



September 22, 2015

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**CULVERTS – 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**  
**GWP 5404-05-00; WP 5404-05-01**

**Submitted to:**  
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REPORT



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# PART A

## FOUNDATION INVESTIGATION REPORT

### CULVERTS – 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

GWP 5404-05-00; WP 5404-05-01



## **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 foundation engineering services for two (2) culvert crossings 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, which includes 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 general location and extent of the various contracts as part of this assignment are shown on the Site Location Plan on Drawing 1.

The terms of reference 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 culvert crossings 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 Plan for foundation engineering services for this project, dated April 19, 2010. The Base Plan showing the proposed new alignment for the Contract 2 section of Highway 69 four-laning and the General Arrangement (GA) drawings for the proposed culvert profiles were provided to Golder by URS on December 16, 2009 and August 24, 2012, respectively.

This report addresses the investigation carried out for the proposed Contract 2 culvert crossings only. A list of the Contract 2 culvert details is presented in Table 1. Separate reports address the foundation investigations for the related swamp crossings and high fill areas and bridge structures within Contract 2 of the project.

The purpose of this investigation is to establish the subsurface conditions along the proposed culvert alignments by methods of borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The culverts were located in the field by Callon Dietz Inc., a professional surveying company retained by URS. The two culverts are located within a swamp crossing (designated as Swamp 202) which was investigated by Golder Associates Ltd. The results of the swamp investigation are presented in a report titled:

- 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, GWP 5404-05-00; WP 5404-05-01, Geocres No. 41H-115, dated July 2012.

## **2.0 SITE DESCRIPTION**

The overall 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 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 culverts are located within the Contract 2 highway alignment approximately 2.4 km from the southern limit of Contract 2, corresponding to approximately 1.2 km northeast of the junction between existing Highway 69 and Highway 529.

In general, the topography of the Contract 2 section of the project consists of rolling terrain, sparsely to densely treed areas, with valleys and swamps containing areas of standing water and various types of vegetation and



organic soils. The ground surface along the Contract 2 culvert alignments varies between about Elevation 183 m and Elevation 181 m, referenced to Geodetic datum, and is gently sloping downward from northeast to southwest towards Georgian Bay. A detailed description of the two investigated culvert alignments is presented in Section 4.0.

## **3.0 INVESTIGATION PROCEDURES**

### **3.1 Foundation Investigation**

The investigation for the Contract 2 culvert crossings was carried out between February 18 and March 11, 2011, during which time a total of seven (7) boreholes were advanced at or near the culvert alignments. In addition, three (3) boreholes advanced from March 3 to 13, 2011 as part of the field investigation work carried out by Golder Associates Ltd. for the Contract 2 swamp crossings and high fill areas in Swamp 202 were utilized to supplement the culvert investigation, and the methods of investigation for these supplemental additional boreholes are provided in the report referenced in Section 1.0. The boreholes associated with each culvert are summarized in Table 1 and are shown on Drawings A1 and B1 in Appendix A and Appendix B, for Culverts C201 and C202, respectively.

The field investigation was carried out using track-mounted D25 and D50 drill rigs supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using 127 mm outside diameter (O.D.) solid-stem augers and 'NW' casing with wash boring techniques. 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 driven by automatic hammers in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). Relatively undisturbed samples of the cohesive soils were obtained at selected locations using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling). Field vane shear tests were carried out 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. Samples of the bedrock were obtained using an 'NQ' size rock core barrel. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 Wells (as amended). Boreholes which exhibited artesian groundwater conditions during drilling were backfilled with a cement/barite grout mixture following measurement of the water level in the drill casing.

The culvert boreholes were advanced to depths up to 27.7 m below existing ground surface, generally penetrating 3 m into competent material or to refusal. In two boreholes, Dynamic Cone Penetration Tests (DCPT) were carried out from the bottom of the borehole to determine the depth to refusal. In general, the boreholes were terminated on refusal to further casing and/or split-spoon advancement or dynamic cone penetration. These depths to refusal do not confirm bedrock surface elevations, but may be inferred to indicate potential proximity to the bedrock surface. In two (2) of the boreholes advanced along the Culvert C201 alignment, bedrock was cored for a depth of about 2.4 m and 3.0 m, and photographs of the recovered rock samples from the culvert borehole are provided in Appendix A.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets provided in Appendices A and B. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.





The fieldwork 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 core 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. In addition, a one-dimensional consolidation (oedometer) test was carried out on one (1) selected sample of the cohesive deposit obtained from the culvert boreholes and the summary of the consolidation test result is presented in Section 4.0. It is noted that additional consolidation tests were carried out on samples obtained from the boreholes advanced within Swamp 202 and are provided in the report referenced in Section 1.0. The results of the laboratory testing on samples from the culvert boreholes are included in Appendices A and 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)<sup>1</sup>. 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 the International Society for Rock Mechanics (ISRM<sup>2</sup>) standard classification system.

The proposed centreline of the new highway alignment was staked in the field by Callon Dietz prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the centreline alignment and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevations at the centreline median and to temporary benchmarks which were then surveyed by Callon Dietz upon completion of the fieldwork. The borehole locations given in the Record of Borehole Sheets and shown on Drawings A1 and B1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole / DCPT Depth (m)
	Northing	Easting		
C201-01	5074231.7	225371.4	182.6	16.6
C201-02	5074236.3	225389.8	182.6	26.2
C201-03	5074241.2	225408.1	182.5	27.7
C201-04	5074246.9	225429.2	182.5	22.7
C202-01	5074238.2	225345.3	182.6	21.3
C202-02	5074247.4	225386.7	182.7	27.1
C202-03	5074254.7	225405.1	182.8	20.4
S202-04	5074226.7	225356.0	182.5	14.3
S202-05	5074244.1	225362.1	182.5	23.0
S202-19	5074259.4	225424.2	183.0	18.7

<sup>1</sup>Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

<sup>2</sup> 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.



## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

As delineated in *The Physiography of Southern Ontario*<sup>3</sup>, 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.

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 typically consist of very 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 overlying soft/loose native soils, sometimes to significant depth, 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<sup>4</sup>. 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, together with the results of the laboratory tests carried out on selected soil samples, are presented on the attached Record of Borehole sheets and the laboratory test sheets provided in Appendices A and B. 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. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The inferred soil stratigraphy as encountered in the boreholes advanced for the Contract 2 culverts are shown in profile on Drawings A2 and B2. The orientation (i.e. north, south, east, west) stated in the text of the report is typically referenced to project north and/or up-chainage (along the proposed Highway 69 alignment). For purposes of this report, Highway 69 is oriented north-south.

In general, the stratigraphy encountered along the two (2) alignments culverts investigated is similar and generally consists of thick deposits of cohesive soil underlain by layers of non-cohesive soils. The stratigraphy from ground surface to refusal or bedrock generally consists of:

- Surficial layers of topsoil, organic silt to organic silty sand, peat root mat;
- Non-cohesive deposit of sand;
- Thick cohesive deposits of clayey silt to clay; and,

<sup>3</sup> 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.

<sup>4</sup> *Geology of Ontario*, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.





- Non-cohesive deposits of silt to silty sand to sand to sand and gravel, underlain by cobbles/boulders in places and underlain by granite gneiss bedrock.

Detailed descriptions of the subsurface conditions along each investigated culvert alignment is provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

### **4.3 Highway 69 SBL and NBL – STA 11+207 (Culvert 201)**

The plan and profile along the Culvert 201 centreline showing the borehole locations and interpreted stratigraphy at approximately STA 11+207 in the Township of Henvey are shown on Drawings A1 and A2 in Appendix A. The culvert alignment will extend across the proposed new Highway 69 Northbound Lanes (NBL) and Southbound Lanes (SBL) embankments within Swamp 202. The proposed embankments at the culvert location are approximately 6.5 m high relative to the existing ground surface. A total of four (4) boreholes (Boreholes C201-01 to C201-04) were advanced along the length of the culvert to investigate the subsurface conditions at this culvert location. In addition, one (1) borehole (Borehole S202-04) advanced at the west toe of the proposed Highway 69 SBL embankment for the swamp crossing in the culvert area was utilized to supplement the subsurface information along the culvert alignment. The Record of Borehole sheets and associated results of the laboratory tests carried out on selected soil samples for these boreholes are included in Appendix A.

This section of the proposed Highway 69 alignment is located within the confines of tree covered valley slopes to the north and south, and consists of wet grassy areas/pasture land and a small creek traversing the valley from east to west. In general, the ground cover in the culvert area consists of a grassy field and creek bed with shrub cover and moderately treed areas and bedrock outcrops to the north and south.

The subsurface soils along the culvert alignment consist of peat and topsoil at the ground surface, underlain by deposits of organic silty sand and sand underlain in places by layers of silty clay and organic silt. These deposits are underlain by a thick deposit of clayey silt to clay, underlain by either bedrock or deposits of silt, silty sand, sand, sandy silt and sand and gravel which extends to the refusal depth. The bedrock consists of granite gneiss bedrock.

#### **4.3.1 Peat / Topsoil**

An approximately 0.2 m thick layer of peat (root mat) was encountered at the ground surface (about Elevation 182.5 m) in Borehole S202-04, at the west end of the proposed culvert. An approximately 0.1 m to 0.3 m thick layer of topsoil was encountered at the ground surface (between about Elevation 182.6 m and 182.5 m) in Boreholes C201-01 to C201-03.

#### **4.3.2 Organic Silty Sand**

A deposit of grey organic silty sand containing rootlets was encountered locally below the peat in Borehole S202-04. The top of this deposit is at about Elevation 182.3 and the thickness of the deposit is about 0.5 m.



One SPT 'N'-value of 1 blow per 0.3 m of penetration was recorded within this deposit, indicating a very loose relative density.

The natural water content measured on one (1) specimen of this deposit is about 46 per cent.

#### **4.3.3 Sand**

A deposit of dark grey to brown sand, some silt, containing organics, rootlets and wood fragments was encountered either at the ground surface or below the topsoil in Boreholes C201-01 to C201-04, and below the organic silty sand in Borehole S202-04. The top of this deposit ranges from about Elevation 182.5 m to 181.8 m and its thickness ranges from about 0.2 m to 1.1 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 four (4) selected samples of this deposit ranges from about 30 per cent and 93 per cent.

#### **4.3.4 Silty Clay and Organic Silt**

An approximately 0.3 m to 1.6 m thick deposit of organic silt, some sand containing layers of fibrous peat and rootlets was encountered below a 0.2 m and 0.4 m thick silty clay layer containing fibrous peat layers and wood fragments in Boreholes C201-01 and C201-04, respectively, and below the sand deposit in Borehole C201-03. The top of the organic silt deposit varies between about Elevation 181.9 m and Elevation 181.4 m.

The SPT 'N'-values measured within the organic silt deposit range from 0 blows (weight of hammer) to 2 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content measured on three (3) selected samples of the deposit ranges between about 57 per cent and 152 per cent. Laboratory organic testing on three (3) samples of the organic silt measured an organic content between about 13 per cent and 15 per cent. Laboratory organic testing on two (2) samples of silty clay measured an organic content of about 4 per cent.

#### **4.3.5 Clayey Silt to Clay**

A thick deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay, some silt, trace sand and trace gravel, was encountered underlying either the sand deposit or the organic silt layer in all the boreholes. The upper 2.7 m of the cohesive deposit contains organics and/or layers of fibrous peat. The silty clay to clay portion of the cohesive deposit contains silt interlayers, up to 1.1 m thick, at various depths and the clayey silt portion of the cohesive deposit contains silty clay seams. The top of the cohesive deposit ranges from about Elevation 181.6 m to 180.3 m. The thickness of the cohesive deposit ranges from about 10.4 m to 18.4 m. The bottom of this deposit is defined by bedrock in Borehole S202-04.

The SPT 'N'-values recorded within the cohesive deposit typically range from 0 blows (weight of hammer) to 5 blows per 0.3 m of penetration. In situ field vane tests carried out within the deposit measured undrained shear strengths ranging from about 15 kPa to 96 kPa, but typically less than 40 kPa, and the sensitivity is



calculated to range from about 2 to 4. The field vane tests results indicate that the clayey silt to clay deposit has a predominantly soft to firm consistency with some higher shear strengths and stiff consistency occurring within the upper portion of the cohesive deposit.

The natural water content measured on twenty-four (24) samples of this deposit range from about 38 per cent to 87 per cent, but are typically greater than 55 per cent.

The results of grain size distribution tests completed on twelve (12) samples of the clayey silt to silty clay and clay portions of the cohesive deposit are shown on Figure A.C201-01A and A.C201-01B in Appendix A, respectively.

Atterberg limits tests were carried out on twelve (12) samples of the cohesive deposit and measured liquid limits ranging from 30 per cent to 66 per cent, plastic limits ranging from 18 per cent to 23 per cent and plasticity indices ranging from 11 per cent to 43 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure A.C201-02A and A.C201-02B in Appendix A and indicate the material is classified predominantly as a silty clay of intermediate plasticity to clay of high plasticity.

#### **4.3.6 Silt (Interlayer)**

An approximately 1.1 m thick interlayer of grey silt, trace to some clay and trace sand was encountered within the deposit of silty clay to clay in Borehole C201-04 at about Elevation 178.9 m.

One SPT 'N'-value of 11 blows per 0.3 m of penetration was recorded in this interlayer, indicating a compact relative density.

The natural water content measured on one (1) sample of this interlayer is about 29 per cent.

The grain size distribution of one (1) sample of the silt interlayer is shown on Figure A.C201-03 in Appendix A. An Atterberg limits test on one (1) sample of the silt deposit indicates this material to be non-plastic.

#### **4.3.7 Silt**

A deposit of grey silt, trace to some sand and trace to some clay was encountered underlying the clay deposit in Boreholes C201-02 and C201-03 at approximately Elevation 165.4 m and 162.4 m, respectively. The thickness of the deposit is about 1.9 m and 2.9 m at the respective boreholes.

Two SPT 'N'-values measured within the silt deposit are 8 blows and 10 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on two (2) selected samples of the deposit is 24 per cent and 25 per cent.

The results of grain size distribution tests completed on two (2) samples of the silt to deposit are shown on Figure A.C201-04 in Appendix A. An Atterberg limits test on one (1) sample of the silt deposit indicates this material to be non-plastic.



#### **4.3.8 Sandy Silt to Sand to Sand and Gravel**

Underlying the clayey silt to clay deposit or the silt deposit, Boreholes C201-01 to C201-04 encountered a deposit of grey non-cohesive soil grading from sandy silt to silty sand to sand some silt. The deposit in places contains trace to some clay, trace to some silt and trace to some gravel. The top of the sandy silt to sand deposit ranges from about Elevation 169.6 m to 159.5 m and the thickness of the deposit ranges from about 1.2 m to greater than 4.7 m, and may be up to about 7.1 m as inferred from the refusal at a Dynamic Cone Penetration Test carried out from the bottom of Borehole C201-02. Borehole C201-03 was terminated within this deposit, where as in Boreholes C201-01 and C201-02, the bottom of this deposit was defined by bedrock and by refusal to further cone penetration, respectively.

The SPT 'N'-values measured within this deposit range from 7 blows to 76 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

The natural water content measured on three (3) samples of this deposit ranges from 14 per cent to 24 per cent.

The results of grain size distribution tests completed on one (1) sample of the sandy silt portion of the deposit and two (2) samples of the sand portion of the deposit are shown on Figure A.C201-05A and A.C201-05B, respectively, in Appendix A.

In Borehole C201-04, the non-cohesive sand deposit grades to sand and gravel containing cobbles. The top of the coarser portion of the deposit is at about Elevation 160.9 m and the thickness of this portion of the deposit is about 1.1 m. Borehole C201-04 was terminated within this deposit upon refusal to further casing advancement. One SPT 'N'-value of 83 blows per 0.3 m of penetration was measured within the sand and gravel portion of the deposit, indicating a very dense relative density. The natural water content measured on sample of the sand and gravel deposit is 15 per cent.

#### **4.3.9 Bedrock / Refusal**

Bedrock outcrops are present to the southern and northern limits of the investigated area. The bedrock surface at the borehole locations along the culvert alignment, was proven by coring or was inferred (except in Borehole C201-03 which was terminated within the silty sand deposit) by refusal to further casing advancement or dynamic cone penetration between depths of about 11.3 m and 26.2 m below the ground surface, corresponding to between about Elevation 171.2 m and 156.4 m.

Bedrock was encountered and core samples were recovered from Boreholes S202-04 and C201-01, as shown on the photograph of the recovered core samples presented on Figure A.C201-06. The depth to the surface of the bedrock in these boreholes is about 14.2 m and 11.3 m, corresponding to Elevation 168.4 m and 171.2 m in Boreholes C201-01 and S202-04, respectively. The bedrock consists of granite gneiss and the core samples are described as fresh to slightly weathered, foliated, slightly porous, medium crystalline, strong, pink, grey and black with a mafic dyke encountered at varying intervals, as presented on the Record of Drillhole sheets in Appendix A.

The Rock Quality Designation (RQD) measured on the core samples ranges between 84 per cent and 100 per cent, indicating a rock mass of good to excellent quality, in accordance with Table 3.10 of CFEM (2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the rock core samples are between 96 per cent and 100 per cent, and between 78 per cent and 98 per cent, respectively.



#### **4.3.10 Groundwater Conditions**

In general, the soil samples taken in the boreholes were moist to wet. During drilling operations, artesian conditions were observed in all the boreholes when advanced to depths between about 19.6 m and 24.2 m below ground surface. Upon completion of drilling, artesian conditions were noted in Boreholes C201-01 and C201-02 with the groundwater levels measured in the casing at about 1.5 m and 0.5 m above ground surface, corresponding to about Elevation 184.1 m and 183.1 m, respectively. In the other boreholes, the groundwater levels measured in the open borehole ranged from about Elevation 182.5 m to 181.7 m, measured at the ground surface or to depths up to about 0.8 m below ground surface.

### **4.4 Highway 69 SBL and NBL – STA 11+220 (Culvert 202)**

The plan and profile along Culvert 202 centreline showing the borehole locations and interpreted stratigraphy at approximately STA 11+220 in the Township of Henvey are shown on Drawings B1 and B2 in Appendix B. The culvert alignment will extend across the proposed new Highway 69 Northbound Lanes (NBL) and Southbound Lanes (SBL) embankments within Swamp 202. The proposed embankments at the culvert location are approximately 6.5 m high relative to the existing ground surface. A total of three (3) boreholes (Boreholes C202-01 to C202-03) were advanced along the length of the culvert to investigate the subsurface conditions at this culvert location. In addition, two (2) boreholes (Boreholes S202-05 and S202-19) advanced for the proposed Highway 69 NBL and SBL embankments for the swamp crossing in the culvert area was utilized to supplement the subsurface information along the culvert alignment. The Record of Borehole sheets and the associated results of the laboratory tests carried out on selected soil samples for these boreholes are included in Appendix B.

This section of the proposed Highway 69 alignment is located within the confines of tree covered valley slopes to the north and south, and consists of wet grassy areas/pasture land and a small creek traversing the valley from east to west. In general, the ground cover in the culvert area consists of a grassy field and creek bed with shrub cover and moderately treed areas and bedrock outcrops to the north and south.

The subsurface soils along the culvert alignment consist of peat and topsoil at the ground surface, underlain by near surface deposits of organic silty sand and sand, underlain by a thick deposit of clayey silt to clay. The cohesive deposit is underlain by non-cohesive deposits consisting of silty sand, sand, and sand and gravel which either extends to refusal or is underlain by cobbles and boulders deposit in places.

