

**REPORT ON  
GEOTECHNICAL/HYDROGEOLOGICAL  
INVESTIGATION  
1200mm SANITARY SEWER DIVERSION  
FROM FLETCHER'S CREEK TRUNK SEWER TO  
ETOBICOKE CREEK TRUNK SEWER  
REGION OF PEEL**

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Prepared for

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**PART 1 - FACTUAL DATA**

**1.1 INTRODUCTION AND BACKGROUND**

The investigation described in this report was carried out by Geo-Canada Ltd. (Geo-Canada) at the request of KMK Consultants Limited (KMK), in connection with the design and construction of a proposed 1200mm dia. gravity trunk sanitary sewer pipe between the existing Fletcher's Creek trunk sewer system and the Etobicoke Creek sewer system.

The alignment of the pipe generally follows the boundary between the City of Mississauga and the City of Brampton on the south side of the Hydro One easement. An exception to this is at the crossing at Hwy 410, where the sewer alignment encroaches into the City of Mississauga.

The total length of the route is 4545m, of which 3124m will be open cut and the remainder will be tunneled. Relatively short tunnels are proposed at the crossings of Kennedy Road (30m) and Tomken Road (40m). Starting near Hurontario Road (Hwy 10),

1121m length of pipe will be laid in tunnel at depths up to 15m. A further 230m long tunnel is proposed beneath Hwy 410, about 7m below the pavement surface.

Presented in this report are the factual data obtained from twenty three (23) geotechnical boreholes and one (1) test well, the geotechnical properties of the soil types underlying the route of the pipeline, the interpretation of the relevant data, and the evaluation of the anticipated geotechnical and hydrogeological related construction conditions of the project.

The anticipated construction conditions are described in this report for the benefit of the design engineer in order that their impact on the design can be evaluated and constructibility established. Construction methods described in this report must not be considered as specifications or recommendations to the contractor or as the only suitable methods. Prospective contractors should evaluate all of the factual information, obtain additional subsurface data as they might deem necessary, and select their construction methods, sequencing and equipment based on their own experience.

## **1.2 REGIONAL GEOLOGY**

The site of the project lies within the physiographic area of a Halton Till Plain. The overburden in this region consists of competent glacial tills of well-consolidated clayey silt to sandy silt, which are generally suitable for open cut construction. Within the creek valleys and floodplains, surficial alluvial deposits are present overlying the till, often with

high moisture content and some organic content. These deposits are typically poorly consolidated.

Ordovician shales with interbedded limestone and calcareous siltstones of the Georgian Bay Formation lie at relatively shallow depths along Etobicoke Creek near the east end of the alignment, but at significantly greater depths at the Fletcher's Creek in the west. At the Etobicoke Creek S.13 interconnection, a previous investigation by Geo-Canada in 2001 encountered the top of bedrock at Elev. 174.3m, only 1.8m below ground surface.

The Ontario Department of Mines Drift Thickness Map of the Brampton Area (Map 2179), shows the overburden thickness in the Fletcher's Creek area to be quite variable, in the range of 15m to 30m.

### **1.3 PREVIOUS GEOTECHNICAL INVESTIGATIONS**

A preliminary investigation for the proposed sanitary sewer diversion was done in 2004 by Geo-Canada. It consisted of putting down fourteen (14) boreholes at the approximate locations shown in Drawing No. 1, 2 and 3. Borehole logs of these 2004-series boreholes (i.e. Boreholes 04-1 to 04-13) are presented in Appendix A of this report. Drawing No. 3 shows also the location of one (1) borehole (Borehole 01-14) put down by Geo-Canada in 2001 for the geotechnical investigation of Section S.13 of the Etobicoke Creek Trunk Sewer project at the east terminus of this project. Borehole log of Borehole 01-14 is also presented in Appendix A of this report.



#### **1.4 METHOD OF INVESTIGATION**

The field work for the present investigation consisted of putting down twenty (20) exploratory boreholes and one (1) test well at the approximate locations shown on Drawings No. 1, 2 and 3. The locations and ground elevations of the boreholes designated as BH 05-1 to BH 05-21 and the monitoring well BH 05-4 were surveyed by KMK. An additional borehole designated as BH 06-1 was suggested to be added by MTO's Central Region Corridor Management Office, and two (2) additional boreholes denoted as BH 06-2 and BH 06-3 were later added to better establish the top level of bedrock. The three additional boreholes were laid out in the field by Geo-Canada and their elevations were estimated based on the geodetic elevations shown in the site plan provided to us by KMK. As such, the elevation of BH 06-1, BH 06-2 and BH 06-3 should be considered accurate to no better than  $\pm 0.5\text{m}$ .

The site investigation work for the twenty (20) boreholes (Boreholes 05-1 to 05-3 and 05-5 to 05-21) was undertaken from October 24 to November 9, 2005 by DBW Drilling Limited, Borehole 06-1 on June 30, 2006 by Eastern Soil and Boreholes 06-2 and 06-3 by DBW Drilling Limited on September 14 to 15, 2006, with borehole logging services provided by the engineering staff from Geo-Canada. The boreholes were advanced with a power auger machine to depths ranging between 4.9 and 18.3m, and the sampling of the soil was by the Standard Penetration Test (SPT) method at frequent intervals of depth. The SPT 'N' values are indicated on the Borehole Logs (Refer to Appendix A). Soil samples were visually classified in the field. Upon encountering bedrock, the boreholes were advanced by augering and diamond core drilling over lengths ranging between 0.8m

(Borehole 05-14) and 4.4m (Borehole 06-2). The coring of the rock was with NQ or HQ size double tube wireline equipment, allowing recovery of 47mm (NQ size) or 63mm (HQ size) diameter rock cores. The monitoring technician recorded the standard penetration test resistances and visually described the soil and rock samples. For the rock cores, the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) values and Fracture Indices (FI) were recorded in accordance with the conventions used by the International Society for Rock Mechanics (ISRM). An explanation of these terms is presented in the fly sheet at the beginning of Appendix A.

Upon completion of the boreholes, the short term groundwater level was recorded, and in twenty (20) boreholes (Boreholes 05-1 to 05-3 and 05-5 to 05-20), standpipe type piezometers (19mm dia or 50mm dia) were installed for the long term monitoring of the piezometric levels.

Borehole 05-4 was drilled on November 10, 2005 by Canadian Soil Drilling Inc., with borehole logging services provided by the engineering staff from Geo-Canada. The borehole was advanced with a power auger machine to a depth of 27.4m. Grab samples of the overburden soils were visually classified in the field. A 160mm dia. test well with a 4m long screen was installed in this borehole.

Water level readings in the piezometers and the test well were obtained during the field work on December 5 and 6, 2005 and January 6 to 9, 2006, i.e. about one month and two months after the completion of the field work, respectively.

To assess the permeability of the soil, in-situ falling head permeability tests were performed in nine (9) selected boreholes and in the test well.

The soil samples were taken to Geo-Canada's laboratory where they were re-examined and representative samples were selected for geotechnical index testing. The testing program consisted of the measurement of the natural moisture contents of all samples, grain size analyses for fifty one (51) samples and consistency (Atterberg) limits for twenty nine (29) samples. Test results are shown on the individual borehole logs presented in Appendix A. The grain size distribution curves and the results of the consistency (Atterberg) limit tests for the soil samples obtained from this investigation are plotted on Figures 2005-1 to 2005-9 attached to this report in Appendix B. Previous laboratory testing results are presented in Figures 2004-1 through 2004-8 of Appendix B.

A number of soil samples were also selected for environmental and chemical analyses to determine their environmental quality and corrosion potential. Eight (8) samples were analyzed for the O. Reg. 558 leachate quality criteria (inorganic parameters). Fifteen (15) samples were analyzed for the general and inorganic parameters as set out in the MOE Soil Standards for Use under Part XV.1 of the Environmental Protection Act. In addition, five (5) soil samples were analyzed for PCBs and five (5) soil samples for sulphate ( $\text{SO}_4$ ) attack on concrete.

The rock cores were visually re-examined in the laboratory. Twenty three (23) representative samples were selected for point load index strength tests in the laboratory,

and six (6) samples were forwarded to the Rock Mechanics Laboratory of Queen's University for determining their uniaxial compressive strength (UCS), bulk density ( $\gamma$ ), Poisson's ratio ( $\nu$ ) and Young's Modulus of elasticity (E). The uniaxial compression test results are shown on the log of rock cores and are also tabulated in Table C-1 of Appendix C. The results of the Point Load Index Strength tests, to augment the uniaxial compression tests, are also shown on the log of rock cores and are summarized in Table C-2, Appendix C.

Photographs of the rock cores are also provided within Appendix C.

## **1.5 SUMMARIZED SUBSURFACE CONDITIONS**

### **1.5.1 Overview**

The boreholes revealed the presence of a variety of soil types ranging in texture from sand to silty clay. The typical stratigraphic sequence is cohesive glacial tills underlain by fine grained, cohesionless glacial tills. In some areas, zones of cohesionless glacial tills exist within the cohesive glacial till. The contact between these till sheets lies randomly between El. 197.9m and 179.1m along the alignment of the project. Silty sand and sand lenses were also found at depths ranging from 2.3 to 6.7m below the existing ground level (El. 181.9 to 177.5m) in Boreholes 05-18 and 05-19 within and below glacial tills. A 7m thick sand layer (water bearing stratum) was found at a depth of 19.8m below the existing ground surface (El. 184.2) in the test well (Borehole 05-4) below glacial tills.

Bedrock of the Georgian Bay Formation was contacted at depths ranging between 4.0m and 26.8m below the existing ground level (El. 184.1 to 177.2m) at Boreholes 05-4, 05-14, 05-15, 05-18, 05-20, 05-21, 06-1, 06-2 and 06-3. The boreholes suggest an irregular, undulating rock surface, possibly as a result of glacial erosion.

Details of the subsurface conditions are given on the individual borehole log sheets presented in Appendix A. The following notes are, therefore, intended only to summarize the data and to amplify some of the general characteristics of the deposits.

### **1.5.2 Topsoil and Fill**

Topsoil was encountered at the ground surface in the majority of the boreholes and had a generally cohesive silty and clayey texture. Where encountered, the thickness of these organic soils varied between 0.2 and 0.8m. The consistency of the topsoil was found to be soft to very stiff, as inferred from SPT 'N' values of 4 to 16 blows per 0.3m penetration.

Fill deposits were found in some boreholes extending to depths of 0.8m to 2.6m below ground surface. The fills are mainly composed of silty clay to clayey silt with traces of sand and gravel. The consistency of the fills was found to be firm to hard, as inferred from SPT 'N' values of 7 to 87 blows per 0.3m penetration. Sandy silt and silt and sand fills with a thickness of 0.3 to 0.8m were found locally in Boreholes 05-10, 05-14 and 06-2. Crushed rock and sand fill with a thickness of 0.8m was found in Borehole 05-13.

### **1.5.3 Cohesive Native Soils**

Cohesive native soils such as silty clay, clayey silt, clayey sandy silt and glacial tills of similar texture were encountered in all of the boreholes generally near the ground surface. The consistency of these soils were found to be stiff to hard, but generally very stiff to hard, as inferred from SPT 'N' values of 8 to 69 blows per 0.3m penetration.

Figure 2005-1 shows the results of sixteen (16) particle size distribution tests performed on selected samples of the silty clay to clayey sandy silt till. The tested samples contain 1 to 10% gravel, 14 to 33% sand, 38 to 51% silt and 19 to 39% clay size particles.

Figure 2005-8 shows the results of consistency (Atterberg) limit tests on fourteen (14) representative samples of these soil types. The tests indicate liquid limits of 21 to 35%, plastic limits of 13 to 21% and plasticity indices of 4 to 17%. Based on these, the soils are classified as low to intermediate plasticity clay (CL to CI) to Clay-Silt mixture (CL-ML) based on the Unified Soil Classification System. Natural moisture contents in these deposits ranged between 10 and 25%, but generally were below 15%.

### **1.5.4 Non-Cohesive Native Soils**

Soil types belonging to this group include sand and silty sand and glacial tills of sandy gravel, sandy silt, sand and silt, and silty sand texture. These soils, which form the majority of the soil profile, are broadly graded deposits.

Selected grain size analyses indicated that the finer textured sandy silt and sand and silt tills are composed of 2 to 26% gravel, 24 to 52% sand, 34 to 56% silt and 5 to 19% clay size particles.

Testing of selected samples of coarser textured silty sand till showed 7 to 21% gravel, 38 to 42% sand, 29 to 34% silt and 11 to 17% clay size particles. A single sample of a sandy gravel till contained 57% gravel, 23% sand, 20% silt and clay size particles.

A sample of a sand lense found within the till contained 84% sand, 13% silt and 3% clay size particles.

Grain size distribution curves for the non-cohesive granular native soils are presented on Figures 2005-3 to 2005-6 in Appendix B.

Figure 2005-9 show the results of consistency (Atterberg) limit tests on fifteen (15) representative samples of this soil group, indicating liquid limits of 14 to 28%, plastic limits of 12 to 16% and plasticity indices of 2 to 12%. Based on these, the soils are classified as low plasticity clayey silt (CL) to Clay-Silt mixture (CL-ML) and Silt (ML) based on Unified Soil Classification System. Natural moisture contents in these deposits ranged between 5 and 25%, but were typically less than 10%.

Standard penetration test resistances ('N' values) of 19 to greater than 100 blows per 0.3m were recorded in these deposits, indicating compact to very dense, but generally a dense to very dense state of compactness.

#### **1.5.5 Residual Soils**

Overlying the bedrock, a thin (0.9m) layer of residual soil was encountered in Borehole 05-18. This deposit consists of rock which has weathered to the consistency of a soil. The resulting soil resembles clayey sandy silt to silty clay, which contains fresh, hard shale and limestone rock fragments/slabs.

Figure 2005-2 shows the results of a particle size distribution test performed on a sample of the residual soil, showing 11% gravel, 24% sand, 44% silt and 21% clay size particles.

A standard penetration test performed within this deposit gave an 'N' value greater than 100 blows/0.3m penetration, indicating hard consistency and presence of rock fragments. The natural moisture content of the tested sample was 13%.

#### **1.5.6 Till/Shale Complex**

A till/shale complex was encountered overlying bedrock in Borehole 06-1. This deposit consists of a matrix of clayey silt with some sand and trace of gravel interspersed with shale and limestone slabs/fragments.



Figure 2005-7 shows the results of a particle size distribution test performed on a sample of the till/shale complex, showing 2% gravel, 21% sand, 46% silt and 31% clay size particles.

A standard penetration test performed within this deposit gave an 'N' value greater than 50 blows/0.3m penetration, indicating hard consistency and the presence of rock fragments. The natural moisture content of the tested sample was 8%.

#### **1.5.7 Georgian Bay Formation (Bedrock)**

Bedrock of Georgian Bay Formation (interbedded shale, limestone and siltstone) was encountered or inferred in Boreholes 05-4, 05-14, 05-15, 05-18, 05-20, 05-21, 06-1, 06-2 and 06-3. In Boreholes 05-4, 05-14, 05-18 and 06-1, the bedrock was penetrated only by augering without obtaining rock core samples, thus the rock surface was inferred from resistance to augering and the observation of the cuttings from the auger flights. In these boreholes the rock properties, including the degree of weathering, could not be defined. At the other borehole locations, the rock was cored using NQ or HQ wire line equipment, which provided 47mm or 63mm diameter rock core samples.

Visual examination of the recovered rock cores indicates that the rock belongs to the Upper Ordovician Paleozoic Georgian Bay Formation, which generally consists of moderately weathered to fresh, grey, fine to very fine grained fissile weak to medium strong shale, with frequent fresh, grey, fine grained strong to very strong siltstone and calcareous limestone layers. Rock core photographs are presented in Appendix C. The

descriptive terms used on the record of rock cores and throughout the report are defined in Appendix A on the Explanation of Terms Used in the Bedrock Core Log. Detailed descriptions of the index properties and results of laboratory testing are presented in the following paragraphs.

Total Core Recovery (TCR) ranged between 63 and 100%. Generally, poorer core recovery was experienced near the surface of the rock and improved with depth.

The Solid Core Recovery (SCR) ranged from 38 to 92% and also appears to generally improve with depth. The SCR index was generally influenced by the orientations of the fractures. SCR was low when fractures oblique to the borehole axis were intercepted.

The Rock Quality Designation (RQD) index is highly dependent on the frequency of joints, bedding plane partings and fractures in the rock cores. While the use of double tube core barrel provided reasonably good protection of the core during drilling and core retrieval, the fissile nature of the shale greatly influences the RQD values of the rock cores. Consequently, it is believed that the RQD values recorded underestimate the rock quality classification of the laminated fissile shale. On the basis of the recorded RQD values which range between 0 and 92%, the rock quality is estimated to be very poor to excellent, and the average value of approximately 30% suggests a rock of generally poor quality.

Based on the visual examination of the rock cores, an attempt was made to identify and record the thickness and percentages of the relatively harder siltstone and limestone layers. The percentage of the hard layers per core run ranges between 0 and 64%, averaging approximately 9%. The thickness of these layers varied but was generally less than 100mm. This rock formation, however, is known to contain very strong limestone or siltstone layers up to 600mm in thickness. Encountering such thick layers should be anticipated.

When logging the rock cores, the Fracture Index, i.e. the number of fractures for each 0.3m length of core, was also recorded. The recorded values range between 3 and >25. It was observed that the planes of weaknesses along which the cores tended to break, included planes of fissility and bedding, the contact surfaces between shale and siltstone or limestone bands and some oblique and subvertical joints. The joints along the planes of fissility were generally smooth and clean while those along the bedding surfaces were generally more open and were occasionally infilled with clay. The occasional oblique and subvertical joints, which are found frequently within the limestone beds, were often stepped and the joint surfaces were often uneven and rough.

In general, weathering in the bedrock was limited to the surfaces of major discontinuities. Deeper penetrating weathering has occurred in the zones very close to the bedrock surface, where the degree of weathering is described predominantly as moderately weathered. Below this, the degree of weathering ranged from slightly weathered to fresh as indicated on the Records of Rock Cores. The siltstone and limestone layers were

generally fresh with only slight surficial weathering on joint surfaces in the zone close to bedrock surface.

To determine the compressive strength of the intact rock, six (6) samples of suitable length of cores (three limestone/siltstone samples and one shale sample) were selected for uniaxial compression tests. The uniaxial compressive strength (UCS) of the tested limestone/siltstone samples ranged from 59 to 187 MPa with an average value of approximately 138 MPa, which indicates a very strong rock. The UCS of the tested shale sample is only 8.1 MPa due to core discing which occurred during the loading process. The test results indicated the shale is a weak rock. Point load index tests were performed on four limestone/siltstone samples and nineteen shale samples. The equivalent UCS of limestone/siltstone samples was inferred to range from 130 to 157 MPa in the diametral direction and 125 to 163 MPa in the axial direction, which is close to the values obtained from uniaxial compression tests. The inferred UCS of the shale was much lower than that of limestone/siltstone, ranging between 9 and 82 MPa for shale samples tested in point loading in the axial direction. The shale can be broken by hand in the diametral direction, indicating considerable strength anisotropy along bedding planes.

The unit weight ( $\gamma$ ) of the rock is about 25.0 to 26.5 kN/m<sup>3</sup>.

The Young's Modulus (E) of limestone/siltstone ranged from 28.9 to 46.7 GPa, and the Poisson's ratio ( $\nu$ ) between 0.16 and 0.34. However, the E of tested shale was only 1.3 GPa and  $\nu$  of 0.1 due to the core discing that occurred during testing.

## **1.6 GROUNDWATER CONDITIONS AND PERMEABILITY TESTING**

The groundwater conditions in the boreholes were observed during drilling in the uncased boreholes prior to backfilling as well as in the installed piezometers. On completion of drilling, eleven (11) boreholes were found to be dry, while in the other ten (10) boreholes, the depth to the water level in the uncased boreholes ranged from 2.5 to 17.5m (i.e. El. 176.3m to 198.2m). These short term observations may not be representative of the true stabilized groundwater conditions.

Standpipe type piezometers were installed in twenty (20) boreholes to monitor the groundwater conditions over a longer period of time. The diameter of standpipes installed near the tunnel sites was 50mm to allow the future installation of water level transducer data-loggers. Several weeks after the piezometers were installed, the groundwater level in the piezometers and in the test well was found to be between 0.3 and 5.6m depth (i.e. between El. 178.6 and 200.0m). Over the long term, seasonal fluctuations in the groundwater level are expected. We recommend that the piezometric levels be further monitored.

Groundwater measurements in the test well and piezometers installed during this and the 2004 investigations are shown on the attached borehole log sheets and are also summarized on Table 1.6.1:

**Table 1.6.1: Summary of Piezometric Measurements**

BH No.	Piezometer Diameter (mm)	Depth/Water Level Elevation (m)											
		UCD*	2004			2005						2006	
			Jan. 21	Feb. 5	Mar. 10	Nov. 3	Nov. 4	Nov. 10	Nov. 11	Dec. 5	Dec.6	Jan. 5	Jan. 9
04-1	19	9.0/191.9	4.9/196.0	-	4.5/196.4					5.0/195.9		4.5/196.4	4.9/196.0
04-2	19	Dry	11.2/191.9	-	4.2/198.9			4.5/198.6	4.5/198.6	1.0/202.1		0.5/202.6	0.8/202.3
04-4	19	6.2/199.8		6.1/199.9	6.3/199.7				6.0/200.0	6.0/200.0		6.1/199.9	6.1/199.9
04-5	19	6.6/192.9		1.0/198.5	0.9/198.6					0.9/198.6		1.2/198.3	0.9/198.6
04-6	19	7.6/187.0		1.6/193.0	1.2/193.4						3.6/191.1	4.0/190.7	3.6/191.1
04-7	19	5.5/187.6		1.6/191.5	1.1/192.0		2.3/190.8		2.4/190.7		2.2/190.9	1.9/191.2	1.9/191.2
04-9	19	Dry		3.8/184.3	1.3/186.8		1.5/186.6		1.6/186.5		1.8/186.3		1.9/186.2
04-10	19	Dry		6.3/182.0	2.6/185.7					2.7/185.6			0.7/187.6
04-11	19	Dry		1.6/184.4	0.8/185.2					1.6/184.4		0.7/185.3	0.8/185.2
04-12	19	Dry		1.1/183.8	0.3/184.6				3.1/181.8	0.3/184.6		0.2/184.7	0.2/184.7
05-1	19	Dry						3.1/196.9	3.1/196.9	3.0/197.0		3.0/197.0	3.0/197.0
05-2	19	Dry						3.0/197.5	3.1/197.4	3.1/197.4		2.9/197.6	3.0/197.5
05-3	50	Dry						5.3/197.6	5.2/197.7	4.2/198.7		3.9/199.0	3.9/199.0
05-4	160								4.7/199.3	4.7/199.3		4.7/199.3	4.7/199.3
05-5	50	17.5/188.1							5.7/200.2	5.6/200.0		5.6/200.0	5.6/200.0
05-6	50	5.3/198.2							4.0/199.5	4.0/199.5		4.1/199.4	4.1/199.4
05-7	50	5.0/196.6							2.4/199.2	1.9/199.7		2.5/199.1	2.6/199.2
05-8	50	6.1/193.9							0.5/199.4	0.6/199.4		0.7/199.3	0.7/199.3
05-9	50	Dry							2.9/195.5	2.9/195.5		2.9/195.4	3.0/195.3
05-10	19	Dry							2.1/193.4	2.0/193.5		1.7/193.8	1.9/193.6
05-11	50	Dry					6.5/187.1		1.8/191.8		2.0/191.6	1.9/191.7	2.1/191.5
05-12	19	5.5/187.1					2.8/189.8		2.9/189.7		2.5	2.4/190.3	2.4/190.3
05-13	19	5.9/182.4					0.9/187.5		0.9/187.4		1.0	1.0/187.4	1.0/187.4
05-14	50	Dry								2.3/187.7			2.5/187.5
05-15	19	Dry							1.2/185.7	1.3/185.7			1.1/185.8
05-16	19	7.7/178.7							1.3/185.1	1.4/185.0		1.2/185.2	1.4/185.0
05-17	50	8.2/177.6							2.4/183.4	1.5/184.3		1.0/184.8	1.2/184.6
05-18	19	8.6/176.3				2.9/182.0				0.3/184.6			0.3/184.6
05-19	19	2.5/181.7				4.5/179.7				1.1/183			1.2/182.9
05-20	19	Dry				Dry				1.1/182.5			1.0/182.7
05-21	19	Dry				Dry				4.2/178.6			3.8/179.0

\* UCD indicates groundwater level elevation upon completion of the drilling

Nine (9) falling head permeability tests were performed in piezometers and one (1) in the test well. The coefficient of permeability was calculated based on the formula suggested by NAVFAC (1982) for a piezometer in a saturated isotropic stratum of infinite depth.

Test locations, depths and results are given in Table 1.6.2.

**Table 1.6.2: Falling Head Permeability Test Results**

<b>BH No.</b>	<b>Piezometer Dia./ Screen Dia. (mm)</b>	<b>Test Depth/Elevation* (m)</b>	<b>Soil Type at Screen Location</b>	<b>Coefficient of Permeability k (cm/s)</b>
05-2	19/19	9.4/191.0	Sand and Silt Till	$6 \times 10^{-6}$
05-4	160/140	23.1/180.9	Sand	$10^{-4}$
05-5	50/50	16.9/188.7	Sand and Silt Till	$7 \times 10^{-6}$
05-7	50/50	12.2/189.4	Sand and Silt Till	$2 \times 10^{-5}$
05-9	50/50	10.7/187.7	Sand and Silt Till	$3 \times 10^{-5}$
05-11	50/50	8.4/185.2	Sand and Silt Till	$6 \times 10^{-6}$
05-14	50/50	9.0/181.0	Silty Sand Till	$6 \times 10^{-5}$
05-18	19/19	7.6/177.3	Clayey Sandy Silt to Silty Sand	$3 \times 10^{-5}$
05-19	19/19	6.6/177.6	Clayey Silt Till to Sand	$6 \times 10^{-4}$
05-20	19/19	4.1/178.7	Silty Sand Till	$10^{-4}$

\* Test Depth/Elevation at midpoint of piezometer screen.

## **PART 2 - INTERPRETATION OF DATA**

In this section of the report, the available geotechnical data are reviewed and interpreted as relevant to the design and construction of the proposed project. The anticipated construction conditions are evaluated for the benefit of the design engineer (KMK), in order to assist them in establishing feasibility and to provide guidelines for the preparation of the contract specifications. The comments provided on construction methods, type of equipment, difficulty of excavating, method of dewatering, etc., should not be considered as guidelines or recommendations for the contractors. Furthermore, the comments do not cover every aspect of the construction, particularly as they relate to construction methods, equipment, rate of production, scheduling, etc. The contractors should, therefore, base their bids on the factual data presented in this report and their own interpretation of the data coupled with their experience with similar projects in similar geological environment.

The proposed vertical alignment of the sewer along the selected route contemplates four (4) tunneled sections at the crossings under Hwy 10, Kennedy Road, Hwy 410 and Tomken Road. Due to the high ground surface elevations in the vicinity of Hwy 10, the tunnel in this area will extend to about 250m west and 870m east beyond the highway, and will have a total length of 1121m. The lengths of the tunnels under Kennedy Road and Tomken Road are proposed to be 30 and 40m respectively, while the crossing of Hwy 410 is 230m in length. The remaining sections will be open cut. Excavation depths in the open cut sections will range from approximately 5 to 12m, being generally deeper west of Kennedy Road.



## **2.1     ENGINEERING EVALUATION OF SUBSURFACE CONDITIONS IN OPEN CUT**

### **2.1.1   Pipe Support in Open Cut**

The borehole records indicate that at the proposed sewer invert levels, along the entire length of the sewer, the subgrade will consist of non-cohesive native soils and shale bedrock described in Section 1.5 of this report. These soils and the shale bedrock, in their undisturbed condition, will provide satisfactory support to the pipes using granular bedding materials in accordance with OPSD standards.

### **2.1.2   Excavation in Open Cut**

The anticipated behaviour of the soils as relevant to the support of the sewer and the stability and dewatering of open cut excavations are summarized on Table 2.1.2 and are also briefly discussed in the following text.

**Table 2.1.2: Anticipated Soil and Bedrock Behaviour in Open Cut**

<b>Soil Type</b>	<b>Sewer Pipe Support</b>	<b>Stability During Construction in Open Excavation</b>	<b>Reuse as Backfill*</b>	<b>Possible Means of Groundwater Control</b>
Topsoil and fill	Not suitable	Stable at 30-35°	Not suitable	Sump pump with filter
Native, cohesive soils	Satisfactory	Stable at 45°	Acceptable, provided that moisture content is within $\pm 2\%$ of the optimum	Sump pump with filter
Native, non-cohesive soils, sandy silt and sand and silt till	Satisfactory	Stable at 35-45° above water table; unstable below water table	Acceptable where high compaction not required	Gravity drainage and vacuum well points or eductors in zones with less than 10% clay
Native, non-cohesive soils, silty sand till, silty sand and sand			Acceptable, but may have to be air dried before reuse, where its moisture content is above the optimum	
Residual soils	Satisfactory	Stable at 45°	Acceptable, provided that its moisture content is within $\pm 2\%$ of the optimum	Sump pump with filter
Shale bedrock	Satisfactory	Stable at 70-90°	Acceptable, but requires heavy pad foot rollers	Sump pump

\* Summer construction. These comments do not apply to winter work.

Excavation in the fill, cohesive native soils, non-cohesive native soils and residual soils should generally not present undue difficulties. Due to the very stiff to hard or the dense to very dense condition of the glacial till and shale/till complex, as well as the presence of cobbles, boulders and shale/limestone slabs, progress may be slow and very heavy equipment will be required, possibly combined with special buckets and teeth.

Past experience with excavations in the bedrock belonging to the Georgian Bay Formation indicates that the rock can generally be removed without blasting. The top weaker portion of the bedrock can generally be removed with a powerful excavator equipped with a rock bucket and hardened rock teeth. The removal of the underlying fresh and stronger rock and especially the interbedded limestone and siltstone layers, however, will be arduous and time consuming, and will likely require the assistance of hoe rams, hydraulic splitters and other similar tools. Line drilling may be required in areas where excavations are in close proximity to existing structures. The relative ease/difficulty in excavation of bedrock will also depend on the size (width) and depth of the excavation. For example, excavation of narrow trenches into the shale will obviously be more difficult than forming large open cuts for structures in which excavators can operate from the base of the cut. In view of the possible damage to existing structures, conduits, piping, etc., we do not recommend blasting at this site.

Excavations in the fill described in Section 1.5.2 of this report should be temporarily stable at 30 to 35° (1.7 to 1.4 H in 1 V) cuts above the water table, or the trench walls should be supported by braced sheeting to comply with the Ontario Occupational Health and Safety Act (OHSA). The topsoil and fill along the proposed sewer alignment would be classified as Type 3 Soils above water table and as Type 4 soils below the water table under the OHSA.

Excavations in the cohesive native soils and residual soils described in Sections 1.5.3 and 1.5.5 of this report will require nominal support, however, when unsupported, they

should be cut back to 45° to comply with the OHSA safety regulations. The cohesive native soils along the proposed sewer alignment would be classified as Type 2 Soils, both above and below the water table under the OHSA.

The non-cohesive native soils (refer to Section 1.5.4) can be excavated above the groundwater table with side slopes of 35° to 45° to the horizontal, at which angle these soil types should remain temporarily stable during construction. Below the water table, due to seepage forces, sloughing and ravelling, progressively unstable conditions are expected. In order to maintain stability, excavations in these soils should be cut back to an estimated safe side slope between 2 and 3H in 1V. Steeper side slopes should be supported with braced sheeting or with trench boxes. These non-cohesive soil types are classified as Type 3 above and Type 4 below the water table in the OHSA Classification.

Vertical cuts in any of the soil types should be supported with braced sheeting where the depth of the excavation exceeds 1.2m.

Excavations into the bedrock can be cut on a subvertical face. The face of the excavation, however, should be scaled of any loose rock to protect the workers working in the excavation. Contractors should also bear in mind that the shale (as well as the limestone and siltstone interbeds) are transected by subvertical fractures, typically oriented at right angles to one another, and these fractures may preferentially cause the formation of slabs, wedges or blocks of loose unstable rock which will require removal and can often lead to

overbreak beyond the intended excavation cut line. In some cases, there could be a need for securing the rock face with wire-mesh and spot-bolting.

### **2.1.3 Dewatering**

As the excavation will extend below the groundwater table, construction dewatering in glacial till, silty sand and sand lenses and shale bed rock will be required.

The fill, the cohesive soils, and the residual soils are expected to be relatively impervious. The rate of groundwater seepage through these soils is expected to be slow and can be handled by gravity drainage and pumping from filtered sumps established at the base of the trench.

The rate of groundwater infiltration into the excavation through the non-cohesive soil types is expected to be moderate. This is supported by the observations made in the uncased boreholes which at the completion of the borehole, were found to be either free of standing water or the observed water level was much lower than the water table recorded later in the piezometers. The coefficient of permeability of the soils belonging to this soil group appears to increase from west to east along the proposed alignment. The estimated values of coefficient of permeability for the various sections of the project are summarized in Table 2.1.3. The excavation could be dewatered by gravity drainage and pumping from filtered sumps established at the base of the trench. Increased dewatering efforts may locally be required should the excavation extend into a sand lens similar to

that found in the east part of the proposed alignment below the glacial till (Borehole 05-19).

**Table 2.1.3: Estimated Coefficient of Permeability and Rate of Seepage in Open Cut**

Chainage		Soil Type	Estimated Coefficient of Permeability k (cm/s)	Estimated rate of Seepage into Trench* (litre/day per m)
from	to			
0+000	1+000	Sand and Silt Till	$\leq 10^{-5}$	50 - 100
1+000	2+500	Sand and Silt Till	$\leq 5 \times 10^{-5}$	90 - 180
2+500	3+600	Sand and Silt Till to Silty Sand Till Fractured rock	$\leq 10^{-4}$	30 - 60
3+600	4+500	Sand and Silt Till and sand Lenses Fractured rock	$\leq 5 \times 10^{-4}$	60 - 120

\* Under steady state seepage conditions.

