SNC-Lavalin Inc.
Montcalm Wastewater Pumping Station Upgrades - Geotechnical Report

October 2011

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

SNC-Lavalin Inc.
Montcalm Pumping Station Upgrades
Geotechnical Investigation

October 2011

Our File No. 0019 005 00

Prepared for:

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APEGM
Certificate of Authorization
Trek Geotechnical Inc.
No. 4877 Date: October 18, 2011

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1.0 Introduction

This report summarizes the results of the geotechnical investigation completed by TREK Geotechnical Inc. (TREK) for the proposed upgrades to the Montcalm Wastewater Pumping Station in Winnipeg, Manitoba. The terms of reference for the investigation are included in an e-mail to SNC-Lavalin dated July 19, 2011 and included a sub-surface investigation, laboratory testing, riverbank slope stability analysis and the provision of recommendations for the design and construction of underground structures and shoring.

2.0 Background

The Montcalm Pumping Station conveys wastewater from the Mission Sewer District across the Red River to the North End Water Pollution Control Centre along two forcemains. The pump station was constructed in the 1930's and has received minor upgrades over the years. Major upgrades to the facility are now necessary. The proposed upgrades will require a 10.9 m deep excavation adjacent to the southwest corner of the pumping station in order to construct an access chamber and install two flow meters and two isolation valves on the existing forcemains. This excavation will require temporary shoring.

The two forcemains were installed in the winter of 2004 using directional drilling methods. They were connected to the pump house within an excavation which was shored using soldier piles driven to a depth of about 12.2 m from grade (about 3 m below the base of the excavation) and timber lagging. It is our understanding that the soldier piles were removed but the timber lagging was likely left in place.

KGS Group completed a geotechnical investigation in January of 2004 as part of the forcemain upgrades. Three test holes were drilled as part of this investigation in the vicinity of the pump station (TH-01, TH-02, and TH-06) as shown on Figure 01. Test hole logs and survey information from this investigation were provided to TREK by the City of Winnipeg to aid in our analysis. The KGS test hole logs are included in Appendix A as complementary information to this report. The test hole completed by TREK (TH 11-01) supplements the previous subsurface and groundwater information. A cross section adjacent to the pumping station from the 2004 survey was used for the stability analysis.

3.0 Site Investigation

One test hole (TH11-01) was drilled on September 22nd 2011 by Maple Leaf Drilling Ltd. at the location shown on Figure 01. The test hole was drilled to power auger refusal with a mobile B40 drill rig using 125 mm solid stem augers. The test hole was completed under the supervision of TREK personnel and was visually classified using the Unified Soil Classification System (USCS). Disturbed (grab) and relatively undisturbed (Shelby tube) samples were recovered for laboratory testing. Standard penetration testing (SPT) was carried out to measure the consistency of the till and obtain disturbed samples of this soil unit. Soil samples were transported to TREK's soils laboratory in Winnipeg, Manitoba for further classification and testing. A standpipe piezometer was installed in the glacial till to measure short term groundwater levels.

A test hole log has been prepared for the drilling completed by TREK and is included in Appendix A. The test hole log includes a description and relative elevation of the soil units encountered, sample type and depth, the results of field and laboratory testing, and other pertinent information such as sloughing and groundwater seepage.

3.1 Laboratory Testing

Laboratory testing was carried out to determine moisture content, plasticity (Atterberg limits) and undrained shear strength from pocket penetrometer, Torvane and unconfined compression tests. The results of the laboratory testing are included on the test hole log in Appendix A and reported separately in Appendix B.

4.0 Site and Subsurface Conditions

4.1 Site Conditions

The site is located along the outside bend of the Red River at 23 Archibald Street, just upstream of CPR Keewatin Bridge. The majority of site is grass covered with some trees and shrubs near the top of bank and along the property boundaries. The riverbank slopes at about 10H:1V from the upland at the pumping station transitioning to about 4H:1V in the vicinity of the lower bank near the river's edge. Erosion of the lower portion of the riverbank is evident which is typical of riverbanks located on outside bends along the Red River.

4.2 Sub-Surface Conditions

4.2.1 Soil Stratigraphy

In descending order from ground surface, the sub-surface stratigraphy is as follows:

- Fill (Sand and Gravel, Clay)
- Silt
- Lacustrine Clay
- Glacial Till
- Limestone Bedrock

A brief description of the soil units are provided as follows:

Fill

Sand and Gravel

Sand and gravel (fill) was encountered in TH 11-01 from surface to a depth of 0.5 m. The sand and gravel (fill) is light brown, dry to moist, compact and well graded. The moisture content from one sample had a moisture content of 5.1 %. A sand and gravel fill layer was encountered in one of the test holes drilled during the 2004 investigation.

Clay

A 2.0 m thick layer of clay fill underlies the sand and gravel fill. The clay fill is silty, contains trace oxidation, is brown, moist, firm and based on visual classification is highly plastic. Moisture contents range from 37 to 51 % with an average of 44 %. Undrained shear strengths range from 12.5 to 84.3 kPa with an average of 48 kPa based on pocket penetrometer and Torvane tests. Clay (fill) was also encountered in two of the test holes drilled during the 2004 investigation.

Silt

A 0.3 m thick silt layer underlies the clay (fill). The silt contains some clay, is grey, moist and soft. Based on visual classification the silt is of low to intermediate plasticity. The moisture content of one sample was 35 %.

Lacustrine Clay

Lacustrine clay underlies the sand and gravel fill. The clay is brown near the surface, becoming grey at a depth of about 9 m. The brown and grey clay horizons are described separately as follows:

Brown Clay

The brown clay is silty and contains trace amounts of silt inclusions (<10 mm in diameter). Based on visual classification, the clay is highly plastic (CH). Moisture contents range from 44 to 54 % with an average of 51 %. Shear strengths range from 18.7 to 54.1 kPa with and average of 38.2 kPa indicating a soft to stiff consistency. Bulk unit weights from two samples were 16.5 and 16.9 kN/m^3.

Grey Clay

The underlying grey clay is silty and highly plastic based on a plastic limit of 18% and liquid limit of 77%. Moisture contents range from 46 to 62% with an average of 51% with a consistency generally from soft to firm. Measured shear strengths from all test types range from 9.6 to 68.3 kPa with and average of 30.8 kPa. Bulk unit weights range from 16.1 to 17.8 kN/m^3 with an average of 16.7 kN/m^3.

Glacial Till

Glacial silt till underlies the lacustrine clay at a depth of 16.9 m (elevation 213.4 m). A glacial till transition zone was encountered from elevation 213.8 to 213.4 m. For comparison, the glacial silt till contact in the 2004 KGS investigation was reached at elevations ranging from 212.4 to 213.9 m. TH11-01 terminated at power auger refusal in the glacial till at a depth of 17.8 m (elevation 212.5 m). Based on test holes advanced (cored) through the glacial till in 2004, the thickness of this unit is ranges from 6.0 to 7.5 m.

The silt (till) contains trace clay, trace sand, trace gravel, trace cobbles, trace boulders, is light brown, dry to moist and poorly graded. Moisture contents range from 31% near the overlying clay contact to around 9% in the glacial till. The consistency of the till is very dense based on a Standard Penetration blow count (N) of 61 over 229 mm at a depth of 16.7 m.

Bedrock

Limestone bedrock underlies the glacial till as evidenced by test holes from the 2004 investigation.

4.2.2 Groundwater Conditions

Seepage was observed at 16.5 m below surface at the till interface in TH11-01. Within an hour after drilling, the water level in the test hole had risen to 12.1 m below surface. A standpipe piezometer was installed in the till to measure short-term groundwater levels. The piezometer was monitored on two occasions with a stabilized groundwater level reached at an approximate elevation of 223.85 m. It is important to note however, that groundwater conditions may change seasonally, annually or as a result of construction activities.

5.0 Riverbank Stability

There is no visual evidence of riverbank instabilities at this location at the time of the investigation. It is our understanding that no major grading works are required for the proposed construction although minor grading may be considered as part of the site restoration. Although the proposed upgrading works are not expected to negatively impact the existing riverbank stability, analysis was completed to assess the riverbank stability at the shoring location. A minimum factor of safety (FS) of 1.5 against slope instabilities is considered appropriate for potential slip surfaces at the proposed shoring and access chamber. The worst case groundwater and river levels were selected as a first step and compared against the factor of safety criteria. If a minimum factor of safety was not achieved under these conditions a more rigorous analysis would be undertaken.

The stability analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2007 software package (Geo-Slope International Inc.). The cross section geometry used in the model is based on survey information from 2004 and the stratigraphic profile is based on the results of previous and current site investigations. A groundwater level of 2.0 m below surface for the clay and glacial till along with the winter (drawdown) river level (WWL) were used in the analysis as the worst case conditions.

The soil properties used in the slope stability model are presented in Table 1. Unit weights are based on laboratory testing results. The lacustrine clay shear strengths are based on local experience and reflect large strain traixial testing results. The glacial till strengths are based on local experience and the limestone bedrock is considered impenetrable.

Table 1 - Soil Properties Used in Slope Stability Analysis

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (deg)
Lacustrine Clay (Large strain strength envelope)	18	5	14
Glacial Silt Till	20	10	30
Limestone Bedrock	Impenetrable		

The calculated factor of safety for a potential slip surface at the west side of the proposed shoring limits for the assumed groundwater and river conditions is 1.61 as shown on Figure 02. This factor of safety exceeds the minimum target of 1.5 and additional analysis is not considered necessary. A critical factor of safety of 1.30 was calculated for a potential slip surface entering the slope approximately 49 m west of the proposed shoring location.

6.0 Excavations and Shoring

It is our understanding that an excavation depth of 10.9 m (to elevation 219.75 m) is required to complete the proposed upgrading works (City of Winnipeg Drawing 1-0164L-S0001 Rev PB and 1-0164L-B0003 Rev PB). Based on this excavation depth, conventional shoring will need to be braced or tied back. The earth pressure distributions provided in Figure 03 can be used for shoring design using a bulk unit weight of 16.5 kN/m^3 and an active earth pressure coefficient of 0.6. An undrained shear strength of 40 kPa for the brown clay and 30 kPa for the grey clay can be used for the design of shoring and the determination of an adequate factor of safety against toe instabilities. The undrained shear strengths were selected based on the measured undrained shear strength profile from all test types.

Ground movements behind the shoring and associated settlement are largely unavoidable. The amount of movement cannot be predicted with a high degree of accuracy as it is as much a function of the excavation procedures and workmanship as it is of theoretical considerations. In this regard, good contact between the timber lagging and retained soil should be maintained throughout the construction process. Free draining sand fill should be used to fill in any voids behind the lagging. Additional recommendations can be provided should infrastructure sensitive to settlement exist in close proximity to the excavation.

The lacustrine clay is underlain by a layer of glacial till under confined groundwater pressures. As a result, the potential for base heave and/or groundwater seepage into excavations must be considered. If base heave occurs causing hydraulic fracturing of the clay, there exists a potential for groundwater seepage into the excavation. This event could be sudden and catastrophic in nature. In this regard, sufficient resisting forces are required to counteract groundwater pressures. The resisting forces are a function of the thickness and unit weight of the clay above the till and to a lesser degree, shoring dimensions.

An adequate factor of safety against base heave is achieved when the groundwater level in the till is at or below elevation 220.9 m for the proposed excavation depth and geometry. In comparison, a groundwater elevation of 223.8 m was measured at the clay till interface in October 2011. Based on a review of groundwater levels recorded in the winter of 2004, it is anticipated that the groundwater levels in the till may drop to approximately elevation 222.1 m in response to drawdown of the river. It must be recognized however, that groundwater levels are likely to increase substantially during spring freshet before returning to normal summer levels. The recommended safe groundwater elevation is a function of excavation depth and shoring dimensions and should be re-calculated for any base elevation other than 219.75 m or changes in shoring dimensions.

A relief well is recommended to depressurize the till layer and achieve an adequate factor of safety against base heave. The well should be able to maintain the recommended safe groundwater elevation for the length of time the excavation is open and be able to accommodate fluctuations in groundwater elevations. Groundwater quality should be evaluated to determine if it is acceptable to discharge directly into the river. It is important to note that the potential for seepage into the excavation exists when the groundwater elevation is above the base of the excavation. Should this occur, it will be necessary to dewater the excavation and/or lower the groundwater to an elevation lower than the base.

Wood lagging from 2004 (if present) may create excavation difficulties and inhibit the installation of shoring. It is also understood that the excavation from the work carried out in 2004 was backfilled with gravel. In this regard, softening of the clay along the old excavation walls and base may be a consequence of water ponding in the gravel. Based on shop drawings from the 2004 construction, the H-Piles (soldier piles) were to be driven 3 m below the base of the excavation terminating within the clay a few meters above the till. Although it is our understanding that these piles were removed after construction, there may be remaining void spaces that could create preferential pathways for groundwater flow into the excavation.

7.0 Foundations

Structures of this nature are often supported by a mat foundation buried deep into the soil where part (or all) of the loads may be compensated by the weight of removed soil. A maximum allowable bearing capacity of 115 kPa is recommended for the design of foundations on the clay at the proposed elevation of 219.75 m. It should be noted that this bearing capacity is based on a maximum estimated settlement of 25mm at the maximum allowable bearing pressure. Should such settlement not be acceptable, a deep foundation system consisting of driven end bearing piles could be considered. Aside from consolidation settlement, vertical displacements of the structure can ensue if changes in the moisture content of the clay occur during construction, in this case drying. Measures to minimize the drying potential, for example a mud slab, may be considered. The uplift forces acting against the access chamber should also be considered in design and a groundwater level at existing ground surface should be used.

8.0 Waterways Permit

A Waterways Permit from the City of Winnipeg is required to carry out the work. Based on the stability analysis and our review of the proposed works, we recommend that a Waterways permit be granted. It is expected that conditions of the permit are likely to include the stockpiling of materials well away from the top of bank and permission from any adjacent property owners where access may be required. The submission of a Waterway application should therefore include any proposed access and egress routes and stockpile locations.

