



September 28, 2011

FOUNDATION INVESTIGATION REPORT

**REPLACEMENT OF WICKLOW RIVER BRIDGE NORTH
HIGHWAY 7037, SITE NO. 39E-174
TOWNSHIP OF LAMARCHE, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5139-06-00, AGREEMENT NO. 5008-E-0037**

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GEOCRES NO.: 42A-88

Report Number: 09-1191-0022-2

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REPORT





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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Wicklow River North Bridge (Site No. 39E-174), located on Highway 7037 (south of Cochrane) in the Township of Lamarche.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal (RFP) dated November 17, 2008. Golder's proposal P81-1685, dated December 2008, for foundation engineering services associated with the replacement bridge is contained in Sections 5.8 and 6.8 of LEA's Technical Proposal that forms part of the Consultant's Agreement Number 5008-E-0037 for this project. Subsequent to the award of the engineering services contract, the Preliminary and Detail Design investigation phases were combined to Detail Design level only and the originally planned detour was eliminated from the project scope. The work was carried out in accordance with Golder's Supplemental Specialty Quality Control Plan for this project dated September 16, 2009. The General Arrangement drawing for the replacement bridge was provided to Golder by LEA on April 11, 2011.

Subsurface information for the existing bridge is contained in the following Geocon Ltd. report available on GEOCREs (Geocon, 1959):

- "Soil Conditions and Foundations Report for the Proposed Bridge, Highway 11 Detour, Cochrane, Ontario" and "Boring Plan and Soil Stratigraphy, Drawing 59-F-228C" dated April 30, 1959, GEOCREs NO. 42A-015A&B.

The purpose of this investigation is to establish the subsurface conditions at the proposed replacement location by borehole drilling, in situ testing and laboratory testing on selected samples. The location of the investigated area is shown on the Contract Drawings.

2.0 SITE DESCRIPTION

The site is situated in the Township of Lamarche on Highway 7037 crossing the Wicklow River, approximately 1.6 km east of the junction with Highway 11. The surrounding stable land is generally flat, sloping steeply near and towards the river. The area is occupied mainly by residential developments, with grass and tree covered terrain beyond the various property limits. The river banks adjacent to the existing bridge area are vegetated with landscaped grass and small shrubs. The river flows in a northeast to southwest direction and is about 14 m wide at the existing bridge location.

The existing structure consists of a 58 m long by 4.9 m wide single-lane five-span Bailey bridge constructed in 1961. The existing structure is founded on timber piles. Based on available GEOCREs report (Geocon 1959), the piles were to be driven to depths between 9 m and 15 m below the adjacent ground surface. The actual length of the piles is unknown. The existing ground surface at the north and south project limits is at about Elevation 263.9 m and 262.7 m, respectively. The existing ground surface slopes down towards the north and south "abutments" at Elevation 258.2 m and 258.0 m, respectively, and then steeply to the river. The existing embankment front slopes are formed at approximately 3.6 horizontal to 1 vertical (3.6H:1V) on the north side of the river and 2.6H:1V on the south side of the river. The existing embankment appears to be constructed of earth fill, with side slopes ranging between about 1.6H:1V to 2.0H:1V at the northeast and southwest limits, respectively, where the embankment is skewed closer to the river.



The water level in the river was measured between Elevation 250.2 m and 252.1 m during the field investigation (i.e. April 8 to 15, 2011), and changed rapidly in the span of hours due to the Spring runoff (see Section 4.2.11 for details). The high water level is reported to be Elevation 251.8 m. The existing highway embankment grade is approximately 6 m above the surrounding ground surface adjacent to the river.

3.0 INVESTIGATION PROCEDURES

The fieldwork at the bridge site was carried out between April 8 and 15, 2011, during which time a total of six (6) boreholes (WN-1 to WN-6) were advanced: four boreholes (WN-1 to WN-4) at the proposed bridge abutments and approaches; and two boreholes (WN-5 and WN-6) near the toe of the existing northeast and southwest side slopes. The locations of and ground surface elevations at the boreholes are shown on The Contract Drawings.

Boreholes WN-1 to WN-4 were drilled using a CME 55 track-mounted drill rig and Boreholes WN-5 and WN-6 were drilled using a tripod mounted portable drill rig, both supplied and operated by George Downing Estate Drilling Ltd. (Downing) of Grenville-Sur-La-Rouge, Quebec. The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers, NW casing with wash boring and NQ size core barrels. In general, soil samples were obtained at intervals of depth of about 0.75 m to 3.0 m, using a 50 mm outer diameter (O.D.) split-spoon sampler operated by automatic hammers on the drill rigs and by manual hammers with the portable equipment, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Selected samples of the cohesive soils were obtained using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes. Two boreholes were partially advanced by coring through the very dense strata when split-spoon sampling indicated such conditions. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes for the bridge approaches, WN-1 and WN-4, were advanced to a depth of 15.8 m below ground surface. The boreholes for bridge abutments, WN-2 and WN-3, were advanced to refusal at depths of 46.1 m and 37.0 m below ground surface, respectively. The boreholes advanced on the existing side slopes near the toe of the existing embankments, WN-5 and WN-6, were advanced to depths of 17.1 m and 14.3 m below ground surface, respectively.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. Piezometers were installed in Boreholes WN-1 and WN-4 to allow monitoring of the stabilized groundwater level at these locations. The piezometers consist of 19 mm O.D. rigid PVC tubing with a 3.0 m long slotted screen sealed within the silty clay deposit. Flush mounted caps were used at ground surface. Details of the piezometer installations and water level readings are presented on the Record of Borehole sheets in Appendix A. The piezometers will be decommissioned at a later date.

Flowing artesian groundwater conditions were first observed within the silty sand till deposit in Borehole WN-2 and near the bottom of the silty clay to clay deposit in Borehole WN-3. Details of the sealing of the artesian boreholes are given in Section 4.2.11.



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

The fieldwork was supervised throughout by a member of our technical staff who located the boreholes, arranged for the clearance of underground services at the borehole locations, supervised the drilling and sampling operations, logged the boreholes, and examined and cared for the soil and cobbles/boulders core samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. One-dimensional consolidation (oedometer) tests were carried out on two Shelby tube samples of the cohesive soil.

The locations of the boreholes were laid out in the field by Golder relative to the existing bridge features. Golder surveyed the geodetic ground surface elevation of the boreholes once completed, referencing an existing benchmark located approximately 14 m north of the roadway centreline and 86 m east of the east limit of the existing bridge. The northing and easting coordinates were determined by plotting the boreholes relative to the existing bridge features shown on the General Arrangement drawing. The MTM NAD 83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depth for each borehole are presented on the Record of Borehole sheets in Appendix A and are summarised below.

Borehole	Borehole Location		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
WN-1	5428936.6	304214.6	258.3	15.8
WN-2	5428914.5	304207.7	257.6	46.1
WN-3	5428854.7	304217.2	257.9	37.0
WN-4	5428835.0	304209.3	259.2	15.8
WN-5	5428914.4	304225.1	252.3	17.1
WN-6	5428860.8	304206.5	254.5	14.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on terrain mapping by the Ontario Geological Survey¹, the subsurface soils in the vicinity of the site consist of glaciolacustrine plain deposits comprised of silts and clays bordering areas of organic terrain.

Based on bedrock mapping by the Ministry of Northern Development and Mines², this site is located in the Superior Province. The bedrock of this domain consists of mafic to ultramafic metavolcanic rocks bordering with areas of massive granodiorite to granite from the neoarchean to mesoarchean era.

¹ Ministry of Natural Resources, Northern Ontario Engineering Geology Terrain Study, Ontario Geological Survey Map 5026

² Ministry of Northern Development and Mines, Bedrock Geology of Ontario, East-Central Sheet, Map 2543.



4.2 Subsurface Conditions

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

The existing ground surface encountered at the north and south approaches along Highway 7037 (WN-1 and WN-4) is at Elevation 258.3 m and 259.2 m, respectively. The existing ground surface encountered along the side slopes near the proposed abutments (WN-2 and WN-3) is at Elevation 257.6 m and 257.9 m, respectively. The existing ground surface near the toe of the existing northeast slope (WN-5) and about mid-way down the southwest slope (WN-6) is at Elevation 252.3 m and 254.5 m, respectively.

In general, the subsoils consist of fill and alluvium underlain by a deposit of stiff to firm silty clay to clay, the lower portion of which is varved. Cohesionless deposits of silt, silty sand till, sand and gravel and silt till deposits underlie the silty clay to clay deposit at depth. These cohesionless deposits are underlain by cobbles and boulders. Refusal to split-spoon advancement was encountered at drilled depths of 46.1 m and 37.0 m below ground surface at Boreholes WN-2 and WN-3, respectively. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

A 50 mm and 25 mm thick layer of asphalt was encountered from ground surface in Boreholes WN-1 and WN-4, respectively.

4.2.2 Topsoil

A 50 mm to 75 mm thick layer of topsoil was encountered from ground surface in Boreholes WN-2, WN-3, WN-5 and WN-6.

4.2.3 Fill

Boreholes WN-1 and WN-4 were advanced within the shoulders or driving lane of the existing highway and Boreholes WN-2, WN-3 and WN-6 were drilled within the existing embankments. These boreholes encountered roadway/embankment fill consisting of granular fill and/or silty clay fill underlying the asphalt or topsoil. The fill material extends to depths between 0.8 m and 2.3 m below the existing ground surface, between Elevation 257.7 m and 253.7 m.

Granular Fill

Granular fill consisting of frozen to damp, brown gravelly sand, sand and silt, sand and gravel, or sand was encountered in Boreholes WN-1, WN-3, WN-4 and WN-6. The fill in Boreholes WN-2 and WN-6 is slightly organic.



The granular fill is between 0.1 m and 1.4 m thick and was encountered between Elevation 259.1 m and 254.4 m.

One SPT 'N'-value measured in the frozen granular fill is 72 blows per 0.3 m of penetration. One SPT 'N'-value measured in the non-frozen granular fill is 5 blows per 0.3 m of penetration indicating a loose relative density.

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

The natural water content measured on two samples of the granular fill is about 7 percent (gravelly sand fill) and about 22 percent (sand and silt fill).

Silty Clay Fill

A 0.7 m to 2.2 m thick layer of frozen to moist, brown to grey silty clay fill was encountered below the topsoil in Borehole WN-2 and below the granular fill in Boreholes WN-1, WN-3 and WN-4. The silty clay fill contains some to with sand, trace to some gravel and, in Borehole WN-1, is slightly organic. The surface of the silty clay fill was encountered between Elevation 259.0 m and 256.8 m.

The SPT 'N'-values measured in the frozen silty clay fill are between 24 and 27 blows per 0.3 m of penetration. The SPT 'N'-values measured in the non-frozen silty clay fill are between 7 and 10 blows per 0.3 m of penetration, suggesting a firm to stiff relative density.

Grain size distribution tests were carried out on two samples of the silty clay fill and the results are presented on Figure B-2. An Atterberg limits test was carried out on one sample of the silty clay fill and the test result is presented on Figure B-3. The liquid limit is 39 percent, the plastic limit is 20 percent and the plasticity index is 19 percent. These results indicate this sample of the fill is classified as silty clay of intermediate plasticity.

The natural water content measured on two samples of the silty clay fill is about 22 percent.

4.2.4 Clayey Silt to Silty Clay (Alluvium)

A deposit of wet, brown to black to grey, clayey silt to silty clay alluvium was encountered underlying the fill material in Boreholes WN-1, WN-2 and WN-6 and below the topsoil in Borehole WN-5. The alluvium contains trace to with sand and is slightly organic. The surface of the alluvium deposit was encountered between Elevation 256.0 m and 252.2 m and the thickness of the deposit ranges from 1.4 m to 4.8 m.

The SPT 'N'-values measured within the alluvium range from 2 blows to 13 blows per 0.3 m of penetration, suggesting a soft to stiff consistency.

Grain size distribution tests were carried out on three samples of the alluvium and the results are presented on Figure B-4. Atterberg limits tests were carried out on three samples of the alluvium deposit and the results are presented on Figure B-5. The liquid limits range from 32 percent to 45 percent, the plastic limits range from 19 percent to 20 percent and the plasticity indices range from 14 percent to 25 percent. The results indicate the alluvium deposit is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

The natural moisture content measured on seven samples of the alluvium range from about 25 percent to 60 percent.

The organic content measured on three samples of the alluvium is between 4 percent and 5 percent.



4.2.5 Silty Clay to Clay

A deposit of moist to wet, brown to grey, silty clay to clay containing trace to some sand was encountered below the alluvium in Boreholes WN-1, WN-2, WN-5 and WN-6 and below the fill in Boreholes WN-3 and WN-4. The surface of the silty clay deposit was encountered between Elevation 257.7 m and 250.2 m and the thickness of the deposit ranges between 12.2 m and 18.3 m where the deposit was fully penetrated. Boreholes WN-1, WN-4 and WN-6 were terminated within this deposit. The upper 0.8 m to 2.3 m of the silty clay to clay deposit encountered in Boreholes WN-1, WN-3 and WN-4 is considered to be the desiccated/weathered crust. The portion of the deposit between about Elevation 248 m and Elevation 241 m contains clay and silty clay/clayey silt varves. Towards the bottom of the deposit at about Elevation 238 m, a higher concentration of silt layers was encountered.

The SPT 'N'-values measured in the silty clay crust range from 5 blows to 10 blows per 0.3 m of penetration suggesting a stiff consistency. The SPT 'N'-values below the desiccated crust range from 0 blows (i.e. weight of hammer) to 6 blows per 0.3 m. In situ field vane testing carried out in the main portion of the deposit below the stiff upper crust measured undrained shear strengths ranging between 34 kPa and 57 kPa. The sensitivity of the silty clay to clay deposit is calculated to range between 3 and 12. The in situ vane test results, together with the SPT 'N'-values, indicate that the silty clay to clay deposit generally has a firm consistency becoming stiff towards the bottom of the deposit.

Grain size distribution tests were carried out on six samples of this deposit and the results are presented on Figure B-6. Atterberg limits tests were carried out on twenty-one samples of this deposit and the test results are presented on Figure B-7. The liquid limits range from 28 percent to 68 percent, the plastic limits range from about 16 percent to 27 percent and the plasticity indices range from about 11 percent to 41 percent.