The bedrock is susceptible to deterioration once exposed to air and surface water. The subgrade on which the pipe will be supported should, therefore, be protected shortly (a week or less) after the excavation is completed and inspected by placing a working mat of lean mix concrete or granular material. The granular blanket, however, must be kept well drained at all times and placed on a crowned subgrade draining to perimeter ditches and sumps. A minimum thickness of 50mm is recommended for the concrete mud slab.

The estimated rate of groundwater infiltration during steady seepage conditions ranges from 30 to 180 litre/day for per meter length of trench excavation as shown in Table 2.1.3.

The need for an MOE Permit to Take Water may depend on the total length of open trench under construction at a given time. The MOE PTTW is required once the pumping rate exceeds 50,000 L/day.

## 2.2 TUNNELED SECTIONS

Anticipated tunneling conditions for design are discussed in the following sections and are summarized on Table 2.2.

**Table 2.2: Summary of Anticipated Tunneling Conditions**

Tunnel Location	Approx. Invert Level (m)	Length (m)	Soil Type	Water Level (m)	Anticipated Ground Behaviour (**)	Possible Tunneling Methods	Estimated Coefficient of Permeability k (cm/s)	Estimated Total GW Seepage* (litre/day)
Hwy 10	190.5-188.6	1,121	Variable sandy silt, sand & silt till, trace to some clay, trace gravel boulders/ cobbles, very dense	200-198.6	Cohesionless "slowly" to "fast ravelling"	TBM	Clayey silt till: $1 \times 10^{-6}$ Sand & silt till: $5 \times 10^{-5}$ Sand: $5 \times 10^{-4}$	18,000 to 36,000 (200m intervals)
Kennedy Rd.	186.0	30	Silty sand, sand & silt till, trace to some clay, trace gravel, very dense	193.4-191.1	Cohesionless "slowly" to "fast ravelling"	Jack & bore with immediate and full soil support	Clayey silt till: $1 \times 10^{-6}$ Sand & silt till: $5 \times 10^{-5}$	2,700 to 5,400
Hwy 410	181.7-180.9	230	Silty sand, sand & silt till, some clay, trace gravel, boulders/ cobbles, very dense Till/Shale complex over shale/limestone bedrock at Borehole 06-1	187.7-186.3	Cohesionless "slowly" to "fast ravelling" Changing to shale/till complex then bedrock	TBM	Clayey silt till: $1 \times 10^{-6}$ Sand & silt till to silty sand till: $1 \times 10^{-5}$	6,900 -13,800
Tomken Rd.	178	40	Sand & silt till, trace clay and gravel, boulders/ cobbles, very dense	185.6-184.4	Cohesionless "slowly" to "fast ravelling"	Jack & bore with immediate and full soil support	Clayey silt till: $1 \times 10^{-6}$ Sand & silt till: $1 \times 10^{-5}$ Sandy lenses: $5 \times 10^{-4}$	2,400 to 4,800

\* Under steady seepage conditions

\*\* The anticipated ground behaviour indicated is based on Terzaghi's tunneling classification system. It relates to stand up time and primary tunnel lining installation. It does not relate to the ease or difficulty expected in excavating the soil or rock. Definitions of these terms are provided in Appendix C.

Crossings under Hwy 10, Kennedy Road, Hwy 410 and Tomken Road are proposed to be accomplished by tunneling. The tunnel diameter is expected to be of the order of 2.0m.

The information provided by the relevant boreholes indicates that within the zone of tunneling, the soil at each location consists of very dense sandy silt, sand and silt, and silty sand till. Boulders/cobbles were encountered in the boreholes within the zone of tunneling.

The groundwater table at Kennedy Road and Tomken Road crossings, lies 5 to 8m above the proposed tunnel invert level. At the crossings under Hwy 10, the water level lies 8 to 10m above the proposed tunnel invert level while at Hwy 410, it lies 5-6m above the tunnel invert. Fluctuations in the groundwater level can be expected.

The sand and silt till, which is expected to be the predominant soil type within the tunnel horizon at each of the tunneled section can, for the purpose of tunneling, be categorized as "slowly ravelling" ground in accordance with the behaviouristic ground classification



system established by Terzaghi in 1950<sup>1</sup>. Refer to Appendix C for definitions of the ground classification terminology as it relates to tunneling.

Depending on the amount of clay binder present in the soil and the magnitude of the pore water pressure, this initially “slowly ravelling” ground will, with time, change into a “fast ravelling” ground. The time required for the development of the fast ravelling condition could be as short as a few minutes to as long as 1 hour. It follows that support to the ground, particularly at obvert and the upper haunches, should be provided immediately after the excavation is made. This primary support system could range from a steel liner jacked in place to liner plates or steel ribs and timber lagging (lined with non-woven geotextile) installed within a shield close to the mined tunnel face.

For the advancement of the tunnel, a wide range of methods could be considered. These could range from jacking and boring where the tunnel is shorter than say 50m, to hand mining within the protection of a shield or using tunnel boring machines (TBM). The latter will probably be the preferred method where the length of the tunnel is greater than about 100m. This length is considered to be the practical limit for a jack and bore operation and advancement by hand mining would likely be too slow and also too costly. The choice of tunneling method and equipment should also take into consideration the very dense and bouldery condition of the ground. These will not only slow down production, but will also limit the minimum size of the bore (e.g. access to remove

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<sup>1</sup> Tunneling Technology, An Appraisal of the State of Art for Application to Transit Systems. The Ontario Ministry of Transportation and Communications, May 1976.

boulders) and will exclude or limit the use of certain tunneling methods (e.g. micro TBMs, horizontal directional drilling [HDD] or pipe ramming).

Based on the groundwater conditions measured in the boreholes at the crossings, the rate of groundwater seepage is expected to be slow to moderate during tunneling and could be handled by gravity drainage into the launching shaft. The estimated rate of seepage ranges from 30 to 180 litre/day for each meter length of tunnel as shown in Table 2.2 for the proposed tunnel sections. Where the primary tunnel support consists of steel ribs and timber lagging, a non-woven geotextile filter fabric must be placed behind the full perimeter of the lagging in order to prevent the removal of soil fines by groundwater seepage.

With good workmanship, the ground movements at road surfaces are expected to be within acceptable limits (i.e. less than 25mm).

### **2.2.1 Tunnel under Hwy 10**

This tunnel extends from approximately 250m west of Hwy 10 easterly to a total distance of 1121m. The proposed invert level ranges between 190.5±m and 188.6±, or about 11 to 16m below the ground surface.

The ground surface conditions in this section are shown on the Logs of Boreholes 05-3 to 05-8, and Boreholes 04-2 to 04-5 inclusive, as well as on the profile of the “Borehole Location Plans” (Drawings 1 and 2). Reference to these borehole logs indicates that at

the proposed invert level, the base of the tunnel will be in very dense glacial tills of predominantly sand and silt composition. Overlying the sand and silt till are relatively thick layers of cohesive till deposits consisting of silty clay and/or clayey sandy silt. Variations in-between the boreholes can be expected.

The groundwater table in the piezometers was recorded between El. 198.6±m and 200.0±m.

The tunneling conditions are expected to vary along the length of the tunnel. At the westerly portion, the roof of the tunnel is expected to be in the cohesive tills while towards the east, the entire tunnel horizon will be within the cohesionless sand and silt till. The anticipated behaviour of the soil during tunneling will depend on the amount of clay size particles, the degree of cementation present and the pore water pressure in the soil. Using Terzaghi's behaviouristic classification system, the sand and silt till can be classified as a generally "slowly ravelling" material with an estimated stand up time of possibly less than one hour. Due to the anticipated high pore water pressures in areas where the tunnel is more than a few (2-3) metres below the groundwater table, the initially stable ground will change into "fast ravelling" ground, requiring immediate and full support at the crown and the perimeter of the tunnel. The support needed to stabilize the face is expected to vary along the length of the tunnel. The presence of boulders in the till must also be expected when selecting the method of trenchless installation. Groundwater seepage through the till is estimated to be low to moderate and could be

handled by gravity drainage and tunneling “uphill”, i.e. from the east to the west. The estimated rate of seepage ranges from 90 to 180 litre/day per meter length of tunneling.

Because of the length of the tunnel, tunneling with a full size TBM is likely going to be the most practical method of installing the sewer in this section. The TBM, however, must be capable of dealing with boulders and occasionally unstable ground conditions, where the amount of soil particles smaller than 75 microns is low. The control of these ground conditions would likely require a full face TBM with a shield within which the primary tunnel support can be erected.

### **2.2.2 Tunnel under Hwy 410**

The proposed sewer invert elevation at this 230m long crossing ranges between 181.7±m and 180.9±, or about 4 to 7m below the ground surface and 9m below the surface of Hwy 410.

Boreholes 04-9, 04-10 and 05-14 indicate that the soils within the cross-section of the proposed tunnel consist of very dense glacial tills of sand and silt or silty sand texture, which are overlain by very stiff to hard silty clay to clayey sandy silt till. At the location of Borehole 06-1, the lower half of the proposed tunnel horizon is expected to encounter hard shale/till complex (a mixture of hard clayey silt glacial till with slabs and fragments of shale and limestone bedrock) and then shale and limestone bedrock of the Georgian Bay Formation.

The observed groundwater table ranges from El. 186.3 to 187.7m.

The behaviour of the granular tills during tunneling is expected to be generally “slowly ravelling” with an estimated stand up time of less than one hour. Due to the anticipated high pore water pressures (6 to 7m above the proposed sewer invert level), the initially stable ground will change into “fast ravelling” ground, requiring immediate and full support at the full perimeter of the tunnel.

Considering the length of the tunnel (about 260m), it is unlikely that single stage jacking and boring would be practical for its installation. Micro tunneling using a micro tunnel boring machine equipped with a suitable shield would be an alternative if no boulders and bedrock are encountered. The presence of boulders in the till, however, was confirmed in Boreholes 04-9 and 05-15 and bedrock in Borehole 06-1. In view of this, micro tunneling is not considered by us as a suitable method for this crossing. A full size TBM will probably be required for the tunnel construction at this crossing. This TBM should also be suitable for tunneling in the shale rock. Consideration should also be given to the fact that the rock mass also contains numerous limestone layers which could range in thickness between 10 and 600mm. Thus the TBM will encounter a wide range of ground conditions ranging from very dense slightly cohesive to cohesionless sand and silt glacial till (occasional cobbles), shale/till complex and shale bedrock interbedded with strong limestone.

Significant seepage is not expected to be encountered during tunneling. It should be possible to handle the anticipated seepage by gravity drainage into the launching shaft. The “ballpark” estimated rate of seepage ranges from 30 to 60 litre/day per meter length of tunneling.

### **2.2.3 Tunnels under Kennedy Road and Tomken Road**

Proposed sewer invert elevation at the proposed Kennedy Road crossing is at El. 186.0m and at El. 178m under Tomken Road. At these elevations, the invert of the trunk sewer lies about 8m and 7m below the existing ground surface at Kennedy Road and Tomken Road respectively. It is proposed to install the trunk sewer in these sections as a 30 to 40m long tunnel.

Boreholes 04-6, 05-11, 05-17, 04-11 and 04-12 provide information on the subsurface conditions at these locations indicating that the geological profile, as depicted on Drawings 2 and 3, consists of very dense silty sand till or sand and silt till deposits.

The groundwater table lies approximately 5.1 to 7.4m and 6.4 to 7.6m above the proposed sewer invert at the Kennedy Road and Tomken Road crossings respectively. The glacial tills in the tunneling zones are broadly graded materials with significant amounts of soil fines in places. The estimated hydraulic conductivity of the tills is in the range of  $10^{-4}$  to  $10^{-5}$  cm/s. For the purpose of tunneling, the coarser textured silty sand till is classified as a “fast ravelling” ground, while the sand and silt till which contains more clay size particles can be classified as “slowly ravelling” ground for the short term.

For the previously described ground conditions, the “fast ravelling” ground will require immediate and full support, whereas the “slowly ravelling” ground is expected to have initially some stand-up time, but due to the anticipated high pore water pressures (5 to 8m above the proposed sewer invert level), the ground will change into “fast ravelling” ground. As the time required for this change in ground behaviour cannot be predicted with sufficient accuracy, it is recommended that immediate and full support be provided at the crown, the perimeter and the face when the tunneling operation is interrupted.

Since the proposed length of the tunnels are 50m, tunneling could be carried out by jacking and boring, provided that the jacking of the steel liner follows closely the removal of the soil at the face. If unstable conditions develop at the face, the tunneling operation should be carried out uninterrupted around the clock.

With good workmanship, loss of ground and soil relaxation can be minimized, and it should be possible to keep settlements at road level to less than 25mm.

The estimated rate of seepage ranges from 30 to 180 litre/day per meter length of tunneling. At these rates, it should be possible to handle the flow by gravity drainage.

### **2.3 ENVIRONMENTAL QUALITY OF EXCAVATED SOILS**

To provide a general measure of the environmental quality of the excavated soils with respect to on-site reuse or off-site disposal, eight (8) selected samples were analyzed for

the O. Reg. 558 leachate quality criteria (inorganic parameters), fifteen (15) samples were analyzed for inorganic and general parameters set out in the Soil Standards for Use Under Part XV.1 of the Environmental Protection Act (EPA), and five (5) samples were analyzed for PCBs. Five (5) samples were also analyzed for water soluble sulphate (SO<sub>4</sub>). The samples tested and the type of tests performed are listed in Table 2.3.

**Table 2.3: Summary of Environmental and Chemical Tests**

<b>BH No.</b>	<b>Samples No.</b>	<b>Depth (m) from-to</b>	<b>O. Reg. 558</b>	<b>EPA Part XV.1</b>	<b>PCBs</b>	<b>Sulphate</b>
05-1	1	0 – 0.6	√	√	√	
05-2	2	0.8 – 1.2		√		√
05-3	7	9.1 – 9.6	√	√	√	
05-6	12	13.7 – 14.2		√		
05-8	9	10.7 – 11.1	√	√	√	√
05-9	1	0 – 0.6		√		
05-10	4	2.3 – 2.4	√	√	√	√
05-11	2	0.4 – 1.2		√		
05-13	7	4.6 – 4.7	√	√	√	
05-14	8	7.6 – 8.1		√		√
05-15	2	0.8 – 1.2	√	√	√	
05-17	5	3 – 3.3		√		
05-18	4	5 5.8	√	√	√	
05-19	1	0 – 0.6		√		√
05-21	2	0.8 – 1.2	√	√	√	

The analytical data are attached to this report in Appendix F.

Based on the measured inorganic parameters relative to the O. Reg. 558 Leachate Quality Criteria, all of the tested soils are considered as “Non-hazardous Waste”.

The test results show that concentrations of the parameters analyzed are all within the limits set out in “Table 3: Full depth Generic Site Condition Standards in a Non-Potable Ground Water Condition” of Part VX.1 of the Environmental Protection Act, implying



that if the tested soil samples are representative of the deposits, the soils excavated from the subject site can be re-used on-site or disposed off-site at any provincially authorized landfill site.

No PCBs were detected in the test samples.

Based on the available test results and in absence of other aesthetic indicators of impact, such as staining or odours, the site soils are generally considered suitable for either being reused on site (where geotechnically suitable) or for off-site disposal as 'clean' fill by an approved receiver of fill. However, Geo-Canada makes no warranty, express or implied, as to whether or not excavated soils will be accepted by receivers. Off-site receivers will likely require additional testing prior to acceptance of any soils. They may also reject soils based on other criteria, such as presence of organic material, rubble, or elevated moisture content.

Notwithstanding the test results provided herein, vigilance must be kept on the excavated soils. Soils with any evidence of anomalous fill, staining or odours should be stockpiled separately covered with tarps, and this office should be immediately contacted so that additional testing may be performed to assess their environmental quality.

## **2.4 CORROSIVITY POTENTIAL**

The sulphate (SO<sub>4</sub>) resistance of the concrete in contact with the soils was evaluated by performing water-soluble sulphate tests on the five (5) soil samples listed in Table 2.3.

The tests revealed that the sulphate concentrations in the soil samples were between 31.0 and 167 µg/g or between 0.0031 and 0.0167%. Based on this, ordinary Type 10 Portland Cement could be used for the design of the concrete mix as far as soil exposure is concerned. Concrete in contact with sewage may require a higher class of sulphate resistance.

## PART 3 – GEOTECHNICAL DESIGN RECOMMENDATIONS

### 3.1 GEOTECHNICAL DESIGN PARAMETERS

The proposed soil parameters for the design of sewer pipe, manholes and ground support systems are summarized in Table 3.1.

**Table 3.1: Soil Design Parameters**

Soil Parameters	Soils								Shale Bedrock	
	Topsoil & fill	New granular fill		Cohesive native soils		Non-cohesive native Soils		Residual Soils	Highly weathered	Moderately weathered to fresh
	SPT 'N' <50	'A'	'B'	SPT 'N' <50	SPT 'N' ≥50	SPT 'N' <50	SPT 'N' ≥50	SPT 'N' ≥50	SPT 'N' <50	
Unit weight (kN/m <sup>3</sup> )	19	22	20.5	19	21	20	23	20	21	25
Angle of internal friction (°), $\phi'$	28	35	30	32	38	36	42	38	40	-
Unconfined compressive strength (MPa)	-			-	-	-	-	-	-	24 (150 for limestone and siltstone)
Coefficient of lateral earth pressure Active, $K_a$ At rest, $K_o$ Passive, $K_p$	0.36	0.27	0.33	0.31	0.24	0.26	0.20	0.24	0.22	
	0.53	0.43	0.50	0.47	0.38	0.41	0.33	0.38	0.36	
	2.77	3.69	3.0	3.25	4.20	3.85	5.04	4.20	4.60	
Elastic modulus (MPa)	8			12	100	25	200	200	150	1300
Poisson's ratio	0.3			0.3	0.3	0.35	0.35	0.3	0.35	0.15
Modulus of subgrade reaction, k (MN/m <sup>3</sup> )	4	-	-	12	48	20	50	25	40	>50

Soil Parameters	Soils								Shale Bedrock	
	Topsoil & fill	New granular fill		Cohesive native soils		Non-cohesive native Soils		Residual Soils	Highly weathered	Moderately weathered to fresh
Coefficient of Permeability (cm/s)	10 <sup>-6</sup>	10 <sup>-3</sup>	10 <sup>-3</sup>	10 <sup>-6</sup>	10 <sup>-6</sup>	5x10 <sup>-4</sup> - 10 <sup>-5</sup>	5x10 <sup>-4</sup> - 10 <sup>-5</sup>	10 <sup>-6</sup>	10 <sup>-5</sup>	

The horizontal spring constants,  $K_{sh}$ , can be calculated from the value of the modulus of subgrade reaction shown in Table 3.1 as

$$K_{sh} = k * \Delta z \quad (3.1.1)$$

where

$\Delta z$  = height of wall served by spring.

The vertical coefficient of subgrade reaction,  $k_{sv}$ , can be calculated from the value of the modulus of subgrade reaction shown in Table 3.1 as

$$k_{sv} = \frac{k}{B} \quad (3.1.2)$$

where

B = the width of foundation.

## 3.2 **FOOTINGS AND BEDDING**

The proposed structures, such as manholes, founded on non-cohesive native soil and shale bedrock can be designed for an allowable bearing pressure of 400 kPa.

The proposed sewer pipe can be founded on granular bedding in accordance with OPSD 1102.01. The bedding material should be broadly graded (i.e. Granular 'A'). If clear stone is used, it should be completely wrapped with a geotextile filter fabric which has a filtration opening size of 120 microns or smaller in places where the invert is below the water table or where groundwater fluctuations are expected.

### **3.3 SETTLEMENT AND HEAVE**

The total and differential settlements due to the reloading of the subgrade under the weight of the proposed sewer pipe, manholes and backfill are expected to be less than 20mm and 10mm respectively.

The heave of soil during the excavation is expected to be less than 20mm.

In order to ensure that ground settlements at road level are limited to acceptable values, it is recommended that ground movements along the tunnel in critical areas (e.g. at the highway and road crossings) be monitored during the entire tunneling operation.

Settlement monitoring instrumentation should consist of a series of deep and shallow settlement points installed along the tunnel centerline. A series of deep seated benchmark should also be installed as references. The layout of the settlement monitoring instrumentation on Hwy 410 is shown in Drawing No. 4.

The installation details and monitoring frequency and accuracy are presented in Drawing No. 5. A minimum three (3) sets of repeatable baseline readings should be taken on all of the settlement points well in advance of the start of tunneling. Settlement monitoring should be conducted at least three (3) times daily. Readings may be reduced to twice daily when the tunnel face is greater than 50m away from the monitoring points. The frequency of readings can then be reduced to daily for ten (10) days, twice weekly for a period of one month and then once monthly for five months following grouting of the tunnel annular space.

Should settlement monitoring indicate excessive ground movement prior to the tunnel reaching the traveled lanes, immediate changes to the tunneling and ground support procedures must be adopted. The following table details the recommend 'Alert Levels' employed at road crossings:

**Table 3.3: Settlement 'Alert Levels'**

<b>Ground Movement</b>	<b>Notes</b>
<6mm	Proceed. No action required.
6-12mm	Immediately notify MTO & the geotechnical engineer for further assessment; Proceed with caution.
>12mm	Halt mining and bulkhead the tunnel face until further assessment is carried out by the MTO & geotechnical engineer; Carry out immediate remedial work to the settlement zone as approved by the MTO.

### **3.4 UPLIFT**

#### **3.4.1 Uplift of Sewer Pipe and Manholes**

The base of sewer pipe and manhole will be below the groundwater table and the structures will therefore be subjected to uplift pressure.

For the sewer pipe, the weight of sewer pipe and the earth backfill is much greater than the uplift force. Therefore, no post-construction uplift can occur, although care must be taken during construction prior to backfilling, to maintain the groundwater level at the base of the trench at all times.

For the manholes, the estimated design uplift pressures for each of the proposed manholes are summarized in Table 3.4.1, assuming the design water table is 1m higher than the recorded water level in the piezometers. The uplift force can be resisted by the dead weight of the manhole, the weight of earth backfill on top of the structure and the side friction force between the manhole and soils. The side friction,  $F$ , can be calculated based on Equation 3.4.1.1. A factor of safety of at least 1.5 should be applied in design against uplift. Should this be insufficient, additional resistance can be provided by soil/rock anchors.

**Table 3.4.1: Estimated Design Uplift Pressure for Manholes**

<b>MH No.</b>	<b>Ref. BH No.</b>	<b>Suggested Design Water Table Level (m)</b>	<b>Bottom Level of Manhole (*) (m)</b>	<b>Estimated design Uplift Pressure (kPa)</b>
2	05-1	198.0	191.8	62
3	04-2	203.1	191.3	118
4	05-4	199.5	188.1	114
5	05-10	195.5	187.6	79
6	04-6	192.8	187.1	57
7	05-12	191.4	186.4	50
8	05-13	188.3	181.7	66
9	04-10	188.3	180.6	77
10	05-15	186.8	180.2	66
11	05-16	186.2	179.8	64
12	05-17	185.3	179.2	61
13	05-18	184.9	178.7	62
14	05-19	184.0	178.1	59
15	05-20	183.6	177.6	60
16	05-21	180.0	177.1	29

(\*) based on drawing provided by KMK in September, 2006.

$$F = (1 - \sin \phi') \sigma'_v \tan(0.9\phi') \quad (3.4.1.1)$$

where

F = ultimate side friction resistance

$\phi'$  = angle of internal friction of soil as shown in Table 3.1

$\sigma'_v$  = effective vertical stress of soil.

The installation of the soil/rock anchors will be difficult due to the frequent cobbles and boulders present generally below the founding level of the manholes. For this reason, screwed-in, helical soil anchors will not be suitable at this site. It should be possible to install grouted soil/rock anchors with equipment suitable to drill through the boulders.



The theoretical ultimate pullout resistance,  $R$ , for grouted soil anchors can be estimated from the following equation:

$$R = \sigma'_v A_s L_s K_f \quad (3.4.1.2)$$

where

$\sigma'_v$  = effective vertical stress at the midpoint of the fixed anchor length

$A_s$  = effective unit surface area of the anchor

$L_s$  = bonded length of the anchor

$K_f$  = anchorage coefficient, taken as 2

The theoretical pullout resistance obtained from Equation (3.4.1.2) should be confirmed by at least three (3) pullout tests performed at the site. If pullout tests are not carried out, the allowable anchor load should be obtained by dividing the theoretical computed capacity of the anchor by a factor of safety of at least 3.

For rock anchor design, the allowable bond stress between grout and rock can be assumed to be 0.4 MPa, which incorporates a factor of safety of 2.0. In calculating the required depth of embedment, the top 500mm of the rock should be neglected. The bond between the anchors and the grout should also be checked.

The above design values for rock anchors must be confirmed by at least one (1) pull out ('performance') test carried to 200% of the design load within the area of each structure.

The cyclic test procedure as recommended by the Canadian Foundation Engineering

Manual should be used to establish acceptability. Since the capacity and performance of

the anchors depend also on construction techniques and workmanship, all anchors should be proof tested to 130% of their design capacity. After proof testing, the rock anchors can be pre-stressed to their design capacity to minimize the movement required to mobilize the resistance. The pre-stressing force should be included as loading on the foundations. If the anchors are not pre-stressed, then the design should recognize that there will be a slight upward movement of the structure equal to the tensile elongation of the anchors.

### **3.4.2 Base Heave of Excavation Due to Hydrostatic Uplift**

This investigation revealed that at the crossing of Hwy 10, a relatively impermeable glacial till at the proposed invert level is underlain by a water bearing stratum at 19.8m below the existing ground level (El.184.2m). The measured static water level of the water bearing stratum at BH 05-4 was 4.7 m below the existing ground level at El. 199.3m. The uplift pressure at the interface of the water bearing stratum and the impermeable glacial till is expected to be 151 kPa. This is resisted by the weight of native soil in the block of soil below the bottom of the proposed invert level. This resisting force was estimated to be of the order of 156 kN/m<sup>2</sup>. The factor of safety against basal heave is about 1.04 for a large excavation such as for instance, a tunneling shaft. The safety factor for a narrow excavation, such as a 1.5 to 2.0m wide trench, will be somewhat larger due to shearing forces developed along the vertical sides of the block of soil below the base of the trench. We are therefore of the opinion that it may not be necessary to depressurize the water bearing sand stratum for the sewer trench or the tunnel, but such measures will likely be required for larger excavations. It is recommended that prior to starting the excavations,

the piezometers be monitored and the Safety Factors re-evaluated. A minimum Factor of Safety of 1.1 should be observed during the construction period.

### **3.5 BACKFILL**

#### **3.5.1 Trench Backfill and Reuse of Excavated Material for Backfill**

The trenches may be backfilled with excavated inorganic materials, which have a moisture content within 2% of optimum and where approved by qualified geotechnical personnel. Under roadways, driveway, sidewalks or other areas where long term settlement is to be avoided, the backfill materials should be placed in not more than 300mm thick lifts compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). Within the upper metre below design subgrade, the degree of compaction should be increased to 98% of SPMDD. Where surface settlements can be tolerated, such as in easements (excluding the Hydro One Easement) or outside zones of present or future paved areas, the degree of compaction could be between 90 and 92% of SPMDD.

#### **3.5.2 Backfill between Sewer, Primary Tunnel Liner and Soil/Rock**

Any annular void space between the primary tunnel liner and the bedrock or glacial till must be fully grouted using a sanded Portland cement grout. The annular space between the sanitary sewer and the primary tunnel liner, within the bedrock portion of the tunnel alignment (where there is potential for rock squeeze), must be provided with a layer of compressible, non-degradable material to accommodate the rock strains. To this end, a 100mm thick layer of spray-applied polyurethane foam should be installed against the primary tunnel liner and the annular void between the foam and the product pipe can then

be grouted using a sanded Portland mix or equivalent. The spray-applied foam product must have a combustion rating of zero and a smoke generation rating of zero. The contractor must submit his proposed grouting and compressible void former details (including method and timing of application, elastic modulus, and flammability data) in a shop drawing submission for review by the Geotechnical Engineer. The minimum delay time between excavation of the tunnel in rock and final grouting should be indicated in the tunnel contractor's submission.

### **3.6 LATERAL EARTH PRESSURE**

#### **3.6.1 Permanent Structures**

The earth pressure distribution on permanent structures (e.g. manholes) can be taken as hydrostatic, i.e. which is increasing uniformly with depth according to the formula:

$$P_h = K_o \cdot \gamma \cdot h + K_o \cdot q \quad (3.5)$$

where

$P_h$  = horizontal pressure at depth  $h$  (kN/m<sup>2</sup>)

$\gamma$  = unit weight of soil as shown in Table 3.1

$h$  = depth below ground surface (m)

$q$  = surcharge load at ground surface (kPa)

$K_o$  = coefficient of lateral earth pressure at rest for a horizontal ground surface condition  
as shown in Table 3.1

Below the water table, the submerged unit weight of the soil should be used and the full hydrostatic water pressure should be added.

If the ground surface is not horizontal, the uneven portion can be treated as an equivalent surcharge load.

Where the structure is installed in a wide open excavation, the values of  $\gamma$  and  $K_o$  should be those of the backfill material. Elsewhere, where the thickness of the column of backfill material behind the wall is less than half of the buried height of the wall, the values of native soils given in Table 3.1 can be used.

Structures and pipes which extend below the surface of the bedrock and the walls of which are poured in direct contact with the bedrock will be subject to “rock squeeze”.

Although in-situ stress measurements were not made at this site, it is known that bedrock belonging to the Georgian Bay Formation contains high horizontal stresses, the magnitude of which varies between 2.5 and 6 MPa. As a result of the relief of this high horizontal stress, significant elastic displacements occur during and after the excavation. Of these, the long term, time dependant displacements are of greater importance. These are estimated to be of the order of 0.05% of the height of the excavation per log cycle of time (e.g. 2.5mm per log cycle of time for a 5.0m deep excavation or about a total of 11mm over a period of 50 years). Approximately 50% of these displacements (i.e. 5mm) is expected to occur during the first 100 days following excavation. The permanent structure should be designed to resist these displacements.

Alternatively, a layer of compressible material should be placed between the structure or pipe and the rock. This compressible layer could be a synthetic material (e.g. DOW Ethafoam). Properties and proposed thicknesses of the compressible synthetic material should be submitted to this office to evaluate its stiffness and assess its suitability. Certain rigid polystyrene insulation products (especially extruded polystyrene) are considered to be excessively stiff for this application. If soil is used to absorb the long term deformations, then a 900mm thick layer of lightly compacted (92% standard Proctor maximum dry density), sand should be placed between the rock face and the exterior face of the structure or pipe. Settlements at ground surface of the order of 2% of the height of the lightly compacted soil column can be expected.

### **3.6.2 Temporary Structures**

Vertical cuts in the soils should be supported by temporary shoring systems consisting of soldier piles and timber lagging. The design of the temporary earth support system should be the responsibility of the contractor, but the following general guidelines are provided for review.

The soldier piles should continue below the base of the excavation to a sufficient depth to provide the necessary toe resistance. Where adjacent structures resting on soil need to be supported, a caisson wall may be required.

The shoring system must be designed in accordance with the 3<sup>rd</sup> Edition of the Canadian Foundation Engineering Manual. The earth pressure coefficients should be  $K_0$ , where

ground movements must be minimal. Where minor movements can be tolerated,  $K_a$  can be used. Lateral support to the shoring system can be provided either by horizontal struts or tie-back anchors. The design of soil/rock anchors are the same as discussed under Section 3.3 Uplift.

### **3.7 STATEMENT OF LIMITATIONS**

The Statement of Limitation, as quoted in Appendix E, is an integral part of this report.

#### **SHAHEEN & PEAKER LIMITED**

Laifa Cao, Ph.D.

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Designated MTO Contact

Encl.

