March 30, 2011 | CHECKED BY TVA

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	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 ---										
	Dynamic Cone Penetration Test (DCPT)						163				
							162				
							161				
							160				
							159				
							158				
							157				
							156				
155.6											
23.1	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)										

NOTES:

1. Water level in open borehole at a depth of 0.9 m below ground surface (Elev. 177.8 m) upon completion of drilling.

2. A Dynamic Cone Penetration Test was advanced below a depth of 12.5 m; refusal encountered at a depth of 23.1 m below ground surface (Elev. 155.6 m).

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED

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

Golder Associates

RECORD OF BOREHOLE No S204-18

SHEET 1 OF 4

METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01
DIST HWY 69
DATUM Geodetic

LOCATION N 5074795.1 ;E 225189.0
BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring
DATE February 6 and 7, 2010

ORIGINATED BY MR/RA
COMPILED BY OK
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
181.1	GROUND SURFACE						181
0.0 / 180.8	TOPSOIL		1A	SS	5		
0.3	SILTY CLAY, containing rootlets and silty sand layers to a depth of 0.8 m Firm Brown to grey Moist		1B				
			2	SS	6		180
179.0			3A 3B	TO	PH		
2.1	Silty SAND, trace clay Loose to compact Brown Wet		4	SS	8		179
177.4			5	SS	18	▽	178
3.7	SILT, some sand, trace to some clay Loose to compact Brown Wet		6	SS	13		177
			7	SS	4		176
	Becoming grey below a depth of 5.5 m		8	SS	15		175
			9	SS	5		174
			10	SS	9		173
171.4							172
9.7	CLAY Firm to stiff Grey Moist		11	SS	2		171
			12	SS	1		170
			13	SS	2		169
							168
							167

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

	GR	SA	SI	CL
177	0	16	78	6
168	0	1	47	52

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No S204-18 SHEET 2 OF 4 METRIC

PROJECT 09-1111-6014
W.P. 5404-05-01 LOCATION N 5074795.1 ;E 225189.0 ORIGINATED BY MR/RA
DIST HWY 69 BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY OK
DATUM Geodetic DATE February 6 and 7, 2010 CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAY Firm to stiff Grey Moist		14	SS	WH		166				
							165	3 3			
							164				
			15	SS	3		163				
							162	3 3			
161.3											
19.8	SILT, trace to some sand, trace clay Loose Grey Wet						161				
			16	TO	PH*		160				
			17	SS	7				○		0 8 88 4
158.2							159				
22.9	SILTY CLAY Stiff to very stiff Grey Moist						158				
			18	SS	5		157				
							156	4 3			
							155				
			19	TO	PH		154				
							153	3 4			
							152				

Continued Next Page

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

Golder Associates

PROJECT 09-1111-6014

RECORD OF BOREHOLE No S204-18 SHEET 3 OF 4 METRIC

W.P. 5404-05-01 LOCATION N 5074795.1 ;E 225189.0 ORIGINATED BY MR/RA

DIST HWY 69 BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY OK

DATUM Geodetic DATE February 6 and 7, 2010 CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY CLAY Stiff to very stiff Grey Moist		20	SS	7		151				0 1 54 45
							150	4 3			
							149				
			21	SS	5		148				
							147	3 >96			
							146				
	Silt interlayers encountered below a depth of 36.1 m		22	SS	9		145				
143.2							144	>142 >122			
37.9	SAND and SILT, trace clay Compact Grey Wet						143				
			23	SS	21		142				0 35 65 0
							141				
							140				
							139				
138.3			24	SS	12						
42.8	END OF BOREHOLE										

Continued Next Page

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

Golder Associates

PROJECT 09-1111-6014

RECORD OF BOREHOLE No S204-18

SHEET 4 OF 4

METRIC

W.P. 5404-05-01 LOCATION N 5074795.1 ;E 225189.0 ORIGINATED BY MR/RA

DIST HWY 69 BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring COMPILED BY OK

DATUM Geodetic DATE February 6 and 7, 2010 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 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 ---										
	NOTES: * Unable to recover a Shelby tube sample between depths of 20.9 m and 21.3 m (Elev. 160.2 m and 159.8 m) below ground surface. 1. Water level in open borehole at a depth of 3.7 m below ground surface (Elev. 177.4 m) upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No SP1

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014
W.P. 5139-08-01
LOCATION N 5074819.8 ;E 225159.0
ORIGINATED BY MR
DIST HWY 69
BOREHOLE TYPE 213 mm O.D. Continuous Flight Hollow Stem Augers
COMPILED BY TVA
DATUM Geodetic
DATE February 17, 2011
CHECKED BY TVA

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
181.1	GROUND SURFACE										
0.0 / 180.8	TOPSOIL						181				
0.3 / 180.2	Sandy SILT, some clay Brown										
0.9 / 178.7	SILTY CLAY Grey						180				
2.4 / 175.0	SAND to Silty SAND Brown to grey						179				
							178				
							177				
							176				
6.1	END OF BOREHOLE										

NOTES:

1. General stratigraphy interpretations are based on cuttings and auger samples only. Soil types and boundaries shown between soil types are approximate.

2. Water level measurement in Piezometer:

Date	Depth (m)	Elev. (m)
17/02/11	4.0	177.1
27/02/11	4.0	177.1

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

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

RECORD OF PROBEHOLE No. B202-P01

PROJECT No.:	09-1111-6014	**PROJECT NAME:**	Highway 69 / Still River Bridge (NBL)	**DATE:**	March 31, 2011
PROBEHOLE NUMBER:	B202-P01	**PROBEHOLE SIZE:**	NW Casing	**ELEVATION:**	178.9 m
MACHINE TYPE:	D25 Bombardier	**CONTRACTOR:**	Walker Drilling Co.	**DATUM:**	Geodetic
TEMPERATURE:	-2°C	**WEATHER:**	Sunny	**LOCATION:**	N 5074858.6 E 225156.8

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	-	Upper portion of the overburden likely consists of sand based on drilling observation.	-	-	Refusal on probable bedrock at a depth of 25.6 m below ground surface (Elev. 153.3 m).
-	25.6	Refusal to casing advancement.	-	-	-

Comments:

Water level in open hole at a depth of 0.8 m below ground surface (Elev. 178.1 m) upon completion of drilling.

Probehole backfilled with tremie bentonite grout to the surface.

PROJECT No. 09-1111-6014
PROBEHOLE No.: B202-P01
ENGINEER: TVA

RECORD OF PROBEHOLE No. B202-P02

PROJECT No.:	09-1111-6014	**PROJECT NAME:**	Highway 69 / Still River Bridge (NBL)	**DATE:**	March 31, 2011
PROBEHOLE NUMBER:	B202-P02	**PROBEHOLE SIZE:**	NW Casing	**ELEVATION:**	179.1 m
MACHINE TYPE:	D25 Bombardier	**CONTRACTOR:**	Walker Drilling Co.	**DATUM:**	Geodetic
TEMPERATURE:	-2°C	**WEATHER:**	Sunny	**LOCATION:**	N 5074864.1 E 225169.3

Depth From (m)	Depth To (m)	Soil Description	Samples No.	Samples Depth (m)	Remarks
0.0	-	Upper portion of the overburden likely consists of sand based on drilling observation.	-	-	Refusal on probable bedrock at a depth of 25.7 m below ground surface (Elev. 153.4 m).
-	25.7	Refusal to casing advancement.	-	-	-

Comments:

Artesian groundwater condition was noted while drilling; water level in open drill casing at 2.3 m above ground surface (Elev. 181.4 m), measured 53 minutes after completion of drilling.

Probehole backfilled with tremie bentonite grout to the surface.

PROJECT No. 09-1111-6014
PROBEHOLE No.: B202-P02
ENGINEER: TVA

Golder Associates

RECORD OF DCPT No B202-DC01

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

G.W.P. 5139-08-01 LOCATION N 5074869.7 ;E 225152.4 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY MAS

DATUM Geodetic DATE March 29, 2011 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	w_P w w_L WATER CONTENT (%) 25 50 75	γ kN/m³	GR SA SI CL
179.0	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						178 177 176 175 174 173 172 171 170 169 168 167 166				
165.6											
13.4	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)										

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

Golder Associates

RECORD OF DCPT No B202-DC02

SHEET 1 OF 1

METRIC

PROJECT 09-1111-6014

G.W.P. 5139-08-01 LOCATION N 5074875.3 ;E 225164.9 ORIGINATED BY MR

DIST HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY MAS

DATUM Geodetic DATE March 29, 2011 CHECKED BY TVA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
180.2	GROUND SURFACE										
0.0	Dynamic Cone Penetration Test (DCPT)						180 179 178 177 176 175 174 173 172 171 170 169 168				
167.4 12.8	END OF DCPT Refusal to Further Penetration (Hammer Bouncing)										

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

APPENDIX B

Laboratory Test Results and Cobbles/Boulders and Bedrock Core Photographs

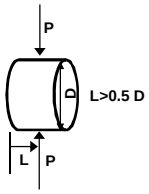
TABLE B1

POINT LOAD TEST RESULTS ON ROCK SAMPLES

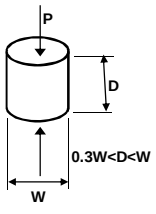
Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core [(2)] Diameter (mm)	**Is (50mm)** (MPa)	**Approx. UCS Value [(1)]** (MPa)
B202-03	1	25.03	153.77	Granite Gneiss	Diametral	56.94	47.00	1.654	31
B202-03	3	27.03	151.77	Granite Gneiss	Axial	45.20	46.99	2.719	52
B202-04	1	10.33	169.07	Granite Gneiss	Axial	42.95	47.14	10.717	204
B202-04	2	12.33	167.07	Granite Gneiss	Diametral	60.23	42.78	10.575	201
B202-05	1	5.43	171.31	Granite Gneiss	Axial	54.03	47.24	5.193	99
B202-07	2	1.61	182.69	Granite Gneiss	Diametral	54.36	45.49	9.483	180
B202-07	3	2.53	181.77	Granite Gneiss	Axial	52.09	51.37	5.304	101
B202-08	5	4.70	179.50	Granite Gneiss	Axial	31.86	37.60	8.331	158
B202-09	1	1.15	185.25	Gneiss	Diametral	49.10	45.84	8.122	154
B202-09	2	1.58	184.82	Schist	Axial	40.45	50.53	1.390	26
B202-09	3	3.10	183.30	Granite Gneiss	Diametral	57.78	45.29	14.119	268
B202-12	1	6.53	172.97	Granite Gneiss	Diametral	59.91	42.25	9.255	176

[(1)] Is_{50} x K, from ASTM Designation: D 5731 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications". A value of K = 19 has been used and is based on the average of 6 Is_{50} tests and the average of 3 UCS tests, for similar bedrock core zones.

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS
Note: Diametral tests are perpendicular to core axis (planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS
Note: Axial tests are parallel to core axis (planes of weakness)



Compiled by: TVA/TZ
Reviewed by: JPD/JMAC

TABLE B2-1
SUMMARY OF UNCONFINED COMPRESSION STRENGTH TEST RESULTS
STILL RIVER BRIDGE (NBL) STRUCTURE
HIGHWAY 69 GWP 5404-05-00; WP 5139-08-01

Borehole Number (Core Run)	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Unconfined Compression Strength (MPa)
B202-03 (3)	27.4	151.4	Granite Gneiss	47.1	69.0
B202-04 (2)	12.5	166.9	Granite Gneiss	47.2	193.2
B202-09 (3)	3.3	183.1	Granite Gneiss	50.5	175.4

Compiled By: TZ

Reviewed By: JPD/JMAC

TABLE B2-2
UNCONFINED COMPRESSION (UC) TEST
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	3
BOREHOLE NUMBER	B202-03	SAMPLE DEPTH, m	27.10-27.25

TEST CONDITIONS

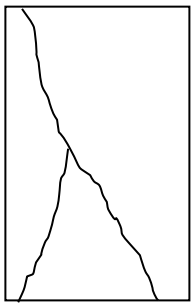
MACHINE SPEED, mm/min	0.00	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.04

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	9.58	WATER CONTENT, (specimen) %	0.39
SAMPLE DIAMETER, cm	4.71	UNIT WEIGHT, kN/m^3	24.83
SAMPLE AREA, cm^2	17.39	DRY UNIT WT., kN/m^3	24.74
SAMPLE VOLUME, cm^3	166.63	SPECIFIC GRAVITY, assumed	-
WET WEIGHT, g	422.10	VOID RATIO	-
DRY WEIGHT, g	420.46		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

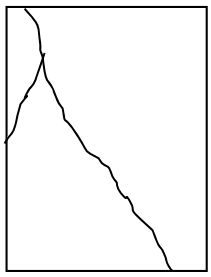
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	69.0
REMARKS: N/A		DATE:	2011-07-14
CHECKED BY: TZ		REVIEWED BY:	JPD/JMAC

TABLE B2-3
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION			
PROJECT NUMBER	09-1111-6014	RUN NUMBER	2
BOREHOLE NUMBER	B202-04	SAMPLE DEPTH, m	12.40-12.55
TEST CONDITIONS			
MACHINE SPEED, mm/min	0.00	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.32
SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	10.93	WATER CONTENT, (specimen) %	0.09
SAMPLE DIAMETER, cm	4.72	UNIT WEIGHT, kN/m^3	27.11
SAMPLE AREA, cm^2	17.50	DRY UNIT WT., kN/m^3	27.09
SAMPLE VOLUME, cm^3	191.25	SPECIFIC GRAVITY, assumed	-
WET WEIGHT, g	528.90	VOID RATIO	-
DRY WEIGHT, g	528.42		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS			
STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	193.2
REMARKS:	N/A	DATE:	2011-07-14
CHECKED BY:	TZ	REVIEWED BY:	JPD/JMAC

TABLE B2-4
UNCONFINED COMPRESSION TEST (UC)
ASTM D 7012-07

SAMPLE IDENTIFICATION

PROJECT NUMBER	09-1111-6014	RUN NUMBER	3
BOREHOLE NUMBER	B202-09	SAMPLE DEPTH, m	3.23-3.38

TEST CONDITIONS

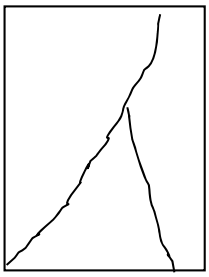
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.32

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.70	WATER CONTENT, (specimen) %	0.07
SAMPLE DIAMETER, cm	5.05	UNIT WEIGHT, kN/m^3	27.29
SAMPLE AREA, cm^2	20.03	DRY UNIT WT., kN/m^3	27.27
SAMPLE VOLUME, cm^3	234.35	SPECIFIC GRAVITY, assumed	-
WET WEIGHT, g	652.45	VOID RATIO	-
DRY WEIGHT, g	651.98		

