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**REPORT ON**

**FOUNDATION INVESTIGATION  
BENSON CREEK CULVERT REPLACEMENT  
HIGHWAY 624, TOWNSHIP OF HEARST  
G.W.P. 5259-03-00, SITE 47-311  
MINISTRY OF TRANSPORTATION, ONTARIO  
DISTRICT TIMISKAMING, NEW LISKEARD**

Submitted to:

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GEOCREs No. 32D-7

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February 2006

04-1111-051B



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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Ltd. (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the Benson Creek culvert replacement at Highway 624, District Timiskaming, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P41-1580, dated September 2004, that form part of the Consultant's Agreement (P.O. 5005-A-000420) for this project. This report addresses the proposed culvert replacement at Benson Creek as part of the Highway 624 Culvert Replacement at Benson Creek and Moosehorn Creek project: a report on the foundation investigation and design for the Moosehorn Creek culvert replacement site was provided separately on August 30, 2005. The work was carried out in accordance with the Quality Control Plan for this project dated February 7, 2005.

The purpose of this investigation is to establish the subsurface conditions at the proposed structure by borehole drilling, dynamic cone penetration testing, in situ testing and laboratory testing on selected samples.

## **2.0 SITE DESCRIPTION**

The site is located on Highway 624, approximately 6.6 km south of the intersection of Highway 624 and Highway 66 in the Township of Hearst, District Timiskaming, New Liskeard Ontario (see Key Plan on Contract Drawings). The existing highway has two lanes, one lane each for northbound and southbound traffic.

In the area of the culvert, the site is generally flat with Hwy 624 separating Benson Creek (i.e. the open water west of the highway) from Larder Lake (i.e. the open water east of the highway). The highway embankment acts as a causeway crossing the two water bodies and the existing timber culvert (along with two corrugated steel pipe culverts located south of the main timber culvert) allows water flow from Benson Creek into Larder Lake. In general, the site beyond the open water to the north and south consists of rolling hills with forest and swamps located on both sides of the existing highway. A 2 m to 3 m high bedrock outcrop is located south of the site, near the existing Benson Creek shoreline.

The existing Highway 624 grade is at about Elevation 287 m within the project limits. The existing culvert invert at the inlet and outlet ends is at about Elevation 284.5 m, resulting in fill embankment heights of up to about 2.5 m. The existing embankment side slopes are graded at about 2H:1V and there are no guide rails along the highway in this area. Surface water drains directly into either Benson Creek or Larder Lake.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Foundation Investigation**

The field work for this culvert investigation was carried out between February 15, 2005 and March 24, 2005 during which time seven (7) boreholes, numbering 05-101 to 05-107, and three (3) Dynamic Cone Penetration Tests (DCPTs), numbering DCPT-1 to DCPT-3, were advanced. The borehole and DCPT locations are shown in plan on the Contract Drawings.

The field investigation was carried out using a track-mounted CME 55 drill rig and portable tri-pod drilling equipment supplied and operated by Marathon Drilling Inc. of Ottawa, Ontario and Colbar Resources of Sudbury, Ontario, respectively. The tri-pod drilling equipment was used to advance boreholes and DCPTs from the top of the ice surface on Benson Creek and Larder Lake. All of the boreholes were advanced using either 108 mm inside diameter (I.D.) continuous flight hollow stem augers or B-type casing. Soil samples were obtained at intervals ranging from 0.75 m to 3.0 m in depth, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. Field Vane shear tests using an MTO 'N' vane or 'B' vane were carried out in the cohesive soils. Shelby tube samples were taken in the cohesive soils at selected locations/depths in order to carry out specialized laboratory consolidation testing and further soil classification. Samples of bedrock were obtained using an 'NQ' size rock core barrel.

The boreholes were advanced to depths ranging from 10.5 m to 20.2 m below the existing ground or ice surface (including rock coring). Borehole 05-102 was advanced to refusal on the bedrock and extended into the bedrock (about 3.3 m) by coring. In two of the boreholes, DCPTs were advanced from the bottom of the hole to refusal (on inferred bedrock) at 18.7 m and 20.1 m of depth. The three DCPTs were advanced to depths ranging from 14.4 m to 18.4 m below the existing ground or ice surface and were terminated upon refusal. The groundwater conditions in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets that follow the text of this report. The boreholes were backfilled with bentonite in accordance with Ontario Reg. 128 (amendment to Reg. 903).

The field work was supervised by members of our technical staff, who located the boreholes, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further detailed 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) and organic content testing was carried out on select samples.

Specialized laboratory consolidation testing was carried out on one sample from Borehole 05-103 (Sa.9).

The boreholes were located in the field, relative to local benchmarks identified on the site plan provided by Morrison Hershfield, by Golder personnel prior to drilling operations. Upon completion of the fieldwork, the elevations of the completed boreholes were surveyed by Golder personnel relative to benchmark geodetic datum elevations provided by Morrison Hershfield and the final borehole locations were converted to MTO Station and Offset relative to the existing Highway 624 centreline.

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

### **4.1 Regional Geology**

From published geologic information, the site is located in the physiographic region known as the Abitibi Uplands that form the easternmost part of the Canadian Precambrian Shield (Ontario Geological Survey, *Geology of Ontario; Special Volume 4, Part I*, 1991). The terrain is comprised largely of metavolcanic and minor metasedimentary rocks. Bostock (1970) describes the Abitibi Uplands as a rocky landscape, scattered with lakes and large areas that are mantled by deposits from Pleistocene glaciation consisting of the lacustrine clays and former shorelines of postglacial lakes. Landforms typically include outwash channels, tills and moraines. The local physiography is generally characterized by variable overburden materials and an irregular, variable bedrock surface with rock outcrops.

### **4.2 Subsurface Conditions**

The detailed subsurface soil, bedrock 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 given on the attached Record of Borehole sheets and in Appendix A following the text of this report.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes at the culvert location is shown on the Contract Drawings.

In general, the subsoils at the site consist of a surficial layer of fill (i.e. the existing highway embankment) composed predominately of silty sand and gravel with cobbles/boulders, underlain by a layer of sand, sandy silt, and silt containing trace to some organics. The sand, sandy silt, and silt layer is typically underlain by a thick deposit of varved silty clay to clay. The varved silty clay to clay is underlain by deposits of sandy silt to silt, typically underlain by bedrock. A layer of silty sand and gravel containing cobbles and boulders was present between the bedrock and sandy silt layer at the south end of the site.

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

#### **4.2.1 Asphalt**

Asphalt was encountered at ground surface in Boreholes 05-101 to 05-103, and 05-107 (i.e. the boreholes put down along existing Highway 624). The asphalt thickness ranged from about 35 mm to 50 mm.

#### **4.2.2 Embankment Fill**

Underlying the asphalt, embankment fill consisting predominantly of silty sand and gravel, sand and gravel, and gravelly sand was encountered in Boreholes 05-101, 05-102, 05-103 and 05-107. The embankment fill contains cobbles and boulders; pockets of organic silt were encountered at depth in 05-103. The top of the fill was encountered between Elevation 287.1 m and 287.3 m and ranged from about 2.0 m to 4.0 m in thickness.

Standard Penetration Testing (SPT) 'N' values recorded within the embankment fill layer ranged between 17 blows per 0.3 m of penetration and greater than 50 blows per 0.03 m of penetration, indicating a compact to very dense state of packing. The higher blow counts may be attributed to the presence of cobbles and boulders and/or frozen ground which was measured to penetrate up to 2.1 m deep at the time of the investigation.

Natural water contents measured on samples of the embankment fill typically ranged between 2 and 15 percent. A grain size distribution curve for a selected sample of the gravelly sand fill is shown on Figure A1 in Appendix A.

The natural water content measured on two samples of the fill containing pockets of organic silt in Borehole 05-103 were 23 percent and 68 percent. A laboratory organic content measured on a sample of the fill containing organic silt in Borehole 05-103 was 15.9 %.

#### **4.2.3 Ice and Water**

Ice and water were encountered at the surface in Boreholes 05-104 to 05-106 (i.e. the boreholes advanced from the Benson Creek and Larder Lake ice surface). The top of the ice surface ranged from Elevation 285.5 m to 285.6 m and the ice thickness was measured to range from 500 mm to 600 mm. Water was encountered directly below the ice and the combined ice/water thickness ranged from 0.9 m to 1.8 m, corresponding to creekbed/lakebed elevations ranging from about 283.7 m to 284.7 m.

#### **4.2.4 Organic Silty Sand / Organic Sandy Silt**

A layer of organic silty sand to organic sandy silt was encountered on the lakebed of Benson Creek in Boreholes 05-105 and 05-106. The lakebed was encountered at a depth of 0.9 m



(Elevation 284.7 m) and 1.8 m (Elevation 283.7) below ice surface and the organic silty sand/sandy silt layer was about 0.3 m to 1.2 m thick.

Standard Penetration Testing (SPT) 'N' values recorded within the organic layer ranged between 0 (i.e. weight of hammer) and 1 blow per 0.3 m of penetration, indicating a very loose consistency.

Natural water contents measured on samples of the organic layer ranged between 73 and 90 percent. A grain size distribution curve for one selected sample of the organic silty sand is shown on Figure A2 in Appendix A. A laboratory organic content measured on a sample of the organic silty sand was 6.8 %.

#### **4.2.5 Sand , Sandy Silt and Silt**

Underlying the embankment fill, a layer of sand, sandy silt or silt was encountered in Boreholes 05-101, 05-102, 05-103, and 05-107. The sand, sandy silt or silt layer was also encountered at the lakebed surface in Borehole 05-104 and below the organic sandy silt in BH05-105. The sand, sandy silt, and silt layer typically contained trace to some gravel, clay, and organics. Occasional clayey silt, silty clay, and sand seams were present in Borehole 05-102, 05-104, 05-105 and 05-107. The top of the sand, sandy silt or silt layer was encountered at a depth ranging between 0.9 m and 4.1 m below ground/ice surface (Elevation 283.1 to Elevation 285.3) and the thickness varied between 1.0 m and 1.9 m.

Standard Penetration Testing (SPT) 'N' values recorded within this layer typically ranged between 2 and 5 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on samples of the sand, sandy silt, and silt layer ranged between 22 and 42 percent. Grain size distribution curves for selected samples of the sand and silt layers are shown on Figures A3 and A4 in Appendix A. The results of an Atterberg Limits test carried out on a silty clay interlayer sample from within the sand and silt layer gave a liquid limit of 37 percent, plastic limit of 24 percent, and a plasticity index of 13 percent. The results are illustrated on the plasticity chart on Figure A7 in Appendix A and indicate that the silty clay interlayer within the sand and silt layer is of medium plasticity.

#### **4.2.6 Clayey Silt**

A thin layer of clayey silt was encountered below the sand, sandy silt or silt layer in Boreholes 05-101, 05-103, 05-104 and 05-105. This stratum may be a transition between the overlying silt and the underlying varved silty clay to clay and is described separately. The clayey silt layer typically contained trace to some sand. The top of the clayey silt layer was encountered at depths of about 2.1 m and 3.0 m below the ice surface and about 4.0 m and 5.7 m below the ground

surface, corresponding to Elevation 281.5 m to Elevation 283.5 m. The thickness of this layer varied between 0.8 m and 1.9 m.

Standard Penetration Testing (SPT) 'N' values recorded within the clayey silt layer ranged between 0 (i.e. weight of hammer) and 2 blows per 0.3 m of penetration, indicating a very soft to soft consistency.

The results of the field vane testing carried out in the clayey silt layer are summarized below:

<i>Borehole</i>	<i>Sample Depth/Elevation (m)</i>	<i>Undisturbed Shear Strength(kPa)</i>	<i>Sensitivity</i>	<i>Notes</i>
05-101	7.0 / 280.2	6	4	
	7.3 / 279.9	6	4	
05-103	4.1 / 283.1	80	3.5	Influenced by silt layer
	4.4 / 282.8	50	2	

Based on the field vane tests, the shear strength of the clayey silt ranges from about 6 kPa to 80 kPa (indicating a very soft to stiff consistency); however, the value of 80 kPa may have been influenced by the overlying silt layer. Remoulded vane shear strengths ranged from 1.4 kPa to 23 kPa, resulting in sensitivity values of between 2 and 4 indicating that the clayey silt is medium sensitive based on the classification system provided in CFEM (1992).