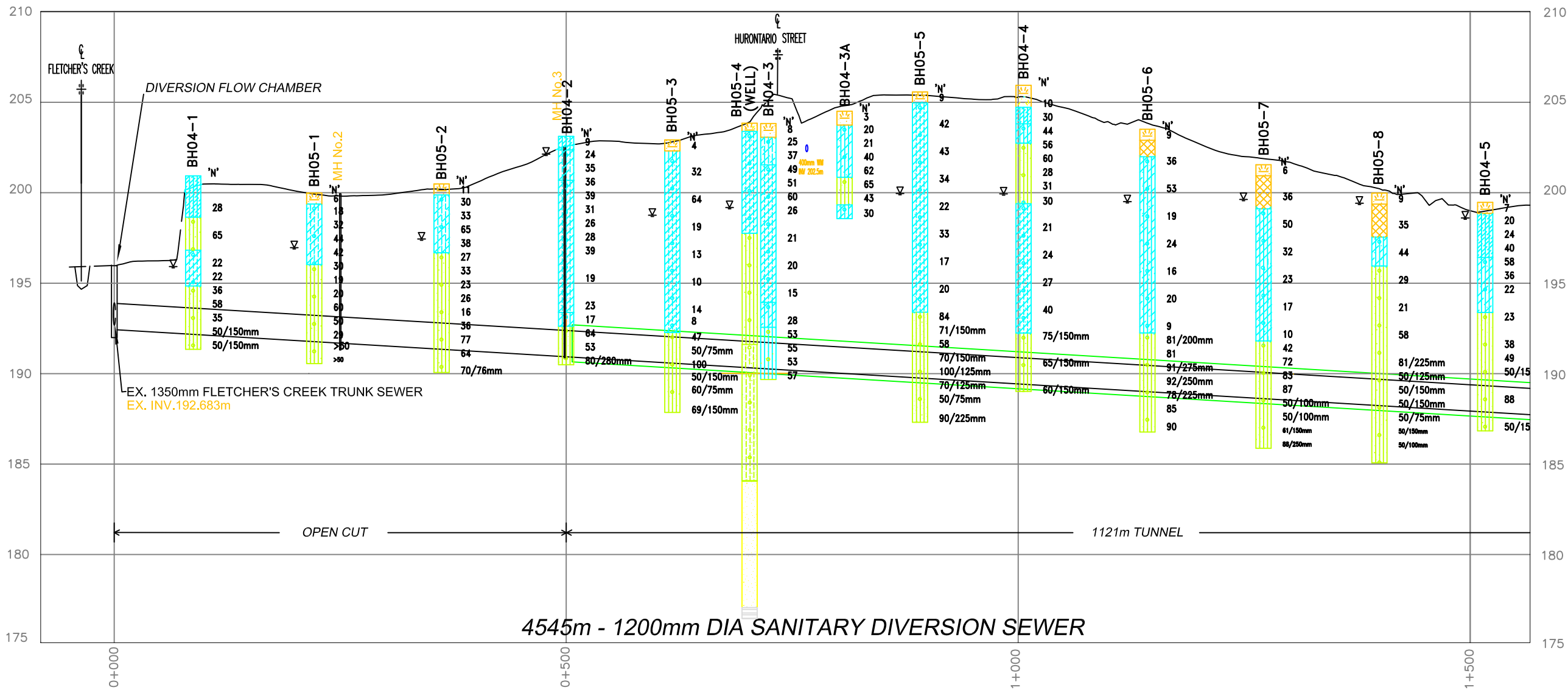
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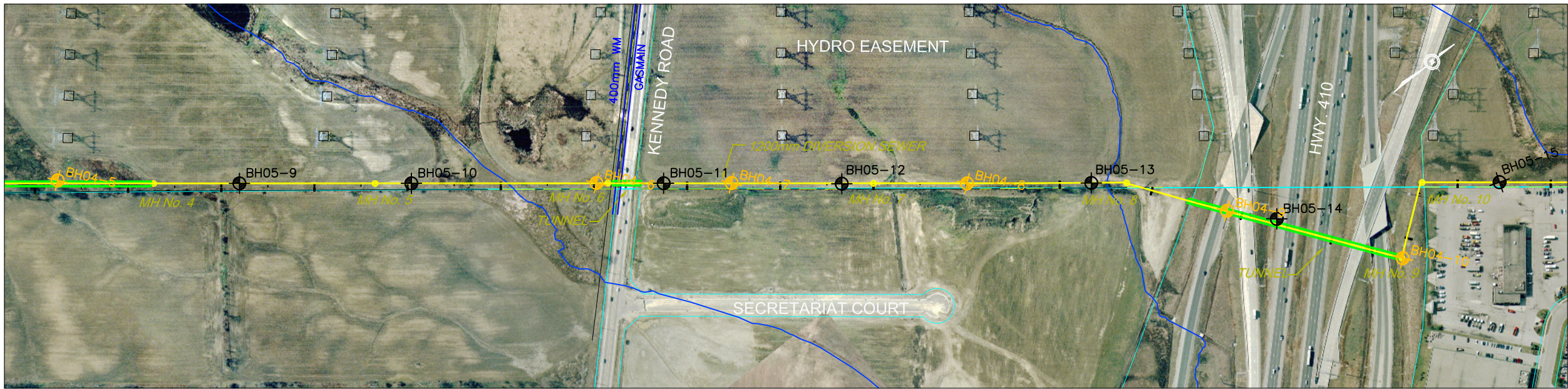
See Drawing No.2

- LEGEND:**
- EX. SANITARY TRUNK SEWER
  - HYDRO TOWER
  - SANITARY SEWER ALIGNMENT
  - TUNNEL SECTION
  - BOREHOLE 2005
  - BOREHOLE 2004
  - BOREHOLE 2001
  - TOPSOIL
  - FILL
  - CLAYEY SILT TO SILTY CLAY
  - SANDY CLAY
  - SILTY SAND / SILT AND SAND
  - SAND
  - SILTY CLAY TO CLAYEY SILT TILL
  - CLAYEY SILT TILL / CLAYEY SANDY SILT TILL
  - SANDY SILT TILL / SAND AND SILT TILL
  - SILTY SAND TILL
  - SHALE



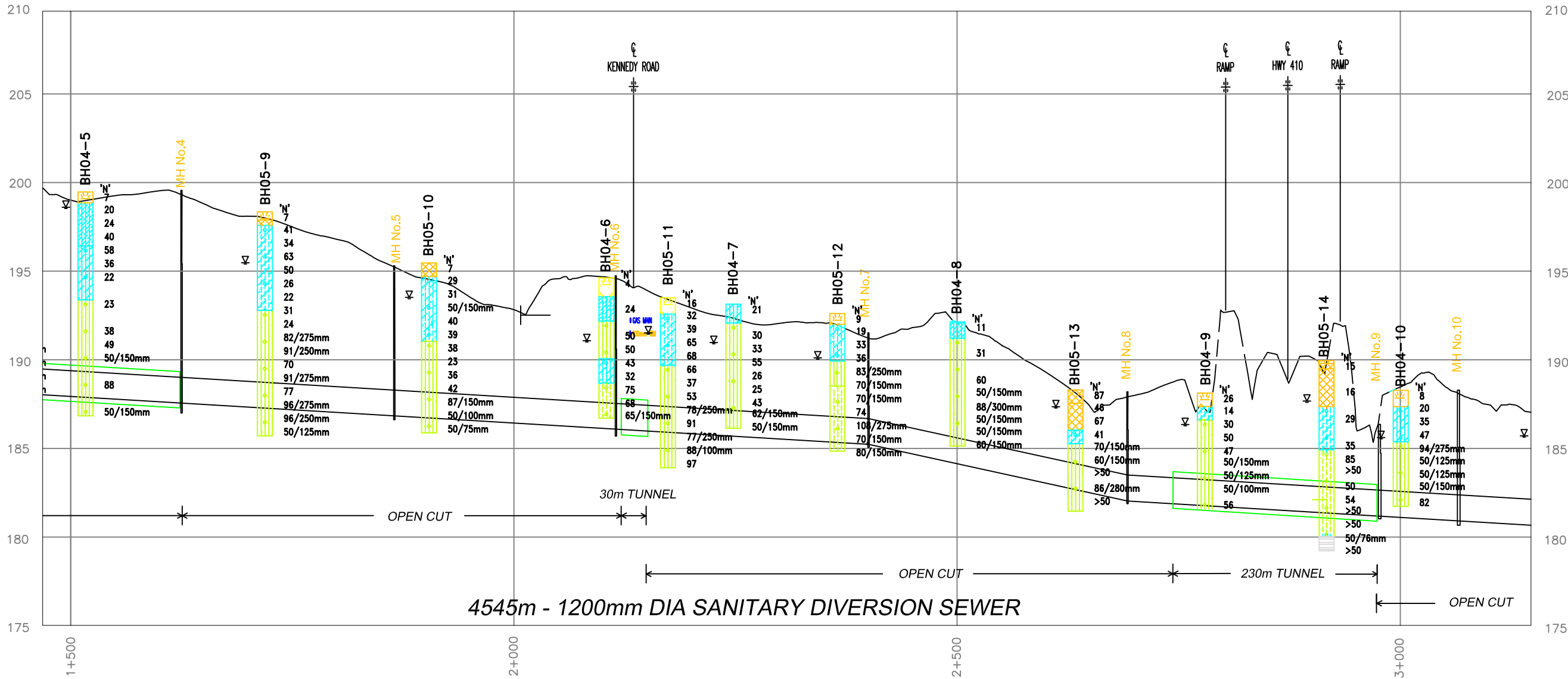


See Drawing No.1



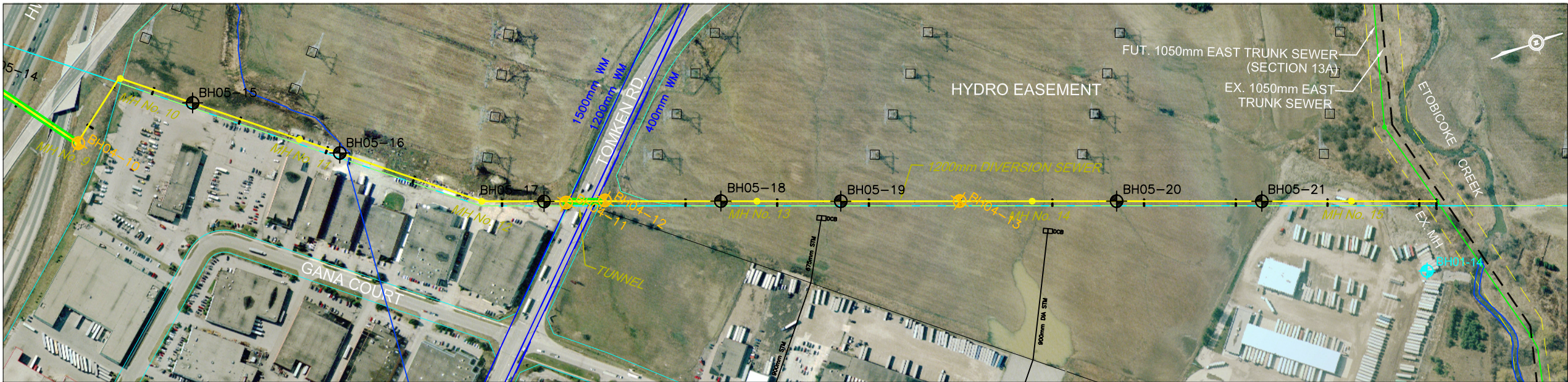
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  - HYDRO TOWER
  - SANITARY SEWER ALIGNMENT
  - TUNNEL SECTION
  - BOREHOLE 2005
  - BOREHOLE 2004
  - BOREHOLE 2001
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  - FILL
  - CLAYEY SILT TO SILTY CLAY
  - SANDY CLAY
  - SILTY SAND / SILT AND SAND
  - SAND
  - SILTY CLAY TO CLAYEY SILT TILL
  - CLAYEY SILT TILL / CLAYEY SANDY SILT TILL
  - SANDY SILT TILL / SAND AND SILT TILL
  - SILTY SAND TILL
  - SHALE

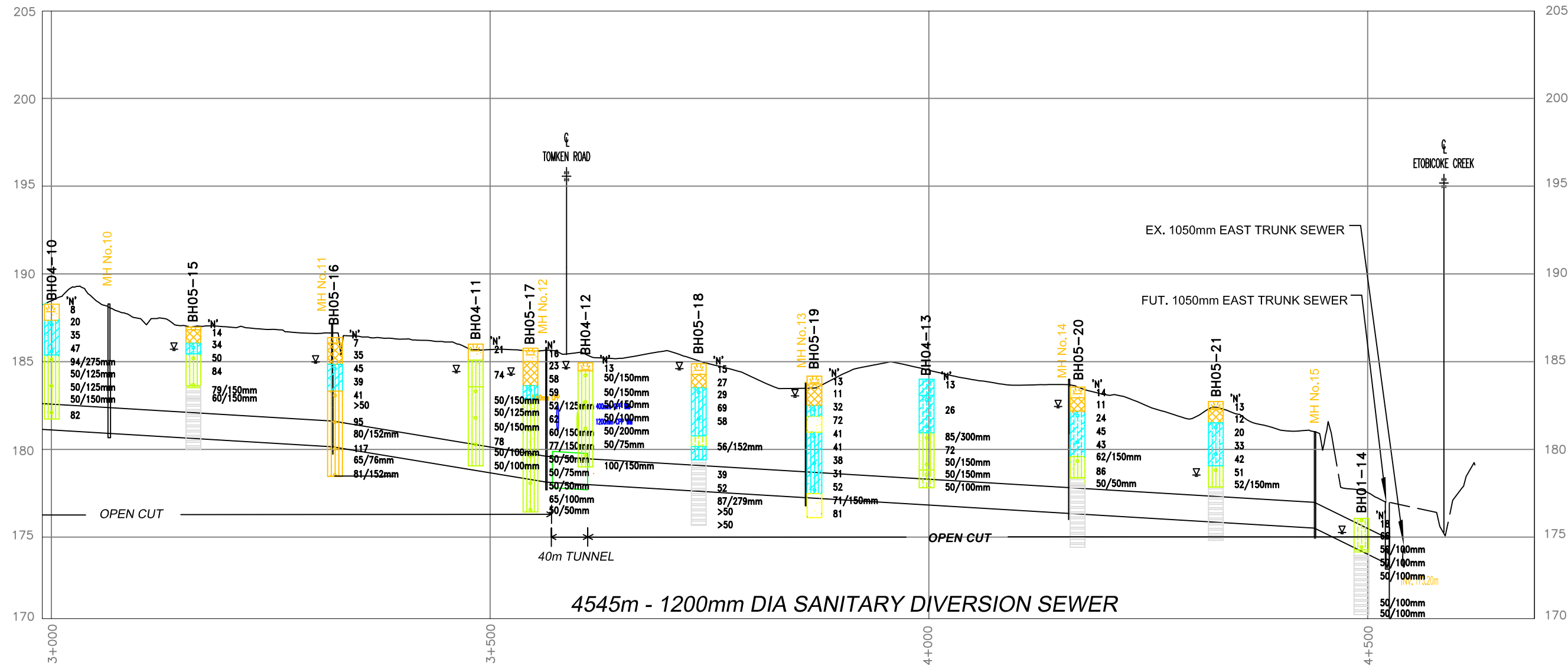




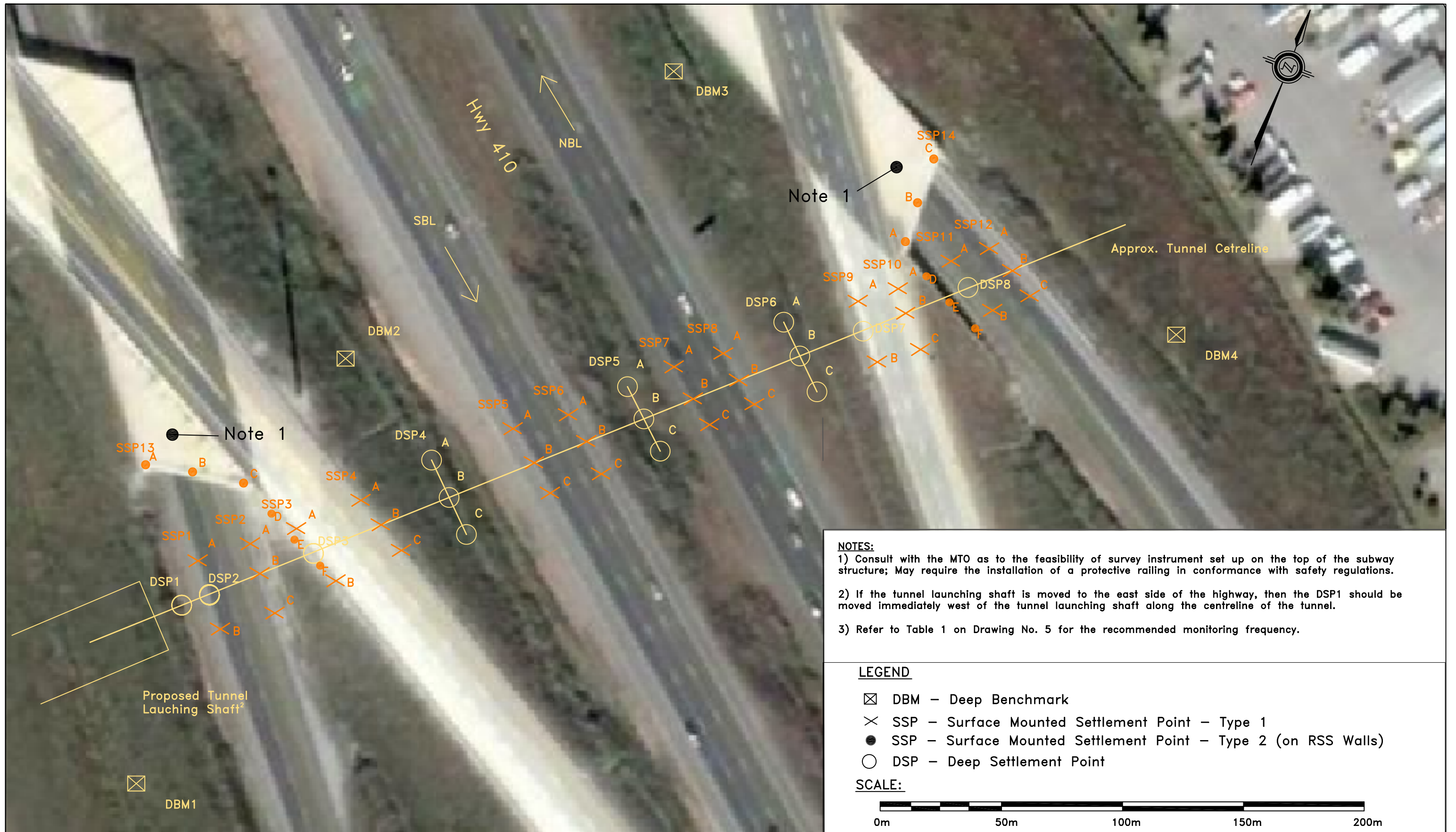
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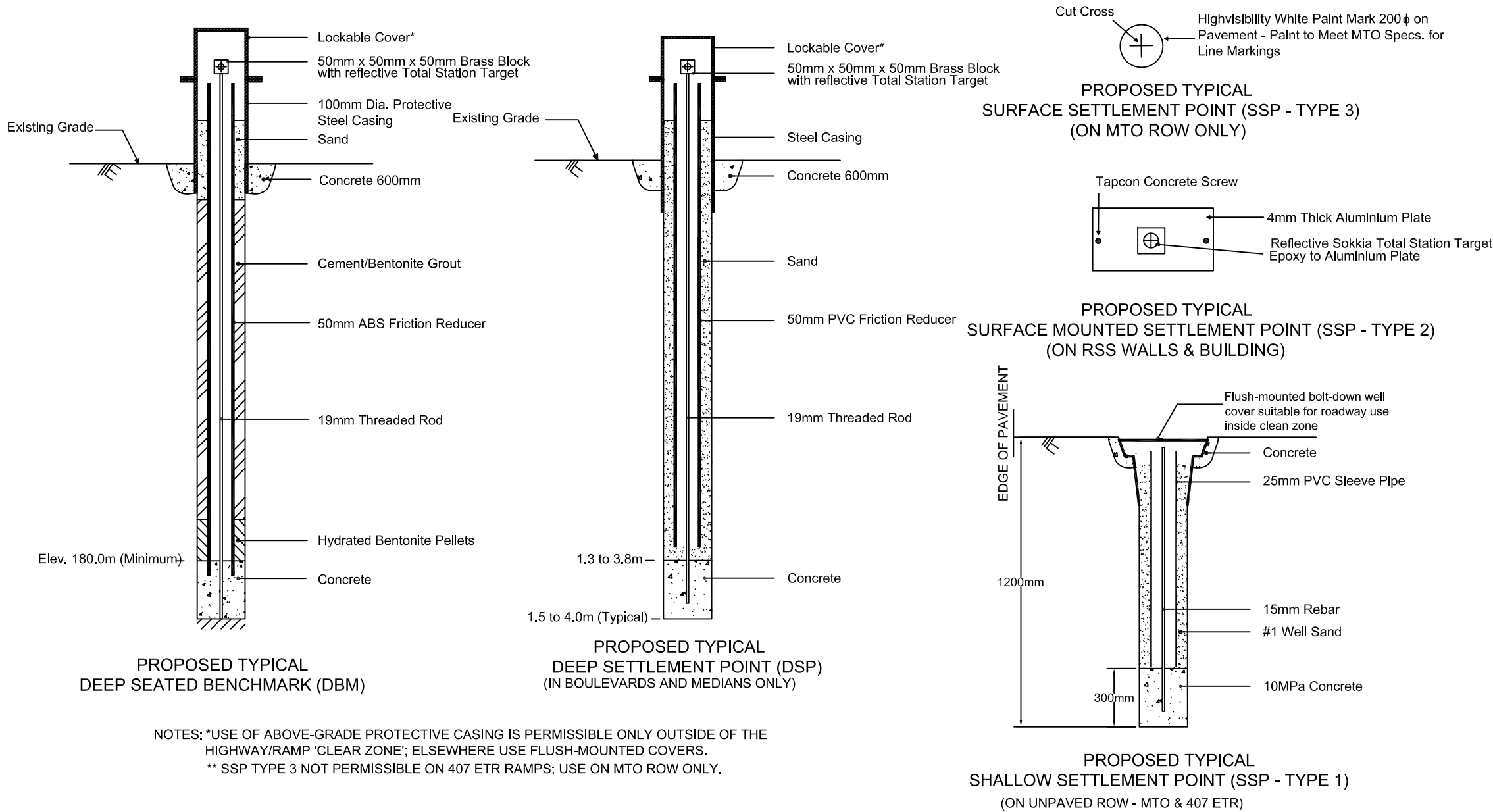
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  - SANDY CLAY
  - SILTY SAND / SILT AND SAND
  - SAND
  - SILTY CLAY TO CLAYEY SILT TILL
  - CLAYEY SILT TILL / CLAYEY SANDY SILT TILL
  - SANDY SILT TILL / SAND AND SILT TILL
  - SILTY SAND TILL
  - SHALE







TYPICAL INSTALLATION DETAILS



NOTES:

1) Deep settlement points are to be founded into the Sand & Silt Till Layer identified in BH04-9, BH05-14, BH06-1 and BH04-10; but no closer than 3m above the crown of the tunnel.

2) Accurate ground surface elevations and depths to the proposed tunnel obvert are required prior to the installation of any Deep Settlement Points.

3) Deep Seated Benchmarks are to be founded a minimum of 0.3m into the shale bedrock; Confirmed by grinding auger and split spoon refusal on the shale bedrock.

4) Shallow Settlement Points are to be flush with or recessed below the surrounding paved shoulder to protect settlement points and passing traffic from potential damage.

SETTLEMENT CRITERIA:

Definition	Movement
Review Level	≥ 6mm
-Immediately notify MTO/407ETR & the geotechnical engineer for further assessment; Proceed with caution.	
Alert Level	≥ 12mm
- Halt mining and bulkhead the tunnel face until further assessment is carried out by the MTO/407ETR & geotechnical engineer; Carry out immediate remedial work to the settlement zone as approved by the MTO/407ETR.	

TABLE 1 FREQUENCY AND ACCURACY OF MONITORING			
Installation Schedule	Baseline Reading	Monitoring Schedule	Monitoring Duration
At least one week prior to start of tunneling	Minimum of three (3) sets of readings prior to tunneling; Accuracy of readings should be 0.5mm or better.	Every four hours, but at least three (3) times per day. Readings may be reduced to twice daily when the tunnel face is greater than 50m away from the monitoring point. Minimum readings are as above within 50m meters.	On completion of tunneling, monitoring is to be maintained at least once daily for a minimum of 10 days; then once every three days for a period of 15 days; then once every ten days for a period of 30 days; then once every 30 days for the following year
Note: - During each monitoring visit, all monitoring points are to be recorded except where the tunnel face is greater than 50m from the instrument; - The above outline is recommended for all installed monitoring devices including the Deep and Shallow Settlement Points.			

INSTALLATION DETAILS OF TYPICAL DEEP BENCHMARKS (DBM), SHALLOW SETTLEMENT POINTS (SSP) & DEEP SETTLEMENT POINTS (DSP)

HWY 410 TUNNEL  
1200mm DIAMETER SANITARY SEWER DIVERSION

Scale: NOT TO SCALE	Project No.: G-05.0701
Date: REV.2 AUG. 2/07	Drawing No.: 5

## Explanation of Terms Used in the Bedrock Core Log

### Strength (ISRM)

Term	Grade	Description	Unconfined Compressive Strength	
			(MPa)	(psi)
Extremely weak rock	RO	Indented by thumbnail	0.25-1.0	36-145
Very weak	R1	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	1.0-5.0	145-725
Weak rock	R2	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	5.0-25	725-3625
Medium Strong	R3	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	25-50	3625-7250
Strong rock	R4	Specimen require more than one blow of geological hammer to fracture it	50-100	7250-14500
Very strong rock	R5	Specimen requires many blows of geological hammer to fracture it	100-250	14500-36250
Extremely strong rock	R6	Specimen can only be chipped with geological hammer	>250	>36250

### Bedding (Geological Society Eng. Group Working Party, 1970. Q.J. of Eng. Geol. Vol. 3)

Term	Bed Thickness	
Very thickly bedded	>2 m	>6.5 ft
Thickly bedded	600 mm-2 m	2.00-6.50 ft
Medium bedded	200 mm-600 mm	0.65-2.00 ft
Thinly bedded	60 mm-200 mm	0.20-0.65 ft
Very thinly bedded	20 mm-60 mm	0.06-0.20 ft
Laminated	6 mm-20 mm	0.02-0.06 ft
Thinly laminated	<6 mm	<0.02 ft

### TCR (Total Core Recovery)

Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

### SCR (Solid Core Recovery)

Sum length of solid, full diameter drill core recovered expressed as a percentage of the total length of the core run.

## Explanation of Terms Used in the Bedrock Core Log

### Weathering (ISRM)

Term	Grade	Description
Fresh	W1	No visible sign of rock material weathering
Slightly	W2	Discolouration indicates weathering of rock weathered material and discontinuity surfaces. All the rock material may be discoloured by weathering and may be somewhat weaker than in its fresh condition
Moderately	W3	Less than half of the rock material is weathered decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a corestone
Highly weathered	W4	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones
Completely weathered	W5	All rock material is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact
Residual soil	W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported

### RQD (Rock Quality Designation, after Deere, 1968)

Sum of lengths of pieces of rock core measured along centreline of core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Core fractured by drilling is considered intact. RQD normally quoted for N-size core.

RQD(%)	Rock Quality
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
0-25	Very poor

### (FI) Fracture Index

Expressed as the number of discontinuities per 300mm (1 ft). Excludes drill-induced fractures and fragmented zones. Reported as ">25" if frequency exceeds 25 fractures/0.3m.

### Broken Zone

Zone of full diameter core of very low RQD which may include some drill-induced fractures.

### Fragmented Zone

Zone where core is less than full diameter and RQD = 0

### Discontinuity Spacing (ISRM)

Term	Average Spacing	
Extremely widely spaced	>6 m	>20.00 ft
Very widely spaced	2 m-6 m	6.50-20.00 ft
Widely spaced	600 mm-2 m	2.00-6.50 ft
Moderately spaced	200 mm-600 mm	0.65-2.00 ft
Closely spaced	60 mm-200 mm	0.20-0.65 ft
Very closely spaced	20 mm-60 mm	0.06-0.20 ft
Extremely closely spaced	<20 mm	>0.06 ft

Note: Excludes drill-induced fractures and fragmented rock.

### Discontinuity Orientation

Discontinuity, fracture and bedding plane orientations are cited as the acute angle measured with respect to the core axis. Fractures perpendicular to the core axis are at 90° and those parallel to the core axis are at 0°.



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 20, 2004

REF. NO.: G-05.0701

ENCL NO.: 1

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)								
200.9	Ground Surface															
0.0	<b>CLAYEY SILT</b> trace gravel and sand, layered, brown, very stiff															
			1	SS	28		200									
							199									
198.6	<b>SANDY SILT</b> (Glacial Till) some clay to clayey, brown, very dense															
2.3			2	SS	65		198									
							197									
196.8	<b>SILTY CLAY</b> (Glacial Till) trace to some sand below 5.3m, trace gravel, grey, very stiff															
4.1			3	SS	22		196									
			4	SS	22		195									
194.8	<b>SANDY SILT to SAND and SILT</b> (Glacial Till) trace gravel, trace to some clay, grey, dense to very dense															
6.1			5	SS	36		194									7 30 52 11
			6	SS	58		193									
			7	SS	35		192									7 45 42 6
			8	SS	50/ 150mm											
			9	SS	50/ 150mm											
191.3	<b>END OF BOREHOLE</b>															
9.6	DATE Jan. 20/04 Jan. 21/04 Mar. 10/04 Dec. 05/05	WL. EL. 191.9m 196.0m 196.4m 195.9m														

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 20, 2004

REF. NO.: G-05.0701

ENCL NO.: 2

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									WATER CONTENT (%)
203.1	Ground Surface							20	40	60	80	100					
0.0	<b>CLAYEY SILT</b> rootlets, brown, stiff		1	SS	9		203										
202.3																	
0.8	<b>CLAYEY SANDY SILT</b> (Glacial Till) oxidized to 1.5m reddish brown, very stiff to hard		2	SS	24		202.1 m Dec 05, 2005										
			3	SS	35												
200.7							201										
2.4	<b>SILTY CLAY</b> (Glacial Till) some sand to sandy , trace gravel, oxidized between 3.8 and 5.1m, very stiff to hard		4	SS	36		200										
	light brown		5	SS	39												
	grey		6	SS	31		199									7 33 38 22	
			7	SS	26		198										
			8	SS	28		197										
			9	SS	39		196										
			10	SS	19		195										
			11	SS	23		194										
193.3							193										
9.8	<b>CLAYEY SILT to SILTY CLAY</b> (Glacial Till) some sand to sandy, some gravel, grey, very stiff		12	SS	17											10 38 37 15	
192.6																	
10.5	<b>SAND and SILT</b> (Glacial Till) trace gravel and clay, grey, very dense		13	SS	64		192									9 43 40 8	
			14	SS	53												

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 20, 2004

REF. NO.: G-05.0701

ENCL NO.: 2

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
191.1								20	40	60	80	100					
12.0							191										
190.5			15	SS	80/ 280mm												
12.6	END OF BOREHOLE																
	DATE WL. EL. Jan. 20/04 dry Jan. 21/04 191.9m Mar. 10/04 198.9m Nov. 10/05 198.6m Nov. 11/05 198.6m Dec. 05/05 202.1m																

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ 8=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 20, 2004

REF. NO.: G-05.0701

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
203.8	Ground Surface						20	40	60	80	100						
0.0	<b>TOPSOIL</b> mixed with <b>SILTY CLAY</b> rootlets, grey/black, firm		1	SS	8												
203.0																	
0.8	<b>CLAYEY SANDY SILT</b> (Glacial Till) oxidized to 1.5m reddish brown, very stiff to hard		2	SS	25												
			3	SS	37												
201.5																	
2.3	<b>SILTY CLAY</b> (Glacial Till) trace gravel, some sand to sandy very stiff to hard		4	SS	49												
			5	SS	51												
			6	SS	60												
			7	SS	26												
			8	SS	21												
			9	SS	20												
			10	SS	15												
193.9																	
9.9	<b>CLAYEY SILT</b> to <b>SILTY CLAY</b> (Glacial Till) some sand to sandy, trace gravel, grey, very stiff																
			11	SS	28												
192.5																	
11.3	<b>SAND</b> and <b>SILT</b> (Glacial Till) trace gravel, trace to some clay, grey, very dense		12	SS	53												

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 20, 2004

REF. NO.: G-05.0701

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)					W <sub>p</sub>	W	W <sub>L</sub>		
191.8								20	40	60	80	100					
12.0	<b>SAND and SILT</b> (Glacial Till) trace gravel, trace to some clay, grey, very dense(continued)		13	SS	55		191										
			14	SS	53												9 35 41 15
189.6			15	SS	57		190										
14.2	<b>END OF BOREHOLE</b>  Borehole dry upon completion.																

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity○  $\epsilon$  = 3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 21, 2004

REF. NO.: G-05.0701

ENCL NO.: 4

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
								20	40	60	80	100						○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL
204.5	Ground Surface																			
0.0	<b>TOPSOIL</b> mixed with <b>CLAYEY SILT</b> brown, soft		1	SS	3											○				
203.7							204													
0.8	<b>CLAYEY SILT</b> (Glacial Till) sandy, trace gravel, oxidized to 2.0m reddish brown, very stiff to hard		2	SS	20											○				
							203													
			3	SS	21											○				
							202									○				
			4	SS	40											○				
							201									○	7 31 39 23			
			5	SS	62															
200.8							200									○				
3.7	<b>SAND and SILT</b> (Glacial Till) clayey below 4.6m, trace gravel, brown to grey, dense to very dense		6	SS	65											○				
							199													
			7	SS	43											○	5 33 41 21			
199.3																				
5.2	<b>CLAYEY SILT</b> (Glacial Till) trace sand, grey, hard						199									○				
198.6			8	SS	30															
5.9	<b>END OF BOREHOLE</b>  Borehole dry upon completion.																			