VISUAL INSPECTION

FAILURE SKETCH



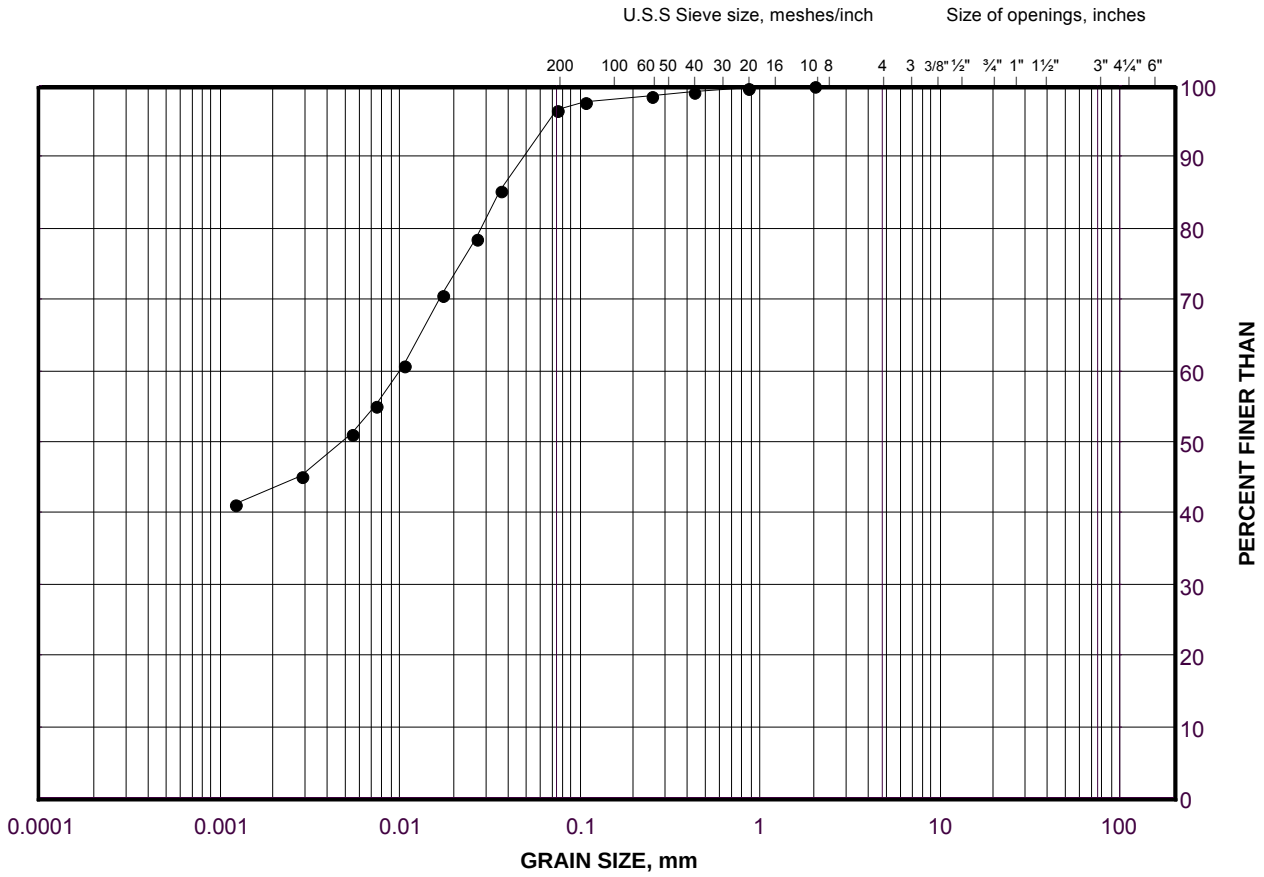
TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	175.4
REMARKS: N/A		DATE:	4/8/2011
CHECKED BY: TZ		REVIEWED BY:	JPD/JMAC

GRAIN SIZE DISTRIBUTION

Silty Clay (Near Surface)
South Abutment

FIGURE B1



LEGEND

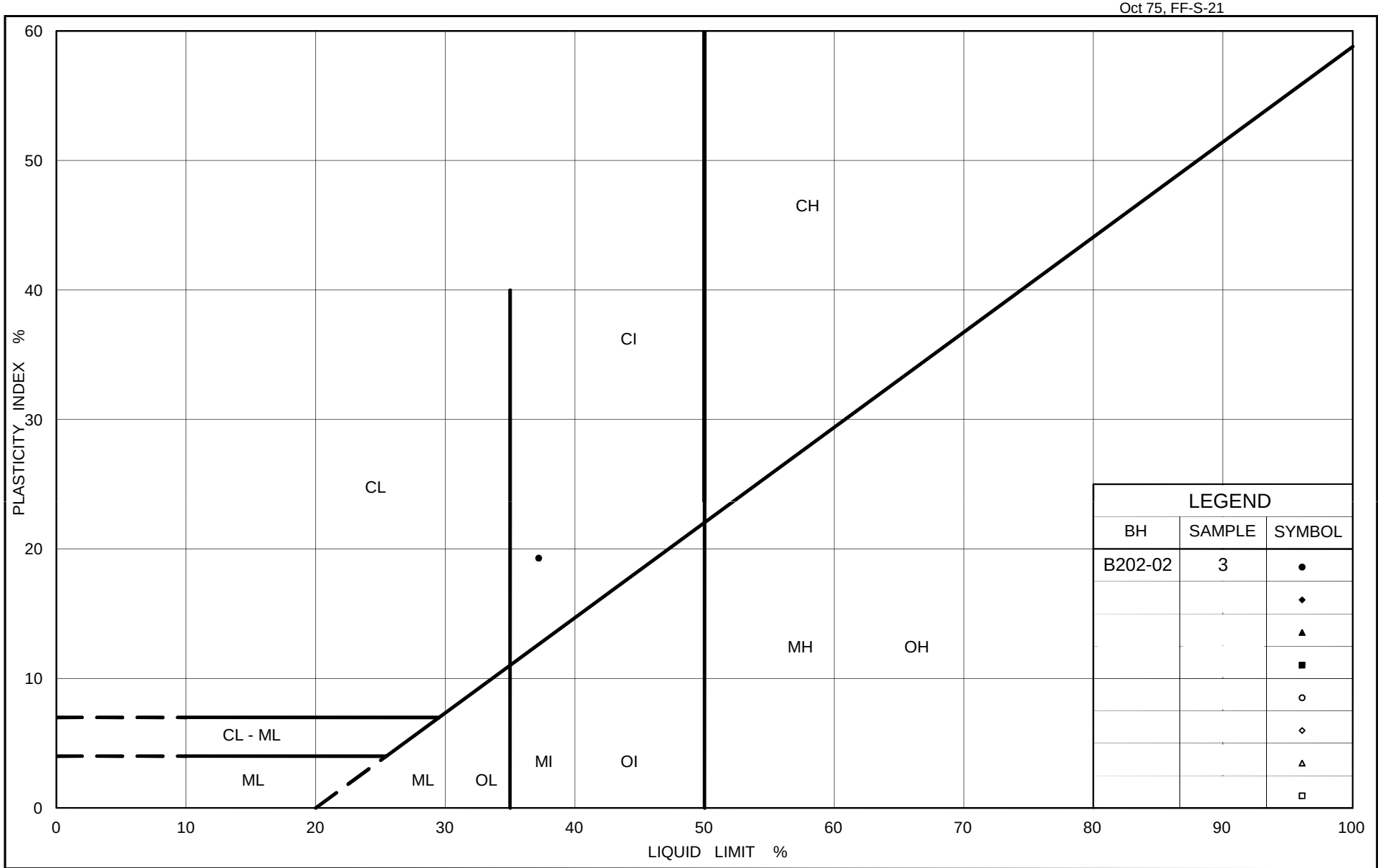
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-02	3	179.2

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Nov-11



Ministry of Transportation

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PLASTICITY CHART
Silty Clay (Near Surface)
South Abutment

Figure No. B2

Project No. 09-1111-6014

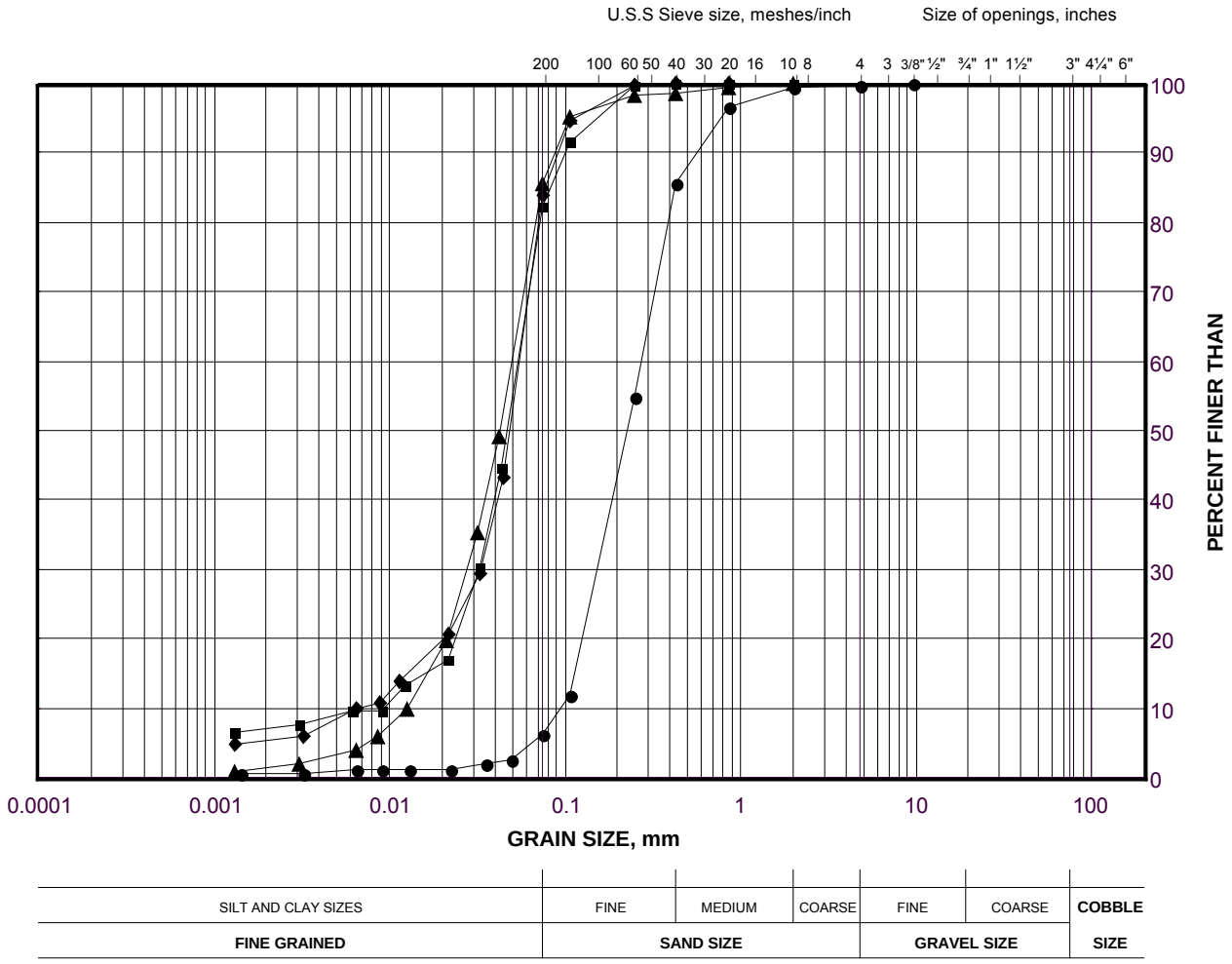
Checked By: TZ

GRAIN SIZE DISTRIBUTION

Sand to Silt (Upper)

South Abutment and Approach

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-01	4	177.8
■	B202-02	6	176.1
◆	S204-18	6	177.0
▲	B202-02	8	173.5

Project Number: 09-1111-6014

Checked By: TZ

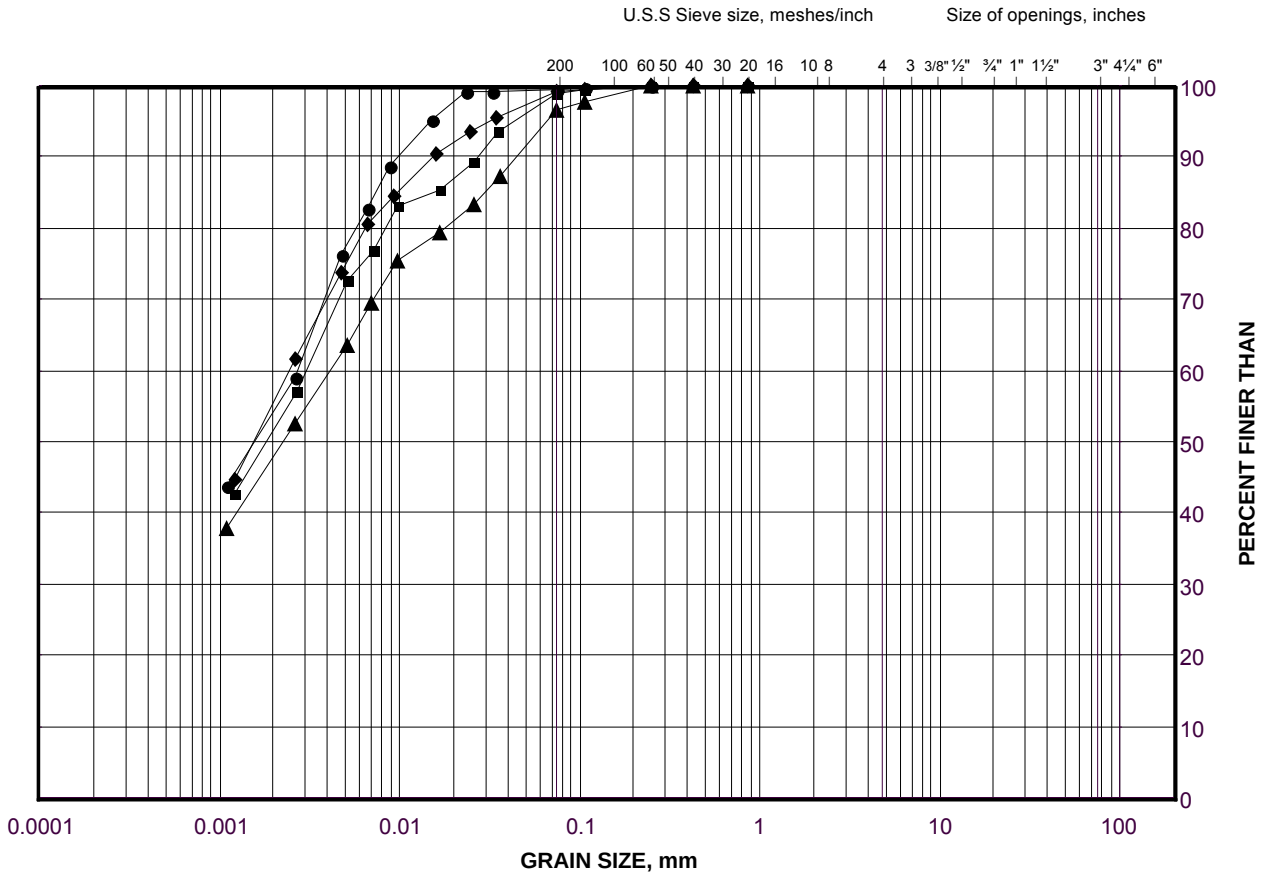
Golder Associates

Date: 29-Nov-11

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay (Upper)
South Abutment and Approach