The natural water content measured on samples of the clayey silt layer ranged between 22 and 59 percent. A grain size distribution curve for a selected sample of the clayey silt is shown on Figure A5 in Appendix A. The results of Atterberg Limits testing carried out on selected samples of the clayey silt are illustrated on the plasticity chart on Figure A7 in Appendix A. The test results are summarized below and indicate the clayey silt has low plasticity.

<i>Borehole</i>	<i>Sample</i>	<i>Elevation (m)</i>	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
05-103	6	282.0-282.6	26	14	12
05-104	4	282.0-282.6	31	14	17
05-105	4	282.0-282.6	28	16	12

#### **4.2.7 Varved Silty Clay to Clay**

A deposit of varved silty clay to clay was encountered below the sandy silt, clayey silt, and organic silty sand / sandy silt layers in Boreholes 05-102 to 05-107. The varved silty clay to clay consisted of alternating grey and dark grey silty clay and clay laminae and contained occasional

sand seams in the upper portion of Borehole 05-105. The top of the varved silty clay to clay deposit was encountered at depths ranging between about 2.9 m and 4.0 m below ground or ice surface, corresponding to between Elevation 281.6 m and Elevation 283.4 m. The thickness of this deposit varied between 7.5 m and 13.7 m. Boreholes 05-104 and 05-106 were terminated in this layer at depths of 10.5 m (Elevation 275.1 m) and 12.0 m (Elevation 273.5 m), respectively. DCPTs were advanced from the bottom of Boreholes 05-104 and 05-106 to refusal at a depth of 18.7 m (Elevation 266.9 m) and 20.1 m (Elevation 265.4 m), respectively.

Standard Penetration Testing (SPT) 'N' values recorded within the varved silty clay to clay deposit typically ranged between 0 (i.e. weight of hammer) and 2 blows per 0.3 m of penetration, indicating a very soft to soft consistency. An 'N' value of 6 was recorded within the varved silty clay in Borehole 05-107 near the interface with the underlying sandy silt.

The results of field vane tests carried out in this stratum to estimate the undrained shear strength are summarized on Figure 1. Based on the field vane tests, the shear strength of the varved silty clay to clay deposit ranges from 9 kPa to 50 kPa, indicating generally very soft to firm consistency. The undrained shear strength typically increases linearly with depth. The sensitivity of the varved silty clay to clay deposit, estimated from the field vane tests, ranges from about 2 to 5 as shown on Figure 2, implying that the varved silty clay to clay in this area is medium sensitive to sensitive based on the classification system provided in CFEM (1992).

The natural water content measured on samples of the varved silty clay to clay deposit ranged between 26 and 68 percent, but typically ranged between 45 and 65. Grain size distribution curves for selected samples of the varved silty clay to clay deposit are shown on Figure A6 in Appendix A.

The results of Atterberg Limits testing carried out on selected samples of the varved silty clay deposit are illustrated on the plasticity chart on Figure A8 in Appendix A. The test results are summarized below and indicate that the varved silty clay has intermediate to high plasticity.

<i>Borehole</i>	<i>Sample</i>	<i>Elevation (m)</i>	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
05-102	7	281.1-280.5	56	22	34
05-103	9	278.1-277.5	57	22	35
05-103	12	273.5-272.9	47	21	26
05-104	8	276.5-275.8	48	22	26
05-105	7	278.0-277.4	53	21	32
05-106	3	282.4-281.8	37	17	19
05-106	6	277.9-277.3	51	25	26
Average	-	-	50	21	29

Laboratory consolidation testing was carried out on a specimen of the varved silty clay to clay obtained from a Shelby tube sample. The details of the test are shown in Figures A9 to A12, and the results are summarized below.

<i>Borehole and Sample No.</i>	<i>Elevation (m)</i>	<i><math>\sigma_{vo}'</math> (kPa)</i>	<i><math>\sigma_p'</math> (kPa)</i>	<i>OCR</i>	<i><math>e_o</math></i>	<i><math>C_r</math></i>	<i><math>C_c</math></i>	<i><math>c_v^*</math> (cm<sup>2</sup>/s)</i>
05-103, Sa #9	278.1–277.5	91	90	1.0	1.69	0.076	0.87	$2.2 \times 10^{-3}$

Note: \* For stress range of  $75 \leq \sigma_v' \leq 150$  kPa

where:  $\sigma_{vo}'$  is the effective overburden pressure in kPa  
 $\sigma_p'$  is the preconsolidation pressure in kPa  
OCR is overconsolidation ratio  
 $e_o$  is initial void ratio  
 $C_c$  is the compression index (based on void ratio)  
 $C_r$  is the recompression index  
 $c_v$  is the coefficient of consolidation in cm<sup>2</sup>/s

The varved silty clay sample used for the consolidation test (i.e. Borehole 05-103, Sa#9) was obtained from below the existing embankment and is considered to be normally consolidated under the embankment loading. Beyond the Culvert ends, the clay is considered to be normally consolidated as well, based on the results of in situ and laboratory testing.

A bulk unit weight of about 16 kN/m<sup>3</sup> and a specific gravity of 2.71 was measured on the consolidation test sample of the varved silty clay.

#### 4.2.8 Sandy Silt to Silt

Beneath the varved silty clay to clay deposit, a layer of sandy silt to silt containing some clay and clayey silt seams was encountered in Boreholes 05-101, 05-102, 05-103, 05-105, and 05-107. In Borehole 05-105, the sandy silt layer contained coarse rock fragments at the bottom of the borehole, near the inferred bedrock surface. The top of the sandy silt to silt layer was

encountered at depths ranging from about 7.6 m to 17.7 m below ground surface, corresponding to between Elevations 279.6 m and 269.5 m. The thickness ranged from about 1.4 m to 5.4 m. Boreholes 05-103, 05-105 and 05-107 were terminated in this layer at depths of 19.6 m (Elevation 267.6 m), 17.8 m (Elevation 267.9) and 20.2 m (Elevation 267.2 m), respectively.

Standard Penetration Test (SPT) 'N' values recorded within the sandy silt to silt typically ranged between 2 and 9 blows per 0.3 m of penetration, indicating a very loose to loose relative density. An SPT 'N' value recorded at the bottom of the sandy silt layer containing rock fragments in Borehole 05-105 recorded 34 blows per 0.1 m of penetration prior to split spoon refusal on the inferred bedrock surface.

The natural water content measured on samples of the sandy silt to silt deposit ranged between 23 and 35 percent. In Borehole 05-101, the water content measured on one silt sample near the interface with the overlying clayey silt measured 62 percent.

#### **4.2.9 Silty Sand and Gravel**

A deposit of silty sand and gravel containing cobbles and boulders was encountered below the silt layer in Borehole 05-101. The top of this deposit was encountered at a depth of 10.8 m (Elevation 276.4 m) and was 1.3 m thick. Borehole BH05-101 was terminated within this deposit at a depth of 12.1 m (Elevation of 275.1 m).

An SPT 'N' value of 28 blows per 0.3 m of penetration was recorded within the deposit of silty sand and gravel indicating a compact relative density.

The natural water content measured on a sample of the silty sand and gravel was 24 percent.

#### **4.2.10 Bedrock**

A bedrock outcrop (approximately 2 m to 3 m high) is located on the west side of the Highway 624 ditchline from approximately Station 10+150 to 10+160.

Bedrock was encountered in Borehole 05-102 at a depth of 12.7 m (Elevation 274.5 m) and was cored for a length of 3.3 m to a depth of 16 m (Elevation 271.2 m). The presence of bedrock was inferred from auger or sampler refusal in Boreholes 05-101, 05-103, 05-105, and 05-107 at depths ranging from 12.1 m (Elevation 275.1 m) to 20.2 m (Elevation 267.2 m).

At all DCPT locations (DCPT-1, DCPT-2 and DCPT-3) and in boreholes where DCPTs were advanced beyond the bottom of the sampled borehole (Boreholes 05-104 and 05-106), the DCPTs were terminated upon cone refusal (as defined by greater than 100 blows per 0.3 m of

penetration) at the inferred bedrock surface at depths ranging from about 14.4 m to 20.1 m (El. 272.8 m to El. 265.4 m).

In general, the bedrock surface slopes from a high of about Elevation 290 m at the south side of the site where it is outcropping (see Contract Drawings) to a low of about Elevation 265 m (Borehole 05-106) on the north side of Benson Creek and appears to rise slightly to about Elevation 267 m (Borehole 05-107) on the north end of the site.

The bedrock samples obtained in Borehole 05-102 are described as fresh, foliated, green, fine to medium grained, very strong, Schist. The bedrock samples typically contained quartz veins and transitioned to a pink Schist with large quartz inclusions at depth. The Total Core Recovery was between 96 percent and 100 percent. The Rock Quality Designation (RQD) measured on the core samples ranged from about 87 to 100 percent, indicating a rock mass of good to excellent quality.

Point load strength tests were performed on selected samples of the rock core from Borehole 05-102. Axial and diametral point load strength index values are shown on the Record of Drillhole Sheets and on Table 1. The diametral point load index ( $Is_{50}$ ) results from the laboratory tests on the bedrock range from 5.9 MPa to 9.6 MPa with an average of about 8.4 MPa. Two axial point load index tests were performed and the results gave 5.7 MPa and 8.3 MPa.

Based on laboratory point load testing results and approximate field measurement techniques (see Drillhole Sheet), the schist bedrock is typically very strong ( $100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ).

#### 4.2.11 Groundwater Conditions

The water levels measured in the open boreholes upon completion of drilling are summarized below.

<i>Borehole</i>	<i>Installation</i>	<i>Ground / Ice Surface Elevation (m)</i>	<i>Depth to Water Level (m)</i>	<i>Water Level Elevation (m)</i>	<i>Date</i>
05-101	Open Borehole	287.2	2.3	284.9	March 6, 2005
05-102	Open Borehole	287.2	2.4	284.8	March 8, 2005
05-103	Open Borehole	287.2	2.1	285.1	March 5, 2005
05-104	Open Borehole	285.6	0.5	285.1	March 24, 2005
05-105	Open Borehole	285.6	0.6	285.0	March 22, 2005
05-106	Open Borehole	285.5	0.6	284.9	March 22, 2005
05-107	Open Borehole	287.4	2.3	285.1	March 4, 2005

The water level in the boreholes was generally found to be at about the same level as Larder Lake and Benson Creek. The water level, typically about 500 mm below the top of the ice and snow, was measured to be at approximate Elevation 285 m in March 2005. The water level may be effected by rainfall and snowmelt conditions and the creek/lake levels in the area of the culvert are known to be subject to seasonal fluctuations.

### 4.3 Closure

The field technician supervising the drilling program was Mr. Chris Radway of Golder's Whitby office. This report was prepared by Mr. Kevin J. Bentley, P.Eng., a geotechnical engineer; the technical aspects were reviewed by Mr. J. Paul Dittrich, P.Eng, and quality control review was provided by Mr. Jorge M.A. Costa, P.Eng, a Designated MTO Contact for Golder.

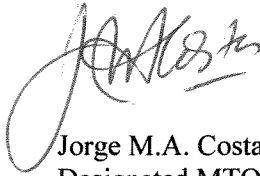
#### GOLDER ASSOCIATES LTD.