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion  
 CLIENT: KMK Consultants  
 PROJECT LOCATION: REGION OF PEEL  
 DATUM ELEVATION: Geodetic  
 BOREHOLE LOCATION: See Drawing No. 1

DRILLING DATA  
 Method: Solid Stem Augering  
 Diameter: 110mm  
 Date: Jan. 21, 2004

REF. NO.: G-05.0701

ENCL NO.: 5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub>	W	W <sub>L</sub>		
206.0	Ground Surface													
0.0	<b>TOPSOIL and CLAYEY SILT</b>													
204.8			1	SS	10		205							
1.2	<b>CLAYEY SILT</b> some sand, brown/grey, hard		2	SS	30		204							
203.9														
2.1	<b>CLAYEY SILT to SILTY CLAY</b> (Glacial Till) some sand, trace gravel, brown, hard		3	SS	44		203							
202.8														
3.2	<b>SAND and SILT</b> (Glacial Till) some gravel and clay compact to very dense		4	SS	56		202							
			5	SS	60		201							
			6	SS	28		200							
			7	SS	31		199							
			8	SS	30		198							
			9	SS	21		197							
			10	SS	24		196							
			11	SS	27		195							
199.4														
6.6	<b>SILTY CLAY</b> (Glacial Till) trace sand and gravel, grey, very stiff to hard													

Continued Next Page

GRAPH  
NOTES+ 3, X 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

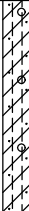




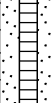
Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 21, 2004

REF. NO.: G-05.0701

ENCL NO.: 5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)		
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE										WATER CONTENT (%)	
194.0	<b>SILTY CLAY</b> (Glacial Till) trace sand and gravel, grey, very stiff to hard(continued)		12	SS	40		193										GR   SA   SI   CL		
192.3																			
13.7			<b>SAND and SILT</b> (Glacial Till) trace gravel and clay, cobbles between 13.7 and 15.0m, grey, very dense		13			SS	75/ 150mm		192								
	14	SS			65/ 50mm		191												
189.1							190												
16.9	<b>END OF BOREHOLE</b>		15	SS	60/ 50mm														
	DATE Jan. 22/04 Feb. 05/04 Mar. 10/04 Nov. 11/05 Dec. 05/05	WL. EL. 199.8m 199.9m 199.7m 200.0m 200.0m																	

GRAPH  
NOTES+ 3, X 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 21, 2004

REF. NO.: G-05.0701

ENCL NO.: 6

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub>	W	W <sub>L</sub>		
199.5	Ground Surface													
0.0	mixture of <b>TOPSOIL</b> and <b>CLAYEY SANDY SILT</b> brown		1	SS	7		199							
198.9														
0.6	<b>CLAYEY SILT</b> to <b>SILTY CLAY</b> trace of gravel, occasional oxidized lenses, brown, very stiff to hard		2	SS	20		198							
			3	SS	24									
			4	SS	40		197							5 30 45 20
196.5														
3.0	<b>CLAYEY SILT</b> to <b>SILTY CLAY</b> (Glacial Till) trace of gravel, some sand to sandy very stiff to hard		5	SS	58		196							7 27 42 24
			6	SS	36									
			7	SS	22		195							
							194							
193.4														
6.1	<b>SAND</b> and <b>SILT</b> (Glacial Till) trace of gravel, trace to some clay, grey, compact to very dense		8	SS	23		193							
							192							
			9	SS	38									
			10	SS	49		191							
			11	SS	50/ 150mm		190							6 42 39 13
			12	SS	88		189							7 45 40 8
							188							

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 21, 2004

REF. NO.: G-05.0701

ENCL NO.: 6

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)					W <sub>p</sub>	W	W <sub>L</sub>		
187.5								20	40	60	80	100					
12.0																	
186.9			13	SS	50/ 150mm		187						o				
12.6	END OF BOREHOLE																
	DATE WL. EL.																
	Jan. 22/04 192.9m																
	Feb. 05/04 198.5m																
	Mar. 10/04 198.6m																
	Dec. 05/05 198.6m																

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 22, 2004

REF. NO.: G-05.0701

ENCL NO.: 7

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) W <sub>P</sub> W W <sub>L</sub>				
194.6	Ground Surface															
0.0	<b>TOPSOIL</b> mixed with <b>SILTY CLAY</b> brown, soft		1	SS	4											
193.5																
1.1	<b>CLAYEY SILT</b> to <b>SILTY CLAY</b> trace to some gravel and sand, light brown, very stiff		2	SS	24											
192.2																
2.4	<b>SAND</b> and <b>SILT</b> (Glacial Till) trace to some clay, trace gravel, very dense		3	SS	50											
			4	SS	50											
190.0																
4.6	<b>CLAYEY SILT</b> (Glacial Till) sandy, trace gravel, grey, hard		5	SS	43											
			6	SS	32											
188.7																
5.9	<b>SILTY SAND</b> (Glacial Till) trace clay, grey, very dense		7	SS	75											
			8	SS	68											
186.7			9	SS	65/ 150mm											
7.9	<b>END OF BOREHOLE</b>															
	DATE Jan. 22/04 Feb. 05/04 Mar. 10/04 Dec. 06/05	WL. EL. 187.0m 193.0m 193.4m 191.1m														



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 22, 2004

REF. NO.: G-05.0701

ENCL NO.: 8

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
193.1	Ground Surface							20	40	60	80	100				
0.0	<b>SANDY CLAY</b> some topsoil and rootlets, brown, very stiff		1	SS	21		193							○		
192.0							192									
1.1	<b>SAND and SILT</b> (Glacial Till) trace to some clay and gravel, compact to very dense		2	SS	30									○		
			3	SS	33									○		6 39 38 17
			4	SS	55		190							○		
	light brown		5	SS	26		189							○		
	grey		6	SS	25									○		15 32 40 13
			7	SS	43		188							○		
			8	SS	62/150mm		187							○		11 44 38 7
186.1			9	SS	50/150mm									○		
7.0	END OF BOREHOLE															
	DATE	WL. EL.														
	Jan. 22/04	187.6m														
	Feb. 05/04	191.5m														
	Mar. 10/04	192.0m														
	Nov. 04/05	190.8m														
	Nov. 11/05	190.7m														
	Dec. 06/05	190.9m														

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity○  $\epsilon=3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 22, 2004

REF. NO.: G-05.0701

ENCL NO.: 9

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									WATER CONTENT (%)			GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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192.1	Ground Surface						192																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 28, 2004

REF. NO.: G-05.0701

ENCL NO.: 10

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
188.1	Ground Surface						20	40	60	80	100						
0.0	mixture of <b>CLAYEY SAND</b> and <b>TOPSOIL</b> brown, frozen		1	SS	26								○				
187.3													○				
0.8	<b>SILTY CLAY</b> some sand , brown, stiff		2	SS	14												
186.6																	
1.5	<b>SAND and SILT</b> (Glacial Till) some clay, trace gravel, cobbles and/or boulders below 5.3m dense to very dense		3	SS	30								○				
			4	SS	50								○			4 36 45 15	
			5	SS	47								○				
			6	SS	50/ 50mm								○			7 41 36 16	
			7	SS	50/ 25mm								○			10 35 (55)	
			8	SS	50/ 100mm								○				
			9	SS	56								○				
181.5																	
6.6	<b>END OF BOREHOLE</b>																
	DATE Jan. 28/04 Feb. 05/04 Mar. 10/04 Nov. 04/05 Nov. 11/05 Dec. 06/05	WL. EL. Dry 184.3m 186.8m 186.6m 186.5m 186.3m															

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 28, 2004

REF. NO.: G-05.0701

ENCL NO.: 11

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W <sub>P</sub> W W <sub>L</sub>				
188.3	Ground Surface							20	40	60	80	100				
0.0	mixture of <b>SILTY CLAY, SILTY SAND</b> and <b>TOPSOIL</b> brown, loose		1	SS	8		188									
187.4																
0.9	<b>CLAYEY SILT</b> (Glacial Till) sandy, trace gravel, brown, very stiff to hard		2	SS	20		187									
			3	SS	35											
			4	SS	47		186									
185.4							W. L. 185.6 m Dec 05, 2005									3 30 44 23
2.9	<b>SANDY SILT</b> to <b>SAND</b> and <b>SILT</b> (Glacial Till) trace gravel, trace to some clay, cobbles and/or boulders below 4.3m, very dense		5	SS	94/ 275mm		185									
			6	SS	50/ 25mm		184									6 32 42 20
	grey/brown  grey oxidized lenses		7	SS	50/ 25mm		183									
			8	SS	50/ 50mm		182									
181.7			9	SS	82											
6.6	<b>END OF BOREHOLE</b>															
	DATE WL. EL. Jan. 28/04 Dry Feb. 05/04 182.0m Mar. 10/04 185.6m Dec. 05/05 185.6m															

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 26, 2004

REF. NO.: G-05.0701

ENCL NO.: 12

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
186.0	Ground Surface							20	40	60	80	100				
0.0	mixture of <b>SANDY SILT</b> and <b>TOPSOIL</b> brown, frozen		1	SS	21											
185.1																
0.9	<b>SAND</b> and <b>SILT</b> some clay, trace of gravel, brown, very dense		2	SS	74											
183.6																
2.4	<b>SAND</b> and <b>SILT</b> (Glacial Till) trace gravel, trace to some clay, clayey in place, grey, very dense		3	SS	50/ 150mm											
			4	SS	50/ 125mm											
			5	SS	50/ 150mm											
			6	SS	78											
			7	SS	50/ 100mm											
			8	SS	50/ 100mm											
179.1	<b>END OF BOREHOLE</b>															
6.9	DATE Jan. 26/04 Feb. 05/04 Mar. 10/04 Dec. 06/05	WL. EL. Dry 184.4m 185.2m 184.4m														

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA



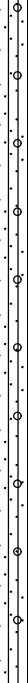

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 26, 2004

REF. NO.: G-05.0701

ENCL NO.: 13

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
184.9	Ground Surface							20	40	60	80	100				
0.0	<b>TOPSOIL</b> dark brown		1	SS	13		W. L. 184.6 m Dec 05, 2005									
184.4	<b>SAND and SILT</b> (Glacial Till) trace of gravel, some clay, very dense  <div>brown</div> <div>grey</div>		2	SS	50/ 150mm		184									
			3	SS	50/ 150mm		183									
			4	SS	50/ 150mm		182									
			5	SS	50/ 100mm		181									
			6	SS	50/ 200mm		180									
			7	SS	50/ 75mm											
179.0			<b>END OF BOREHOLE</b>		8		SS	100/ 150mm		179						
5.9	DATE Jan. 26/04 Feb. 05/04 Mar. 10/04 Nov. 11/05 Dec. 05/05	WL. EL. Dry 183.8m 184.6m 181.8m 184.6m														

GEO-CANADA SOIL LOG BH LOGS G-05.0701.GPJ GEO-CANADA TEMPLATE.GDT 1/23/09

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Jan. 28, 2004

REF. NO.: G-05.0701

ENCL NO.: 14

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
								20	40	60	80	100					
184.0	Ground Surface																
0.0	mixture of <b>TOPSOIL</b> and <b>SILTY CLAY</b> dark brown, frozen		1	SS	13												
183.1																	
0.9	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace of gravel, brown, very stiff		2	SS	26												
181.0																	
3.0	<b>SAND</b> and <b>SILT</b> (Glacial Till) trace gravel, some clay, very dense		3	SS	85/ 300mm												
			4	SS	72												7 35 42 16
			5	SS	50/ 150mm												
178.8																	
5.2	<b>SILTY SAND</b> (Glacial Till) trace gravel, some clay, grey, very dense		6	SS	50/ 150mm												8 51 27 14
177.8																	
6.2	<b>END OF BOREHOLE</b>  Borehole dry upon completion.		7	SS	50/ 100mm												

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 110mm

Date: Feb. 1, 2004

REF. NO.: G-05.0701

ENCL NO.: 15

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)										WATER CONTENT (%)		
								20	40	60	80	100						20	40	60
176.1	Ground Surface																			
0.0			1	SS	18		176													
			2	SS	66		175													
174.3			3	SS	50/ 100mm		174													
1.8			4	SS	50/ 100mm		173													
			5	SS	50/ 100mm		172													
			6	SS	50/ 100mm		171													
170.6			7	SS	50/ 100mm															
5.5	END OF BORHHOLE																			

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity○  $\epsilon=3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 24, 2005

REF. NO.: G-05.0701

ENCL NO.: 1

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)								WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
200.0	Ground Surface															
0.0	<b>TOPSOIL</b> brown, firm		1	SS	6											
199.4																
0.6	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, very stiff to hard		2	SS	18		199									
			3	SS	32		198								3 21 46 30	
			4	SS	44											
			5	SS	42											
196.0			6	SS	30		196								6 40 38 16	
4.0	<b>SAND AND SILT</b> (Glacial Till) trace to some clay and gravel, grey, compact to very dense															
			7	SS	19		195									
			8	SS	20		194									
			9	SS	60		193								13 43 37 7	
			10	SS	50		193									
			11	SS	29		192								13 41 41 5	
			12	SS	>50											
			13	SS	>50		191									
190.5																
9.4	<b>END OF BOREHOLE</b>  borehole dry upon completion  Date WL. El. Nov. 10/05 196.9m Nov. 11/05 196.9m Dec. 05/05 197.0m Jan. 06/06 197.0m Jan. 09/06 197.0m															

GRAPH  
NOTES+ 3, X 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 24, 2005

REF. NO.: G-05.0701

ENCL NO.: 2

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE				WATER CONTENT (%) W <sub>P</sub> W   W <sub>L</sub>				GR	SA	SI	CL
200.5	Ground Surface																		
0.0	<b>TOPSOIL</b> brown, stiff		1	SS	11														
199.9							200												
0.6	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, very stiff to hard		2	SS	30														
							199												
			3	SS	33														
							198												
			4	SS	65														
							197												
			5	SS	38														
196.7																			
3.8	<b>SAND AND SILT</b> (Glacial Till) trace to some clay, trace gravel, grey, compact to very dense		6	SS	27		196												
			7	SS	33														
							195												
			8	SS	23														
							194												
			9	SS	26														
							193												
			10	SS	16														
							192												
			11	SS	36														
							191												
			12	SS	77														
			13	SS	64														
			14	SS	70/														
190.0																			
10.4	<b>END OF BOREHOLE</b> borehole dry upon completion																		
	Date	WL. El. (m)																	
	Nov. 10/05	197.5m																	
	Nov. 11/05	197.4m																	
	Dec. 05/05	197.4m																	
	Jan. 06/06	197.5m																	
	Jan. 09/06	197.5m																	

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 24, 2005

REF. NO.: G-05.0701

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W <sub>P</sub>	W	W <sub>L</sub>		
202.9	Ground Surface							20 40 60 80 100						
0.0	<b>TOPSOIL</b> brown, soft		1	SS	4			20 40 60 80 100						
202.3	<b>SILTY CLAY TO CLAYEY SILT</b> (Glacial Till) trace to some sand trace gravel stiff to hard		2	SS	32		202							
0.6														
			3	SS	64		201							
			4	SS	19		200							
			5	SS	13		199							
			6	SS	10		198							
			7	SS	14		197							
			8	SS	8		196							
			9	SS	47		195							
			10	SS	50/ 75mm		194							
							193							
192.2	<b>SAND AND SILT</b> (Glacial Till) trace to some clay trace gravel grey dense to very dense						192							
10.7														
							191							

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 24, 2005

REF. NO.: G-05.0701

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
190.9							20	40	60	80	100						
12.0	<b>SAND AND SILT</b> (Glacial Till) trace to some clay trace gravel grey dense to very dense(continued) cobbles/boulders		11	SS	100								○	H			
			12	SS	50/ 150mm								○				
			13	SS	60/ 75mm								○				
	cobbles/boulders		14	SS	69/ 150mm								○				
187.8	<b>END OF BOREHOLE</b>																
15.1	Date WL. El. Nov. 10/05 197.6m Nov. 11/05 197.7m Dec. 05/05 198.7m Jan. 06/06 199.0m Jan. 09/06 199.0m																

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity○  $\epsilon=3\%$  Strain at Failure

PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Hollow Stem Auguring

Diameter: 200mm

Date: Nov. 10, 2005

REF. NO.: G-05.0701

ENCL NO.: 4

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  NATURAL MOISTURE CONTENT  LIQUID LIMIT    WATER CONTENT (%)	UNIT WEIGHT  $\gamma$  (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m										
204.0	Ground Surface		1	GRAB											
0.0	TOPSOIL														
203.5	SILTY CLAY TO CLAYEY SILT (Glacial Till) trace sand and gravel   dark brown ----- brown     ----- grey		2	GRAB											
0.5															
			4	GRAB											

Continued Next Page

GRAPH  
NOTES

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

○  $\epsilon = 3\%$  Strain at Failure



2 OF 3

REF. NO.: G-05.0701  
ENCL NO.: 4

GRAPH  
NOTES

○  $\epsilon = 3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA


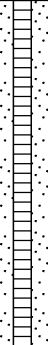


Method: Hollow Stem Auguring

Diameter: 200mm

Date: Nov. 10, 2005

REF. NO.: G-05.0701

ENCL NO.: 4

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)										
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)						
180.0							20	40	60	80	100							
24.0	<b>SAND</b> grey(continued)		17	GRAB			179											
			18	GRAB			178											
177.2																		
26.8	<b>GEORGIAN BAY FORMATION</b> grey, shale/limestone bedrock		19	GRAB			177											
176.6																		
27.4	<b>END OF BOREHOLE</b>																	
	Date WL. El. Nov. 11/05 199.3m Dec. 05/05 199.3m Jan. 06/06 199.3m Jan. 09/06 199.3m																	

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ 8=3% Strain at Failure





## 1 OF 2

REF. NO.: G-05.0701  
ENCL NO.: 5

[illegible]

GRAPH  
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○  $\epsilon = 3\%$  Strain at Failure

GEO-CANADA SOIL LOG BH LOGS G-05.0701.GPJ GEO-CANADA TEMPLATE.GDT 1/23/09



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 25, 2005

REF. NO.: G-05.0701

ENCL NO.: 5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
193.6							20	40	60	80	100						
193.4							20	40	60	80	100						
12.2	<b>SAND AND SILT</b> (Glacial Till) trace to some clay and gravel, very dense, grey		9	SS	84								○				
	cobbles/boulders		10	SS	71/ 150mm								○				
			11	SS	58								○			11 37 38 14	
			12	SS	70/ 150mm								○			15 41 39 5	
	cobbles/boulders		13	SS	100/ 125mm								○				
			14	SS	70/ 125mm								○				
	cobbles/boulders		15	SS	50/ 75mm								○				
			16	SS	90/ 225mm								○				
187.3	<b>END OF BOREHOLE</b>																
18.3	Date WL. El. Oct. 25/05 188.1m Nov. 11/05 200.0m Dec. 05/05 200.0m Jan. 06/06 200.0m Jan. 09/06 200.0m																

GEO-CANADA SOIL LOG BH LOGS G-05.0701.GPJ GEO-CANADA TEMPLATE.GDT 1/23/09

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 26, 2005

REF. NO.: G-05.0701

ENCL NO.: 6

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub>	W	W <sub>L</sub>		
203.5	Ground Surface													
0.0	<b>TOPSOIL</b> brown, stiff		1	SS	9		203							
202.9														
0.6	<b>FILL</b> silty clay to clayey silt trace to some sand, some gravel, brown to grey, hard													
202.0														
1.5	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel, stiff to hard,		2	SS	36		202							
							201							
			3	SS	53		200							
							199							
			4	SS	19									
							198							
			5	SS	24		197							
			6	SS	16		196							
							195							
			7	SS	20		194							
							193							
			8	SS	9									
192.2														
11.3			9	SS	81/ 200mm		192							

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 26, 2005

REF. NO.: G-05.0701

ENCL NO.: 6

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)												
20 40 60 80 100																				
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE																				
							WATER CONTENT (%)			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>P</sub> W W <sub>L</sub>										
191.5	<b>SAND AND SILT</b> (Glacial Till) some clay, trace gravel, grey, very dense(continued) cobbles/boulders		10	SS	81		191													
12.0			11	SS	91/ 275mm		190													
			12	SS	92/ 250mm		189													
			13	SS	78/ 225mm		188													
			14	SS	85		187													
			15	SS	90															
186.7																				
16.8			<b>END OF BOREHOLE</b>																	
	Date WL. El. Oct. 26/05 198.2m Nov. 11/05 199.5m Dec. 05/05 199.5m Jan. 06/06 199.4m Jan. 09/06 199.4m																			

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure

PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 26, 2005

REF. NO.: G-05.0701

ENCL NO.: 7

[illegible]

Continued Next Page

GRAPH  
NOTES

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

○  $\epsilon = 3\%$  Strain at Failure

GEO-CANADA SOIL LOG BH LOGS G-05.0701.GPJ GEO-CANADA TEMPLATE.GDT 1/23/09



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 26, 2005

REF. NO.: G-05.0701

ENCL NO.: 7

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$  (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
								20	40	60	80	100			○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
189.6	12.0	<b>SAND AND SILT</b> (Glacial Till) trace gravel and clay, occasional cobbles, grey, dense to very dense(continued)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ s=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 1

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 27, 2005

REF. NO.: G-05.0701

ENCL NO.: 8

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)					W <sub>p</sub>	W	W <sub>L</sub>		
188.0								20	40	60	80	100					
12.0	<b>SAND AND SILT</b> (Glacial Till) trace to some gravel and clay, grey, compact to very dense(continued)		11	SS	50/ 75mm		187										3 43 45 9
			12	SS	50/ 150mm												
			13	SS	50/ 100mm		186										
	sandy gravel till		14	SS	>50												57 23 20
185.0																	
14.9	<b>END OF BOREHOLE</b>																
	Date WL. El. Oct. 27/05 193.9m Nov. 11/05 199.4m Dec. 05/05 199.4m Jan. 06/06 199.3m Jan. 09/06 199.3m																

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ 8=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 27, 2005

REF. NO.: G-05.0701

ENCL NO.: 9

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub>	W	W <sub>L</sub>		
198.4	Ground Surface													
0.0	<b>TOPSOIL</b> brown, firm		1	SS	7		198							
197.9														
0.5	<b>FILL</b> clayey silt, trace to some gravel and sand, brown to grey, firm													
197.6														
0.8	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace to some gravel occasional cobbles, frequent oxidation stains, hard, brown with grey inclusions		2	SS	41		197							
			3	SS	34		196							
			4	SS	63		195							
			5	SS	50		194							
			6	SS	26		193							
			7	SS	22		192							
			8	SS	31		191							
			9	SS	24		190							
			10	SS	82/ 275mm		189							
			11	SS	91/ 250mm		188							
			12	SS	70		187							
			13	SS	91/ 275mm									
			14	SS	77									
			15	SS	96/ 275mm									
			16	SS	96/ 250mm									

Continued Next Page

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 27, 2005

REF. NO.: G-05.0701

ENCL NO.: 9

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)					W <sub>p</sub>	W	W <sub>L</sub>		
186.4								20	40	60	80	100					
12.0	SAND AND SILT (Glacial Till)		17	SS	50/ 125mm		186										
185.7																	
12.6	END OF BOREHOLE																
	Date WL. El.																
	Oct. 27/05 198.4m																
	Nov. 11/05 195.5m																
	Dec. 05/05 195.5m																
	Jan. 06/06 195.4m																
	Jan. 09/06 199.3m																

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ 8=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Hollow Stem Augering

Diameter: 150

Date: June 30, 2006

REF. NO.: G-05.0701

ENCL NO.: 22

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
190.0	Ground Surface						20	40	60	80	100						
0.0	<b>FILL</b> sandy silt trace to some gravel and clay, brown to grey, compact			SS	13												
				SS	10												
187.6																	
2.4	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace to some gravel brown, hard																
				SS	37												
186.0																	
4.0	<b>SAND AND SILT</b> (Glacial Till) trace gravel, some clay, grey, very dense			SS	57												
				SS	57												
				SS	>50												
183.7																	
6.3	<b>TILL/SHALE COMPLEX</b> Clayey Silt some sand, trace gravel and shale particles mixed with slabs of shale and limestone, grey, hard limestone layer almost continuous from 6.3 to 7.2m			SS	>50												
				SS	50/ 75mm												
181.6																	
8.4	<b>GEORGIAN BAY FORMATION</b> Shale interbedded with limestone and siltstone (inferred) grey			SS	50/ 25mm												
				SS	>50												
				SS	>50												

Continued Next Page

GRAPH  
NOTES+ 3, X 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 28, 2005

REF. NO.: G-05.0701

ENCL NO.: 10

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
195.5	Ground Surface							20	40	60	80	100				
0.0	<b>FILL</b> sandy silt trace to some gravel and clay, dark brown, loose		1	SS	7		195							○		
194.7	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, occasional oxidation stains, brown, very stiff to hard		2	SS	29		194							○	—	2 27 43 28
0.8			3	SS	31		193							○		
			4	SS	50/ 150mm		192							○		
			5	SS	40		191							○		
			6	SS	39		190							○		
191.1	<b>SAND AND SILT</b> (Glacial Till) trace gravel and clay, occasional cobbles grey compact to very dense		7	SS	38		189							○		
4.4			8	SS	23		188							○		
			9	SS	36		187							○		
			10	SS	42		186							○		
			11	SS	87/ 150mm		185							○		
			12	SS	50/ 100mm		184							○		8 39 45 8
			13	SS	50/ 75mm		183							○		
185.9	<b>END OF BOREHOLE</b>						182									
9.6	Date WL. El. Nov. 11/05 193.4m Dec. 05/05 193.5m Jan. 06/06 193.8m Jan. 09/06 193.6m															

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 31, 2005

REF. NO.: G-05.0701

ENCL NO.: 11

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)								
193.6	Ground Surface							20	40	60	80	100				
0.0	<b>TOPSOIL</b> sandy clayey silt brown, very stiff		1	SS	16		193							○		
192.6			2	SS	32		192							○		
0.9	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, hard, brown		3	SS	39		192							○		
			4	SS	65		191							○		
			5	SS	68		190							○		
189.7			6	SS	66		189							○		
3.8	<b>SAND AND SILT</b> (Glacial Till) trace gravel, some clay, grey, dense to very dense		7	SS	37		188							○		
			8	SS	53		187							○		
			9	SS	78/ 250mm		186							○		
			10	SS	91		185							○		
			11	SS	77/ 250mm		184							○		
			12	SS	88/ 100mm									○		
184.0			13	SS	97									○		
9.6	<b>END OF BOREHOLE</b>  borehole dry upon completion  Date WL. El. Nov. 04/05 187.1m Nov. 11/05 191.8m Dec. 06/05 191.6m Jan. 06/06 191.7m Jan. 09/06 191.5m															

GRAPH  
NOTES+ 3 , × 3 : Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA





Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 31, 2005

REF. NO.: G-05.0701

ENCL NO.: 12

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
192.6	Ground Surface							20	40	60	80	100				
0.0	<b>TOPSOIL</b> brown, stiff		1	SS	9											
192.0																
0.6	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, brown, very stiff to hard,		2	SS	19											
			3	SS	33											
			4	SS	36											
189.9																
2.7	<b>SAND AND SILT</b> (Glacial Till) some clay, trace gravel, grey, very dense  boulders/ cobbles		5	SS	83/ 250mm											
188.7			6	SS	70/ 150mm											
4.0	<b>SILTY SAND</b> (Glacial Till) trace clay, some gravel, grey, very dense  boulders/cobbles refusal to advancement augers borehole position moved 1.5m south  boulders/cobbles		7	SS	70/ 150mm											
			8	SS	74											
			9	SS	108/ 275mm											
			10	SS	70/ 150mm											
184.9																
7.8	<b>END OF BOREHOLE</b>		11	SS	80/ 150mm											
	Date Oct. 31/05 Nov. 04/05 Nov. 1105 Dec. 06/05 Jan. 06/06 Jan. 09/06	WL. El. 187.1m 189.8m 189.7m 190.1m 190.3m 190.2m														

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity○  $\epsilon=3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Oct. 31, 2005

REF. NO.: G-05.0701

ENCL NO.: 13

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)		
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20	40	60	80	100						20	40
188.3	Ground Surface																		
0.0	<b>FILL</b> crushed rock and sand, brown, very dense		1	SS	87														
187.6																			
0.8	<b>FILL</b> clayey silt trace sand and gravel, brown, hard		2	SS	46														
			3	SS	67														
186.0																			
2.3	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel, brown, hard		4	SS	41														
185.3																			
3.0	<b>SANDY SILT</b> (Glacial Till) some clay trace to some gravel, grey, very dense		5	SS	70/ 150mm														
			6	SS	60/ 150mm														
			7	SS	>50														
	boulders/cobbles																		
			8	SS	86/ 280mm														
	boulders/cobbles																		
			9	SS	>50														
	boulders/cobbles																		
181.5																			
6.9	<b>END OF BOREHOLE</b>																		
	Date	WL. El.																	
	Oct. 31/05	182.4m																	
	Nov. 04/05	187.5m																	
	Nov. 11/05	187.4m																	
	Dec. 06/05	187.4m																	
	Dec. 06/06	187.4m																	
	Dec. 09/06	187.3m																	

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



## 1 OF 1

REF. NO.: G-05.0701  
ENCL NO.: 14

**GRAPH NOTES** +3, ×3: Numbers refer to Sensitivity ○ 8=3% Strain at Failure





PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering/NQ Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 15

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
186.9	Ground Surface															
186.8	<b>TOPSOIL</b>															
0.2	brown, stiff <b>FILL</b> clayey silt, brown, stiff		1	SS	14											
186.0																
0.9	<b>CLAYEY SILT</b> (Glacial Till) some sand, trace gravel, grey, hard		2	SS	34											
185.4																
1.5	<b>GRAVELLY SANDY SILT</b> (Glacial Till) some clay, grey, very dense		3	SS	50											
			4	SS	84											
	boulders/ cobbles															
183.6																
3.4	<b>GEORGIAN BAY FORMATION</b> grey, highly to moderately weathered, shale/limestone bedrock		5	SS	79/ 150mm											
182.8			6	SS	60/ 150mm											
4.1	Refer to Rock Core Log															

GRAPH  
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 15

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE		TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES AND WEATHERING	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cc) E (GPa)
			NUMBER	SIZE											
182.8	Rock Surface														
182.8	<b>GEORGIAN BAY FORMATION:</b>  <b>SHALE</b> grey, thinly bedded, sub-horizontal bedding planes, fissile, medium strong to strong, occasional interbeds of limy shale/siltstone		1	NQ	72	67	0	0	13	Moderately weathered		53.7			
182.4			2	NQ	87	83	0	9.6	9	Moderately to slightly weathered					
180.8												81.6			
179.9			3	NQ	100	92	10	56	9	Slightly weathered to fresh. Hard layers: Depth (m) Approx. thickness (mm) 6.2 50 7.0 40		45.9			
7.0	<b>END OF BOREHOLE</b>  Date WL. El. Nov. 11/05 185.7m Dec. 05/05 185.7m Jan. 09/06 185.8m									Notes: * - indicates UCS of rock derived from Point Load Test. Taken as UCS = 24 x Is(50).					



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Nov. 2, 2005

REF. NO.: G-05.0701

ENCL NO.: 16

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									WATER CONTENT (%)
186.4	Ground Surface							20	40	60	80	100					
0.0	<b>TOPSOIL</b>																
186.1	brown, firm		1	SS	7		186							○			
0.3	<b>FILL</b>																
	clayey silt, trace sand and gravel, brown, firm to hard		2	SS	35									○			
184.9																	
1.5	<b>SANDY CLAYEY SILT</b> (Glacial Till) trace gravel, brown, hard		3	SS	45									○	┌───┐		6 23 42 29
			4	SS	39		184							○			
183.3																	
3.0	<b>SAND AND SILT</b> (Glacial Till) trace to some clay trace gravel, grey, dense to very dense		5	SS	41		183							○			2 37 42 19
	boulders/cobbles		6	SS	>50									○			
							182										
			7	SS	95									○			
			8	SS	80/ 152mm		181							○			
	boulders/cobbles																
			9	SS	117		180							○			10 39 42 9
			10	SS	65/ 76mm									○			
	boulders/cobbles						179										
178.5			11	SS	81/ 152mm									○			
7.9	<b>END OF BOREHOLE</b>																
	borehole dry upon completion																
	Date	WL. El.															
	Nov. 02/05	178.7m															
	Nov. 11/05	185.1m															
	Dec. 05/05	185.0m															
	Jan. 06/06	185.2m															
	Jan. 09/06	185.0m															

GRAPH  
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 17

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)	
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									WATER CONTENT (%)
185.8	Ground Surface							20	40	60	80	100					
0.0	<b>TOPSOIL</b> brown, very stiff		1	SS	16									○			
185.0																	
0.8	<b>FILL</b> clayey silt trace gravel, some sand, brown, very stiff to hard		2	SS	23									○			
			3	SS	58									○			
183.7																	
2.1	<b>CLAYEY SILT</b> (Glacial Till) trace gravel, brown, hard		4	SS	59									○			
182.9																	
2.9	<b>SAND AND SILT</b> (Glacial Till) trace clay and gravel grey, very dense		5	SS	52/ 125mm									○			
	boulders/ cobbles		6	SS	62									○			
			7	SS	60/ 150mm									○			
			8	SS	77/ 150mm									○			
	boulders/ cobbles		9	SS	50/ 50mm									○			5 51 35 9
	boulders/ cobbles		10	SS	50/ 75mm									○			
	boulders/ cobbles		11	SS	50/ 50mm									○	<b>H</b>		4 32 56 8
			12	SS	65/ 100mm									○			
176.5			13	SS	50/ 50mm									○			
9.3	<b>END OF BOREHOLE</b>																
	Date Nov. 01/05 Nov. 11/05 Dec. 05/05 Jan. 06/06 Jan. 09/06	WL. El. 177.6m 183.4m 184.3m 184.8m 184.6m															

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering

Diameter: 150mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 18

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W <sub>P</sub>	W	W <sub>L</sub>		
184.9	Ground Surface							20	40	60	80	100				
0.0	<b>TOPSOIL</b> dark brown, stiff		1	SS	15		184.6									
184.3							Dec 05, 2005									
0.6	<b>FILL</b> Clayey silt trace sand and gravel, brown, very stiff		2	SS	27		184									
183.5																
1.4	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel, very stiff		3	SS	29		183									
			4	SS	69		182									
			5	SS	58		181									
180.8																
4.1	<b>SILTY SAND</b> trace gravel, grey, very dense		6	SS	56/ 152mm		180									
180.2																
4.7	<b>CLAYEY SANDY SILT</b> (Residual Soil) thinly laminated, grey, hard															
179.3																
5.6	<b>GEORGIAN BAY FORMATION</b> shale/limestone bedrock		7	SS	39		179									
			8	SS	52		178									
			9	SS	87/ 279mm		177									
			10	SS	>50		176									
175.7																
9.2	<b>END OF BOREHOLE</b>		11	SS	>50											
	Date WL. El. Nov. 01/05 176.3m Nov. 03/05 182.0m Dec. 05/05 184.6m Jan. 09/06 184.6m															

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity○  $\epsilon=3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA







Method: Solid Stem Augering

Diameter: 150mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 19

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W <sub>P</sub> W W <sub>L</sub>	WATER CONTENT (%)			GR SA SI CL		
184.2	Ground Surface																		
0.0	<b>TOPSOIL</b> dark brown, stiff		1	SS	13		184							○					
183.7																			
0.5	<b>FILL</b> clayey silt, trace sand and gravel, brown, stiff		2	SS	11														
182.5																			
1.7	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel, brown, hard		3	SS	32									○					
181.7							182							○					
2.4	<b>SAND</b> trace to some silt brown to grey, very dense		4	SS	72									○				84 13 3	
181.0																			
3.2	<b>CLAYEY SILT</b> (Glacial Till) trace gravel, some sand, grey, hard		5	SS	41		181							○					
														○					
			6	SS	41		180							○					
			7	SS	38									○				1 14 51 34	
							179												
			8	SS	31									○					
							178							○					
			9	SS	52														
177.5																			
6.7	<b>SAND</b> trace to same gravel, grey, very dense		10	SS	71/ 150mm		177							○					
176.1			11	SS	81									○					
8.1	<b>END OF BOREHOLE</b>																		
	Date WL. El.																		
	Nov. 01/05 181.7m																		
	Nov. 03/05 179.7m																		
	Dec. 05/05 183.0m																		
	Jan. 09/06 182.9m																		

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering/NQ Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 20

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa) ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
183.6	Ground Surface															
0.0	<b>TOPSOIL</b> dark brown, stiff		1	SS	14											
183.0							183									
0.6	<b>FILL</b> clayey silt, trace sand and gravel, brown, stiff		2	SS	11											
182.2							W. L. 182.5 m Dec 05, 2005									
1.4	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel, brown, very stiff to hard		3	SS	24		182									
			4	SS	45		181									10 25 40 25
			5	SS	43		180									
179.6			6	SS	62/ 150mm		179									
4.0	<b>SANDY SILT</b> (Glacial Till) trace to some gravel and clay grey, very dense		7	SS	86		178									11 34 38 17
178.4																
5.2	<b>GEORGIAN BAY FORMATION</b> completely weathered to moderately weathered, shale with limestone/siltstone interbeds thinly laminated, grey, very dense		8	SS	50/ 50mm		178									
178.0																
5.6	Refer to Rock Core Log						177									
							176									
							175									
174.5																
9.1																

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 20

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE		TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES AND WEATHERING	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cc) E (GPa)
			NUMBER	SIZE											
178.0	Rock Surface														
175.6	<b>GEORGIAN BAY FORMATION:</b>  <b>SHALE</b> grey, thinly bedded, sub-horizontal bedding planes, fissile, weak to medium strong with occasional interbeds of fresh strong to very strong limestone/siltstone		1	NQ	76	74	10	37	>25	Moderately to slightly weathered. Hard layers: Depth (m)    Approx. thickness (mm) 6                60 6.1             30 6.6             50				185.5	2.61
176.6			2	NQ	95	92	13	0	5	Moderately to slightly weathered. Hard layers: Depth (m)    Approx. thickness (mm) 7.1             80 7.3             50 7.4             50 7.5             50 8.4             30			129.5		
175.1			3	NQ	92	92	25	92	4	Slightly weathered to fresh. Hard layers: Depth (m)    Approx. thickness (mm) 8.3             50			45.0	8.1(**)	2.55
174.5										8.7             100					1.34
9.1	<b>END OF BOREHOLE</b>  borehole dry upon completion  Date (2005)    WL. El. Nov. 03/05    dry Dec. 05/05    182.5m Jan. 09/06    182.7m									Notes: * - indicates UCS of rock derived from Point Load Test. Taken as UCS = 24 x Is(50). ** - indicates irregular failure during USC Test.					



