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SNC-Lavalin Inc.

Hurst Regional Pumping Station - Chlorine System Upgrades
Geotechnical Report

Prepared for:
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148 Nature Park Way, Winnipeg, Manitoba
R3P 0X7

Project Number: 0019 013 00

Date: June 29, 2023

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June 29, 2023 Our File No. 0019 013 00

Joel Alo (He/Him/His), P.Eng., CD
Senior Mechanical Engineer/Project Manager
Engineering Services
SNC-Lavalin Inc.
148 Nature Park Way, Winnipeg, Manitoba
R3P 0X7

RE: Hurst Regional Pumping Station - Chlorine System Upgrades
Geotechnical Report

TREK Geotechnical Inc. is pleased to submit our revised report for the geotechnical investigation for the above noted project.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

RBelbas

Ryan Belbas, M.Sc., P.Eng.
Senior Geotechnical Engineer

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	RB	June 29, 2023	Final Report

Authorization Signatures

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ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization

TREK GEOTECHNICAL INC.

No. 4877

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1.0 Introduction

This report provides geotechnical design and construction recommendations for SNC-Lavalin Inc. (SNC) for the proposed chlorine system upgrades at the Hurst Regional Pumping Station (RPS) located at 60 Hurst Way in Winnipeg, Manitoba. The terms of reference for the investigation are included in our proposal to David Beccker, P.Eng. of SNC dated September 16, 2022. The scope of work includes a sub-surface investigation, laboratory testing, and provision of foundation recommendations.

2.0 Background

The City of Winnipeg's regional water distribution system consists of three regional pumping stations (MacLean RPS, McPhillips RPS, and Hurst RPS) and two booster pumping stations (Deacon BPS and Taché BPS). The Deacon BPS station pumps the treated water from the Winnipeg Drinking Water Treatment Plant in Dugald, MB to the three RPS reservoirs located within Winnipeg. The RPSs and BPSs are critical infrastructure for the City of Winnipeg and the failure of any of the pumping systems at these facilities has the potential to disrupt the City's residential, commercial, industrial, and fire protection water supplies.

The MacLean, McPhillips, and Hurst RPSs require chlorine system upgrades which will consist of exterior dry type scrubbers which, based on drawings provided by SNC, will be relatively light. The weight of the scrubber at the Hurst RPS is 93 kN (9,525 kg) and it will be supported by a 3.7 m wide by 5.8 m long by 0.4 m thick concrete grade-supported mat foundation (mat). Considering the weight of the equipment and the mat, the unfactored bearing pressure applied to the bearing surface is approximately 14 kPa. The equipment will be located on the southwest side of the building approximately 2.5 m west of the building's south exit. The mat will be insulated with a 100 mm thick layer of Styrofoam Highload insulation extending 2.4 m outward from the edge of the mat.

TREK performed a sub-surface investigation at the Hurst RPS (constructed in 1961) in the fall of 2021 and provided foundation recommendations to AECOM in a geotechnical report (dated February 2, 2022) for a new chiller and condenser on the south side of the building as part of an upgrade to the cooling system. One test hole (TH22-01) to a depth of 12.0 m below ground surface at the RPS was drilled as part of the 2021 investigation. The test hole was drilled approximately 3.7 m south and 14.1 m east of the southwest corner of the RPS building.

The proposed chlorine scrubber will be constructed approximately 5 to 6 m west of the test hole drilled in 2021. Based on discussion with the City of Winnipeg and SNC on June 6, 2023, it was decided that a test hole would not be required for the proposed chlorine scrubber due to the close proximity of the test hole drilled in 2021 as well as the risk associated with a drill rig crossing critical buried infrastructure to access the area. In this regard, the recommendations provided in this report are based on our findings during the 2021 investigation.

3.0 Field Program

3.1 Sub-surface Investigation

A sub-surface investigation was completed at the Hurst RPS on October 5, 2021 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site. One test hole (TH21-01) was drilled and sampled to a depth of 12.0 m below ground surface at the location shown on Figure 01. The test hole was drilled by Paddock Drilling Ltd. using a Ranger 24 track-mounted drill rig equipped with 125 mm solid stem augers. The test hole was backfilled with auger cuttings and bentonite chips.

Sub-surface soils encountered during drilling were visually classified based on the Unified Soil Classification System (USCS). Disturbed (auger cutting) samples were taken at regular intervals and relatively undisturbed (Shelby tube) samples were collected at select depths. All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba. Laboratory testing consisted of water content determination on all samples as well as bulk unit weight measurements and unconfined compression tests on select Shelby tube samples.