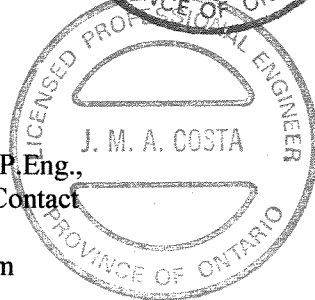
Kevin J. Bentley, P.Eng.  
Geotechnical Engineer



J. Paul Dittrich, P.Eng.,  
Associate



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



KJB/JPD/JMAC/sm

N:\Active\2004\1111\04-1111-051 MH Benson Creek Hwy 624\Reports\Benson\FIR\04-1111-051B RPT FIR 06 Feb FIN Report Culverts Benson.doc

**TABLE 1**  
**SUMMARY OF POINT LOAD TESTS ON ROCK CORE SAMPLES**

PROJECT NO. : 04-1111-051B													
LOCATION: Benson Creek, Hwy. 624, New Liskeard													
DATE: 4/21/05													
Borehole Number	Run Test Number	Sample Depth (ft)	Sample Depth (m)	Test Type	Core Length (mm)	Core <sup>(2)</sup> Diameter (mm)	Equivalent Diameter (mm)	Ram Pressure (kPa)	Load (P) (kN)	Is Axial (MPa)	Is Diametral (MPa)	Is (50mm) (MPa)	Approx. UCS <sup>1</sup> (MPa)
05-102	R1 (1)	43.0	13.1	D	75.00	47.00		20,660	19.98		9.045	8.797	202
05-102	R1 (2)	43.9	13.4	D	130.00	47.00		22,080	21.35		9.667	9.401	216
05-102	R2 (3)	46.3	14.1	A	36.00	47.00	46.41	13,040	12.61	5.854		5.693	131
05-102	R2 (4)	47.7	14.5	D	96.00	47.00		22,480	21.74		9.842	9.571	220
05-102	R2 (5)	48.3	14.7	A	32.00	47.00	43.76	16,980	16.42	8.576		8.340	192
05-102	R3 (6)	52.2	15.9	D	80.00	47.00		13,800	13.35		6.042	5.876	135
<b>SUMMARY:</b>										<b>Average Axial</b>		<b>7.017</b>	<b>162</b>
										<b>Average Diametrical</b>		<b>8.411</b>	<b>193</b>
										<b>St. Dev. Axial</b>		<b>1.872</b>	<b>43</b>
										<b>St. Dev. Diametrical</b>		<b>1.722</b>	<b>40</b>
										<b>Number of Axial Tests</b>		<b>2</b>	
										<b>Number of Diametrical Tests</b>		<b>4</b>	

<sup>(1)</sup> UCS = Is x 23 (actual value will have to be confirmed by UCS testing), from ISRM ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol. 22, No. 2, 1985, pp. 51-60.

<sup>(2)</sup> Actual Distance between point load cones at time of failure



## 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

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

### 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.)

#### Consistency

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

#### Dynamic Cone Penetration Resistance; $N_d$ :

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

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

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

## LIST OF SYMBOLS

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

### I. General

$\pi$	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
F	factor of safety
V	volume
W	weight

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	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

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	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
$w_l$	liquid limit
$w_p$	plastic limit
$I_p$	plasticity index $= (w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index $= (w - w_p) / I_p$
$I_C$	consistency index $= (w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_a$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation pressure
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

- Notes:** 1  $\tau = c' + \sigma' \tan \phi'$   
 2 shear strength = (compressive strength)/2  
 \* density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

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

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

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

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

## BEDDING THICKNESS

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

## JOINT OR FOLIATION SPACING

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

## GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

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

## CORE CONDITION

### Total Core Recovery

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

### Solid Core Recovery (SCR)

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

### Rock Quality Designation (RQD)

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

## DISCONTINUITY DATA

### Fracture Index

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

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

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

### Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring 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

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

PROJECT 04-1111-051		<b>RECORD OF BOREHOLE No 05-101</b>		1 OF 1 <b>METRIC</b>																
W.P. 5259-03-00		LOCATION Station 10+172, Offset 3.0 m Left		ORIGINATED BY CR																
DIST HWY 624		BOREHOLE TYPE Power Augering using 108 mm ID Hollow Stem Augers		COMPILED BY JDR																
DATUM Geodetic		DATE 06-Mar-2005		CHECKED BY BC																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			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		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m <sup>3</sup>	GR SA SI CL			
							20 40 60 80 100	20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>										
287.2	GROUND SURFACE																			
0.0	Asphalt						287													
0.3	Sand and gravel (FILL) Sand and gravel, some cobbles (FILL) Compact Brown to grey Moist		1	AS	-		286													
	Frozen to 1.7 m depth.		2	AS	-		285													
			3	SS	22		284													
			4	SS	19		283													
283.1	Sand, some gravel, trace organics Very loose to loose Brown Wet		5	SS	4		282													
281.5	Clayey Silt Very soft Grey		6	SS	WH		281													
							280	4.0 + 4.0 +												
279.6	Silt Very loose Grey Wet		7	SS	WH		279	4.0 + 4.0 +												
			8	SS	2		278	2.0 +												
276.4	Silty Sand and Gravel, some clay, contains cobbles/boulders in lower zone Compact Grey Wet		9	SS	28		277													
275.1	Auger Refusal End of Borehole						276													
	Note:  Water level at 2.3 m depth (Elev 284.9 m) upon completion of drilling.																			


PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-102</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+194, Offset 3.0 m Right</u>		ORIGINATED BY <u>CR</u>	
DIST <u>HWY 624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>08-Mar-2005</u>		CHECKED BY <u>BC</u>	

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							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× REMOULDED						
287.2	GROUND SURFACE						20 40 60 80 100								
0.0	Asphalt		1	AS	-	▽	287								
	Silty sand and gravel to gravelly sand, contains cobbles and boulders (FILL) Very dense Brown Moist		2	SS	50/.05		286								
			3	AS	-		285								
284.5			4	AS	-		284								
2.7	Sandy Silt, some silty clay seams, trace organics Very loose to loose Grey Wet		5	SS	4		283								
283.4							282								
3.8	Varved Silty Clay to Clay Very soft to firm Grey and dark grey		6	TO	PH		281								
							280								
			7	SS	WH		279								
						278									
			8	TO	PH	277									
						276									
275.9						275									
11.3	Sandy Silt, some clay and silty clay seams Grey Loose Wet		9	SS	WH	274									
274.5						273									
12.7	Auger Refusal														
	Green Schist Bedrock See Record of Drillhole 05-102														

Continued Next Page

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

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PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-102</b>				2 OF 2 <b>METRIC</b>																	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+194, Offset 3.0 m Right</u>				ORIGINATED BY <u>CR</u>																	
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>				COMPILED BY <u>JDR</u>																	
DATUM <u>Geodetic</u>		DATE <u>08-Mar-2005</u>				CHECKED BY <u>BC</u>																	
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 ---						<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</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>																
271.2	Auger Refusal  Green Schist Bedrock See Record of Drillhole 05-102					272																	
16.0	End of Borehole  Note:  1. Water level at 2.4 m depth (Elev 284.8 m) upon completion of drilling.																						

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Marathon Drilling Ltd.

CHECKED: KJB

MIS-RCK 002 041111051AARCK.GPJ GAL-CANADA.GDT 24/1/06 JDR



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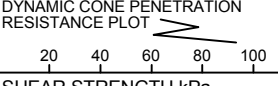
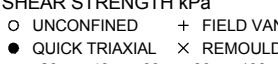
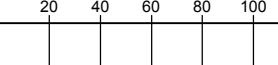

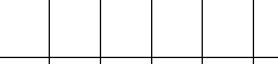


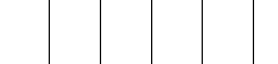




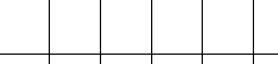


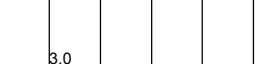



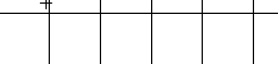





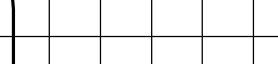
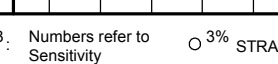

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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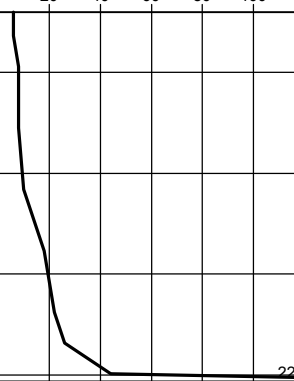
PROJECT 04-1111-051		RECORD OF BOREHOLE No 05-103				2 OF 2 METRIC											
W.P. 5259-03-00		LOCATION Station 10+205, Offset 3.0 m Left				ORIGINATED BY CR											
DIST HWY 624		BOREHOLE TYPE Power Augering using 108 mm ID Hollow Stem Augers				COMPILED BY JDR											
DATUM Geodetic		DATE 05-Mar-2005				CHECKED BY BC											
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									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
269.5	Varved Silty Clay to Clay Very soft to firm Grey and dark grey		13	TO	PH												
271																	
270																	
269.5	Fine Sandy Silt, some clay Loose to very Loose Grey Wet		14	SS	4												
269																	
268																	
267.6	Auger refusal End of Borehole																
19.6	Note:  1. Apparent groundwater encountered at 2.1 m depth (Elev 285.1 m).  2. Laboratory consolidation test performed on Sample 9.																

PROJECT 04-1111-051			RECORD OF BOREHOLE No 05-104			1 OF 2 METRIC							
W.P. 5259-03-00			LOCATION Station 10+213, Offset 9.0 m Right			ORIGINATED BY CR							
DIST HWY 624			BOREHOLE TYPE Portable Power Drilling using 'B' Casing			COMPILED BY JDR							
DATUM Geodetic			DATE 24-Mar-2005			CHECKED BY BC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	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 (%)
285.6	ICE SURFACE												
0.0	Ice												
285.1	Water												
0.5	Water												
284.7													
0.9	Sandy Silt, some sand seams, some clay and gravel, trace organics Very loose Grey Wet		1	SS	3								
283.5			2	SS	3								
2.1	Clayey Silt, trace fine to medium sand seams Very soft to soft Grey		3	SS	2								
281.9			4	SS	WH								
3.7	Varved Silty Clay to Clay Very soft to firm Grey and dark grey												
281.9			5	SS	WH								
													
			6	SS	1								
													
			7	SS	1								
													
			8	SS	WH								
275.1	End of Borehole												
274.6	Dynamic cone penetration test begins at 11.0 m depth.												
11.0													
													
													
													
													
													
													
													
													

Continued Next Page

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

MIS-MTO 001 041111051AAMTO.GPJ ON\_MOT.GDT 24/1/06

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-104</b>				2 OF 2 <b>METRIC</b>							
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+213, Offset 9.0 m Right</u>				ORIGINATED BY <u>CR</u>							
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Portable Power Drilling using 'B' Casing</u>				COMPILED BY <u>JDR</u>							
DATUM <u>Geodetic</u>		DATE <u>24-Mar-2005</u>				CHECKED BY <u>BC</u>							
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</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>						
15.0													
266.9							224						
18.7	Cone Refusal End of Dynamic Cone Penetration Test  Notes:  1. Water level at 0.5 m from the ground surface (Elev 285.1 m) upon completion of drilling.  2. Borehole advanced from ice surface (ie. water level at ground surface).  3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT N values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.												