#### **4.4.1 Peat / Topsoil**

An approximately 0.2 m thick layer of peat (root mat) was encountered at the ground surface at about Elevation 182.5 m in Borehole S202-05. In Boreholes C202-01, C202-03 and S202-19, an approximately 0.2 m to 0.3 m thick layer of topsoil was encountered at the ground surface between about Elevation 183.0 m and 182.6 m.



#### **4.4.2 Organic Silty Sand**

A layer of dark grey to brown organic silty sand, trace clay was encountered below the peat in Borehole S202-05. The top of this deposit is at about Elevation 182.3 and the thickness of the deposit is about 0.5 m.

One SPT 'N'-value of 1 blow per 0.3 m of penetration was recorded within this deposit, indicating a very loose relative density.

The natural water content measured on one (1) specimen of this deposit is about 39 per cent.

#### **4.4.3 Silty Sand to Sand**

A deposit of grey to brown silty sand to sand trace to some silt, containing organics, rootlets and wood fragments was encountered underlying the topsoil or at ground surface in Boreholes C202-01 to C202-03, and below the organic silty sand layer in Borehole S202-05. The top of this deposit ranges from about Elevation 182.7 m to 181.8 m and its thickness ranges from about 0.2 m to 0.9 m.

The SPT 'N'-values measured within this deposit are 2 blows and 3 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content measured on two (2) samples of this deposit is 37 per cent.

#### **4.4.4 Clayey Silt to Clay**

A thick deposit of cohesive soil comprised of brown to grey clayey silt, silty clay and clay, trace to some silt, trace to some sand and trace gravel was encountered underlying the sand to silty sand deposit and/or topsoil in all the boreholes. The upper portion of the cohesive deposit (to a depth of about 2.1 m below ground surface) contains organics, rootlets and fibrous peat layers. The cohesive deposit contains silt and sand and silt/sand interlayers in places. The top of the cohesive deposit ranges from about Elevation 182.7 m to 181.6 m, and the thickness of the cohesive deposit ranges from about 16.3 m to 22.0 m.

The SPT 'N'-values recorded within the cohesive deposits range from 0 blows (weight of hammer) to 5 blows per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 16 kPa to 85 kPa, but typically less than 40 kPa and the sensitivity is calculated to range from about 2 to 5. The field vane tests results indicate that the clayey silt to clay deposit has a predominantly soft to firm consistency with higher shear strengths and stiff consistency occurring within the upper portion of the cohesive deposit.

The natural water content measured on thirty-three (33) samples of the deposit range from about 21 per cent to 84 per cent, but are typically greater than 50 per cent.

The results of grain size distribution tests completed on fifteen (15) samples of the clayey silt, silty clay and clay portion of the cohesive deposit are shown on Figures B.C202-01A, B.C202-01B and B.C202-01C in Appendix B.

Atterberg limits tests were carried out on sixteen (16) samples of the cohesive deposit and measured liquid limits ranging from 24 per cent to 57 per cent, plastic limits ranging from 16 per cent to 21 per cent and plasticity indices ranging from 7 per cent to 38 per cent. The results of the Atterberg limits tests are shown on the





plasticity chart on Figure B.C202-02A and B.C202-02B in Appendix B and indicate the material is classified as clayey silt of low 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 C202-02. A preconsolidation stress of about 160 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 17 kN/m<sup>3</sup> and a specific gravity of about 2.76 were measured on the consolidation test specimen. Details of the test results are shown on Figure B.C202-03 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	$\sigma_{vo}'$ (kPa)	$\sigma_p'$ (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	$C_c$	$C_r$	$e_o$	$c_v^*$ (cm <sup>2</sup> /s)
Borehole C202-02 Sample 13	15.2 m / 167.5 m	120	160	40	1.3	0.91	0.07	1.39	$8.7 \times 10^{-4}$

Note: \* For stress range of between effective overburden stress and final stress due to 6.5 m high embankment, that is  $120 \text{ kPa} \leq \sigma_v' \leq 245 \text{ kPa}$

where:  $\sigma_{vo}'$  is the in situ vertical effective overburden stress in kPa  
 $\sigma_p'$  is the preconsolidation stress in kPa  
 $\sigma_v'$  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<sup>2</sup>/s

#### 4.4.5 Sand and Silt to Sand / Silt (Interlayers)

An approximately 1.0 m thick interlayer of grey sand and silt to sand trace silt, trace to some clay and trace gravel was encountered within the cohesive deposit in Borehole C202-02 at about Elevation 179.5 m, and an approximately 0.4 m thick interlayer of grey silt was encountered in Borehole S202-19 at approximately Elevation 179.0 m.

A single SPT 'N'-value measured within the sand and silt to sand interlayer is 11 blows per 0.3 m of penetration indicating a compact relative density.

The natural water content measured on one (1) sample of the sand and silt portion of the interlayer is about 24 per cent.

The results of a grain size distribution test completed on one (1) sample of the sand and silt portion of the interlayer is shown on Figure B.C202-04 in Appendix B.

An Atterberg limits test was carried out on a portion of the sample of the sand and silt interlayer and measured a liquid limit of 18 per cent, a plastic limit of 16 per cent and a plasticity index of 2 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B.C202-05 in Appendix B and indicates that the fines portion of the sand and silt interlayer is classified as silt of slight plasticity.



#### **4.4.6 Silty Sand to Sand to Sand and Gravel**

Underlying the clayey silt to clay deposit, all the boreholes encountered a non-cohesive deposit comprised of silty sand, sand, and sand and gravel. The sand and gravel portion of the deposit encountered in Borehole C202-01 contains cobbles. The top of the non-cohesive deposit ranges from about Elevation 166.4 m to 159.8 m and the thickness of the deposit ranges from about 0.9 m to 3.2 m, and may be up to about 4.2 m thick as inferred from the refusal of a Dynamic Cone Penetration Test carried out in Borehole C202-02. Boreholes C202-01 was terminated within this deposit, whereas the bottom of Boreholes C202-02 and S202-05, were defined by refusal to further split-spoon, casing advancement or dynamic cone penetration in this layer, respectively.

The SPT 'N'-value measured within this deposit range from 7 blows to 93 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

The natural water content measured on three (3) samples of this deposit ranges from 11 per cent and 22 per cent.

The result of a grain size distribution test completed on one (1) sample of the sand portion of the deposit is shown on Figure B.C202-06 in Appendix B. An Atterberg limits test on one (1) sample of the silty sand portion of the deposit indicates this material to be non-plastic.

#### **4.4.7 Cobbles and Boulders**

In Boreholes C202-03 and S202-19 advanced near the east end of the proposed culvert, a deposit of cobbles and/or boulders was encountered underlying the silty sand to sand and gravel deposit at about Elevation 164.0 m and 165.5 m, respectively, and cored for depths of about 1.6 m and 1.2 m, prior to termination of the boreholes.

#### **4.4.8 Refusal**

Bedrock outcrops are present to the southern and northern limits of the valley within which the culvert is located. Refusal to further split-spoon and casing advancement or dynamic cone penetration was encountered in Boreholes C202-02 and S202-05 at depths of about 27.1 m and 23.0 m, respectively, below the ground surface, corresponding to Elevation 155.6 m and 159.5 m.

#### **4.4.9 Groundwater Conditions**

In general, the soil samples taken in the boreholes were moist to wet. During drilling operation, artesian conditions were observed in all the boreholes when casing was advanced to depths between about 17.1 m and 23.9 m below ground surface. Upon completion of drilling, artesian conditions were noted in Boreholes C202-01 and C202-03 with the groundwater levels measured in the casing at about 1.8 m and 1.2 m above ground surface, corresponding to about Elevation 184.4 m and 184.0 m, respectively. In the other boreholes, the groundwater levels measured in the open borehole ranged from about Elevation 182.3 m to 179.0 m, measured at depths between 0.2 m and 4.0 m below ground surface.



## **5.0 CLOSURE**

The drilling program was supervised by Mr. Matt Rhody, a senior technician with Golder. This report was prepared by Ms. T. Veronica Ayetan, P.Eng. with assistance provided by Mr. Billy Murphy, 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.



**FOUNDATION REPORT – CULVERTS – CONTRACT 2  
HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

## Report Signature Page



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



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BM/TVA/JPD/JMAC/sm

[Http://capws/sites/0911116014highway69FourLaning/Contract 2/Reporting/Final/Culverts/09-1111-6014-2521 RPT 15Sep22 Highway 69 Culverts - Contract 2.docx](http://capws/sites/0911116014highway69FourLaning/Contract%202/Reporting/Final/Culverts/09-1111-6014-2521%20RPT%2015Sep22%20Highway%2069%20Culverts%20-%20Contract%202.docx)



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## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	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
$\gamma'$	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

### (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
$C_\alpha$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

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

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

Notes: 1  
2

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





## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive Soils

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### (b) Cohesive Soils Consistency

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

#### Dynamic Cone Penetration Resistance; N<sub>d</sub>:

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<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q<sub>t</sub>), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### IV. SOIL TESTS

w	water content
w <sub>p</sub>	plastic limit
w <sub>l</sub>	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
D <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
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 <sub>4</sub>	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	



# TABLES



**FOUNDATION REPORT – CULVERTS – CONTRACT 2**  
**HIGHWAY 69 GWP 5404-05-00; WP 5404-05-01**

**Table 1: Summary of Culvert Details**  
**Highway 69 Four-Laning**

<i><b>Culvert Designation</b></i>	<i><b>Culvert Location (Associated Swamp)</b></i>	<i><b>Approximate Proposed Embankment Height<sup>3</sup> (m)</b></i>	<i><b>Culvert Type</b></i>	<i><b>Invert Elevations<sup>1</sup></b></i>		<i><b>Culvert Dimensions<sup>1</sup></b></i>			<i><b>Boreholes / DCPTs</b></i>
				<i><b>East End of Culvert (m)</b></i>	<i><b>West End of Culvert (m)</b></i>	<i><b>Width (m)</b></i>	<i><b>Height (m)</b></i>	<i><b>Length (m)</b></i>	
C201	Highway 69 SBL and NBL STA 11+207 (Swamp 202)	6.5	Pre-Cast Box Culvert	182.24	180.94	3	2.4	87	5 Boreholes (C201-01 to C201-04 and S202-04)
C202	Highway 69 SBL and NBL STA 11+220 (Swamp 202)	6.5	Cast-in-Place Box Culvert	183.34	182.89	5	5	81	5 Boreholes (C202-01 to C202-03, S202-05 and S202-19)

Notes 1 Invert elevations and culvert dimensions as shown on profiles drawings provided by URS on August 24, 2012.

**Prepared By:** TVA

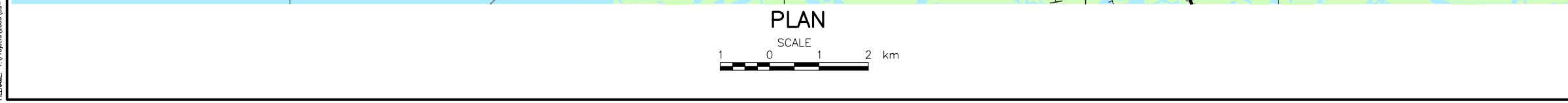
**Checked By:** CN/JPD

**Reviewed By:** JMAC



# **DRAWINGS**





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

CONT No.  
GWP No. 5404-05-00



HIGHWAY 69  
SITE LOCATION PLAN



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN  
NOT TO SCALE

## 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-119					
HWY. 69			PROJECT NO. 09-1111-6014	DIST.	
SUBM'D. TVA	CHKD. TVA	DATE: August 2012	SITE:		
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 1		





# APPENDIX A

## Highway 69 SBL and NBL – STA 11+207 (Culvert 201)

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

CONT No.  
WP No. 5404-05-01

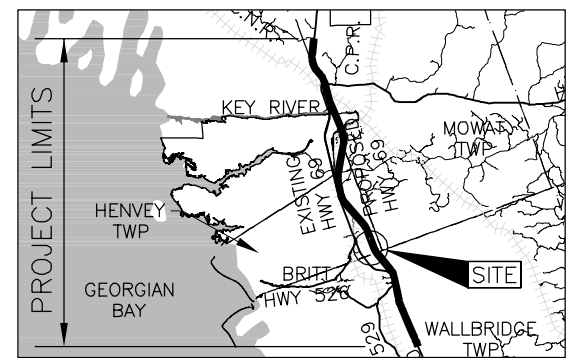


HIGHWAY 69  
CULVERT 201 STA 11+207  
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.  
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE  
0 6 12 km

### LEGEND

● Borehole - Current Investigation

#### BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C201-01	182.6	5074231.7	225371.4
C201-02	182.6	5074236.3	225389.8
C201-03	182.5	5074241.2	225408.1
C201-04	182.5	5074246.9	225429.2
S202-04	182.5	5074226.7	225356.0

### NOTES

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

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

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

### REFERENCE

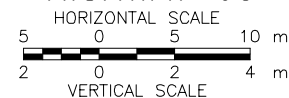
Base plans provided in digital format by URS, drawing files Hwy69\_base.dwg, Hwy69\_plan.dwg, received December 16, 2009. And Contours from Hwy69\_Contours-Plan\_C2\_C3.dwg, received July 14, 2011, Location of Culvert obtained from culv 11+207 Aug 2012.dwg, received August 24 2012.



NO.	DATE	BY	REVISION
1			
Geocres No. 41H-119			
HWY. 69	PROJECT NO. 09-1111-6014		DIST.
SUBM'D. TVA	CHKD. TVA	DATE: August 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. A1

SHEET

**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



NO.	DATE	BY	REVISION				
Geocres No. 41H-119							
HWY. 69			PROJECT NO. 09-1111-6014			DIST.	
SUBM'D. TVA		CHKD. TVA		DATE: August 2012		SITE:	
DRAWN: JFC		CHKD. CN		APPD. JPD/JMAC		DWG. A2	


PROJECT		RECORD OF BOREHOLE		No C201-01		SHEET 1 OF 2		METRIC											
W.P. 5404-05-01		LOCATION		N 5074231.7 ; E 225371.4		ORIGINATED BY		MR											
DIST		HWY 69		BOREHOLE TYPE		NW Casing, Wash Boring		COMPILED BY											
MAS/SB		DATE		February 27 and 28, 2011		CHECKED BY		TVA											
DATUM		Geodetic																	
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		W <sub>p</sub> W W <sub>L</sub>		WATER CONTENT (%)		γ		GR SA SI CL		
182.6	0.0	GROUND SURFACE		1A					20 40 60 80 100	○ UNCONFINED	○ FIELD VANE								
		TOPSOIL		1B	SS	5		182		● QUICK TRIAXIAL	× REMOULDED								
182.1	0.7	SAND, some silt, containing organics and rootlets Loose Brown Moist to wet		1C				181											
		SILTY CLAY, containing organics and rootlets Very soft Grey Moist		2	SS	1		180											
		Organic SILT, containing layers of fibrous peat Very loose Dark grey to dark brown Moist		3	SS	1		179											
180.3	2.3	SILTY CLAY, trace sand Firm to stiff Brown to grey Moist to wet		4	SS	WH		178											
		Containing grey silt interlayers between depths of 4.0 m and 4.6 m		5	SS	3		177											
				6	TO*	PH		176											
				7	SS	WH		175											
				8	TO	PH		174											
				9	SS	1		173											
				10	SS	1		172											
				11A	SS	7		171											
				11B				170											
169.6	13.0	Sandy SILT, trace to some clay Loose Grey Wet		12	SS	50/0.0		169											
169.0	13.6	Silty SAND, trace gravel, containing sandy silt layers Grey Wet		1	NQ RC	REC 97%		168											
168.4	14.2																		

Continued Next Page

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

RQD = 94%

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

PROJECT		RECORD OF BOREHOLE				No C201-01		SHEET 2 OF 2		METRIC							
W.P. 09-1111-6014		LOCATION				N 5074231.7 ; E 225371.4		ORIGINATED BY		MR							
DIST		HWY 69		BOREHOLE TYPE		NW Casing, Wash Boring		COMPILED BY		MAS/SB							
DATUM Geodetic		DATE		February 27 and 28, 2011		CHECKED BY		TVA									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
166.0	Granite Gneiss (BEDROCK)		1	NQ RC	REC 97%												
16.6	Bedrock cored from depths of 14.2 m to 16.6 m  For bedrock coring details, refer to Record of Drillhole C201-01		2	NQ RC	REC 100%												
166.0	END OF BOREHOLE																
16.6	NOTES:  *Unable to recover a Shelby tube sample between depths of 5.5 m and 5.9 m.  1. Water level in casing at 0.8 m above ground surface upon completion of drilling (Elev. 183.7 m).  Water level in casing at 1.5 m above ground surface (Elev. 184.1 m) measured at about 7:15 a.m. on February 28, 2011 - Artesian Condition. Casing set at a depth of 14.3 m below ground surface (Elev. 168.3 m) at the time of water level measurement.																

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: C201-01**

SHEET 1 OF 1

LOCATION: N 5074231.7 ; E 225371.4

DRILLING DATE: February 27 and 28, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bombardier

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint		BD - Bedding		PL - Planar		PO - Polished		BR - Broken Rock	
									FLT - Fault	SHR - Shear	FN - Foliation	CO - Contact	CU - Curved	K - Slickensided	NOTE: For additional abbreviations refer to list of abbreviations & symbols.			
									VN - Vein	CJ - Conjugate	OR - Orthogonal	CL - Cleavage	UN - Undulating	SM - Smooth				
									ST - Stepped	IR - Irregular	Ro - Rough	MB - Mechanical Break						
RECOVERY		R.Q.D. %		FRACT. INDEX PER 0.25		DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		Diametral Point Load Index (MPa)		RMC -Q' AVG.						
TOTAL CORE %	SOLID CORE %	%	%	%	%	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10	10	10	10	2	4	
Continued from Record of Borehole C201-01		168.4																
GRANITE GNEISS Slightly weathered, foliated, strong, pink, dark grey and black with mafic dyke between depths of 15.5 m and 15.8 m.	NW Casing February 27, 2011	14.2																
	NORC February 28, 2011	1																
		2																
		END OF DRILLHOLE	166.0 16.6															

DEPTH SCALE

1 : 50



LOGGED:

CHECKED: MAS/TVA





PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C201-02</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074236.3 ;E 225389.8</u>		ORIGINATED BY <u>MR</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>		COMPILED BY <u>MAS/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>February 18,22 and 23, 2011</u>		CHECKED BY <u>TVA</u>			

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

○ 3% STRAIN AT FAILURE



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No C201-03</b>		SHEET 1 OF 3		<b>METRIC</b>	
W.P. 5404-05-01		LOCATION N 5074241.2 ; E 225408.1		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY ARM/SB			
DATUM Geodetic		DATE February 24, 2011		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
182.5	GROUND SURFACE													
0.0	TOPSOIL													
0.2	SAND, some silt, containing organics Very loose to loose Brown to grey Wet		1	SS	6								93.2	
181.4			2A	SS	2									
1.1	Organic SILT, some sand, containing rootlets Very loose Dark grey to brown Moist		2B										108.1	
180.8			3A	SS	1									
1.7	SILTY CLAY, trace sand, containing organics to a depth of 2.6 m Soft to stiff Grey Moist		3B											
			4	TO	PH									
178.6														
3.9	CLAYEY SILT, trace sand, containing silt seams Stiff Grey Wet		5	SS	5									
177.3														
5.2	CLAY, some silt, trace sand Firm Grey Moist to wet  Containing silt layers between depths of 5.2m and 6.7 m		6	SS	WH									
			7	SS	WH									
			8	SS	WH									
			9	SS	WH									
			10	SS	WH									
			11	SS	WH									

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

PROJECT 09-1111-6014		RECORD OF BOREHOLE No C201-03		SHEET 2 OF 3		METRIC							
W.P. 5404-05-01		LOCATION N 5074241.2 ; E 225408.1		ORIGINATED BY MR									
DIST HWY 69		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY ARM/SB									
DATUM Geodetic		DATE February 24, 2011		CHECKED BY TVA									
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						SHEAR STRENGTH kPa
<div style="display: flex; justify-content: space-between;"> <div>           20 40 60 80 100            ○ UNCONFINED + FIELD VANE            ● QUICK TRIAXIAL × REMOULDED         </div> <div>           20 40 60 80 100            20 40 60         </div> </div>													
--- CONTINUED FROM PREVIOUS PAGE ---													
	CLAY, some silt, trace sand Firm Grey Moist to wet		12	TO	PH								
			13	SS	1								
			14	TO	PH								
162.4													
20.1	SILT, trace to some clay, trace sand Compact Grey Moist		15	SS	10								
159.5													
23.0	SAND, some gravel, trace to some silt Compact to very dense Grey Wet		16	SS	11								
			17	SS	29								
155.1			18A										
154.8	Silty SAND Very dense Grey Wet		18B	SS	76								
27.7													

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No C201-03</b>				SHEET 3 OF 3		<b>METRIC</b>									
W.P. 5404-05-01		LOCATION N 5074241.2 ; E 225408.1				ORIGINATED BY MR											
DIST HWY 69		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY ARM/SB											
DATUM Geodetic		DATE February 24, 2011				CHECKED BY TVA											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED + FIELD VANE</span> <span>● QUICK TRIAXIAL × REMOULDED</span> </div>										
	END OF BOREHOLE  NOTES:  1. Water flowing from top of casing when advanced to a depth of 24.2 m below ground surface (Elev. 158.3 m).  Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 181.7 m) upon completion of drilling.																