The test hole location was determined by measuring offsets to the existing RPS building. The test hole elevation was surveyed using a rod and level relative to a temporary benchmark assigned an arbitrary elevation of 100.0 m. The temporary benchmark selected for this project was the top of the concrete slab located near the south exit of the RPS building; its location is shown on Figure 01. The UTM coordinates of the test hole are provided on the test hole log. The test hole log also includes a description of the soil units encountered and other pertinent information such as groundwater and sloughing conditions, and a summary of the laboratory testing results. Laboratory test results are included in Appendix A.

3.1.1 *Soil Stratigraphy*

A brief description of the soil units encountered during drilling is provided below. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole log.

The stratigraphy at the test hole location consists of 1.5 m of clay fill over 9.7 m of native silty clay over silt till at 11.2 m below ground surface. The clay fill is silty and contains traces of sand and gravel. It is moist, firm to stiff and of high plasticity. The native silty clay is of high plasticity, moist and stiff becoming firm with depth. The silt till is heterogenous mixture of clay, sand, and gravel within a silt matrix. The till is moist, loose and of low plasticity.

3.1.2 *Groundwater Conditions*

Seepage and sloughing conditions were not observed during drilling. Squeezing of the test hole was observed within the native silty clay below 10.7 m depth.

The groundwater observations made during drilling are short-term and should not be considered reflective of (static) groundwater levels at the site which would require monitoring over an extended period to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities.

4.0 Foundation Recommendations

A grade-supported mat foundation is a suitable foundation alternative provided seasonal movements associated with freeze/thaw and moisture and volume changes of the underlying clay fill soils can be tolerated. Design and construction parameters for the mat are provided in this section and are based on Limit States Design in accordance with National Building Code of Canada (NBCC 2010).

TREK anticipates that the clay fill at the site was placed during original construction of the RPS in 1961 and, as such, consolidation settlement of the fill and the underlying native clay is assumed to be complete. In this regard, movements of a new mat foundation will likely be associated with seasonal volumetric changes within the bearing soils as described in more detail below.

TREK understands that building upgrades have been recently completed at the RPS which has resulted in placement of new fills around the perimeter of the building. Details of the fill placement such as type of fill and level of compaction is unknown. Poorly compacted fill will undergo long-term settlement which could have a negative impact on the new mat. Additionally, if the mat expands across varying soils (e.g. fill and clay) it could be subjected to additional differential settlement.

4.1 Limit States Design

Limit States Design recommendations for shallow foundations in accordance with the National Building Code of Canada (NBCC, 2010) are provided below. Limit States Design requires consideration of distinct loading scenarios comparing the structural loads to the foundation bearing capacity using resistance and load factors that are based on reliability criteria. Two general design scenarios are evaluated corresponding to the serviceability and ultimate capacity requirements.

The **Ultimate Limit State (ULS)** is concerned with ensuring that the maximum structural loads do not exceed the nominal (ultimate) capacity of the foundation units. The ULS foundation bearing capacity is obtained by multiplying the nominal (ultimate) bearing capacity by a resistance factor (reduction factor), which is then compared to the factored (increased) structural loads. The ULS bearing capacity must be greater or equal to the maximum factored load to provide an adequate margin of safety. Table 1 summarizes the resistance factors that can be used for the design of shallow and deep foundations as per the NBCC (2010) depending upon the method of analysis and verification testing completed during construction.

The **Service Limit State (SLS)** is concerned with limiting deformation or settlement of the foundation under service loading conditions such that the integrity of the structure will not be impacted. The Service Limit State should generally be analysed by calculating the settlement resulting from applied service loads and comparing this to the settlement tolerance of the structure. However, the settlement tolerance of the structure is typically not yet defined at the preliminary design stage. As such, SLS bearing capacities are often provided that are developed on the basis of limiting settlement to 25 mm or less. A more detailed settlement analysis should be conducted to refine the estimated settlement and/or adjust the SLS capacity if a more stringent settlement tolerance is required or if large groups of piles are used.

Table 1. ULS Resistance Factors for Shallow Foundations (NBCC, 2010)

Resistance to Vertical Loads for Shallow Foundations (Analysis Methods)	Resistance Factor
Semi-empirical analysis using laboratory and in-situ test data	0.5

4.2 Mat Foundations

A grade-supported mat foundation is a suitable foundation provided seasonal movements associated with freeze/thaw and moisture and volume changes of the underlying clay fill and native clay soils can be tolerated. A piled foundation will be required if seasonal movements cannot be tolerated. A mat bearing on firm to stiff clay fill or native clay (if present at the bearing surface level) can be designed based on a factored ULS bearing resistance of 100 kPa and a SLS bearing resistance of 70 kPa. The SLS bearing resistances are based on limiting settlement to 25 mm or less and the factored ULS bearing resistances were calculated using a resistance factor of 0.5.