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Solid Stem Augering/NQ Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 21

[illegible]

GRAPH  
NOTES

**+ 3, × 3:** Numbers refer to Sensitivity

○  $\epsilon = 3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Rock Coring

Diameter: 150mm/47mm

Date: Nov. 1, 2005

REF. NO.: G-05.0701

ENCL NO.: 21

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE		TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES AND WEATHERING	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cc) E (GPa)
			NUMBER	SIZE											
177.9	Rock Surface														
174.9	<b>GEORGIAN BAY FORMATION:</b>  SHALE grey, thinly bedded, sub-horizontal bedding planes, fissile, weak to medium strong, with occasional fresh, strong to very strong interbeds of limestone/siltstone		1	NQ	63	38	10	13	>25	Moderately to slightly weathered. Hard layers: Depth (m)    Approx. thickness (mm) 5.5            100 5.8            50				143.3	2.63
176.4			2	NQ	67	57	13	32	>25	Moderately to slightly weathered. Hard layers: Depth (m)    Approx. thickness (mm) 6.5            100 6.9            100		55.4		187.4	2.63
6.4												33.4	24.3		34.07
174.9	<b>END OF BOREHOLE</b>  borehole dry upon completion  Date                      WL. El. Nov. 03/05              dry Dec. 05/05              178.6m Jan. 09/06              179.0m									Notes: * - indicates UCS of rock derived from Point Load Test. Taken as UCS = 24 x Is(50).					
7.9															



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Hollow Stem Augering

Diameter: 150

Date: June 30, 2006

REF. NO.: G-05.0701

ENCL NO.: 22

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							WATER CONTENT (%)		
								20 40 60 80 100							10 20 30		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							w <sub>p</sub> w w <sub>L</sub>		
190.0	Ground Surface																
0.0	<b>FILL</b> sandy silt trace to some gravel and clay, brown to grey, compact			SS	13												
							189										
				SS	10												
							188										
187.6	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace to some gravel brown, hard																
2.4				SS	37												
							187										
186.0	<b>SAND AND SILT</b> (Glacial Till) trace gravel, some clay, grey, very dense						186										
4.0				SS	57												
							185										
				SS	57												
183.7	<b>TILL/SHALE COMPLEX</b> Clayey Silt some sand, trace gravel and shale particles mixed with slabs of shale and limestone, grey, hard limestone layer almost continuous from 6.3 to 7.2m			SS	>50		184										
6.3																	
				SS	>50		183										
				SS	50/ 75mm		182										
181.6	<b>GEORGIAN BAY FORMATION</b> Shale interbedded with limestone and siltstone (inferred) grey			SS	50/ 25mm												
8.4							181										
				SS	>50												
							180										
				SS	>50												
							179										
	less weathered																

Continued Next Page

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 2

## DRILLING DATA

Method: Hollow Stem Augering

Diameter: 150

Date: June 30, 2006

REF. NO.: G-05.0701

ENCL NO.: 22

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE															
178.0								20	40	60	80	100		10	20	30							
172.0								20	40	60	80	100											
12.2	END OF BOREHOLE borehole dry upon completion																						

PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

#### Method: Hollow Stem Augering

Diameter: 200mm/63mm

Date: Sept. 14, 2006

REF. NO.: G-05.0701

ENCL NO.: 23

[illegible]

GEO-CANADA SOIL LOG BH LOGS G-05.0701.GPJ GEO-CANADA TEMPLATE.GDT 1/23/09

GRAPH  
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○  $\epsilon = 3\%$  Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Rock Coring

Diameter: 200mm/63mm

Date: Sept. 14, 2006

REF. NO.: G-05.0701

ENCL NO.: 23

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE		TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES AND WEATHERING	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cc) E (GPa)
			NUMBER	SIZE											
183.8	Rock Surface														
184.8	<b>GEORGIAN BAY FORMATION:</b>  <b>SHALE</b> grey, thinly bedded, sub-horizontal bedding planes, fissile, weak to strong, interbeds of strong to very strong limestone/siltstone		1	HQ	100	70	40	0	5	Moderately to slightly weathered Hard layers: 50mm thick at 4.4m & 4.5m depth Hard layers: 280mm thick at 4.8m depth; 175mm thick at 5.2m depth		163			
183.8			2	HQ	93	67	64	57	6			64		112.0	2.70
183.8									3						
182.8			3	HQ	83	67	38	37	5	Hard layers: 115mm at 5.5m depth					
5.3			4	HQ	100	88	0	0	5			11.2			
182.5									6	Weak layers: Depth (m)    Approx. thickness (mm) 6.3            75 6.6            75 6.9            50					
182.5									6						
182.5									5						
5.8			5	HQ	72	53	0	0	5			38.7			
									5						
181.0									5	Hard layers: 50mm thick at 7.9m depth Weak layers: Depth (m)    Approx. thickness (mm) 7.2            50 7.4            50 7.8            75 8.0            50					
7.1			6	HQ	88	84	4	18	5			8.7			
									3						
179.7									3			16.2			
8.4	<b>END OF BOREHOLE</b>								7			124.8			
									8.1	100					



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

PROJECT LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Hollow Stem Augering

Diameter: 200mm/47mm

Date: Sept. 15, 2006

REF. NO.: G-05.0701

ENCL NO.: 24

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	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 AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									
183.6	Ground Surface							20	40	60	80	100					
0.0	<b>TOPSOIL</b> brown, very stiff		1	SS	16		183										
183.0																	
0.6	<b>FILL</b> clayey silt, some sand and gravel, brown to grey, very stiff		2	SS	22												
182.2																	
1.4	<b>CLAYEY SANDY SILT</b> (Glacial Till) trace gravel brown, very stiff to hard		3	SS	22		182										
			4	SS	35		181										6 30 40 24
180.7																	
2.9	<b>SANDY SILT</b> (Glacial Till) trace to some gravel, some clay, dense to very dense		5	SS	54/ 75mm		180										
			6	SS	>50												
	brown		7	CORE			179										10 41 35 14
	grey boulders/cobbles		8	CORE													
	gravelly																
178.1							178										
178.6	<b>GEORGIAN BAY FORMATION</b>		9	SS	>50												
5.6	Refer to Rock Core Log						177										
							176										
							175										
174.5																	
9.1																	

GRAPH  
NOTES+ 3, × 3: Numbers refer  
to Sensitivity

○ s=3% Strain at Failure



PROJECT: Sanitary Sewer Diversion

CLIENT: KMK Consultants

LOCATION: REGION OF PEEL

DATUM ELEVATION: Geodetic

BOREHOLE LOCATION: See Drawing No. 3

## DRILLING DATA

Method: Rock Coring

Diameter: 200mm/47mm

Date: Sept. 15, 2006

REF. NO.: G-05.0701

ENCL NO.: 24

(m) ELEV DEPTH	ROCK DESCRIPTION	GROUND WATER CONDITIONS	CORE SAMPLE		TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES AND WEATHERING	HYDRAULIC CONDUCTIVITY (cm/sec)	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MPa)*	UNIAXIAL COMPRESSION (MPa)	DENSITY (g/cc) E (GPa)
			NUMBER	SIZE											
178.0	Rock Surface														
175.6	<b>GEORGIAN BAY FORMATION:</b>  <b>SHALE</b> grey, thinly bedded, sub-horizontal bedding planes, fissile, medium strong to strong, occasional interbeds of limestone/siltstone		1	NQ	83	69	3	0	5	Moderately to slightly weathered Hard layers: 50mm thick at 5.9m depth Weak layers: 50mm thick at 5.7m depth; 50mm thick at 6.3m depth Hard layers: Depth (m)    Approx. thickness (mm) 6.5            50 7.0            25 Weak layers: Depth (m)    Approx. thickness (mm) 7.8            100					
177.2 6.4									7						
									7						
			2	NQ	92	85	5	20	8						
									5						
									5						
									5						
									8						
									6						
175.6 8.0			3	NQ	100	96	0	15	7						
									7						
									7						
	4														
174.5 9.1	END OF BOREHOLE														



# LOG OF BOREHOLE 01-14

CLIENT : KMK Consultant  
PROJECT : Etobicoke Creek Trunk Sewer (S.13)  
LOCATION : Brampton, Mississauga  
DATUM ELEVATION : Geodetic

DRILLING DATA  
Method : Solid Stem Augering  
Diameter : 110 mm  
Date : Feb. 1, 2001

REF. NO. : G-20.1201  
ENCL. NO. : 14

(m) ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRATA PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	BLOWS 0.3 M			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
176.1	Ground Surface																
0.0	~200mm TOPSOIL over SILTY SAND trace of organics, trace of gravel dark brown, damp compact		1	SS	18		176										1 64 35
175.2							W.L. 175.3 m 01/02/01										
0.9	SILTY SAND (Glacial Till) gravelly, trace of clay grey very dense		2	SS	66												
174.3			3	SS	50/100mm												22 36 30 12
1.8	GEORGIAN BAY FORMATION shale interbedded with limestone layers (inferred)  Approx depths at which 'hard' augering was encountered (inferred strong to very strong layers) 1.83 - 1.92m 2.13 - 2.22m 2.43 - 2.53m 3.08 - 3.17m 3.35 - 3.47m 4.27 - 4.36m 4.63 - 4.72m		2	SS	50/50mm		174										
			5	SS	50/50mm												
			6	SS	50/50mm		172										
			7	SS	50/50mm												
170.6																	
5.5	END OF BOREHOLE																



## **APPENDIX B**

**GRAIN SIZE DISTRIBUTION CURVES (FIGURES 2005-1 – 2005-7)**

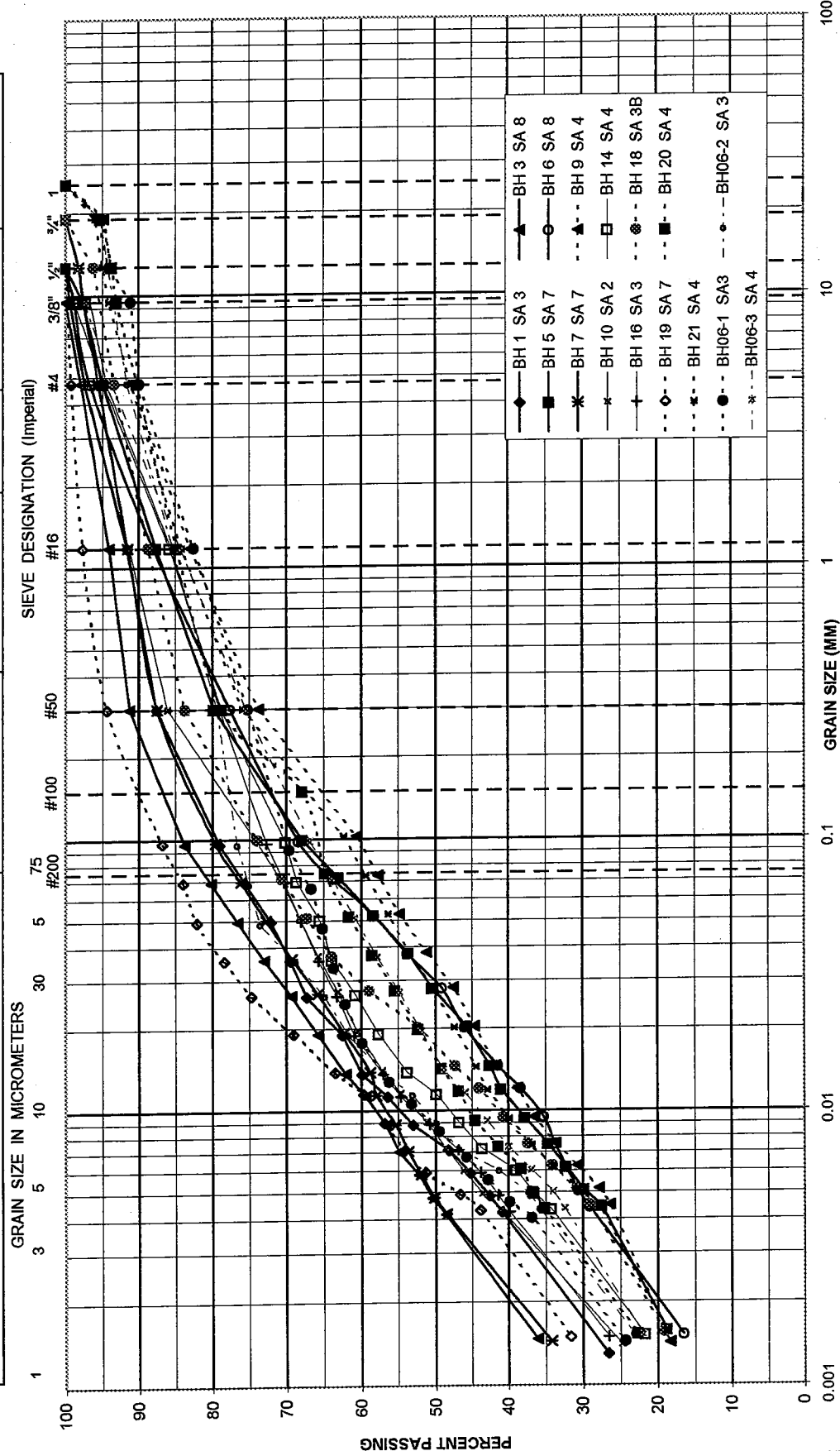
**GRAIN SIZE DISTRIBUTION CURVES (FIGURES 2004-1 – 2004-7)**

**PLASTICITY CHART (FIGURES 2005-8 – 2005-9)**

**PLASTICITY CHART (FIGURE 2004-8)**

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION  
Cohesive Native Soils (Silty Clay Till to Clayey Sandy Silt Till)

GEO - CANADA

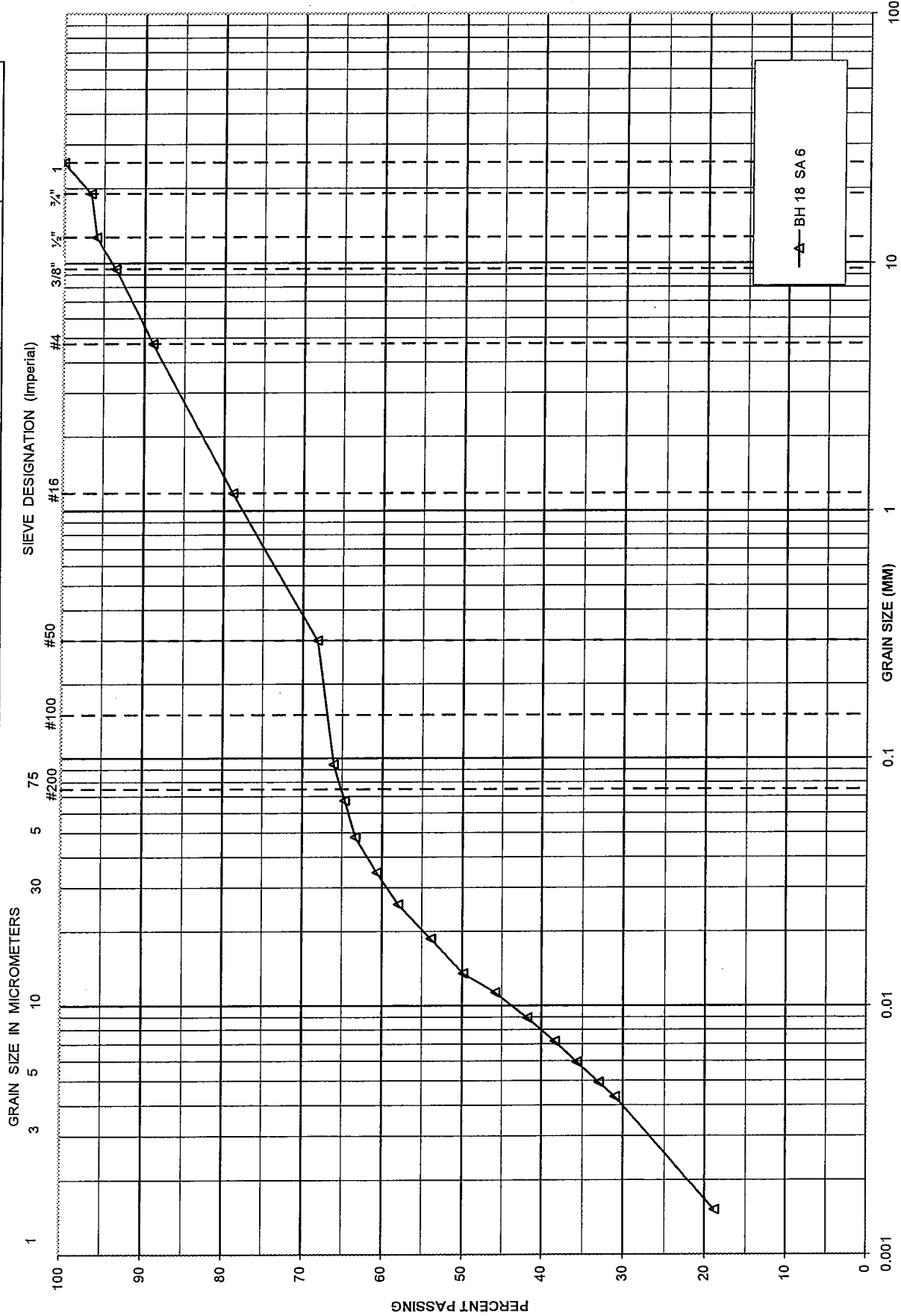
FIGURE No. 2005-1

REF. No. G-050701

DATE SEPT. 2006

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

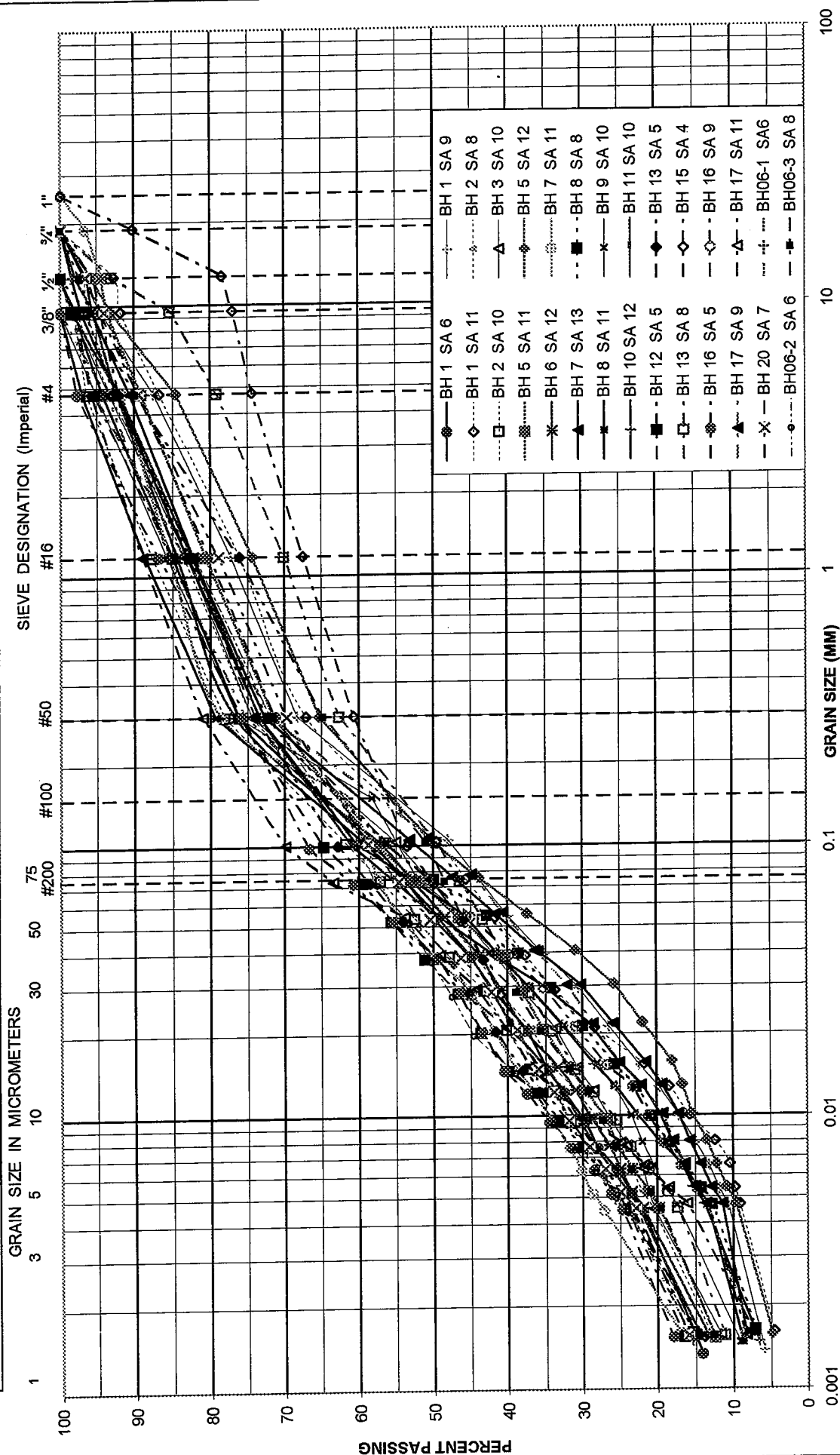


GRAIN SIZE DISTRIBUTION  
Residual Soils (Clayey Sandy Silt)

GEO - CANADA

FIGURE No. 2005-2  
REF. No. G-050701  
DATE DECEMBER 2005

# UNIFIED SOIL CLASSIFICATION SYSTEM

[illegible]

**GEO - CANADA**

GRAIN SIZE DISTRIBUTION

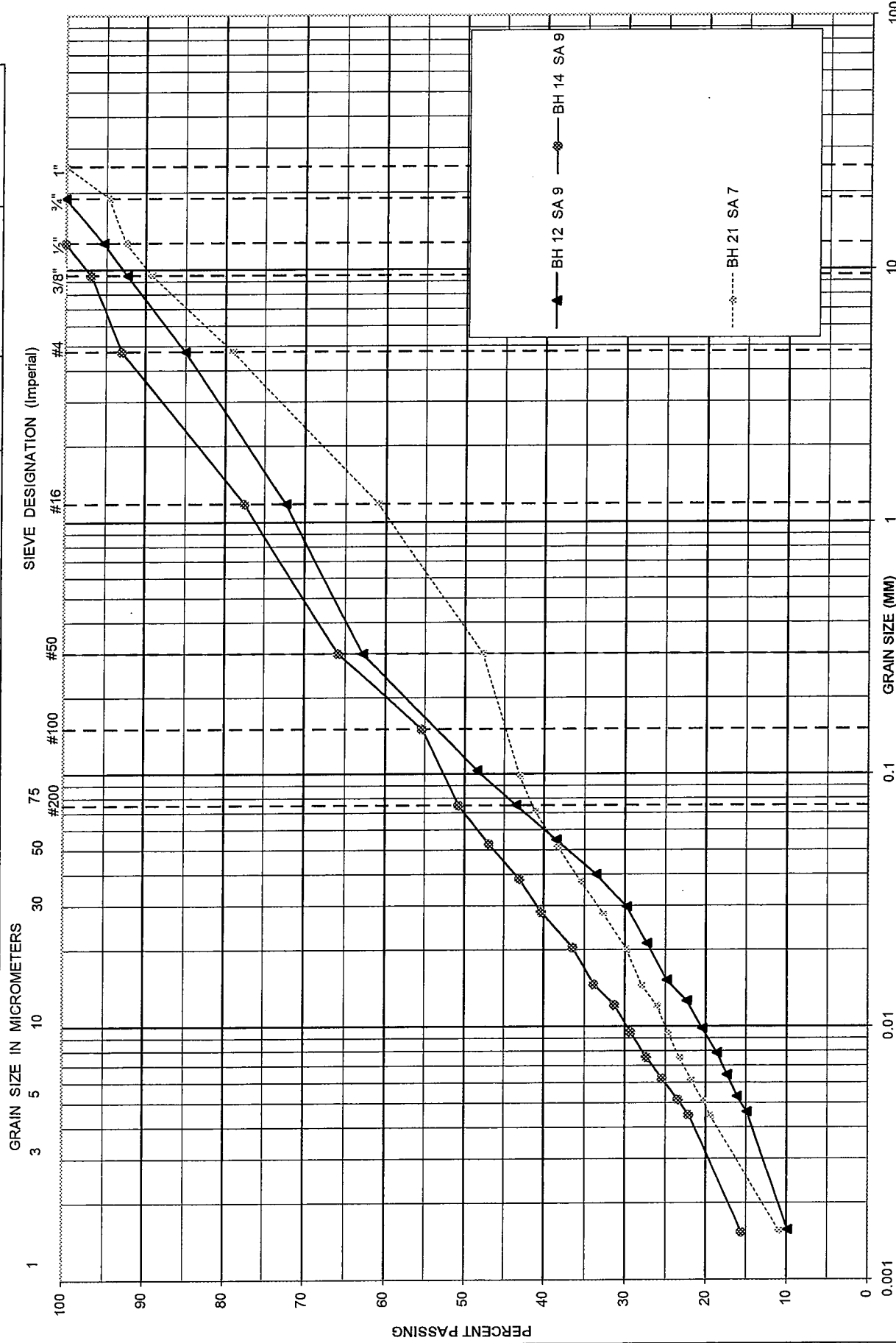
FIGURE No. 2005-3

REF. No.	G-050701
----------	----------

DATE SEPT. 2006

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



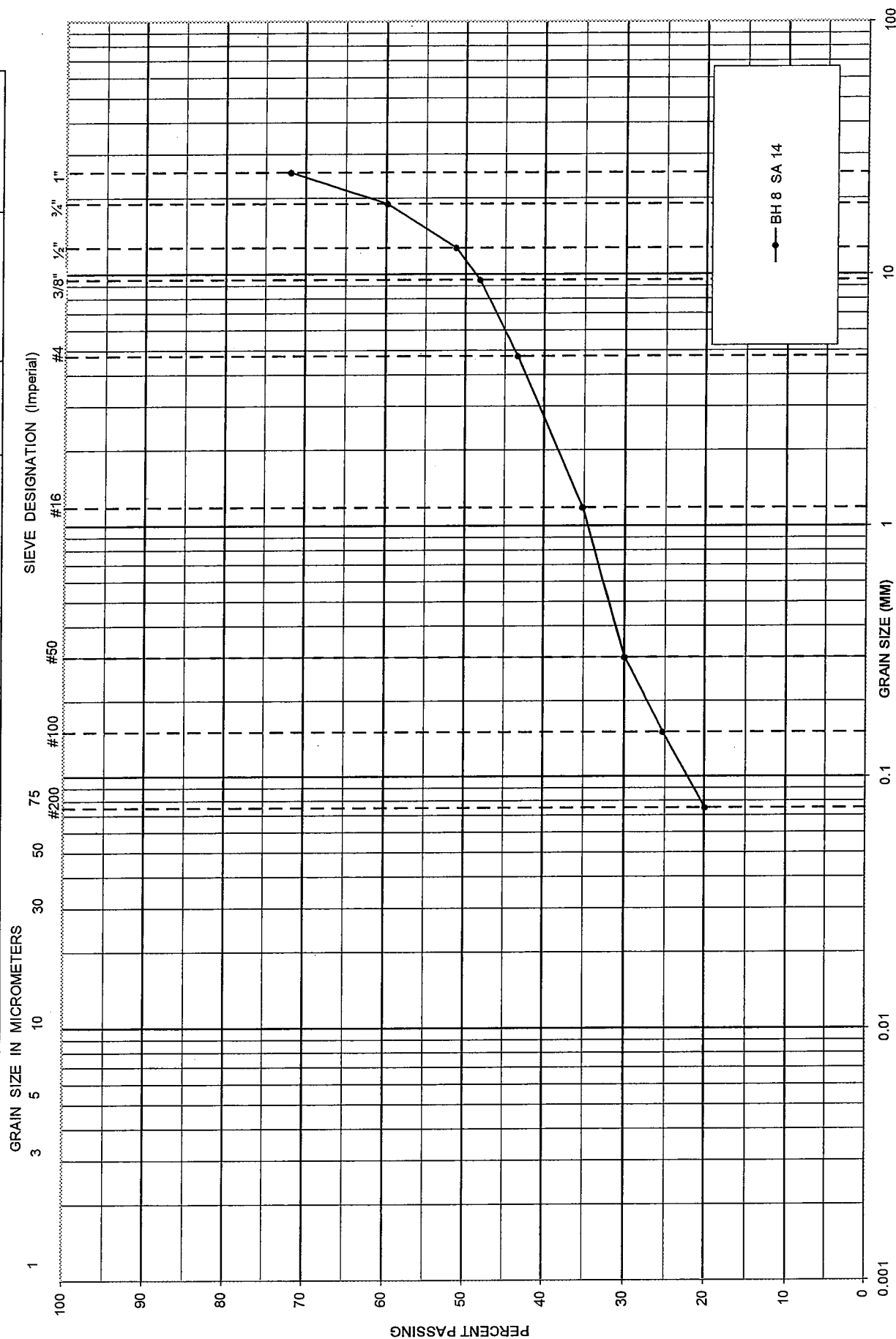
GEO - CANADA

GRAIN SIZE DISTRIBUTION  
Non-Cohesive Native Soils (Silty Sand Till)