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15



PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C201-04</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074246.9 ;E 225429.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>ARM/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>March 1 and 2, 2011</u>		CHECKED BY <u>TVA</u>			

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



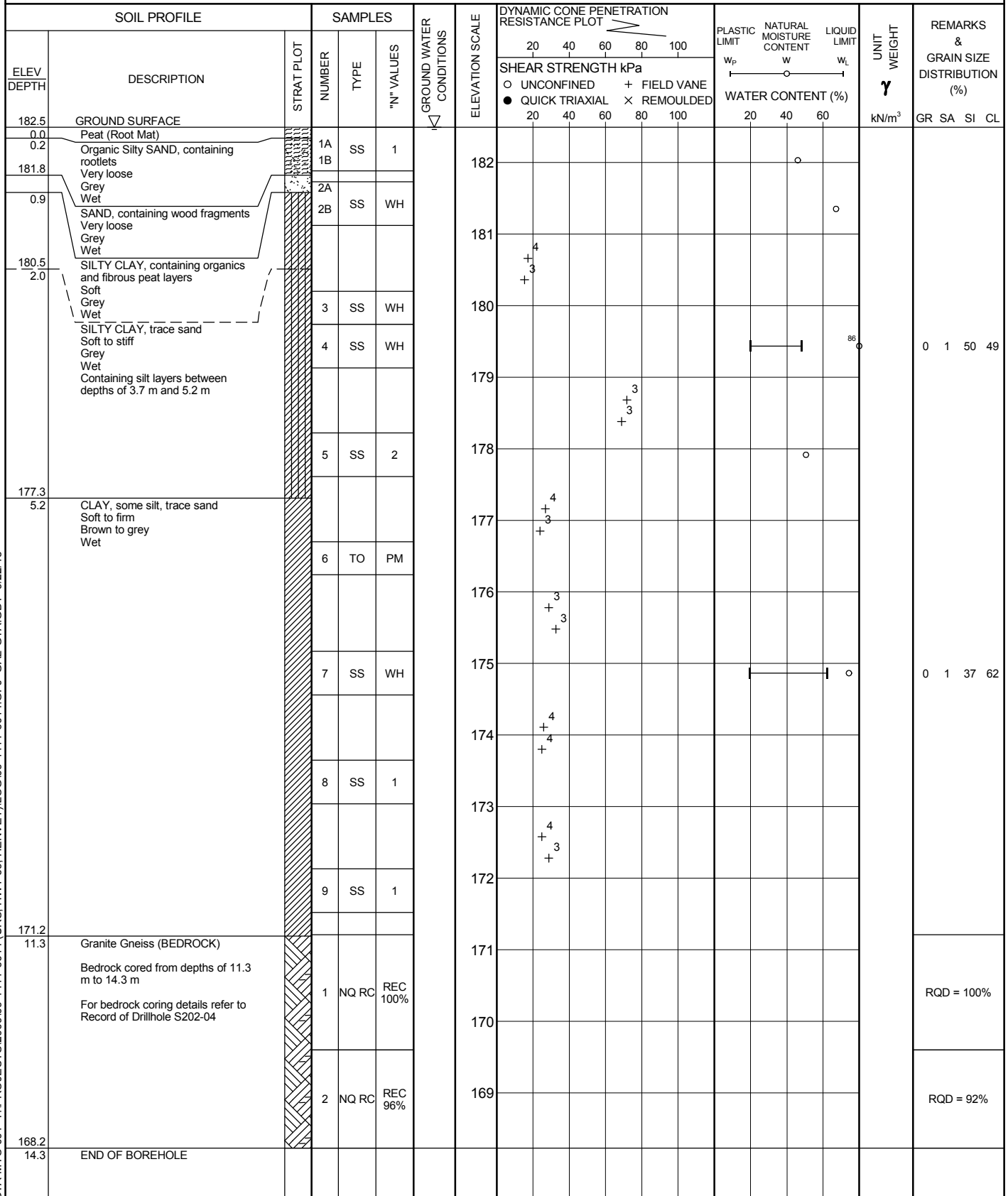
PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C201-04</b>		SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074246.9 ; E 225429.2</u>		ORIGINATED BY <u>MR</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>ARM/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>March 1 and 2, 2011</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	20	40	60	80	100		W <sub>p</sub>	W	W <sub>L</sub>			
	--- CONTINUED FROM PREVIOUS PAGE ---		13																	
	CLAY, some silt, trace sand, trace gravel, containing silt interlayers Firm to stiff Grey Wet																			
			14	SS	3															
162.7																				
19.8	SAND, some gravel, trace silt, trace clay Compact Grey Wet																			
			15	SS	11															
160.9																				
21.6	SAND and GRAVEL, containing cobbles Very dense Grey Wet																			
			16	SS	83															
159.8																				
22.7	END OF BOREHOLE CASING REFUSAL		17	SS	50/0															
	NOTES:  * Unable to recover a Shelby tube between depths of 2.3 m and 2.7 m.  1. Water flowing from top of casing when advanced to a depth of 20.7 m below ground surface (Elev. 161.8 m).  Water level in open borehole at a depth of 0.3 m below ground surface (Elev. 182.2 m) upon completion of drilling.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No S202-04</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. 5404-05-01		LOCATION N 5074226.7 ; E 225356.0		ORIGINATED BY MR			
DIST HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY ARM			
DATUM Geodetic		DATE March 12, 2011		CHECKED BY TVA			



Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 9/22/15



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

PROJECT: 09-1111-6014

**RECORD OF DRILLHOLE: S202-04**

SHEET 1 OF 1

LOCATION: N 5074226.7 ; E 225356.0

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D25 Bomb

DRILLING CONTRACTOR: Walker Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	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.	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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RECOVERY		R.Q.D. %	FRACT INDEX PER 0.25	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec			Diametral Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 cm			10 cm	10 cm																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	NW Casing March 12, 2011	Continued from Record of Borehole C201-1		171.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	</

DEPTH SCALE

1 : 50



LOGGED: MR

CHECKED: TVA

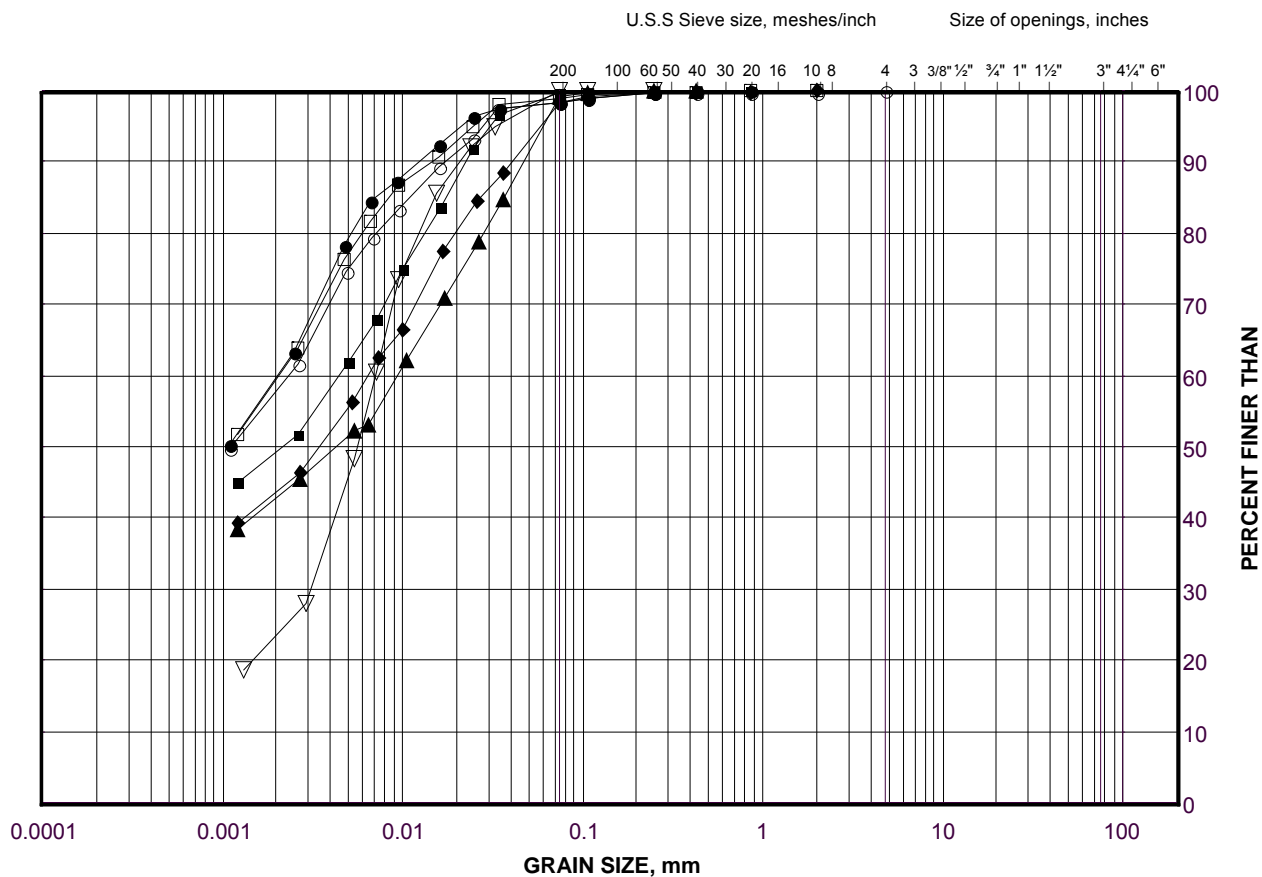
GTA-RCK 018 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-MISS.GDT 9/22/15

# GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

Highway 69 (SBL and NBL) Culvert C201 at STA 11+207

FIGURE A.C201-01A



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C201-04	10	172.2
■	S202-04	4	179.6
◆	C201-02	4	179.4
▲	C201-01	4	179.8
▽	C201-03	5	177.8
○	C201-02	7	174.8
□	C201-01	7	175.3

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

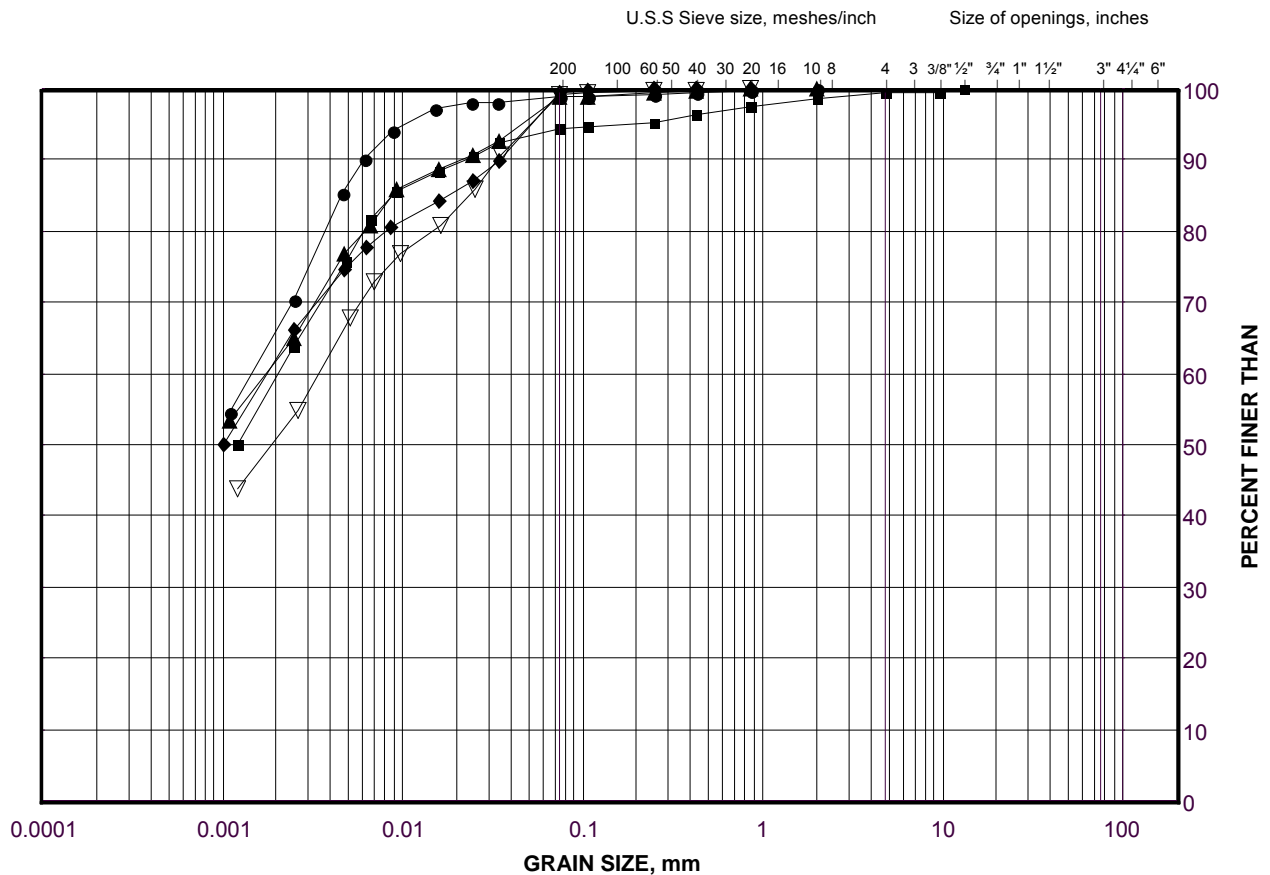
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Clay

Highway 69 (SBL and NBL) Culvert C201 at STA 11+207

FIGURE A.C201-01B



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C201-02	11	168.7
■	C201-04	13	167.6
◆	S202-04	7	174.8
▲	C201-03	7	174.7
▽	C201-03	9	171.7

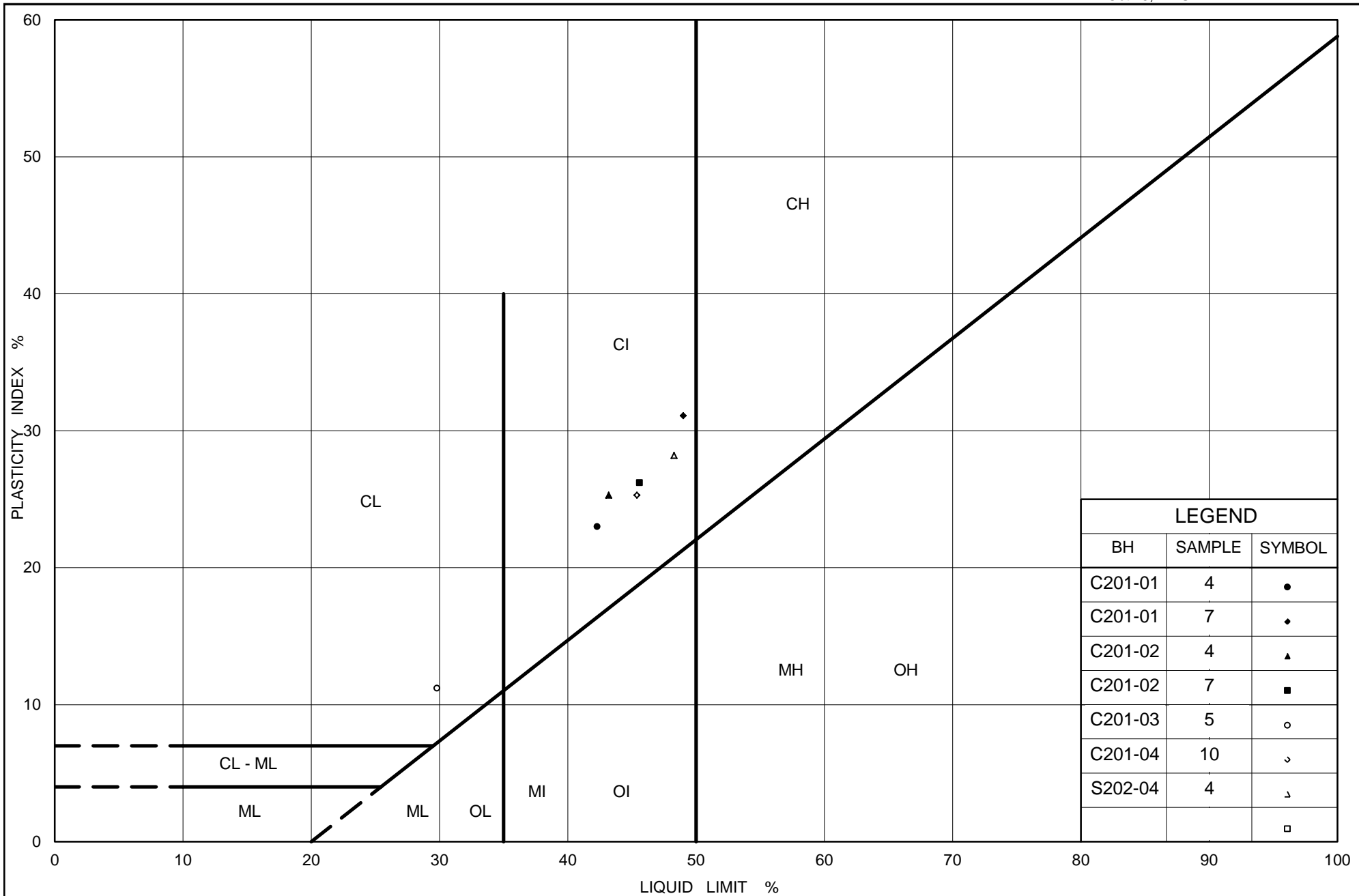
Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