The mat will be subject to vertical movements associated with moisture and volume changes of the underlying clay fill and native clay. Although difficult to predict, these movements (total and differential) could be in the order of 50 mm or more. In this regard, flexible pipe connections should be considered to accommodate these movements. It should be understood that seasonal movements are independent of displacement required to mobilize bearing capacity.

The clay fill and native clay soils at the site are frost susceptible, which refers to the propensity of the soil to grow ice lenses and heave during freezing. TREK understands that a 100 mm thick layer of Styrofoam Highload insulation extending 2.4 m outward from the edge of the mat will be installed to provide frost protection. The insulation must be continuous below the entire mat footprint to be effective. The insulation selected should have sufficient load-displacement properties to transfer the applied bearing pressures to the bearing surface without excessive deformation or damaging the insulation. An insulation manufacturer or supplier should be contacted to verify the insulation design.

Additional Design Recommendations:

1. The mat should be designed by a structural engineer to resist axial, lateral, and bending loads from the structure as well as forces induced from seasonal movements (i.e. shrinkage/swelling and frost-related movements) of the bearing soils.

Additional Construction Recommendations:

1. Organics, debris, and all other deleterious materials should be removed such that the bearing surfaces consist of firm to stiff clay fill or native clay.
2. Excavations for the mat should be completed by an excavator equipped with a smooth-bladed bucket operating from the edge of the excavation.
3. After excavation, the upper 200 mm of the clay fill should be scarified, moisture conditioned and compacted to a minimum of 95% of the Standard Proctor Maximum Dry Density (SPMDD). This

isn't required for native clay (if present at the bearing surface level) provided it is of firm to stiff consistency.

4. The bearing surface should be protected from freezing, drying, and inundation at all times. If any of these conditions occur, the disturbed material should be removed in its entirety and the clay fill or native clay bearing surface should be compacted to 95% of the SPMDD. If groundwater seepage is encountered, it should be controlled and removed from the bearing surface, such that concrete is placed under dry conditions.
5. The final bearing surface should be inspected and documented by TREK prior to concrete placement to verify the adequacy of the bearing surface and proper installation of the foundation.

4.3 Foundation Concrete

Based on local experience gathered through previous work in Winnipeg, the degree of exposure for concrete subjected to sulphate attack is classified as severe according to Table 3, CSA A23.1-14 (Concrete Materials and Methods of Concrete Construction). Accordingly, all concrete in contact with the native soil should be made with high sulphate-resistant cement (HS or HSb). Furthermore, the concrete should have a minimum specified 56-day compressive strength of 32 MPa and have a maximum water to cement ratio of 0.45 in accordance with Table 2, CSA A23.1-14 for concrete with severe sulphate exposure (S2). Concrete that may be exposed to freezing and thawing should be adequately air entrained to improve freeze-thaw durability in accordance with Table 4, CSA A23.1-14.

4.4 Foundation Inspection Requirements

In accordance with Section *4.2.2.3 Field Review* of the NBCC (2010) states that the designer or other suitably qualified person shall carry out a field review on:

a) continuous basis during:
    i. the construction of all deep foundation units with all pertinent information recorded for each *foundation unit*,
    iii. during the placement of engineered fills that are to be used to support the *foundation units*,

b) on an as-required basis for the construction of shallow foundation units and in excavating, dewatering and other related works.

In consideration of the above and relative to this particular project, TREK is familiar with the geotechnical conditions and the basis for the foundation recommendations and can provide any design modifications deemed to be necessary should unexpected sub-surface conditions be encountered. TREK, as the geotechnical engineer of record, should be retained to observe the installation of any foundation elements.

5.0 Temporary Excavations

Excavations must be carried out in compliance with the appropriate regulations under the Manitoba Workplace Safety and Health Act. Any open-cut excavation greater than 3 m deep must be designed and sealed by a professional engineer and reviewed by the geotechnical engineer of record (TREK). If space is limited or the stability of adjacent structures may be endangered by an excavation, a shoring system may be required to prevent damage to, or movement of, any part of adjacent structures, and the creation of a hazard to workers and the public.

Excavation stability is the responsibility of the Contractor for the duration of construction. Excavations should be monitored regularly and flattened as necessary to maintain stability recognizing that excavation stability is time and weather dependent. Excavated slopes should be covered with polyethylene sheets to prevent wetting and drying.

Stockpiles of excavated material and heavy equipment should be kept away from the edge of any excavation by a distance equal to or greater than the depth of excavation. Dewatering measures should be completed as necessary to maintain a dry excavation and permit proper completion of the work. If seepage is encountered, it should be collected and pumped out of the excavation.