FIGURE No. 2005-4  
REF. No. G-050701  
DATE DECEMBER 2005

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



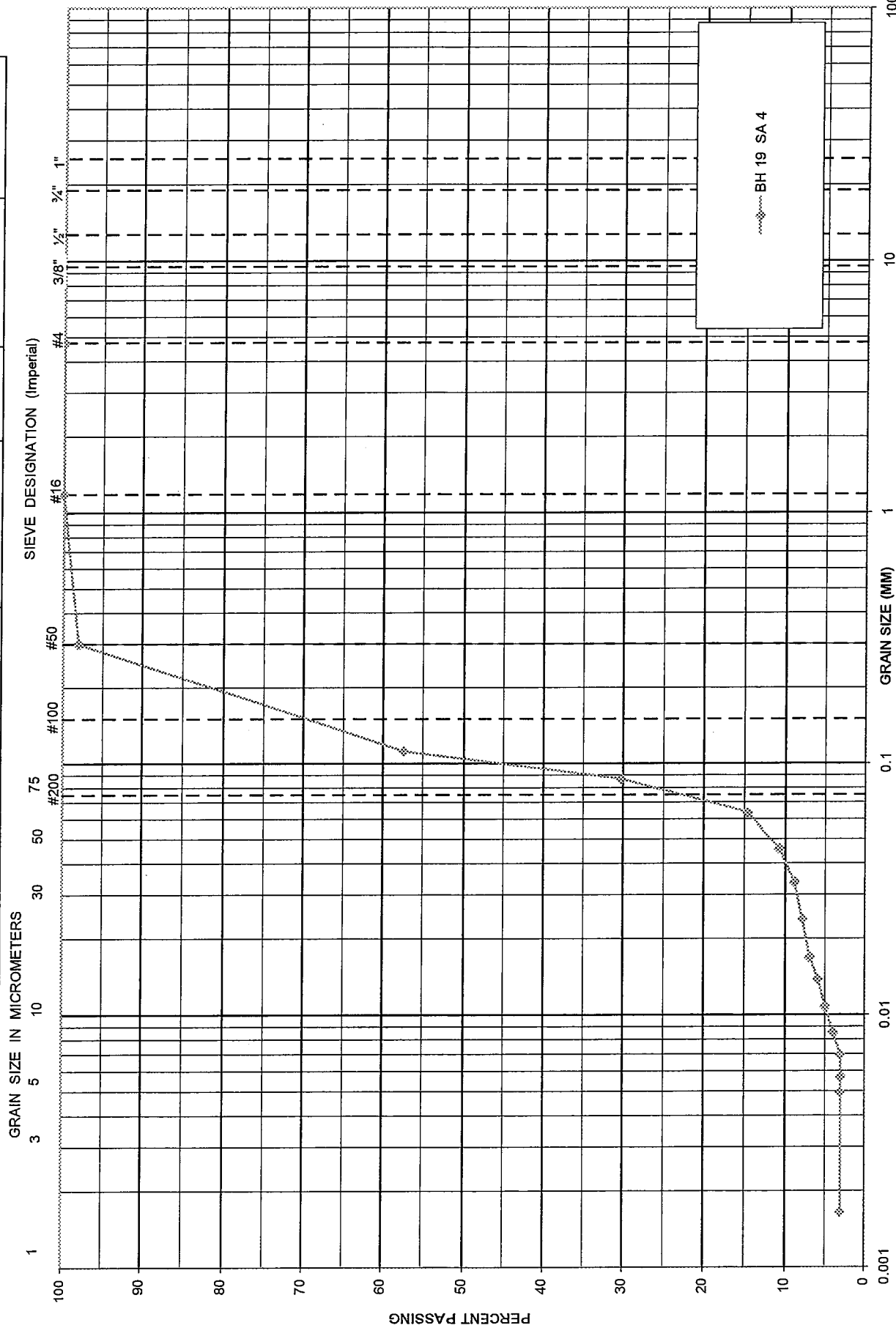
### GRAIN SIZE DISTRIBUTION

Non-Cohesive native Soils ( Sandy Gravel Till)

FIGURE No.	2005-5
REF. No.	G-050701
DATE	DECEMBER, 2005

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	



GEO - CANADA

GRAIN SIZE DISTRIBUTION  
Non-Cohesive native Soils (Sand)

FIGURE No. 2005-6

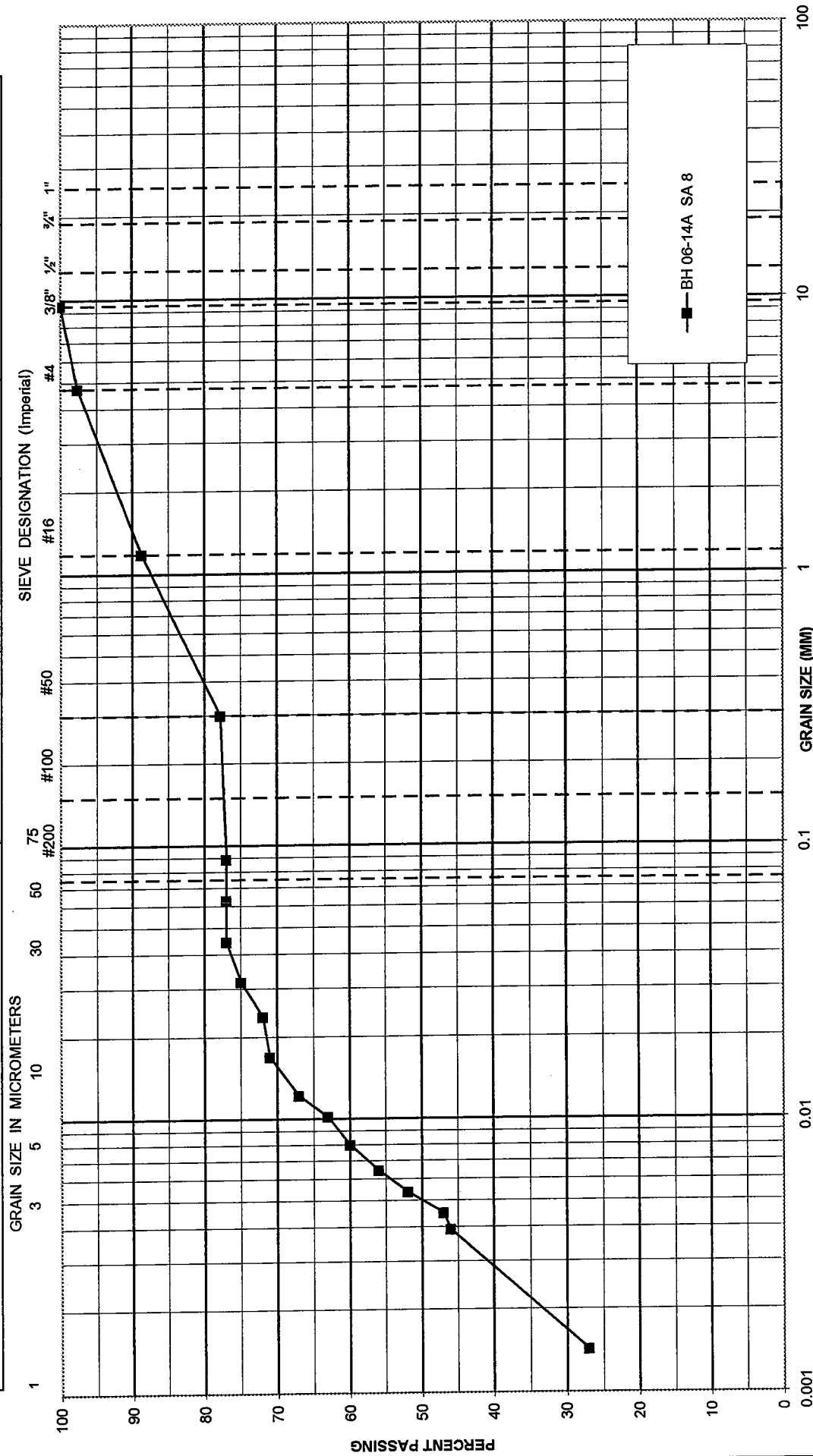
REF. No. G-050701

DATE DECEMBER 2005



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION  
Till/Shale Complex

GEO - CANADA

FIGURE No. 2005-7  
REF. No. G-050701  
DATE JULY, 2006

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND				GRAVEL		
		Fine	Medium	Coarse		Fine	Coarse	

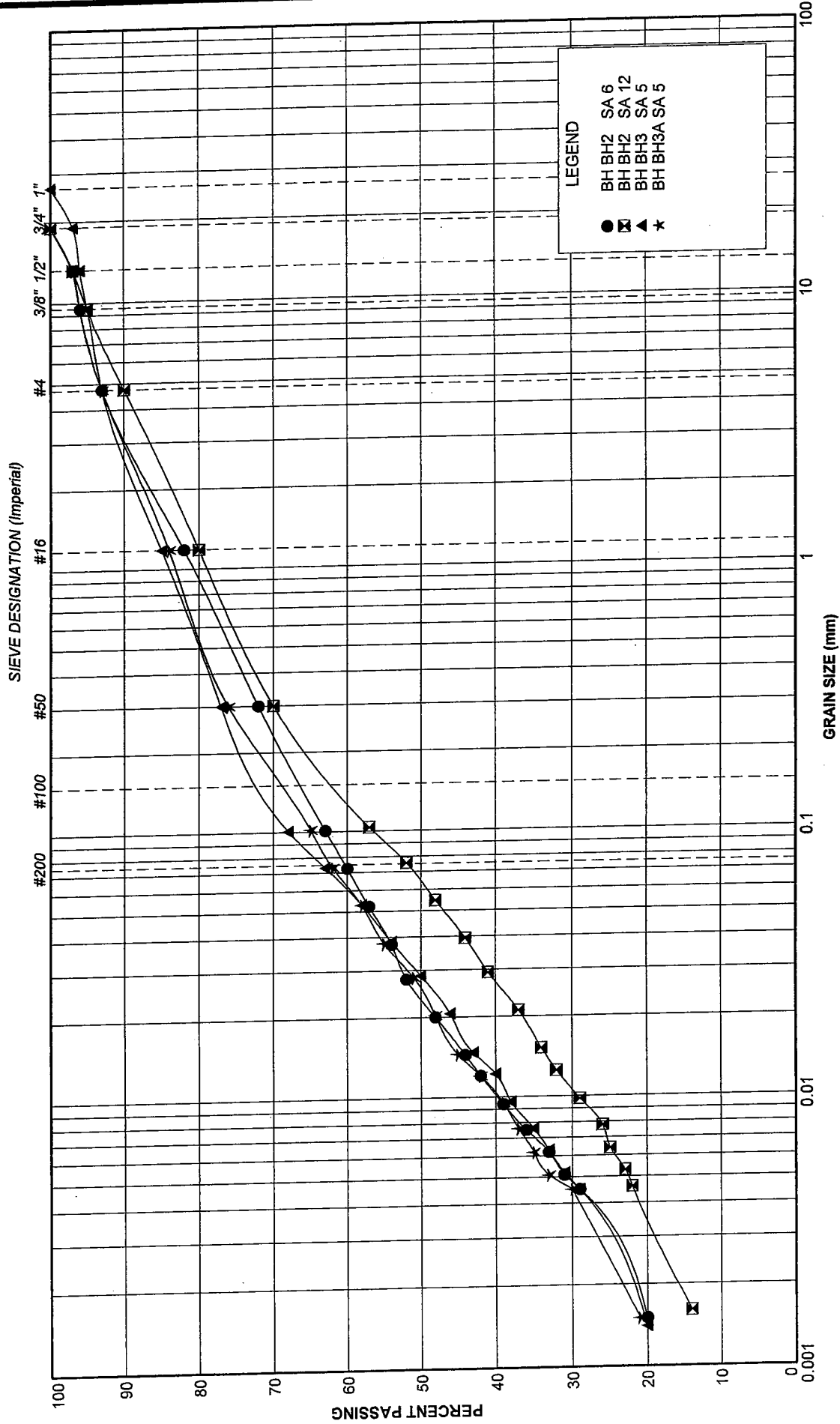


FIGURE NO. 2004- 1

JOB NO. G-03.1101

DATE Feb. 2004

GRAIN SIZE DISTRIBUTION  
Cohesive Native Soils

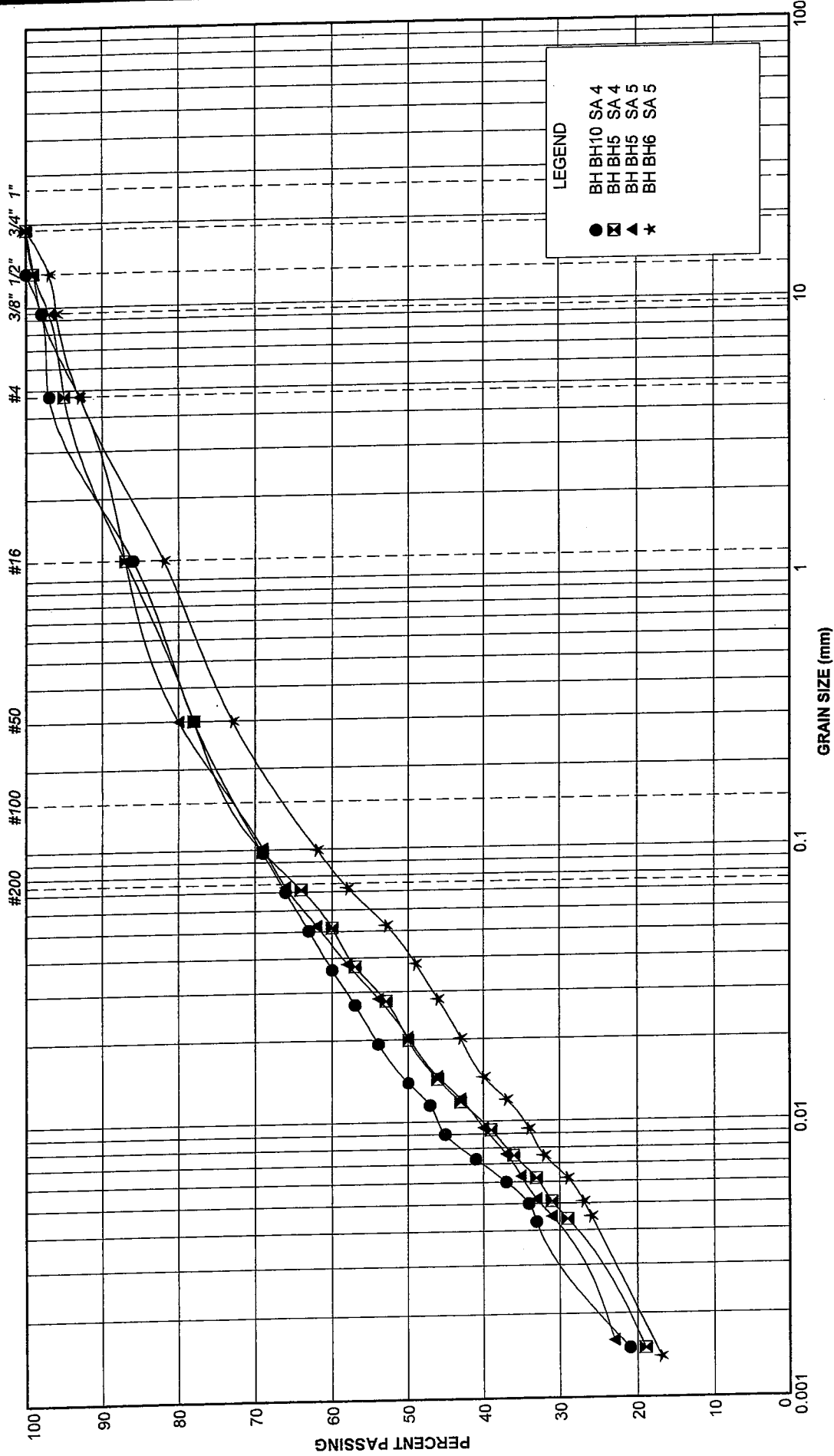
GEO-CANADA



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

SIEVE DESIGNATION (Imperial)



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

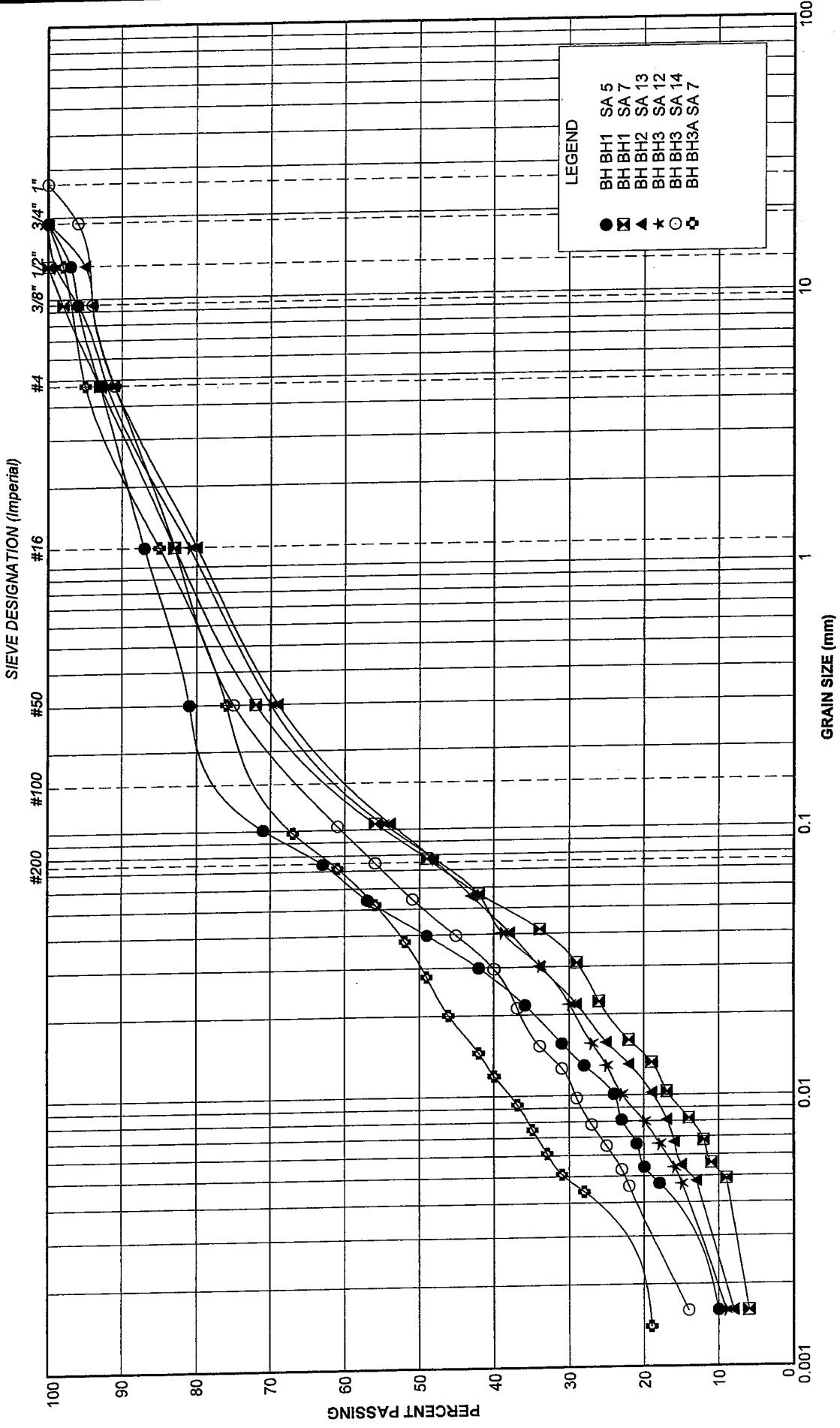


FIGURE NO.2004- 3

GRAIN SIZE DISTRIBUTION  
Non-Cohesive Native Soils (Sandy Silt and Sand and Silt Textured)

GEO-CANADA



JOB NO. G-03.1101  
DATE Feb. 2004

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL		
	Fine	Medium	Coarse	Fine	Coarse	

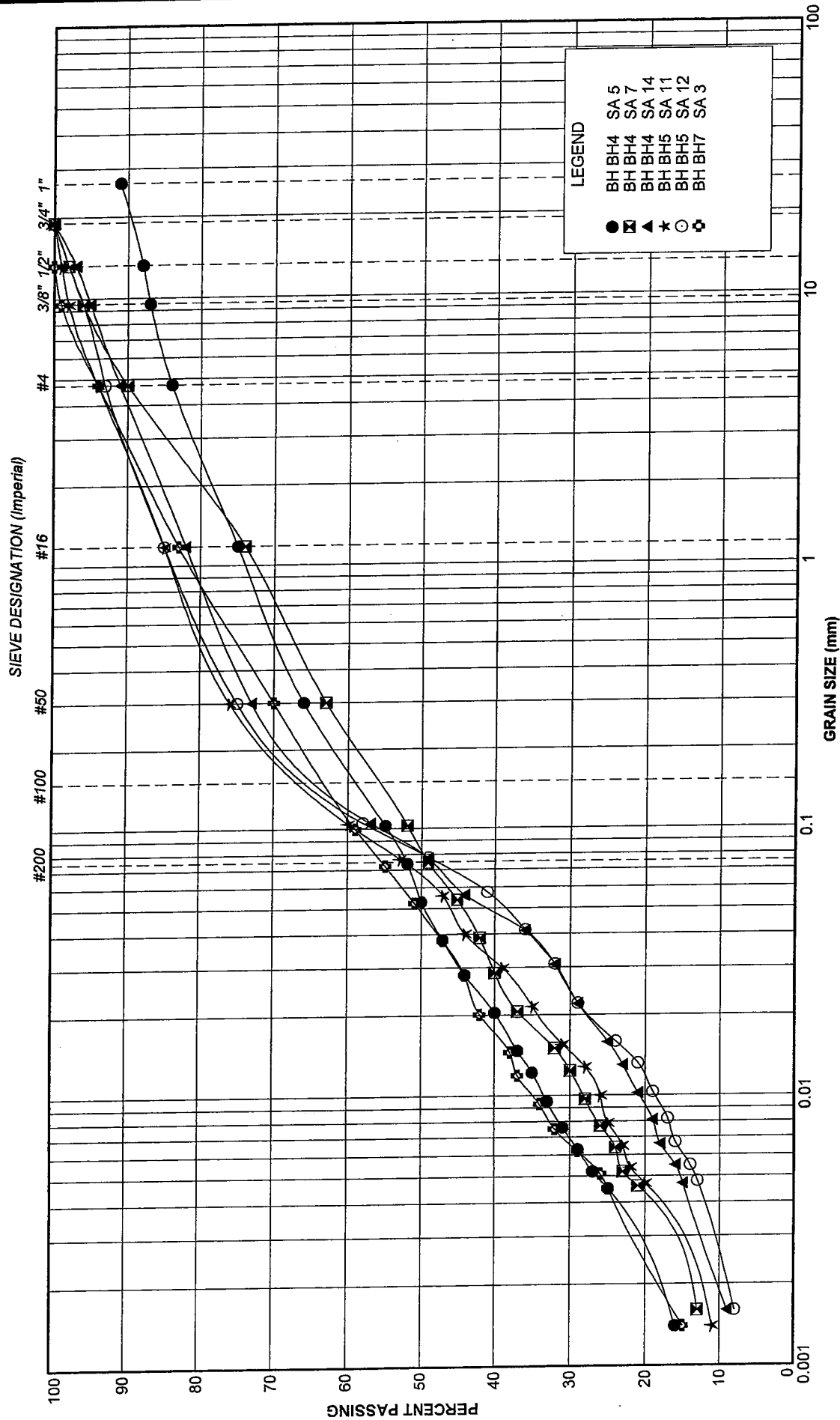


FIGURE NO. 2004-4

JOB NO. G-03.1101

DATE Feb. 2004

## GRAIN SIZE DISTRIBUTION

Non-Cohesive Native Soils (Sandy Silt and Sand and Silt Textured)

**GEO-CANADA**

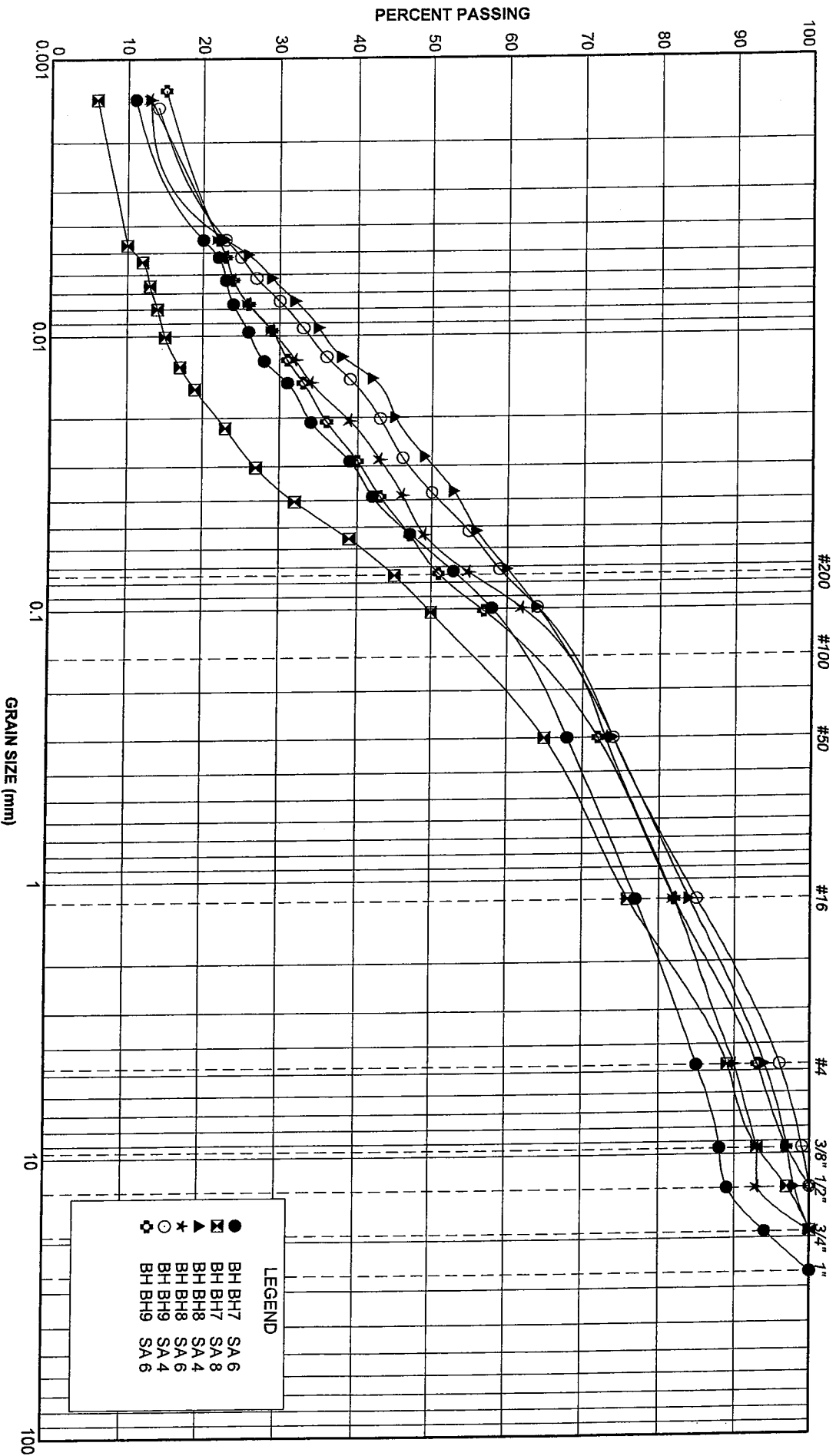


CLAY AND SILT

UNIFIED SOIL CLASSIFICATION SYSTEM

SAND			GRAVEL		
Fine	Medium	Coarse	Fine	Coarse	

SIEVE DESIGNATION (Imperial)



GEO-CANADA

GRAIN SIZE DISTRIBUTION

Non-Cohesive Native Soils (Sandy Silt and Sand and Silt Textured)

FIGURE NO. 2004-5

JOB NO. G-03.1101

DATE Feb. 2004

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

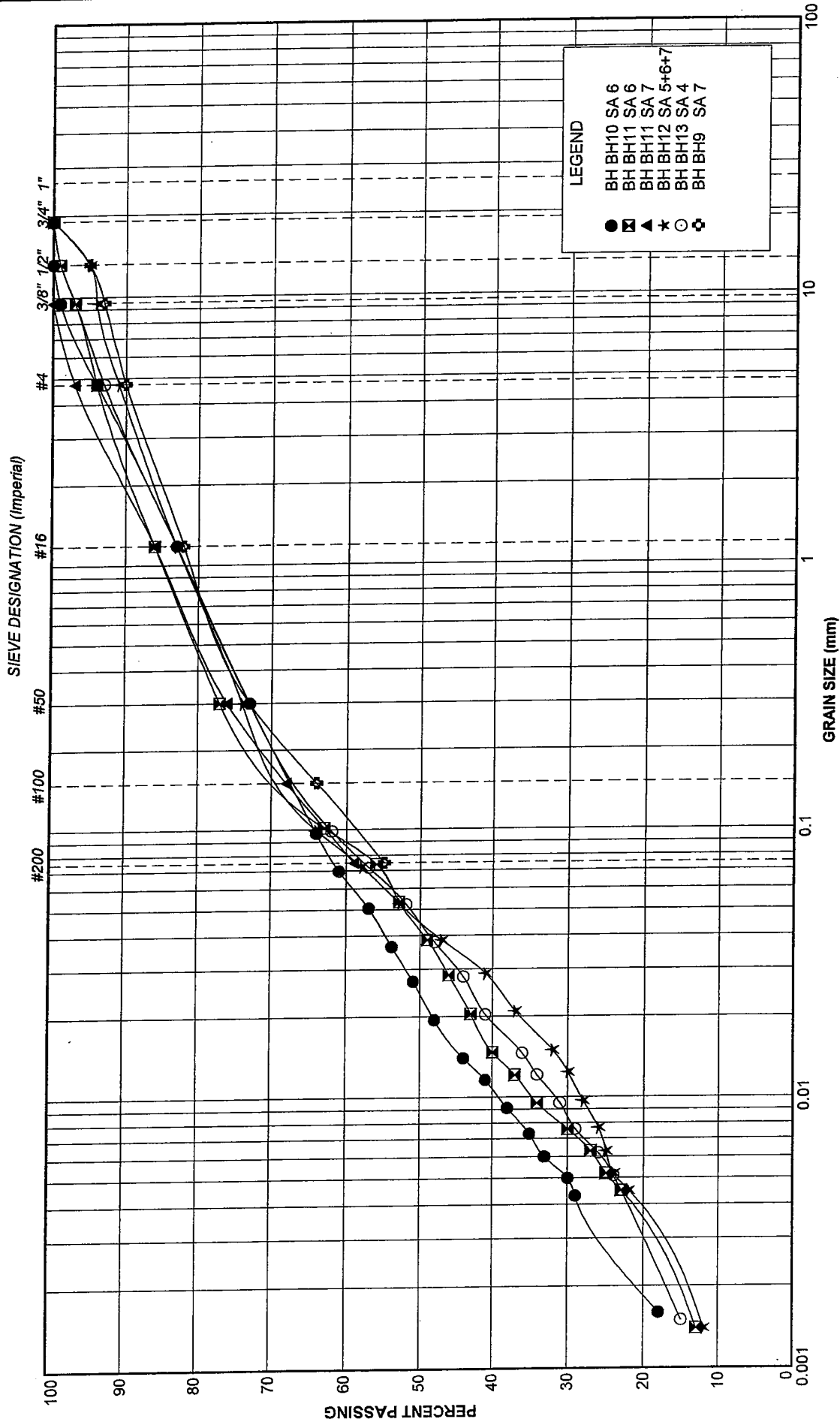


FIGURE NO. 2004-6

JOB NO. G-03.1101

DATE Feb. 2004

## GRAIN SIZE DISTRIBUTION

Non-Cohesive Native Soils (Sandy Silt and Sand and Silt Textured)

**GEO-CANADA**



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT

SAND

GRAVEL

Fine

Coarse

Fine

Medium

Coarse

SIEVE DESIGNATION (Imperial)

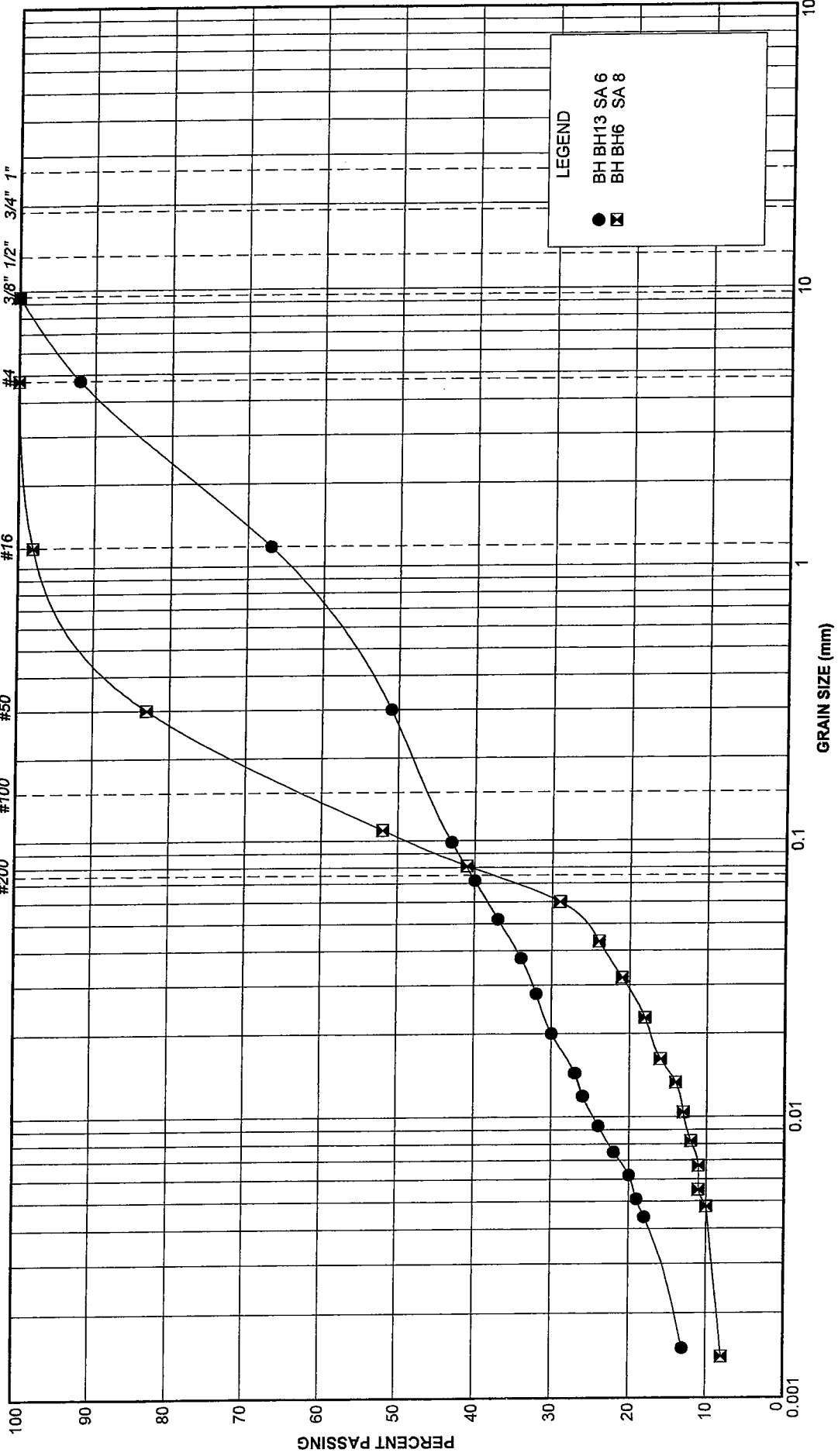
#4 3/8" 1/2" 3/4" 1"