9.0 Closure

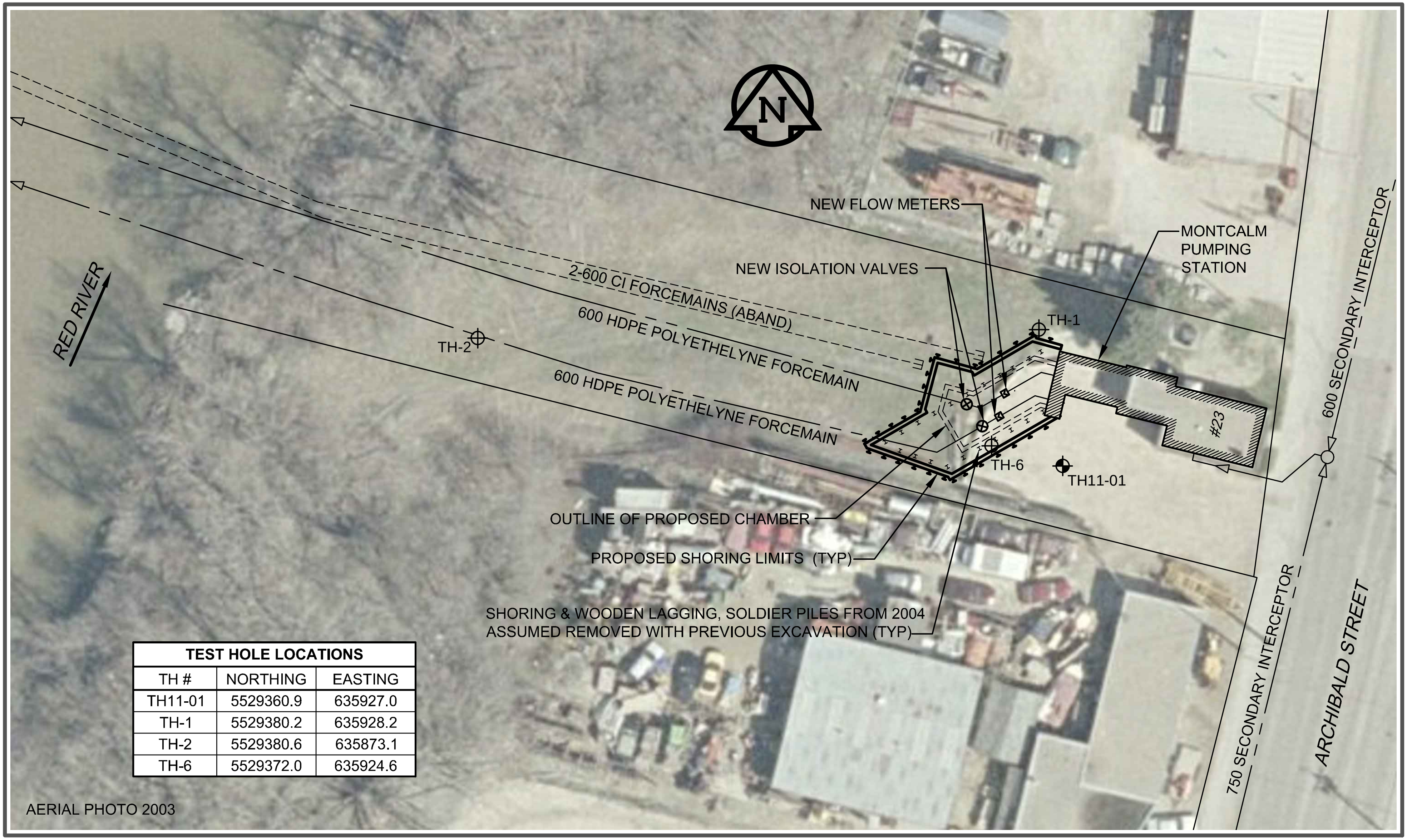
The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings and recommendations of this report were based on information provided (field investigations, laboratory testing, geometries, equipment specifications) and interpolation of soil and groundwater information between test holes. Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, or if the assumptions presented in this report are not keeping with the overall design or construction procedures, we should be notified to review our recommendations and adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

Figures

SNC-Lavalin Inc

Montcalm Wastewater Pumping Station
2011 Upgrades



TEST HOLE LOCATIONS

TH #	NORTHING	EASTING
TH11-01	5529360.9	635927.0
TH-1	5529380.2	635928.2
TH-2	5529380.6	635873.1
TH-6	5529372.0	635924.6

LEGEND:

- ⯐ TEST HOLE (TREK GEOTECHNICAL, 2011)
- ⊕ TEST HOLE (KGS GROUP, 2004)

Site Plan &
Test Hole Layout
Figure 01

0019 005 00 - SNC Lavalin - Montcalm Pump Station Upgrades
23 Archibald Street
Working Cross Section 1
Existing Geometry

Winter River Level (WRL)
Elev. 222 m

Groundwater Elevation
2 m below ground

Name: Clay
Unit Weight: 16.5 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Silt Till
Unit Weight: 20 kN/m³
Cohesion: 10 kPa
Phi: 30 °

Name: Bedrock

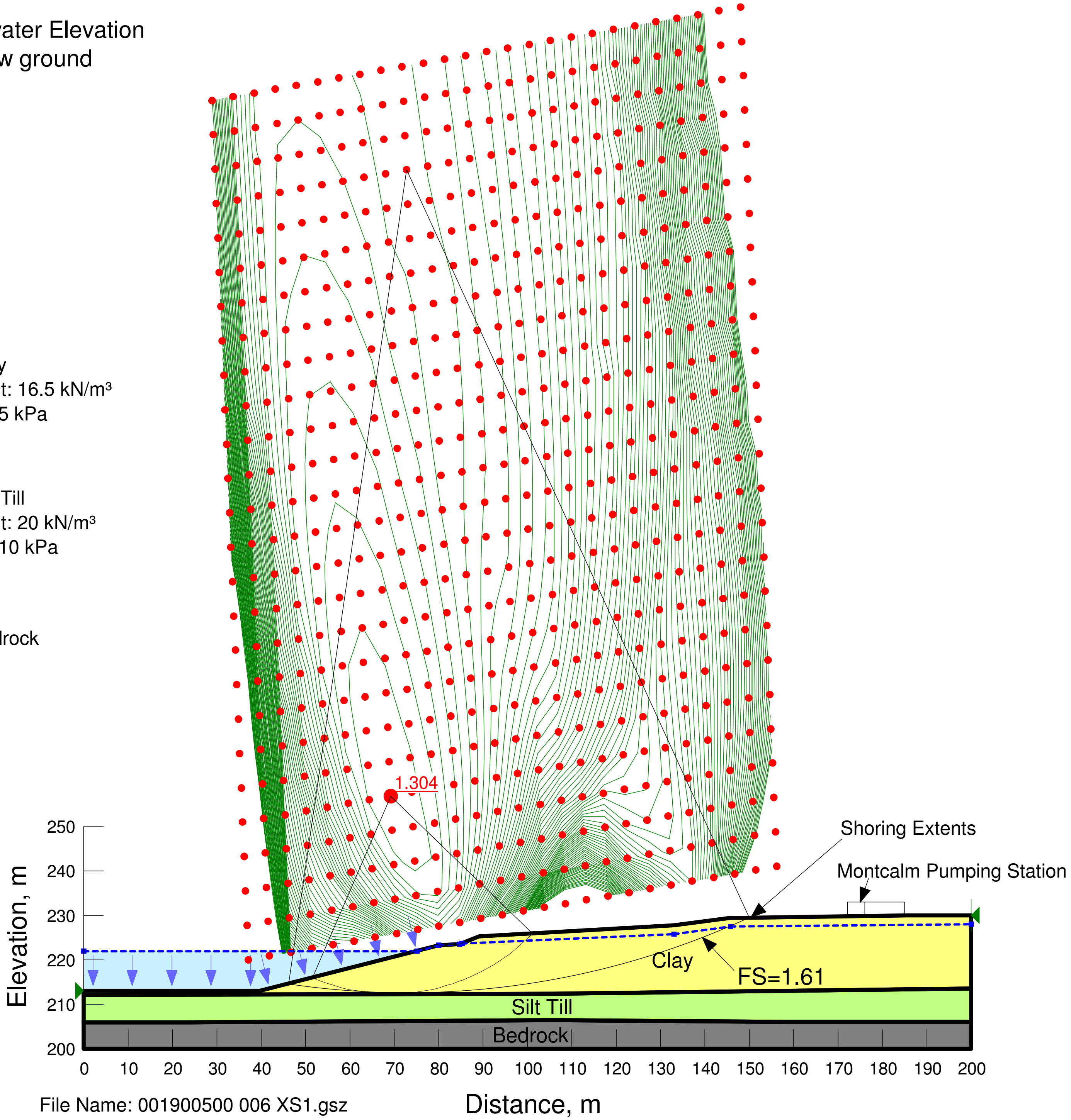


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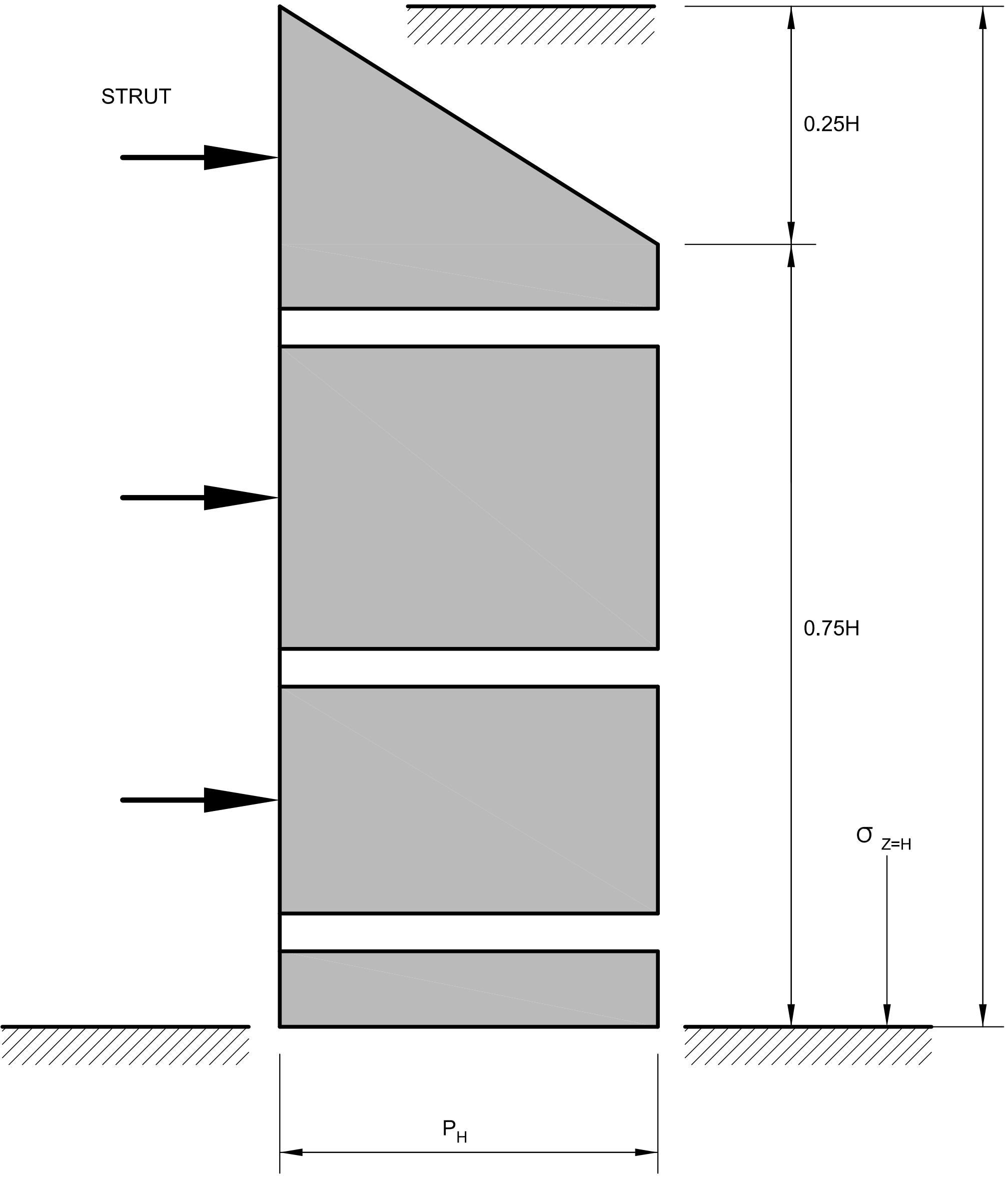
Figure 02



$P_H = 0.6\ \gamma\ H$

WHERE:
H = DEPTH OF EXCAVATION (m)
P_H = LATERAL EARTH PRESSURE (kPa)
γ = SOIL UNIT WEIGHT (16.5 kN/m³)

NOTE:
ADD SURFACE LOAD SURCHARGE WHERE APPLICABLE

Apparent Earth Pressure Distributions
Soft to Firm Cohesive Soils
Figure 03

Appendix A

Borehole Logs

Sub-Surface Log

Test Hole TH11-01

1 of 2

Client: SNC Lavalin Inc.

Project Number: 0019 005 00

Project Name: Montcalm Pumping Station Upgrades

Location: UTM 14 N-5529360.9 E-635927.0

Contractor: Maple Leaf Drilling

Ground Elevation: 230.294 m Existing Ground

Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount

Date Drilled: September 22, 2011

Sample Type: ◢ Grab (G) ▌▐ Shelby Tube (T) ☒ Split Spoon (S) ⧗ Split Barrel (B) ▐ Core (C)

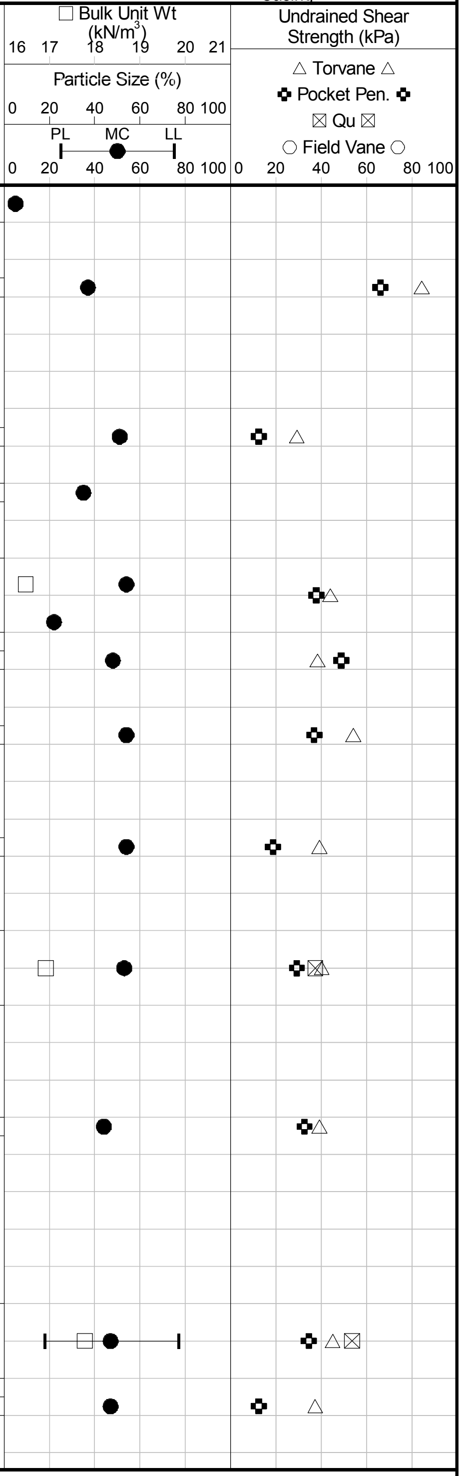
Particle Size Legend: ▨ Clay ▥ Silt ▒ Sand ▚ Gravel ▧ Cobbles ■ Boulders