If saturated silts or sands are encountered, shoring or slope flattening may be required. To prevent wet silts and sands from entering the excavation, gravel buttressing could be used in conjunction with sump pits for dewatering. Surface water should be diverted away from the excavation and the excavation should be backfilled as soon as possible following construction.

6.0 Site Drainage

The ground level adjacent to the mat should promote runoff away from the structure. A minimum gradient of at least 2% should be used around the mat and maintained throughout the life of the structure. The water discharge from roof leaders and run-off from the mat should be directed away from the structure.

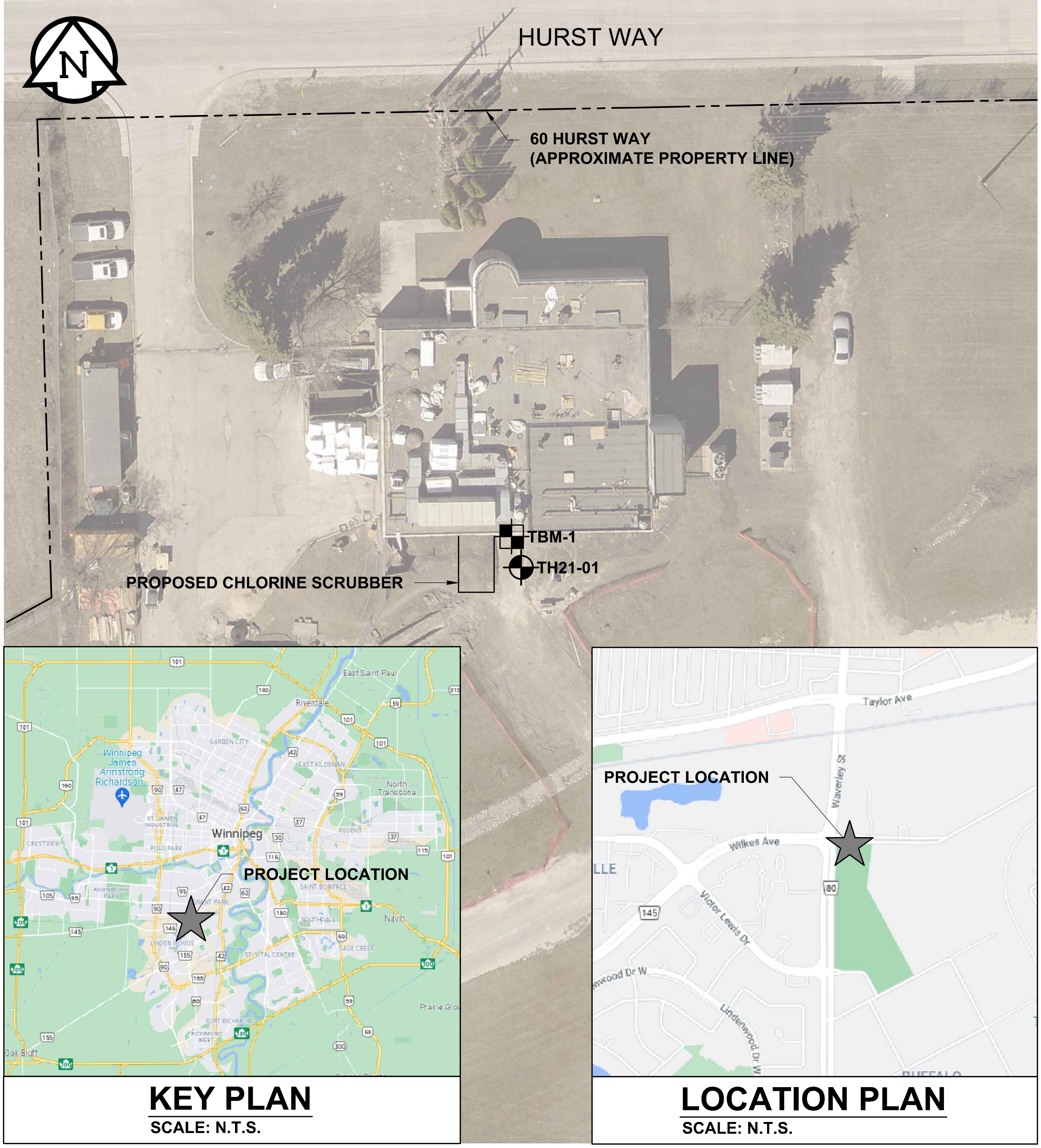
7.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If subsurface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to 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.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of SNC-Lavalin Inc. (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figure



KEY PLAN

SCALE: N.T.S.

LOCATION PLAN

SCALE: N.T.S.