FIGURE B4



LEGEND

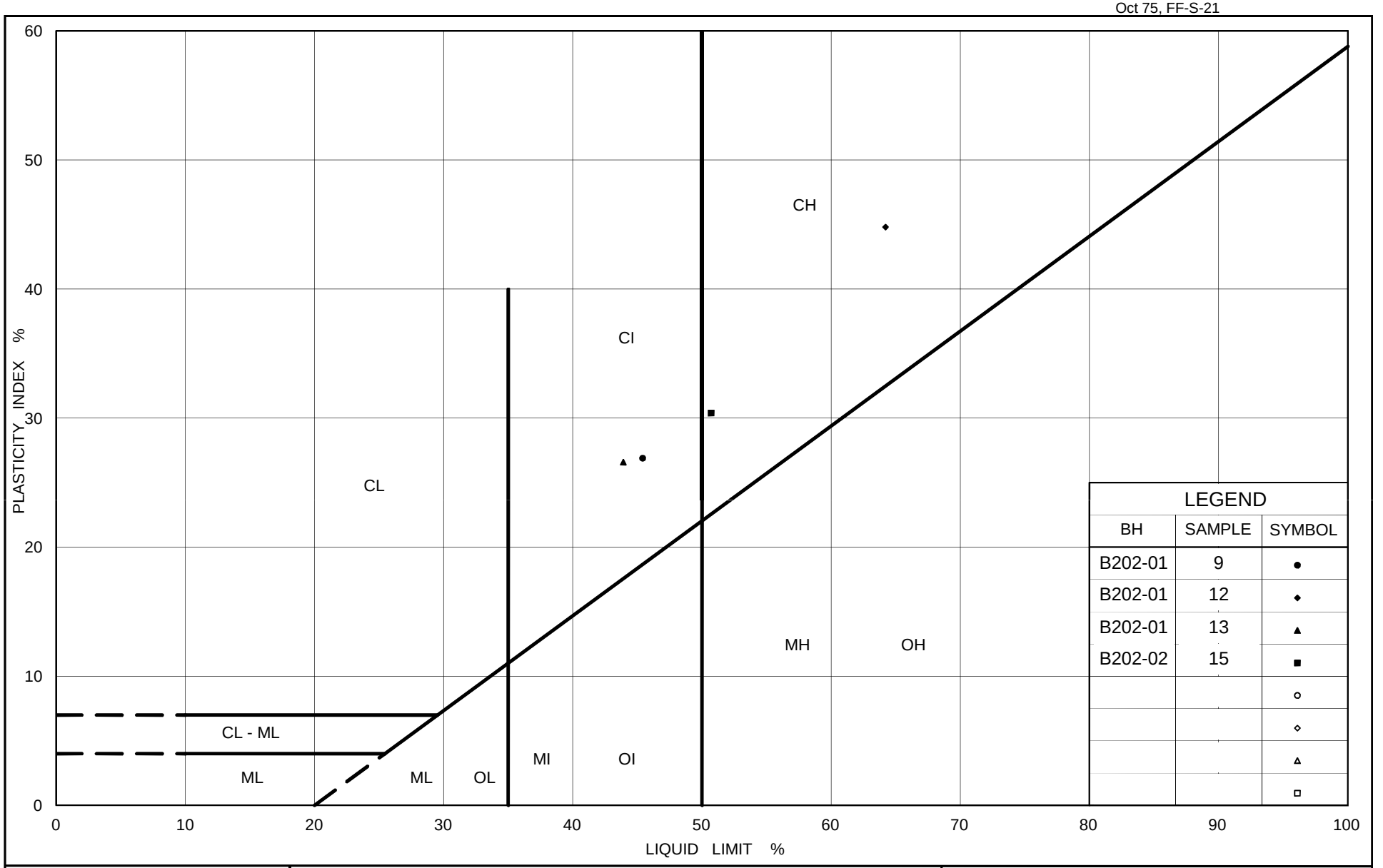
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-01	13	165.6
■	S204-18	13	167.5
◆	B202-02	15	163.0
▲	B202-01	9	171.7

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Nov-11



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PLASTICITY CHART
Silty Clay to Clay (Upper)
South Abutment and Approach

Figure No. B5

Project No. 09-1111-6014

Checked By: TZ

CONSOLIDATION TEST SUMMARY

FIGURE B6
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	12
Borehole Number	B202-01	Sample Depth, m	13.72-14.17

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	6		
Date Started	7/14/2011		
Date Completed	8/03/2011		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m^3	16.63
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	10.70
Area, cm^2	31.48	Specific Gravity, measured	2.77
Volume, cm^3	59.62	Solids Height, cm	0.746
Water Content, %	55.35	Volume of Solids, cm^3	23.49
Wet Mass, g	101.10	Volume of Voids, cm^3	36.13
Dry Mass, g	65.08	Degree of Saturation, %	99.7

TEST COMPUTATIONS

Pressure	Corr. Height	Void	Average Height	t_{90}	c_v	m_v	k
kPa	cm	Ratio	cm	sec	cm^2/s	m^2/kN	cm/s
0.00	1.894	1.538	1.894				
5.04	1.894	1.538	1.894	2	3.80E-01		
9.99	1.893	1.537	1.894	330	2.30E-03	7.47E-05	1.69E-08
20.49	1.889	1.531	1.891	167	4.54E-03	2.16E-04	9.62E-08
40.01	1.880	1.519	1.885	305	2.47E-03	2.38E-04	5.76E-08
78.94	1.860	1.492	1.870	609	1.22E-03	2.81E-04	3.35E-08
156.84	1.810	1.426	1.835	306	2.33E-03	3.33E-04	7.62E-08
311.51	1.617	1.166	1.714	923	6.74E-04	6.61E-04	4.37E-08
622.54	1.449	0.941	1.533	789	6.31E-04	2.86E-04	1.77E-08
1246.59	1.324	0.774	1.386	519	7.85E-04	1.05E-04	8.11E-09
2494.73	1.223	0.639	1.273	383	8.98E-04	4.27E-05	3.76E-09
1246.59	1.238	0.659	1.230				
311.51	1.269	0.700	1.253				
78.94	1.313	0.759	1.291				
20.49	1.354	0.815	1.333				
5.04	1.385	0.855	1.369				

Note:
k calculated using cv based on t_{90} values.
Specimen swelled under 5kPa

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.38	Unit Weight, kN/m^3	19.38
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	14.64
Area, cm^2	31.48	Specific Gravity, measured	2.77
Volume, cm^3	43.59	Solids Height, cm	0.746
Water Content, %	32.34	Volume of Solids, cm^3	23.49
Wet Mass, g	86.13	Volume of Voids, cm^3	20.09
Dry Mass, g	65.08		

Prepared By: LH

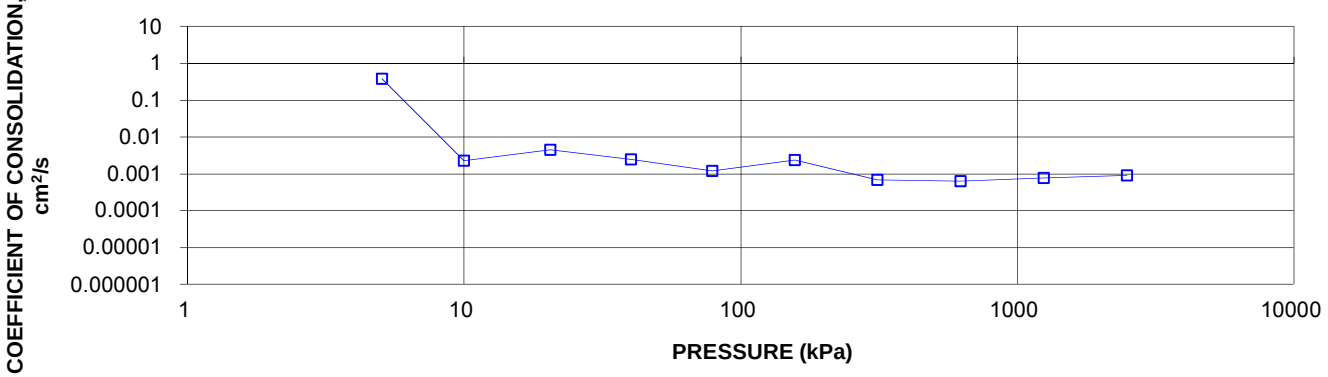
Golder Associates

Checked By: TZ

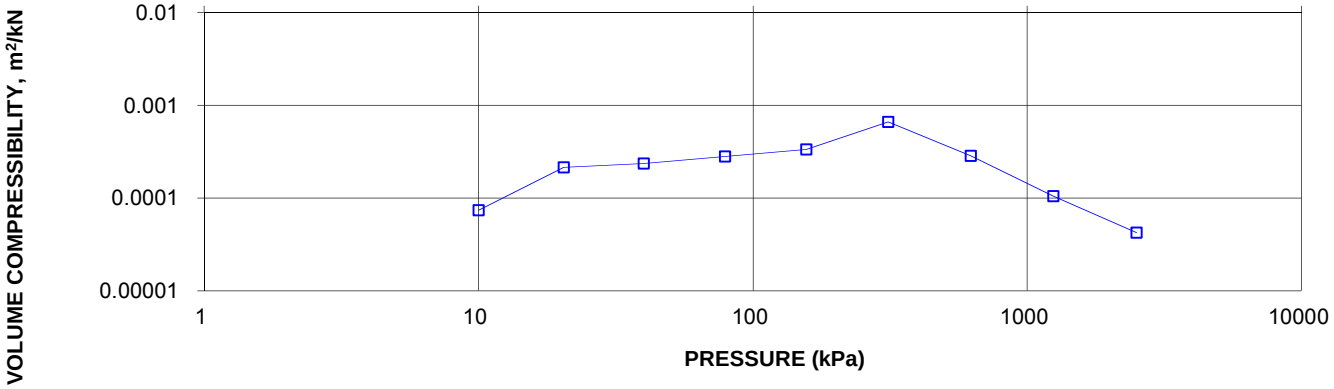
CONSOLIDATION TEST SUMMARY

FIGURE B6
Sheet 2 of 4

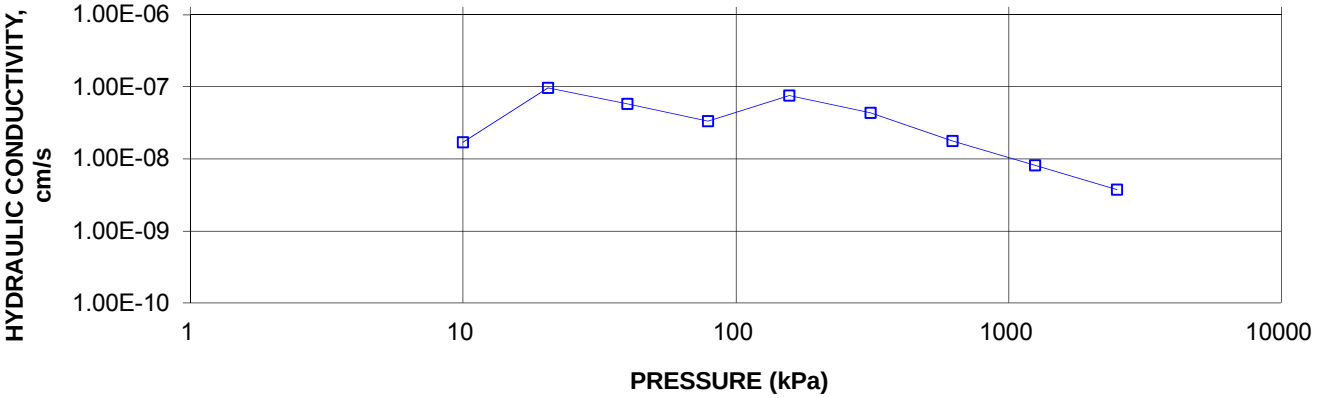
CONSOLIDATION TEST
C_V cm²/s VS PRESSURE (kPa)
BH B202-01 SA 12



CONSOLIDATION TEST
M_V m²/kN vs PRESSURE (kPa)
BH B202-01 SA 12



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH B202-01 SA 12



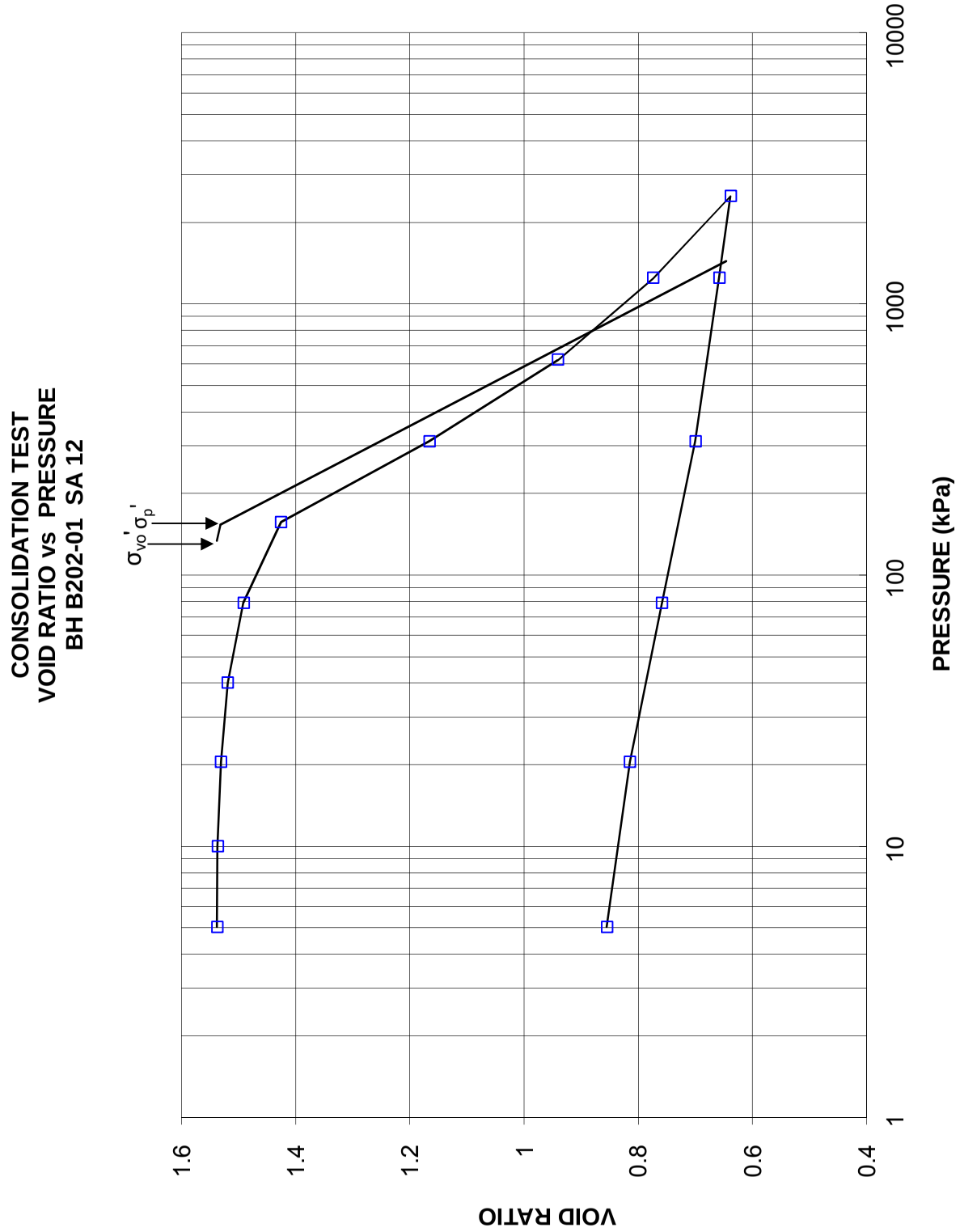
Project No. 09-1111-6014
Prepared By: LH