The wide range of plasticity is indicative of the varved nature of the deposit. Where possible, Atterberg limits tests were carried out on samples from the Shelby tubes separated into the clay varved fraction and the 'siltier' varved fraction. The test results confirm that the clay varves are classified as a clay of high plasticity and the 'siltier' varves are a clayey silt to silty clay of low to intermediate plasticity. In most cases, it was not possible to separate the varves as they were too thin and, therefore, the combined test results were within the ranges noted above and typically comprise a silty clay of intermediate plasticity.

The natural moisture content measured on several samples of the silty clay to clay deposit ranges from 22 percent to 59 percent.

Two laboratory consolidation (oedometer) tests were carried out on specimens of the silty clay to clay obtained from Boreholes WN-2 (north abutment) and WN-3 (south abutment) and the test results are shown on Figures B8 and B-9, respectively. The preconsolidation stresses were estimated from the Void Ratio versus logarithmic Pressure plots using the Casagrande method as well as from the Total Work versus Pressure plots. The unit weight of the samples from Boreholes WN-2 and WN-3 is 17.1 kN/m^3 and 18.4 kN/m^3 , respectively, and the measured specific gravity is 2.7. The relevant consolidation test results are summarized below.



Borehole/ Sample Number	Elevation (m)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	e_o	C_r	C_c	c_v^* (cm ² /s)
WN-2/10	243.6	165	170	5	1.0	1.4	0.05	0.66	1.2×10^{-3}
WN-3/10	248.4	137	180	43	1.3	1.0	0.04	0.40	1.4×10^{-3}

Note: *For approximate stress range between the effective overburden stress and the final stress due to a 2.0 m and 1.6 m embankment grade raise at the north and south abutments that is $140 \text{ kPa} \leq \sigma_v' \leq 190 \text{ kPa}$.

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

4.2.6 Silt

A deposit of moist to wet, grey silt containing trace to some clay was encountered below the silty clay to clay deposit in Boreholes WN-2, WN-3 and WN-5. The surface of the silt deposit was encountered between Elevation 238.6 m and 237.5 m and the thickness of the deposit ranges from 3.4 m to 6.1 m. Borehole WN-5 was terminated within this deposit.

The SPT 'N'-values measured in the silt deposit range from 6 blows to 12 blows per 0.3 m of penetration. The portable tripod drill rig could not advance Borehole WN-5 below Elevation 238 m. A Dynamic Cone Penetration Test (DCPT) was initially driven from the bottom of the borehole between Elevation 238 m and 235.8 m, followed by a split-spoon at the bottom of the cone hole, yielding an SPT 'N'-value of 18 blows per 0.3 m of penetration. The SPT 'N'-values indicate that the silt deposit is compact to dense in relative density.

Grain size distribution tests were carried out on three samples of the silt deposit and the results are shown on Figure B-10. An Atterberg limits test was carried out on one sample of this deposit and the test result is presented on Figure B-11. The liquid limit is 25 percent, the plastic limit is about 20 percent and the plasticity index is about 5 percent, indicating that the deposit may be classified as silt of slight plasticity.

The natural moisture content measured on five samples of the silt ranges from 24 percent to 29 percent.

4.2.7 Silty Sand and Gravel (Till)

A deposit of moist to wet, grey silty sand and gravel till containing trace to some clay was encountered below the silt deposit in Boreholes WN-2 and WN-3. The surface of the till deposit was encountered at Elevation 232.1 m and 232.0 m and the deposit is 11.8 m and 9.5 m thick at the respective boreholes.

The SPT 'N'-values measured in the silty sand and gravel till range from 10 blows to 180 blows per 0.3 m of penetration indicating a compact to dense relative density. SPT 'N'-values of 43 blows and 133 blows per 0.15 m of penetration were recorded within this deposit and the split-spoon sampler was noted to be bouncing.

Seven samples of the till deposit were obtained using an NQ sized core barrel at depths where split-spoon samples could not be taken and coring was required to advance the borehole. In Borehole WN-2, the recovered soil core samples contained a 0.3 m diameter boulder between Elevation 223.9 m and 223.6 m and below Elevation 223.6 m contained gravel and cobble fragments. In Borehole WN-3, the recovered soil core sample also contained 0.15 m and 0.18 m diameter (cobble-size) rock.



Grain size distribution tests were carried out on four samples of the silty sand and gravel till and the results are shown on Figure B-12. Due to the nature of sampling method (i.e. NW casing with wash boring or NQ coring) within this deposit, it is suspected that some fines (i.e. silt and/or clays) were “washed” from the samples. In addition, due to the relatively large size of the coarse fractions (i.e. gravel), the grain size distributions may be skewed. Based on the laboratory test results and our visual examination, this deposit generally consists of silty sand and gravel till containing trace to some clay.

The natural moisture content measured on six samples of the silty sand and gravel till ranges between 6 percent and 26 percent and is typically lower with depth.

4.2.8 Silt (Till)

A deposit of moist to wet, grey silt till containing trace clay, sand and gravel was encountered underlying the silty sand and gravel till deposit in Borehole WN-2 and underlying the silty sand till deposit in Borehole WN-3. The surface of the silt till deposit was encountered at Elevation 220.3 m and 222.5 m and the thickness of the deposit is 4.5 m thick in Borehole WN-2 where it was fully penetrated and is 1.6 m thick in Borehole WN-3, which terminated within this deposit.

Soil/rock coring using an NQ sized core barrel was used to advance through the upper 1.5 m of the silt till deposit in Borehole WN-2. The SPT ‘N’-values measured within the silt till range from 127 blows to 207 blows per 0.15 m of penetration, indicating a very dense relative density.

Grain size distribution tests were carried out on two samples of the silt till deposit and the results are shown on Figure B-13.

The natural moisture content measured on two samples of the silt till is 13 percent and 18 percent.

4.2.9 Cobbles and Boulders

A deposit of cobbles and boulder within a silt, sand and gravel matrix was encountered underlying the silt till deposit in Borehole WN-2. The surface of the cobbles and boulders deposit was encountered at Elevation 215.8 m and the deposit was penetrated for 4.3 m to the borehole termination depth.

Soil/rock coring using an NQ sized core barrel was used to advance the borehole through the cobbles and boulders to a depth of 46.1 m below ground surface (i.e. to Elevation 211.5 m). The recovered core samples contained soil and granite rock core of cobble and boulder sizes between 0.15 m and 0.30 m. A split-spoon sample was taken at a depth of 46.1 m and the split-spoon was noted to be bouncing during the 100 blows driven for a penetration of 0.02 m.

4.2.10 Groundwater

Groundwater levels were measured in the open boreholes during and upon completion of drilling. Piezometers were installed in WN-1 and WN-4 and sealed within the silty clay deposit to monitor the groundwater levels over time. The measured groundwater levels in the open boreholes and piezometers are presented below.



Borehole	Installation	Time and/or Date	Groundwater Depth (m)	Groundwater Elevation (m)
WN-1	Open Borehole	Dry to bottom of borehole at 15.8 m depth (Elev. 242.5 m) upon completion of drilling	--	--
	Piezometer	April 21, 2011	12.8	245.5
		April 28, 2011	11.5	246.8
		July 3, 2011	3.10	255.2
WN-2	Open Borehole	April 9, 2011	2.1 m above ground surface (9.5 m above river level at time of drilling)	259.7
WN-3	Open borehole	April 13, 2011	2.4 m above ground surface (8.2 m above river level at time of drilling)	260.3
WN-4	Open Borehole	Dry to bottom of borehole at 15.8 m depth (Elev. 243.3 m) upon completion of drilling	--	--
	Piezometer	April 21, 2011	5.9	253.2
		April 28, 2011	7.8	251.4
		July 3, 2011	2.3	256.9
WN-5	Open Borehole	Upon completion of drilling (April 14, 2011)	0.3	252.0
WN-6	Open Borehole	Upon completion of drilling (April 15, 2011)	4.3	250.2

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling.

The water level in Wicklow River was measured between Elevation 250.2 m and 252.1 m during the field investigation from April 8 to 15, 2011 and at Elevation 250.2 m on July 3, 2011. The high water level is reported to be Elevation 251.8 m. It should be noted that the river water level fluctuated rapidly and significantly during the course of the drilling at this site, up to 1.9 m in a matter of hours, attributed to Spring runoff.

Groundwater and river water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

Artesian groundwater conditions were observed when advancing Borehole WN-2 through the silty sand till deposit in and near the bottom of the silty clay to clay deposit in Borehole WN-3.

Boreholes WN-2 and WN-3 were sealed full column with cement grout, consistent with Ontario Regulation 903 - Wells (as amended) using a mix design appropriate for the level of artesian head. On April 21 and during return visits to the site on April 28 and July 3, 2011 to obtain water level readings in the piezometers, it was confirmed visually that Boreholes WN-2 and WN-3 did not show artesian flow groundwater conditions.



5.0 CLOSURE

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



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DAM/SEMC/JMAC/lb

n:\active\2009\1190 sudbury\1191\09-1191-0022 lea brule and wicklows\7000 reporting\wicklow n\part a only\09-1191-0022 final 11sep28 wicklow north fir.docx



APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

1. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

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

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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



V. MINOR SOIL CONSTITUENTS

Percent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

1 OF 2 METRIC

CHECKED BY SC

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

PROJECT <u>09-1191-0022</u>		RECORD OF BOREHOLE No WN-1				2 OF 2 METRIC											
W.P. <u>5139-06-00</u>		LOCATION <u>N 5428936.6; E 304214.6</u>				ORIGINATED BY <u>ID</u>											
DIST <u>Cochrane</u> HWY <u>7037</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>JJL</u>											
DATUM <u>Geodetic</u>		DATE <u>April 11 and 12, 2011</u>				CHECKED BY <u>SC</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---																
242.5 15.8	SILTY CLAY, trace to some sand Firm Grey Wet Containing silt layers below approximately Elev. 243 m. END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling. 2. Water level in piezometer at a depth of 12.8 m (Elev. 245.5 m), 11.5 m (Elev. 246.8 m), and 3.1 m (Elev. 255.2 m) on April 21, 2011, April 28, 2011, and July 3, 2011 respectively.		10	SS	2		243								o		

PROJECT		09-1191-0022		RECORD OF BOREHOLE		No WN-2		1 OF 4		METRIC										
W.P.		5139-06-00		LOCATION		N 5428914.5; E 304207.7		ORIGINATED BY		ID										
DIST		Cochrane HWY 7037		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring		COMPILED BY		JJL										
DATUM		Geodetic		DATE		April 8 to 10, 2011		CHECKED BY		SC										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	20 40 60	γ	GR SA SI CL						
257.6	GROUND SURFACE																			
257.4	ORGANICS (Topsoil)																			
	Silty clay, some sand, trace gravel (FILL)																			
	Firm to stiff																			
	Brown																			
	Moist																			
255.3			1	SS	10		257													
2.3			2	SS	7		256													
	SILTY CLAY, trace sand, slightly organic (ALLUVIUM)																			
	Firm to stiff																			
	Brown to grey																			
	Moist																			
			3	SS	6		255													
			4	SS	4		254													
			5	SS	11		253													
			6	SS	13		252													
			7	SS	10		251													
			8	SS	5		250													
	Silty clay / clayey silt varves below approximately Elev. 248 m.																			
			9	TO	PH		249													
			10	TO	PH		248													
							247													
							246													
							245													
							244													
							243													

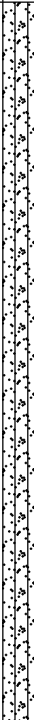

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+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT		09-1191-0022		RECORD OF BOREHOLE		No WN-2		2 OF 4		METRIC										
W.P.		5139-06-00		LOCATION		N 5428914.5; E 304207.7		ORIGINATED BY		ID										
DIST		Cochrane HWY 7037		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring		COMPILED BY		JJL										
DATUM		Geodetic		DATE		April 8 to 10, 2011		CHECKED BY		SC										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL			
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			W _p W W _L 20 40 60			18.1						
237.5	SILTY CLAY to CLAY, trace sand Firm to stiff Grey Wet Switched to NW Casing at 15.2 m depth. Containing silt layers below approximately Elev. 241 m.		11	TO	PH		242	4 + 4 +												
20.1	SILT, trace to some clay Loose to compact Grey Wet Containing some sand below 22.4 m depth (Elev. 235.2 m).		12	SS	9		241				4 4									
			13	SS	10		240													
			14	SS	11		239	5 + 5 +												
			15	SS	12		238													
232.1	Silty SAND and Gravel, trace to some clay (TILL) Dense to very dense Grey Wet Artesian conditions (water flowing out of casing) below 25.9 m depth (Elev. 231.7 m).		16	SS	35		237													
25.5			17	SS	47		236				○						0 0 89 11			
			18	SS	43/0.15		235													
			19	RC	REC 33%		234													
							233				○									
							232													
							231													
							230				○						30 40 25 5			
							229													
							228													

Continued Next Page


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

PROJECT		09-1191-0022		RECORD OF BOREHOLE No WN-2		3 OF 4 METRIC																									
W.P.		5139-06-00		LOCATION		N 5428914.5; E 304207.7																									
DIST		Cochrane HWY 7037		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring																									
DATUM		Geodetic		DATE		April 8 to 10, 2011																									
				ORIGINATED BY		ID																									
				COMPILED BY		JJL																									
				CHECKED BY		SC																									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)																
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL																			
--- CONTINUED FROM PREVIOUS PAGE ---																															
220.3 37.3	Silty SAND and Gravel, trace to some clay (TILL) Dense to very dense Grey Wet Artesian conditions (water flowing out of casing) below 25.9 m depth (Elev. 231.7 m). Boulder cored between 33.7 m and 34.0 m depth (Elev. 223.9 -223.6 m) Gravel and cobble fragments recovered from core sample numbers 23 and 24. Pockets of clayey silt, trace sand, trace gravel at 36.6 m depth.		20	RC	REC 30%		227																								
			21	RC	REC 20%		226																								
			22	RC	REC 40%		225																								
			23	RC	REC 15%		224																								
			24	RC	REC 20%		223																								
			25	RC	REC 7%		222																								
215.8 41.8	SILT, trace clay, sand and gravel (TILL) Very dense Grey Wet Switched to NW casing at 38.8 m depth. Casing refusal at 41.8 m depth. COBBLES and BOULDERS in a silt / sand / gravel matrix Switched to NQ coring at 41.8 m depth. Recovered pink / grey granite rock core at: <table border="1" style="font-size: small;"> <tr> <th>Depth (m)</th> <th>Thickness (mm)</th> </tr> <tr><td>41.8</td><td>305</td></tr> <tr><td>42.3</td><td>150</td></tr> <tr><td>42.6</td><td>150</td></tr> <tr><td>42.9</td><td>150</td></tr> <tr><td>43.2</td><td>150</td></tr> <tr><td>43.3</td><td>230</td></tr> <tr><td>43.8</td><td>305</td></tr> <tr><td>44.5</td><td>280</td></tr> </table>	Depth (m)	Thickness (mm)	41.8	305	42.3	150	42.6	150	42.9	150	43.2	150	43.3	230	43.8	305	44.5	280		26	SS	207/0.15		221						
		Depth (m)	Thickness (mm)																												
		41.8	305																												
42.3	150																														
42.6	150																														
42.9	150																														
43.2	150																														
43.3	230																														
43.8	305																														
44.5	280																														
27	SS	136/0.15		220																											
28	RC	REC 56%		219																											
			29	RC	REC 64%		218																								
							217																								
							216																								
							215																								
							214																								
							213																								