Backfill Legend: ▌▐ Bentonite Seal ▨ Drill Cuttings Backfill ▒ Filter Pack Sand ☐ Blank section ▌ Top Cap ☐ Protective Casing

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
		SAND AND GRAVEL (Fill) - light brown, dry to moist, compact, well graded	◢	G1
229.8		CLAY - silty, trace oxidation - brown - moist, firm - high plasticity	◢	G2
		- soft below 1.8 m	◢	G3
		- trace silt inclusions (<10 mm diam.) below 2.1 m		
227.9		SILT - some clay, grey, moist, soft, low to intermediate plasticity	◢	G4
227.6		CLAY - silty, trace silt inclusions (<10 mm diam.) - brown - moist, firm - high plasticity	▌▐	T5
		- trace oxidation, trace gravel (<20 mm diam.) at 3.0 m - trace silt seam (<50 mm thick) at 3.4 m - trace precipitates (<10 mm diam.) below 3.7 m	◢	G6
			◢	G7
			◢	G8
			▌▐	T9
		- trace sand (coarse grained) below 7.6 m	◢	G10
221.2		CLAY - silty - grey - moist, soft to firm - high plasticity	▌▐	T11
			◢	G12

Depth scale (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

SPT (N)

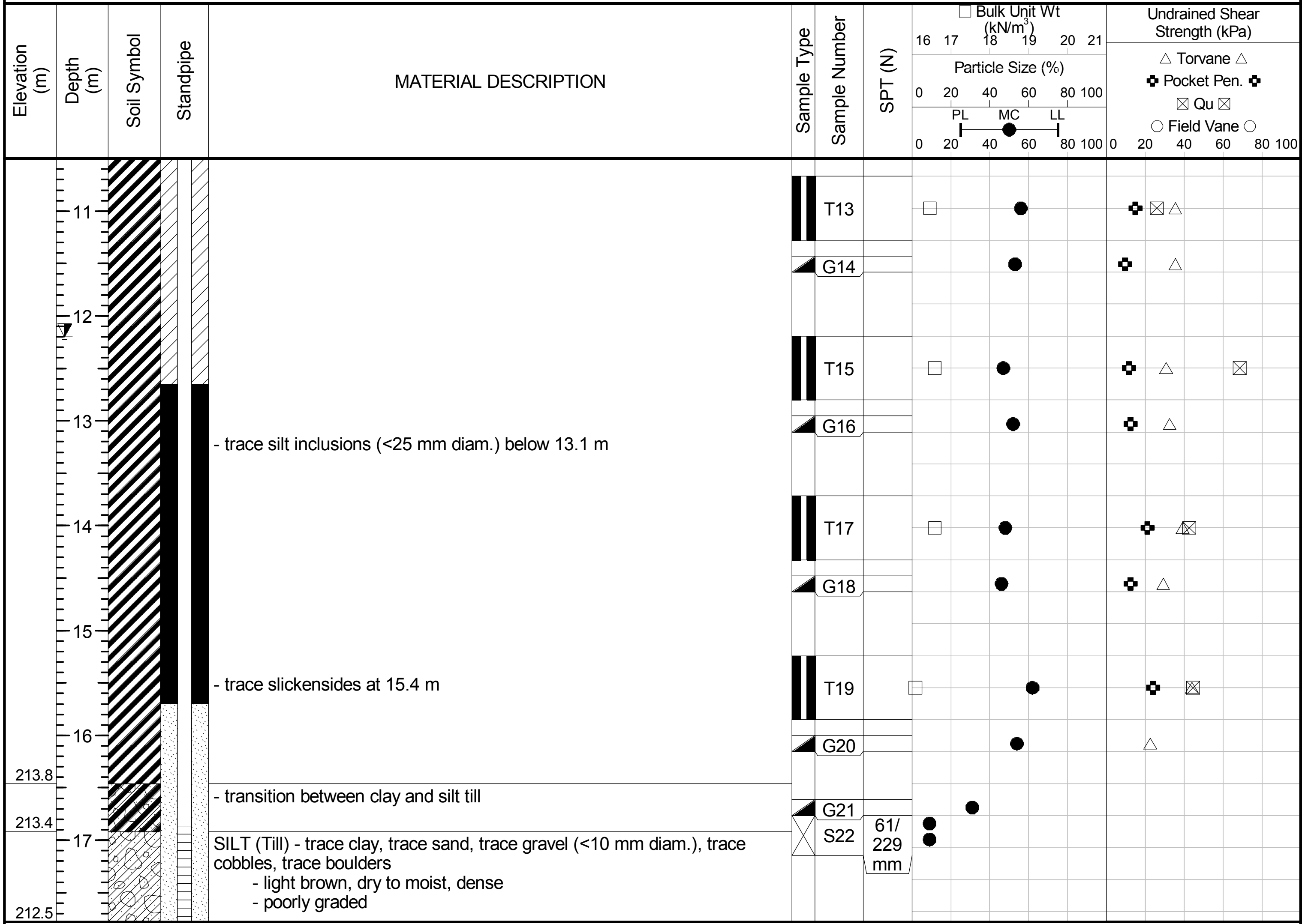


Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH11-01

2 of 2



- trace silt inclusions (<25 mm diam.) below 13.1 m

- trace slickensides at 15.4 m

- transition between clay and silt till

SILT (Till) - trace clay, trace sand, trace gravel (<10 mm diam.), trace cobbles, trace boulders
- light brown, dry to moist, dense
- poorly graded

END OF TEST HOLE AT 17.8 m IN SILT TILL

Notes:

1. Power Auger Refusal (PAR) at 17.8 m below ground.
2. No sloughing was observed.
3. Seepage observed at 16.5 m below ground.
4. Standpipe piezometer SP1 installed in test hole to 17.8 m below ground.
5. Water level was 12.1 m below ground one hour after drilling.
6. Water level in SP1 was 6.45 m below ground on October 11, 2011.

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

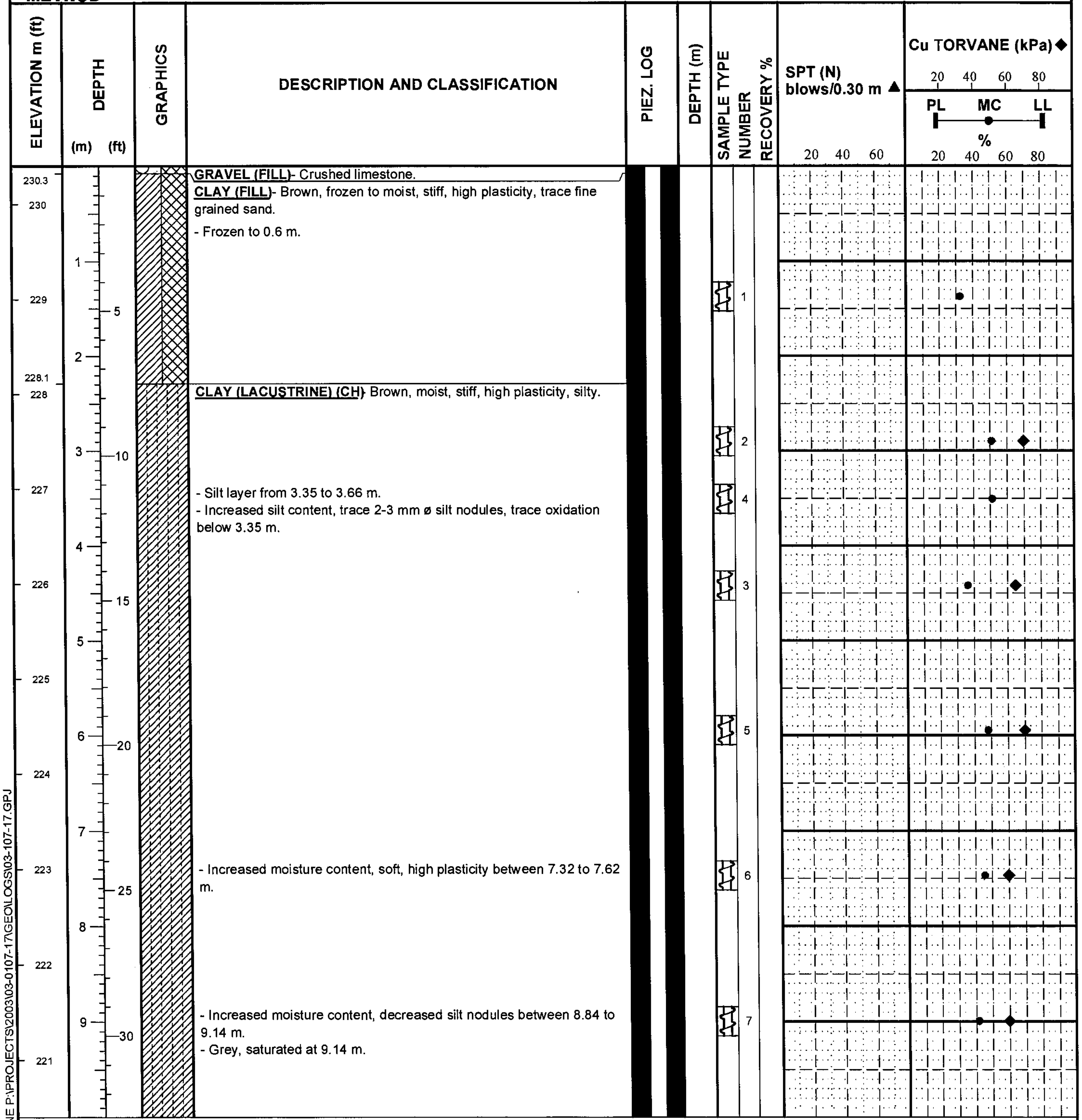
KGS GROUP

SUMMARY LOG

HOLE NO. **TH-1**

SHEET 1 of 3

CLIENT	CITY OF WINNIPEG	JOB NO.	03-107-17
PROJECT	MONTCALM FORCE MAIN REPLACEMENT	GROUND ELEV.	230.40 m
SITE	MONTCALM FORCE MAIN	WATER ELEV.	222.48 m (9-Jan-04)
LOCATION	RUE ARCHIBALD, EAST TOP OF BANK, 5529380.2 N 635928.9 E		
DRILLING METHOD	150 mm ø Solid Stem Auger, Nodwell and HQ Coring	DATE DRILLED	6-Jan-04, 8-9-Jan-04



GRAVEL (FILL)- Crushed limestone.

CLAY (FILL)- Brown, frozen to moist, stiff, high plasticity, trace fine grained sand.

- Frozen to 0.6 m.

CLAY (LACUSTRINE) (CH)- Brown, moist, stiff, high plasticity, silty.

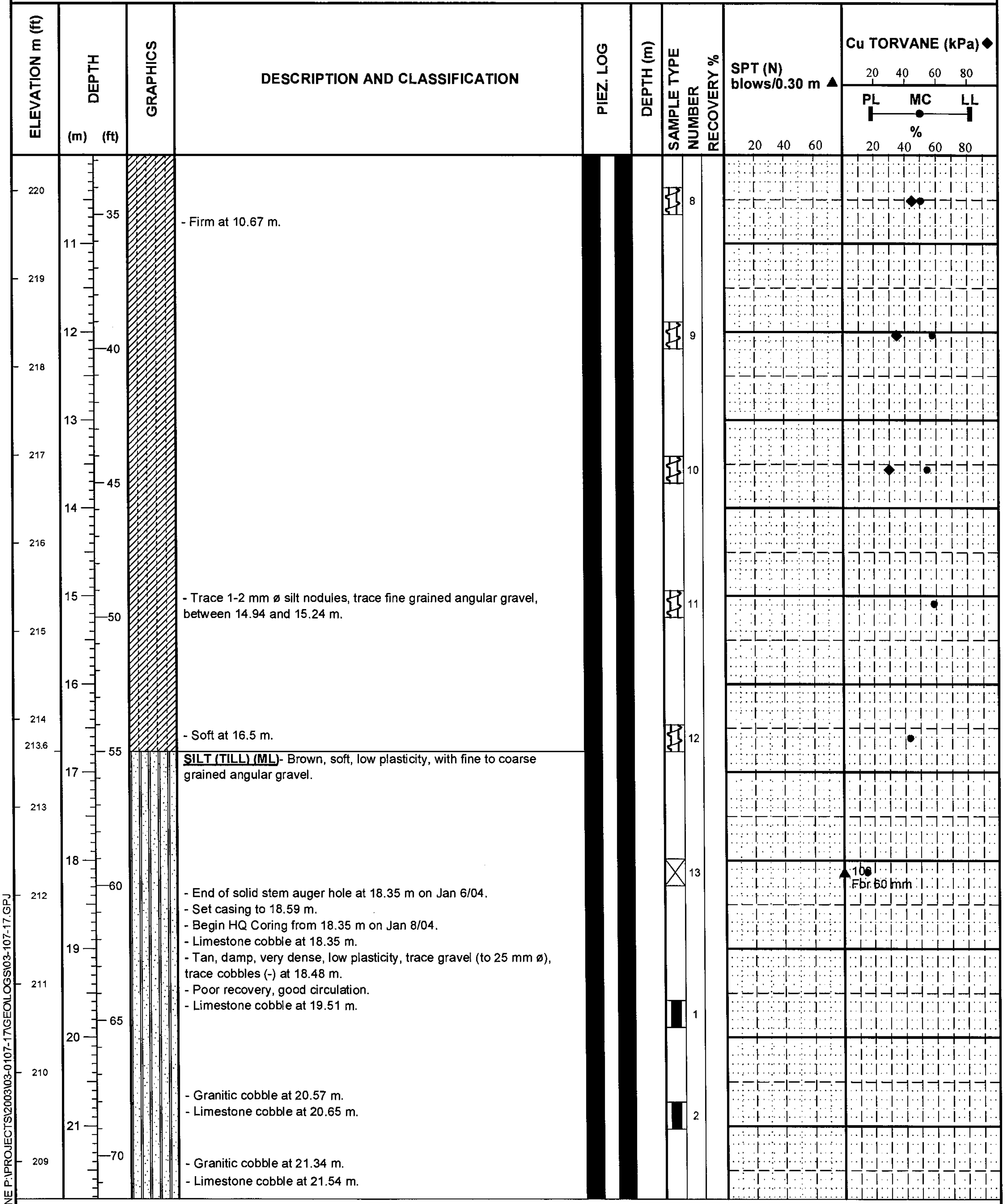
- Silt layer from 3.35 to 3.66 m.
- Increased silt content, trace 2-3 mm ø silt nodules, trace oxidation below 3.35 m.