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE

FIGURE B6
Sheet 3 of 4



Project No. 09-1111-6014

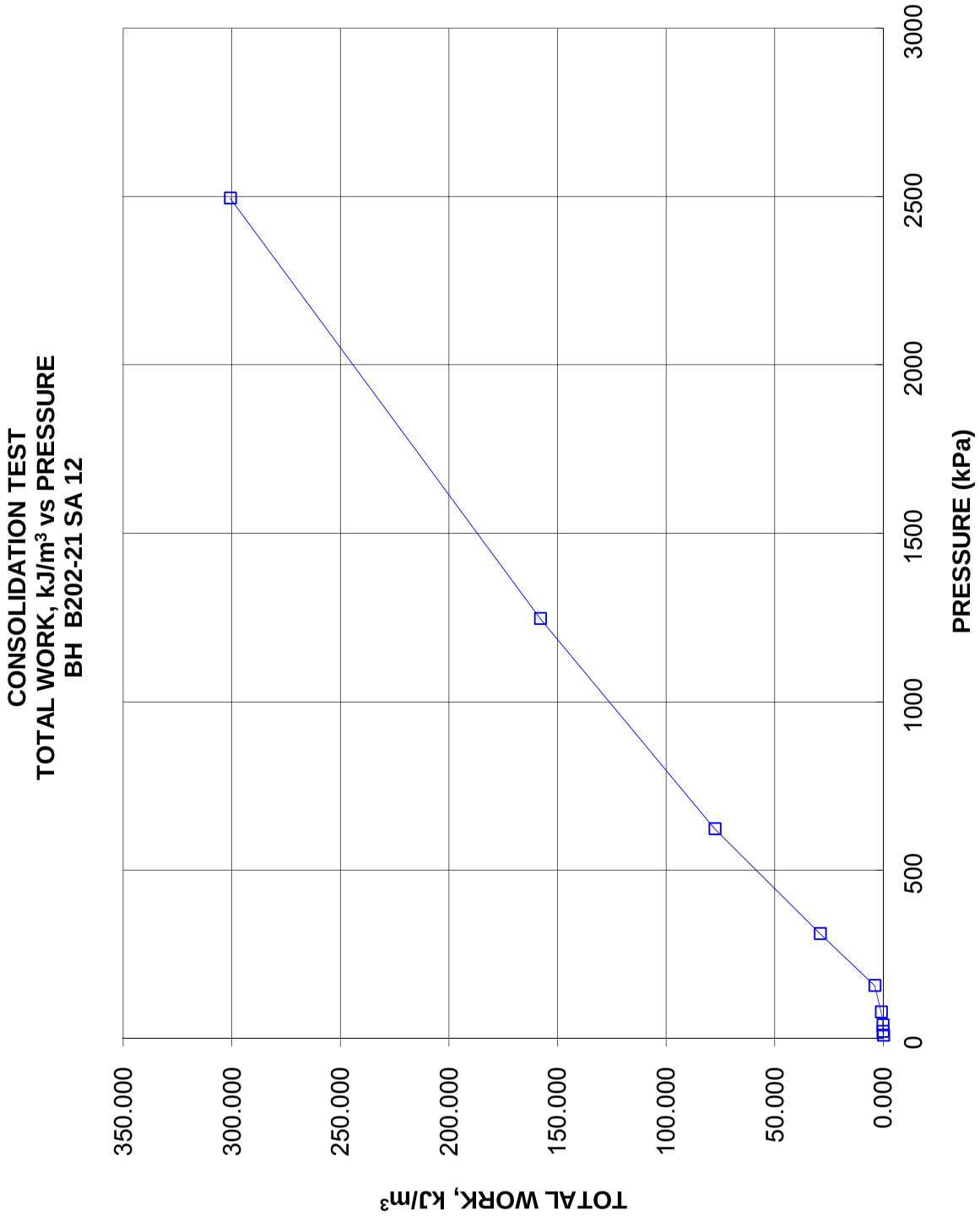
Prepared By: LH/TZ

Golder Associates

Checked By: TZ

CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B6
Sheet 4 of 4



Project No. 09-1111-6014

Prepared By: LH

Golder Associates

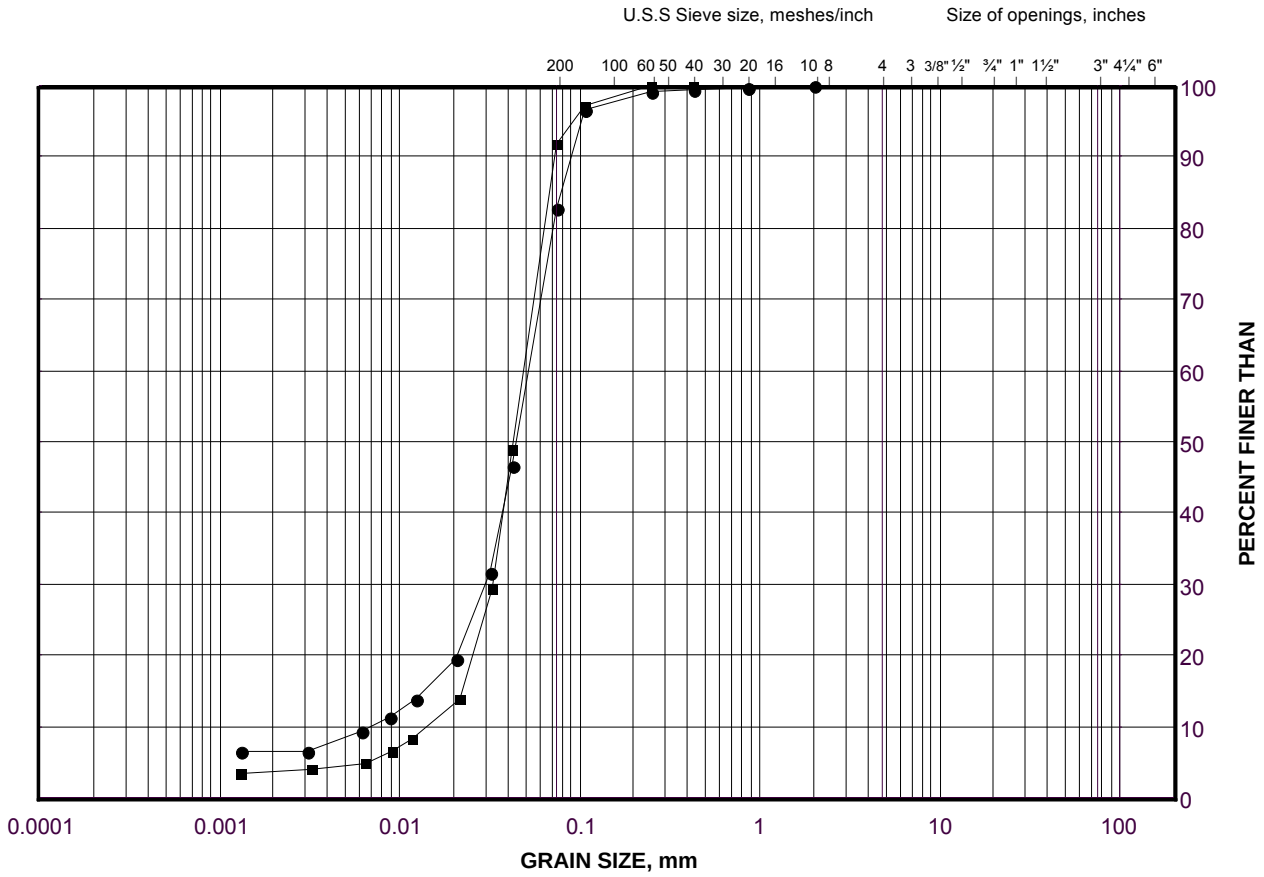
Checked By: TZ

GRAIN SIZE DISTRIBUTION

Silt Interlayers

South Abutment and Approach

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-02	11	170.0
■	S204-18	17	159.5

Project Number: 09-1111-6014

Checked By: TZ

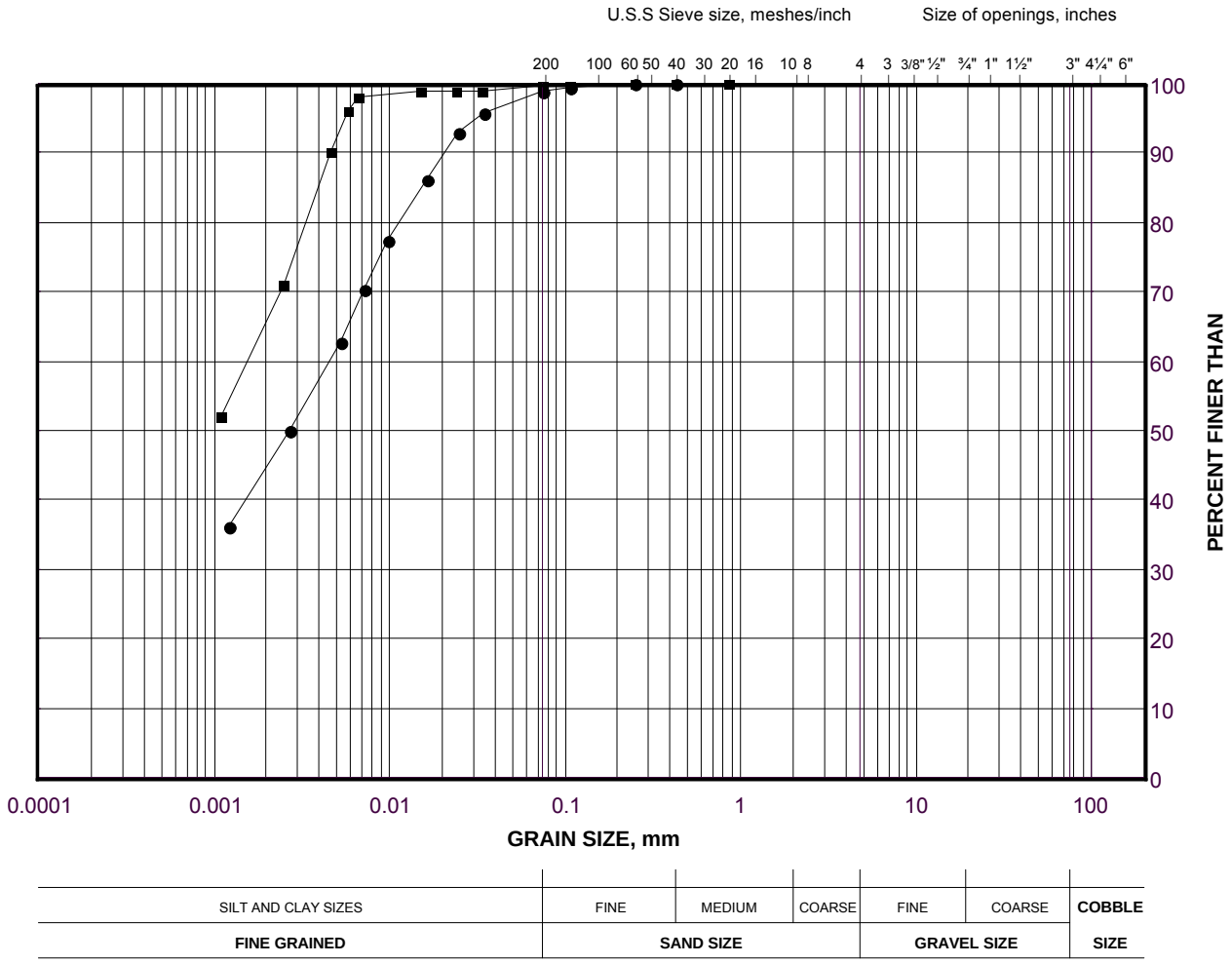
Golder Associates

Date: 29-Feb-12

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay (Lower)
South Abutment and Approach

FIGURE B8



LEGEND

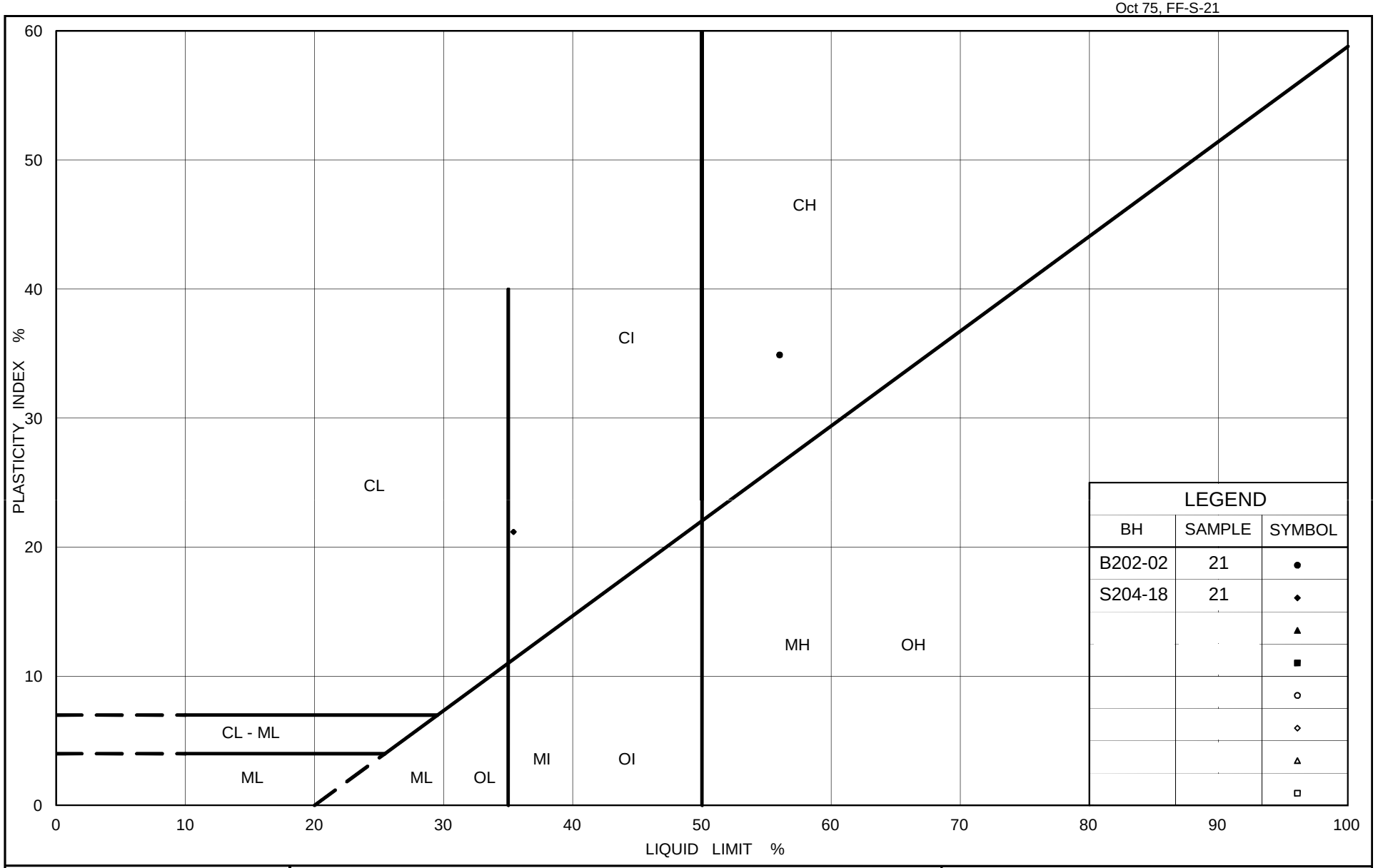
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-18	20	150.8
■	B202-02	21	144.7