Continued Next Page

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

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

PROJECT <u>09-1191-0022</u>		RECORD OF BOREHOLE No WN-2				4 OF 4 METRIC										
W.P. <u>5139-06-00</u>		LOCATION <u>N 5428914.5; E 304207.7</u>				ORIGINATED BY <u>ID</u>										
DIST <u>Cochrane</u> HWY <u>7037</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring</u>				COMPILED BY <u>JJL</u>										
DATUM <u>Geodetic</u>		DATE <u>April 8 to 10, 2011</u>				CHECKED BY <u>SC</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p W W _L			
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					20 40 60 WATER CONTENT (%)				
211.5 46.1	END OF BOREHOLE SPOON REFUSAL Note: 1. Water level at 2.1 m above ground surface (Elev. 259.7 m) prior to coring through cobbles and boulders deposit.		30	RC	REC 40%	212										
			31	CS	100/0.02											

PROJECT 09-1191-0022			RECORD OF BOREHOLE No WN-3			1 OF 3 METRIC						
W.P. 5139-06-00			LOCATION N 5428854.7; E 304217.2			ORIGINATED BY ID						
DIST Cochrane HWY 7037			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring			COMPILED BY JJL						
DATUM Geodetic			DATE April 13 and 14, 2011			CHECKED BY SC						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL
257.9	GROUND SURFACE											
0.0	ORGANICS (Topsoil)		1	AS	-							5 58 25 13
257.1	Silty sand, trace to some gravel, trace clay, slightly organic (FILL) Frozen Brown to black		2	SS	8		257					11 43 22 24
256.4	Silty clay, with sand, trace to some gravel (FILL) Firm to stiff Brown		3	SS	8		256					
1.5	Moist SILTY CLAY, trace sand Firm to stiff Brown to grey Moist		4	SS	8		255					
			5	SS	5							
254.1	SILT CLAY, trace sand Firm to stiff Grey Wet		6	SS	3		254					
3.8			7	SS	3		253					
			8	SS	3		252					
			9	TO	PH		250					
			10	TO	PH		249					
							248					
							247					
							246					
							245					
							244					
							243					

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

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PROJECT 09-1191-0022			RECORD OF BOREHOLE No WN-3			2 OF 3 METRIC		
W.P. 5139-06-00			LOCATION N 5428854.7; E 304217.2			ORIGINATED BY ID		
DIST Cochrane HWY 7037			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring			COMPILED BY JLL		
DATUM Geodetic			DATE April 13 and 14, 2011			CHECKED BY SC		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60
<div style="display: flex; justify-content: space-between;"> UNIT WEIGHT γ kN/m³ REMARKS & GRAIN SIZE DISTRIBUTION (%) </div> <div style="display: flex; justify-content: space-between;"> GR SA SI CL </div>								
238.1	SILT CLAY, trace sand Firm to stiff Grey Wet Switched to NW Casing at 15.2 m depth. Artesian conditions (water flowing out of casing) first encountered below 16.8 m depth (Elev. 241.1 m) Containing silt layers below approximately Elev. 241 m.		12	SS	5		242	
			13	SS	3		241	
			14	SS	4		240	6 + 6 +
							239	
19.8	SILT, trace to some clay and / or clayey layers, trace sand Loose to compact Grey Wet Artesian groundwater level measurement taken within silt deposit at 22.9 m depth (Elev. 235.0 m)		15	SS	7		238	H o
			16	SS	12		237	
			17	SS	12		236	
			18	SS	9		235	
							234	
							233	o
232.0	Silty SAND and Gravel, trace to some clay (TILL) Compact to very dense Grey Wet Casing refusal at 27.9 m depth. Switched to NQ coring between 27.9 m and 29.4 m depth. Recovered a 0.15 m length grey granite cobble at 28.1 m depth and a 0.18 m length white quartz cobble at 28.9 m depth..		19	SS	16		232	
25.9			20	SS	24		231	o
			-	RC	REC 28%		230	
			21	SS	10		229	o
							228	

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

Continued Next Page

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

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

PROJECT 09-1191-0022				RECORD OF BOREHOLE No WN-4				1 OF 2 METRIC					
W.P. 5139-06-00				LOCATION N 5428835.0; E 304209.3				ORIGINATED BY ID					
DIST Cochrane HWY 7037				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY JLL					
DATUM Geodetic				DATE April 15, 2011				CHECKED BY SC					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					
259.2	GROUND SURFACE												
0.0	ASPHALT (Surface Treatment)												
0.2	Sand and gravel, trace silt (FILL) Frozen Brown												
	Silty clay, some sand (FILL) Very stiff (Frozen) Brown		1	SS	24								
257.7													
1.5	CLAYEY SILT, trace sand Stiff Brown Moist		2	SS	9								
256.9													
2.3	SILTY CLAY to CLAY, trace to some sand Firm Grey Wet		3	SS	6								
			4	SS	6								
			5	SS	4								
			6	SS	3								
			7	SS	4								
			8	SS	1								
			9	SS	WH								

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

Continued Next Page

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

PROJECT <u>09-1191-0022</u>		RECORD OF BOREHOLE No WN-4		2 OF 2 METRIC	
W.P. <u>5139-06-00</u>		LOCATION <u>N 5428835.0; E 304209.3</u>		ORIGINATED BY <u>ID</u>	
DIST <u>Cochrane</u> HWY <u>7037</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>JJL</u>	
DATUM <u>Geodetic</u>		DATE <u>April 15, 2011</u>		CHECKED BY <u>SC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) w _p w w _L					GR	SA	SI	CL
-- CONTINUED FROM PREVIOUS PAGE --								20	40	60	80	100									
243.4 15.8	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling. 2. Water level in piezometer at a depth of 5.9 m (Elev. 253.2 m), 7.8 m (Elev. 251.4 m), and 2.3 m (Elev. 256.9 m) on April 21, 2011, April 28, 2011 and July 3, 2011 respectively.		10	SS	WH		244								o						

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

[illegible]

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

Continued Next Page

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

PROJECT		RECORD OF BOREHOLE				No WN-5		2 OF 2		METRIC								
W.P. 5139-06-00		LOCATION				N 5428914.4; E 304225.1		ORIGINATED BY ID										
DIST Cochrane HWY 7037		BOREHOLE TYPE				Portable Equipment, NW Casing, Wash Boring		COMPILED BY JJL										
DATUM Geodetic		DATE				April 12 to 14, 2011		CHECKED BY SC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa										
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60 WATER CONTENT (%)						
235.2	SILT, some clay and / or clay layers Loose to compact Grey Wet Split Spoon advanced from bottom of DCPT hole at 16.5 m depth for 2.2 m.		10	SS	18		237											
17.1	END OF BOREHOLE Note: 1. Tripod could not advance borehole beyond 14.3 m depth (Elev. 240.2 m). 2. Water level at a depth of 0.3 m below ground surface (Elev. 252.0 m) upon completion of drilling.						236										0 0 86 14	

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

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

SUD-MTO 001 09-1191-0022.GPJ GAL-MISS.GDT 28/09/11 DATA INPUT:

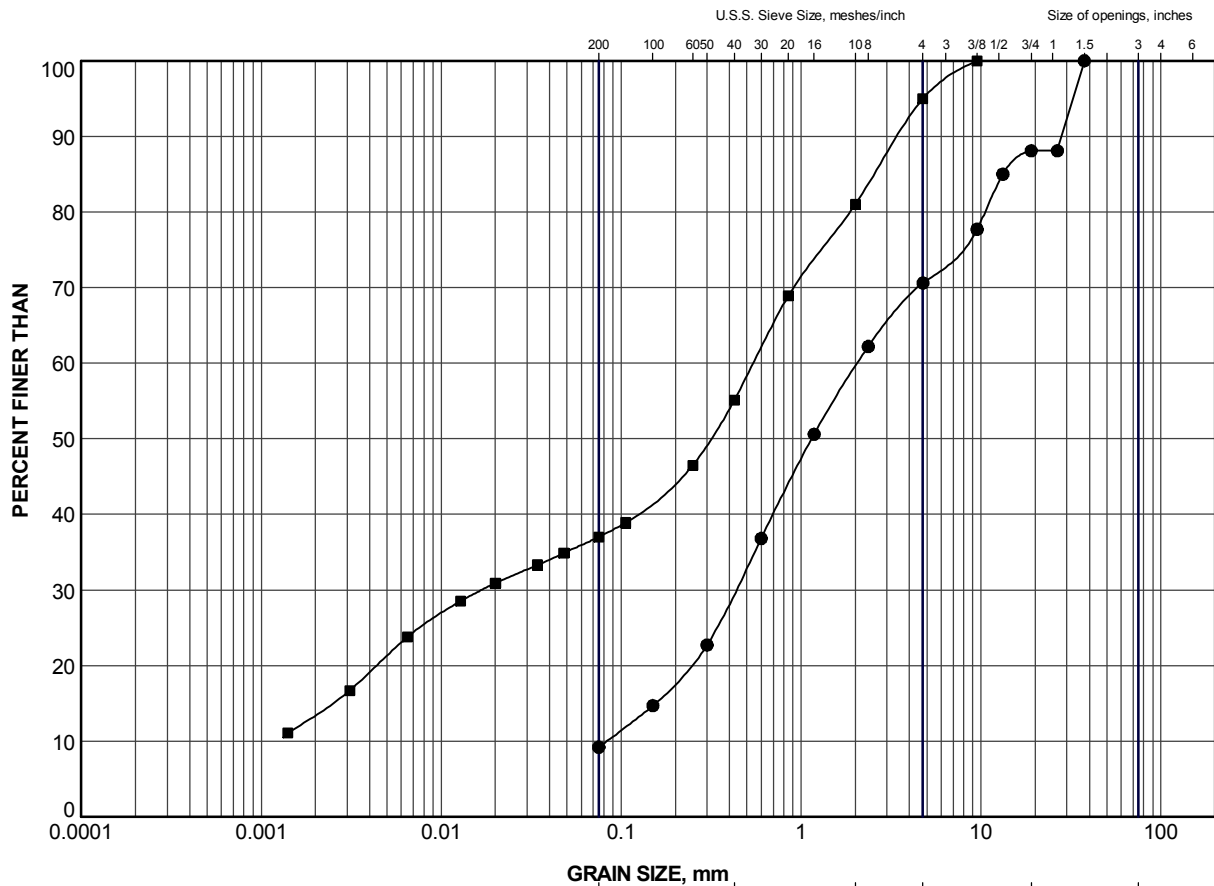
PROJECT <u>09-1191-0022</u>		RECORD OF BOREHOLE No WN-6				2 OF 2 METRIC	
W.P. <u>5139-06-00</u>		LOCATION <u>N 5428860.8; E 304206.5</u>				ORIGINATED BY <u>ID</u>	
DIST <u>Cochrane</u> HWY <u>7037</u>		BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>				COMPILED BY <u>JJL</u>	
DATUM <u>Geodetic</u>		DATE <u>April 14 and 15, 2011</u>				CHECKED BY <u>SC</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
	<p style="text-align: center;">--- CONTINUED FROM PREVIOUS PAGE ---</p> <p>END OF BOREHOLE</p> <p>Note:</p> <p>1. Tripod could not advance borehole beyond 14.3 m depth (Elev. 240.2 m).</p> <p>2. Water level at a depth of 4.3 m below ground surface (Elev. 250.2 m) upon completion of drilling.</p>															



APPENDIX B


Laboratory Test Results

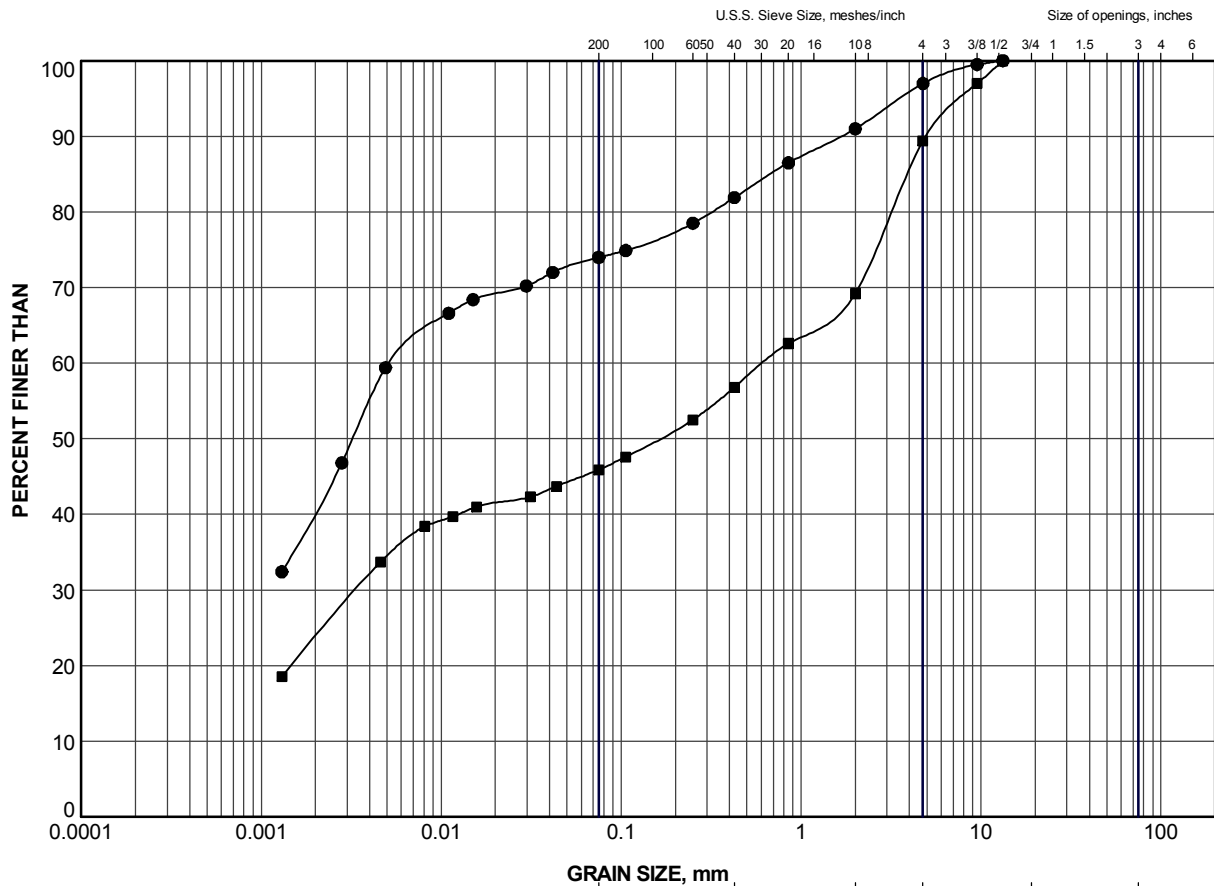


CLAY AND SILT	GRAVEL SIZE, mm						Cobble Size
	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-1	1	257.2
■	WN-3	1	257.6