- Increased moisture content, soft, high plasticity between 7.32 to 7.62 m.

- Increased moisture content, decreased silt nodules between 8.84 to 9.14 m.
- Grey, saturated at 9.14 m.

SAMPLE TYPE 🅂 Auger Grab ☒ Split Spoon ▮ Select Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J. CHING / G.E. HARRISON		19/01/04



- Firm at 10.67 m.
- Trace 1-2 mm ø silt nodules, trace fine grained angular gravel, between 14.94 and 15.24 m.
- Soft at 16.5 m.

<u>SILT (TILL) (ML)</u>- Brown, soft, low plasticity, with fine to coarse grained angular gravel.

- End of solid stem auger hole at 18.35 m on Jan 6/04.
- Set casing to 18.59 m.
- Begin HQ Coring from 18.35 m on Jan 8/04.
- Limestone cobble at 18.35 m.
- Tan, damp, very dense, low plasticity, trace gravel (to 25 mm ø), trace cobbles (-) at 18.48 m.
- Poor recovery, good circulation.
- Limestone cobble at 19.51 m.
- Granitic cobble at 20.57 m.
- Limestone cobble at 20.65 m.
- Granitic cobble at 21.34 m.
- Limestone cobble at 21.54 m.

SAMPLE TYPE ⌇ Auger Grab ☒ Split Spoon ▮ Select Core Barrel

CONTRACTOR
Paddock Drilling Ltd.

INSPECTOR
J. CHING / G.E. HARRISON

APPROVED ________ DATE 19/01/04

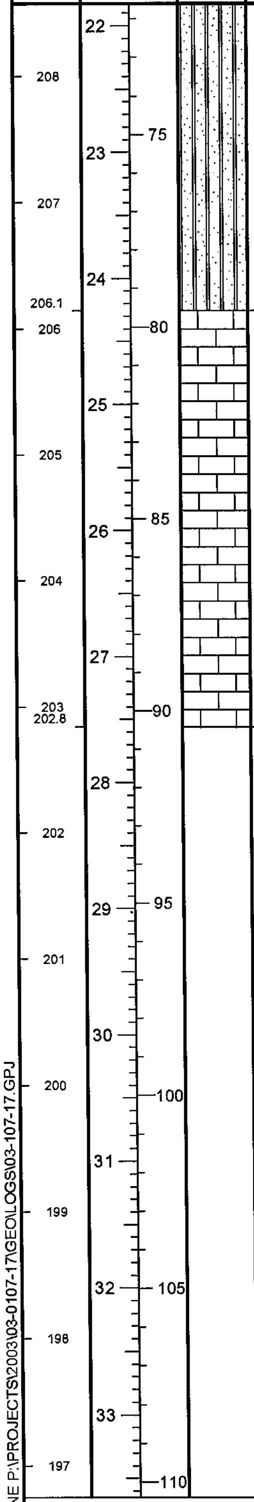
KGS GROUP

SUMMARY LOG

HOLE NO. **TH-1**

SHEET 3 of 3

ELEVATION m (ft)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.30 m ▲ 20 40 60	Cu TORVANE (kPa) ◆ 20 40 60 80 / PL MC LL % 20 40 60 80



- Limestone boulder at 22.40 m.

- Coarse grained, numerous granitic (10%) and limestone pebbles to 0.08 mm ø, minimal recovery, fine grained sand visible in drill fluid.

- Loss of circulation. Advance casing to 24.8 m.

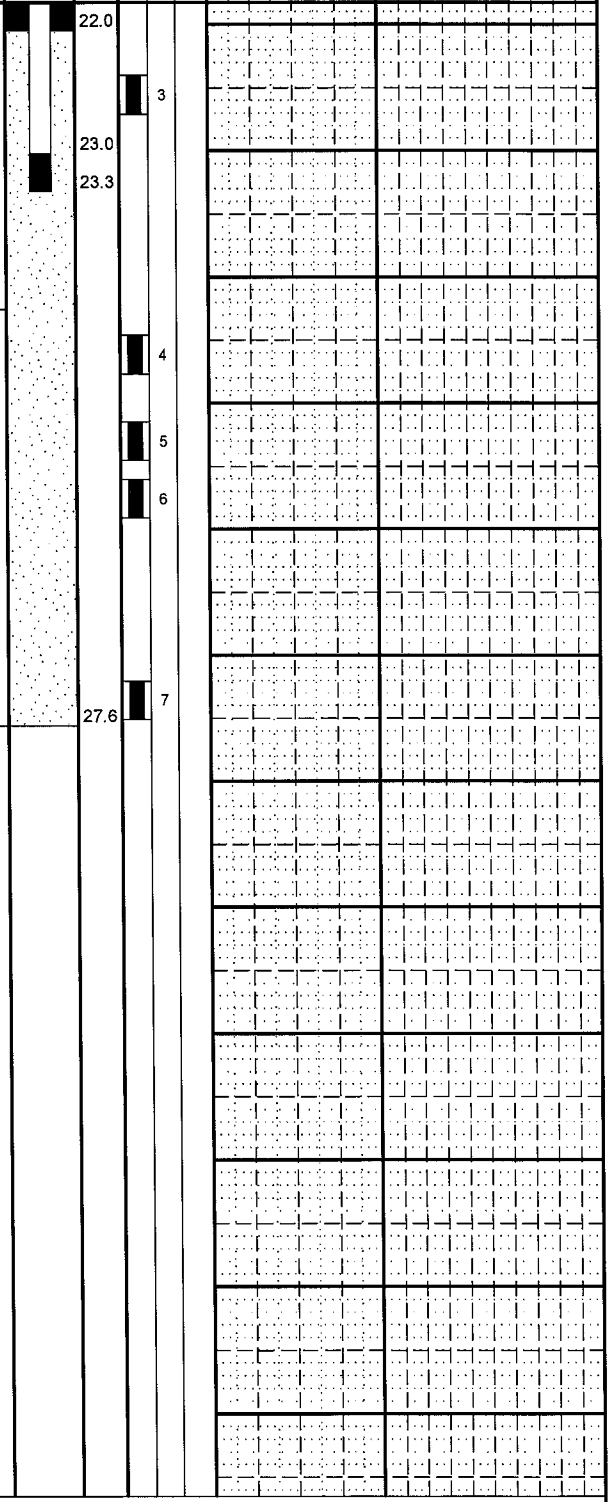
LIMESTONE (BEDROCK)- Solid buff limestone core, very strong.

- Distinct sedimentation planes with vug holes at 25.15 m.

- White, massive at 27.0 m.

END OF HOLE AT 27.56 m

Notes:
1. Installed Casagrande standpipe at 23.32 m depth. Pipe consists of 25 mm diameter PVC with response zone from 22.05 to 27.56 m depth.
2. Lockable protective steel casing installed at ground surface.
3. Groundwater depth at 7.92 m below ground surface on January 11, 2004.



SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Select Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J. CHING / G.E. HARRISON		19/01/04

KGS GROUP

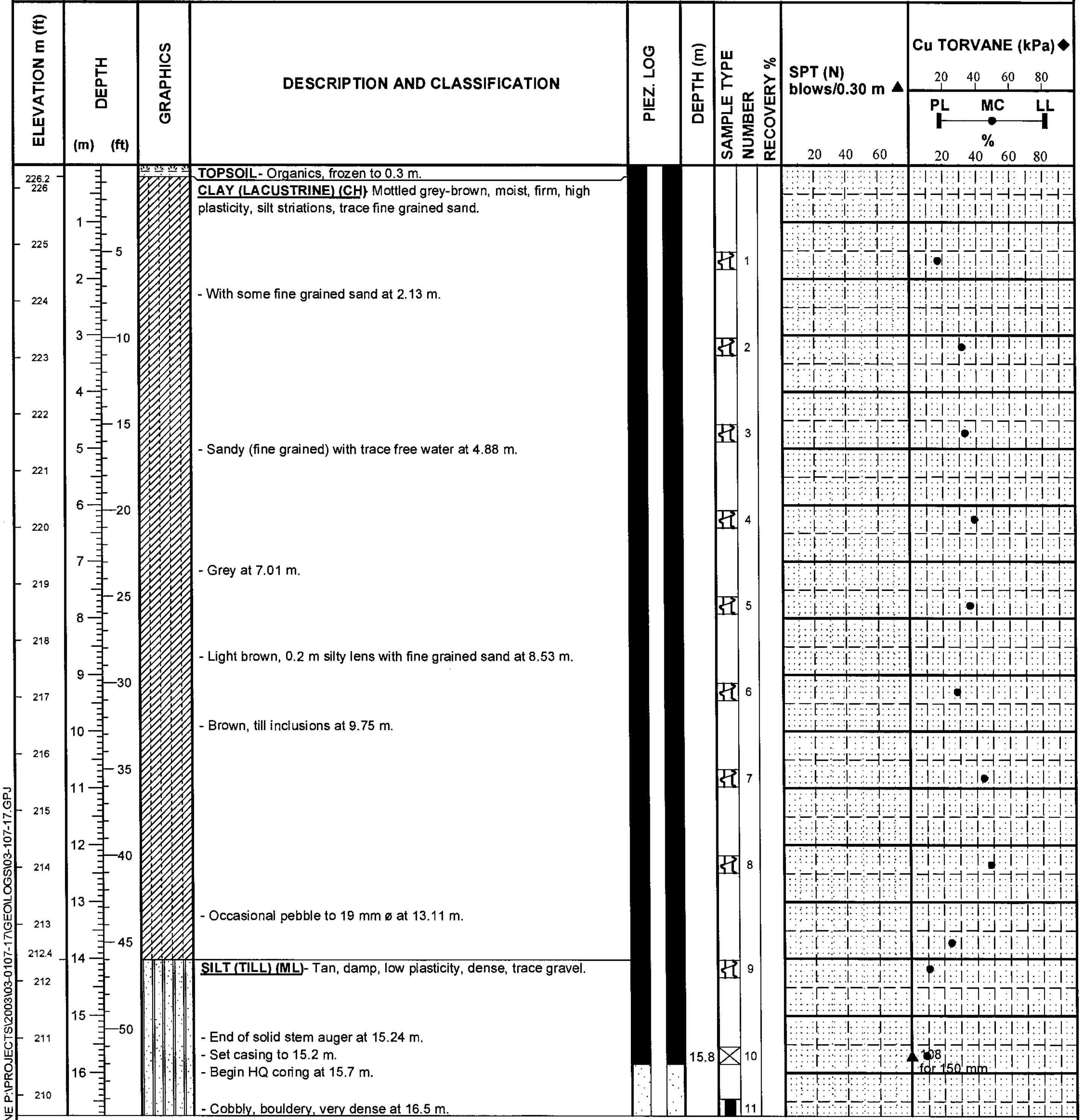
SUMMARY LOG

HOLE NO. **TH-2**

SHEET 1 of 2

CLIENT CITY OF WINNIPEG
PROJECT MONTCALM FORCE MAIN REPLACEMENT
SITE MONTCALM FORCE MAIN
LOCATION RUE ARCHIBALD, EAST BANK NEAR RIVER, 5529380.6 N 635873.1 E
DRILLING METHOD 150 mm ø Solid Stem Auger, Nodwell and HQ Coring

JOB NO. 03-107-17
GROUND ELEV. 226.40 m
WATER ELEV. 222.30 m (8-Jan-04)
DATE DRILLED 6-7-Jan-04



TOPSOIL- Organics, frozen to 0.3 m.

CLAY (LACUSTRINE) (CH)- Mottled grey-brown, moist, firm, high plasticity, silt striations, trace fine grained sand.

- With some fine grained sand at 2.13 m.
- Sandy (fine grained) with trace free water at 4.88 m.
- Grey at 7.01 m.
- Light brown, 0.2 m silty lens with fine grained sand at 8.53 m.
- Brown, till inclusions at 9.75 m.
- Occasional pebble to 19 mm ø at 13.11 m.

SILT (TILL) (ML)- Tan, damp, low plasticity, dense, trace gravel.

- End of solid stem auger at 15.24 m.
- Set casing to 15.2 m.
- Begin HQ coring at 15.7 m.
- Cobbly, bouldery, very dense at 16.5 m.

SAMPLE TYPE 🅂 Auger Grab ☒ Split Spoon ▮ Select Core Barrel

CONTRACTOR
Paddock Drilling Ltd.

INSPECTOR
G.E. HARRISON

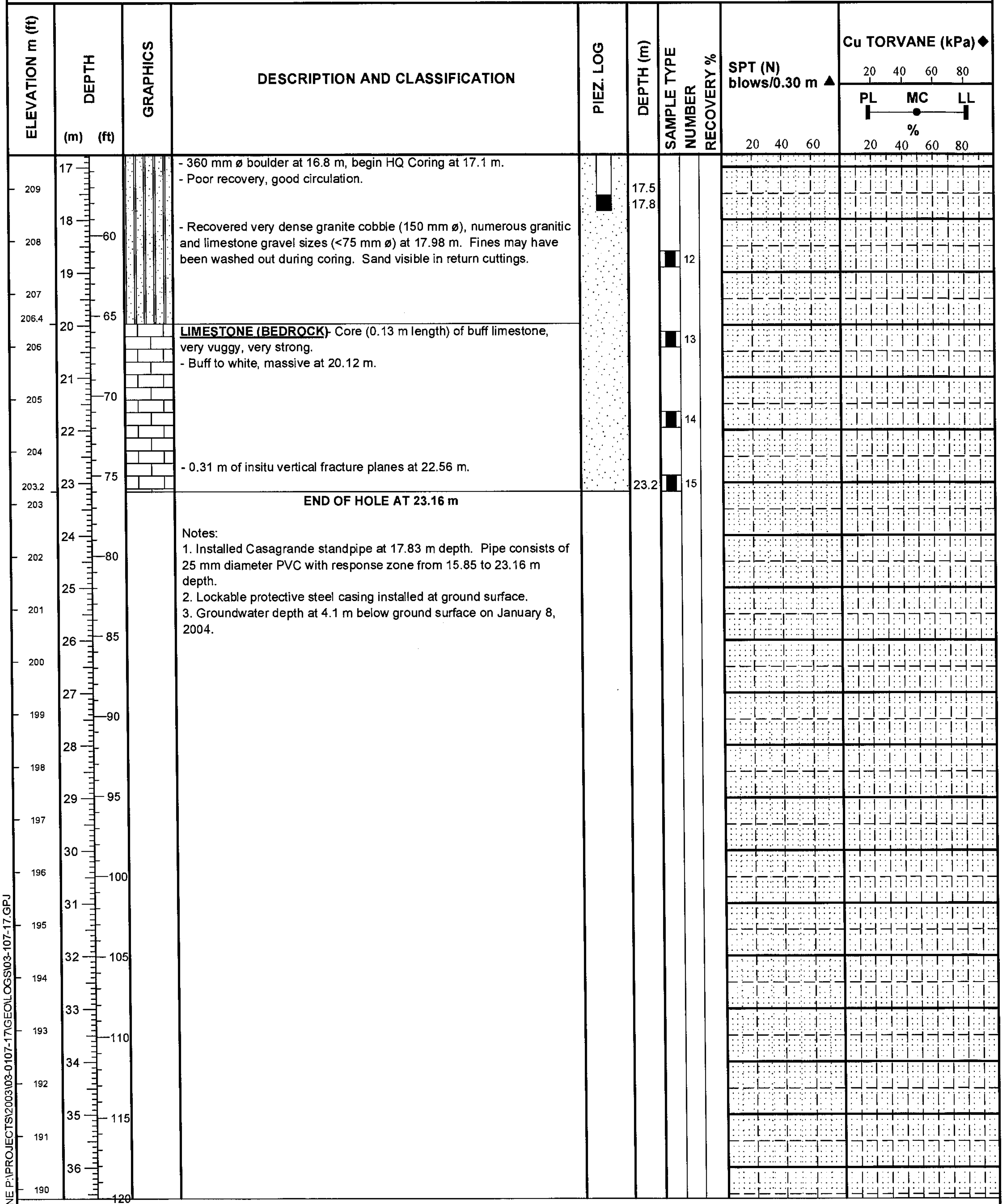
APPROVED ________ DATE 19/01/04

KGS GROUP

SUMMARY LOG

HOLE NO. **TH-2**

SHEET 2 of 2



- 360 mm ø boulder at 16.8 m, begin HQ Coring at 17.1 m.
- Poor recovery, good circulation.