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-105</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+196, Offset 16.5 m Left</u>		ORIGINATED BY <u>CR</u>	
DIST <u>HWY 624</u>		BOREHOLE TYPE <u>Portable Power Drilling using 'B' Casing</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>22-Mar-2005</u>		CHECKED BY <u>BC</u>	

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							WATER CONTENT (%)			
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED										
285.6	ICE SURFACE																	
0.0	Ice					▽	285											
285.0							284											
284.7	Water						283											
284.4	Organic Sandy Silt, some clay Very loose Brown to Grey Wet		1	SS	WH		282											
1.2	Sand and Silt, some clay and organics, contains silty clay interlayers Very loose to loose Brown to grey Wet		2	SS	2		281	3.1 + 2.7 +										
			3	SS	4		280	2.5 + 2.4 +										
282.6	Clayey Silt, trace to some fine sand seams Very Soft Grey Wet		4	SS	1		279											
3.0							278	3.0 + 3.1 +										
281.6	Varved Silty Clay to Clay, contains sand seams in upper zone Very soft to firm Grey and dark grey Wet		5	SS	1		277	3.5 + 3.0 +										
4.0							276											
			6	SS	WH		275	1.6 + 2.3 +										
							274	2.3 + 2.7 +										
			7	SS	WH		273											
							272	2.6 + 2.4 +										
			8	SS	WH		271	3.2 +										
270.8																		
14.8																		

Continued Next Page

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

MIS-MTO 001 041111051AAMTO.GPJ ON\_MOT.GDT 24/1/06

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

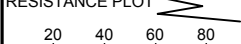
MIS-MTO 001 041111051AAMTO.GPJ ON MOT.GDT 24/1/06

PROJECT		RECORD OF BOREHOLE		No 05-106		1 OF 2		METRIC														
W.P.		LOCATION		Station 10+220, Offset 19.0 m Left		ORIGINATED BY		CR														
DIST		BOREHOLE TYPE		Portable Power Drilling using 'B' Casing		COMPILED BY		JDR														
DATUM		DATE		22-Mar-2005		CHECKED BY		BC														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			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		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ					
285.5	0.0	ICE SURFACE							20	40	60	80	100	20	40	60						
284.9	0.6	Water						285														
283.7	1.8	Organic Silty Sand, some clay, trace gravel, contains wood fragments Very loose Grey to brown Wet		1	50 DO	WH		283														
282.5	3.0	Varved Silty Clay to Clay Very soft to firm Grey and dark grey		2	50 DO	1		282														
				3	50 DO	1		281														
				4	50 DO	WH		280														
				5	50 DO	WH		279														
				6	50 DO	WH		278														
				7	50 DO	WH		277														
				8	50 DO	WH		276														
273.5	12.0	End of Borehole						275														
271.5	14.0	Dynamic Cone Penetration Test begins at 14.0 m depth.						274														
270.5								273														
								272														
								271														

Continued Next Page

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

MIS-MTO 001 041111051AAMTO.GPJ ON\_MOT.GDT 24/1/06

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-106</b>				2 OF 2 <b>METRIC</b>				
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+220, Offset 19.0 m Left</u>				ORIGINATED BY <u>CR</u>				
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Portable Power Drilling using 'B' Casing</u>				COMPILED BY <u>JDR</u>				
DATUM <u>Geodetic</u>		DATE <u>22-Mar-2005</u>				CHECKED BY <u>BC</u>				
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
15.0	--- CONTINUED FROM PREVIOUS PAGE ---									
265.4										
20.1	Cone Refusal End of Dynamic Cone Penetration Test.  Notes:  1. Water level at 0.6 m from the ground surface (Elev 284.9 m) upon completion of drilling.  2. Borehole advanced from ice surface (ie. water level at ground surface).  3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT N values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.									

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-107</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+262, Offset 2.0 m Left</u>		ORIGINATED BY <u>CR</u>	
DIST <u>HWY 624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>04-Mar-2005</u>		CHECKED BY <u>BC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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>		
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED					
287.4	GROUND SURFACE													
0.9	Asphalt		1	AS	-									
	Silty Sand and Gravel, cobbles and boulders (FILL) Dense to very dense Brown Frozen to 2.1 m		2	SS	50/08									
			3	SS	50/08									
285.3														
2.1	Sandy Silt, some clay, contains clayey silt seams. Loose to very loose Brown Wet		4	SS	4									
			5	SS	4									
283.4														
4.0	Varved Silty Clay to Clay Very soft to firm Grey to dark grey		6	SS	WH									
			7	TO	PH									
			8	SS	WH									
			9	TO	PH									
			10	SS	WH									
			11	TO	PH									
			12	SS	6									
272.6														
14.8														

Continued Next Page

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

MIS-MTO 001 041111051AAMTO.GPJ ON\_MOT.GDT 24/1/06



PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-107</b>		2 OF 2 <b>METRIC</b>														
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+262, Offset 2.0 m Left</u>		ORIGINATED BY <u>CR</u>														
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>														
DATUM <u>Geodetic</u>		DATE <u>04-Mar-2005</u>		CHECKED BY <u>BC</u>														
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			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>	
--- CONTINUED FROM PREVIOUS PAGE ---																		
	Sandy Silt, some clay Very Loose to loose Grey Wet		13	SS	4		272											
							271											
							270											
							269											
				14	SS	7	268											
267.2																		
20.2	Auger Refusal End of Borehole  Note:  1. Apparent groundwater encountered at 2.3 m depth (Elev 285.1 m).																	

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

MIS-MTO 001 041111051AAMTO.GPJ ON\_MOT.GDT 24/1/06


PROJECT <u>04-1111-051</u>		<b>RECORD OF PENETRATION TEST No DCPT-2</b>		1 OF 2 <b>METRIC</b>													
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+205, Offset 3.0 m Right</u>		ORIGINATED BY <u>KB</u>													
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>JDR</u>													
DATUM <u>Geodetic</u>		DATE <u>15-Feb-2005</u>		CHECKED BY <u>BC</u>													
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						WATER CONTENT (%)			
287.2 0.0	GROUND SURFACE Augered to about 0.9 m depth to penetrate through frozen soil.					▽	287	20	40	60	80	100	20	40	60		
286.3 0.9	Start of Dynamic Cone Penetration Test at 0.9 m depth.						286										
285.4 1.8	Refusal - 45 blows/0.15 m Refusal on timber/cobbles/boulders at 1.8 m depth Augered to 2.74 m depth and continued DCPT.						285										
284.5 2.7							284										
							283										
							282										
							281										
							280										
							279										
							278										
							277										
							276										
							275										
							274										
							273										

Continued Next Page

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


PROJECT <u>04-1111-051</u>		<b>RECORD OF PENETRATION TEST No DCPT-2</b>				2 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 10+205, Offset 3.0 m Right</u>				ORIGINATED BY <u>KB</u>	
DIST <u>          </u> HWY <u>624</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>15-Feb-2005</u>				CHECKED BY <u>BC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE						
	--- CONTINUED FROM PREVIOUS PAGE ---									
268.8						272 271 270 269				
18.4	End of DCPT						Refusal - 100 blows/0.08m			

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

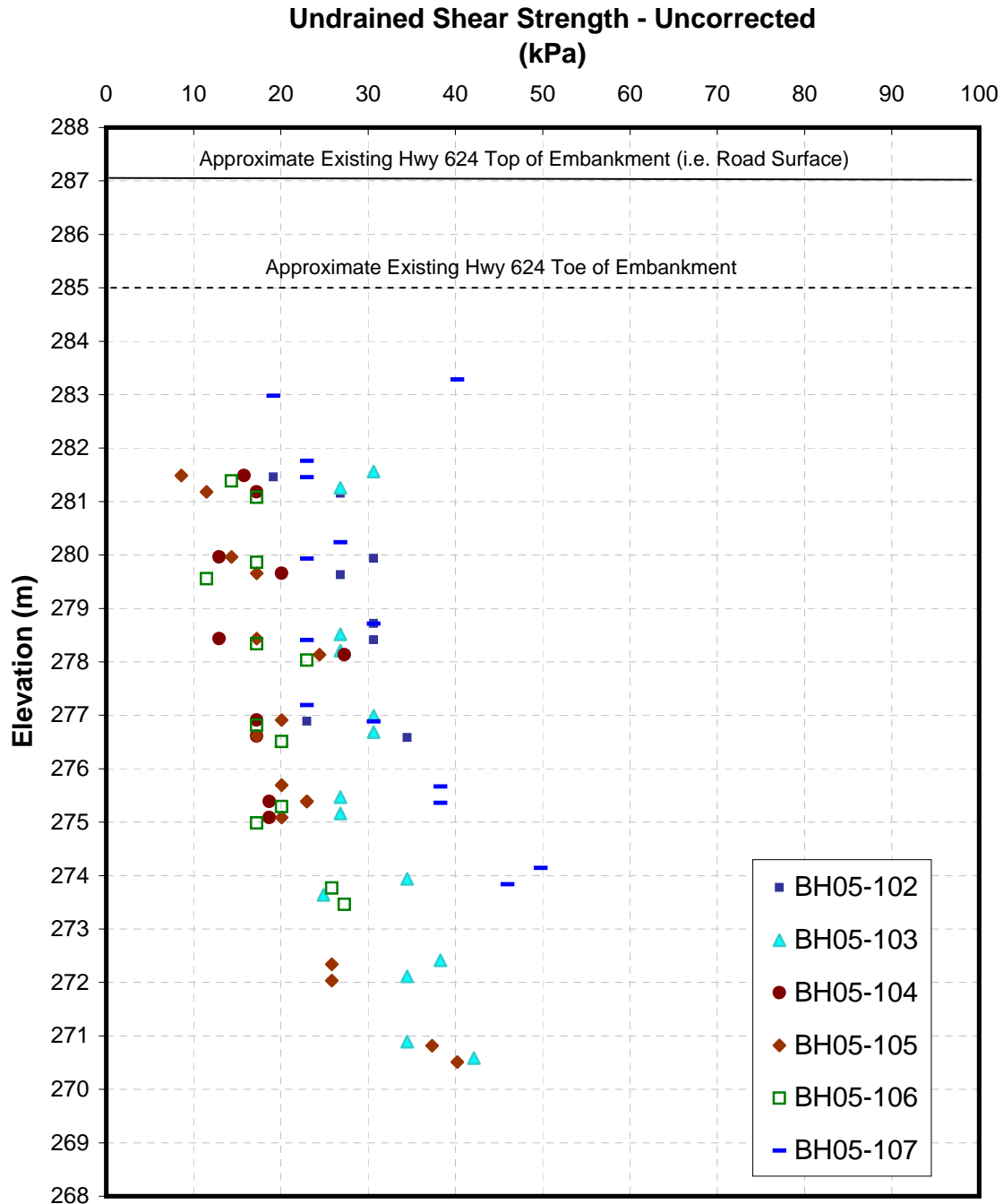
MIS-MTO 001 041111051AAMTO.GPJ ON MOT.GDT 24/1/06

PROJECT 04-1111-051		RECORD OF PENETRATION TEST No DCPT-3				2 OF 2		METRIC								
W.P. 5259-03-00		LOCATION Station 10+207, Offset 15.0 m Left				ORIGINATED BY KB										
DIST HWY 624		BOREHOLE TYPE Dynamic Cone Penetration Test				COMPILED BY JDR										
DATUM Geodetic		DATE 23-Mar-2005				CHECKED BY BC										
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					WATER CONTENT (%)				GR SA SI CL
15.0																
268.2	End of DCPT						Refusal - 40 blows/0.1 m									
17.4	Notes:  1. Augered through about 0.6 m of ice and DCPT rods sank to 0.9 m into water to start test.  2. DCPT advanced using portable drilling equipment with a half-weight hammer. The dynamic cone penetration resistance values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.															