Date: 03-Feb-12





Ministry of Transportation

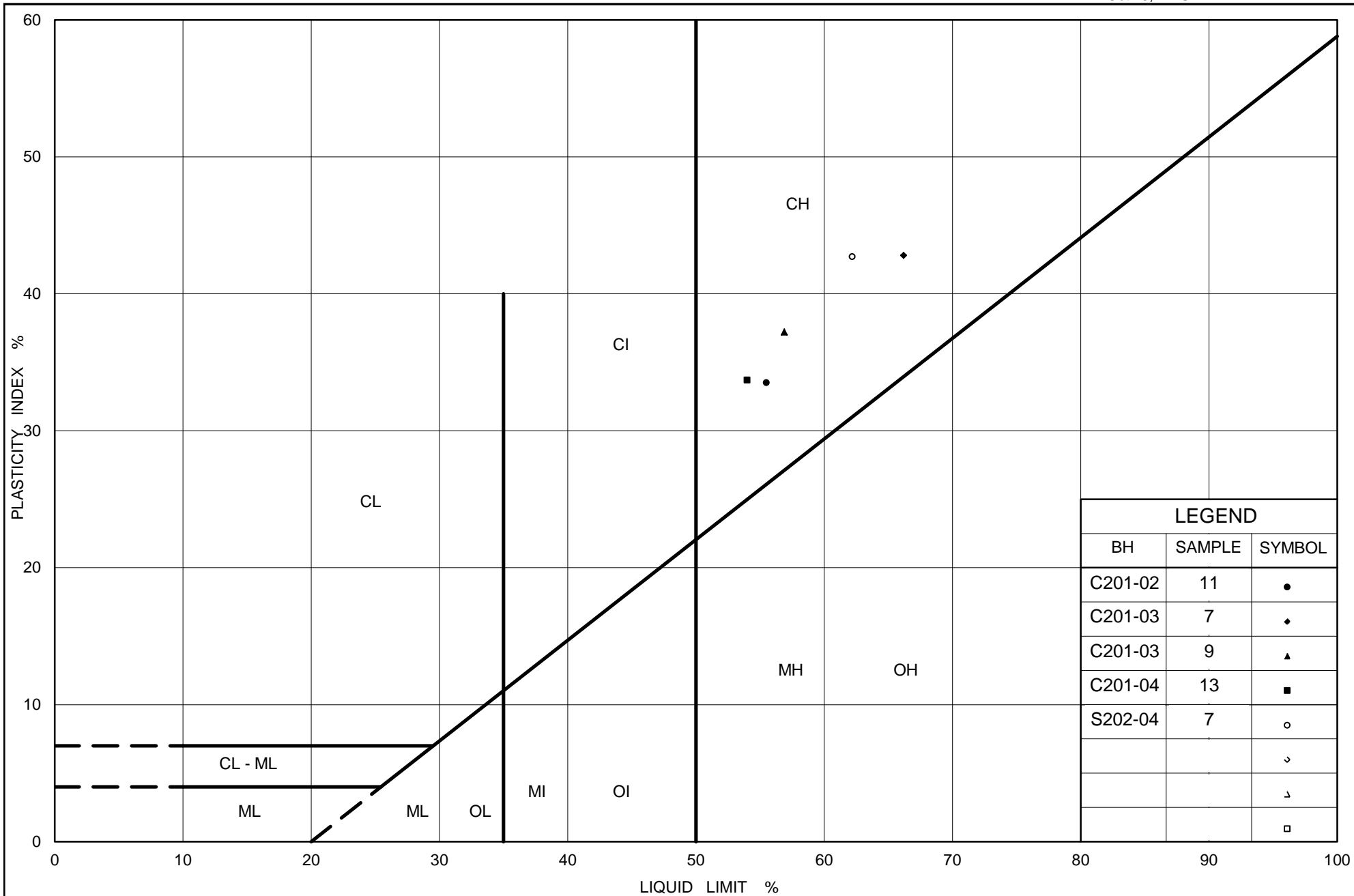
Ontario

**PLASTICITY CHART**  
 Clayey Silt to Silty Clay  
 Highway 69 (SBL and NBL) Culvert C201 at STA 11+207

Figure No. A.C201-02A

Project No. 09-1111-6014

Checked By: JPD



Ministry of Transportation

Ontario

# PLASTICITY CHART Clay

Highway 69 (SBL and NBL) Culvert C201 at STA 11+207

Figure No. A.C201-02B

Project No. 09-1111-6014

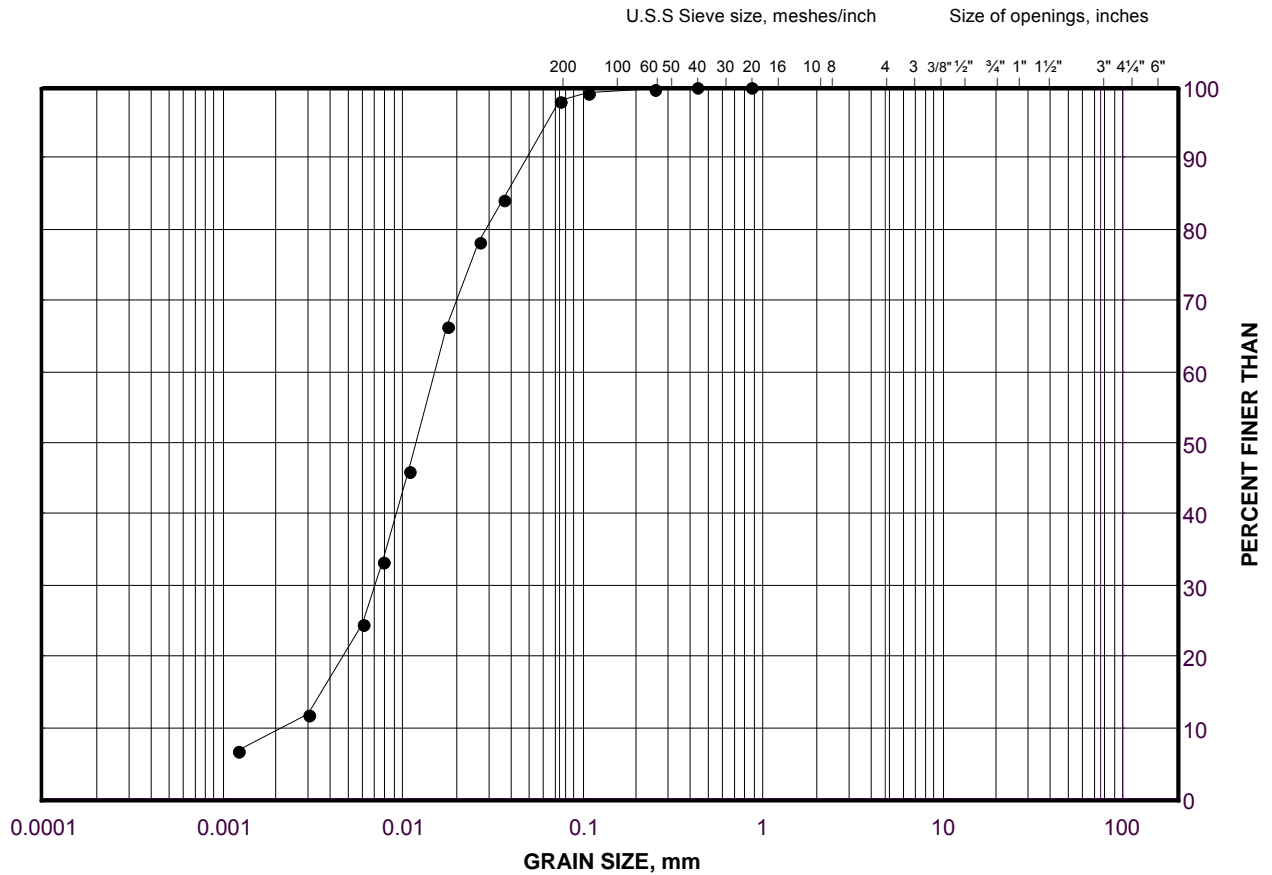
Checked By: JPD

# GRAIN SIZE DISTRIBUTION

Silt (Interlayer)

Highway 69 (SBL and NBL) Culvert 201 at STA 11+207

FIGURE A.C201-03



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C201-04	6	178.2

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

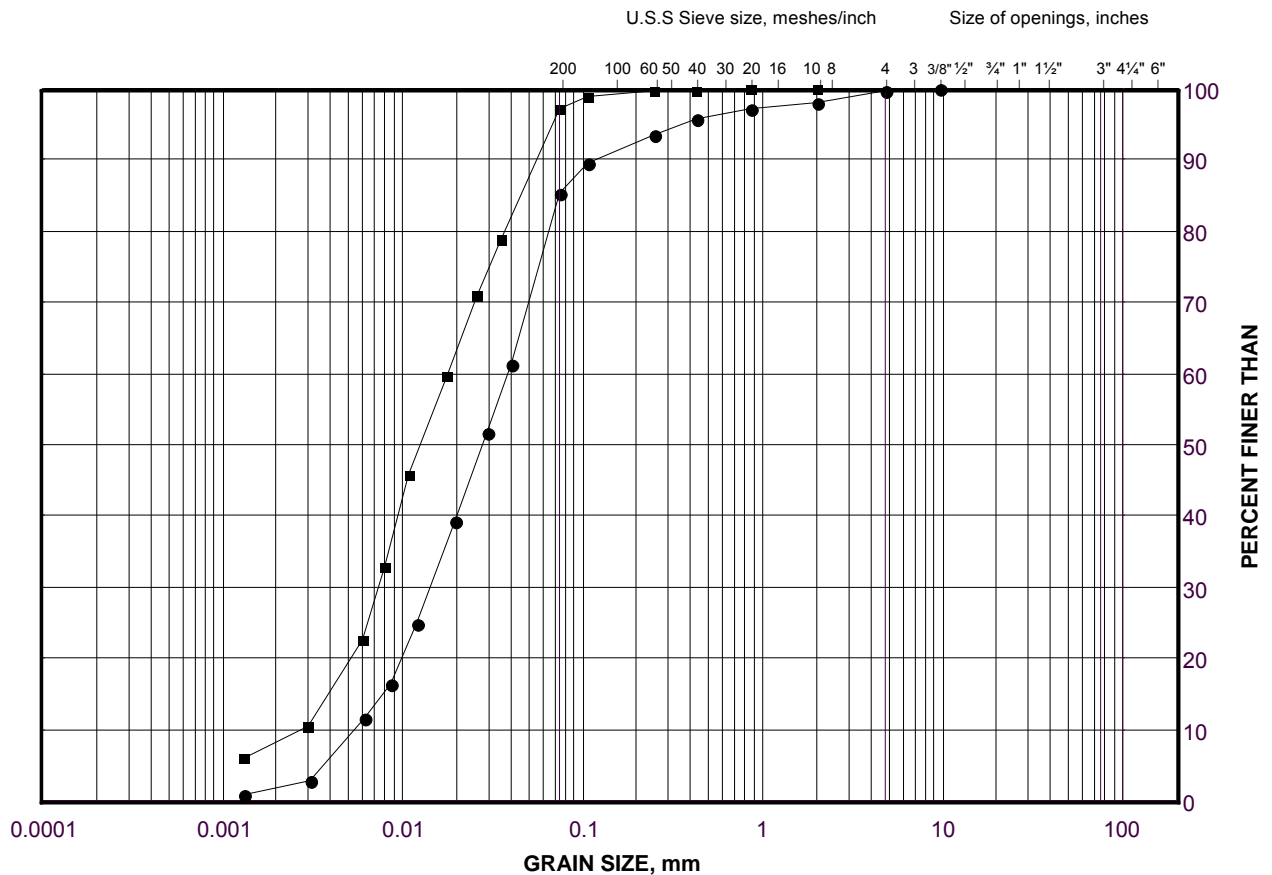
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Silt

Highway 69 (SBL and NBL) Culvert C201 at STA 11+207

FIGURE A.C201-04



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C201-02	13	164.2
■	C201-03	15	161.0

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

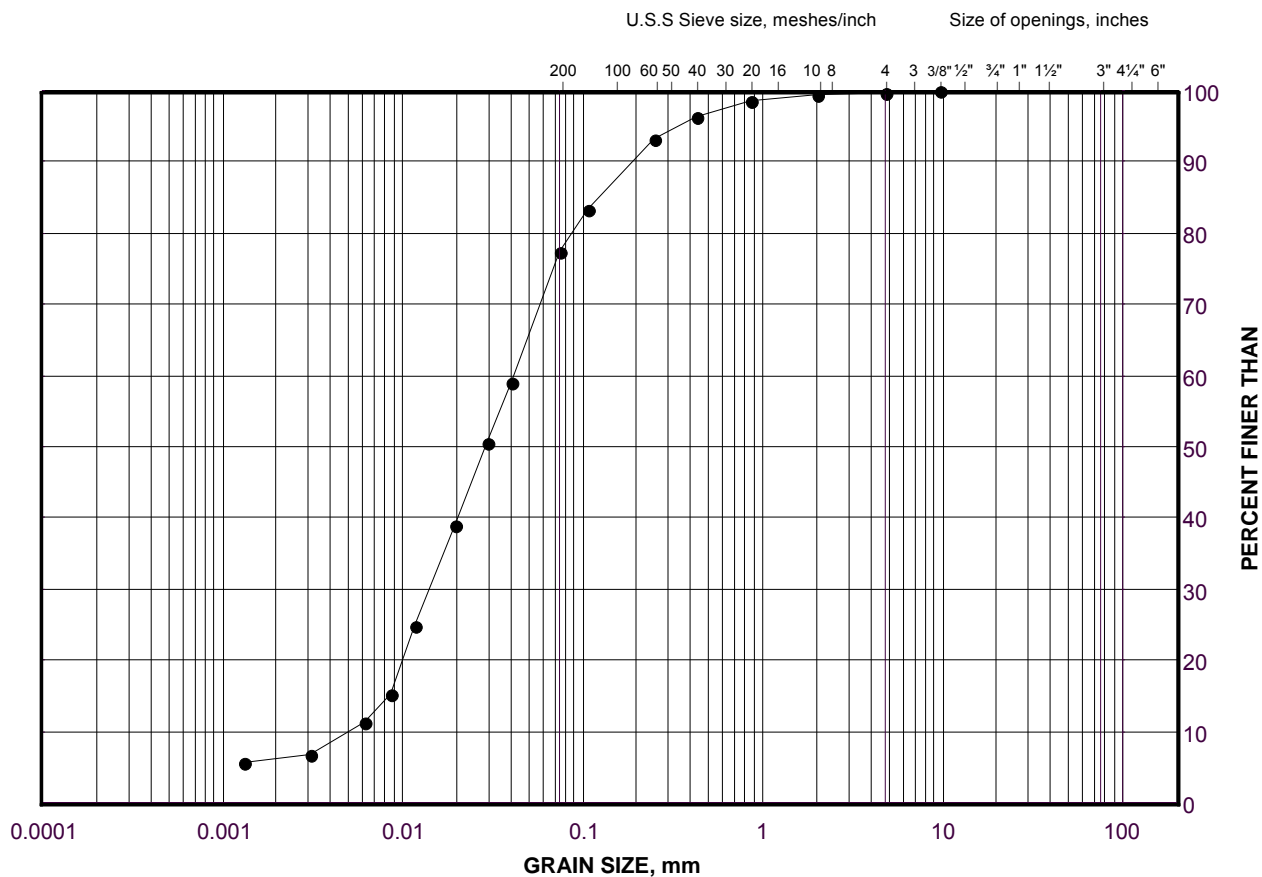
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Sandy Silt

Highway 69 (SBL and NBL) Culvert 201 at STA 11+207

FIGURE A.C201-05A



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C201-01	11A	169.2

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

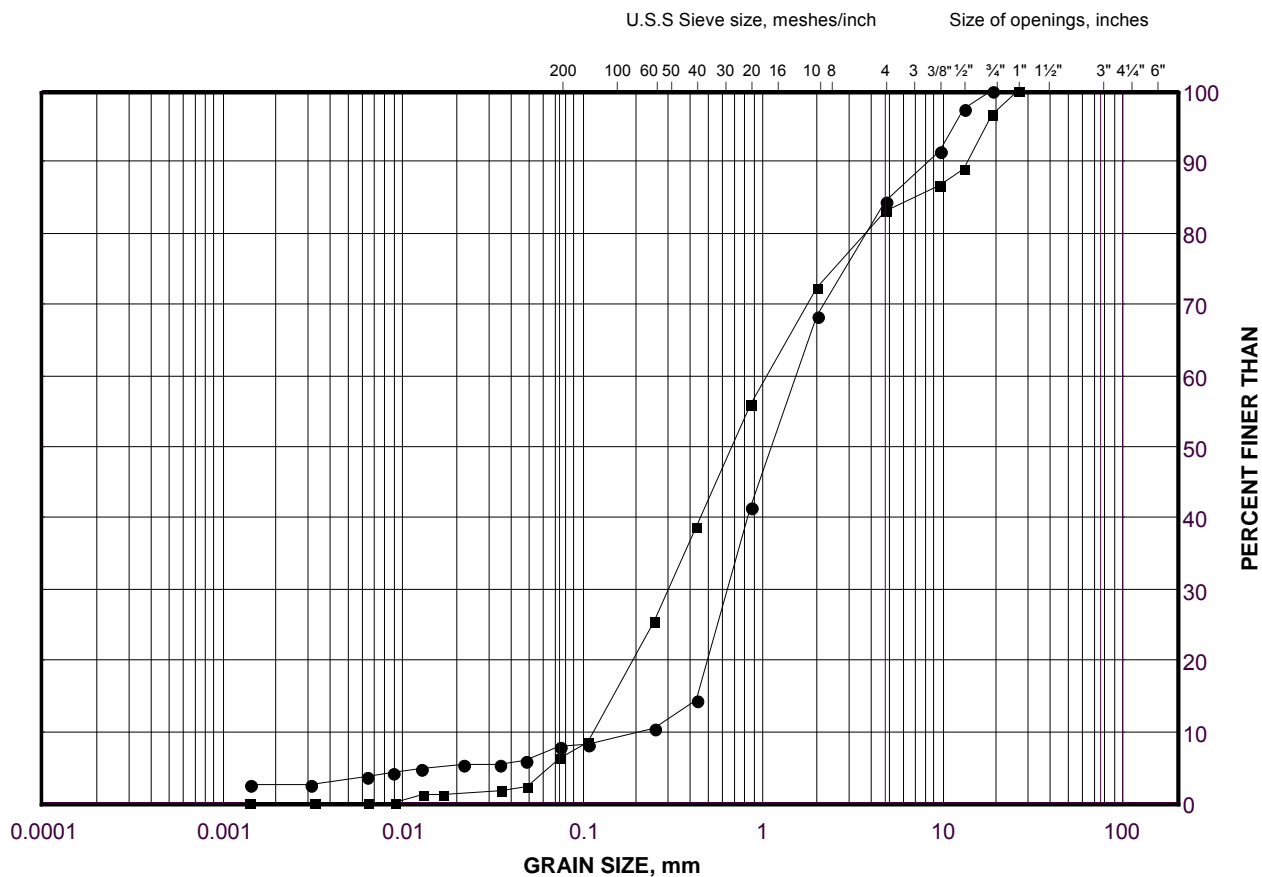
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (SBL and NBL) Culvert 201 at STA 11+207