- Recovered very dense granite cobble (150 mm ø), numerous granitic and limestone gravel sizes (<75 mm ø) at 17.98 m. Fines may have been washed out during coring. Sand visible in return cuttings.

LIMESTONE (BEDROCK) - Core (0.13 m length) of buff limestone, very vuggy, very strong.
- Buff to white, massive at 20.12 m.

- 0.31 m of insitu vertical fracture planes at 22.56 m.

END OF HOLE AT 23.16 m

Notes:
1. Installed Casagrande standpipe at 17.83 m depth. Pipe consists of 25 mm diameter PVC with response zone from 15.85 to 23.16 m depth.
2. Lockable protective steel casing installed at ground surface.
3. Groundwater depth at 4.1 m below ground surface on January 8, 2004.

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Select Core Barrel

CONTRACTOR
Paddock Drilling Ltd.

INSPECTOR
G.E. HARRISON

APPROVED ______

DATE 19/01/04

SPT & TORVANE P:\PROJECTS\2003\03-0107-17\GEOLOGS\03-107-17.GPJ

KGS GROUP

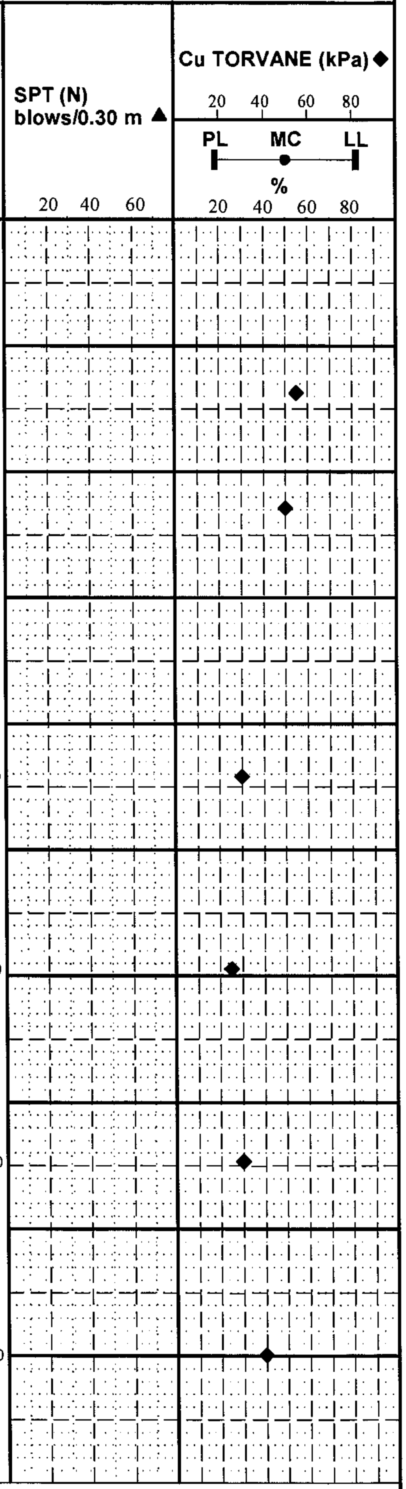
SUMMARY LOG

HOLE NO. **TH-6**

SHEET 1 of 2

CLIENT	CITY OF WINNIPEG	JOB NO.	03-107-17
PROJECT	MONTCALM FORCE MAIN REPLACEMENT	GROUND ELEV.	230.40 m
SITE	MONTCALM FORCE MAIN	WATER ELEV.	
LOCATION	EAST TOP OF BANK AT SHAFT, 5529372 N 635924.6 E		
DRILLING METHOD	150 mm ø Solid Stem Auger, Acker MP5-T	DATE DRILLED	16 Jan 04

ELEVATION m (ft)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
230.3			**GRAVEL FILL**			
			CLAY (FILL) (CH)- Brown, moist, stiff, high plasticity, trace organics, trace coarse grained gravel, trace silt.			
230						
229.5						
	1		**CLAY (LACUSTRINE) (CH)**- Brown, moist, stiff, trace to some fine to coarse grained sand, trace fine grained gravel (-), trace oxidation.			
229				⌇	1	100
		5				
	2					
			- Firm at 2.25 m.	⌇	2	100
228						
	3	10				
227						
	4					
226				⌇	3	100
		15				
			- Grey, wet at 4.57 m.			
	5					
225						
	6	20		⌇	4	100
224						
	7					
223				⌇	5	100
		25	- Trace 1-2 mm ø silt nodules at 7.62 m. - Water seepage at 7.62 m.			
	8					
222						
	9	30		⌇	6	100
			- Increased silt nodules (3-5 mm ø) at 9.14 m.			
221						



SAMPLE TYPE ⌇ Auger Grab ☒ Split Spoon

CONTRACTOR
Paddock Drilling Ltd.

INSPECTOR
J. CHING

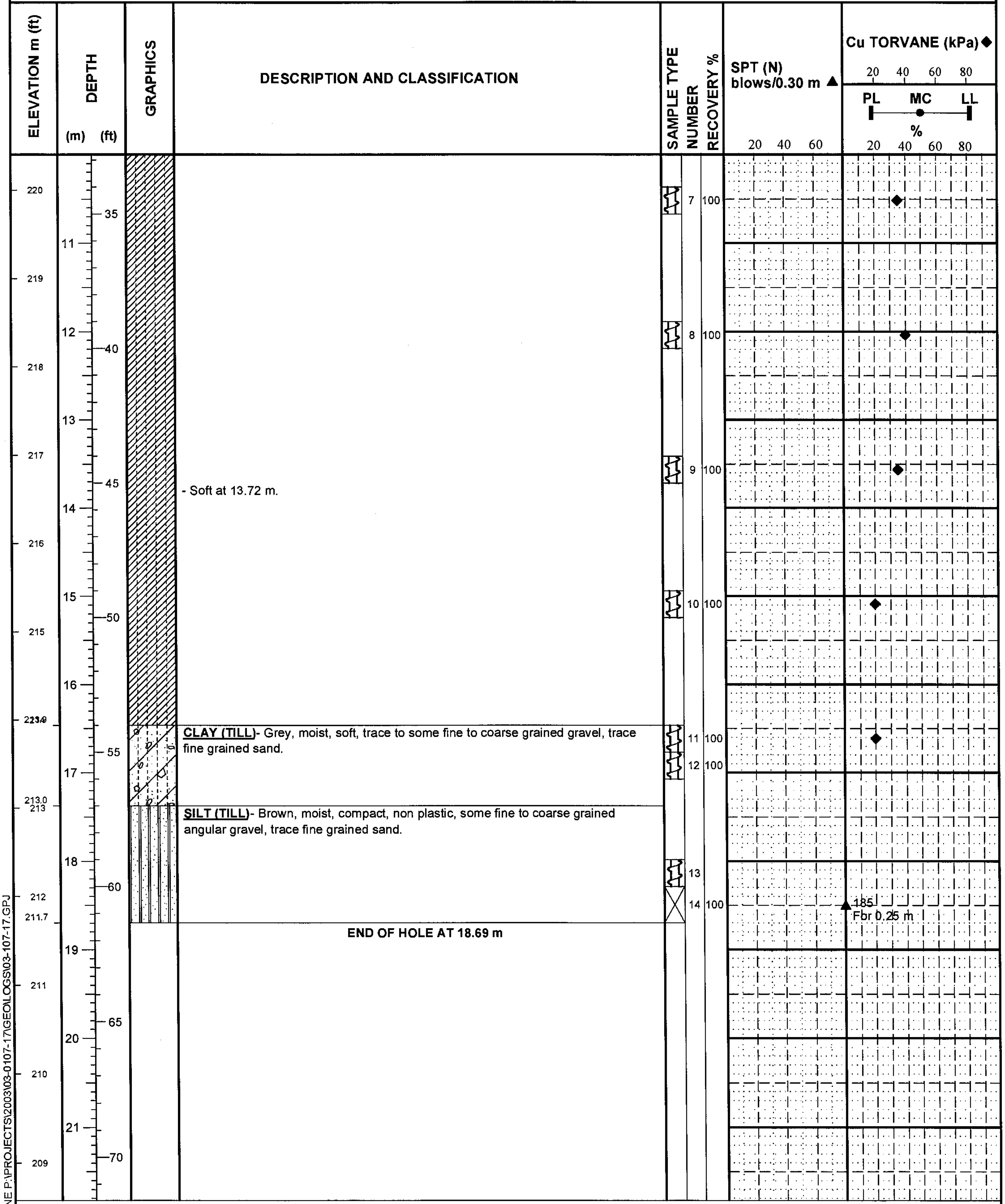
APPROVED ________ DATE 19/01/04

KGS GROUP

SUMMARY LOG

HOLE NO. **TH-6**

SHEET 2 of 2



- Soft at 13.72 m.

CLAY (TILL)- Grey, moist, soft, trace to some fine to coarse grained gravel, trace fine grained sand.

SILT (TILL)- Brown, moist, compact, non plastic, some fine to coarse grained angular gravel, trace fine grained sand.

END OF HOLE AT 18.69 m

SAMPLE TYPE	NUMBER	RECOVERY %
Auger Grab	7	100
Auger Grab	8	100
Auger Grab	9	100
Auger Grab	10	100
Auger Grab	11	100
Auger Grab	12	100
Auger Grab	13	
Split Spoon	14	100

SAMPLE TYPE 🅃 Auger Grab ☒ Split Spoon

CONTRACTOR
Paddock Drilling Ltd.

INSPECTOR
J. CHING

APPROVED ________

DATE 19/01/04

SPT & TORVANE P:\PROJECTS\2003\03-0107-17\GEOLOGS\03-107-17.GPJ

Appendix B

Laboratory Testing

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Moisture Content Report
ASTM D2216-98

Project No. 0019 005 00
Client SNC Lavalin
Project Montcalm Pumping Station

Sample Date September 23, 2011
Test Date September 30, 2011
Technician LB

Test Hole	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01
Depth (m)	0.0 - 0.3	0.8 - 0.9	2.0 - 2.1	2.4 - 2.6	3.1 - 3.3	3.5 - 3.7
Sample #	G1	G2	G3	G4	T5A	T5B
Tare ID	A13	D37	C1	A23	E18	D32
Mass of tare	8.3	8.2	8.3	8.5	8.4	8.3
Mass wet + tare	497.6	404.8	398.7	420.3	386.6	425.6
Mass dry + tare	473.7	298.2	266.9	313.7	253.5	351.2
Mass water	23.9	106.6	131.8	106.6	133.1	74.4
Mass dry soil	465.4	290.0	258.6	305.2	245.1	342.9
Moisture %	5.1%	36.8%	51.0%	34.9%	54.3%	21.7%

Test Hole	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01
Depth (m)	3.8 - 4.0	4.4 - 4.6	5.3 - 5.5	6.1 - 6.7	7.6 - 7.8	9.1 - 9.8
Sample #	G6	G7	G8	T9	G10	T11
Tare ID	C12	C6	D47	A24	E73	E24
Mass of tare	8.4	8.3	8.5	8.5	8.4	8.2
Mass wet + tare	433	428.8	408.1	405	425.5	428.4
Mass dry + tare	295.1	281.3	268.3	267.7	297.3	295.1
Mass water	137.9	147.5	139.8	137.3	128.2	133.3
Mass dry soil	286.7	273.0	259.8	259.2	288.9	286.9
Moisture %	48.1%	54.0%	53.8%	53.0%	44.4%	46.5%

Test Hole	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01
Depth (m)	9.9 - 10.1	10.7 - 11.3	11.4 - 11.6	12.2 - 12.8	13.0 - 13.1	13.7 - 14.3
Sample #	G12	T13	G14	T15	G16	T17
Tare ID	E37	C24	E44	C3	E42	E12
Mass of tare	8.3	8.4	8.5	8.4	8.2	8.4
Mass wet + tare	417.3	440.1	401.2	404.4	410.2	486
Mass dry + tare	287.5	285.8	265.6	277.5	273.3	330.5
Mass water	129.8	154.3	135.6	126.9	136.9	155.5
Mass dry soil	279.2	277.4	257.1	269.1	265.1	322.1
Moisture %	46.5%	55.6%	52.7%	47.2%	51.6%	48.3%

Moisture Content Report
ASTM D2216-98

Project No. 0019 005 00
Client SNC Lavalin
Project Montcalm Pumping Station

Sample Date September 23, 2011
Test Date September 30, 2011
Technician LB

Test Hole	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01	TH11-01
Depth (m)	14.5 - 14.6	15.2 - 15.8	16.0 - 16.2	16.6 - 16.8	16.8 - 17.2	16.8 - 17.2
Sample #	G18	T19	G20	G21	S22A	S22B
Tare ID	D10	D22	E118	E64	E87	E133
Mass of tare	8.4	8.4	8.3	8.5	8.4	8.4
Mass wet + tare	505.9	416.8	416.9	470.6	214.2	199.4
Mass dry + tare	349.1	260.1	274.5	361.7	197.1	184.3
Mass water	156.8	156.7	142.4	108.9	17.1	15.1
Mass dry soil	340.7	251.7	266.2	353.2	188.7	175.9
Moisture %	46.0%	62.3%	53.5%	30.8%	9.1%	8.6%