LEGEND:

⊕	TEST HOLE (TREK, 2021)
▞	TEMPORARY BENCHMARK TBM-1

NOTES:

1. AERIAL IMAGERY FROM CITY OF WINNIPEG, (2021).
2. TEMPORARY BENCHMARK WAS ESTABLISHED AT THE TOP OF THE CONCRETE SLAB NEAR THE SOUTH EXIT OF THE BUILDING.

0 5 10 15 20 25 m

SCALE = 1 : 600 (216 mm x 279 mm)

Figure 01

Test Hole Location Plan

Z:\Projects\0019 SNC Lavalin\0019 013 00 RPS Chlorine System Upgrades\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 2023-06-20 Hurst RPS 0_A 0019-013-00.dwg, 2023-06-20 3:13:03 PM ANSI full bleed A (8.50 x 11.00 Inches)

Test Hole Log

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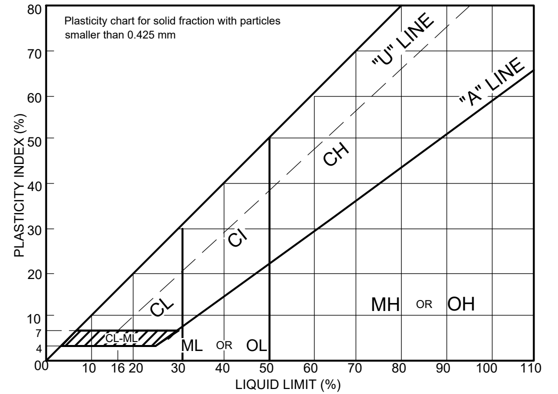
EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the Unified Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent....... GW, GP, SW, SP More than 12 percent....... GM, GC, SM, SC 6 to 12 percent....... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	◌	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	☰	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH	▮	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH	▰	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⩊	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size	
		mm	ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	○	Cobbles
░	Concrete	⊞	Limestone Bedrock	●	Boulders and Cobbles
▩	Fill	☰	Cemented Shale	▥	Silt Till
		▨	Non-Cemented Shale	▩	Clay Till

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EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD- Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength

VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

▼ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent
with *	with silt, with sand	> 35 percent

* Used when the material is classified based on behaviour as a cohesive material

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Sub-Surface Log

Test Hole TH21-01 (Hurst RPS)

1 of 2

Client: SNC-Lavalin Inc.

Project Name: Hurst Regional Pumping Station - Chlorine System Upgrades

Contractor: Paddock Drilling Ltd.

Method: 125 mm Solid Stem Augers Ranger 24 Track Mount

Project Number: 0013 040 00

Location: 60 Hurst Way; 3.7 m S and 14.1 m E of SW corner of pump

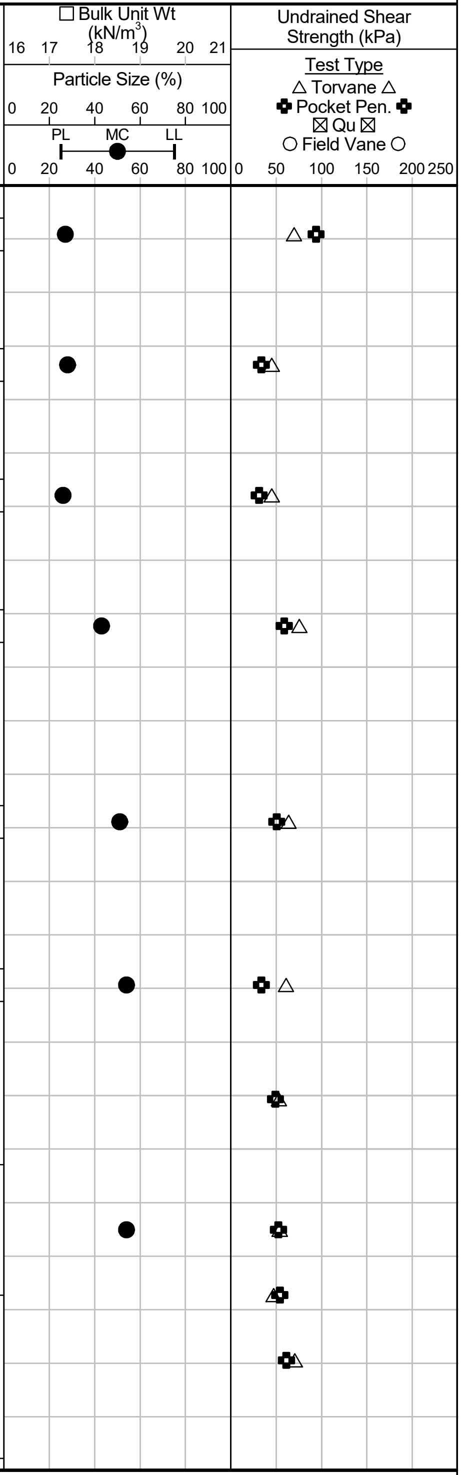
Ground Elevation: 99.74 m Existing Ground (local datum)