## Summary of Field Vane Test Results

Varved Silty Clay to Clay  
Benson Creek - Highway 624

FIGURE 1



N:\Active\2004\1111\04-1111-051 MH Benson Creek Hwy 624\Reports\Benson\Final\Figure 1-Benson.xls\Figure 1

WP No. 5259-03-00  
Date: 1-Jan-06  
Project: 04-1111-051B

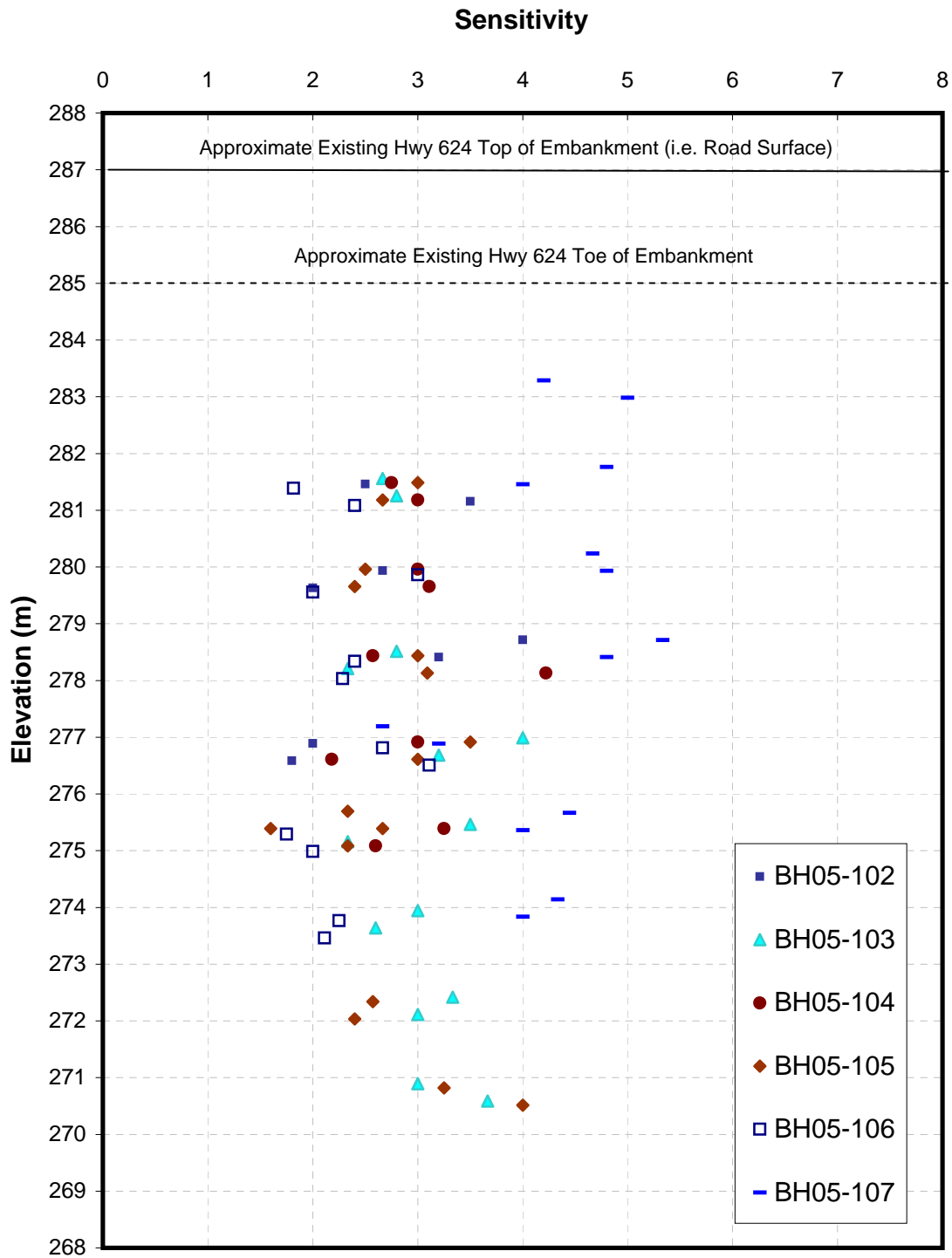
**Golder Associates**

Drawn by: KJB  
Checked by: JPD

## Summary of Sensitivity Results

Varved Silty Clay to Clay  
Benson Creek - Highway 624

FIGURE 2



WP No. 5259-03-00  
Date: 17-Jan-06  
Project: 04-1111-051B

Drawn by: KJB  
Checked by: JPD

**Golder Associates**

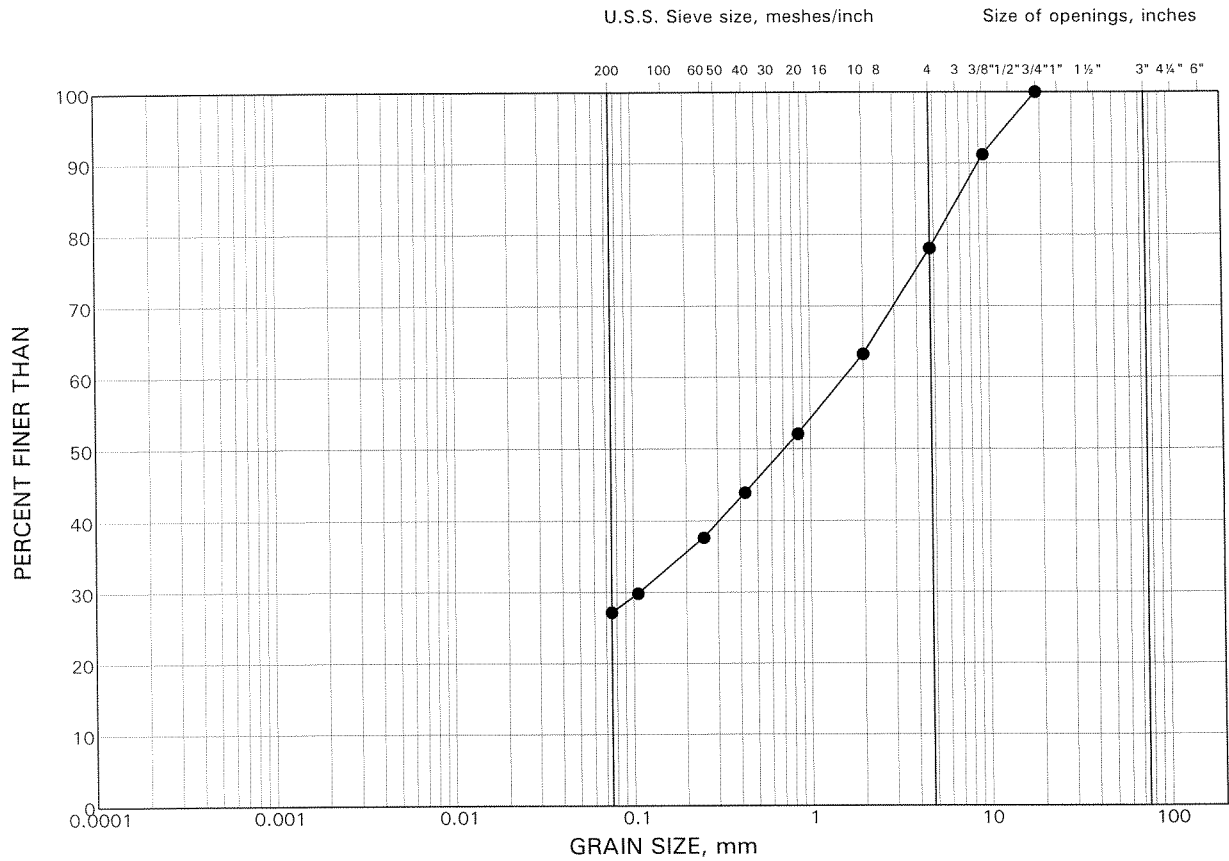


**APPENDIX A**  
**LABORATORY TEST DATA**

# GRAIN SIZE DISTRIBUTION

Gravelly Sand (Fill)

FIGURE A1



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

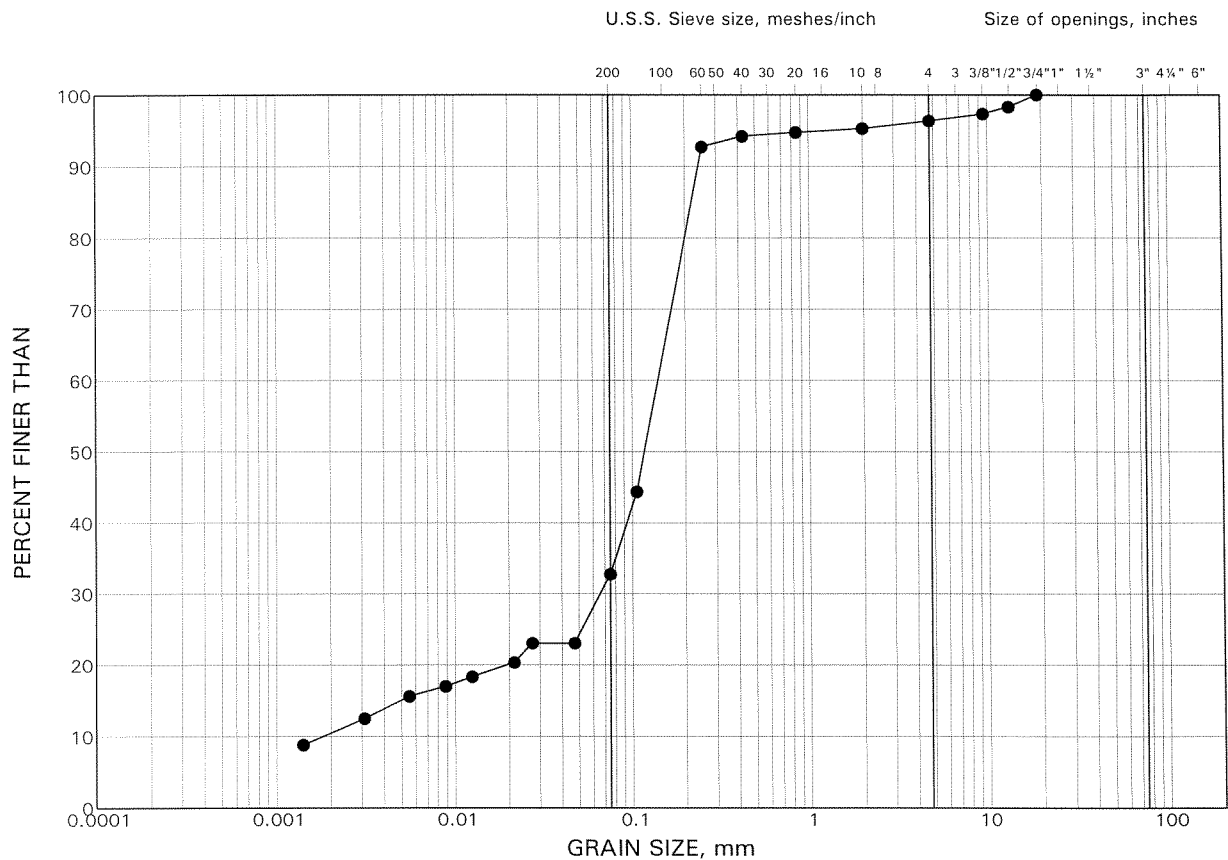
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	05-102	3	1.5-2.3