#16

#50

#100

#200



**GEO-CANADA**

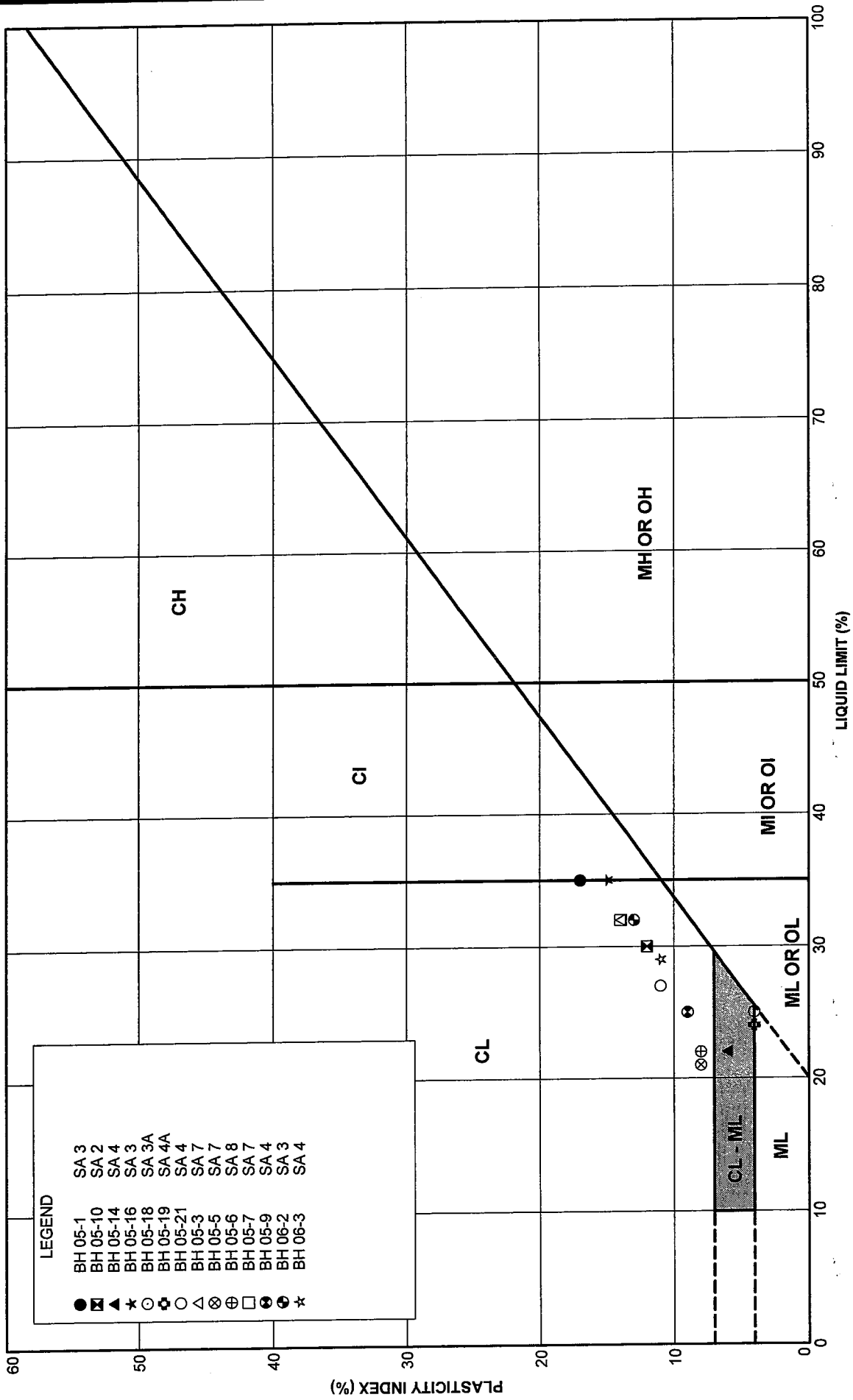
GRAIN SIZE DISTRIBUTION  
Non-Cohesive Native Soils (Silty Sand Textured)

FIGURE NO. 2004-7

JOB NO. G-03.1101

DATE Feb. 2004





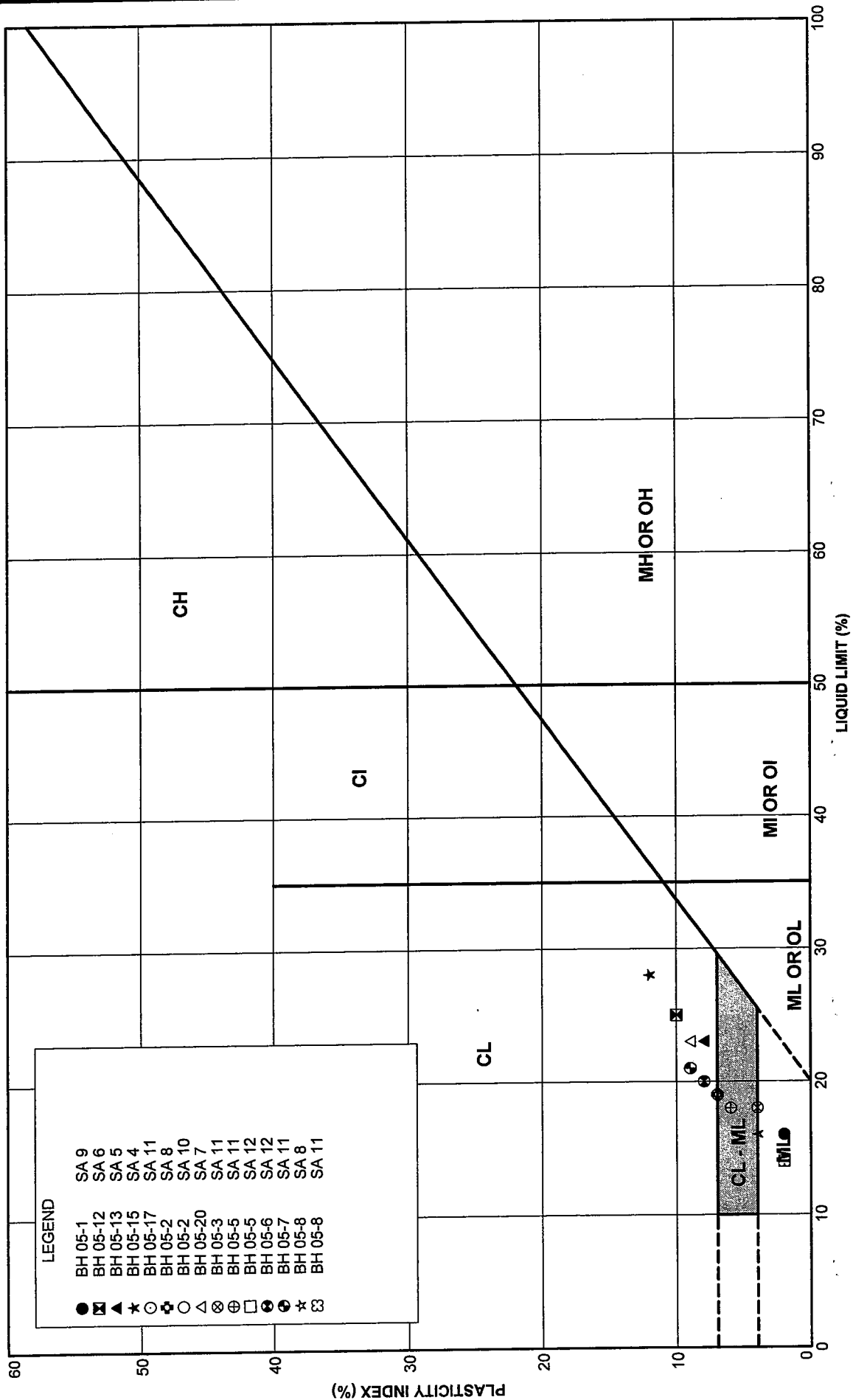


FIGURE NO. 2005-9  
 JOB NO. G-05.0701  
 DATE DECEMBER, 2005

PLASTICITY CHART (Non-Cohesive Native Soils)

GEO-CANADA



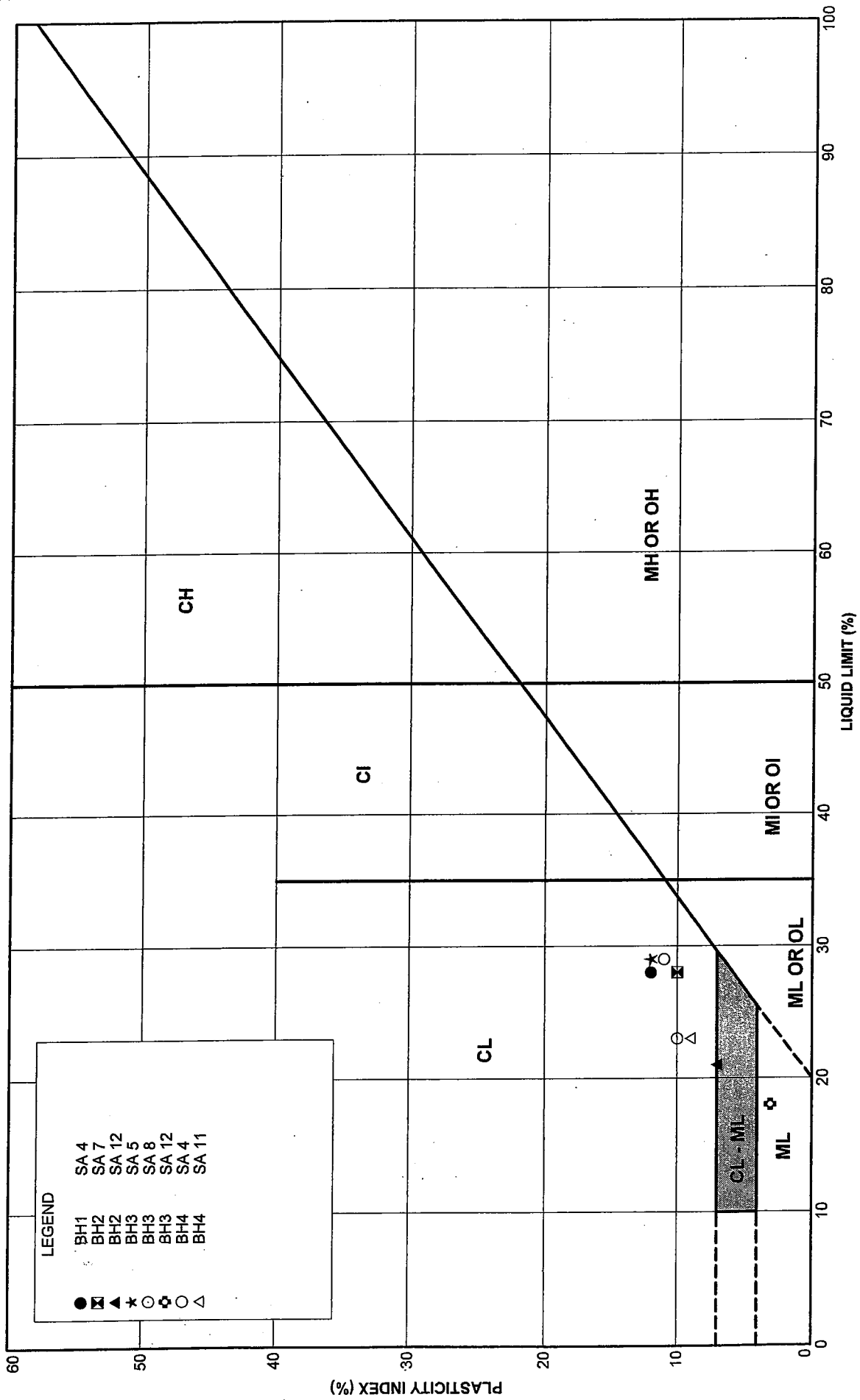


FIGURE NO. 2004-8

JOB NO. G-03.1101

DATE Feb. 2004

# PLASTICITY CHART

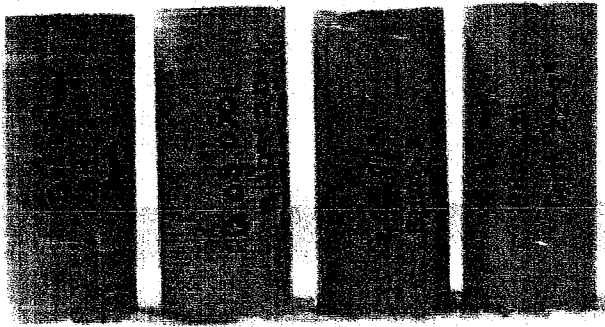
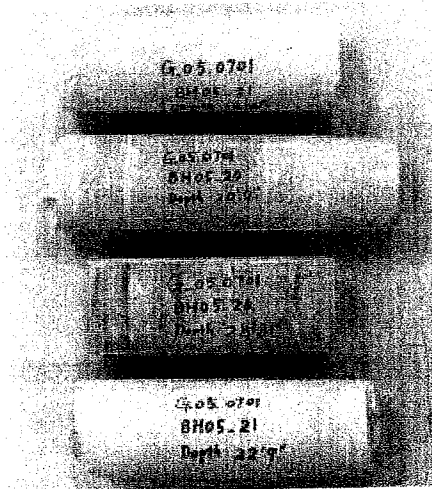
**GEO-CANADA**





## **APPENDIX C**

**PHOTOGRAPHS OF ROCK CORE  
PHOTOGRAPHS OF ROCK SAMPLES FOR UNCONFINED COMPRESSION TEST  
RESULTS OF UNCONFINED COMPRESSION TESTS  
RESULTS OF POINT LOAD INDEX STRENGTH TESTS  
TUNNELMAN'S GROUND CLASSIFICATION AND  
PROBABLE WORKING CONDITIONS**

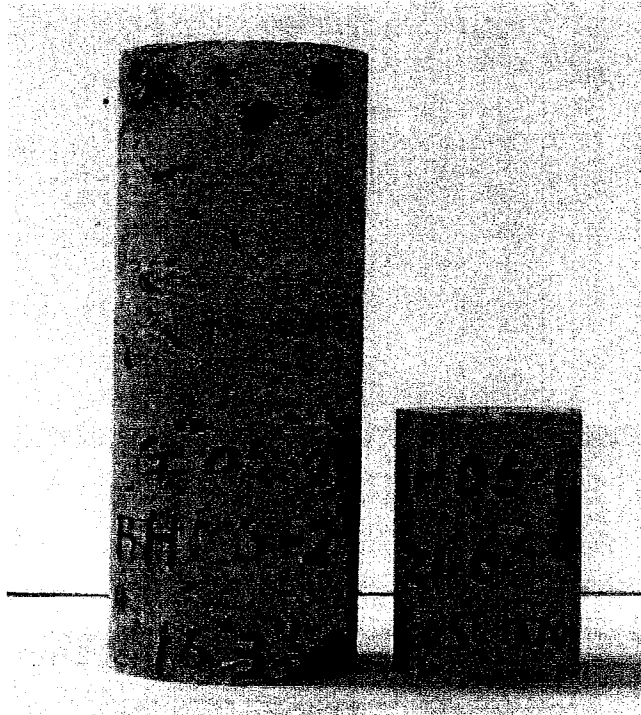


Specimens As-Received  
And Before Testing

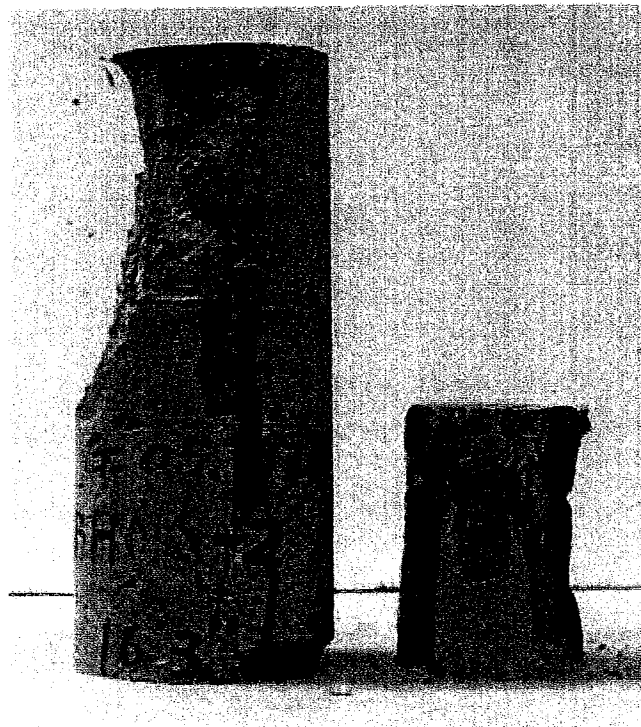


Specimens After  
Unconfined Strength Testing

Photographs of Rock Samples for Unconfined Compression Tests  
(BH 05-20 and BH 05-21)

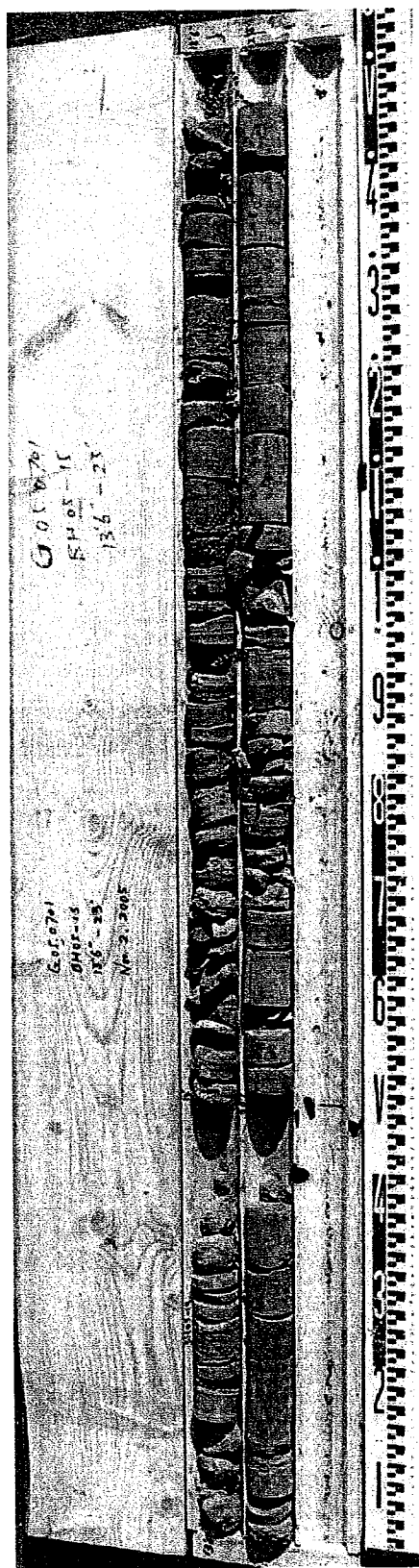


Specimens As-Received And Before Testing



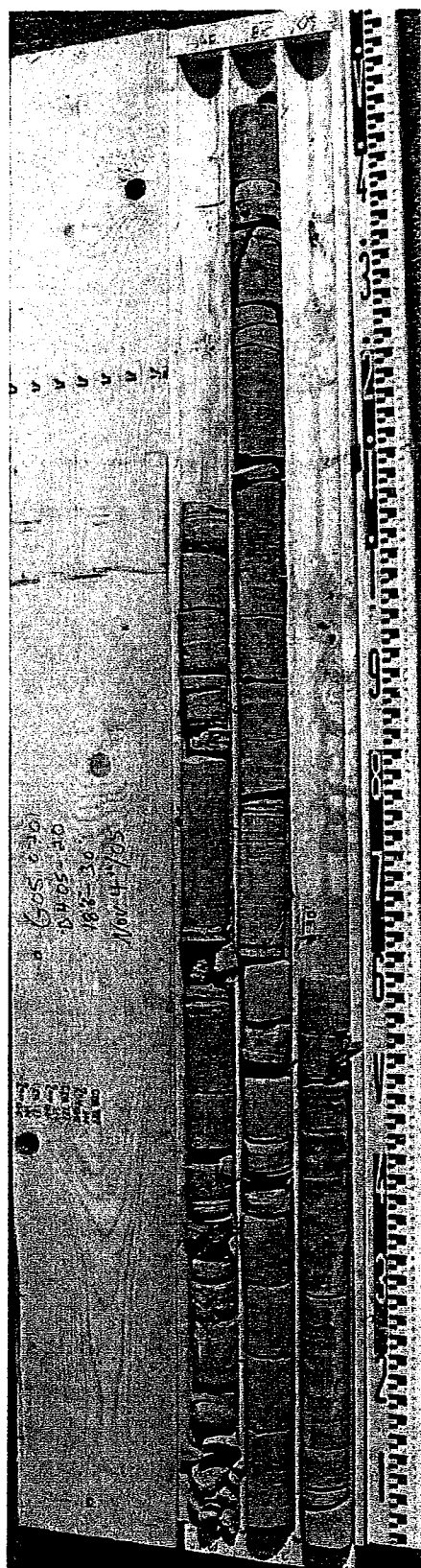
Specimens After Unconfined Strength Testing

Photographs of Rock Samples for Unconfined Compression Tests  
(BH 06-2 and BH 06-3)



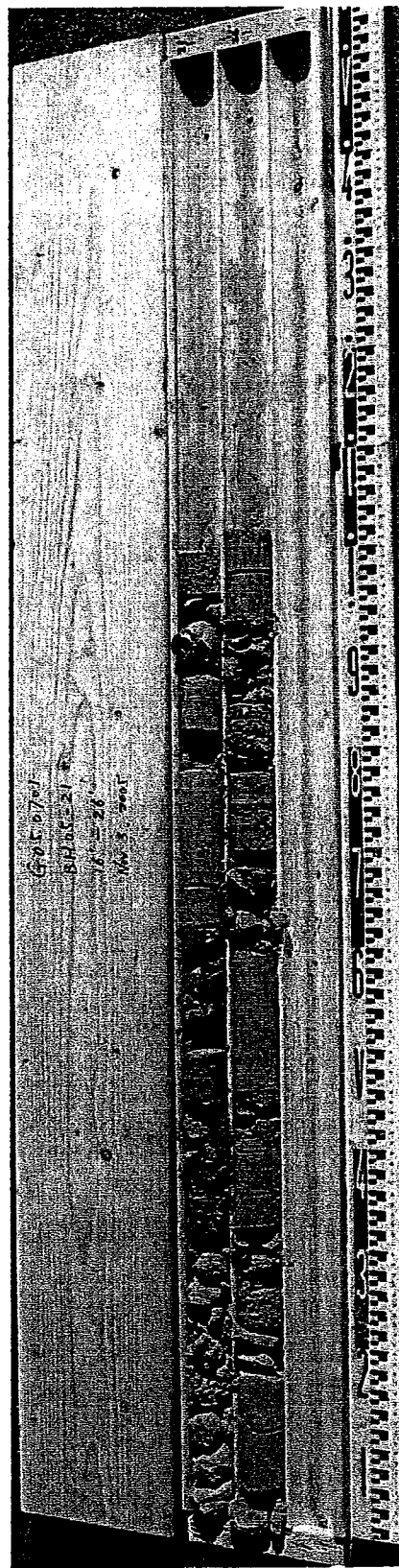
**Borehole 05-15**

(Run 1: 4.1 to 4.6m; Run 2: 4.6 to 6.1m; Run 3: 6.1 to 7.0m)



**Borehole 05-20**

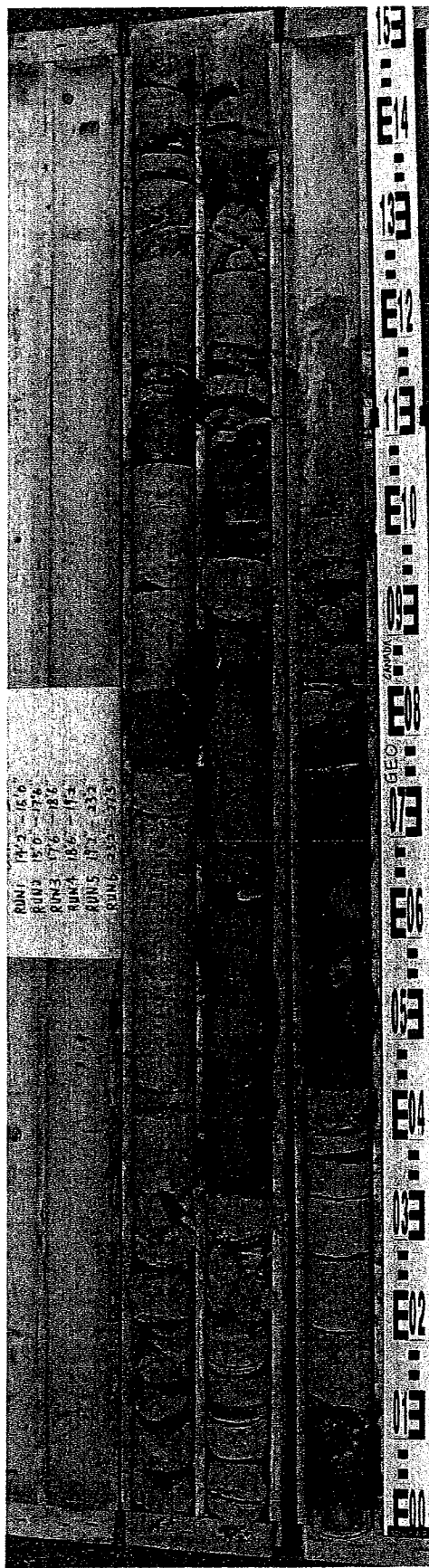
(Run 1: 5.6 to 7.0m; Run 2: 7.0 to 8.5m; Run 3: 8.5 to 9.1m)



**Borehole 05-21**

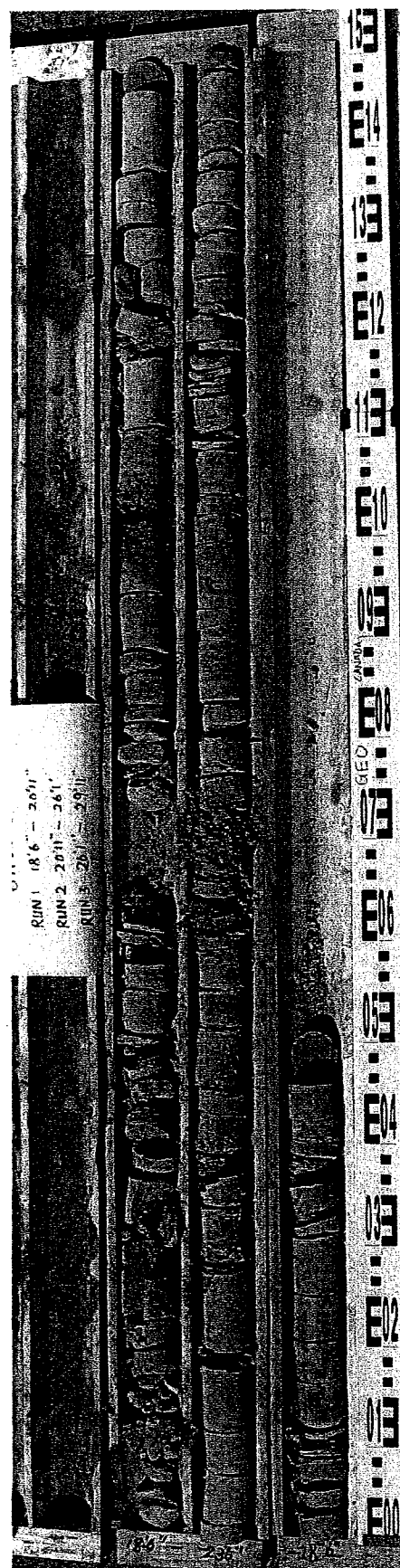
(Run 1: 4.9 to 6.4m; Run 2: 6.4 to 7.9m)





### Borehole 06-2

(Run 1: 4.3 to 4.6m; Run 2: 4.6 to 5.3m; Run 3: 5.3 to 5.6m; Run 4: 5.6 to 5.8m; Run 5: 5.8 to 7.1m; Run 6: 7.1 to 8.4m)



### Borehole 06-3

(Run 1: 5.6 to 6.4m; Run 2: 6.4 to 8.0m; Run 3: 8.0 to 9.1m)

**TABLE C-1: RESULTS OF UNCONFINED COMPRESSION TEST**

**(by Rock Mechanics Laboratory of Queen's University)**

<b>BH No.</b>	<b>Sample Depth/Elevation (m)</b>	<b>Unconfined Compressive Strength (MPa)</b>	<b>Young's Modulus (GPa)</b>	<b>Poisson's ratio</b>	<b>Bulk density (g/cm<sup>3</sup>)</b>
05-20	6.3/177.3	185.5	28.904	0.18	2.61
05-20	8.7/174.9	8.1	1.344	0.10	2.55
05-21	5.6/177.2	143.3	29.565	0.16	2.63
05-21	6.9/175.9	187.4	34.068	0.18	2.63
06-2	5.0/183.1	112.0	46.700	0.34	2.70
06-3	6.6/172.0	59.3	29.766	0.20	2.67

**TABLE C-2: RESULTS OF POINT LOAD INDEX STRENGTH TESTS**

BH No.	Depth/ Elevation (m)	Moisture Content (%)	Point Load Index, $I_{s(50)}$ (MPa)		Approximate Uniaxial Compressive Strength (MPa)*
			Diametral	Axial	
05-15	4.3/182.6	1.5		2.2	53.7
05-15	5.9/181.0	1.9		3.4	81.6
05-15	6.8/180.1	2.7		1.9	45.9
05-20	6.6/177.0	0.5	5.4		129.5
05-20	7.4/176.2	0.4	6.5		156.8
05-20	8.9/174.7	2.8		1.9	45.0
05-20	8.5/175.1	2.4		2.3	55.8
05-21	7.4/175.4	2.6		2.3	55.4
05-21	6.7/176.1	1.7		1.4	33.4
05-21	7.1/175.7	3.1		1.0	24.3
06-2	4.5/183.6			6.8	163
06-2	5.1/183.0			2.7	64
06-2	5.2/182.9		0.3		6
06-2	5.7/182.4			0.5	11
06-2	6.0/182.1			1.6	39
06-2	7.1/181.0			0.4	9
06-2	7.7/180.4			0.7	16
06-2	8.0/180.1			5.2	125
06-3	6.2/177.4			2.4	58
06-3	6.4/177.2			1.3	32
06-3	7.2/176.4			2.0	47
06-3	8.2/175.4			1.7	40
06-3	8.9/174.7			1.4	34

\* Approximate uniaxial compressive strength based on the relationship  $UCS \approx 24 I_{s(50)}$  [MPa].

### Tunnelman's Ground Classification And Probable Working Conditions

Soil Classification	Representative Soil Types	Tunnel Working Conditions
Hard	Very hard calcareous clay; Cemented sand and gravel	Tunnel heading may be advanced without roof support.
Firm	Loess above GWT; Various calcareous clay with low plasticity	Tunnel heading may be advanced without roof support. permanent support can be constructed before the ground will start to move.
Slow Ravelling and Fast Ravelling	Fast ravelling occurs in residual soils or in sand with clay binder below the GWT. Above the GWT, the same soils may be <u>Slow Ravelling</u> or even <u>Firm</u>	Chunks of material may drop out of the crown or the sides some time after the ground has been exposed. In <u>Fast Ravelling</u> ground, the process starts within a few minutes; otherwise; it is classed as <u>Slow Ravelling</u> .
Squeezing	Soft or medium-soft clay	Ground slowly advances into tunnel without fracturing and without perceptible increase of water content in ground surrounding the tunnel.
Swelling	Heavily pre-compressed clays with a plasticity index greater than 30. Sedimentary formations containing layers of anhydrite.	Like squeezing ground, moves slowly into tunnel, but the movement is associated with a very considerable volume increase in the ground surrounding the tunnel.
Cohesive Running and Running	Occurs in clean, fine moist sand  Occurs in clean, coarse or medium sand above the GWT	Removal of the lateral support of any surface rising at an angle of more than about 34° to the horizontal is followed by a "run", whereby the material flows like granulated sugar until the slope angle is approx. 34°. If the "run" is preceded by a brief period of ravelling, the ground is called <u>Cohesive Running</u> .
Very Soft Squeezing	Clays and silts with high plasticity indices	Ground advances rapidly into the tunnel in a plastic flow
Flowing	Any ground below the GWT that has an effective grain size in excess of about 0.00 mm	Flowing ground moves like a viscous liquid. It can invade the tunnel not only through the roof and the sides, but also through the invert. If the flow is not stopped, it will eventually completely fill the tunnel.
Bouldery	Boulder glacial till; riprap fill; some land slide deposits, some residual soils. The matrix between boulders may be gravel, sand, silt, clay and in any combination	Problems incurred in advancing shield or in forepoling; blasting or hand mining ahead of machine may become necessary.