Date Drilled: October 6, 2021

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧗ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ○ Cobbles ■ Boulders

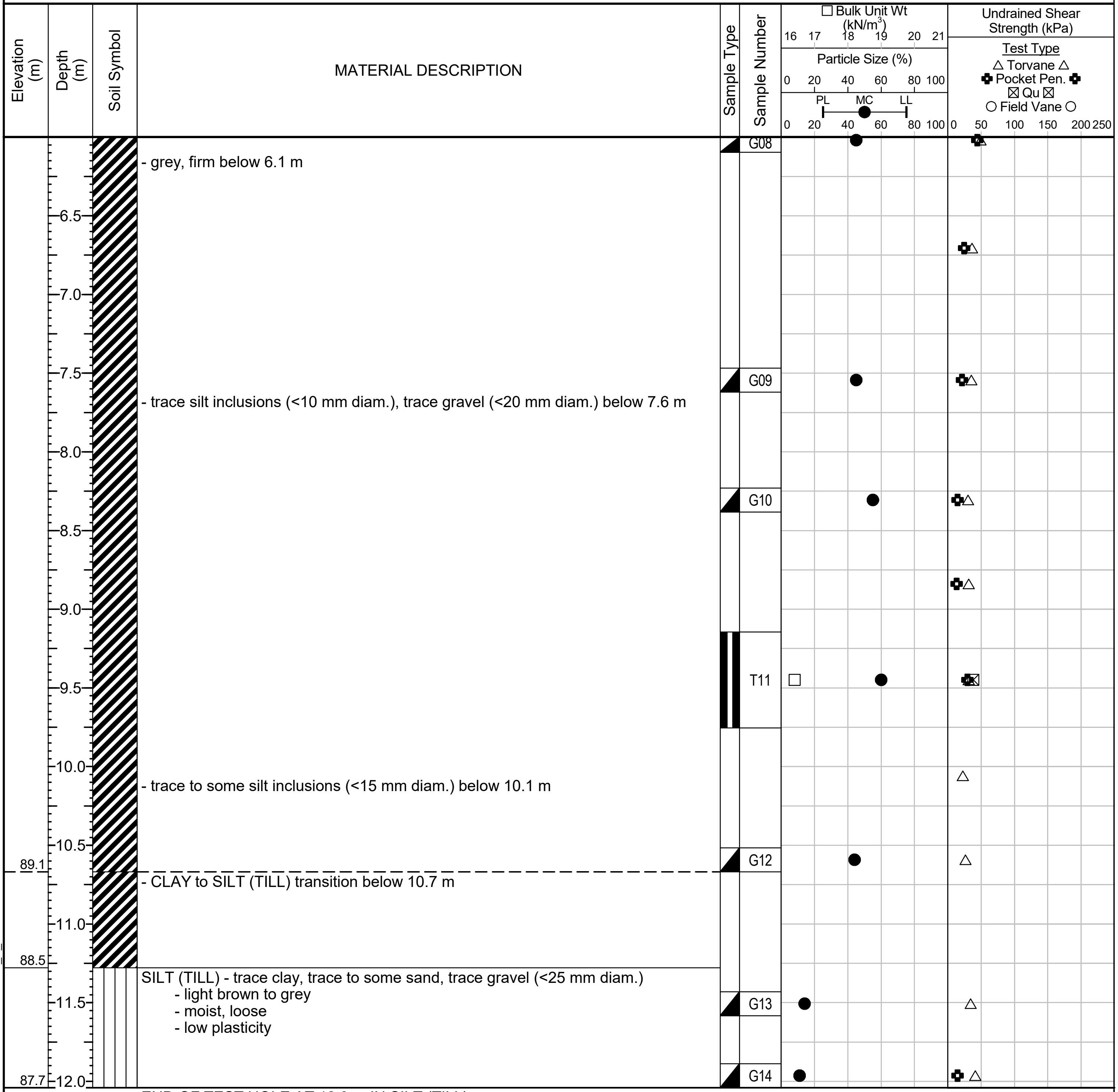
Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
99.7			ORGANIC CLAY (TOPSOIL) - black, moist, friable		
		▩	CLAY (FILL) - silty, trace sand, trace gravel (<15 mm diam.), trace organics (rootlets) to 25 mm - brown - moist, stiff to 0.3 m, firm below 0.3 m - high plasticity	◢	G01
	0.5	▩			
		▩		◢	G02
	1.0	▩			
		▩		◢	G03
98.2	1.5	▨	CLAY - silty, trace silt inclusions (<5 mm diam.) - brown - moist, stiff - high plasticity		
	2.0	▨		◢	G04
	2.5	▨			
		▨		◢	G05
	3.0	▨	- trace precipitates (<10 mm diam.) below 3.0 m		
	3.5	▨			
		▨		◢	G06
	4.0	▨			
	4.5	▨			
		▨	- mottled brown and grey below 4.6 m	▮	T07
	5.0	▨			
	5.5	▨			