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Atterberg Limits
ASTM D4318

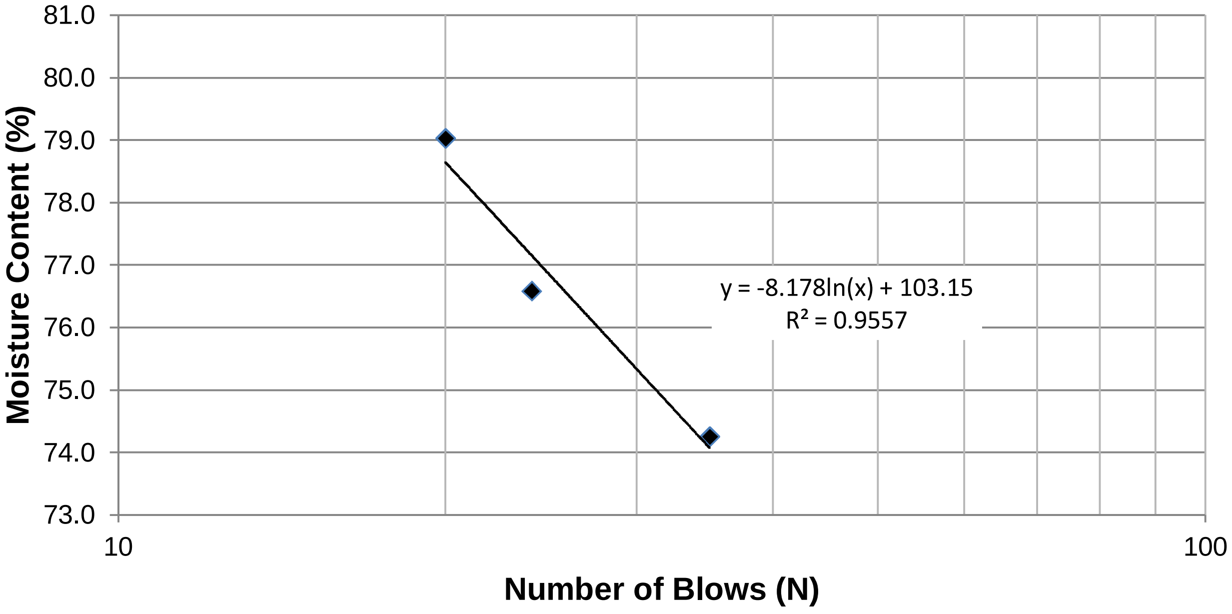
Project No.	0019 005 00
Client	SNC Lavalin
Project	Montcalm Pumping Station

Test Hole	TH11-01
Sample #	T11
Depth (m)	9.1 - 9.8
Sample Date	22-Sep-11
Test Date	13-Oct-11
Technician	Dan Mroz

Liquid Limit	76.8
Plastic Limit	17.8
Plasticity Index	59.0

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	35	24	20		
Mass Wet Soil + Tare (g)	26.701	25.002	24.714		
Mass Dry Soil + Tare (g)	21.209	20.190	19.852		
Mass Tare (g)	13.813	13.907	13.700		
Mass Water (g)	5.492	4.812	4.862		
Mass Dry Soil (g)	7.396	6.283	6.152		
Moisture Content (%)	74.256	76.588	79.031		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.158	20.336			
Mass Dry Soil + Tare (g)	19.223	19.393			
Mass Tare (g)	13.955	14.131			
Mass Water (g)	0.935	0.943			
Mass Dry Soil (g)	5.268	5.262			
Moisture Content (%)	17.749	17.921			

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Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Test Hole TH11-01
Sample # T5
Depth (m) 3.0 - 3.7
Sample Date 22-Sep-11
Test Date 6-Oct-11
Technician Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	-	-
Max S_u	-	-

Specimen Data

Description CLAY - silty, trace silt inclusions (<5 mm diam.), trace gravel (<20 mm diam>), trace oxidation, trace silt laminations (<2mm thick), brown, moist, firm, high plasticity

Length	139.1	(mm)	**Moisture %**	54%	
Diameter	72.5	(mm)	**Bulk Unit Wt.**	16.5	(kN/m^3)
L/D Ratio	1.9		**Dry Unit Wt.**	10.7	(kN/m^3)
Initial Area	0.00413	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.45	44.1	0.92

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.80	39.2	0.82
0.75	36.8	0.77
0.75	36.8	0.77
Average	**37.6**	**0.79**

Failure Geometry

Sketch:

No qu

Photo:

No qu

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Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Test Hole	TH11-01
Sample #	T9
Depth (m)	6.1 - 6.7
Sample Date	22-Sep-11
Test Date	6-Oct-11
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	75.0	1.57
Max S_u	37.5	0.78

Specimen Data

Description CLAY - silty, trace silt inclusions (<20 mm diam.), trace gravel (<10 mm diam>), homogeneous, light grey, moist, soft, high plasticity

Length	144.7	(mm)	**Moisture %**	53%	
Diameter	72.1	(mm)	**Bulk Unit Wt.**	16.9	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	11.1	(kN/m^3)
Initial Area	0.00408	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

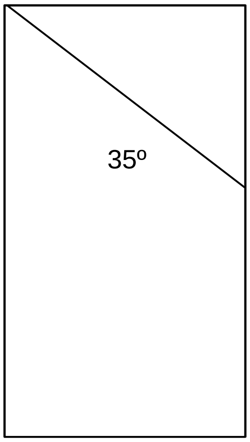
Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.41	40.2	0.84

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.50	24.5	0.51
0.60	29.4	0.61
0.70	34.3	0.72
Average	**29.4**	**0.61**

Failure Geometry

Sketch:



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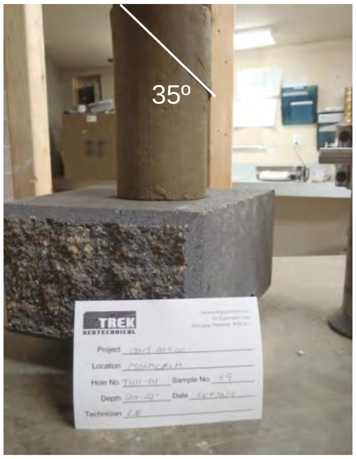

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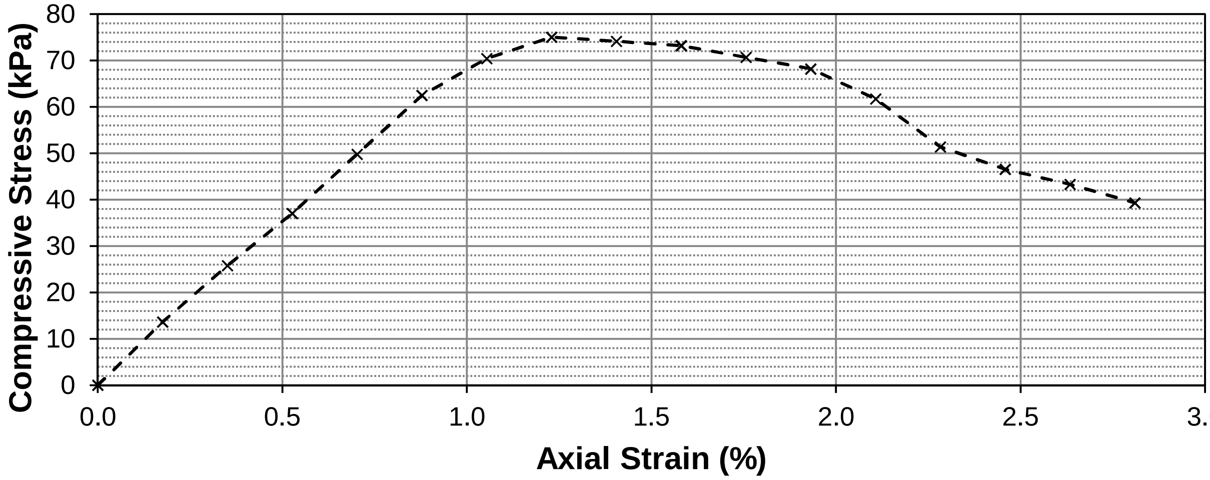
Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004079	0.0	0.00	0.00
10	17	0.2540	0.18	0.004086	55.7	13.62	6.81
20	32	0.5080	0.35	0.004093	105.5	25.78	12.89
30	46	0.7620	0.53	0.004100	151.7	36.99	18.50
40	62	1.0160	0.70	0.004108	204.4	49.76	24.88
50	78	1.2700	0.88	0.004115	257.2	62.49	31.25
60	88	1.5240	1.05	0.004122	290.2	70.39	35.20
70	94	1.7780	1.23	0.004129	309.9	75.05	37.52
80	93	2.0320	1.40	0.004137	306.6	74.12	37.06
90	92	2.2860	1.58	0.004144	303.3	73.19	36.60
100	89	2.5400	1.76	0.004152	293.4	70.68	35.34
110	86	2.7940	1.93	0.004159	283.5	68.17	34.09
120	78	3.0480	2.11	0.004166	257.2	61.72	30.86
130	65	3.3020	2.28	0.004174	214.3	51.35	25.67
140	59	3.5560	2.46	0.004181	194.5	46.52	23.26
150	55	3.8100	2.63	0.004189	181.4	43.29	21.65
160	50	4.0640	2.81	0.004197	164.9	39.28	19.64

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Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Test Hole	TH11-01
Sample #	T11
Depth (m)	9.1 - 9.8
Sample Date	22-Sep-11
Test Date	6-Oct-11
Technician	Stephen Renner

Unconfined Strength

	kPa	ksf
Max q_u	107.3	2.24
Max S_u	53.6	1.12

Specimen Data

Description CLAY - silty, trace silt inclusions (<15 mm diam.), trace gravel (<20 mm diam.), trace oxidation, homogeneous, brown to grey, moist, soft to firm, high plasticity

Length	148.4	(mm)
Diameter	72.4	(mm)
L/D Ratio	2.1	
Initial Area	0.00411	(m^2)
Load Rate	1.00	(%/min)

Moisture %	46%	
Bulk Unit Wt.	17.8	(kN/m^3)
Dry Unit Wt.	12.1	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.46	45.1	0.94

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.60	29.4	0.61
0.75	36.8	0.77
0.75	36.8	0.77
Average	**34.3**	**0.72**

Failure Geometry

Sketch:

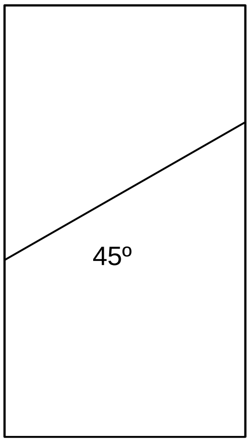


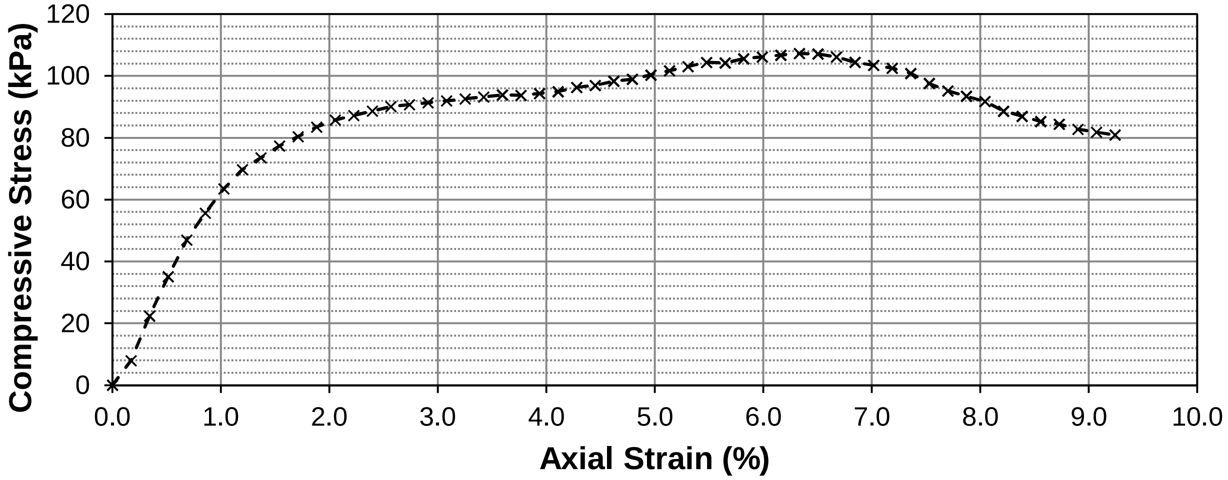
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004113	0.0	0.00	0.00
10	10	0.2540	0.17	0.004121	32.7	7.94	3.97
20	28	0.5080	0.34	0.004128	92.3	22.36	11.18
30	44	0.7620	0.51	0.004135	145.1	35.08	17.54
40	59	1.0160	0.68	0.004142	194.5	46.97	23.48
50	70	1.2700	0.86	0.004149	230.8	55.62	27.81
60	80	1.5240	1.03	0.004156	263.8	63.47	31.73
70	88	1.7780	1.20	0.004163	290.2	69.69	34.85
80	93	2.0320	1.37	0.004171	306.6	73.52	36.76
90	98	2.2860	1.54	0.004178	323.1	77.34	38.67
100	102	2.5400	1.71	0.004185	336.4	80.39	40.19
110	106	2.7940	1.88	0.004192	349.9	83.46	41.73
120	109	3.0480	2.05	0.004200	360.0	85.72	42.86
130	111	3.3020	2.22	0.004207	366.8	87.18	43.59
140	113	3.5560	2.40	0.004214	373.5	88.62	44.31
150	115	3.8100	2.57	0.004222	380.2	90.06	45.03
160	116	4.0640	2.74	0.004229	383.6	90.69	45.35
170	117	4.3180	2.91	0.004237	387.0	91.33	45.67
180	118	4.5720	3.08	0.004244	390.3	91.97	45.98
190	119	4.8260	3.25	0.004252	393.7	92.59	46.30
200	120	5.0800	3.42	0.004259	397.0	93.22	46.61
210	121	5.3340	3.59	0.004267	400.4	93.85	46.92
220	121	5.5880	3.76	0.004274	400.4	93.68	46.84
230	122	5.8420	3.94	0.004282	403.8	94.30	47.15