FIGURE A.C201-05B



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C201-04	15	161.5
■	C201-03	17	157.2

### Borehole C201-01

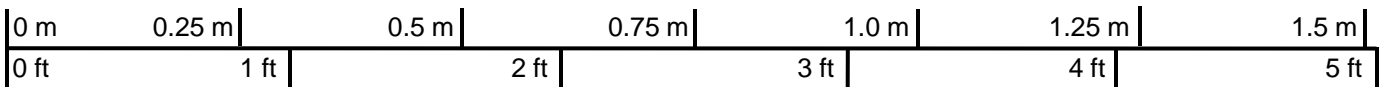


Box 1: 14.17 m – 16.60 m


### Borehole S202-04



Box 1: 11.28 m – 14.26 m



Scale

PROJECT				<b>Culverts</b>			
				<b>Highway 69 Four-Laning</b>			
				<b>GWP 5402-05-00; WP 5402-05-01</b>			
TITLE				<b>Bedrock Core Photographs – Culvert 201</b>			
				<b>Highway 69 (SBL and NBL) STA 11+207</b>			
				PROJECT No. 09-1111-6014		FILE No. ----	
				DESIGN	AT		SCALE NTS REV.
				CADD	--		
				CHECK	AT		<b>FIGURE A.C201-06</b>
				REVIEW	TVA		





# APPENDIX B

## Highway 69 SBL and NBL – STA 11+220 (Culvert 202)

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

CONT No.  
WP No. 5404-05-01

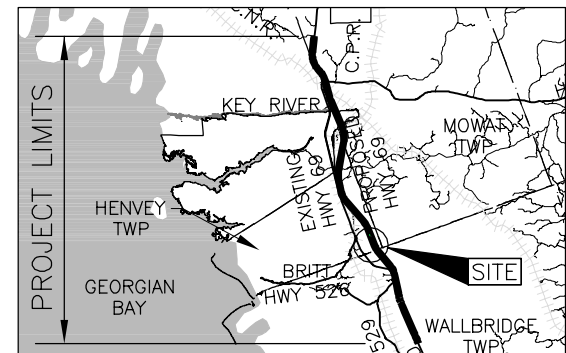


HIGHWAY 69  
CULVERT 202 STA 11+220  
BOREHOLE LOCATIONS

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



LEGEND

● Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C202-01	182.6	5074238.2	225345.3
C202-02	182.7	5074247.4	225386.7
C202-03	182.8	5074254.7	225405.1
S202-05	182.5	5074244.1	225362.1
S202-19	183.0	5074259.4	225424.2

NOTES

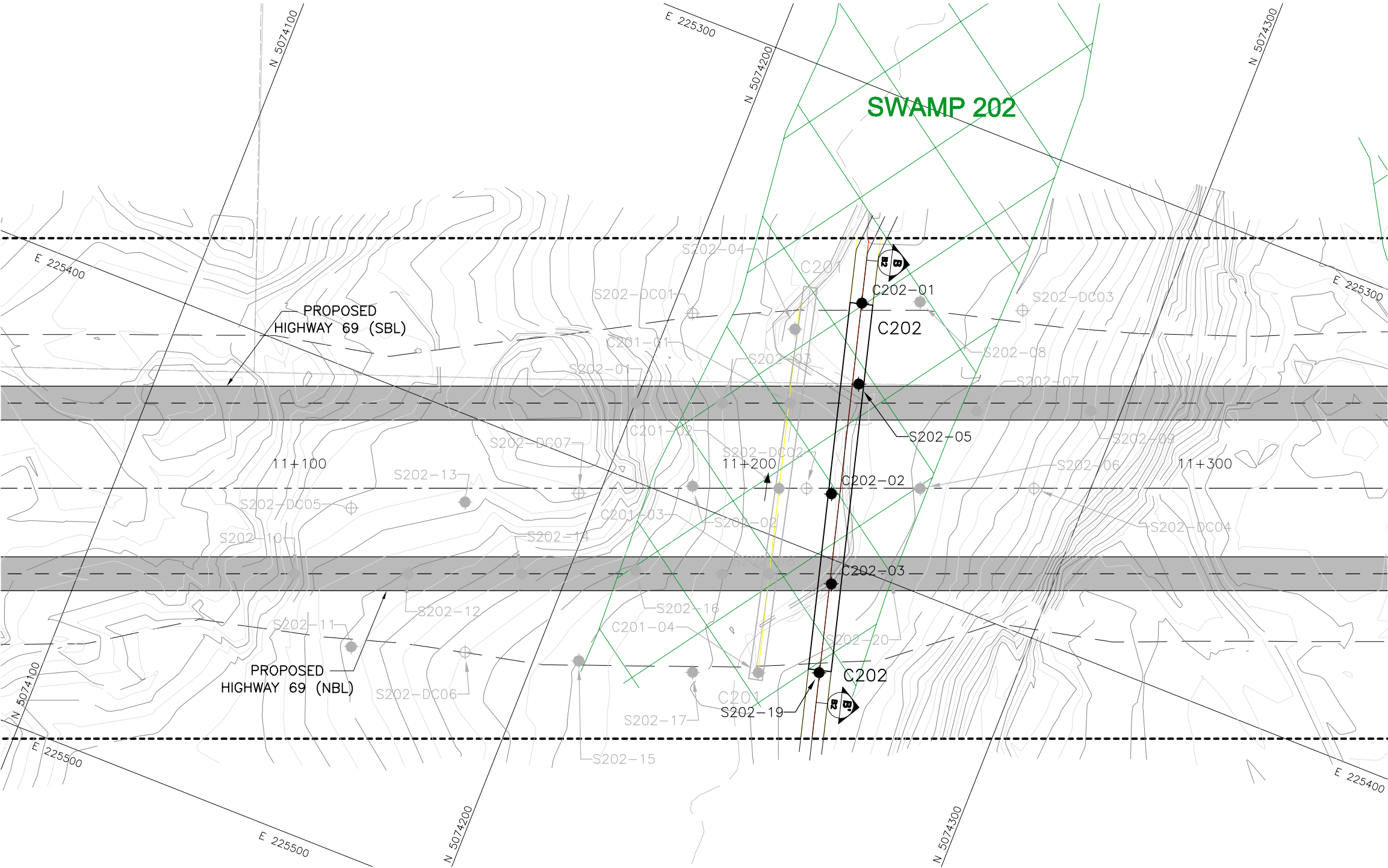
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69\_base.dwg, Hwy69\_plan.dwg, received December 16, 2009. And Contours from Hwy69\_Contours-Plan\_C2\_C3.dwg, received July 14, 2011, Culvert Location obtained from culv 11+220 aug 2012.dwg, received August 24, 2012.



PLAN

SCALE  
10 0 10 20 m



NO.	DATE	BY	REVISION
Geocres No. 41H-119			
HWY. 69		PROJECT NO. 09-1111-6014	
SUBM'D. TVA		CHKD. TVA	DATE: August 2012
DRAWN: JFC		CHKD. CN	APPD. JPD/JMAC
		DIST. SITE: DWG. B1	

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

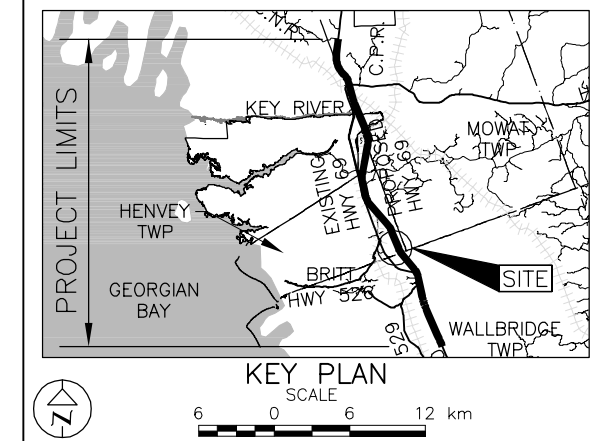
CONT No.  
WP No. 5404-05-01

HIGHWAY 69  
CULVERT 202 STA 11+220  
SOIL STRATA

SHEET



**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA



#### LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling
- REC Recovery (%)
- R Refusal

#### BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C202-01	182.6	5074238.2	225345.3
C202-02	182.7	5074247.4	225386.7
C202-03	182.8	5074254.7	225405.1
S202-05	182.5	5074244.1	225362.1
S202-19	183.0	5074259.4	225424.2

#### NOTES

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

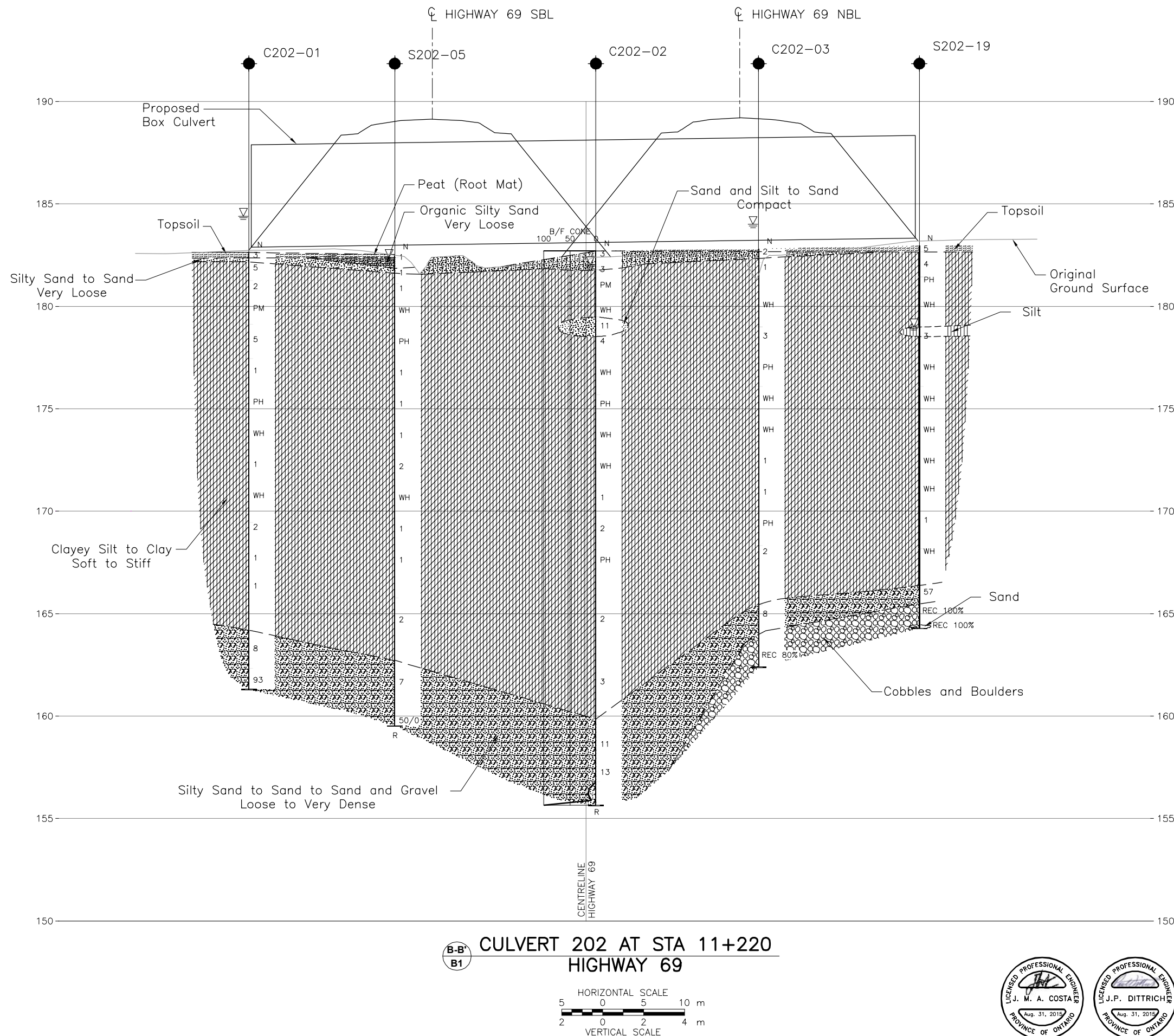
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

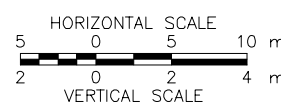
#### REFERENCE

Base plans provided in digital format by URS, drawing files Hwy69\_base.dwg, Hwy69\_plan.dwg, received December 16, 2009.  
Cross-Section drawing obtained from culv 11+220 aug 2012.dwg, received August 24, 2012.

NO.	DATE	BY	REVISION
Geocres No. 41H-119			
HWY. 69		PROJECT NO. 09-1111-6014	
SUBM'D. TVA		CHKD. TVA	DATE: August 2012
DRAWN: JFC		CHKD. CN	APPD. JPD/JMAC
		DIST. SITE: DWG. B2	



**CULVERT 202 AT STA 11+220  
HIGHWAY 69**




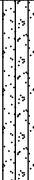

PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No C202-01</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. 5404-05-01		LOCATION N 5074238.2 ; E 225345.3		ORIGINATED BY MR			
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY MAS/SB			
DATUM Geodetic		DATE March 10 and 11, 2011		CHECKED BY TVA			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	WATER CONTENT (%)					
182.6	GROUND SURFACE							20 40 60 80 100						GR SA SI CL
182.3	TOPSOIL		1A	SS	3									
0.5	SAND, trace to some silt, containing organics and rootlets Very loose Brown Moist		1B 1C				182							
181.2	CLAYEY SILT, some sand, containing rootlets Firm Brown Moist		2	SS	5									
1.4	SILTY CLAY, trace sand, containing rootlets to a depth of 2.1 m Soft Grey Moist		3	SS	2		181							
179.1	CLAYEY SILT, trace sand Firm Grey Wet		4	TO*	PM		180	5						
3.5			5	SS	5		179	2						
177.4	SILTY CLAY, trace sand Soft to firm Grey Moist		6	SS	1		178							
			7	TO	PH		177							
			8	SS	WH		176	3						
			9	SS	1		175	3						
			10	SS	WH		174	3						
							173	3						
							172							
							171	3						
							170	3						
169.4	CLAY, some silt, trace to some sand, trace gravel, containing silt interlayers Firm Grey Wet		11	SS	2		169							
13.2							168	4						

Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

PROJECT		RECORD OF BOREHOLE		No C202-01		SHEET 2 OF 2		METRIC								
W.P. 09-1111-6014		LOCATION		N 5074238.2 ; E 225345.3		ORIGINATED BY		MR								
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY								
DATUM		Geodetic		DATE		March 10 and 11, 2011		CHECKED BY								
								TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
164.2	CLAY, some silt, trace to some sand, trace gravel, containing silt interlayers Firm Grey Wet		12	SS	1											
18.4	Silty SAND, trace to some gravel Loose Grey Wet		13	SS	1											
162.3	SAND and GRAVEL, containing cobbles Very dense Grey Wet		14	SS	8											
20.3																
161.3																
21.3	END OF BOREHOLE															
	NOTES:  * Unable to recover Shelby tube sample between depths of 2.6 m and 3.0 m.  1. Water flowing from top of casing when advanced to a depth of 20.7 m below ground surface (Elev. 161.9 m).  Water level in casing at a depth of 0.8 m below ground surface (Elev. 181.8 m) at about 6:30 pm on March 10, 2011. Casing set at a depth of 20.7 m below ground surface (Elev. 161.9 m) at the time of water level measurement.  Water level in casing at 1.8 m above ground surface (Elev. 184.4 m) measured at about 7:15 am on March 11, 2011 - Artesian Condition. Casing set at a depth of 20.7 m below ground surface (Elev. 161.9 m) at the time of water level measurement.															



PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C202-02</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074247.4 ;E 225386.7</u>		ORIGINATED BY <u>MR</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MAS/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>February 28 and March 1, 2011</u>		CHECKED BY <u>TVA</u>			


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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



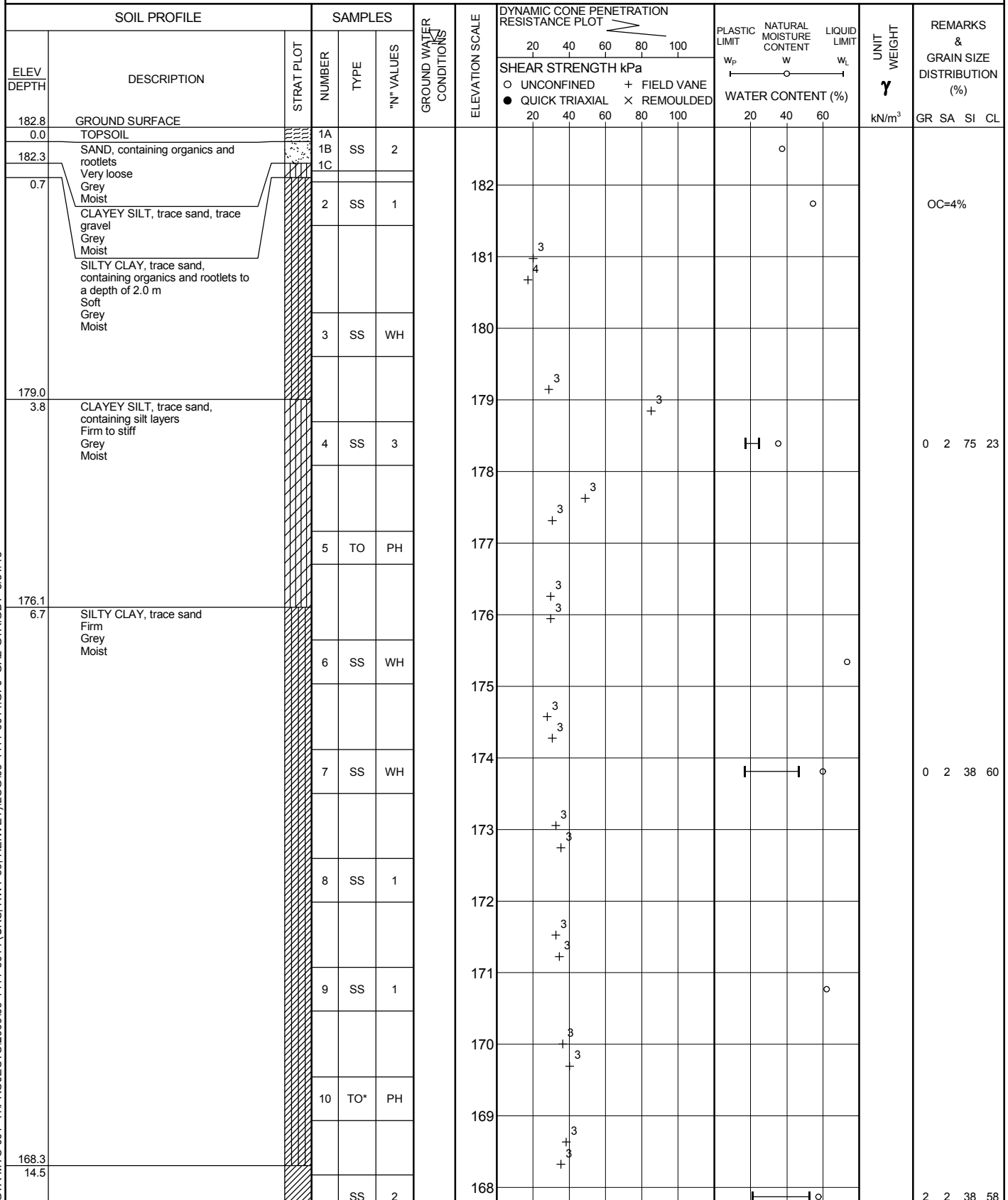
PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C202-02</b>		SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074247.4 ;E 225386.7</u>		ORIGINATED BY <u>MR</u>			
DIST <u>        </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MAS/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>February 28 and March 1, 2011</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa								WATER CONTENT (%)		
							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED										
							20 40 60 80 100								20 40 60		
--- CONTINUED FROM PREVIOUS PAGE ---																	
159.8 22.9	SILTY CLAY, trace sand Firm to stiff Grey Moist  Containing silt layers below a depth of 19.7 m		13	TO	PH		167							17.1			
			14	SS	2												
												</					