# GRAIN SIZE DISTRIBUTION

Organic Silty Sand

FIGURE A2



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

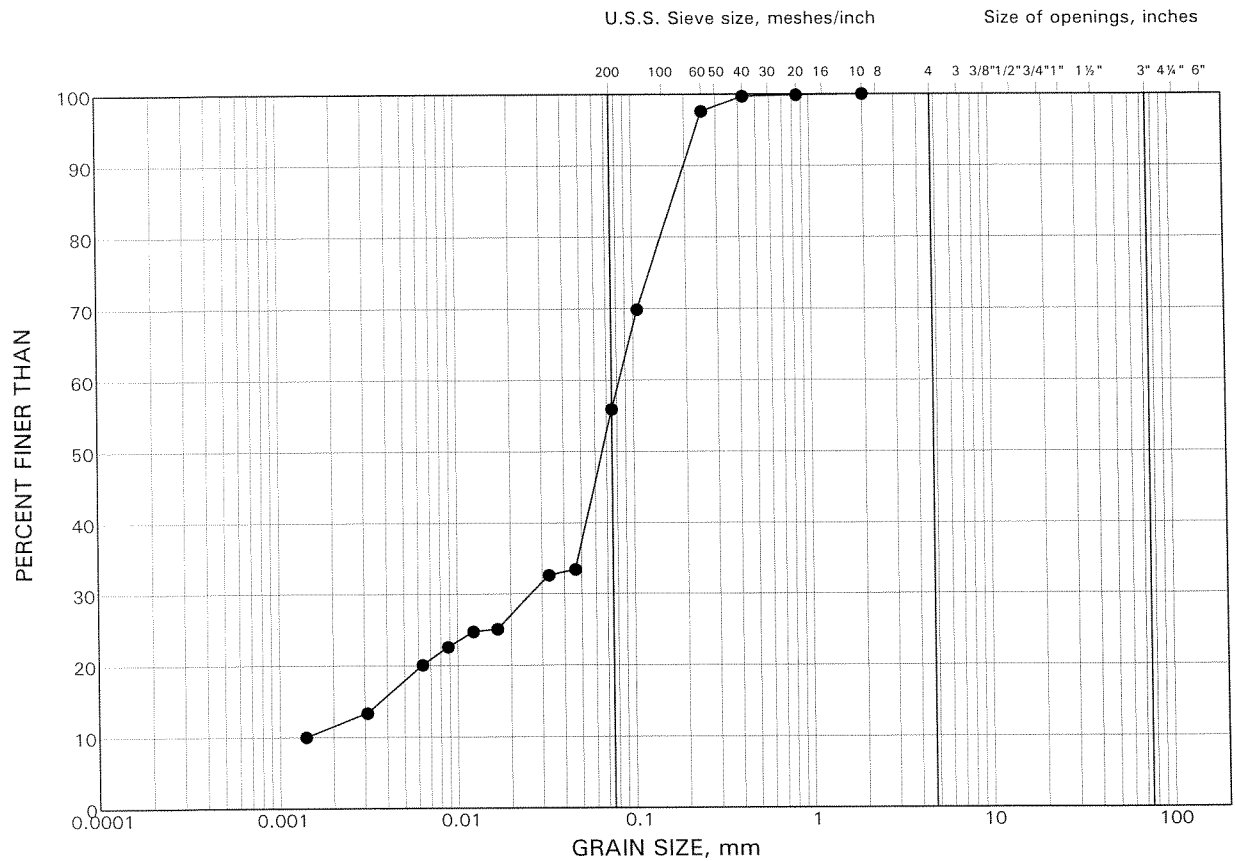
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	05-106	2	2.4-3.1

# GRAIN SIZE DISTRIBUTION

## Sand and Silt

FIGURE A3



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

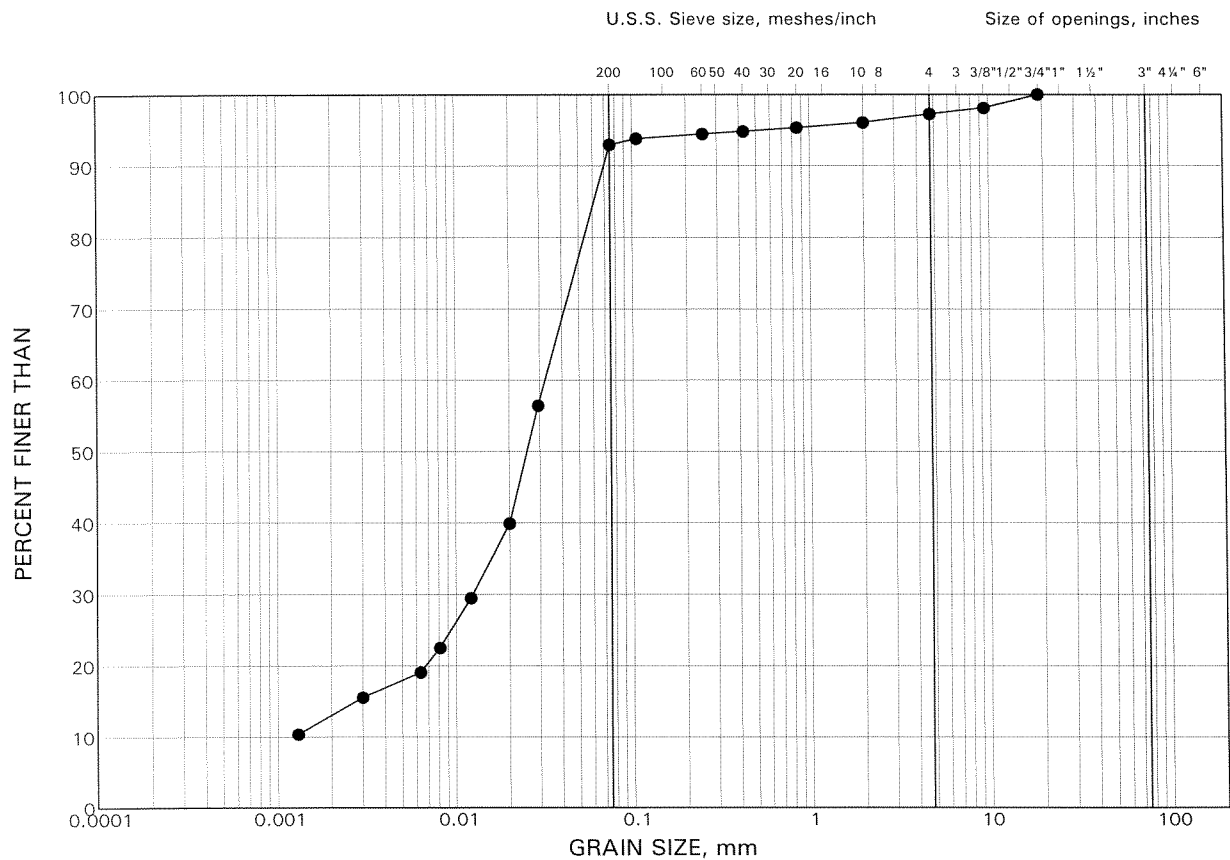
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	05-105	3	2.3-2.9

# GRAIN SIZE DISTRIBUTION

Silt

FIGURE A4



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

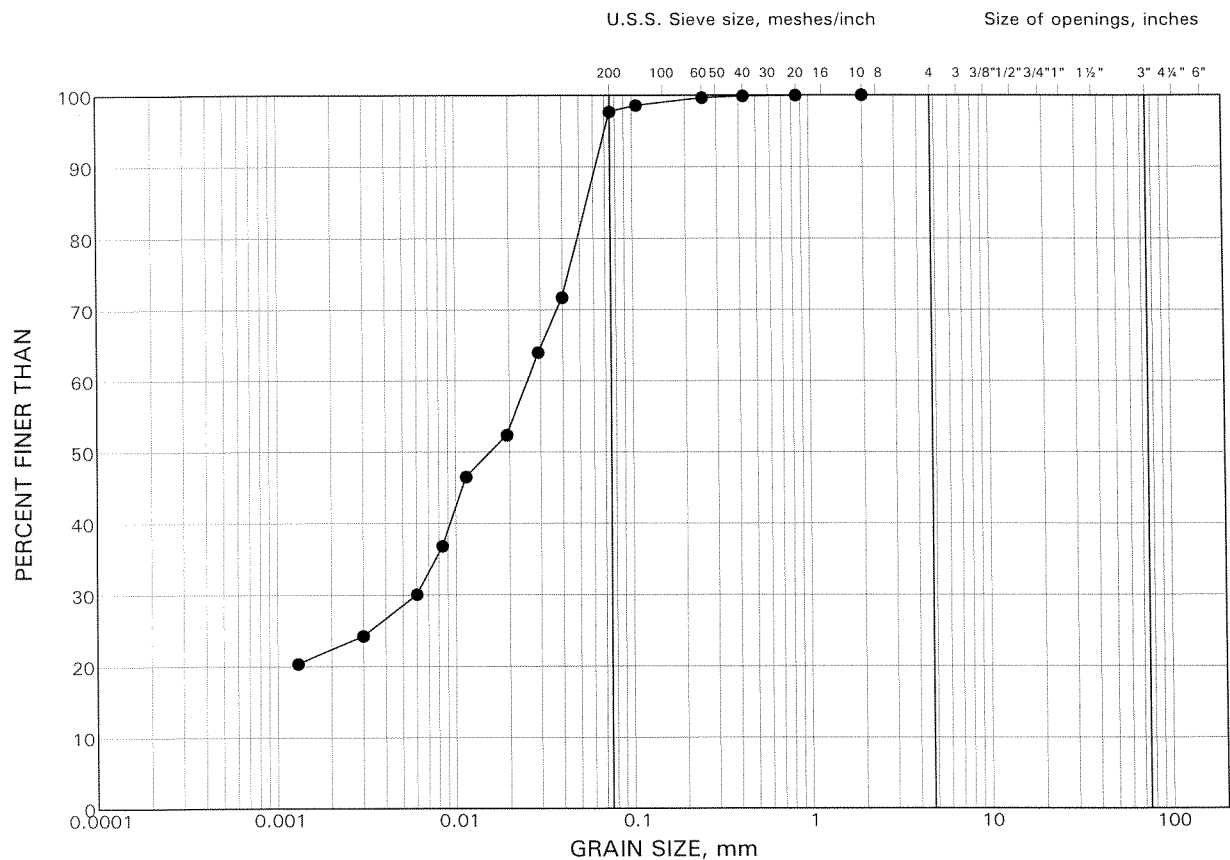
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	05-103	5	3.1-3.7

# GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE A5



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

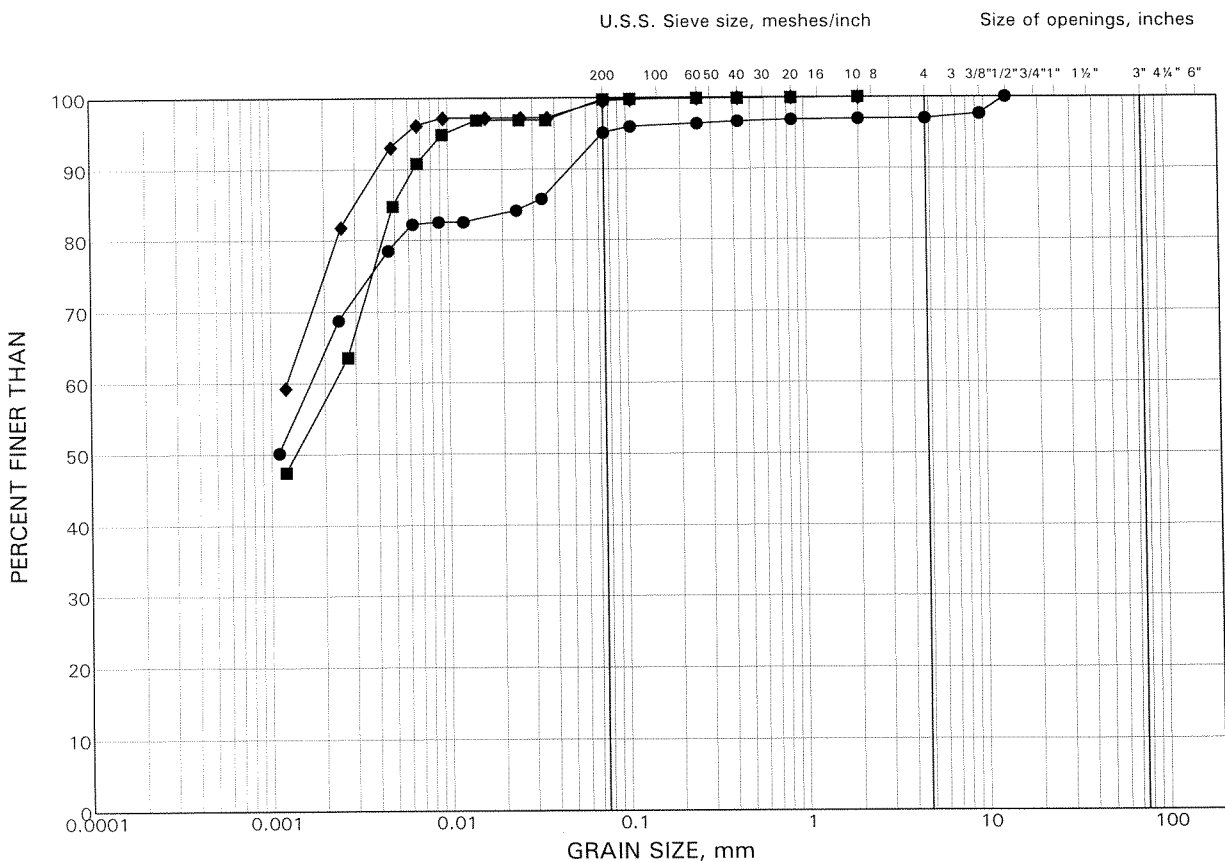
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
•	05-104	3	2.1-2.7