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Nov-11



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PLASTICITY CHART
Silty Clay to Clay (Lower)
South Abutment and Approach

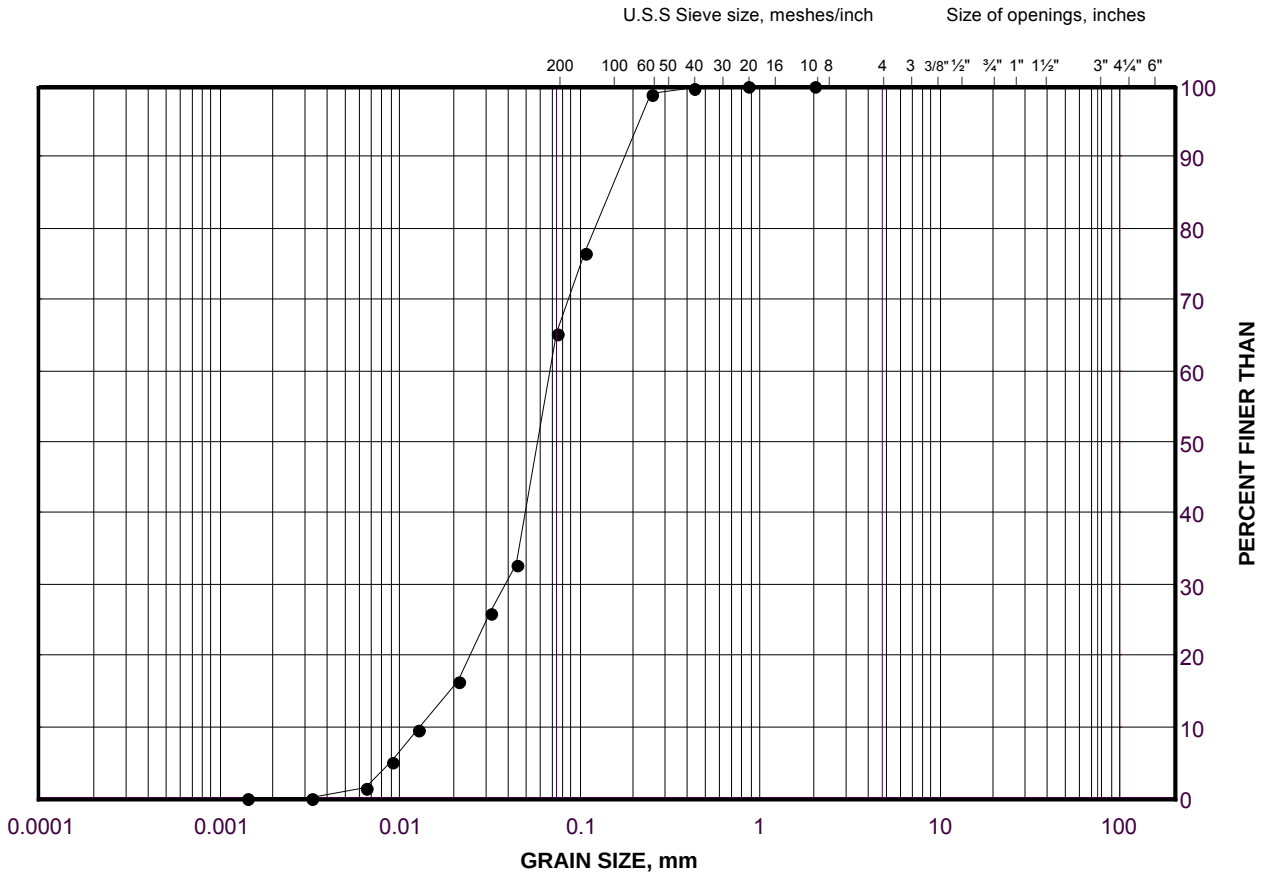
Figure No. B9

Project No. 09-1111-6014

Checked By: TZ

GRAIN SIZE DISTRIBUTION
Sand and Silt (Lower)
South Approach

FIGURE B10



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S204-18	23	141.6

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

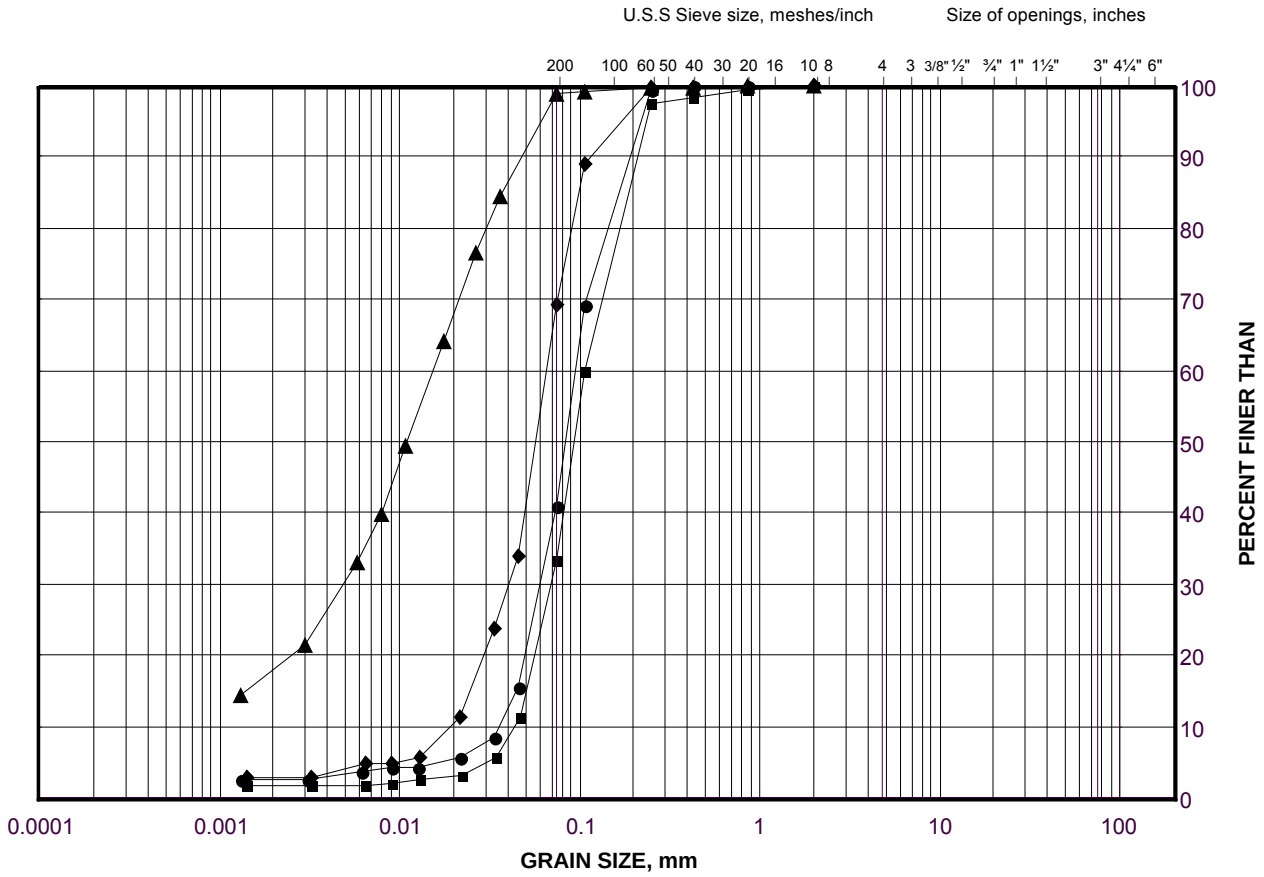
Date: 29-Nov-11

GRAIN SIZE DISTRIBUTION

Sand and Silt to Silt

Centre Pier

FIGURE B11



LEGEND

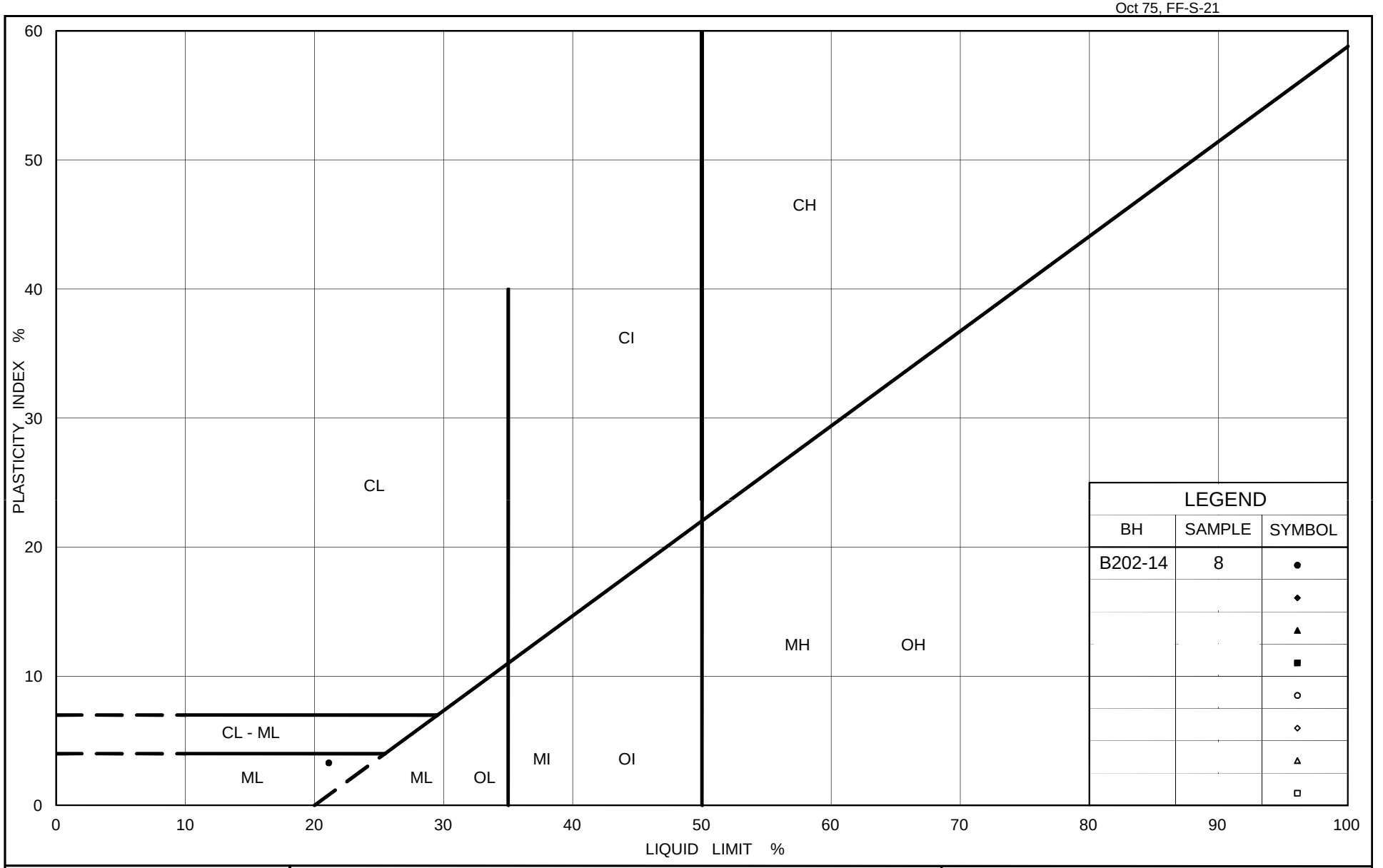
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-14	4	176.1
■	B202-15	5	175.1
◆	B202-03	7	174.3
▲	B202-14	8	171.5