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15

<b>PROJECT</b> 09-1111-6014		<b>RECORD OF BOREHOLE No C202-03</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. 5404-05-01		LOCATION N 5074254.7 ; E 225405.1		ORIGINATED BY MR			
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY MAS/SB			
DATUM Geodetic		DATE March 8, 2011		CHECKED BY TVA			






Continued Next Page

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15



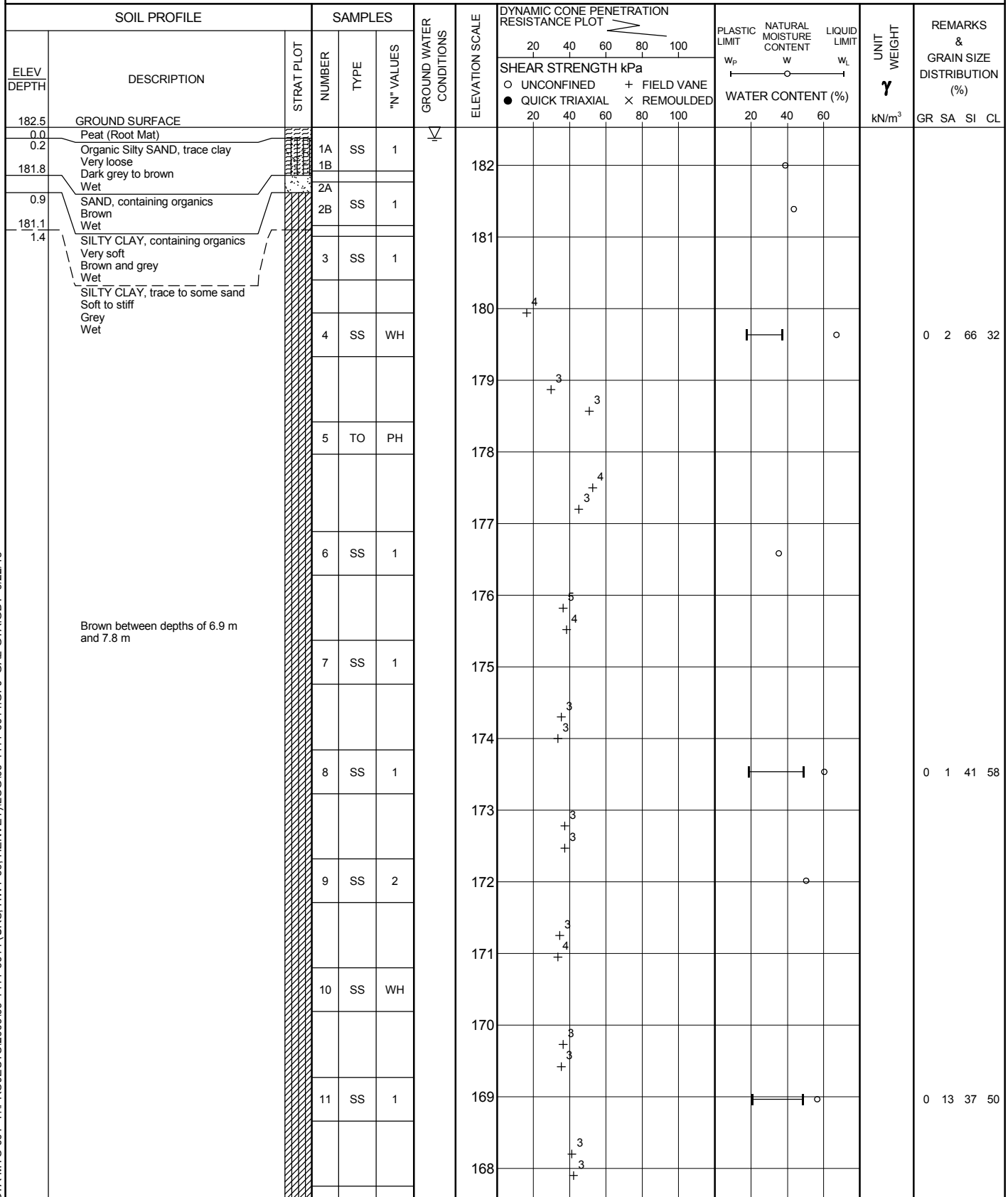
PROJECT <u>09-1111-6014</u>		<b>RECORD OF BOREHOLE No C202-03</b>		SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>5404-05-01</u>		LOCATION <u>N 5074254.7 ; E 225405.1</u>		ORIGINATED BY <u>MR</u>			
DIST <u>          </u> HWY <u>69</u>		BOREHOLE TYPE <u>127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring</u>		COMPILED BY <u>MAS/SB</u>			
DATUM <u>Geodetic</u>		DATE <u>March 8, 2011</u>		CHECKED BY <u>TVA</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		GR	SA	SI	CL
					○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED					WATER CONTENT (%)										
	--- CONTINUED FROM PREVIOUS PAGE ---		11																	
165.4	CLAY, some silt, trace sand, trace gravel, containing silt interlayers Stiff Grey Wet																			
17.4	SAND and GRAVEL Loose Grey Wet		12	SS	8															
164.0																				
18.8	Cobbles and Boulders, containing sand interlayers		13	SC	REC 80%															
162.4																				
20.4	END OF BOREHOLE  NOTES:  * Unable to recover Shelby tube sample between depths of 13.3 m and 13.9 m.  1. Water flowing from top of casing when advanced to a depth of 17.7 m below ground surface (Elev. 165.1 m).  Water level in casing at 1.2 m above surface (Elev. 184.0 m) measured at about 30 min. after completion of drilling - Artesian Condition.																			

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

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 8/31/15



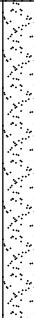
PROJECT 09-1111-6014		<b>RECORD OF BOREHOLE No S202-05</b>		SHEET 1 OF 2		<b>METRIC</b>	
W.P. 5404-05-01		LOCATION N 5074244.1 ; E 225362.1		ORIGINATED BY MR			
DIST _____ HWY 69		BOREHOLE TYPE 127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY MAS			
DATUM Geodetic		DATE March 13, 2011		CHECKED BY TVA			



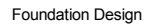
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE





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PROJECT		RECORD OF BOREHOLE		No S202-05		SHEET 2 OF 2		METRIC						
W.P. 09-1111-6014		LOCATION		N 5074244.1 ; E 225362.1		ORIGINATED BY		MR						
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY						
DATUM		Geodetic		DATE		March 13, 2011		CHECKED BY						
								TVA						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60					
165.7	SILTY CLAY, trace to some sand Soft to stiff Grey Wet		12	SS	1		167							
166														
165.8	CLAY, some silt, containing grey silt layers Stiff Brown Wet		13	SS	2		165							
164														
162.7							164							
163							163							
19.8	SAND, some silt Loose Grey Wet		14	SS	7		162							
161														
160							160							
159.5														
23.0	END OF BOREHOLE SPOON AND CASING REFUSAL  NOTES:  1. Water flowing from top of casing when advanced to a depth of 20.7 m below ground surface (Elev. 161.8 m).  Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 182.3 m) upon completion of drilling.		15	SS	50/0.0									

GTA-MTO 001 T:\PROJECTS\2009\09-1111-6014 (URS, HWY 69, HENVEY)\LOG\09-1111-6014.GPJ GAL-GTA.GDT 9/22/15



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

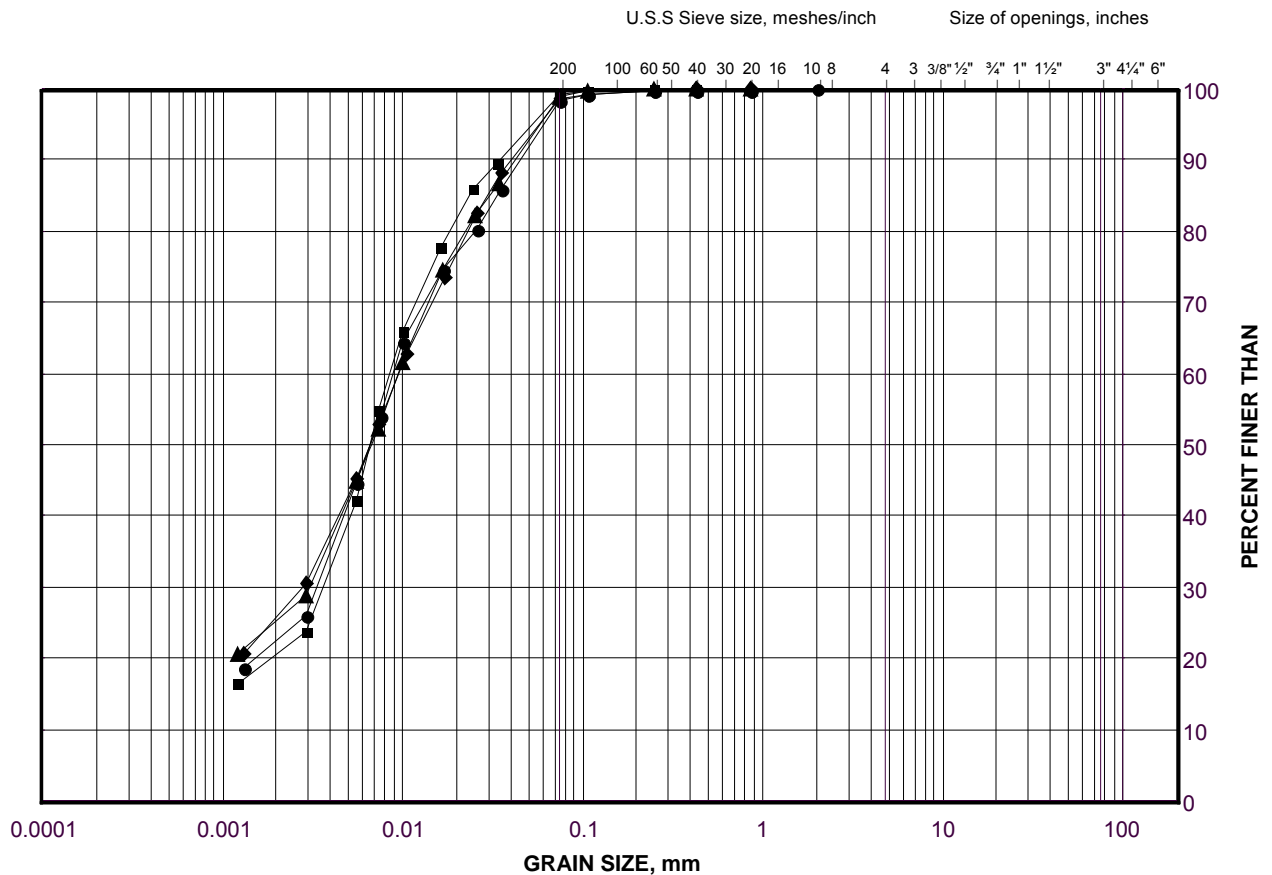
PROJECT		RECORD OF BOREHOLE		No S202-19		SHEET 2 OF 2		METRIC								
W.P. 09-1111-6014		LOCATION		N 5074259.4 ; E 225424.2		ORIGINATED BY		MR								
DIST		HWY 69		BOREHOLE TYPE		127 mm O.D. Continuous Flight Solid Stem Augers, NW Casing, Wash Boring		COMPILED BY								
DATUM		Geodetic		DATE		March 3, 2011		CHECKED BY								
								TVA								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
166.4	SILTY CLAY, trace sand, containing grey silt interlayers Stiff Brown Moist		12	SS	WH											
166	Silty SAND, some gravel, containing cobbles Very dense Grey Wet		13	SS	57											
165.5	Boulder Dark grey with reddish pink bands		14	SC	REC 100%											
164.5	SAND COBBLE Dark grey END OF BOREHOLE		15	SC	REC 100%											
18.7	NOTES:  1. Water flowing from top of casing when advanced to a depth of 17.1 m below ground surface (Elev. 165.9 m), height of casing at about 0.7 m above ground surface.  Water level in open borehole at a depth of 4.0 m below ground surface (Elev. 179.0 m) upon completion of drilling.															

# GRAIN SIZE DISTRIBUTION

Clayey Silt

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

FIGURE B.C202-01A



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C202-03	4	178.4
■	C202-01	5	178.2
◆	S202-19	5B	178.3
▲	C202-02	7	176.6

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

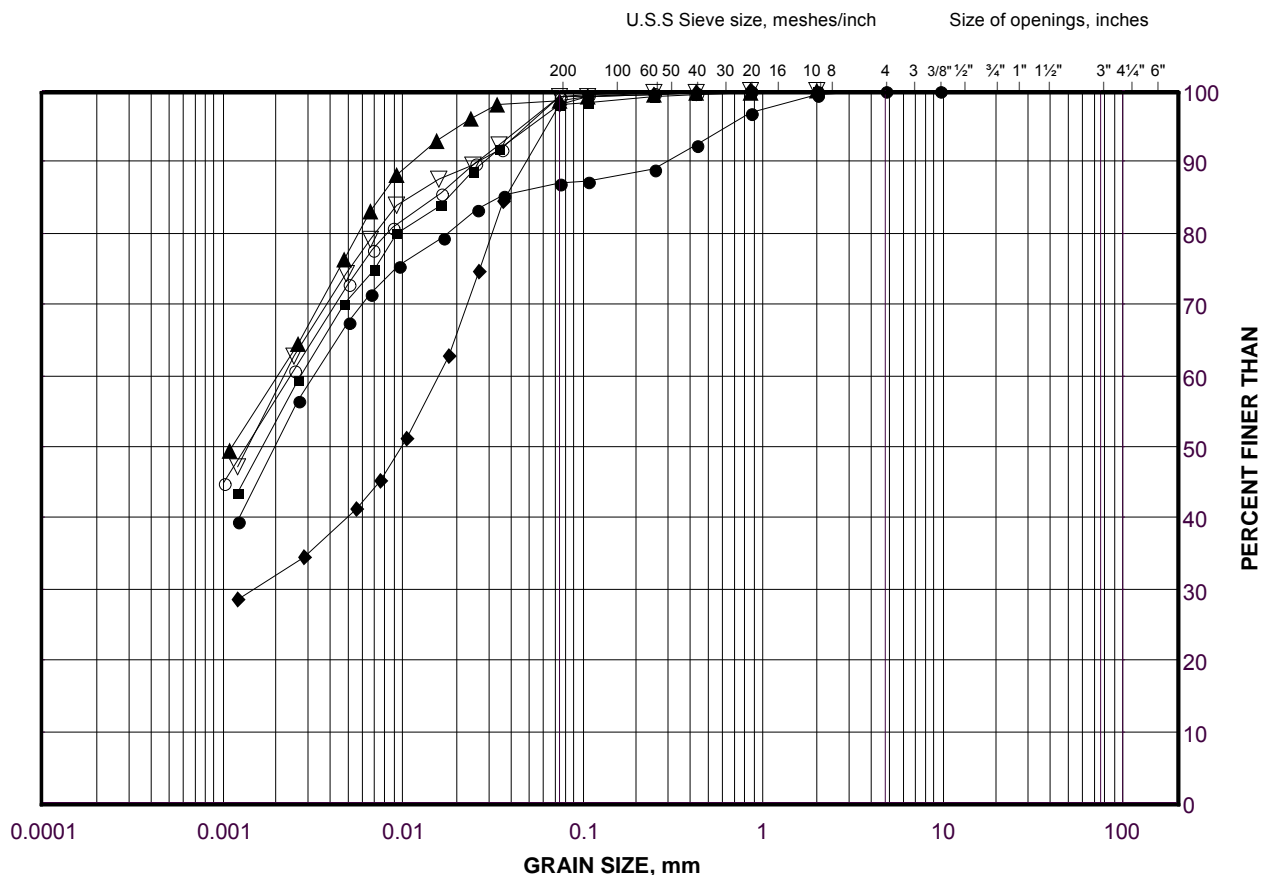
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Silty Clay

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

FIGURE B.C202-01B



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-05	11	168.9
■	C202-02	12	169.0
◆	S202-05	4	179.6
▲	C202-03	7	173.8
▽	S202-05	8	173.5
○	C202-01	9	172.1

Project Number: 09-1111-6014

Checked By: TVA

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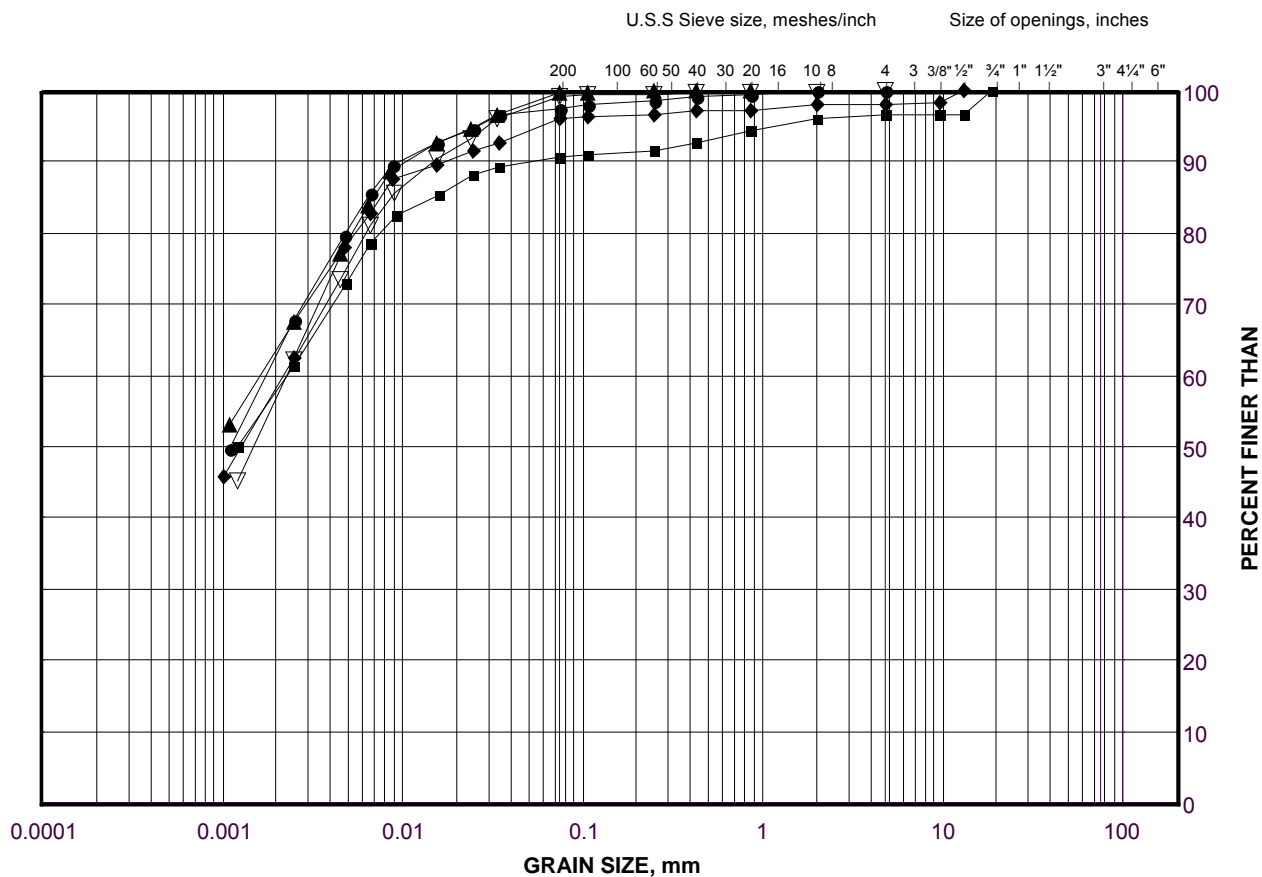
Date: 03-Feb-12