PROJECT						WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE						GRAIN SIZE DISTRIBUTION GRAVELLY SAND TO SILTY SAND (FILL)					
PROJECT No.			09-1191-0022			FILE No.			09-1191-0022.GPJ		
DRAWN		J.J.L.		Sep 2011		SCALE		N/A		REV.	
CHECK		DAM		Sep 2011							
APPR				Sep 2011							
 Golder Associates SUDBURY, ONTARIO						FIGURE B-1					

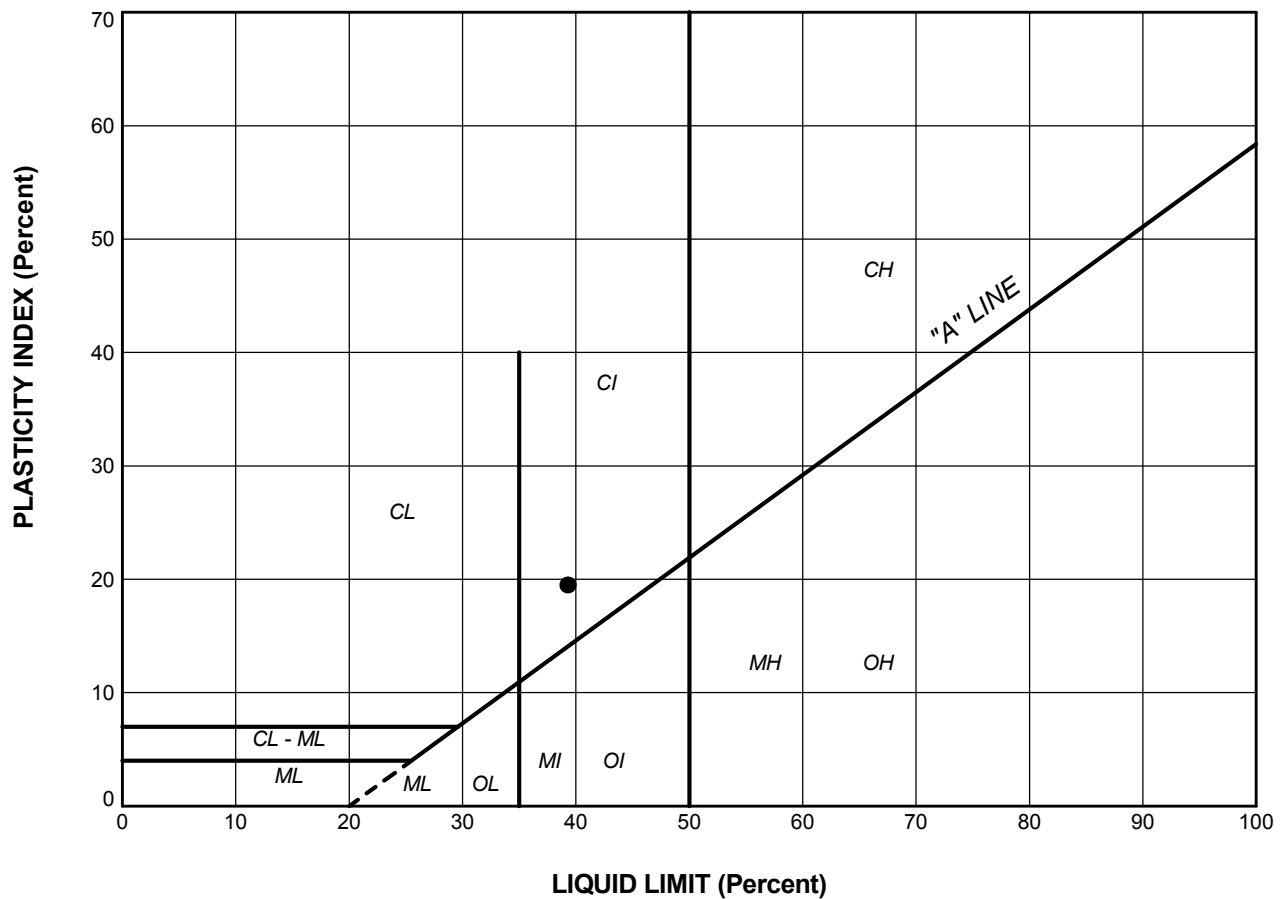


GRAVEL SIZE, mm						Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-2	1	256.5
■	WN-3	2	256.8

PROJECT						WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE						GRAIN SIZE DISTRIBUTION SILTY CLAY (FILL)					
PROJECT No.			09-1191-0022			FILE No.			09-1191-0022.GPJ		
DRAWN		J.J.L.		Sep 2011		SCALE		N/A		REV.	
CHECK		DAM		Sep 2011							
APPR				Sep 2011							
 Golder Associates SUDBURY, ONTARIO						FIGURE B-2					

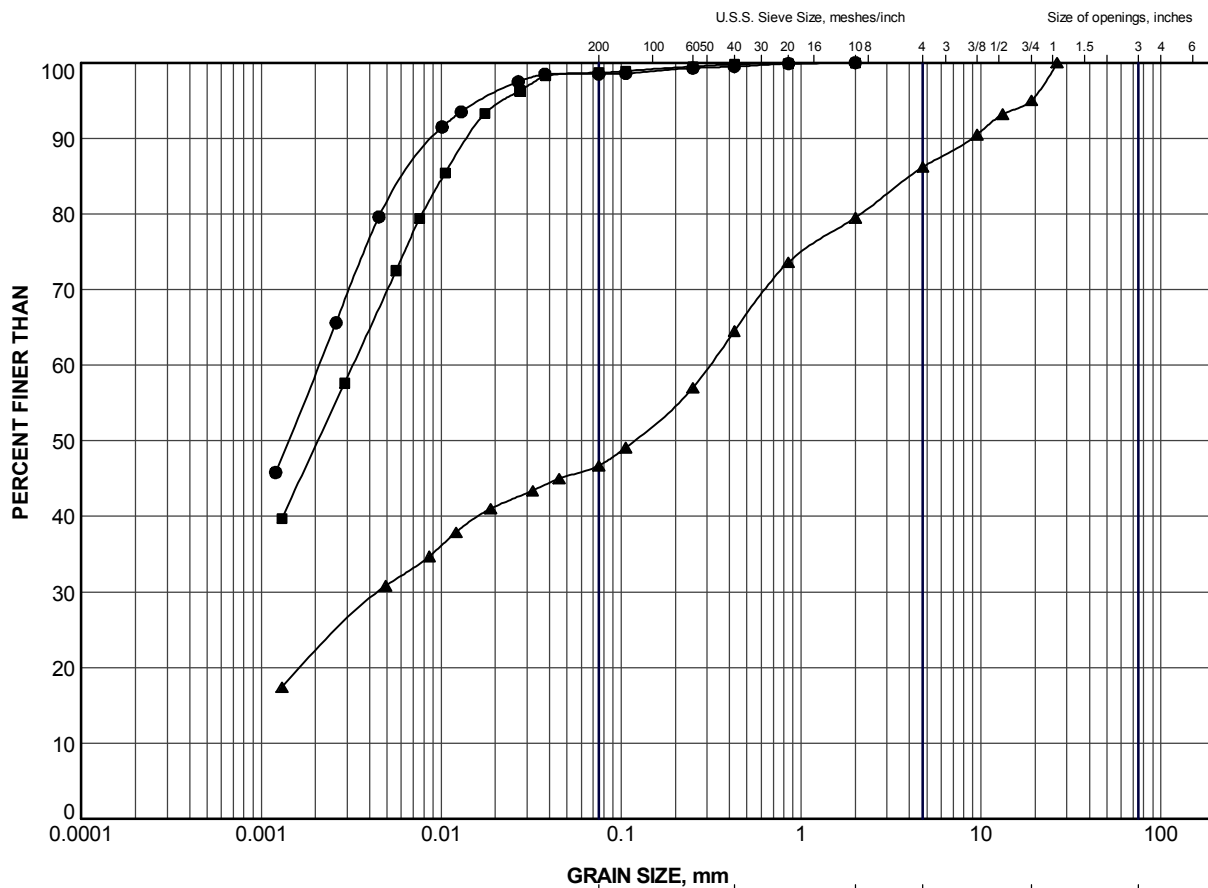


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	WN-2	1	39.3	19.8	19.5

PROJECT					
WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE					
PLASTICITY CHART SILTY CLAY (FILL)					
PROJECT No. 09-1191-0022			FILE No. 09-1191-0022.GPJ		
DRAWN	JJL	Sep 2011	SCALE	N/A	REV.
CHECK	DAM	Sep 2011	FIGURE B-3		
APPR		Sep 2011			




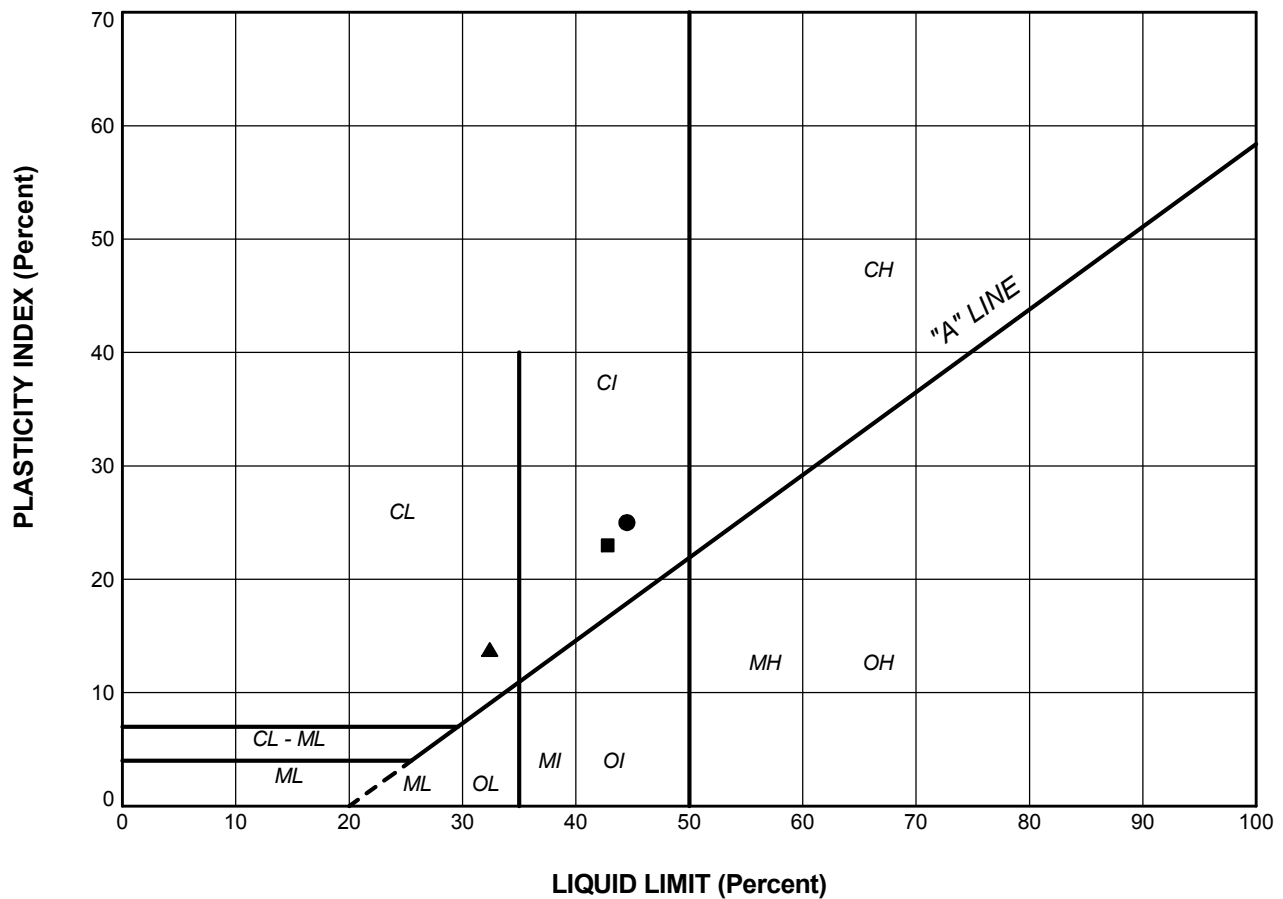


CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-1	3	255.7
■	WN-2	6	252.8
▲	WN-6	3	252.7