Logged By: Reinhardt Van Rensburg **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

Sub-Surface Log

Test Hole TH21-01 (Hurst RPS)



- grey, firm below 6.1 m

- trace silt inclusions (<10 mm diam.), trace gravel (<20 mm diam.) below 7.6 m

- trace to some silt inclusions (<15 mm diam.) below 10.1 m

- CLAY to SILT (TILL) transition below 10.7 m

SILT (TILL) - trace clay, trace to some sand, trace gravel (<25 mm diam.)
- light brown to grey
- moist, loose
- low plasticity

END OF TEST HOLE AT 12.0 m IN SILT (TILL)
Notes:
1. Power auger refusal encountered at 12.0 m depth.
2. Seepage or sloughing not observed.
3. Squeezing observed in clay below 10.7 depth.
4. Test hole open to 10.7 m depth and dry immediately after drilling.
5. Test hole backfilled with auger cuttings to 3.0 m depth and topped with bentonite chips to surface.

Logged By: Reinhardt Van Rensburg **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

Appendix A

Laboratory Testing

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No.	0019-013-00
Client	SNC-Lavalin Inc.
Project	Hurst Regional Pumping Station - Chlorine System Upgrades

Sample Date	06-Oct-21
Test Date	07-Oct-21
Technician	DJ

Test Hole	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01
Depth (m)	1.5 - 0.3	0.8 - 0.9	1.4 - 1.5	2.0 - 2.1	2.9 - 3.0	3.7 - 3.8
Sample #	G01	G02	G03	G04	G05	G06
Tare ID	Z66	D50	D32	AB16	E24	E75
Mass of tare	8.5	8.5	8.5	6.6	8.6	8.5
Mass wet + tare	231.0	247.4	242.8	226.9	262.5	279.0
Mass dry + tare	183.8	194.6	194.7	160.2	176.8	184.3
Mass water	47.2	52.8	48.1	66.7	85.7	94.7
Mass dry soil	175.3	186.1	186.2	153.6	168.2	175.8
Moisture %	26.9%	28.4%	25.8%	43.4%	51.0%	53.9%

Test Hole	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01
Depth (m)	5.9 - 6.1	7.5 - 7.6	8.2 - 8.4	10.5 - 10.7	11.4 - 11.6	11.9 - 12.0
Sample #	G08	G09	G10	G12	G13	G14
Tare ID	F131	E94	H35	A106	A8	D40
Mass of tare	8.4	8.5	8.5	8.2	8.2	8.3
Mass wet + tare	229.6	217.3	224.8	221.0	263.7	271.2
Mass dry + tare	161.0	152.4	148.4	155.9	232.9	244.6
Mass water	68.6	64.9	76.4	65.1	30.8	26.6
Mass dry soil	152.6	143.9	139.9	147.7	224.7	236.3
Moisture %	45.0%	45.1%	54.6%	44.1%	13.7%	11.3%

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Shelby Tube Visual

Project No.	0019-013-00
Client	SNC-Lavalin Inc.
Project	Hurst Regional Pumping Station - Chlorine System Upgrades

Test Hole	TH21-01
Sample #	T07
Depth (m)	4.6 - 5.2
Sample Date	06-Oct-21
Test Date	09-Oct-21
Technician	DJ

Tube Extraction

Recovery (mm) 560

5.11 m 4.97 m 4.81 m 4.65 m

Bottom - 5.2 m **Top - 4.6 m**

Toss	Keep	Moisture Content PP/TV Visual	Keep	Toss
30 mm	140 mm	160 mm	160 mm	50 mm

Visual Classification

Material	CLAY
Composition	silty

trace silt inclusions (<12 mm diam.)