# GRAIN SIZE DISTRIBUTION

Clay

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

FIGURE B.C202-01C



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	S202-19	11	169.4
■	C202-01	11	169.1
◆	C202-03	11	167.9
▲	S202-05	13	164.5
▽	S202-19	8	173.8

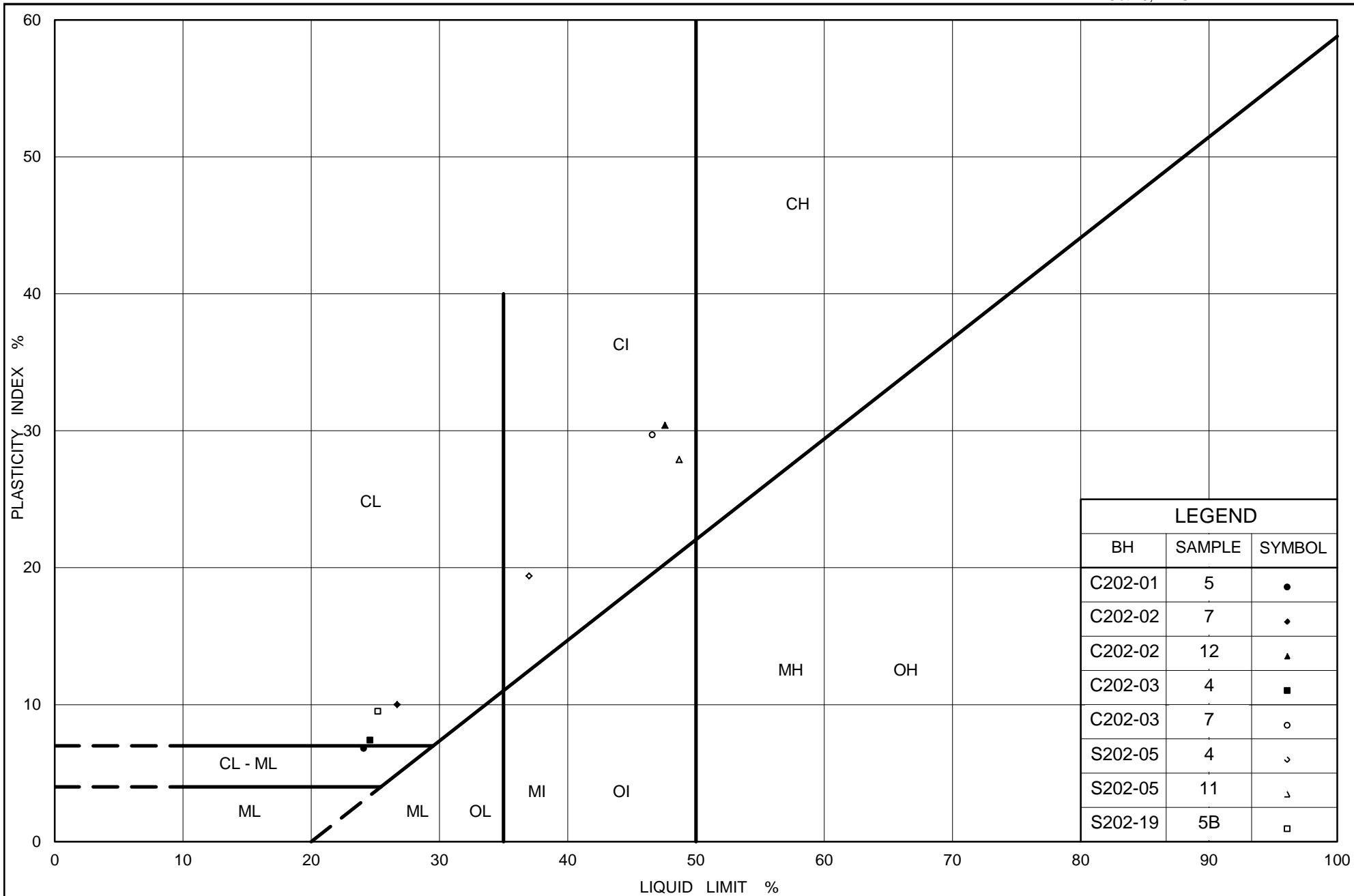
Project Number: 09-1111-6014

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Date: 03-Feb-12





Ministry of Transportation

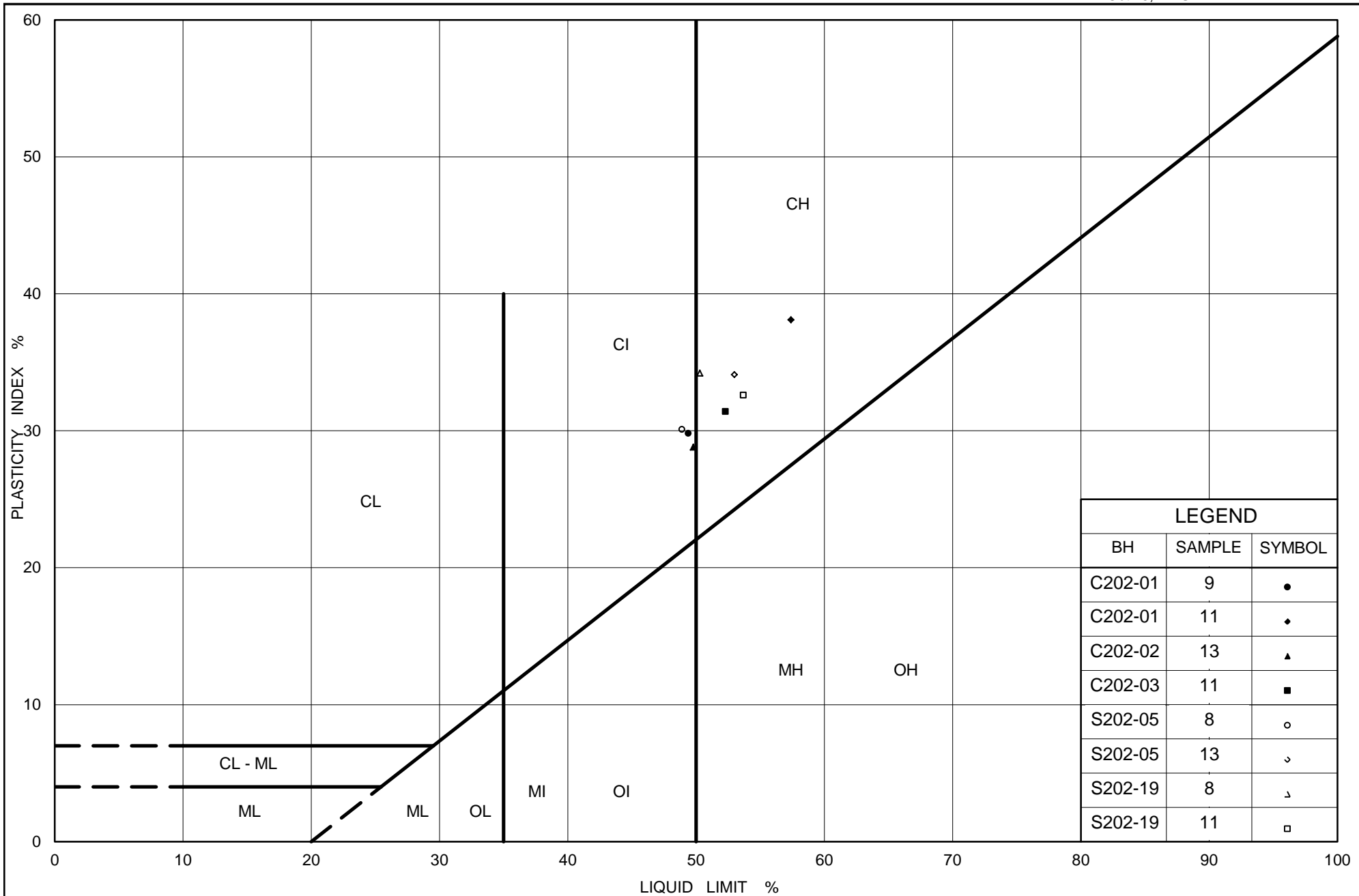
Ontario

**PLASTICITY CHART**  
 Clayey Silt to Silty Clay  
 Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

Figure No. B.C202-02A

Project No. 09-1111-6014

Checked By: JPD



Ministry of Transportation

Ontario

## PLASTICITY CHART

Silty Clay to Clay

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

Figure No. B.C202-02B

Project No. 09-1111-6014

Checked By: JPD

**CONSOLIDATION TEST SUMMARY**  
**Highway 69 (SBL and NBL) Culvert C202 at STA 11+220**

**FIGURE B.C202-03**  
**Sheet 1 of 4**

**SAMPLE IDENTIFICATION**

Project Number	09-1111-6014	Sample Number	13
Borehole Number	C202-02	Sample Depth, m	15.2

**TEST CONDITIONS**

Test Type	Standard	Load Duration, hr	24
Oedometer Number	8		
Date Started	5/02/2011		
Date Completed	5/15/2011		

**SAMPLE DIMENSIONS AND PROPERTIES - INITIAL**

Sample Height, cm	1.91	Unit Weight, kN/m <sup>3</sup>	17.09
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m <sup>3</sup>	11.35
Area, cm <sup>2</sup>	31.40	Specific Gravity, measured	2.76
Volume, cm <sup>3</sup>	59.91	Solids Height, cm	0.800
Water Content, %	50.56	Volume of Solids, cm <sup>3</sup>	25.12
Wet Mass, g	104.38	Volume of Voids, cm <sup>3</sup>	34.79
Dry Mass, g	69.33	Degree of Saturation, %	100.7

**TEST COMPUTATIONS**

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t <sub>90</sub> sec	c <sub>v</sub> cm <sup>2</sup> /s	m <sub>v</sub> m <sup>2</sup> /kN	k cm/s
0.00	1.908	1.385	1.908				
5.00	1.910	1.388	1.909	1	7.73E-01		
10.00	1.909	1.386	1.910	38	2.03E-02	1.05E-04	2.09E-07
20.00	1.907	1.384	1.908	118	6.54E-03	9.96E-05	6.38E-08
39.97	1.896	1.370	1.901	540	1.42E-03	2.99E-04	4.16E-08
79.74	1.875	1.344	1.886	254	2.97E-03	2.68E-04	7.78E-08
157.62	1.830	1.288	1.853	623	1.17E-03	3.05E-04	3.49E-08
317.01	1.634	1.042	1.732	1124	5.66E-04	6.46E-04	3.58E-08
630.61	1.510	0.887	1.572	406	1.29E-03	2.07E-04	2.61E-08
1252.71	1.410	0.762	1.460	240	1.88E-03	8.42E-05	1.55E-08
2500.15	1.322	0.652	1.366	194	2.04E-03	3.70E-05	7.39E-09
1252.71	1.331	0.664	1.326				
317.01	1.355	0.694	1.343				
79.74	1.386	0.733	1.371				
20.00	1.425	0.782	1.406				
5.00	1.453	0.816	1.439				

Note:  
k calculated using cv based on t<sub>90</sub> values.  
Specimen swelled under 10kPa

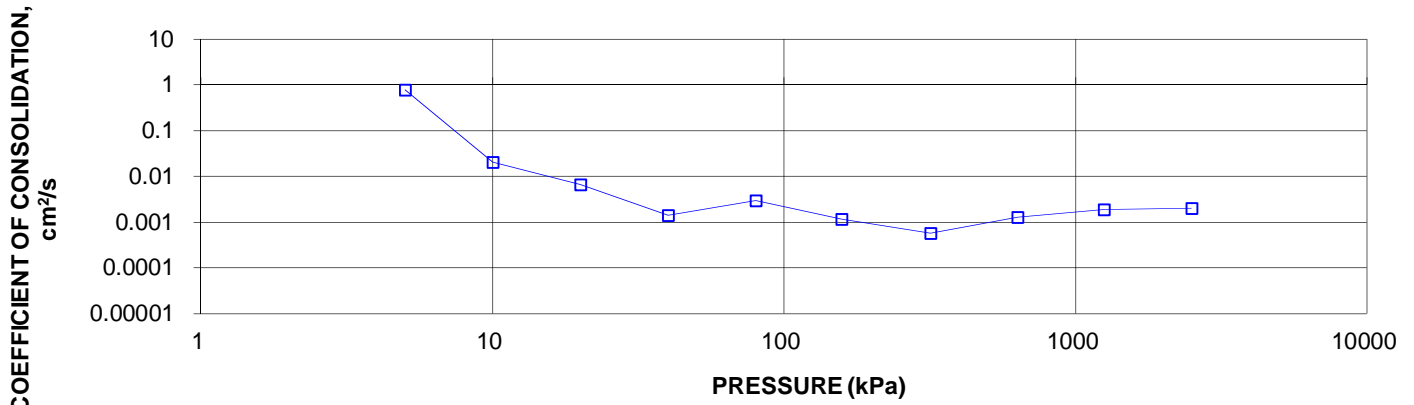
**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.45	Unit Weight, kN/m <sup>3</sup>	19.46
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m <sup>3</sup>	14.91
Area, cm <sup>2</sup>	31.40	Specific Gravity, measured	2.76
Volume, cm <sup>3</sup>	45.61	Solids Height, cm	0.800
Water Content, %	30.52	Volume of Solids, cm <sup>3</sup>	25.12
Wet Mass, g	90.49	Volume of Voids, cm <sup>3</sup>	20.49
Dry Mass, g	69.33		

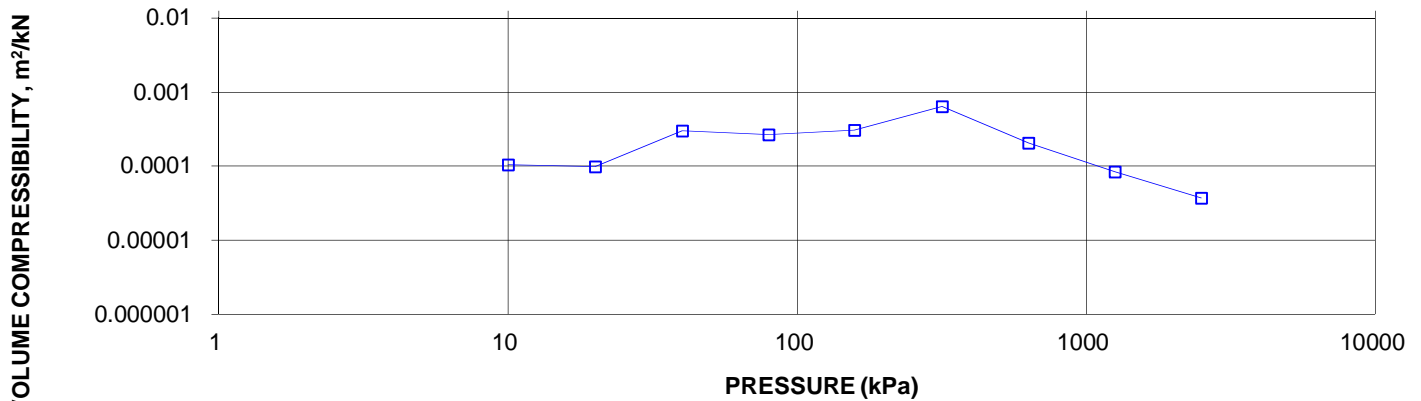
**CONSOLIDATION TEST SUMMARY**  
**Highway 69 (SBL and NBL) Culvert C202 at STA 11+220**

**FIGURE B.C202-03**  
**Sheet 2 of 4**

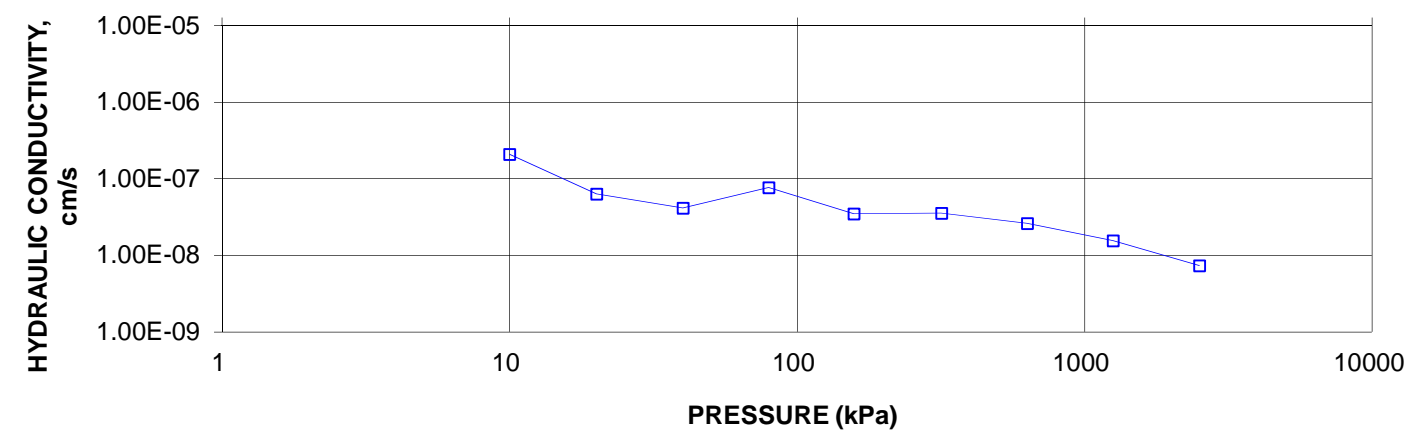
**CONSOLIDATION TEST**  
 **$C_v$  cm<sup>2</sup>/s VS PRESSURE (kPa)**  
**BH C202-02 SA 13**