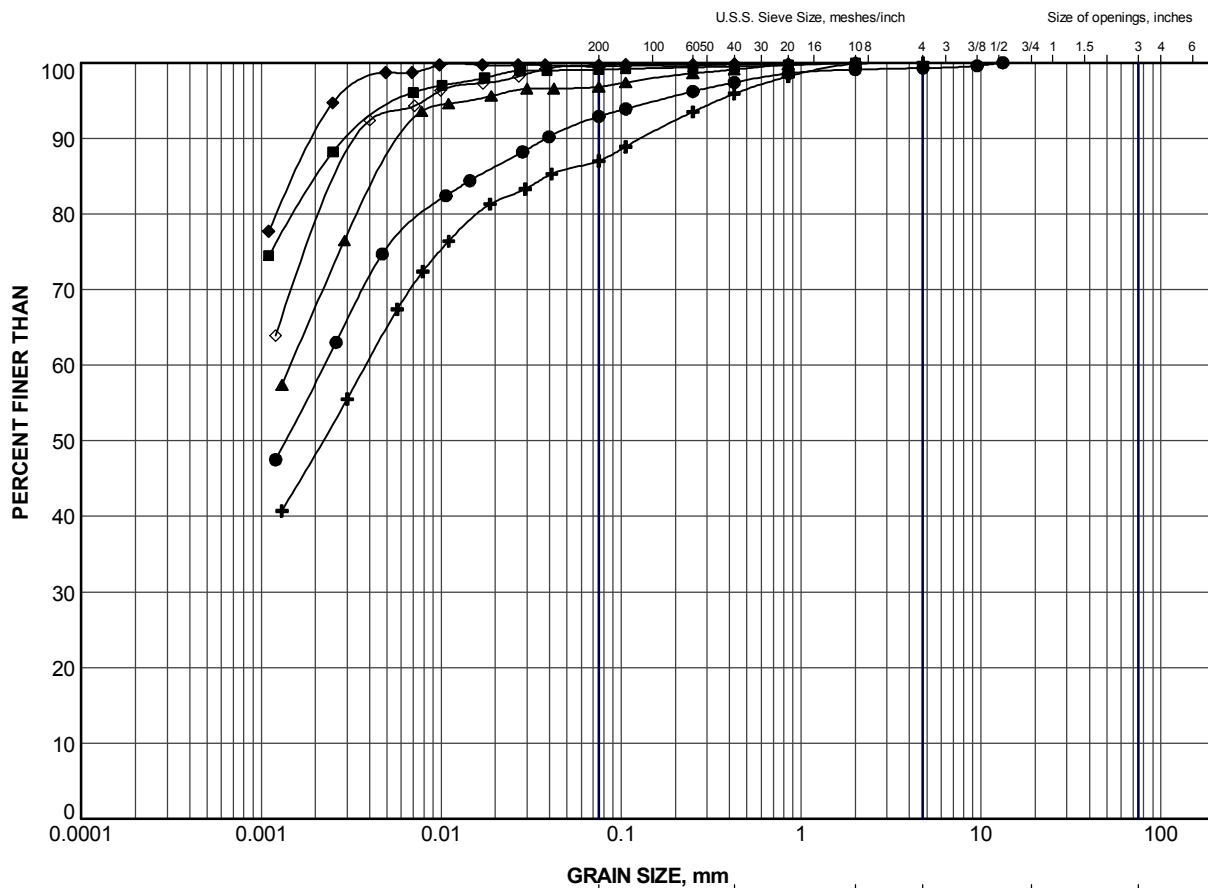
PROJECT					
WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILTY CLAY (ALLUVIUM)					
PROJECT No.		09-1191-0022		FILE No. 09-1191-0022.GPJ	
DRAWN	JJL	Sep 2011	SCALE	N/A	REV.
CHECK	DAM	Sep 2011			
APPR		Sep 2011			
 Golder Associates SUDBURY, ONTARIO			FIGURE B-4		



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	WN-1	3	44.5	19.5	25.0
■	WN-2	6	42.8	19.8	23.0
▲	WN-6	3	32.4	18.6	13.8

PROJECT					
WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE					
PLASTICITY CHART CLAYEY SILT TO SILTY CLAY (ALLUVIUM)					
PROJECT No.		09-1191-0022		FILE No.	
DRAWN		J.J.L.		Sep 2011	
CHECK		DAM		Sep 2011	
APPR				Sep 2011	
SCALE		N/A		REV.	
 Golder Associates SUDBURY, ONTARIO				FIGURE B-5	



CLAY AND SILT		GRAVEL SIZE, mm				Cobble Size	
		fine	medium	coarse	fine		coarse
		SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-1	8	248.9
■	WN-2	9	246.6
▲	WN-3	10	248.5
+	WN-4	6	252.8
◆	WN-5	6	247.4
◇	WN-6	9	243.5

PROJECT

WICKLOW RIVER BRIDGE NORTH
HIGHWAY 7037

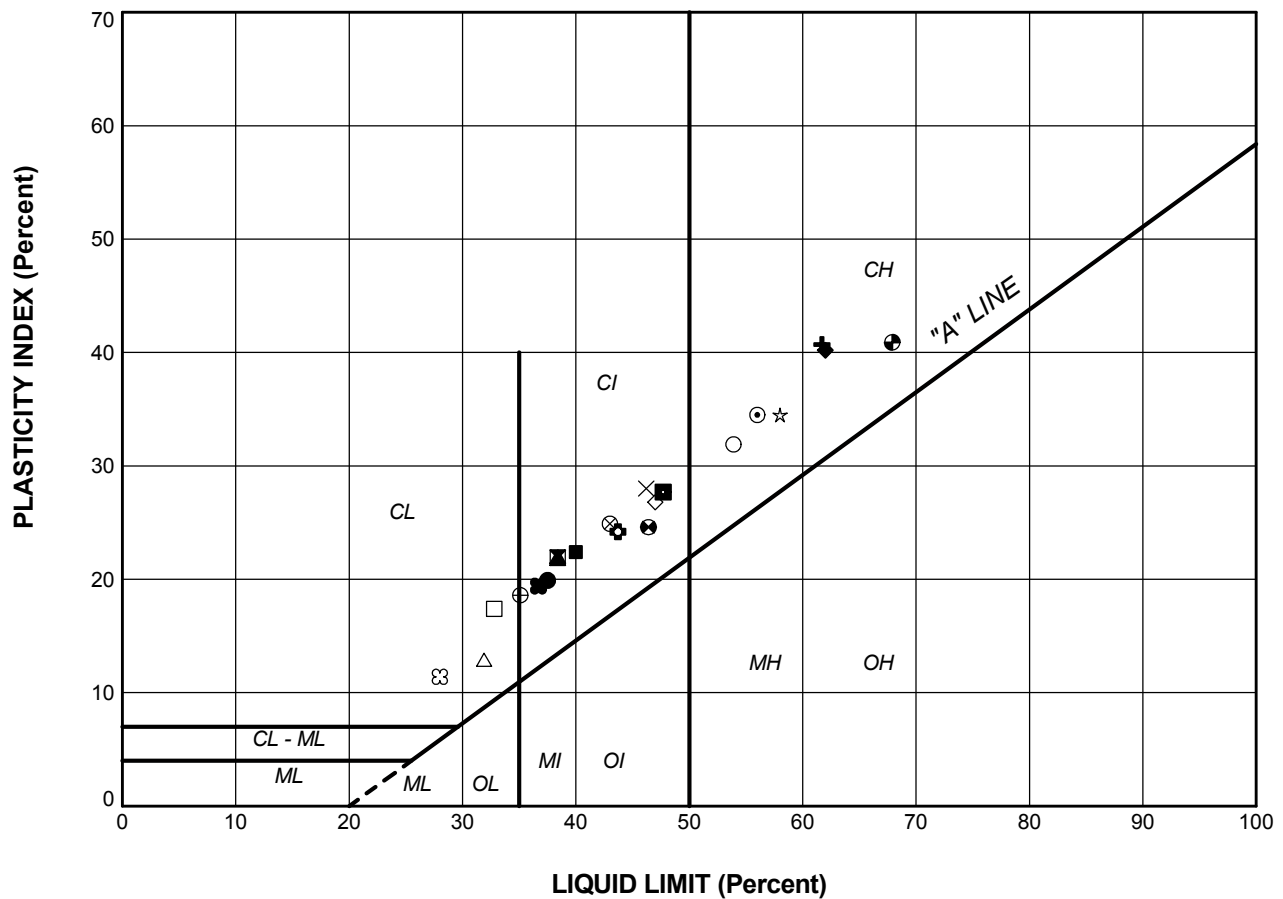
TITLE

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY



Golder Associates
SUDBURY, ONTARIO

PROJECT No. 09-1191-0022			FILE No. 09-1191-0022.GPJ		
DRAWN	JJL	Sep 2011	SCALE	N/A	REV.
CHECK	DAM	Sep 2011	FIGURE B-6		
APPR		Sep 2011			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	WN-1	5	37.5	17.6	19.9
■	WN-1	8	40.0	17.6	22.4
▲	WN-2	8	38.4	16.4	22.0
+	WN-2	9	61.7	21.0	40.7
◆	WN-2	10	62.0	21.8	40.2
◇	WN-2	10	47.0	20.2	26.8
○	WN-2	11	53.9	22.0	31.9
△	WN-2	11	31.9	19.0	12.9
⊗	WN-3	4	43.0	18.1	24.9
⊕	WN-3	8	35.1	16.5	18.6
□	WN-3	9	32.8	15.4	17.4
⊙	WN-3	10	46.4	21.8	24.6
⊛	WN-3	11	67.9	27.0	40.9
☆	WN-3	11	58.0	23.5	34.5
⊗	WN-4	2	28.0	16.6	11.4
⊕	WN-4	4	38.4	16.5	21.9
⊙	WN-4	8	56.0	21.5	34.5
⊛	WN-5	4	43.7	19.5	24.2
×	WN-5	6	46.2	18.2	28.0
■	WN-6	5	36.7	17.3	19.4
■	WN-6	9	47.7	20.0	27.7

PROJECT				
WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037				
TITLE				
PLASTICITY CHART CLAYEY SILT TO CLAY				
PROJECT No.		09-1191-0022		FILE No.
DRAWN		JJL	Sep 2011	SCALE
CHECK		DAM	Sep 2011	REV.
APPR		Sep 2011		FIGURE B-7



CONSOLIDATION TEST SUMMARY**FIGURE B-8****Pg. 1 of 4****SAMPLE IDENTIFICATION**

Project Number: 09-1191-0022

Sample Number: 10

Borehole Number: WN-2

Sample Depth, m: 13.7

TEST CONDITIONS

Test Type Standard

Load Duration, hr 24

Oedometer Number 1

Date Started June 18/11

Date Completed June 30/11

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.550	Unit Weight, kN/m ³	17.12
Sample Diameter, cm	6.330	Dry Unit Weight, kN/m ³	11.02
Area, cm ²	31.47	Specific Gravity, assumed	2.70
Volume, cm ³	80.25	Solids Height, cm	1.061
Water Content, %	55.36	Volume of Solids, cm ³	33.39
Wet Mass, g	140.06	Volume of Voids, cm ³	46.86
Dry Mass, g	90.15	Degree of Saturation, %	106.5

TEST COMPUTATIONS

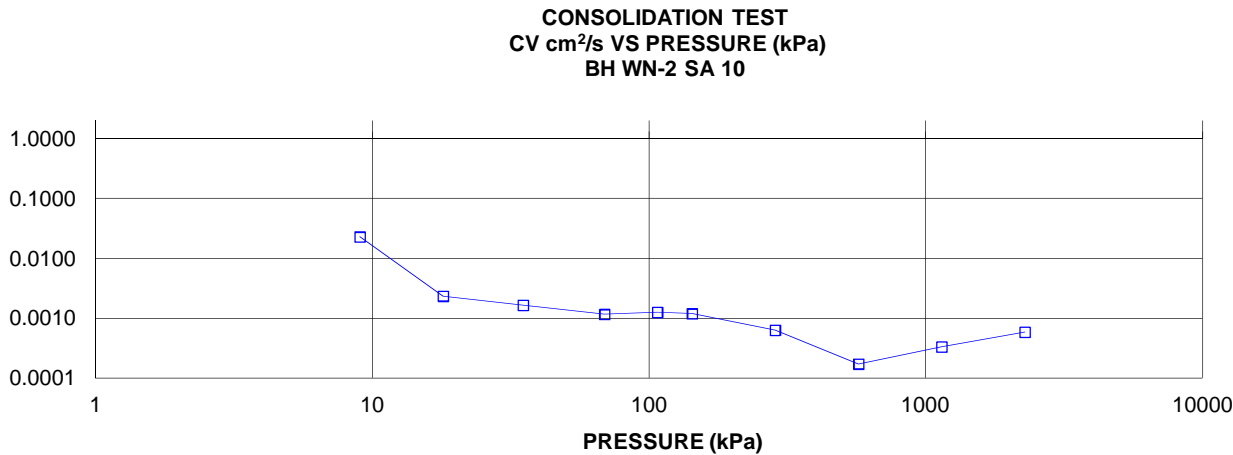
Pressure kPa	Primary Consolidation	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s	Total Work kJ/m ³
0	0	2.550	1.403	2.550					
9	0.02	2.548	1.401	2.549	60	0.0230	1.05E-04	2.37E-07	0.004
18	0.04	2.544	1.397	2.546	580	0.0024	1.70E-04	3.94E-08	0.025
35	0.08	2.535	1.390	2.540	820	0.0017	1.90E-04	3.11E-08	0.111
69	0.14	2.521	1.376	2.528	1160	0.0012	1.65E-04	1.89E-08	0.404
107	0.11	2.510	1.366	2.516	1058	0.0013	1.14E-04	1.41E-08	0.788
143	0.09	2.501	1.357	2.506	1109	0.0012	1.06E-04	1.25E-08	1.245
285	0.68	2.433	1.293	2.467	2018	0.0006	1.88E-04	1.18E-08	7.063
571	2.10	2.223	1.095	2.328	6615	0.0002	2.88E-04	4.90E-09	44.003
1140	1.32	2.091	0.971	2.157	2940	0.0003	9.10E-05	2.99E-09	94.799
2279	0.96	1.995	0.880	2.043	1500	0.0006	3.31E-05	1.91E-09	173.279
1140	-0.16	2.011	0.896	2.003					
285	-0.58	2.069	0.950	2.040					
69	-0.72	2.141	1.018	2.105					
9	-1.138	2.254	1.125	2.197					

Note:

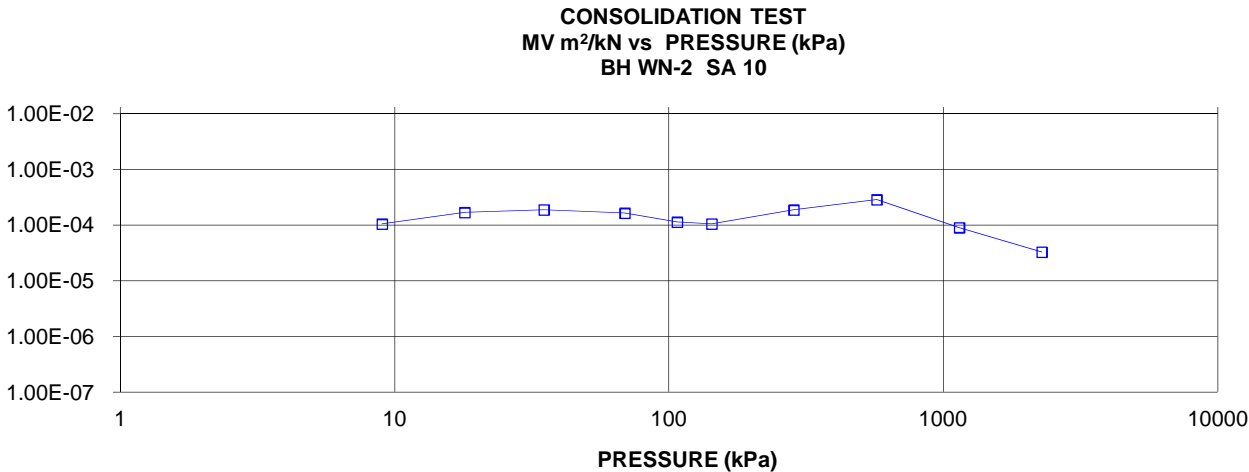
k calculated using α based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	2.254	Unit Weight, kN/m ³	17.25
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	12.46
Area, cm ²	31.47	Specific Gravity, assumed	2.70
Volume, cm ³	70.94	Solids Height, cm	1.061
Water Content, %	38.45	Volume of Solids, cm ³	33.39
Wet Mass, g	124.81	Volume of Voids, cm ³	37.55
Dry Mass, g	90.15		

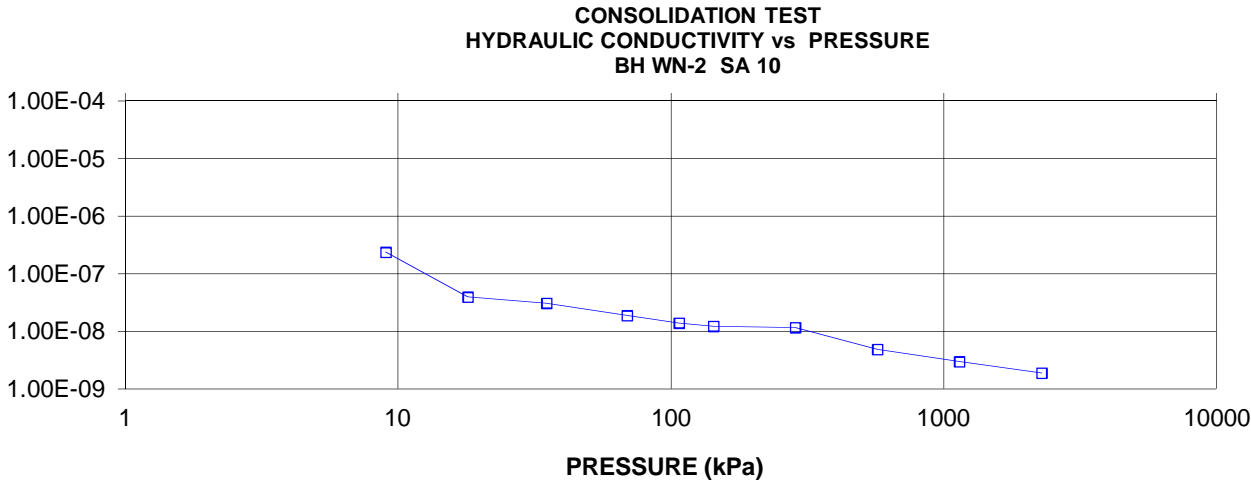
COEFFICIENT OF CONSOLIDATION,
cm²/s



VOLUME COMPRESSIBILITY, m²/kN



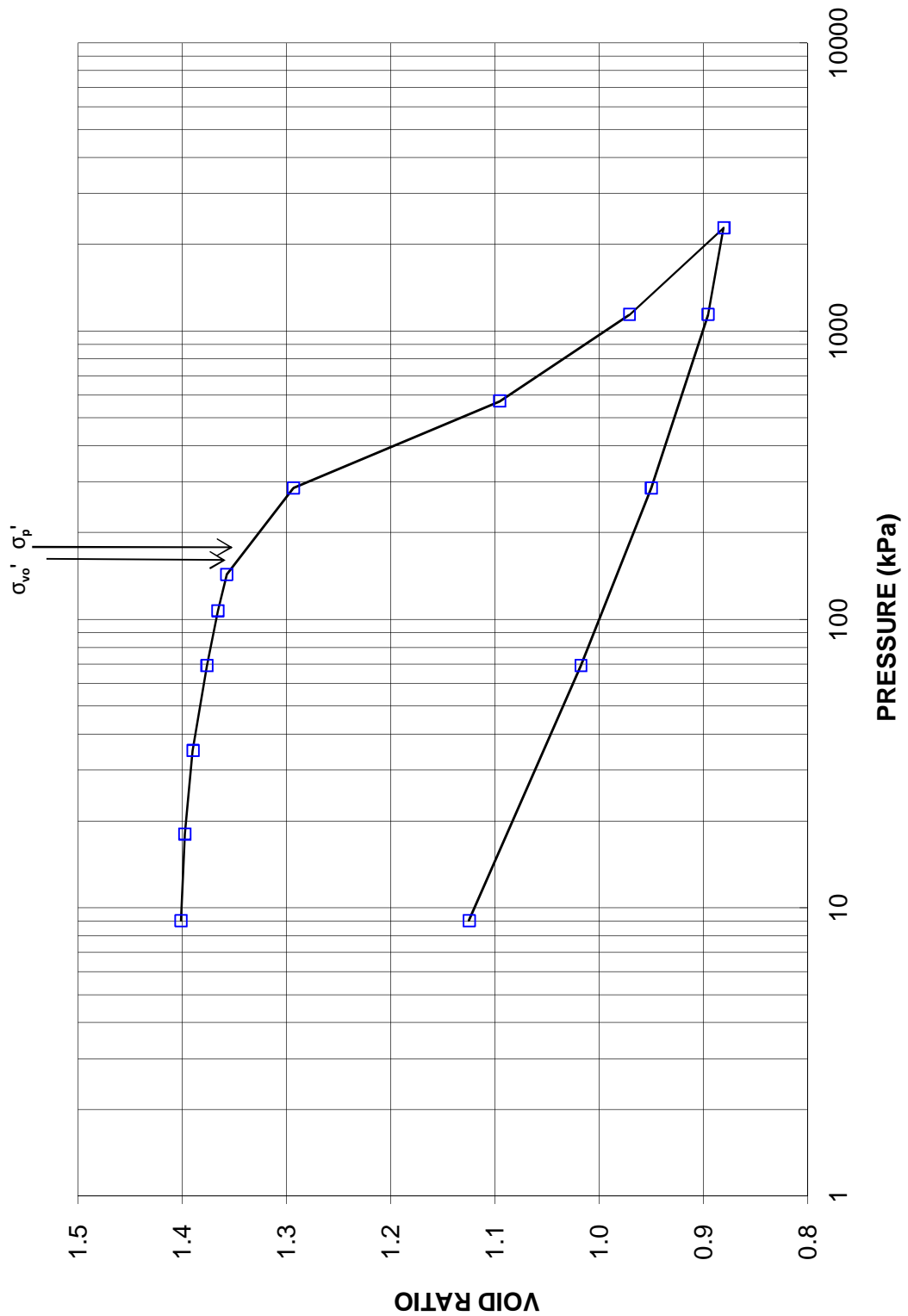
HYDRAULIC CONDUCTIVITY,
cm/s



CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE

FIGURE B-8
Pg. 3 of 4

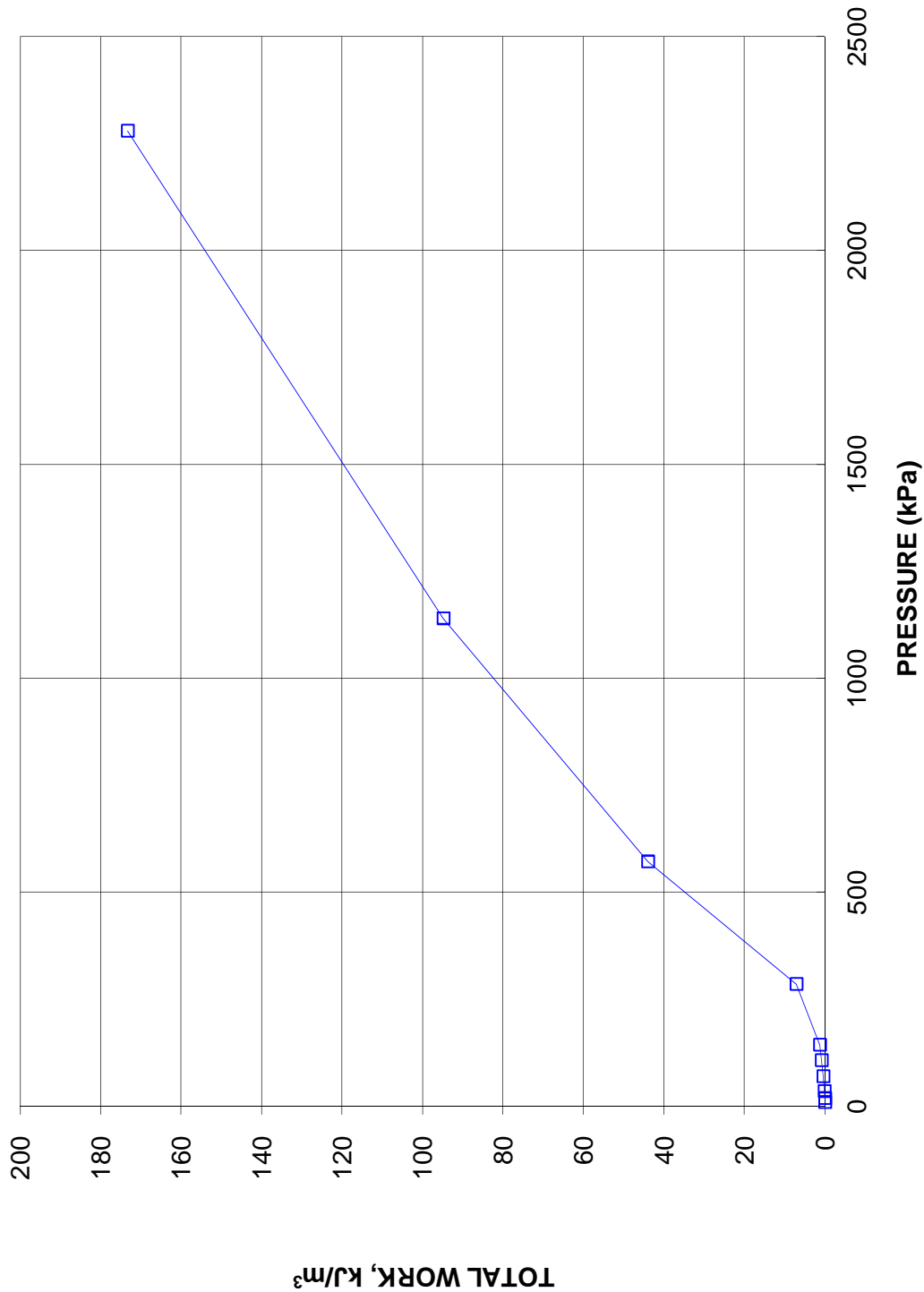
CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH WN-2 SA 10



CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B-8
Pg. 4 of 4

CONSOLIDATION TEST
TOTAL WORK, kJ/m^3 vs PRESSURE
BH WN-2 SA 10



CONSOLIDATION TEST SUMMARY**FIGURE B-9**

Pg. 1 of 4

SAMPLE IDENTIFICATION

Project Number: 09-1191-0022

Sample Number: 10

Borehole Number: WN-3

Sample Depth, m: 9.5

TEST CONDITIONS

Test Type Standard

Load Duration, hr 24

Oedometer Number 1

Date Started May 11/11

Date Completed May 25/11

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.550	Unit Weight, kN/m ³	18.41
Sample Diameter, cm	6.330	Dry Unit Weight, kN/m ³	13.28
Area, cm ²	31.47	Specific Gravity, measured	2.71
Volume, cm ³	80.25	Solids Height, cm	1.276
Water Content, %	38.64	Volume of Solids, cm ³	40.17
Wet Mass, g	150.63	Volume of Voids, cm ³	40.08
Dry Mass, g	108.65	Degree of Saturation, %	104.7

TEST COMPUTATIONS

Pressure kPa	Primary Consolidation	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s	Total Work kJ/m ³
0	0	2.550	0.998	2.550					
18	0.03	2.547	0.996	2.549	60	0.0230	6.10E-05	1.37E-07	0.010
35	0.06	2.541	0.991	2.544	1080	0.0013	1.38E-04	1.72E-08	0.072
69	0.12	2.530	0.982	2.535	840	0.0016	1.34E-04	2.13E-08	0.310
143	0.20	2.510	0.966	2.520	840	0.0016	1.06E-04	1.66E-08	1.148
285	0.45	2.465	0.931	2.487	1220	0.0011	1.24E-04	1.31E-08	4.985
571	1.32	2.333	0.828	2.399	2770	0.0004	1.81E-04	7.81E-09	27.908
1140	1.05	2.228	0.745	2.280	1650	0.0007	7.24E-05	4.74E-09	66.418
2279	0.84	2.144	0.679	2.186	1160	0.0009	2.89E-05	2.47E-09	130.881
1140	-0.09	2.153	0.687	2.148					
285	-0.36	2.189	0.715	2.171					
69	-0.50	2.239	0.754	2.214					
18	-0.44	2.283	0.788	2.261					

Note:

k calculated using α based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	2.283	Unit Weight, kN/m ³	18.94
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m ³	14.83
Area, cm ²	31.47	Specific Gravity, measured	2.71
Volume, cm ³	71.83	Solids Height, cm	1.276
Water Content, %	27.71	Volume of Solids, cm ³	40.17
Wet Mass, g	138.76	Volume of Voids, cm ³	31.67
Dry Mass, g	108.65		