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Nov-11



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt
Centre Pier

Figure No. B12

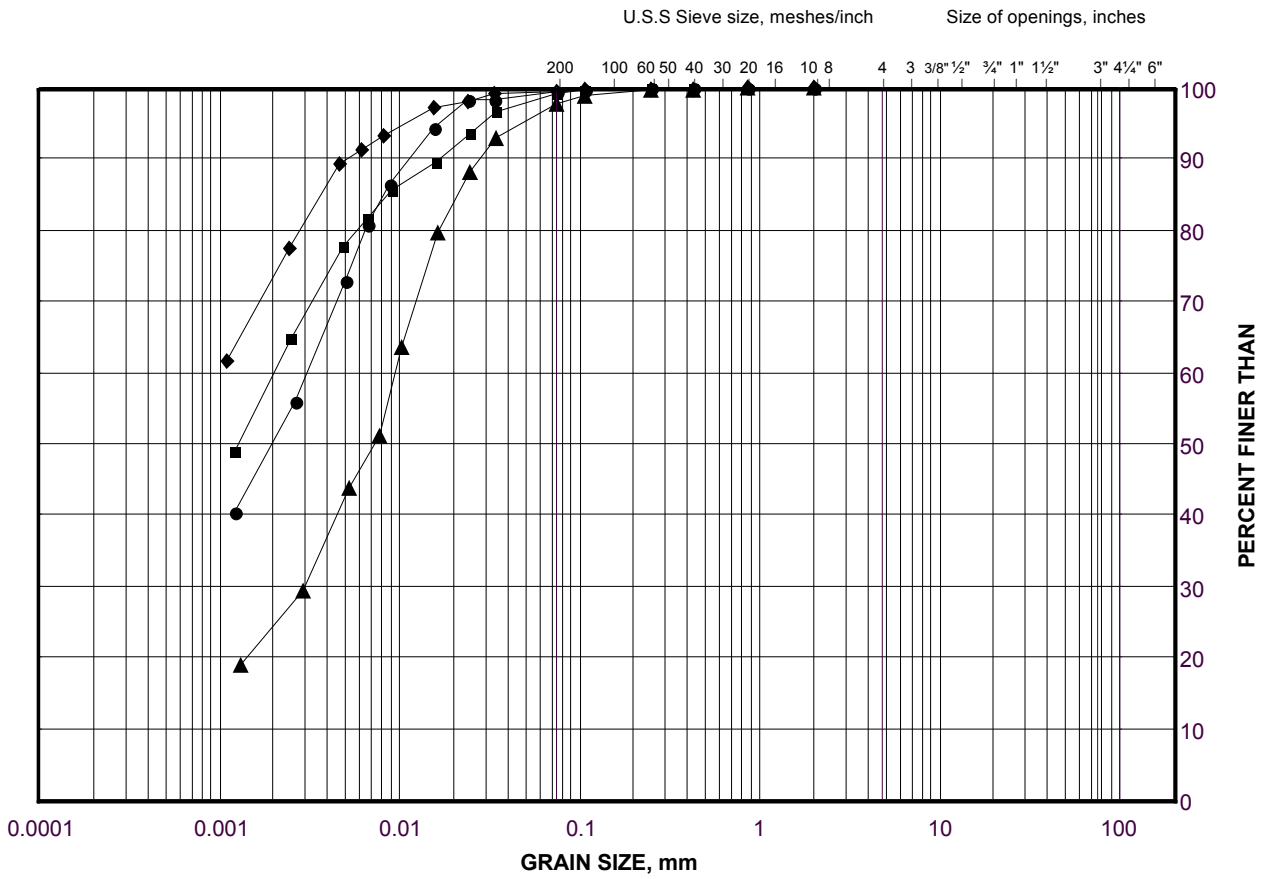
Project No. 09-1111-6014

Checked By: TZ

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clay
Centre Pier

FIGURE B13



LEGEND

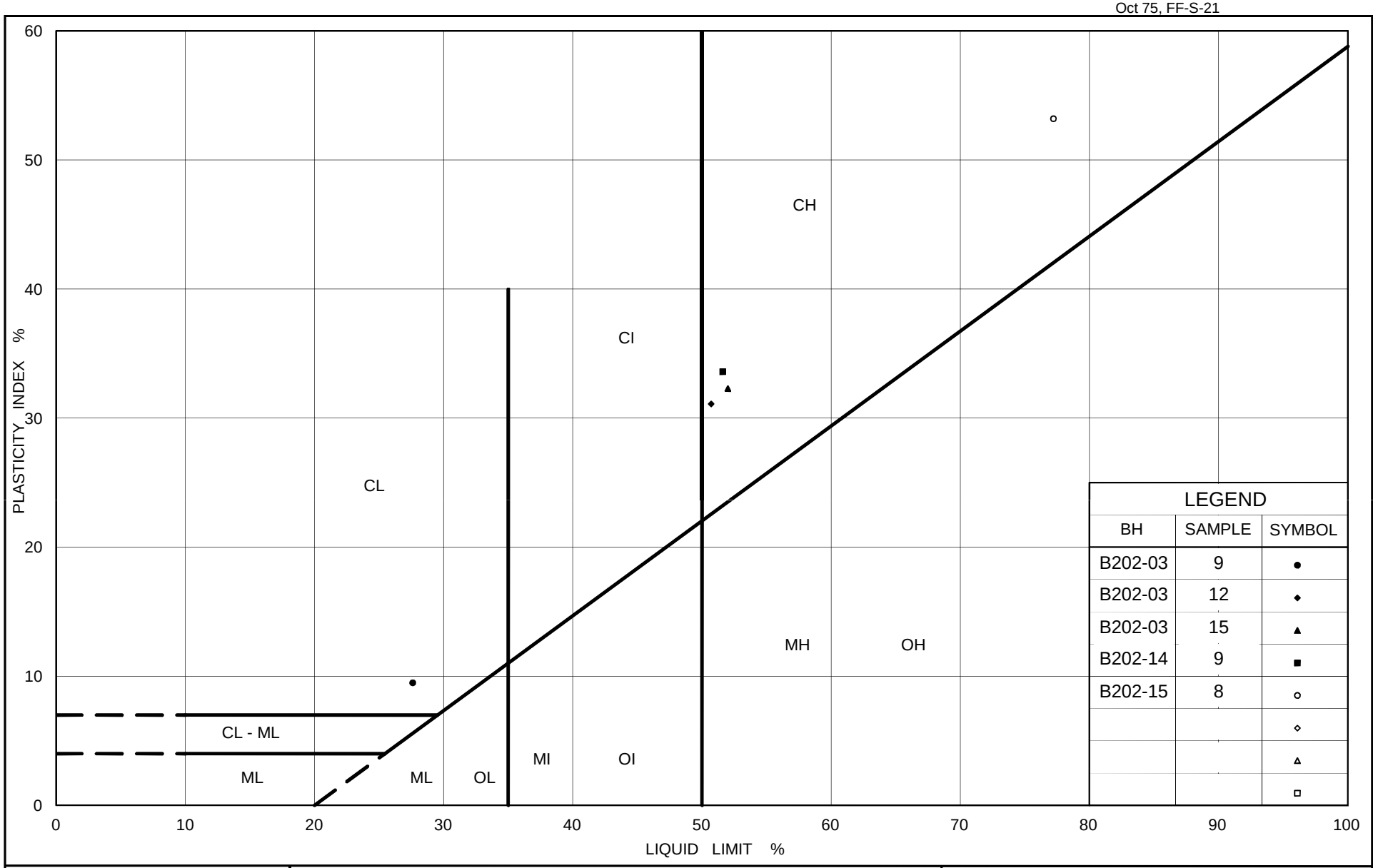
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-03	12	166.7
■	B202-03	15	160.6
◆	B202-15	8	168.2
▲	B202-03	9	171.2

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Feb-12



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Ontario

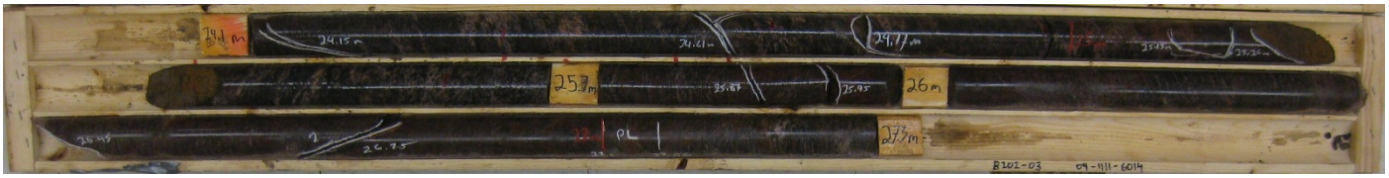
PLASTICITY CHART
Clayey Silt to Clay
Centre Pier

Figure No. B14

Project No. 09-1111-6014

Checked By: TZ

Borehole B202-03



Box 1: 24.11 m – 27.34 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Scale

PROJECT

Still River Bridge (NBL) Structure
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE

Bedrock Core Photograph – Centre Pier

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	TZ		SCALE NTS	REV.
CADD	--		**FIGURE B15**	
CHECK	TZ			
REVIEW	CN			

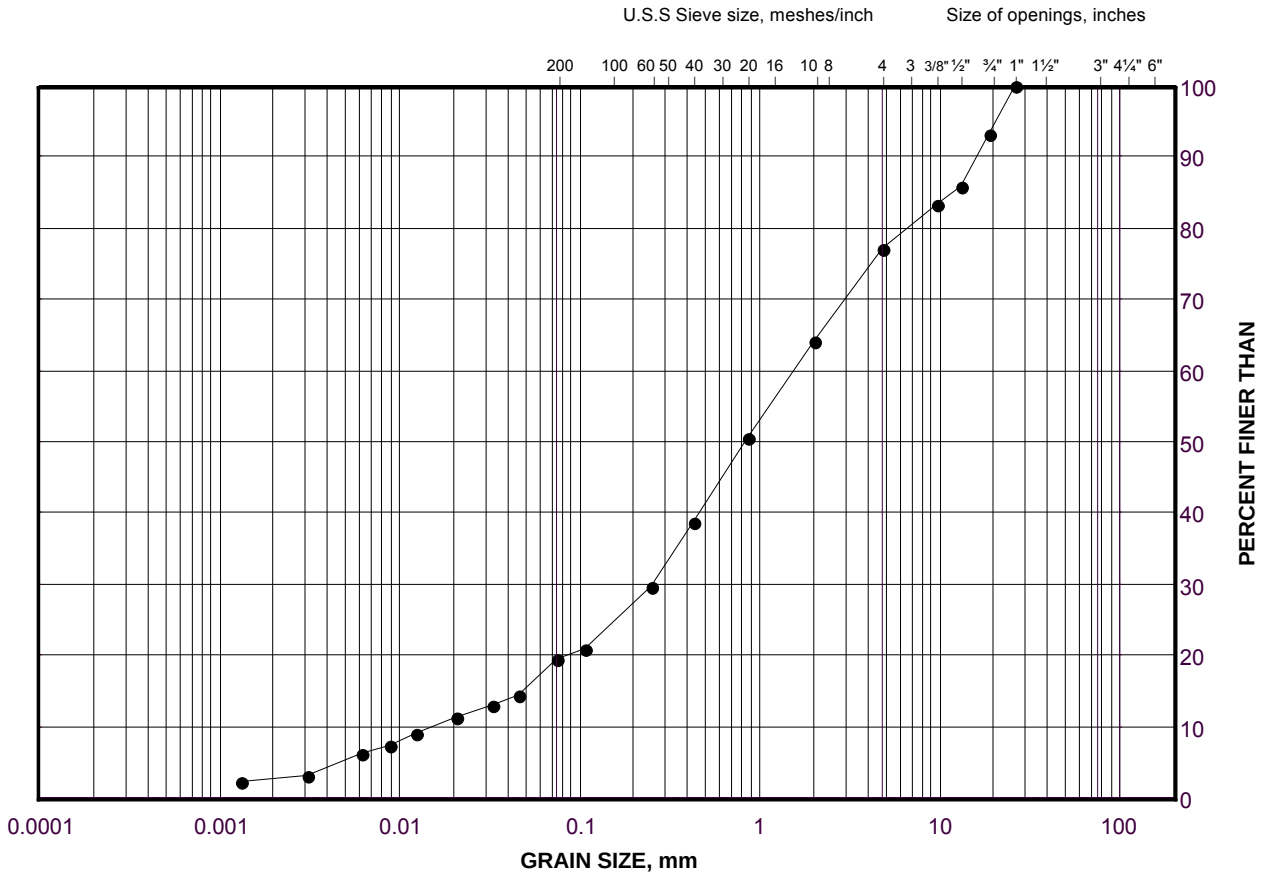
REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

GRAIN SIZE DISTRIBUTION

Gravelly Sand

North Abutment (Two-Span Bridge)

FIGURE B16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-06	1B	183.5

Project Number: 09-1111-6014

Checked By: TZ

Golder Associates

Date: 29-Nov-11

Borehole B202-07

Box 1: 0.58 m – 4.17 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT	**Still River Bridge (NBL) Structure Highway 69 Four-Laning GWP 5404-05-00; WP 5139-08-01**
TITLE	**Cobbles/Boulders and Bedrock Core Photograph – North Abutment (Two-Span Bridge)**

Golder Associates

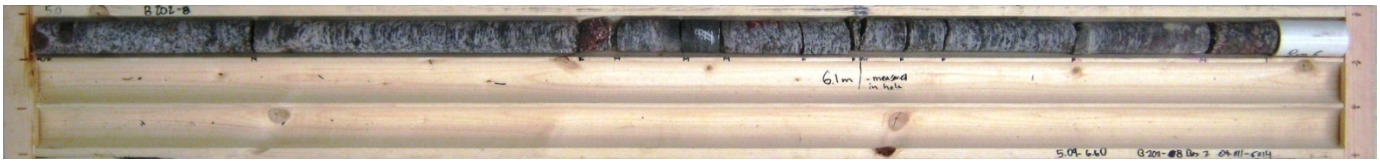
PROJECT No. 09-1111-6014			FILE No.	----	
DESIGN	TZ		SCALE	NTS	REV.
CADD	--		**FIGURE B17**		
CHECK	TZ				
REVIEW	CN				

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

Borehole B202-08

Box 1: 0.33 m – 0.86 m; 1.19 m – 1.89 m; 2.00 m – 5.09 m

Borehole B202-08



Box 2: 5.09 m – 6.60 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Scale

PROJECT: **Still River Bridge (NBL) Structure**
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE: **Cobbles/Boulders and Bedrock Core Photograph – North Abutment (Two-Span Bridge)**

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----		
DESIGN	TZ		SCALE NTS	REV.	
CADD	--				
CHECK	TZ				
REVIEW	CN				

FIGURE B18

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

Borehole B202-09

Box 1: 0.27 m – 3.70 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT

Still River Bridge (NBL) Structure
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE

Bedrock Core Photograph – North Abutment (Two-Span Bridge)

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	TZ		SCALE NTS	REV.
CADD	--		**FIGURE B19**	
CHECK	TZ			
REVIEW	CN			

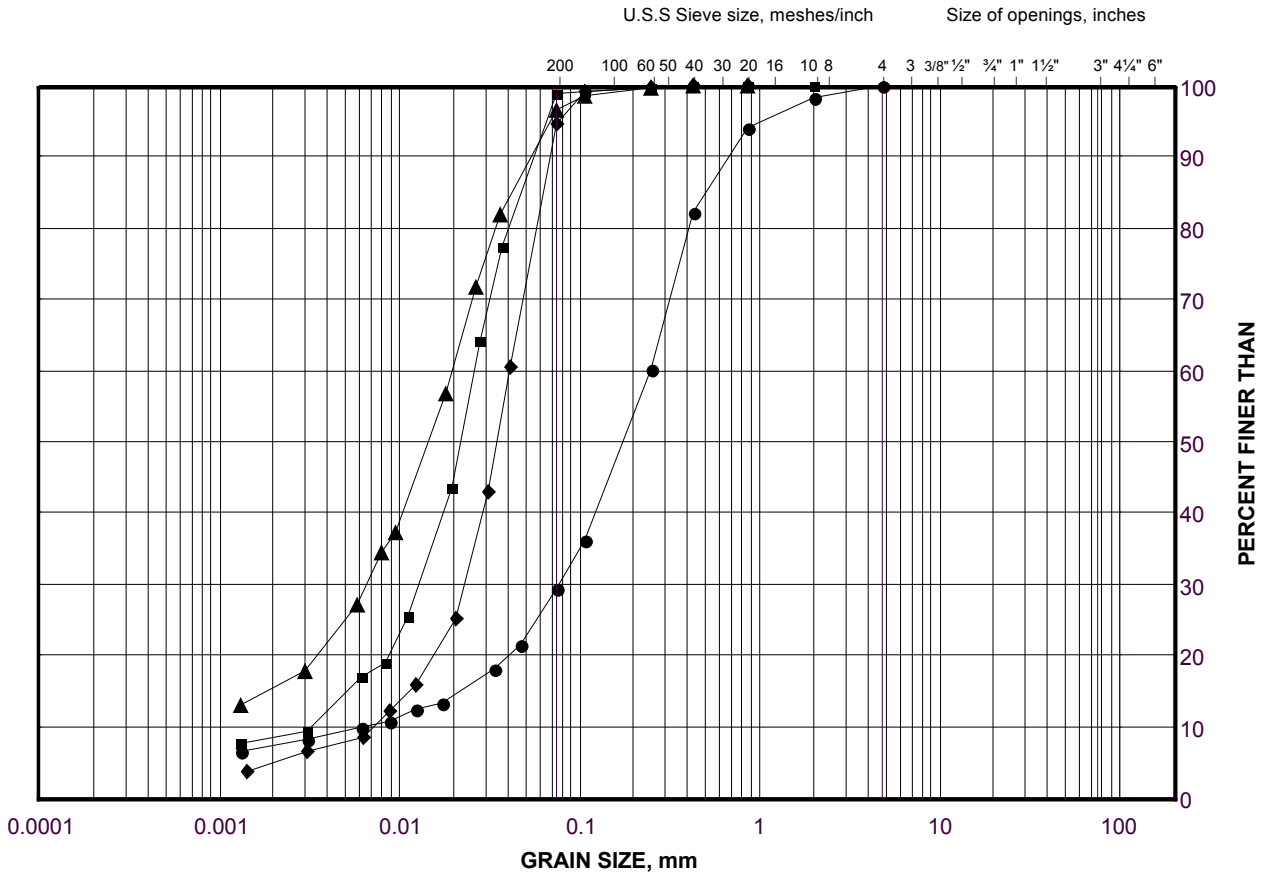
REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