**CONSOLIDATION TEST**  
 **$M_v$  m<sup>2</sup>/kN vs PRESSURE (kPa)**  
**BH C202-02 SA 13**



**CONSOLIDATION TEST**  
**HYDRAULIC CONDUCTIVITY vs PRESSURE**  
**BH C202-02 SA 13**

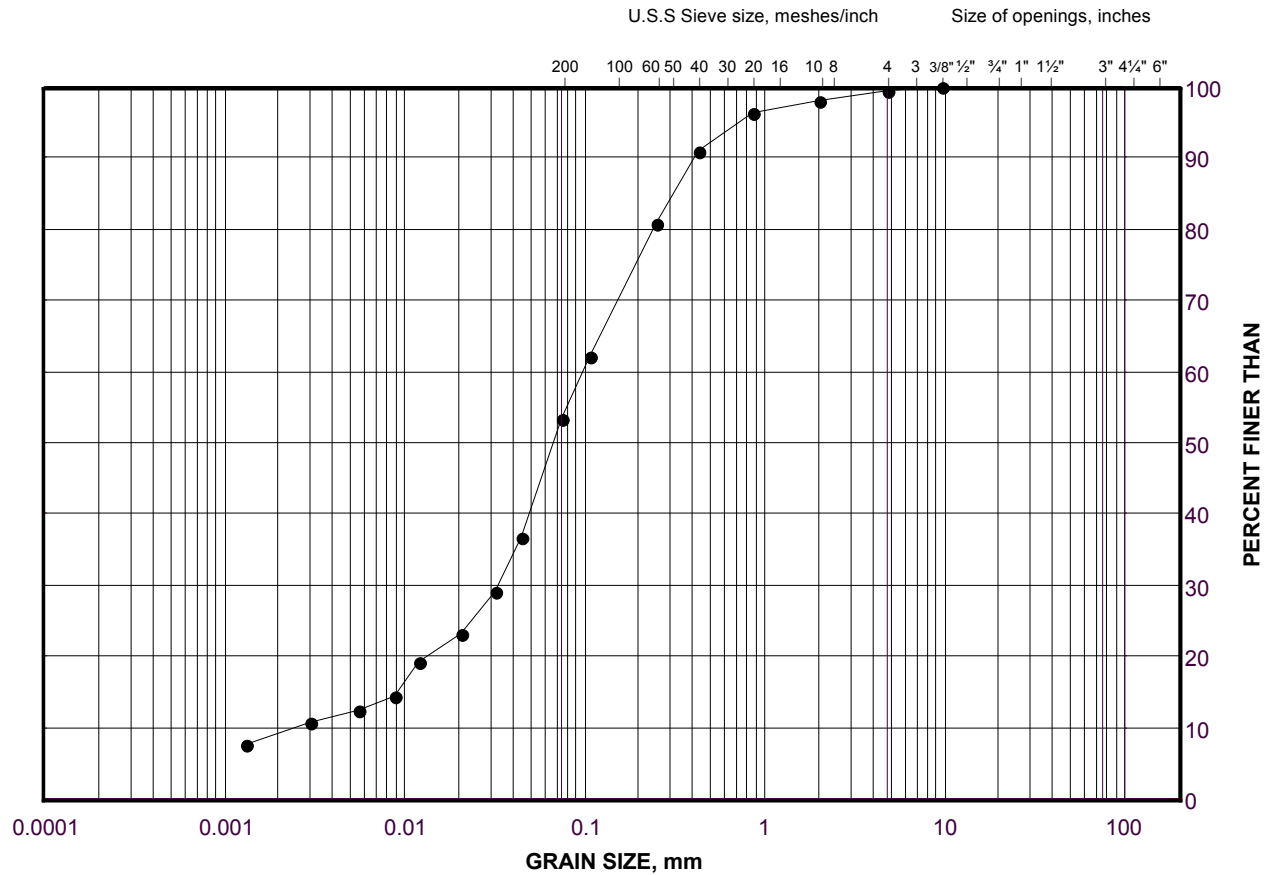


# GRAIN SIZE DISTRIBUTION

Sand and Silt (Interlayer)

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

FIGURE B.C202-04



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

## LEGEND

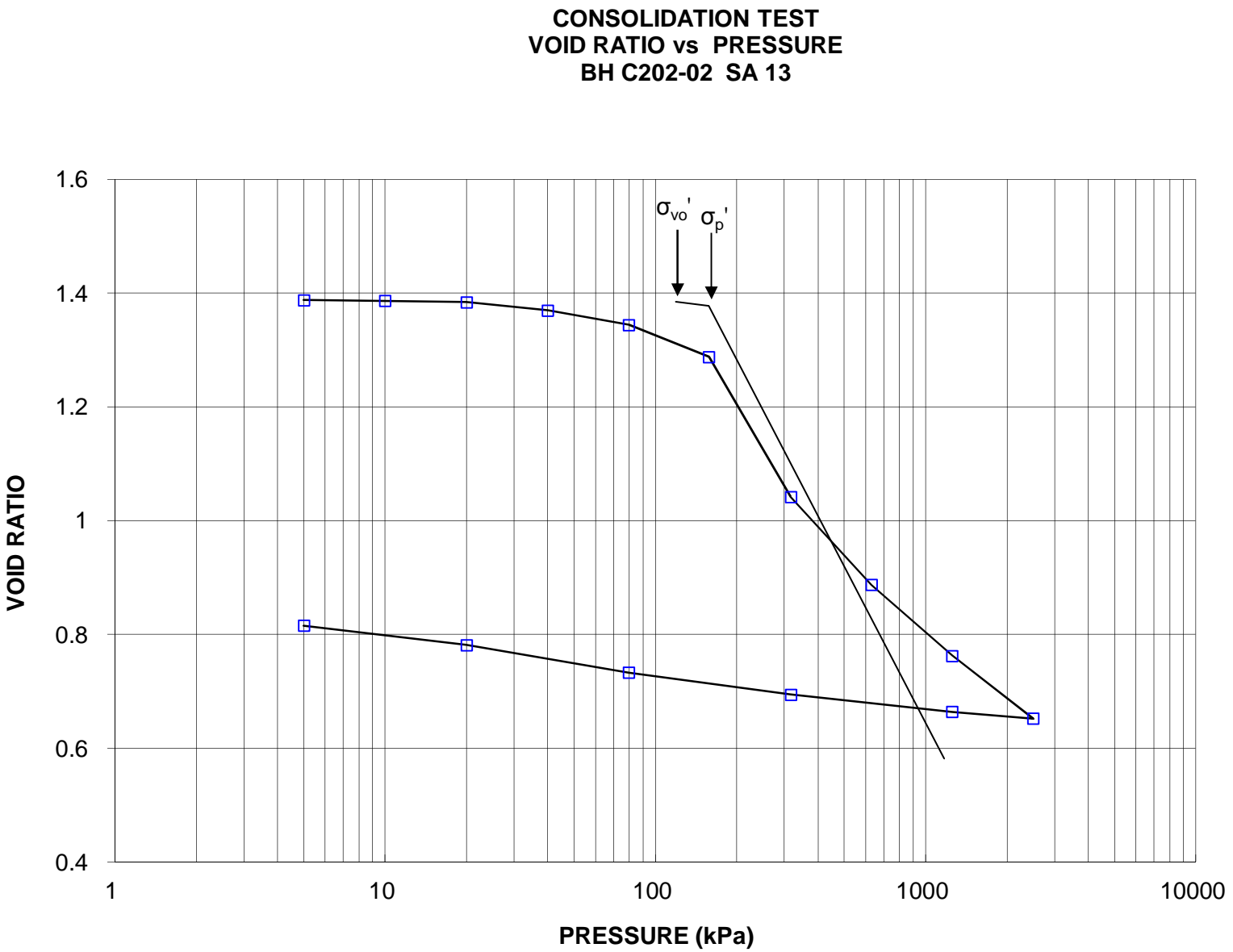
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C202-02	4B	179.4

Project Number: 09-1111-6014

Checked By: TVA

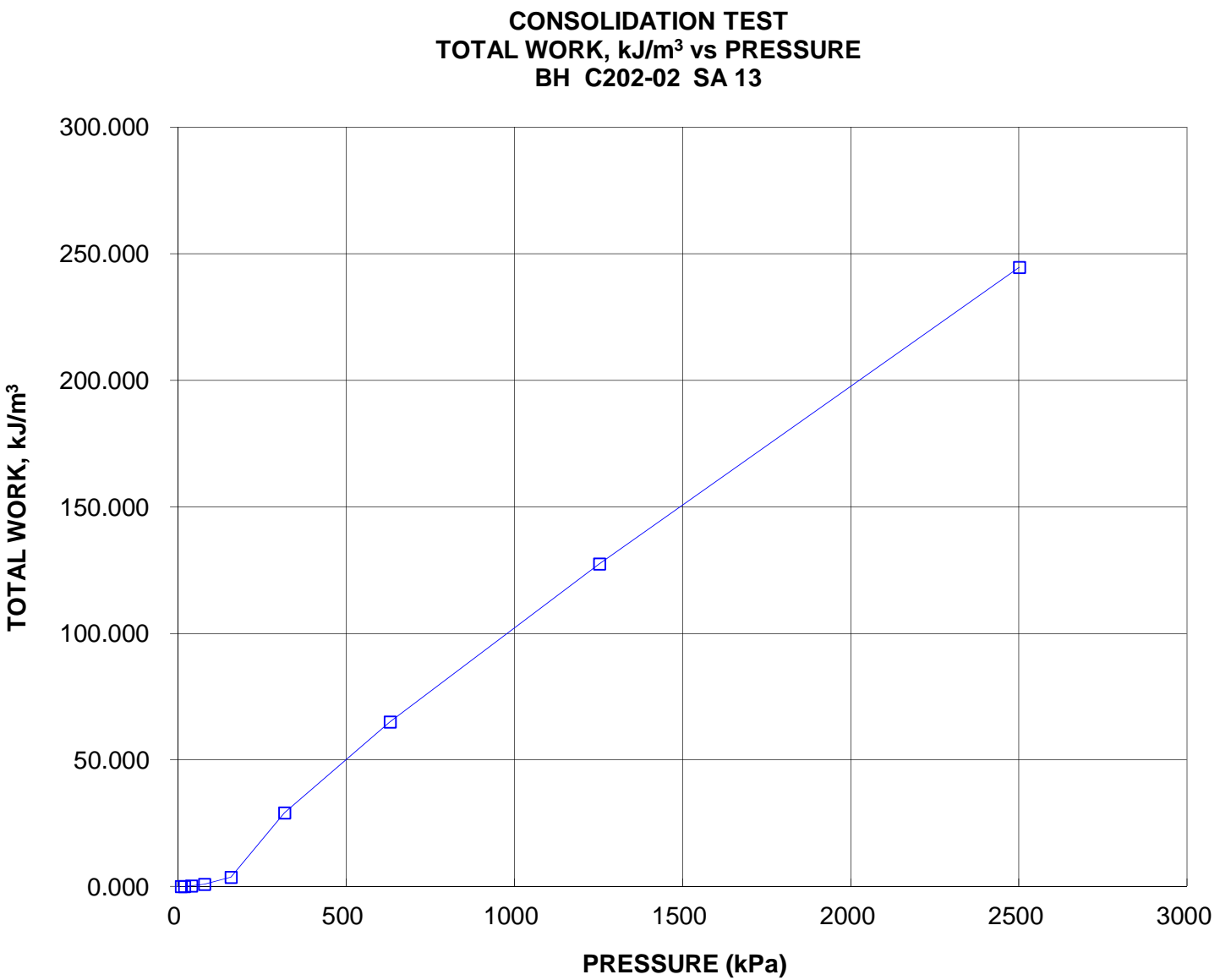
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**CONSOLIDATION TEST  
TOTAL WORK VS PRESSURE**

**FIGURE**

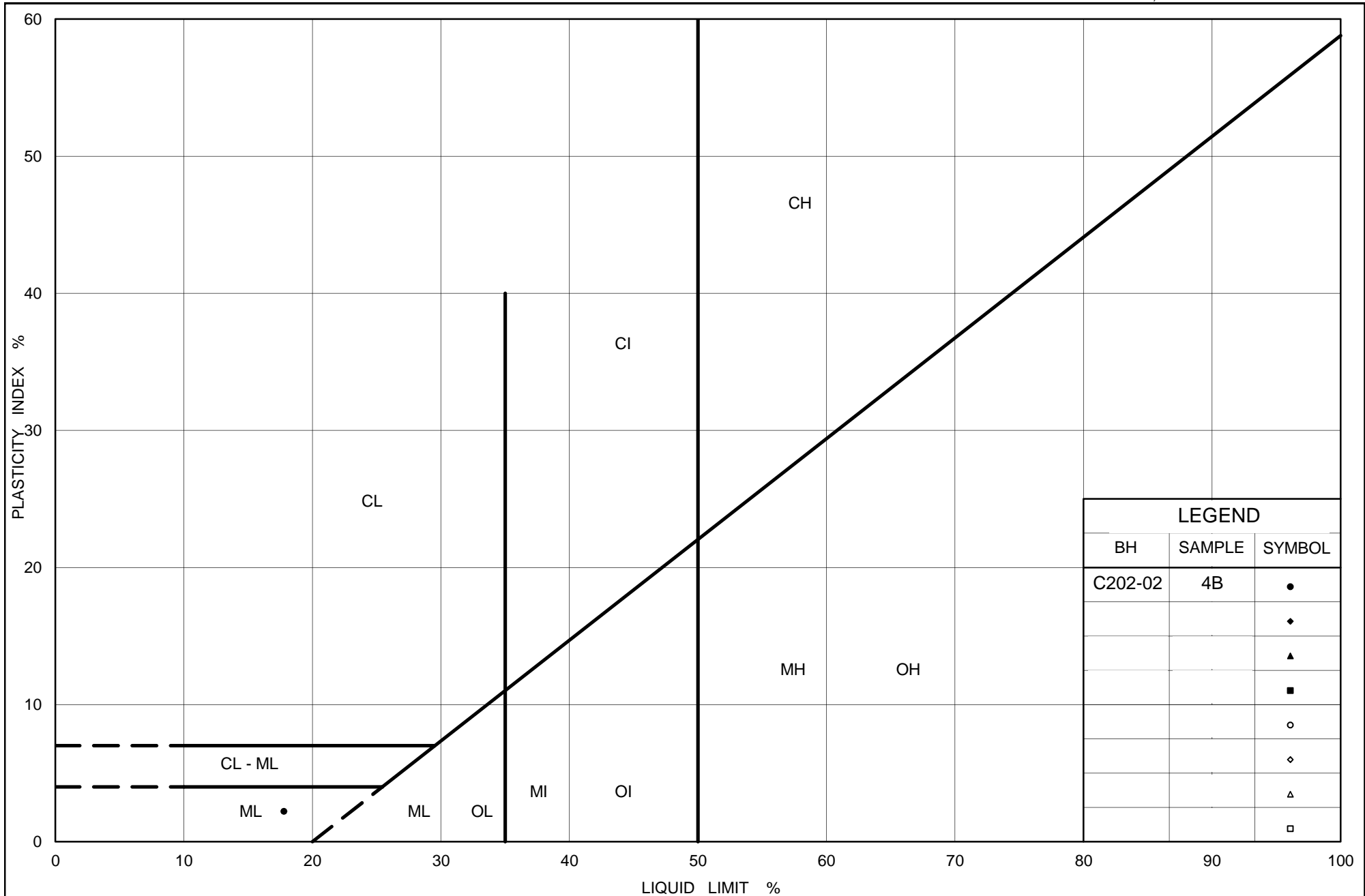


Project No. 09-1111-6014

Prepared By: LFG

**Golder Associates**

Checked By: TZ



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**PLASTICITY CHART**  
 Sand and Silt (Interlayer)  
 Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

Figure No. B.C202-05

Project No. 09-1111-6014

Checked By: JPD

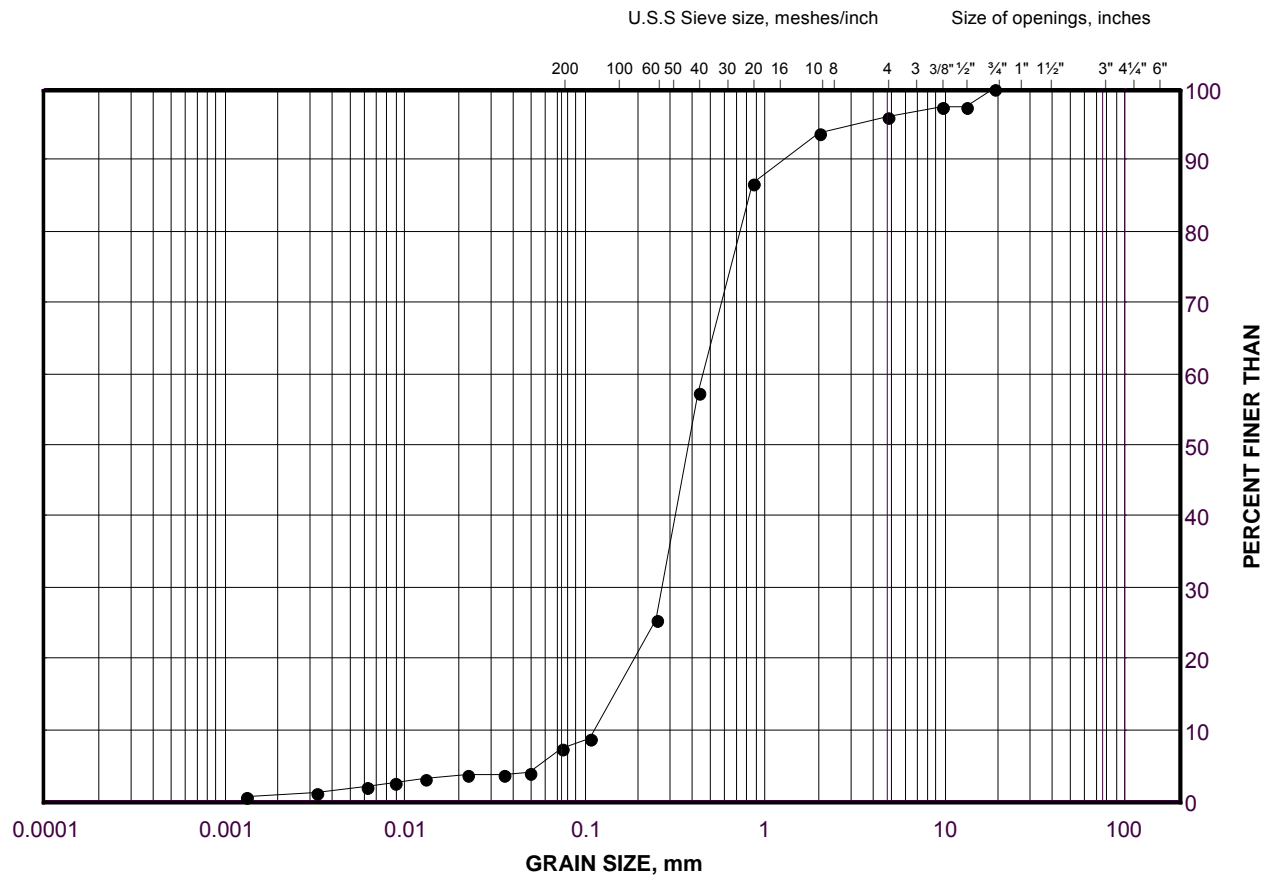


# GRAIN SIZE DISTRIBUTION

Sand

Highway 69 (SBL and NBL) Culvert C202 at STA 11+220

FIGURE B.C202-06



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C202-02	16	158.5

Project Number: 09-1111-6014

Checked By: TVA

**Golder Associates**

Date: 03-Feb-12

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