# GRAIN SIZE DISTRIBUTION

## Varved Silty Clay to Clay

FIGURE A6



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
●	05-105	5	4.6-5.2
■	05-105	11	13.7-14.3
◆	05-106	7	9.1-9.8

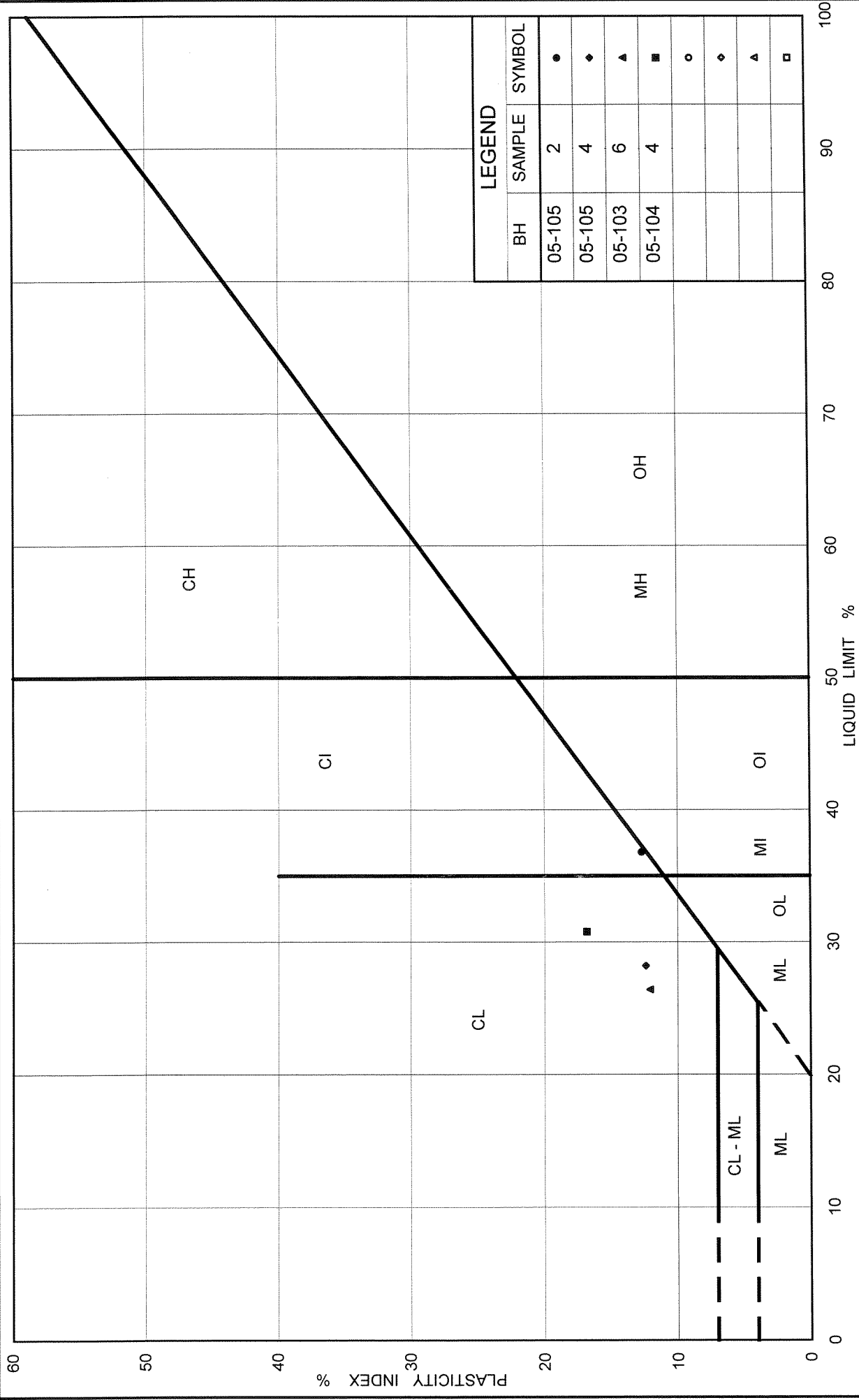


FIG No.A7

# PLASTICITY CHART Clayey Silt to Silty Clay

Ministry of Transportation

Project No. 04-1111-051B



Ontario



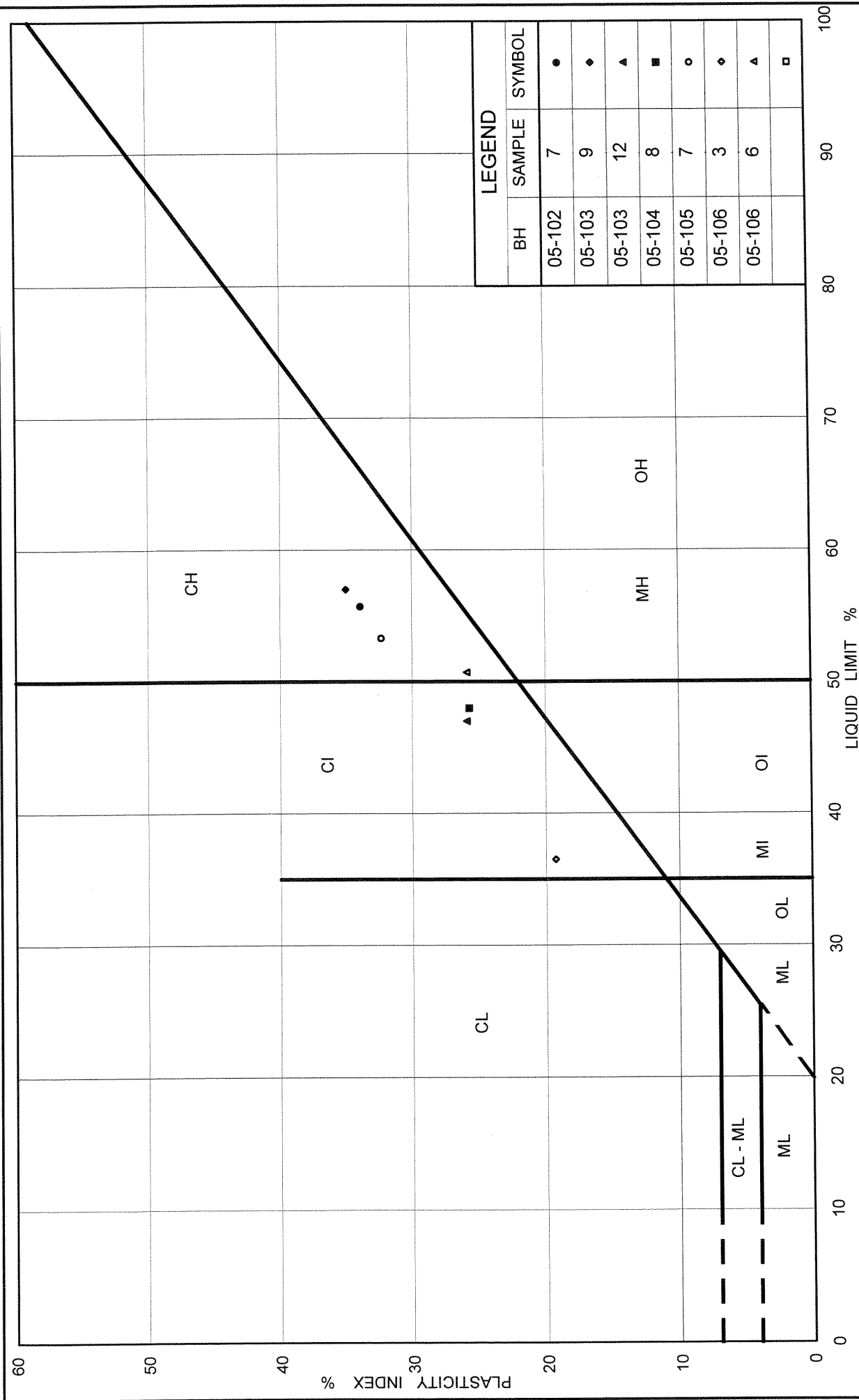


FIG No. A8

PLASTICITY CHART  
Varved Silty Clay to Clay

Ministry of Transportation



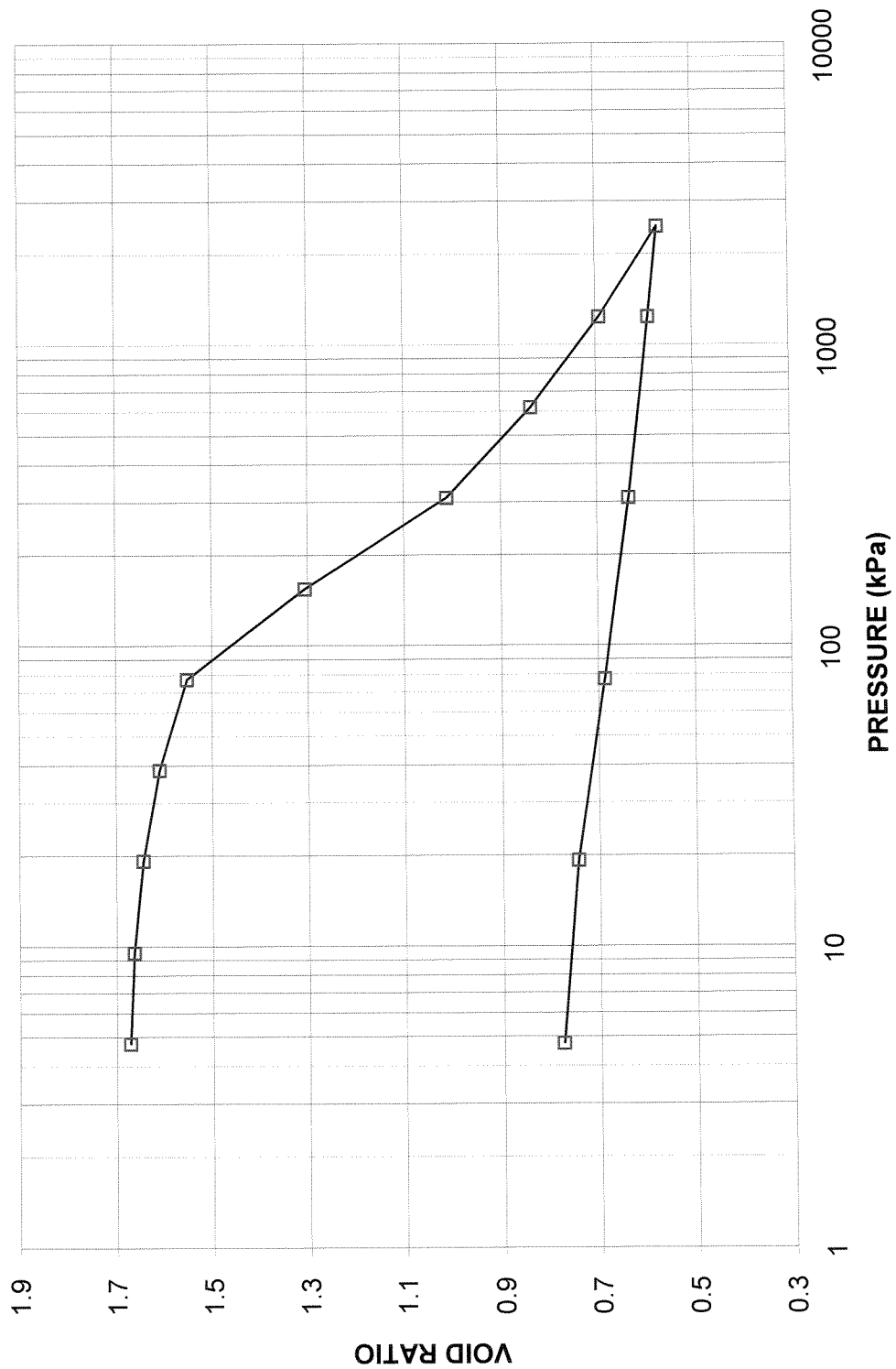
Ontario

Project No. 04-1111-051B

CONSOLIDATION TEST  
VOID RATIO VS. PRESSURE

FIGURE A9

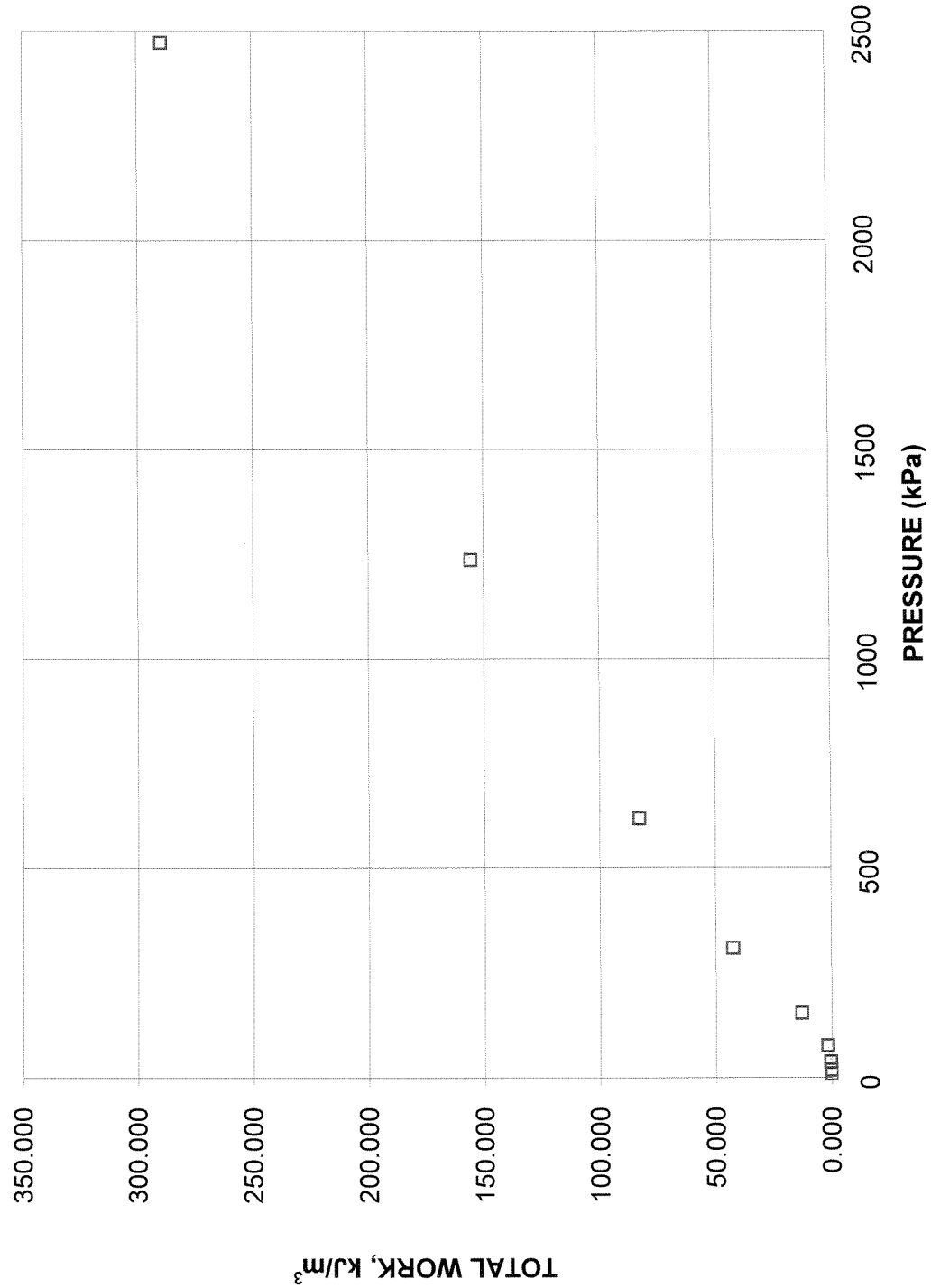
CONSOLIDATION TEST  
VOID RATIO vs PRESSURE  
BH 05-103 SA 9



**CONSOLIDATION TEST  
TOTAL WORK VS. PRESSURE**

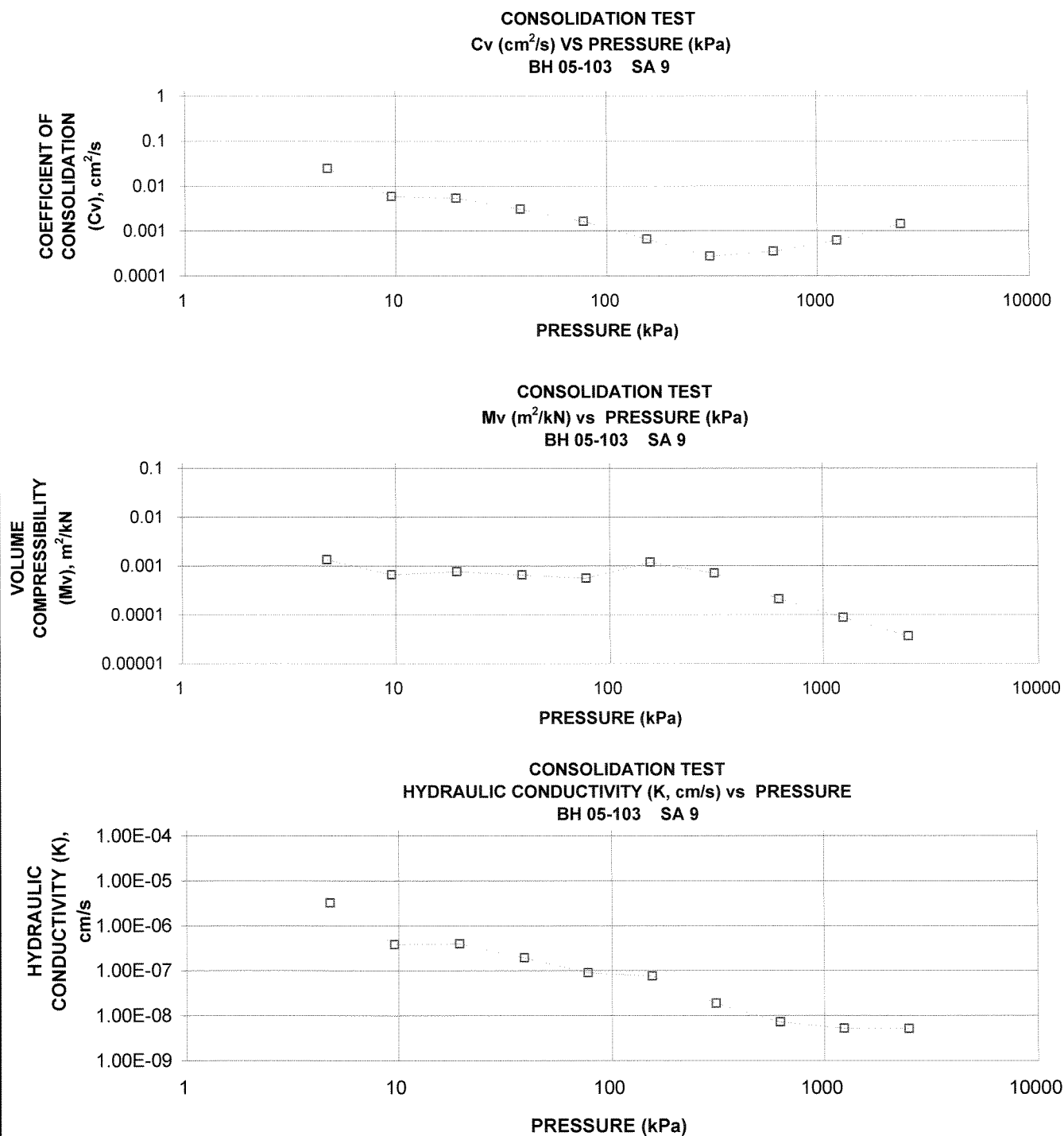
**FIGURE A10**

**CONSOLIDATION TEST  
TOTAL WORK vs PRESSURE  
BH 05-103 SA 9**



**PLOTS OF CONSOLIDATION TEST RESULTS  
Cv, Mv, and K VS. PRESSURE**

**FIGURE A11**



# CONSOLIDATION TEST SUMMARY

FIGURE A12

## SAMPLE IDENTIFICATION

Project Number	04-1111-051	Sample Number	9
Borehole Number	05-103	Sample Depth, m	9.1-9.7

## TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	6		
Date Started	03/12/2005		
Date Completed	03/26/2005		

## SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.90	Unit Weight, kN/m <sup>3</sup>	16.11
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m <sup>3</sup>	9.88
Area, cm <sup>2</sup>	31.67	Specific Gravity, measured	2.71
Volume, cm <sup>3</sup>	60.17	Solids Height, cm	0.707