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	123	6.0960	4.1068	0.004290	407.1	94.91	47.46
250	125	6.3500	4.28	0.004297	413.9	96.32	48.16
260	126	6.6040	4.45	0.004305	417.2	96.92	48.46
270	128	6.8580	4.62	0.004313	424.0	98.32	49.16
280	129	7.1120	4.79	0.004320	427.4	98.92	49.46
290	131	7.3660	4.96	0.004328	434.1	100.30	50.15
300	133	7.6200	5.13	0.004336	440.8	101.66	50.83
310	135	7.8740	5.30	0.004344	447.6	103.04	51.52
320	137	8.1280	5.48	0.004352	454.3	104.39	52.20
330	137	8.3820	5.65	0.004360	454.3	104.21	52.10
340	139	8.6360	5.82	0.004368	461.1	105.56	52.78
350	140	8.8900	5.99	0.004376	464.4	106.13	53.07
360	141	9.1440	6.16	0.004383	467.8	106.71	53.36
370	142	9.3980	6.33	0.004391	471.2	107.29	53.64
380	142	9.6520	6.50	0.004400	471.2	107.09	53.55
390	141	9.9060	6.67	0.004408	467.8	106.13	53.06
400	139	10.1600	6.84	0.004416	461.1	104.41	52.21
410	138	10.4140	7.02	0.004424	457.7	103.46	51.73
420	137	10.6680	7.19	0.004432	454.3	102.50	51.25
430	135	10.9220	7.36	0.004440	447.6	100.80	50.40
440	131	11.1760	7.53	0.004448	434.1	97.59	48.79
450	128	11.4300	7.70	0.004457	424.0	95.14	47.57
460	126	11.6840	7.87	0.004465	417.2	93.45	46.72
470	124	11.9380	8.04	0.004473	410.5	91.77	45.89
480	120	12.1920	8.21	0.004482	397.0	88.60	44.30
490	118	12.4460	8.38	0.004490	390.3	86.93	43.47
500	116	12.7000	8.56	0.004498	383.6	85.27	42.63
510	115	12.9540	8.73	0.004507	380.2	84.37	42.18
520	113	13.2080	8.90	0.004515	373.5	82.71	41.36
530	112	13.4620	9.07	0.004524	370.1	81.82	40.91
540	111	13.7160	9.24	0.004532	366.8	80.92	40.46

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Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Test Hole	TH11-01
Sample #	T13
Depth (m)	10.7 - 11.3
Sample Date	22-Sep-11
Test Date	7-Oct-11
Technician	Stephen Renner

Unconfined Strength

	kPa	**ksf**
Max q_u	51.4	1.07
Max S_u	25.7	0.54

Specimen Data

Description CLAY - silty, trace silt inclusions (<25 mm diam.), trace sand (fine grained), homogeneous, grey, moist, soft, high plasticity

Length	150.9	(mm)	**Moisture %**	56%	
Diameter	72.1	(mm)	**Bulk Unit Wt.**	16.5	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	10.6	(kN/m^3)
Initial Area	0.00408	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.36	35.3	0.74

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.30	14.7	0.31
0.35	17.2	0.36
0.25	12.3	0.26
Average	**14.7**	**0.31**

Failure Geometry

Sketch:

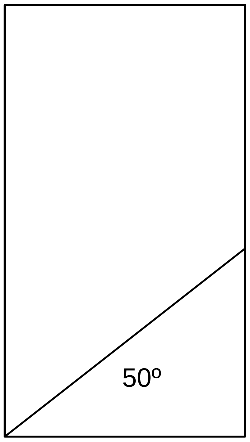


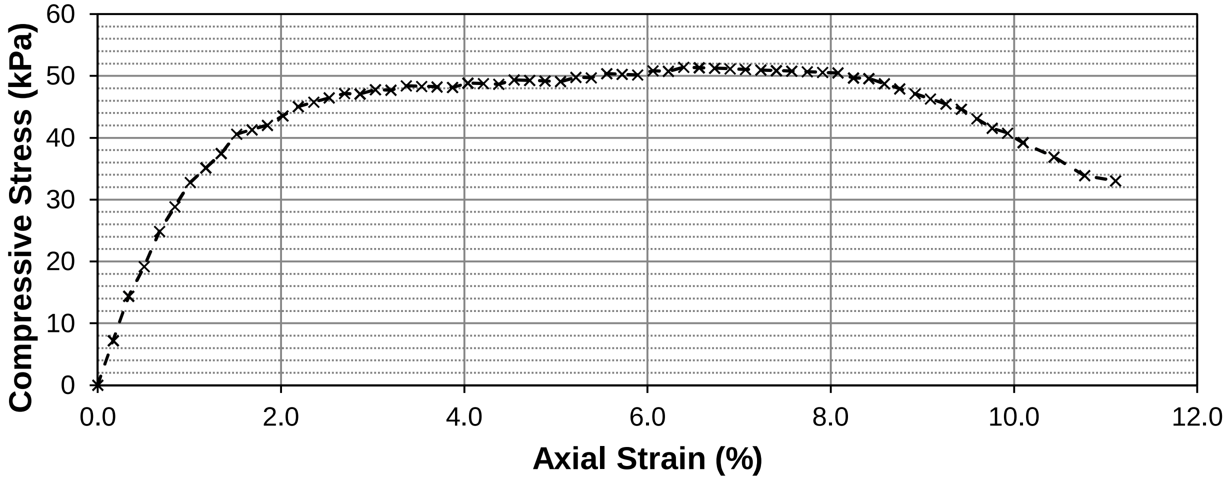
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004081	0.0	0.00	0.00
10	9	0.2540	0.17	0.004088	29.4	7.20	3.60
20	18	0.5080	0.34	0.004095	58.9	14.39	7.20
30	24	0.7620	0.50	0.004102	78.6	19.17	9.59
40	31	1.0160	0.67	0.004109	102.2	24.88	12.44
50	36	1.2700	0.84	0.004116	118.7	28.84	14.42
60	41	1.5240	1.01	0.004123	135.2	32.79	16.40
70	44	1.7780	1.18	0.004130	145.1	35.13	17.56
80	47	2.0320	1.35	0.004137	155.0	37.46	18.73
90	51	2.2860	1.51	0.004144	168.1	40.58	20.29
100	52	2.5400	1.68	0.004151	171.4	41.30	20.65
110	53	2.7940	1.85	0.004158	174.7	42.02	21.01
120	55	3.0480	2.02	0.004165	181.4	43.54	21.77
130	57	3.3020	2.19	0.004172	187.9	45.05	22.52
140	58	3.5560	2.36	0.004179	191.2	45.76	22.88
150	59	3.8100	2.52	0.004187	194.5	46.46	23.23
160	60	4.0640	2.69	0.004194	197.8	47.17	23.58
170	60	4.3180	2.86	0.004201	197.8	47.09	23.54
180	61	4.5720	3.03	0.004208	201.1	47.79	23.89
190	61	4.8260	3.20	0.004216	201.1	47.70	23.85
200	62	5.0800	3.37	0.004223	204.4	48.40	24.20
210	62	5.3340	3.53	0.004230	204.4	48.32	24.16
220	62	5.5880	3.70	0.004238	204.4	48.23	24.12
230	62	5.8420	3.87	0.004245	204.4	48.15	24.07

Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	63	6.0960	4.0389	0.004253	207.7	48.85	24.42
250	63	6.3500	4.21	0.004260	207.7	48.76	24.38
260	63	6.6040	4.38	0.004268	207.7	48.68	24.34
270	64	6.8580	4.54	0.004275	211.0	49.36	24.68
280	64	7.1120	4.71	0.004283	211.0	49.27	24.64
290	64	7.3660	4.88	0.004290	211.0	49.19	24.59
300	64	7.6200	5.05	0.004298	211.0	49.10	24.55
310	65	7.8740	5.22	0.004306	214.3	49.78	24.89
320	65	8.1280	5.39	0.004313	214.3	49.69	24.84
330	66	8.3820	5.55	0.004321	217.6	50.36	25.18
340	66	8.6360	5.72	0.004329	217.6	50.27	25.14
350	66	8.8900	5.89	0.004336	217.6	50.18	25.09
360	67	9.1440	6.06	0.004344	220.9	50.85	25.43
370	67	9.3980	6.23	0.004352	220.9	50.76	25.38
380	68	9.6520	6.39	0.004360	224.2	51.42	25.71
390	68	9.9060	6.56	0.004368	224.2	51.33	25.67
400	68	10.1600	6.73	0.004375	224.2	51.24	25.62
410	68	10.4140	6.90	0.004383	224.2	51.15	25.57
420	68	10.6680	7.07	0.004391	224.2	51.05	25.53
430	68	10.9220	7.24	0.004399	224.2	50.96	25.48
440	68	11.1760	7.40	0.004407	224.2	50.87	25.43
450	68	11.4300	7.57	0.004415	224.2	50.78	25.39
460	68	11.6840	7.74	0.004423	224.2	50.68	25.34
470	68	11.9380	7.91	0.004431	224.2	50.59	25.30
480	68	12.1920	8.08	0.004440	224.2	50.50	25.25
490	67	12.4460	8.25	0.004448	220.9	49.67	24.83
500	67	12.7000	8.41	0.004456	220.9	49.57	24.79
510	66	12.9540	8.58	0.004464	217.6	48.75	24.37
520	65	13.2080	8.75	0.004472	214.3	47.92	23.96
530	64	13.4620	8.92	0.004481	211.0	47.10	23.55
540	63	13.7160	9.09	0.004489	207.7	46.28	23.14
550	62	13.9700	9.26	0.004497	204.4	45.45	22.72
560	61	14.2240	9.42	0.004506	201.1	44.63	22.32
570	59	14.4780	9.59	0.004514	194.5	43.09	21.55
580	57	14.7320	9.76	0.004522	187.9	41.56	20.78
590	56	14.9860	9.93	0.004531	184.6	40.75	20.38
600	54	15.2400	10.10	0.004539	178.0	39.22	19.61
620	51	15.7480	10.43	0.004556	168.1	36.90	18.45
640	47	16.2560	10.77	0.004574	155.0	33.89	16.94
660	46	16.7640	11.11	0.004591	151.7	33.04	16.52

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Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Test Hole TH11-01
Sample # T15
Depth (m) 12.2 - 12.8
Sample Date 22-Sep-11
Test Date 7-Oct-11
Technician Stephen Renner

Unconfined Strength

	kPa	ksf
Max q_u	136.6	2.85
Max S_u	68.3	1.43

Specimen Data

Description CLAY - silty, trace silt inclusions (<10 mm diam.), homogeneous, grey, moist, soft, high plasticity

Length	138.6	(mm)	**Moisture %**	47%	
Diameter	72.4	(mm)	**Bulk Unit Wt.**	16.6	(kN/m^3)
L/D Ratio	1.9		**Dry Unit Wt.**	11.3	(kN/m^3)
Initial Area	0.00411	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

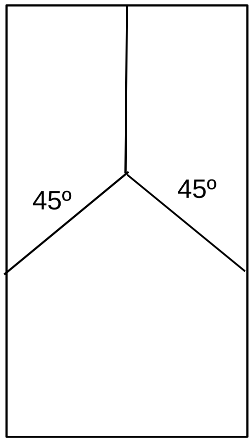
Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.31	30.4	0.64

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.25	12.3	0.26
0.20	9.8	0.20
0.25	12.3	0.26
Average	**11.4**	**0.24**

Failure Geometry

Sketch:



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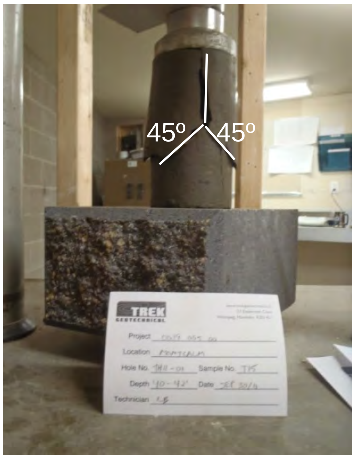

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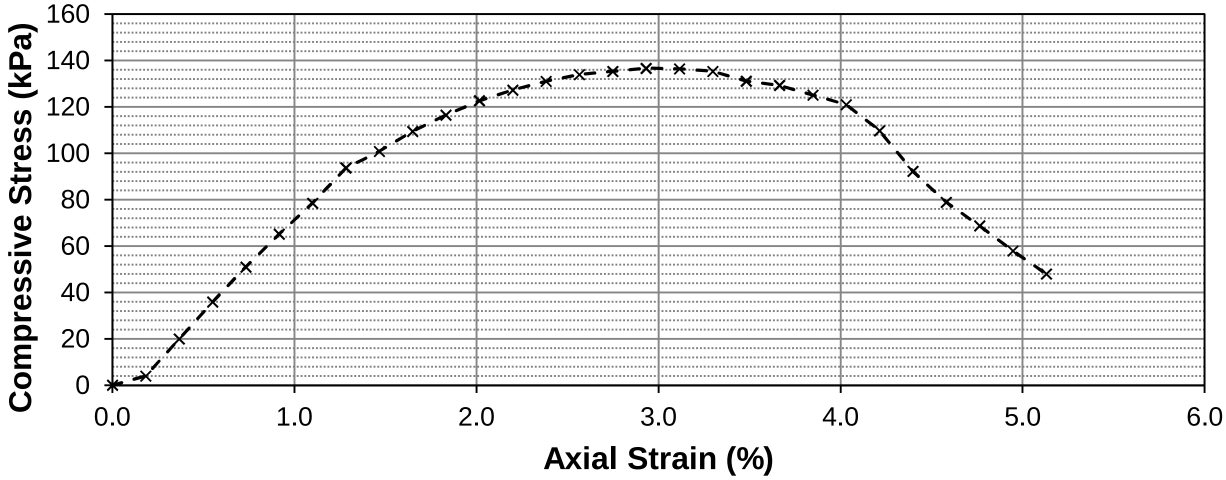
Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004113	0.0	0.00	0.00
10	5	0.2540	0.18	0.004121	16.3	3.97	1.98
20	25	0.5080	0.37	0.004129	82.4	19.96	9.98
30	45	0.7620	0.55	0.004136	148.3	35.87	17.93
40	64	1.0160	0.73	0.004144	211.0	50.92	25.46
50	82	1.2700	0.92	0.004151	270.4	65.12	32.56
60	99	1.5240	1.10	0.004159	326.4	78.48	39.24
70	118	1.7780	1.28	0.004167	390.3	93.67	46.84
80	127	2.0320	1.47	0.004175	420.6	100.76	50.38
90	138	2.2860	1.65	0.004182	457.7	109.43	54.71
100	147	2.5400	1.83	0.004190	488.0	116.45	58.23
110	155	2.7940	2.02	0.004198	514.9	122.66	61.33
120	161	3.0480	2.20	0.004206	535.1	127.23	63.62
130	166	3.3020	2.38	0.004214	552.0	130.99	65.50
140	170	3.5560	2.57	0.004222	565.5	133.94	66.97
150	172	3.8100	2.75	0.004230	572.2	135.28	67.64
160	174	4.0640	2.93	0.004238	578.9	136.62	68.31
170	174	4.3180	3.11	0.004246	578.9	136.36	68.18
180	173	4.5720	3.30	0.004254	575.6	135.31	67.65
190	168	4.8260	3.48	0.004262	558.7	131.09	65.55
200	166	5.0800	3.66	0.004270	552.0	129.27	64.64
210	161	5.3340	3.85	0.004278	535.1	125.09	62.54
220	156	5.5880	4.03	0.004286	518.3	120.92	60.46
230	142	5.8420	4.21	0.004294	471.2	109.71	54.86

Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	120	6.0960	4.40	0.004303	397.0	92.28	46.14
250	103	6.3500	4.58	0.004311	339.8	78.82	39.41
260	90	6.6040	4.76	0.004319	296.7	68.70	34.35
270	76	6.8580	4.95	0.004328	250.6	57.90	28.95
280	63	7.1120	5.13	0.004336	207.7	47.91	23.95

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Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Test Hole	TH11-01
Sample #	T17
Depth (m)	13.7 - 14.3
Sample Date	22-Sep-11
Test Date	11-Oct-11
Technician	Stephen Renner

Unconfined Strength

	kPa	ksf
Max q_u	85.2	1.78
Max S_u	42.6	0.89

Specimen Data

Description CLAY - silty, trace silt inclusions (<20 mm diam.), homogeneous, grey, moist, soft, high plasticity

Length	145.3	(mm)	**Moisture %**	48%	
Diameter	72.6	(mm)	**Bulk Unit Wt.**	16.6	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	11.2	(kN/m^3)
Initial Area	0.00414	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.40	39.2	0.82

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.50	24.5	0.51
0.35	17.2	0.36
0.45	22.1	0.46
Average	**21.3**	**0.44**

Failure Geometry

Sketch:

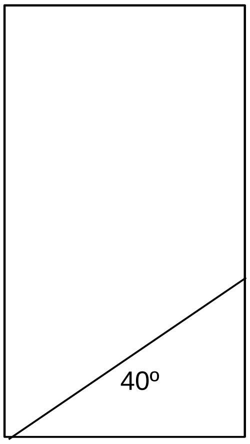


Photo:

TREK GEOTECHNICAL

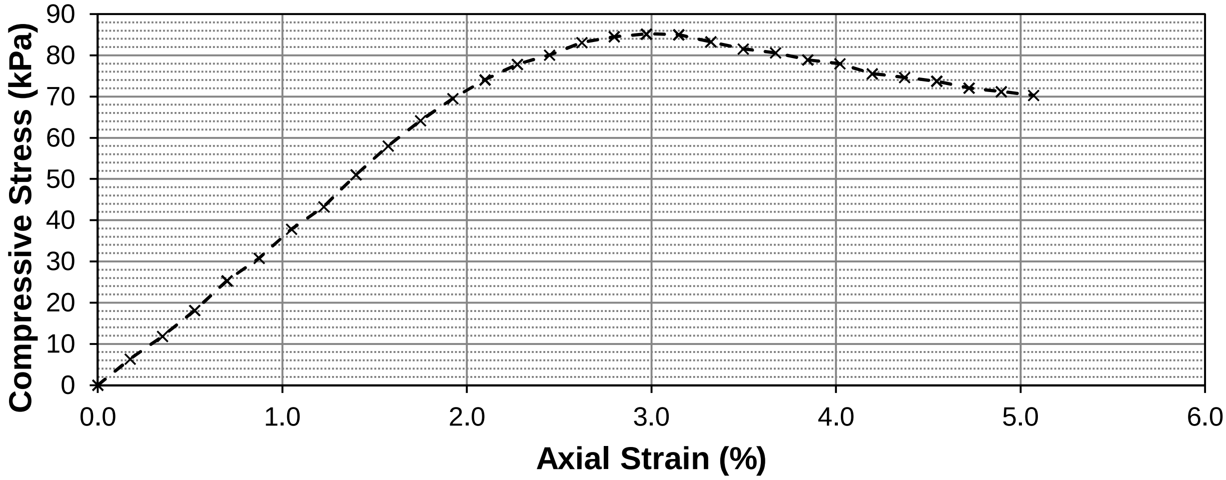
Project 0019 005 00
Location MONTCALM PUMPING STATION
Hole No. TH11- 01 Sample No. T17
Depth 45 - 47' Date 07/10/11
Technician LB

Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004140	0.0	0.00	0.00
10	8	0.2540	0.17	0.004148	26.2	6.31	3.15
20	15	0.5080	0.35	0.004155	49.1	11.82	5.91
30	23	0.7620	0.52	0.004162	75.3	18.10	9.05
40	32	1.0160	0.70	0.004170	105.5	25.31	12.65
50	39	1.2700	0.87	0.004177	128.6	30.79	15.39
60	48	1.5240	1.05	0.004184	158.3	37.82	18.91
70	55	1.7780	1.22	0.004192	181.4	43.27	21.63
80	65	2.0320	1.40	0.004199	214.3	51.04	25.52
90	74	2.2860	1.57	0.004207	244.0	58.00	29.00
100	82	2.5400	1.75	0.004214	270.4	64.16	32.08
110	89	2.7940	1.92	0.004222	293.4	69.51	34.76
120	95	3.0480	2.10	0.004229	313.2	74.06	37.03
130	100	3.3020	2.27	0.004237	329.7	77.82	38.91
140	103	3.5560	2.45	0.004244	339.8	80.06	40.03
150	107	3.8100	2.62	0.004252	353.3	83.09	41.54
160	109	4.0640	2.80	0.004260	360.0	84.51	42.26
170	110	4.3180	2.97	0.004267	363.4	85.15	42.58
180	110	4.5720	3.15	0.004275	363.4	85.00	42.50
190	108	4.8260	3.32	0.004283	356.7	83.28	41.64
200	106	5.0800	3.50	0.004290	349.9	81.55	40.78
210	105	5.3340	3.67	0.004298	346.6	80.63	40.31
220	103	5.5880	3.85	0.004306	339.8	78.91	39.46
230	102	5.8420	4.02	0.004314	336.4	77.99	38.99

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	99	6.0960	4.1957	0.004322	326.4	75.53	37.76
250	98	6.3500	4.37	0.004330	323.1	74.63	37.31
260	97	6.6040	4.55	0.004338	319.8	73.73	36.87
270	95	6.8580	4.72	0.004346	313.2	72.07	36.04
280	94	7.1120	4.90	0.004354	309.9	71.19	35.59
290	93	7.3660	5.07	0.004362	306.6	70.30	35.15

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Unconfined Compressive Strength

ASTM D2166

Project No.	0019 005 00
Client	SNC Lavalin Inc.
Project	Montcalm Pumping Station Upgrades

Test Hole	TH11-01
Sample #	T19
Depth (m)	15.2 - 15.8
Sample Date	22-Sep-11
Test Date	6-Oct-11
Technician	Stephen Renner

Unconfined Strength

	kPa	ksf
Max q_u	89.2	1.86
Max S_u	44.6	0.93

Specimen Data

Description CLAY - silty, trace silt inclusions (<20 mm diam.), trace sand (coarse grained), homogeneous, grey, moist, soft to firm, high plasticity

Length	148.8	(mm)	**Moisture %**	62%	
Diameter	72.4	(mm)	**Bulk Unit Wt.**	16.1	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	9.9	(kN/m^3)
Initial Area	0.00412	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.45	44.1	0.92

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.45	22.1	0.46
0.50	24.5	0.51
0.50	24.5	0.51
Average	**23.7**	**0.50**

Failure Geometry

Sketch:

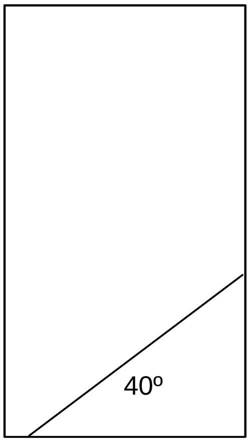
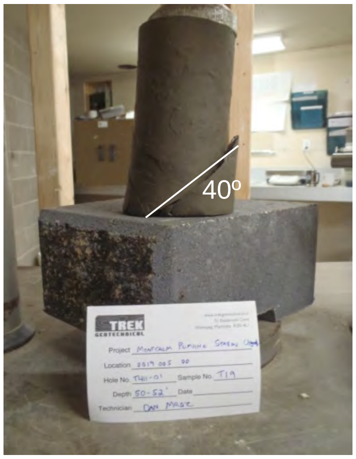


Photo:

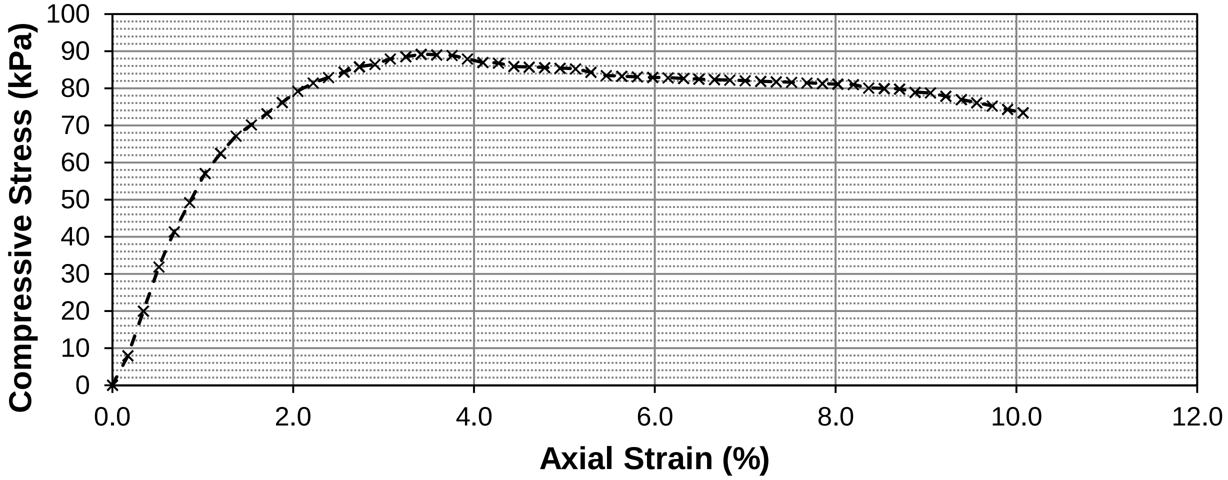


Unconfined Compressive Strength

ASTM D2166

Project No. 0019 005 00
Client SNC Lavalin Inc.
Project Montcalm Pumping Station Upgrades

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004118	0.0	0.00	0.00
10	10	0.2540	0.17	0.004125	32.7	7.93	3.96
20	25	0.5080	0.34	0.004132	82.4	19.95	9.97
30	40	0.7620	0.51	0.004140	131.9	31.86	15.93
40	52	1.0160	0.68	0.004147	171.4	41.34	20.67
50	62	1.2700	0.85	0.004154	204.4	49.21	24.60
60	72	1.5240	1.02	0.004161	237.4	57.05	28.53
70	79	1.7780	1.19	0.004168	260.4	62.48	31.24
80	85	2.0320	1.37	0.004175	280.2	67.12	33.56
90	89	2.2860	1.54	0.004183	293.4	70.16	35.08
100	93	2.5400	1.71	0.004190	306.6	73.18	36.59
110	97	2.7940	1.88	0.004197	319.8	76.20	38.10
120	101	3.0480	2.05	0.004205	333.1	79.22	39.61
130	104	3.3020	2.22	0.004212	343.2	81.48	40.74
140	106	3.5560	2.39	0.004219	349.9	82.93	41.46
150	108	3.8100	2.56	0.004227	356.7	84.38	42.19
160	110	4.0640	2.73	0.004234	363.4	85.82	42.91
170	111	4.3180	2.90	0.004241	366.8	86.47	43.23
180	113	4.5720	3.07	0.004249	373.5	87.90	43.95
190	114	4.8260	3.24	0.004256	376.9	88.54	44.27
200	115	5.0800	3.41	0.004264	380.2	89.17	44.59
210	115	5.3340	3.58	0.004272	380.2	89.02	44.51
220	115	5.5880	3.76	0.004279	380.2	88.86	44.43
230	114	5.8420	3.93	0.004287	376.9	87.91	43.96

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Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	113	6.0960	4.0968	0.004294	373.5	86.97	43.48
250	113	6.3500	4.27	0.004302	373.5	86.81	43.41
260	112	6.6040	4.44	0.004310	370.1	85.89	42.94
270	112	6.8580	4.61	0.004317	370.1	85.73	42.87
280	112	7.1120	4.78	0.004325	370.1	85.58	42.79
290	112	7.3660	4.95	0.004333	370.1	85.43	42.71
300	112	7.6200	5.12	0.004341	370.1	85.27	42.64
310	111	7.8740	5.29	0.004348	366.8	84.34	42.17
320	110	8.1280	5.46	0.004356	363.4	83.41	41.71
330	110	8.3820	5.63	0.004364	363.4	83.26	41.63
340	110	8.6360	5.80	0.004372	363.4	83.11	41.56
350	110	8.8900	5.97	0.004380	363.4	82.96	41.48
360	110	9.1440	6.15	0.004388	363.4	82.81	41.41
370	110	9.3980	6.32	0.004396	363.4	82.66	41.33
380	110	9.6520	6.49	0.004404	363.4	82.51	41.25
390	110	9.9060	6.66	0.004412	363.4	82.36	41.18
400	110	10.1600	6.83	0.004420	363.4	82.21	41.10
410	110	10.4140	7.00	0.004428	363.4	82.06	41.03
420	110	10.6680	7.17	0.004436	363.4	81.91	40.95
430	110	10.9220	7.34	0.004445	363.4	81.76	40.88
440	110	11.1760	7.51	0.004453	363.4	81.61	40.80
450	110	11.4300	7.68	0.004461	363.4	81.45	40.73
460	110	11.6840	7.85	0.004469	363.4	81.30	40.65
470	110	11.9380	8.02	0.004478	363.4	81.15	40.58
480	110	12.1920	8.19	0.004486	363.4	81.00	40.50
490	109	12.4460	8.36	0.004494	360.0	80.10	40.05
500	109	12.7000	8.53	0.004503	360.0	79.95	39.98
510	109	12.9540	8.71	0.004511	360.0	79.80	39.90
520	108	13.2080	8.88	0.004520	356.7	78.91	39.46
530	108	13.4620	9.05	0.004528	356.7	78.77	39.38
540	107	13.7160	9.22	0.004537	353.3	77.87	38.94
550	106	13.9700	9.39	0.004545	349.9	76.98	38.49
560	105	14.2240	9.56	0.004554	346.6	76.11	38.05
570	104	14.4780	9.73	0.004562	343.2	75.22	37.61
580	103	14.7320	9.90	0.004571	339.8	74.34	37.17
590	102	14.9860	10.07	0.004580	336.4	73.46	36.73