GRAIN SIZE DISTRIBUTION

Silty Sand to Silt

North Abutment (One-Spand Bridge)

FIGURE B20



LEGEND

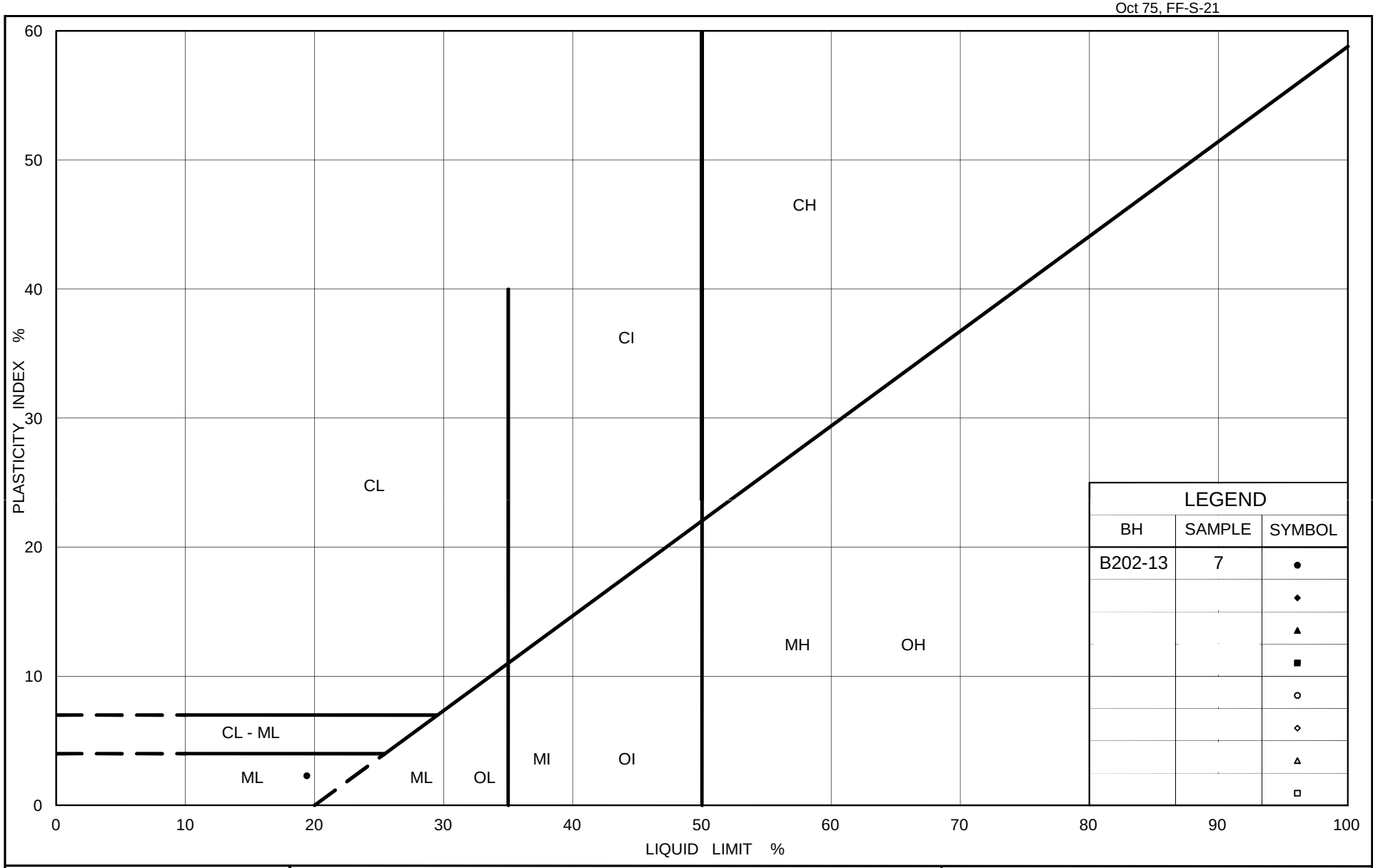
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-12	3	177.7
■	B202-04	5	176.4
◆	B202-13	5	176.4
▲	B202-13	7	174.8

Project Number: 09-1111-6014,09-1111-0018

Checked By: TZ

Golder Associates

Date: 29-Feb-12



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt
North Abutment (One-Span Bridge)

Figure No. B21

Project No. 09-1111-6014

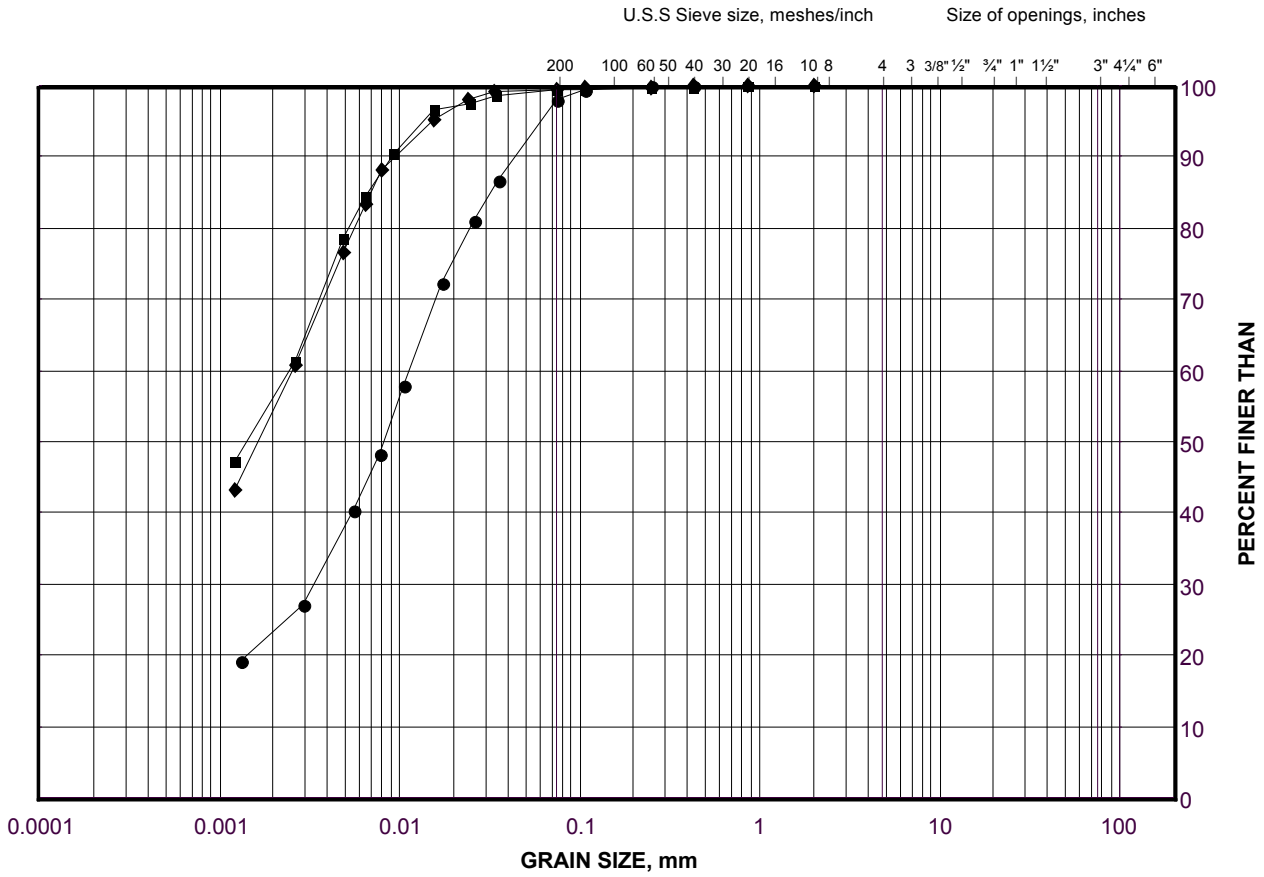
Checked By: TZ

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

North Abutment and Approach (One-Spand Bridge)

FIGURE B22



LEGEND

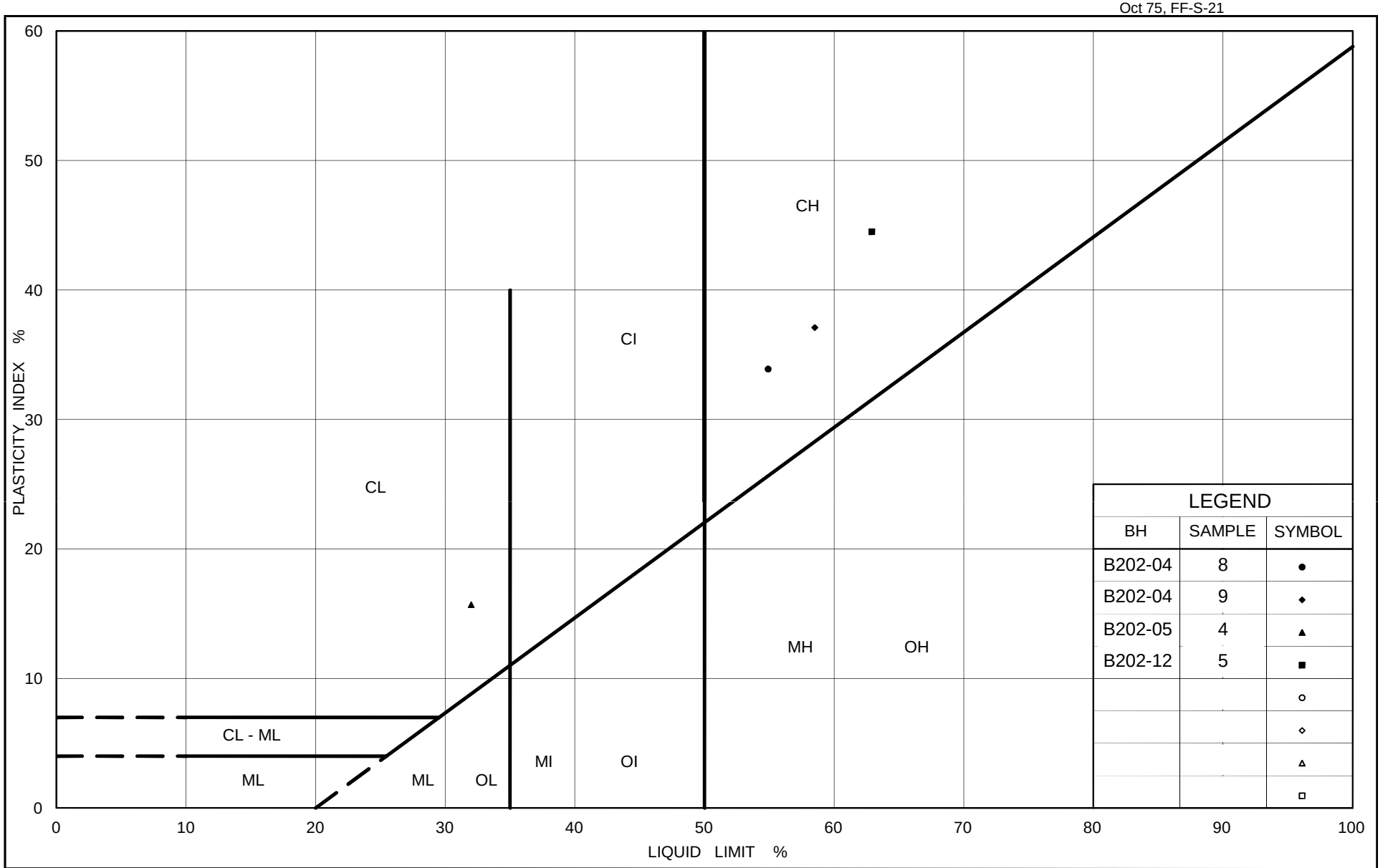
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B202-05	4	178.7
■	B202-12	5	175.5
◆	B202-04	8	173.3

Project Number: 09-1111-6014

Checked By: _____

Golder Associates

Date: 29-Feb-12



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt to Clay

North Abutment and Approach (One-Span Bridge)

Figure No. B23

Project No. 09-1111-6014

Checked By: TZ

CONSOLIDATION TEST SUMMARY

FIGURE B24
Sheet 1 of 4

SAMPLE IDENTIFICATION

Project Number	09-1111-6014	Sample Number	9
Borehole Number	B202-04	Sample Depth, m	7.32-7.75

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	7/14/2011		
Date Completed	7/28/2011		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m^3	16.54
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	10.60
Area, cm^2	31.46	Specific Gravity, measured	2.77
Volume, cm^3	59.46	Solids Height, cm	0.737
Water Content, %	56.07	Volume of Solids, cm^3	23.20
Wet Mass, g	100.29	Volume of Voids, cm^3	36.26
Dry Mass, g	64.26	Degree of Saturation, %	99.4

TEST COMPUTATIONS

Pressure	Corr. Height	Void	Average Height	t_{90}	c_v	m_v	k
kPa	cm	Ratio	cm	sec	cm^2/s	m^2/kN	cm/s
0.00	1.890	1.563	1.890				
5.04	1.892	1.566	1.891	1	7.58E-01		
9.99	1.896	1.571	1.894	2	3.80E-01		
20.47	1.885	1.556	1.891	113	6.71E-03	5.65E-04	3.72E-07
40.04	1.874	1.542	1.880	383	1.96E-03	2.89E-04	5.54E-08
79.04	1.858	1.519	1.866	420	1.76E-03	2.28E-04	3.93E-08
156.78	1.814	1.460	1.836	290	2.46E-03	2.98E-04	7.20E-08
315.86	1.595	1.163	1.704	1385	4.45E-04	7.28E-04	3.17E-08
627.57	1.424	0.931	1.509	706	6.84E-04	2.90E-04	1.95E-08
1250.02	1.307	0.772	1.365	519	7.61E-04	9.93E-05	7.41E-09
2493.47	1.206	0.636	1.257	452	7.41E-04	4.27E-05	3.10E-09
1250.02	1.220	0.654	1.213				
315.86	1.256	0.703	1.238				
79.04	1.307	0.773	1.281				
20.47	1.349	0.830	1.328				
5.04	1.378	0.869	1.364				

Note:
k calculated using cv based on t_{90} values.
Specimen swelled under 10 kPa

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.38	Unit Weight, kN/m^3	19.28
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	14.53
Area, cm^2	31.46	Specific Gravity, measured	2.77
Volume, cm^3	43.36	Solids Height, cm	0.737
Water Content, %	32.66	Volume of Solids, cm^3	23.20
Wet Mass, g	85.25	Volume of Voids, cm^3	20.17
Dry Mass, g	64.26		