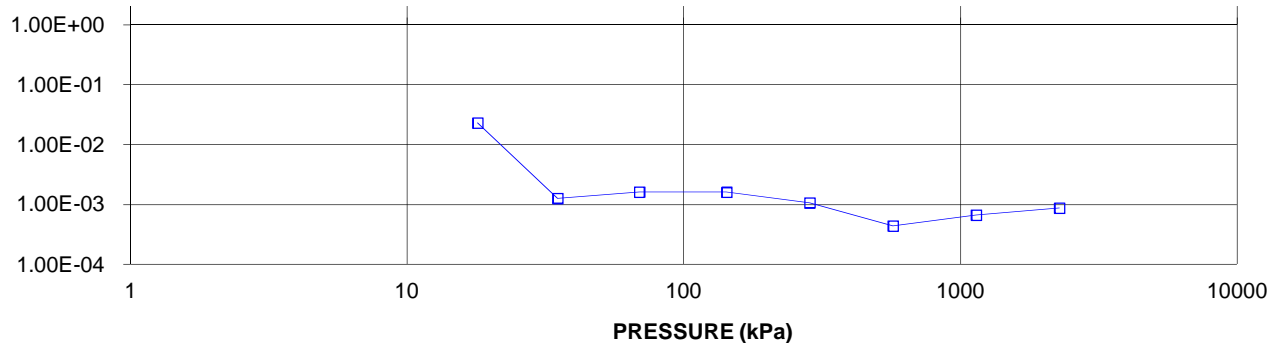
CONSOLIDATION TEST SUMMARY

FIGURE B-9

Pg. 2 of 4

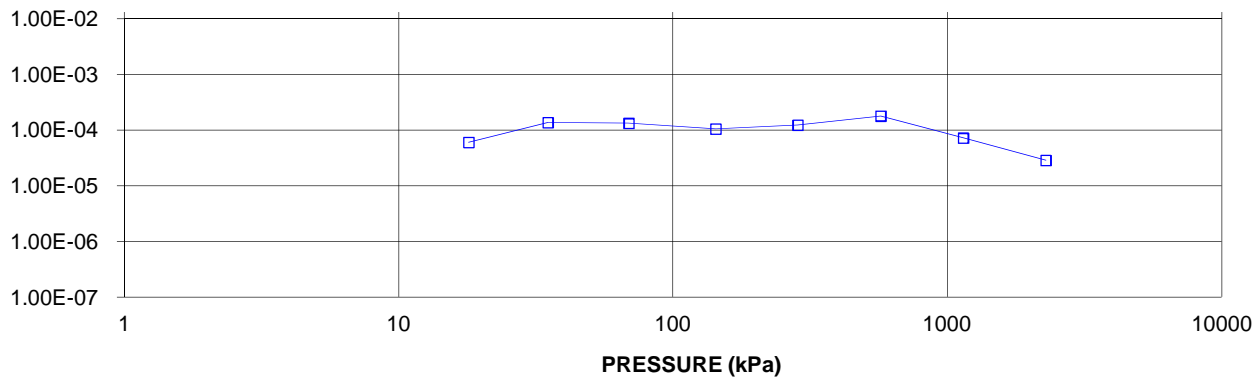
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH WN-3 SA 10



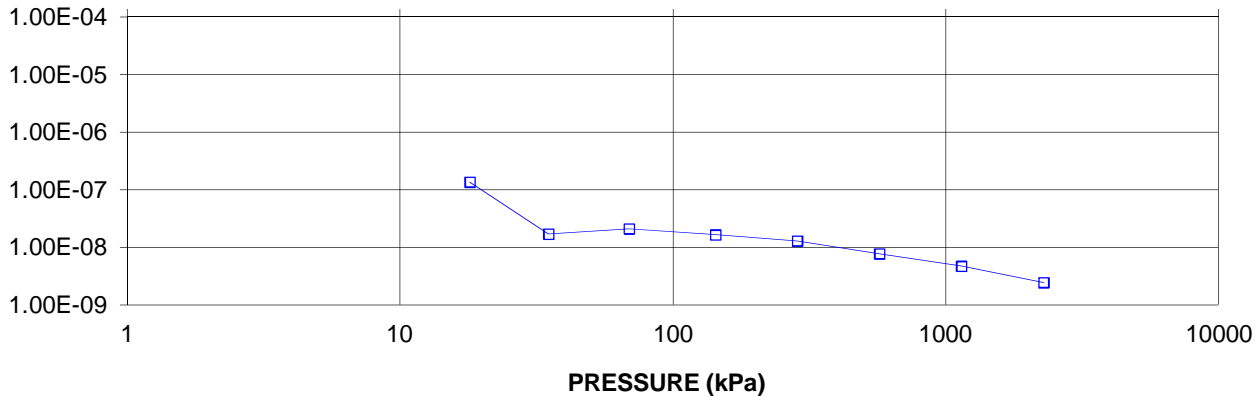
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
MV m²/kN vs PRESSURE (kPa)
BH WN-3 SA 10



HYDRAULIC CONDUCTIVITY,
cm/s

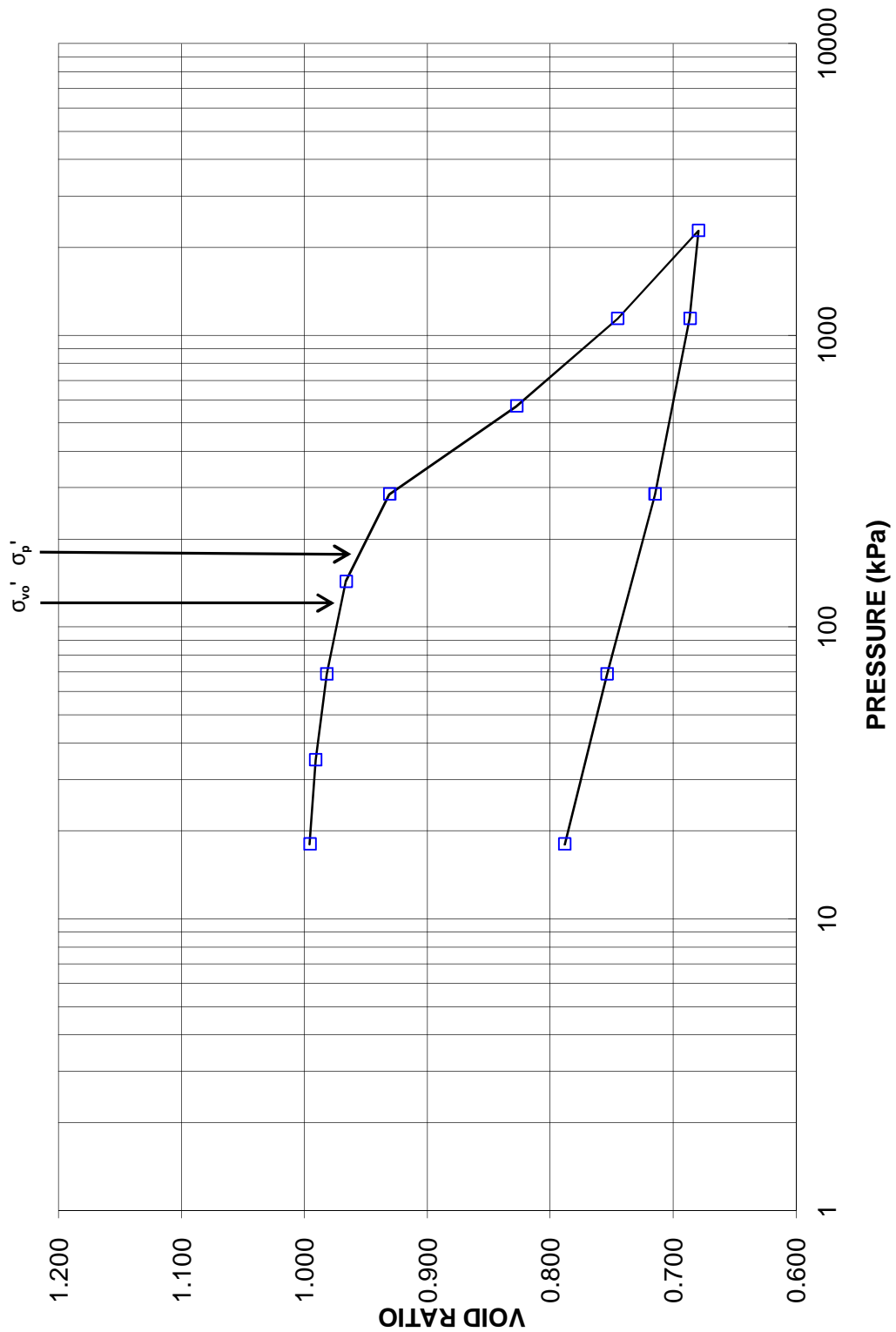
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH WN-3 SA 10



**CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE**

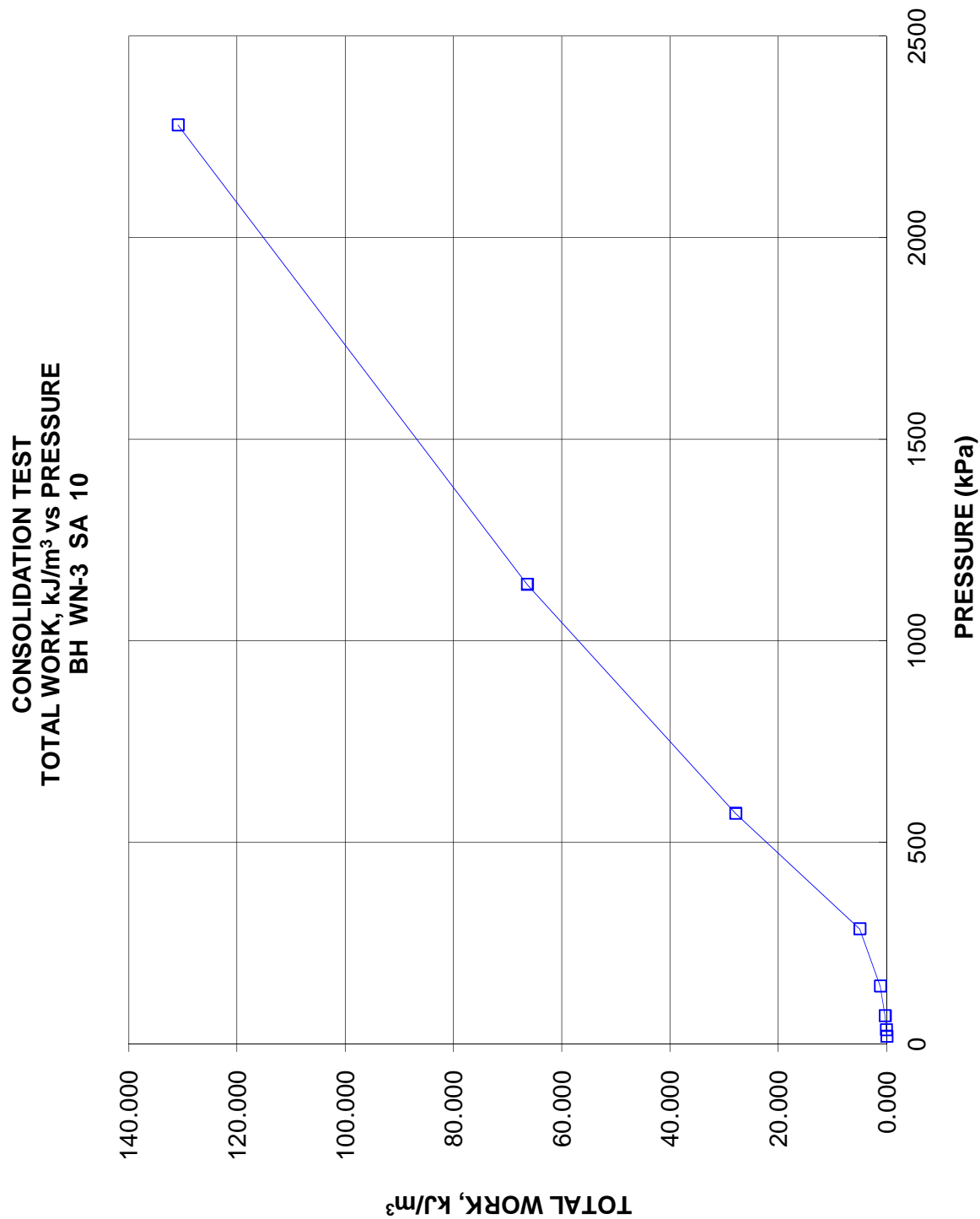
FIGURE B-9
Pg. 3 of 4

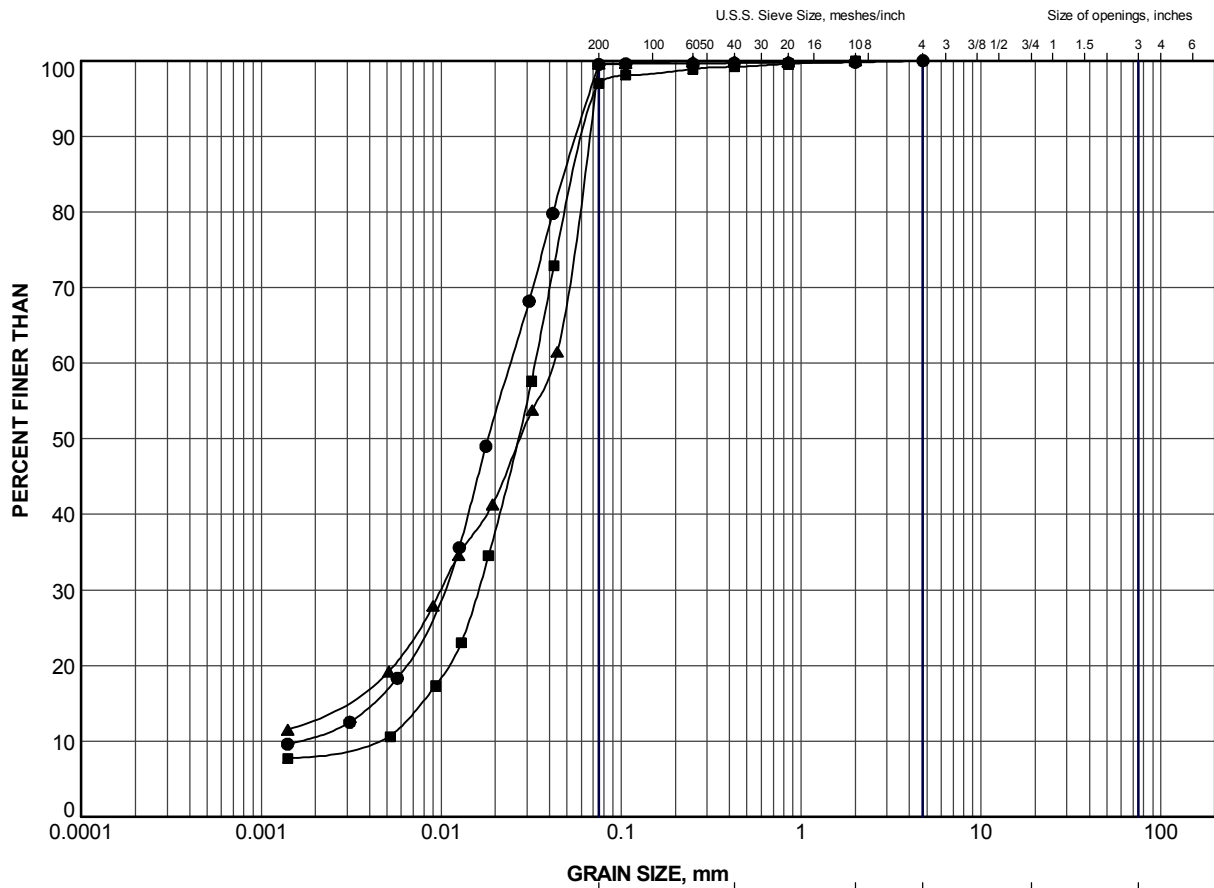
**CONSOLIDATION TEST
VOID RATIO VS PRESSURE
BH WN-3 SA 10**