**APPENDIX D**


**CHEMICAL TEST RESULTS**

Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-06.0701  
 P.O. :  
 Sample Type: Soil  
 Date Received: Nov 18/05  
 Date Analysed: Nov 21-24/05  
 Date Reported: Nov 25/05

# ENTECH

A Division of Agri-Service Lab Inc.  
 6820 Kilmat Rd., Unit #4  
 Mississauga, ON L5N 5K3

TEL: (905) 821-1112  
 FAX: (905) 821-2095

  
 Sam Sanyal, M.Sc., C.Chem.  
 Manager, Inorganic Analysis.

## CERTIFICATE OF ANALYSIS - SOIL STANDARDS FOR USE UNDER PART XV.1 OF THE ENVIRONMENTAL PROTECTION ACT (GENL. & INORGANIC)

Data Pertain To Specific Sample(s) Tested

PARAMETER	Standards (µg/g)		Method Detection Limit (µg/g)	CONTROL SAMPLE		Recovery %	SAMPLE DATA (µg/g)				
	Tables 2 Agricultural & Other Prop. Use.	Tables 2 & 3 Res./Ind. Comm		Tables 4 & 5 Res./Ind. Comm	Expected		Concentration	60122	60123	60124	60125
					Concentration (µg/g)		Found (µg/g)	BH05-1-SA-1	BH05-2-SA-2	BH05-3-SA-7	BH05-6-SA-12
Dry Matter (%)		-	-	-	-	-	83.54	86.59	88.79	93.49	
pH (units)	5 to 9	5 to 9	5 to 11	7.41	7.42	100	7.41	8.55	8.53	8.90	
E C (mS/cm)	0.7	0.7/1.4	N.A./N.A.	0.15	0.15	100	0.14	0.14	0.22	0.18	
SAR	5	5/12	N.A./N.A.	-	-	-	0.43	0.38	0.51	0.50	
Arsenic	20	20/40	40/N.V.	75.00	85.00	113	4.61	4.38	4.34	3.86	
Cadmium	3	12/12	41/41	34.00	35.80	105	<1	<1	<1	<1	
Chromium (VI)	8	8/8	600/1100	0.79	0.77	97	<1	<1	<1	<1	
Chromium (total)	750	750/750	2500/5000	64.00	68.20	107	24.51	17.73	18.12	12.77	
Cobalt	40	40/80	2500/3400	28.00	28.80	103	9.81	7.96	7.90	4.84	
Copper	150	225/225	2500/2500	690	763	111	26.63	19.25	21.66	22.06	
Lead	200	200/1000	1000/N.V.	233	221	95	4.08	2.98	<2	<2	
Mercury	10	10/10	57/57	0.19	0.18	95	<0.05	<0.05	<0.05	<0.05	
Molybdenum	5	40/40	550/550	4.00	3.20	80	<2	<2	<2	<2	
Nickel	150	150/150	710/710	231	212	92	21.18	18.30	15.71	9.21	
Boron(HWE) *	1.5	1.5/2.0	2.0/N.V.	1.00	0.96	96	0.06	0.03	0.40	0.43	
Cyanide Free	100	100/100	100/390	0.20	0.19	95	<0.1	<0.1	<0.1	<0.1	
Selenium	2	10/10	2500/2500	64.20	54.40	85	<1	<1	<1	<1	
Silver	20	20/40	240/240	0.19	0.20	105	<0.3	<0.3	<0.3	<0.3	
Zinc	600	600/600	2500/5000	6775	5670	84	59	48	45	31	
Antimony *	13	13/40	44/44	0.01	0.01	98	<1	<1	<1	<1	
Barium	750	750/1500	2500/4100	102	105	103	68.42	53.78	39.35	26.36	
Beryllium	1.2	1.2/1.2	1.2/3.1	94.4	99	105	<0.5	<0.5	<0.5	<0.5	
Vanadium	200	200/200	910/910	19	22	116	35.78	23.51	22.18	16.92	

All guideline criteria are for coarse textured soil  
 HWE - Hot water extractable  
 Sample data and MDL units are in µg/g unless  
 otherwise specified

Analyst(s): AP, SS, BH, EG, SJ, PI, AD, HG

\* Control Sample Unit is µg/mL for the specified parameter instead of µg/g unless otherwise specified.

Method:

pH: Extraction/Electrometric (EPA 9045)  
 EC: Extraction/Electrometric (EPA 120.1)  
 As, Se, Sb: Digestion/HGFAAS (EPA 3050A/7062/7742)  
 Hg: Digestion/CV-AAS (EPA 7471A/245.6)  
 SAR: Extraction/ICP-AES (EPA 200.7)

Metals: Digestion/ICP-AES (EPA 3050A/200.7)  
 Cyanide Free: Extraction/Auto-Color (EPA 335.4)  
 B (HWE): Extraction/ICP-AES  
 Cr(VI): Alkaline Digestion/Colorimetry (EPA 3060A/7196)

Client: Geo-Canada Ltd.  
Attention: Laifa Cao  
Project: G-05.0701  
P.O.:

Sample Type: Soil  
Date Received: Nov 18/05  
Date Analysed: Nov 21-24/05  
Date Reported: Nov 25/05

**ENTECH**

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**CERTIFICATE OF ANALYSIS - SOIL STANDARDS FOR USE UNDER PART XV.1 OF THE ENVIRONMENTAL PROTECTION ACT (GENL. & INORGANIC)**

Data Pertain To Specific Sample(s) Tested

PARAMETER	Standards (µg/g)			Method Detection	CONTROL SAMPLE			SAMPLE DATA (µg/g)			
	Tables 2 Agricultural & Other Prop. Use.	Tables 2 & 3 Res./Ind. Comm	Tables 4 & 5 Res./Ind. Comm		Expected Concentration (µg/g)	Concentration (µg/g)	Recovery %	60126 BH05-8-SA-8	60127 BH05-9-SA-1	60128 BH05-10-SA-4	60129 BH05-11-SA-2
Dry Matter (%)				-	-	-	-	93.00	81.87	90.07	89.04
pH (units)	5 to 9	5 to 9	5 to 11	-	7.41	7.42	100	8.74	8.40	8.57	8.70
EC (mS/cm)	0.7	0.7/1.4	N.A./N.A.	-	0.15	0.15	100	0.18	0.12	0.12	0.18
SAR	5	5/12	N.A./N.A.	-	-	-	-	0.54	0.21	0.34	0.63
Arsenic	20	20/40	40/N.V.	1	75.00	85.00	113	4.47	3.30	4.96	5.39
Cadmium	3	12/12	41/41	1	34.00	35.80	105	<1	<1	<1	<1
Chromium (VI)	8	8/8	600/1100	1	0.79	0.77	97	<1	<1	<1	<1
Chromium (total)	750	750/750	2500/5000	1	64.00	68.20	107	9.85	24.10	19.10	18.44
Cobalt	40	40/80	2500/3400	1	28.00	28.80	103	4.04	8.35	9.29	9.74
Copper	150	225/225	2500/2500	1	690	763	111	19.63	15.80	28.33	28.93
Lead	200	200/1000	1000/N.V.	2	233	221	95	<2	7.15	2.54	<2
Mercury	10	10/10	57/57	0.05	0.19	0.18	95	0.06	<0.05	<0.05	<0.05
Molybdenum	5	40/40	550/550	2	4.00	3.20	80	<2	<2	<2	<2
Nickel	150	150/150	710/710	2	231	212	92	7.69	14.51	16.97	18.90
Boron(HWE) *	1.5	1.5/2.0	2.0/N.V.	0.02	1.00	0.96	96	0.28	0.10	0.12	0.06
Cyanide Free	100	100/100	100/390	0.1	0.20	0.19	95	<0.1	<0.1	<0.1	<0.1
Selenium	2	10/10	2500/2500	1	64.20	54.40	85	<1	<1	<1	<1
Silver	20	20/40	240/240	0.3	0.19	0.20	105	<0.3	<0.3	<0.3	<0.3
Zinc	600	600/600	2500/5000	1	6775	5670	84	30	68	50	59
Antimony *	13	13/40	44/44	1	0.01	0.01	98	<1	<1	<1	<1
Barium	750	750/1500	2500/4100	1	102	105	103	17.61	73.49	51.44	49.61
Beryllium	1.2	1.2/1.2	1.2/3.1	0.5	94.4	99	105	<0.5	<0.5	<0.5	<0.5
Vanadium	200	200/200	910/910	1	19	22	116	13.59	33.54	23.56	23.42

a) Table 2: Full Depth Generic Site Condition Standards in a potable groundwater condition

b) Table 3: Full Depth Generic Site Condition Standards in a non-potable groundwater condition

c) Table 4: Stratified Site Condition Standards in a potable groundwater condition

d) Table 5: Stratified Site Condition Standards in a non-potable groundwater condition

Sample Disposal: 30 Days from the Reporting Date.

\* Control Sample Unit is µg/mL for the specified parameter instead of µg/g unless otherwise specified.

Method:

pH: Extraction/Electrometric (EPA 9045)

EC: Extraction/Electrometric (EPA 120.1)

As, Se, Sb: Digestion/HGFAAS (EPA 3060A/7062/7742)

Hg: Digestion/CV-AAS (EPA 7471A/245.5)

SAR: Extraction/ICP-AES (EPA 200.7)

Metals: Digestion/ICP-AES (EPA 3060A/200.7)

Cyanide Free: Extraction/Auto-Color (EPA 335.4)

B (HWE): Extraction/ICP-AES

Cr(VI): Alkaline Digestion/Colorimetry (EPA 3060A/7196)

Analyst(s): AP, SS, BH, EG, SJ, PI, AD, HG

All guideline criteria are for coarse textured soil

HWE - Hot water extractable

Sample data and MDL units are in µg/g unless otherwise specified

Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-05.0701  
 P.O.:  
 Sample Type: Soil  
 Date Received: Nov 18/05  
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**CERTIFICATE OF ANALYSIS - SOIL STANDARDS FOR USE UNDER PART XV.I OF THE ENVIRONMENTAL PROTECTION ACT (GENL. & INORGANIC)**

**Data Pertain To Specific Sample(s) Tested**

PARAMETER	Standards (µg/g)		Method	CONTROL SAMPLE			SAMPLE DATA (µg/g)			
	Tables 2 Agricultural & Other Prop. Use.	Tables 2 & 3 Res./Ind. Comm		Expected Concentration (µg/g)	Concentration Found (µg/g)	Recovery %	60130 BH05-13-SA-7	60131 BH05-14-SA-8	60132 BH05-15-SA-2	60133 BH05-17-SA-6
Dry Matter (%)	-	-	-	-	-	-	94.44	91.53	88.36	92.92
pH (units)	5 to 9	5 to 11	-	7.41	7.42	100	8.71	8.24	8.60	8.69
E.C. (mS/cm)	0.7	0.7/1.4	-	0.15	0.15	100	0.21	0.26	0.13	0.15
SAR	5	5/12	-	-	-	-	0.78	0.63	0.46	0.26
Arsenic	20	20/40	1	75.00	85.00	113	4.35	10.49	5.89	5.58
Cadmium	3	12/12	1	34.00	35.80	105	<1	<1	<1	<1
Chromium (VI)	8	8/8	1	0.79	0.77	97	<1	<1	<1	<1
Chromium (total)	750	750/750	1	64.00	68.20	107	11.17	27.91	20.51	16.34
Cobalt	40	40/80	1	28.00	28.80	103	5.33	16.66	11.95	8.83
Copper	150	225/225	1	690	763	111	24.35	99.19	29.83	30.61
Lead	200	200/1000	2	233	221	95	<2	<2	4.40	3.67
Mercury	10	10/10	0.05	0.19	0.18	95	<0.05	0.05	<0.05	0.19
Molybdenum	5	40/40	2	4.00	3.20	80	<2	<2	<2	<2
Nickel	150	150/150	2	231	212	92	8.93	30.85	21.67	16.79
Boron(HWE) *	1.5	1.5/2.0	0.02	1.00	0.96	96	0.39	0.89	0.18	0.10
Cyanide Free	100	100/100	0.1	0.20	0.19	95	<0.1	<0.1	<0.1	<0.1
Selenium	2	10/10	1	64.20	54.40	85	<1	<1	<1	<1
Silver	20	20/40	0.3	0.19	0.20	105	<0.3	<0.3	<0.3	<0.3
Zinc	600	600/600	1	6775	5670	84	38	78	64	48
Antimony *	13	13/40	1	0.01	0.01	98	<1	<1	<1	<1
Barium	750	750/1500	1	102	105	103	19.05	65.41	58.31	36.38
Beryllium	1.2	1.2/1.2	0.5	94.4	99	105	<0.5	0.67	<0.5	<0.5
Vanadium	200	200/200	1	19	22	116	15.44	32.49	22.38	19.87

- a) Table 2: Full Depth Generic Site Condition Standards in a potable groundwater condition  
 b) Table 3: Full Depth Generic Site Condition Standards in a non-potable groundwater condition  
 c) Table 4: Stratified Site Condition Standards in a potable groundwater condition  
 d) Table 5: Stratified Site Condition Standards in a non-potable groundwater condition

Sample Disposal: 30 Days from the Reporting Date.

\* Control Sample Unit is µg/mL for the specified parameter instead of µg/g unless otherwise specified.

**Method:**

pH: Extraction/Electrometric (EPA 9045)  
 EC: Extraction/Electrometric (EPA 120.1)  
 As, Se, Sb: Digestion/HGFAAS (EPA 3060A/7062/7742)  
 Hg: Digestion/CV-AAS (EPA 7471A/245.5)  
 SAR: Extraction/ICP-AES (EPA 200.7)

Metals: Digestion/ICP-AES (EPA 3060A/200.7)  
 Cyanide Free: Extraction/Auto-Color (EPA 335.4)  
 B (HWE): Extraction/ICP-AES  
 Cr(VI): Alkaline Digestion/Colorimetry (EPA 3060A/7196)

Analyst(s): AP, SS, BH, EG, SJ, PI, AD, HG

All guideline criteria are for coarse textured soil  
 HWE - Hot water extractable  
 Sample data and MDL units are in µg/g unless otherwise specified



Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-06.0701  
 P.O.:  
 Sample Type: Soil  
 Date Received: Nov 18/05  
 Date Analysed: Nov 21-24/05  
 Date Reported: Nov 25/05

**ENTECH**

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Data Pertain To Specific Sample(s) Tested

PARAMETER	Standards (µg/g)		Method Detection Limit (µg/g)	CONTROL SAMPLE			SAMPLE DATA (µg/g)			
	Tables 2 Agricultural & Other Prop. Use.	Tables 2 & 3 Res./Ind. Comm		Expected Concentration (µg/g)	Found (µg/g)	Recovery %	Blank	60134 BH05-18-SA-4	60135 BH05-19-SA-1	60136 BH05-21-SA-2
Dry Matter (%)		-	-	-	-	-	-	87.04	88.02	86.87
pH (units)	5 to 9	5 to 11	-	7.41	7.42	100	-	8.40	8.30	8.44
E.C (mS/cm)	0.7	0.7/1.4	-	0.15	0.15	100	-	0.15	0.19	0.08
SAR	5	5/12	-	-	-	-	-	1.35	0.67	0.23
Arsenic	20	20/40	1	75.00	85.00	113	<1	2.47	4.14	8.70
Cadmium	3	12/12	1	34.00	35.80	105	<1	<1	<1	<1
Chromium (VI)	8	8/8	1	0.79	0.77	97	<1	<1	<1	<1
Chromium (total)	750	750/750	1	64.00	68.20	107	<1	43.70	29.77	28.94
Cobalt	40	40/80	1	28.00	28.80	103	<1	12.47	9.11	10.01
Copper	150	225/225	1	690	763	111	<1	29.96	22.20	81.82
Lead	200	200/1000	2	233	221	95	<2	<2	9.24	13.71
Mercury	10	10/10	0.05	0.19	0.18	95	<0.05	0.08	0.08	0.06
Molybdenum	5	40/40	2	4.00	3.20	80	<2	<2	<2	<2
Nickel	150	150/150	2	231	212	92	<2	24.88	18.84	27.04
Boron(HWE) *	1.5	1.5/2.0	0.02	1.00	0.96	96	<0.02	0.21	0.11	0.09
Cyanide Free	100	100/100	0.1	0.20	0.19	95	<0.1	<0.1	<0.1	<0.1
Selenium	2	10/10	1	64.20	54.40	85	<1	<1	<1	<1
Silver	20	20/40	0.3	0.19	0.20	105	<0.3	1.60	<0.3	<0.3
Zinc	600	600/600	1	6775	5670	84	<1	70	91	81
Antimony *	13	13/40	1	0.01	0.01	98	<1	<1	<1	<1
Barium	750	750/1500	1	102	105	103	<1	157	92.45	114
Beryllium	1.2	1.2/1.2	0.5	94.4	99	105	<0.5	<0.5	<0.5	0.53
Vanadium	200	200/200	1	19	22	116	<1	50.15	29.75	32.25

- a) Table 2: Full Depth Generic Site Condition Standards in a potable groundwater condition  
 b) Table 3: Full Depth Generic Site Condition Standards in a non-potable groundwater condition  
 c) Table 4: Stratified Site Condition Standards in a potable groundwater condition  
 d) Table 5: Stratified Site Condition Standards in a non-potable groundwater condition

Sample Disposal: 30 Days from the Reporting Date.

\* Control Sample Unit is µg/mL for the specified parameter instead of µg/g unless otherwise specified.

Method:

pH: Extraction/Electrometric (EPA 9045)  
 EC: Extraction/Electrometric (EPA 120.1)  
 As, Se, Sb: Digestion/HGFAAS (EPA 3050A/7062/7742)  
 Hg: Digestion/CV-AAS (EPA 7471A/246.5)  
 SAR: Extraction/ICP-AES (EPA 200.7)

Metals: Digestion/ICP-AES (EPA 3050A/200.7)  
 Cyanide Free: Extraction/Auto-Color (EPA 336.4)  
 B (HWE): Extraction/ICP-AES  
 Cr(VI): Alkaline Digestion/Colorimetry (EPA 3060A/7196)

Analyst(s): AP, SS, BH, EG, SJ, PI, AD, HG

All guideline criteria are for coarse textured soil  
 HWE - Hot water extractable  
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Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-06.0701  
 P.O. :  
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# CERTIFICATE OF ANALYSIS - SOIL STANDARDS FOR USE UNDER PART XV.I OF THE ENVIRONMENTAL PROTECTION ACT (GENL. & INORGANIC)

Data Pertain To Specific Sample(s) Tested

PARAMETER	Standards (µg/g)			Method Detection Limit (µg/g)	CONTROL SAMPLE			SAMPLE DATA (µg/g)		
	Tables 2 Agricultural & Other Prop. Use.	Tables 2 & 3 Res./Ind. Comm	Tables 4 & 5 Res./Ind. Comm		Expected Concentration (µg/g)	Found (µg/g)	Recovery %	60131	BH05-14-BA-8 Duplicate	
Dry Matter (%)		-	-	-	-	-	-	91.53		
pH (units)	5 to 9	5 to 9	5 to 11	-	7.41	7.42	100	8.30		
E.C (mS/cm)	0.7	0.7/1.4	N.A./N.A.	-	0.15	0.15	100	0.26		
SAR	5	5/12	N.A./N.A.	-	-	-	-	0.72		
Arsenic	20	20/40	40/N.V.	1	75.00	85.00	113	10.15		
Cadmium	3	12/12	41/41	1	34.00	35.80	105	<1		
Chromium (VI)	8	8/8	600/1100	1	0.79	0.77	97	<1		
Chromium (total)	750	750/750	2500/5000	1	64.00	68.20	107	26.59		
Cobalt	40	40/80	2500/3400	1	28.00	28.80	103	16.39		
Copper	150	225/225	2500/2500	1	690	763	111	102		
Lead	200	200/1000	1000/N.V.	2	233	221	95	<2		
Mercury	10	10/10	57/57	0.05	0.19	0.18	95	0.05		
Molybdenum	5	40/40	550/550	2	4.00	3.20	80	<2		
Nickel	150	150/150	710/710	2	231	212	92	30.31		
Boron(HWE) *	1.5	1.5/2.0	2.0/N.V.	0.02	1.00	0.96	96	0.76		
Cyanide Free	100	100/100	100/390	0.1	0.20	0.19	95	<0.1		
Selenium	2	10/10	2500/2500	1	64.20	54.40	85	<1		
Silver	20	20/40	240/240	0.3	0.19	0.20	105	<0.3		
Zinc	600	600/600	2500/5000	1	6775	5670	84	77		
Antimony *	13	13/40	44/44	1	0.01	0.01	98	<1		
Barium	750	750/1500	2500/4100	1	102	105	103	62.38		
Beryllium	1.2	1.2/1.2	1.2/3.1	0.5	94.4	99	105	0.59		
Vanadium	200	200/200	910/910	1	19	22	116	30.49		

- a) Table 2: Full Depth Generic Site Condition Standards in a potable groundwater condition  
 b) Table 3: Full Depth Generic Site Condition Standards in a non-potable groundwater condition  
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Sample Disposal: 30 Days from the Reporting Date.

\* Control Sample Unit is µg/mL for the specified parameter instead of µg/g unless otherwise specified.

Method:

pH: Extraction/Electrometric (EPA 9045)

EC: Extraction/Electrometric (EPA 120.1)

As, Se, Sb: Digestion/HGFAAS (EPA 3060A/7062/7742)

Hg: Digestion/CV-AAS (EPA 7471A/246.5)

SAR: Extraction/ICP-AES (EPA 200.7)

Analyst(s): AP, SS, BH, EG, SJ, PI, AD, HG

Metals: Digestion/ICP-AES (EPA 3060A/200.7)

Cyanide Free: Extraction/Auto-Color (EPA 336.4)

B (HWE): Extraction/ICP-AES

Cr(VI): Alkaline Digestion/Colorimetry (EPA 3060A/7196)


All guideline criteria are for coarse textured soil

HWE - Hot water extractable

Sample data and MDL units are in µg/g unless otherwise specified

Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-05.0701  
 P.O.:  
 Sample Type: Soil  
 Date Received: Nov 18/05  
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## CERTIFICATE OF ANALYSIS FOR ONTARIO REGULATION 558/00 TCLP - LEACHATE QUALITY CRITERIA (INORGANICS)

Data Pertain To Specific Sample(s) Tested

CONTAMINANT	SCHEDULE 4 Concentration (mg/L)	Method Detection Limit (mg/L)	CONTROL SAMPLE		Recovery %	Blank	SAMPLE DATA (mg/L)		
			Expected Conc. (mg/L)	Found Conc. (mg/L)			60122 BH05-1-SA- 1	60124 BH05-3-SA- 7	60128 BH05-10-SA 4
Arsenic	2.5	0.001	0.26	0.28	109	<0.001	<0.001	<0.001	<0.001
Barium	100	0.01	0.85	0.82	96	<0.01	0.15	0.63	0.53
Boron	500	0.01	0.90	0.84	93	<0.01	0.03	0.07	0.03
Cadmium	0.5	0.005	0.51	0.50	99	<0.005	<0.005	<0.005	<0.005
Chromium	5.0	0.01	0.38	0.41	109	<0.01	<0.01	<0.01	<0.01
Cyanide Free	20.0	0.005	0.20	0.19	95	<0.005	<0.005	<0.005	<0.005
Fluoride	150	0.05	3.10	3.08	99	<0.05	0.27	0.27	0.25
Lead	5.0	0.02	0.20	0.21	106	<0.02	<0.02	<0.02	<0.02
Mercury	0.1	0.0001	0.004	0.004	103	<0.0001	<0.0001	<0.0001	<0.0001
(Nitrate+Nitrite)-N	1000	0.01	6.77	6.36	94	<0.01	0.19	0.02	0.03
Selenium	1.0	0.001	0.02	0.02	97	<0.001	<0.001	<0.001	<0.001
Silver	5.0	0.005	0.20	0.19	98	<0.005	<0.005	<0.005	<0.005
Initial pH (units)	-	-	-	-	-	4.89	7.70	9.45	9.30
Fluid No.	-	-	-	-	-	1	1	1	1
Fluid pH (units)	-	-	-	-	-	4.93	4.89	4.89	4.89
Final pH (units)	-	-	-	-	-	4.89	4.89	6.3	6.28

Analyst(s): AP, SS, EG, SJ, PI, BH

Sample Disposal: 30 Days from the Reporting Date.  
 All Results except pH are expressed in mg/L (parts per million).  
 Note: "x" means the result exceeds the Schedule 4 concentration.

Method:

As, Se: HG-FAAS (EPA 3005/7062/7742)  
 Hg: CV-AAS (EPA 245.1)  
 Metals: ICP-AES (EPA 3005/200.7)  
 pH: Electrometric/pH-Meter (EPA 150.1)

Cyanide Free: Auto-Color (EPA 365.1)  
 Fluoride: ISE (EPA 340.2)  
 (NO3 + NO2)-N: Auto-Color (EPA 353.2)

Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-05.0701  
 P.O.:  
 Sample Type: Soil  
 Date Received: Nov 18/05  
 Date Analysed: Nov 21-29/05  
 Date Reported: Dec 05/05

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*Sam Sanyal*

Sam Sanyal, M.Sc. C. Chem.  
 Manager, Inorganic Analysis.

## CERTIFICATE OF ANALYSIS FOR ONTARIO REGULATION 558/00 TCLP - LEACHATE QUALITY CRITERIA (INORGANICS)

Data Pertain To Specific Sample(s) Tested

CONTAMINANT	SCHEDULE 4 Concentration (mg/L)	Method Detection Limit (mg/L)	CONTROL SAMPLE		Recovery	SAMPLE DATA (mg/L)		
			Expected Conc. (mg/L)	Found Conc. (mg/L)		60132 BH05-16-SA 2	60134 BH05-18-SA 4	60136 BH05-21-SA 2
Arsenic	2.5	0.001	0.26	0.28	109	<0.001	<0.001	<0.001
Barium	100	0.01	0.85	0.82	96	0.39	1.19	0.48
Boron	500	0.01	0.90	0.84	93	<0.01	<0.01	<0.01
Cadmium	0.5	0.005	0.51	0.50	99	<0.005	<0.005	<0.005
Chromium	5.0	0.01	0.38	0.41	109	<0.01	<0.01	<0.01
Cyanide Free	20.0	0.005	0.20	0.19	95	<0.005	<0.005	<0.005
Fluoride	150	0.05	3.10	3.08	99	0.20	0.21	0.12
Lead	5.0	0.02	0.20	0.21	106	<0.02	<0.02	<0.02
Mercury	0.1	0.0001	0.004	0.004	103	<0.0001	<0.0001	<0.0001
(Nitrate+Nitrite)-N	1000	0.01	6.77	6.36	94	0.02	<0.01	0.07
Selenium	1.0	0.001	0.02	0.02	97	<0.001	<0.001	<0.001
Silver	5.0	0.005	0.20	0.19	98	<0.005	<0.005	<0.005
Initial pH (units)	-	-	-	-	-	9.36	9.14	8.92
Fluid No.	-	-	-	-	-	1	1	1
Fluid pH (units)	-	-	-	-	-	4.89	4.89	4.89
Final pH (units)	-	-	-	-	-	6.32	6.27	5.87

Analyst(s): AP, SS, EG, SJ, PI, BH

Sample Disposal: 30 Days from the Reporting Date.  
 All Results except pH are expressed in mg/L (parts per million).  
 Note: "+" means the result exceeds the Schedule 4 concentration.

Method:

As, Se: HG-FAAS (EPA 3005/7062/7742)

Hg: CV-AAS (EPA 245.1)

Metals: ICP-AES (EPA 3005/200.7)

pH: Electrometric/pH-Meter (EPA 150.1)

Cyanide Free: Auto-Color (EPA 365.1)

Fluoride: ISE (EPA 340.2)

(NO3 + NO2)-N: Auto-Color (EPA 353.2)

Client: Geo-Canada Ltd.  
 Attention: Laifa Cao  
 Project: G-05.0701  
 P.O.:  
 Sample Type: Soil  
 Date Received: Nov 18/05  
 Date Analysed: Nov 21-29/05  
 Date Reported: Dec 05/05

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*Sam Sanyal*

Sam Sanyal, M.Sc. C. Chem.  
 Manager, Inorganic Analysis.

## CERTIFICATE OF ANALYSIS FOR ONTARIO REGULATION 558/00 TCLP - LEACHATE QUALITY CRITERIA (INORGANICS)

Data Pertain To Specific Sample(s) Tested

CONTAMINANT	SCHEDULE 4 Concentration (mg/L)	Method Detection Limit (mg/L)	CONTROL SAMPLE			SAMPLE DATA (mg/L)		
			Expected Conc. (mg/L)	Found Conc. (mg/L)	Recovery %	Blank	60126 BH05-8-SA- 9	60130 BH05-13-SA 7 7 Duplicate
Arsenic	2.5	0.001	0.26	0.28	109	<0.001	<0.001	<0.001
Barium	100	0.01	0.85	0.82	96	<0.01	0.24	0.21
Boron	500	0.01	0.90	0.84	93	<0.01	0.05	0.05
Cadmium	0.5	0.005	0.51	0.50	99	<0.005	<0.005	<0.005
Chromium	5.0	0.01	0.38	0.41	109	<0.01	<0.01	<0.01
Cyanide Free	20.0	0.005	0.20	0.19	95	<0.005	<0.005	<0.005
Fluoride	150	0.05	3.10	3.08	99	<0.05	0.37	0.44
Lead	5.0	0.02	0.20	0.21	106	<0.02	<0.02	<0.02
Mercury	0.1	0.0001	0.004	0.004	103	<0.0001	<0.0001	<0.0001
(Nitrate+Nitrite)-N	1000	0.01	6.77	6.36	94	<0.01	<0.01	<0.01
Selenium	1.0	0.001	0.02	0.02	97	<0.001	<0.001	<0.001
Silver	5.0	0.005	0.20	0.19	98	<0.005	<0.005	<0.005
Initial pH (units)	-	-	-	-	-	2.88	9.19	9.47
Fluid No.	-	-	-	-	-	2	2	2
Fluid pH (units)	-	-	-	-	-	2.88	2.89	2.89
Final pH (units)	-	-	-	-	-	2.89	5.54	5.53

Analyst(s): AP, SS, EG, SJ, PI, BH

Sample Disposal: 30 Days from the Reporting Date.  
 All Results except pH are expressed in mg/L (parts per million).  
 Note: "x" means the result exceeds the Schedule 4 concentration.

Method:

As, Se: HG-FAAS (EPA 3005/7062/7742)  
 Hg: CV-AAS (EPA 245.1)  
 Metals: ICP-AES (EPA 3005/200.7)  
 pH: Electrometric/pH-Meter (EPA 150.1)

Cyanide Free: Auto-Color (EPA 385.1)  
 Fluoride: ISE (EPA 340.2)  
 (NO<sub>3</sub> + NO<sub>2</sub>)-N: Auto-Color (EPA 353.2)

Client: Geo - Canada Ltd.

Attention: Laifa Cao

Client Reference: Proj: G-05.0701

Date Received: Nov. 18, 2005

Date Analyzed: Nov. 29, 2005

Date Reported: Dec. 05, 2005

Sample Type: TCLP(leachate)

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## Certificate of Analysis

### Total PCB's

ENTECH#	Sample Identification	Conc. (mg/L)	Surrogate Recovery (%)
All units are in mg/L (ppm)			
60122	BH05-1-SA-1	<	128
60124	BH05-3-SA-7	<	122
60126	BH05-8-SA-9	<	120
60128	BH05-10-SA-4	<	120
60130	BH05-13-SA-7	<	130
60132	BH05-15-SA-2	<	120
60134	BH05-18-SA-4	<	113
60136	BH05-21-SA-2	<	87
Lab Blank		<	125
Reg. 558, Leachate Quality Criteria		0.3	

### Comments:

Method Detection Limits (MDL) = 0.0001mg/L; < = mean less than MDL.

Ref. Method: Entech #: OWA-8: solvent extraction/GC/ECD.

Total PCB quantification based on a mixture of Aroclors 1254 and 1260.

Surrogate spike recovery control limits = 70%-130%.

Surrogate used is Decachlorobiphenyl.

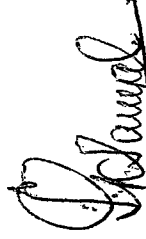
Reported results only for specified samples tested.

Dr. Asit Rakshit, Ph.D., C. Chem.  
Manager, Organics

# ENTECH

Client: Geo-Canada Ltd.  
Attention: Laifa Cao  
Project/P.O.: G-05-0701  
Sample Type: Soil  
Date Received: Nov 18/05  
Date Analysed: Nov 18/05  
Date Reported: Nov 24/05

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Sam Sanyal, M.Sc., C. Chem  
Manager, Inorganic Analysis.

## Certificate of Analysis

Data Pertain To Specific Sample(s) Tested

PARAMETER	Units	Method	CONTROL SAMPLE		SAMPLE DATA							
			Expected	Found	Recovery	Blank	60123	60126	60128	60131	60135	60135
		Detection  Limit	Conc.	Conc.	%		BH05-2- SA-2	BH05-8- SA-9	BH05-10- SA-4	BH05-14- SA-8	BH05-19- SA-1	BH05-19- SA-1 Duplicate
Sulphate	µg/g	0.25	12.60	12.06	96	<0.25	33.56	156	31.00	167	41.36	41.52

Sample Disposal: 30 Days from the Reporting Date.

Method:

Anions - Ion Chromatography (EPA 300.0)

Analyst(s): PI



**APPENDIX E**

**STATEMENT OF LIMITATIONS**



## **LIMITATIONS OF REPORT**

The conclusions and recommendations given in this report are based on information determined at the borehole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the borehole locations and may not be suitable for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Shaheen & Peaker Limited, accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.