Prepared By: LH

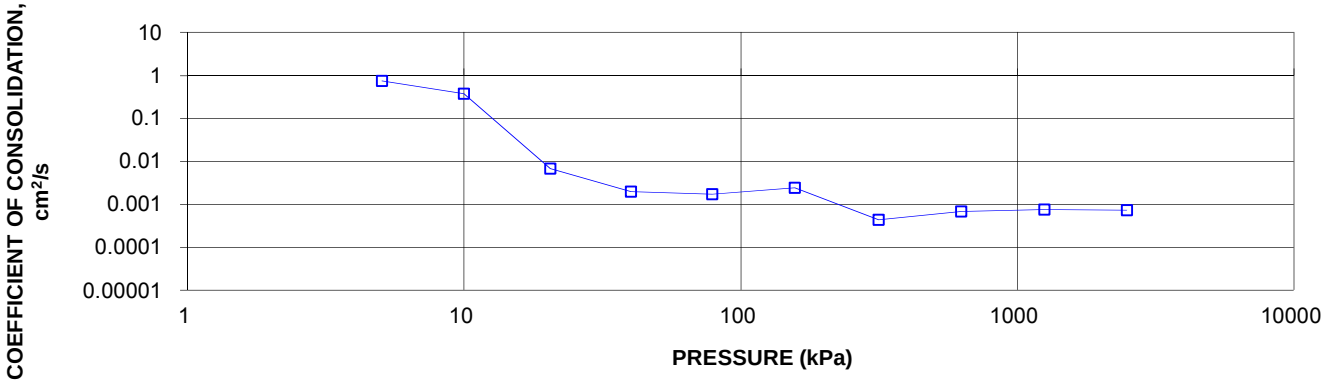
Golder Associates

Checked By: TZ

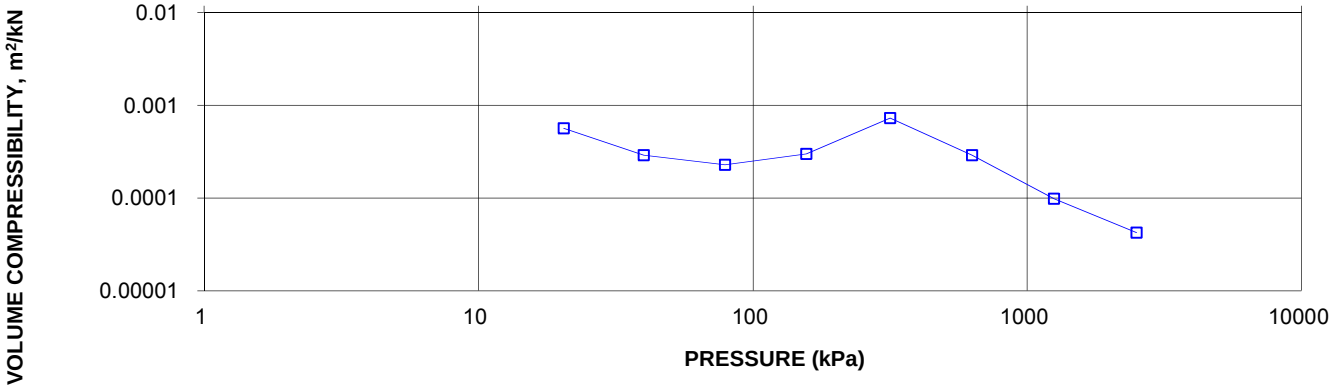
CONSOLIDATION TEST SUMMARY

FIGURE B24
Sheet 2 of 4

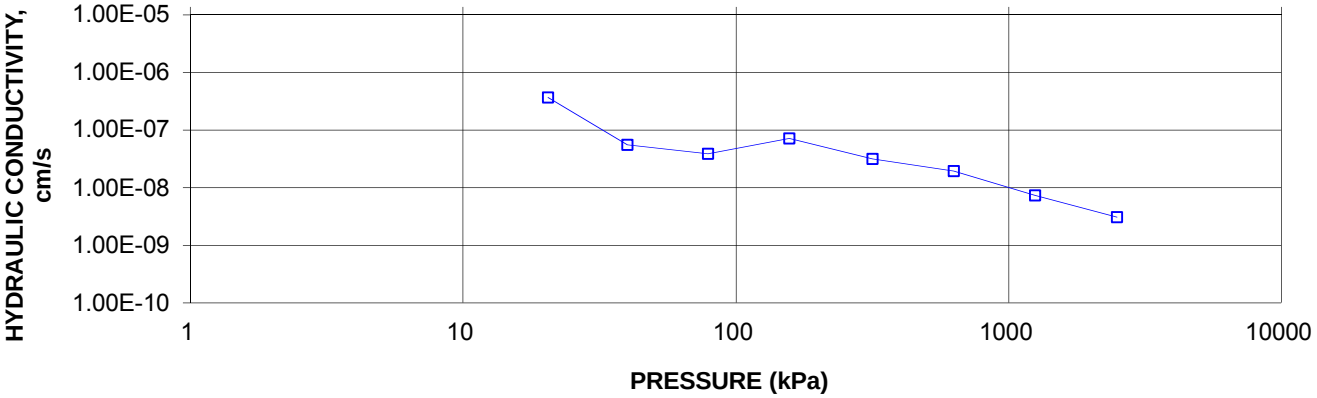
CONSOLIDATION TEST
C_V cm²/s VS PRESSURE (kPa)
BH B202-04 SA 9



CONSOLIDATION TEST
M_V m²/kN vs PRESSURE (kPa)
BH B202-04 SA 9



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH B202-04 SA 9



Project No. 09-1111-6014
Prepared By: LH

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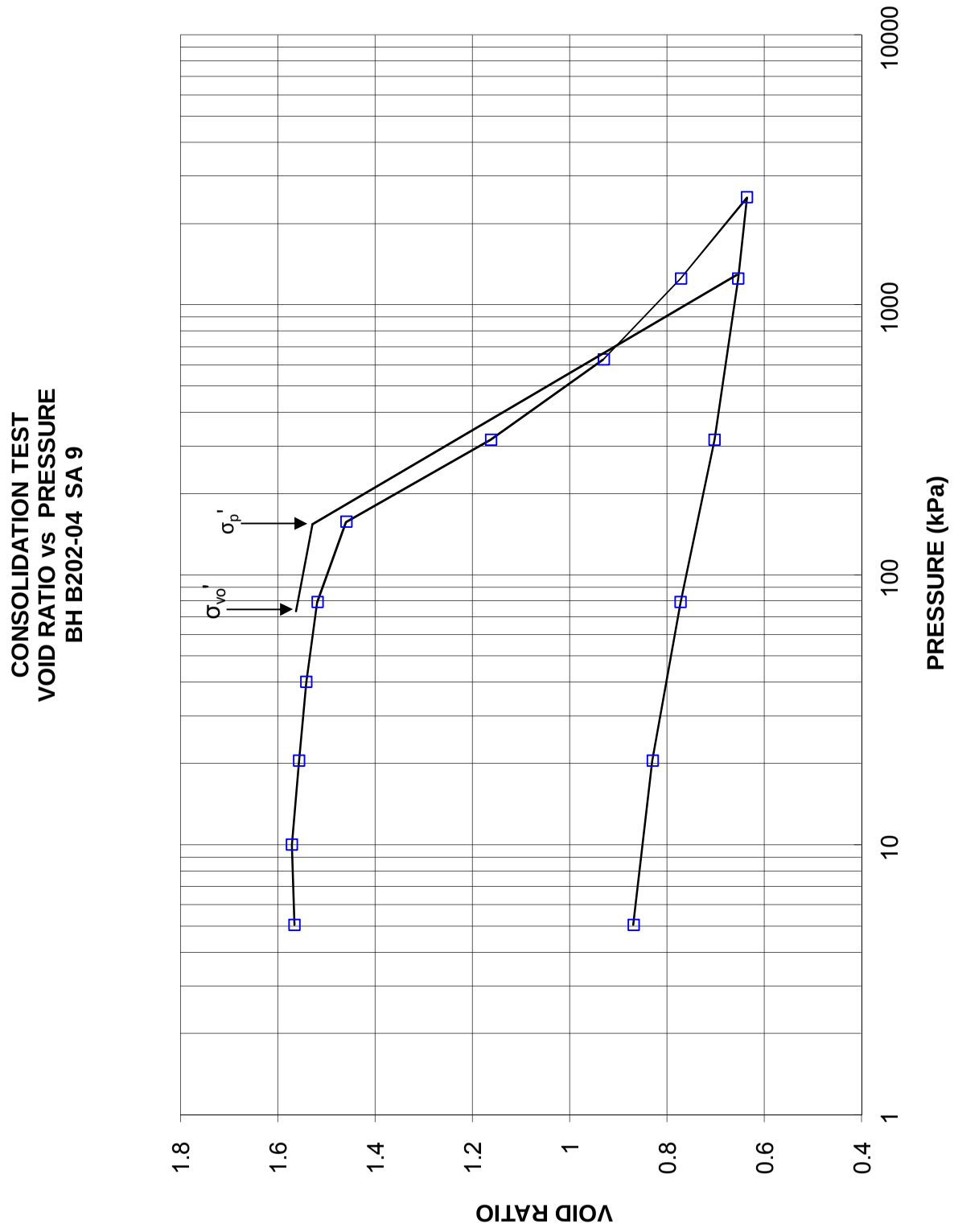
Checked By: TZ

CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE

FIGURE B24
Sheet 3 OF 4



Project No. 09-1111-6014

Prepared By: LH/TZ

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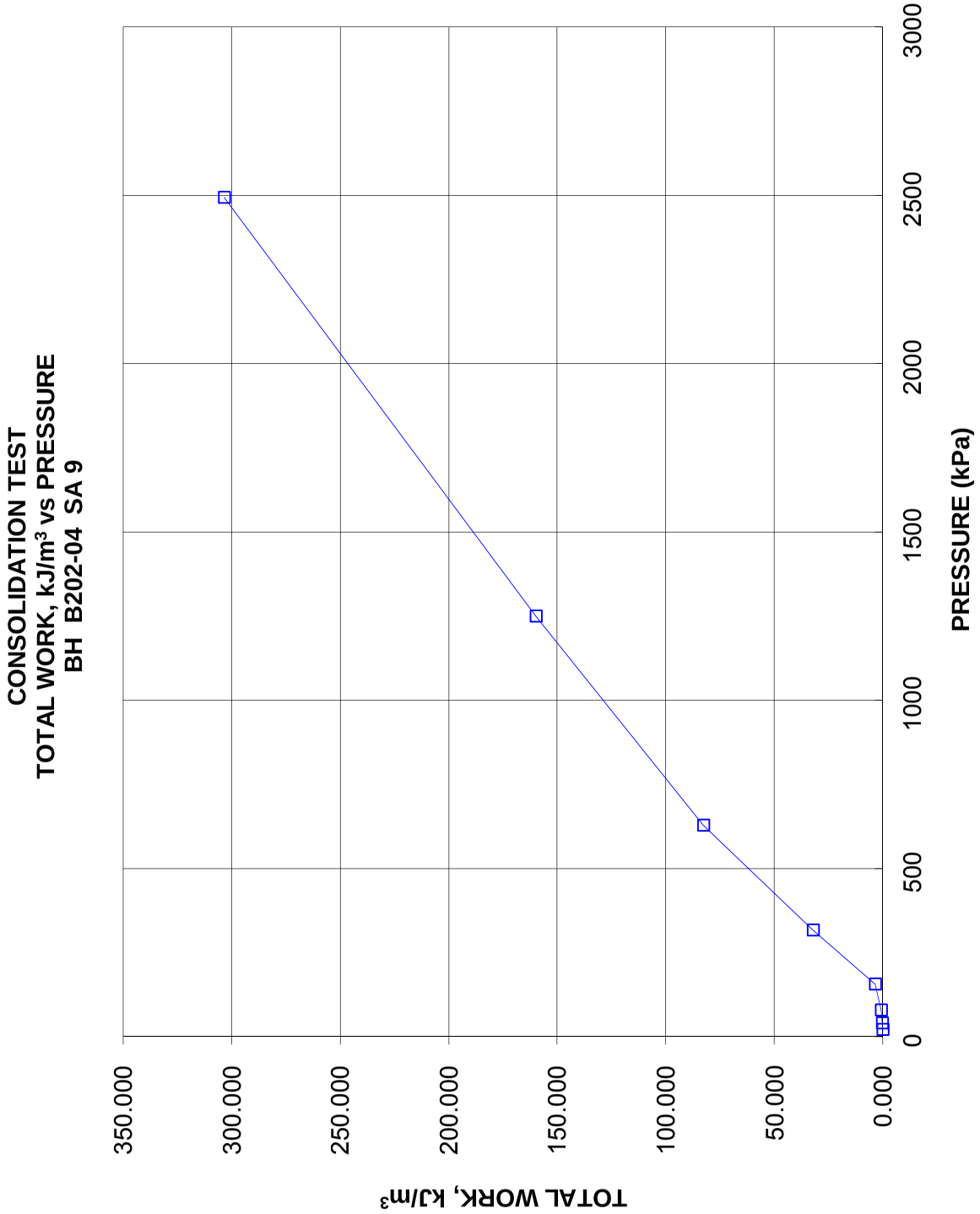
Checked By: TZ

CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B24
Sheet 4 of 4



Project No. 09-1111-6014

Prepared By: LH

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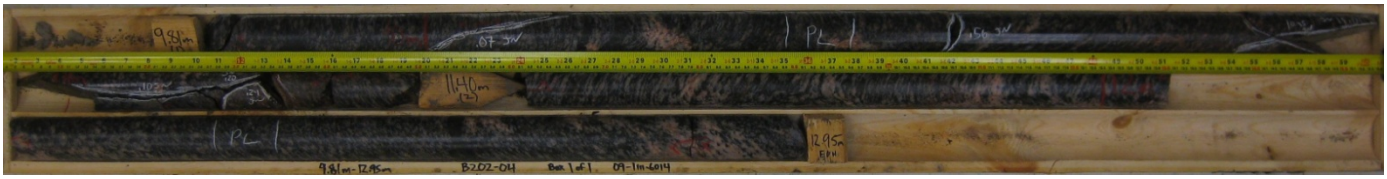
Checked By: TZ

Borehole B202-04



Box 1: 9.81 m – 13.00 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Scale

PROJECT

Still River Bridge (NBL) Structure
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE

Bedrock Core Photograph – North Abutment (One-Span Bridge)

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	TZ		SCALE NTS	REV.
CADD	--		**FIGURE B25**	
CHECK	TZ			
REVIEW	CN			

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

Borehole B202-05

Box 1: 4.57 m – 6.19 m

0 m | 0.25 m | 0.5 m | 0.75 m | 1.0 m | 1.25 m | 1.5 m

0 ft | 1 ft | 2 ft | 3 ft | 4 ft | 5 ft

Scale

PROJECT

Still River Bridge (NBL) Structure
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE

Bedrock Core Photograph – North Approach (One-Span Bridge)

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	TZ		SCALE NTS	REV.
CADD	--		**FIGURE B26**	
CHECK	TZ			
REVIEW	CN			

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

Borehole B202-12

Box 1: 5.90 m – 7.50 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT

Still River Bridge (NBL) Structure
Highway 69 Four-Laning
GWP 5404-05-00; WP 5139-08-01

TITLE

Bedrock Core Photograph – North Abutment (One-Span Bridge)

Golder Associates

PROJECT No. 09-1111-6014			FILE No. ----	
DESIGN	TZ		SCALE NTS	REV.
CADD	--		**FIGURE B27**	
CHECK	TZ			
REVIEW	CN			

REVISION DATE: April 13, 2011 BY: AT Project: 09-1111-6014

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