CONSOLIDATION TEST
TOTAL WORK VS PRESSURE

FIGURE B-9
Pg. 4 of 4




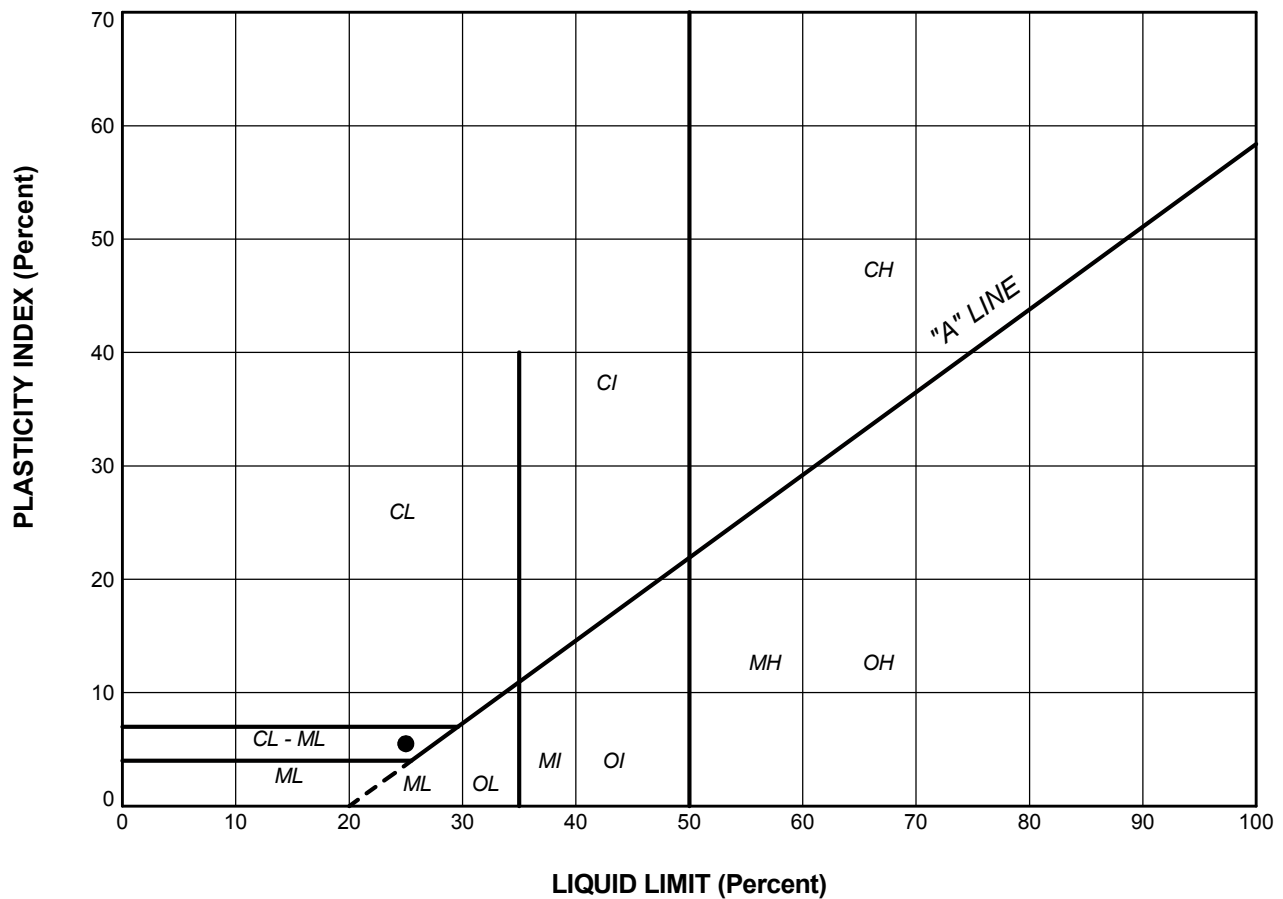


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-2	13	236.0
■	WN-3	18	233.2
▲	WN-5	10	235.5

PROJECT						WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE						GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.			09-1191-0022			FILE No.			09-1191-0022.GPJ		
DRAWN		J.J.L.		Sep 2011		SCALE		N/A		REV.	
CHECK		DAM		Sep 2011							
APPR				Sep 2011							
 Golder Associates SUDBURY, ONTARIO						FIGURE B-10					

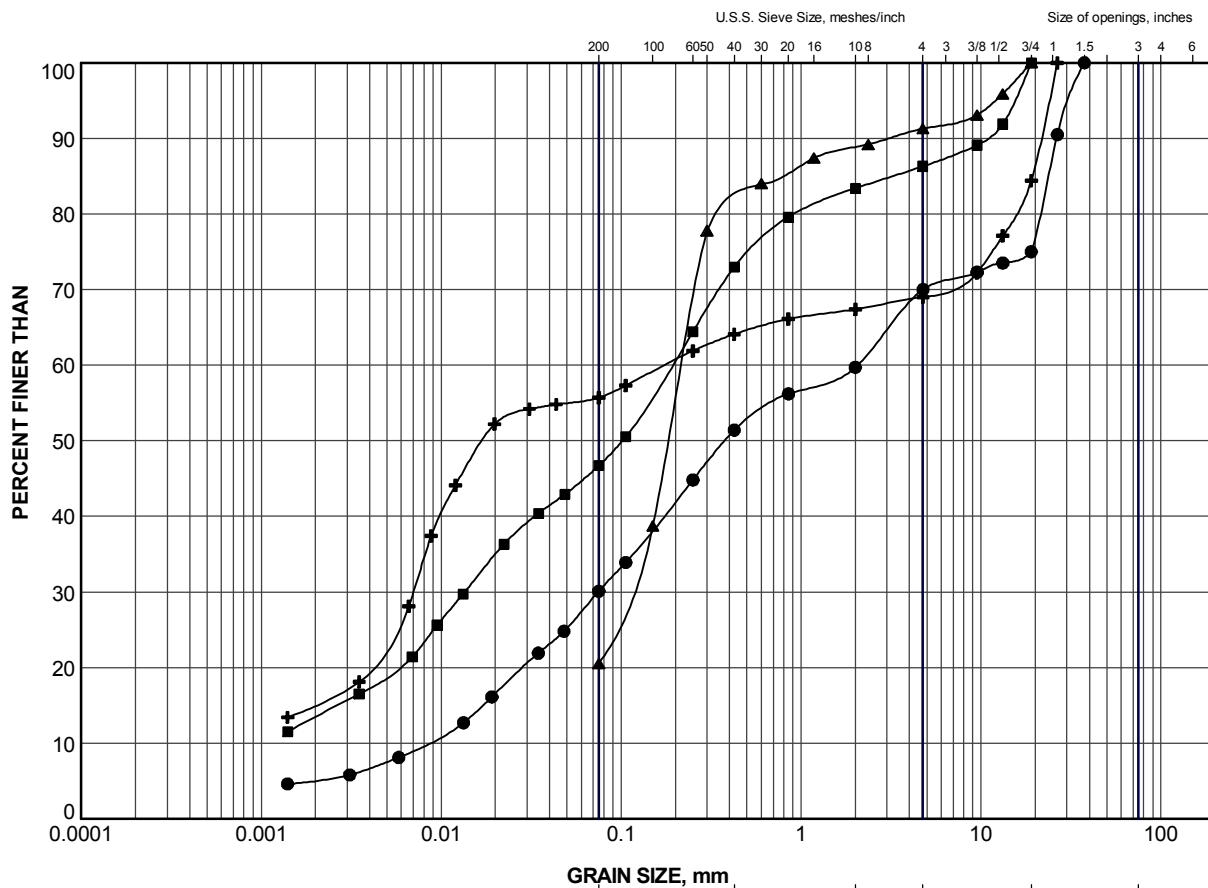


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	WN-3	15	25.0	19.5	5.5

PROJECT					
WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037					
TITLE					
PLASTICITY CHART SILT					
PROJECT No. 09-1191-0022			FILE No. 09-1191-0022.GPJ		
DRAWN	JJL	Sep 2011	SCALE	N/A	REV.
CHECK	DAM	Sep 2011	FIGURE B-11		
APPR		Sep 2011			




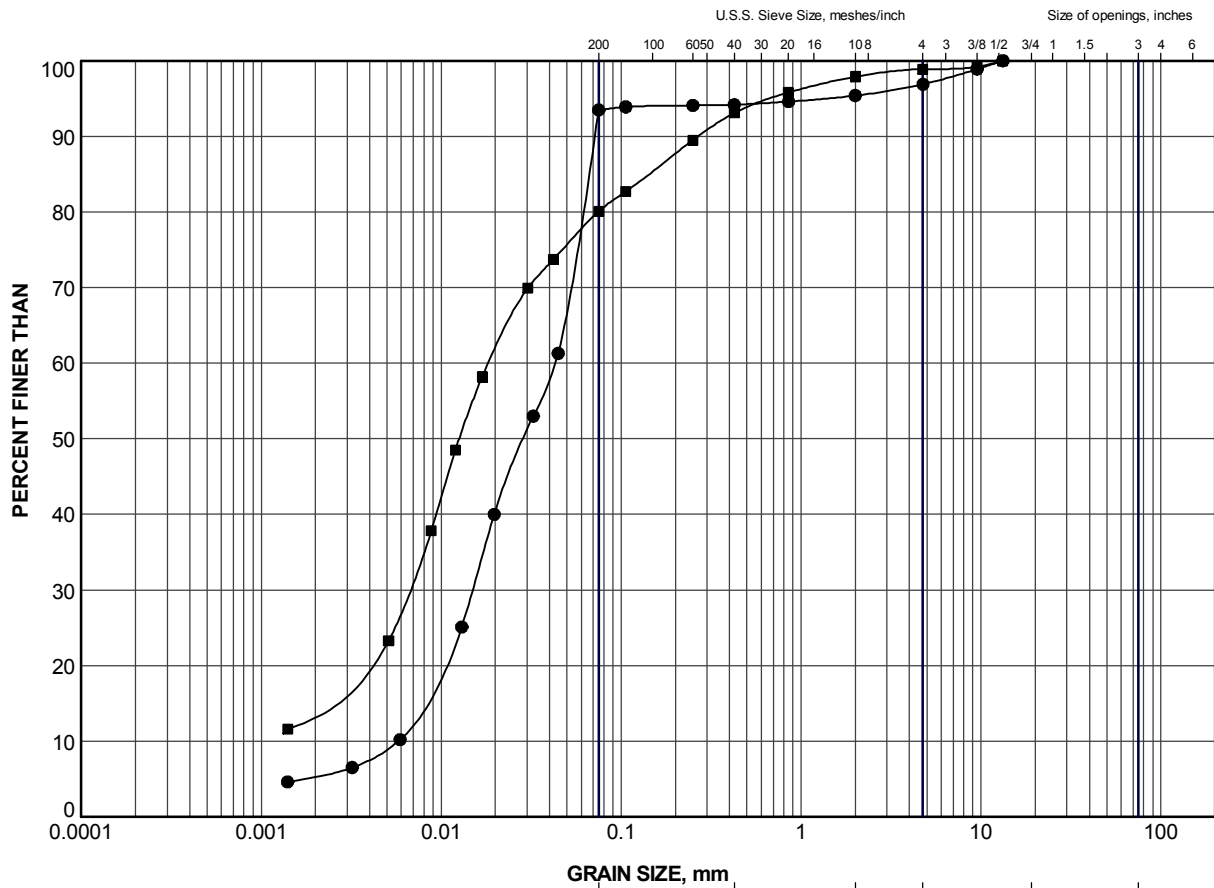


CLAY AND SILT		GRAVEL SIZE, mm				Cobble Size	
		fine	medium	coarse	fine		coarse
		SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-2	17	229.9
■	WN-2	22	224.1
▲	WN-3	21	228.2
+	WN-3	23	225.4


PROJECT					WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037				
TITLE					GRAIN SIZE DISTRIBUTION SILTY SAND AND GRAVEL (TILL)				
PROJECT No.		09-1191-0022		FILE No.		09-1191-0022.GPJ			
DRAWN	JJL	Sep 2011	CHECK	DAM	Sep 2011	SCALE	N/A	REV.	
APPR		Sep 2011	FIGURE B-12						
 Golder Associates SUDBURY, ONTARIO									



CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	WN-2	26	218.6
■	WN-3	25	222.5

PROJECT					WICKLOW RIVER BRIDGE NORTH HIGHWAY 7037				
TITLE					GRAIN SIZE DISTRIBUTION SILT (TILL)				
PROJECT No.		09-1191-0022		FILE No.		09-1191-0022.GPJ			
DRAWN	JJL	Sep 2011	SCALE	N/A	REV.				
CHECK	DAM	Sep 2011							
APPR		Sep 2011							
 Golder Associates SUDBURY, ONTARIO			FIGURE B-13						

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

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