Water Content, %	63.04	Volume of Solids, cm <sup>3</sup>	22.38
Wet Mass, g	98.87	Volume of Voids, cm <sup>3</sup>	37.80
Dry Mass, g	60.64	Degree of Saturation, %	101.2

## TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t <sub>90</sub> sec	cv. cm <sup>2</sup> /s	mv m <sup>2</sup> /kN	k cm/s
0.00	1.900	1.689	1.900				
4.75	1.888	1.672	1.894	31	2.45E-02	1.33E-03	3.20E-06
9.54	1.882	1.664	1.885	129	5.84E-03	6.59E-04	3.77E-07
19.25	1.868	1.644	1.875	141	5.29E-03	7.59E-04	3.93E-07
38.68	1.844	1.610	1.856	240	3.04E-03	6.50E-04	1.94E-07
77.38	1.803	1.552	1.824	433	1.63E-03	5.58E-04	8.90E-08
154.68	1.629	1.306	1.716	960	6.50E-04	1.18E-03	7.55E-08
309.90	1.421	1.011	1.525	1815	2.72E-04	7.05E-04	1.88E-08
619.05	1.298	0.837	1.360	1116	3.51E-04	2.09E-04	7.21E-09
1237.05	1.196	0.693	1.247	540	6.10E-04	8.69E-05	5.20E-09
2473.54	1.110	0.571	1.153	197	1.43E-03	3.66E-05	5.13E-09
1237.05	1.124	0.591	1.117				
309.90	1.155	0.635	1.140				
77.38	1.192	0.687	1.174				
19.25	1.233	0.745	1.213				
4.75	1.256	0.778	1.245				

Note:  
k calculated using cv based on t<sub>90</sub> values.

## SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.26	Unit Weight, kN/m <sup>3</sup>	19.99
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m <sup>3</sup>	14.95
Area, cm <sup>2</sup>	31.67	Specific Gravity, measured	2.71
Volume, cm <sup>3</sup>	39.78	Solids Height, cm	0.707
Water Content, %	33.71	Volume of Solids, cm <sup>3</sup>	22.38
Wet Mass, g	81.08	Volume of Voids, cm <sup>3</sup>	17.40
Dry Mass, g	60.64		

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