Color	dark grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.55
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	53.9

Pocket Penetrometer

Reading	**1**	1.10
	2	1.05
	3	1.05
	Average	1.07
Undrained Shear Strength (kPa)		52.3

Moisture Content

Tare ID	K19
Mass tare (g)	8.4
Mass wet + tare (g)	308.1
Mass dry + tare (g)	203.4
Moisture %	53.7%

Unit Weight

Bulk Weight (g)		-
Length (mm)	**1**	-
	2	-
	3	-
	4	-
Average Length (m)		-
Diam. (mm)	**1**	-
	2	-
	3	-
	4	-
Average Diameter (m)		-
Volume (m^3)		-
Bulk Unit Weight (kN/m^3)		-
Bulk Unit Weight (pcf)		-
Dry Unit Weight (kN/m^3)		-
Dry Unit Weight (pcf)		-

Shelby Tube Visual

Project No.	0019-013-00
Client	SNC-Lavalin Inc.
Project	Hurst Regional Pumping Station - Chlorine System Upgrades
Test Hole	TH21-01
Sample #	T11
Depth (m)	9.1 - 9.8
Sample Date	06-Oct-21
Test Date	09-Oct-21
Technician	DJ

Tube Extraction

Recovery (mm) 600

9.65 m 9.47 m 9.37 m 9.23 m

Bottom - 9.8 m **Top - 9.2 m**

Toss	Qu Bulk	Moisture Content PP/TV Visual	Keep	Toss
150 mm	180 mm	100 mm	140 mm	30 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<12 mm diam.)	
Color	dark grey
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.32
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	31.4

Pocket Penetrometer

Reading	**1**	0.60
	2	0.60
	3	0.60
	Average	0.60
Undrained Shear Strength (kPa)		29.4

Moisture Content

Tare ID	F141
Mass tare (g)	8.9
Mass wet + tare (g)	334.2
Mass dry + tare (g)	212
Moisture %	60.2%

Unit Weight

Bulk Weight (g)		1050.0
Length (mm)	**1**	150.93
	2	151.30
	3	151.52
	4	151.07
Average Length (m)		0.151
Diam. (mm)	**1**	72.41
	2	73.28
	3	71.82
	4	73.27
Average Diameter (m)		0.073
Volume (m^3)		6.28E-04
Bulk Unit Weight (kN/m^3)		16.4
Bulk Unit Weight (pcf)		104.5
Dry Unit Weight (kN/m^3)		10.2
Dry Unit Weight (pcf)		65.2

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Unconfined Compressive Strength

ASTM D2166

Project No. 0019-013-00
Client SNC-Lavalin Inc.
Project Hurst Regional Pumping Station - Chlorine System Upgrades

Test Hole TH21-01
Sample # T11
Depth (m) 9.1 - 9.8
Sample Date 6-Oct-21
Test Date 9-Oct-21
Technician DJ

Unconfined Strength

	kPa	ksf
Max q_u	76.5	1.6
Max S_u	38.3	0.8

Specimen Data

Description CLAY - silty, trace silt inclusions (<12 mm diam.), dark grey, moist, firm, high plasticity

Length	151.2	(mm)	**Moisture %**	60%	
Diameter	72.7	(mm)	**Bulk Unit Wt.**	16.4	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	10.2	(kN/m^3)
Initial Area	0.00415	(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**
0.32	31.4	0.66
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	0.60	29.4	0.61
	0.60	29.4	0.61
	0.60	29.4	0.61
Average	**0.60**	**29.4**	**0.61**

Failure Geometry

Sketch:

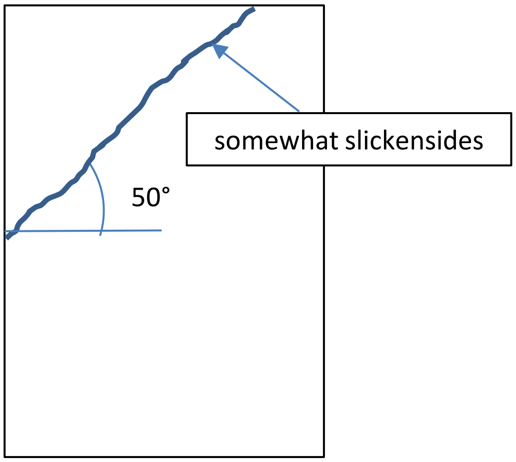
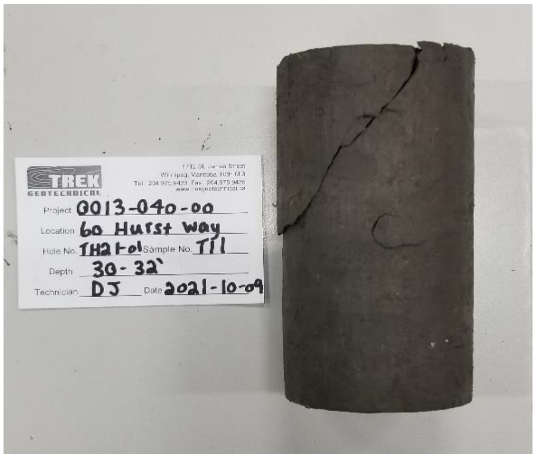


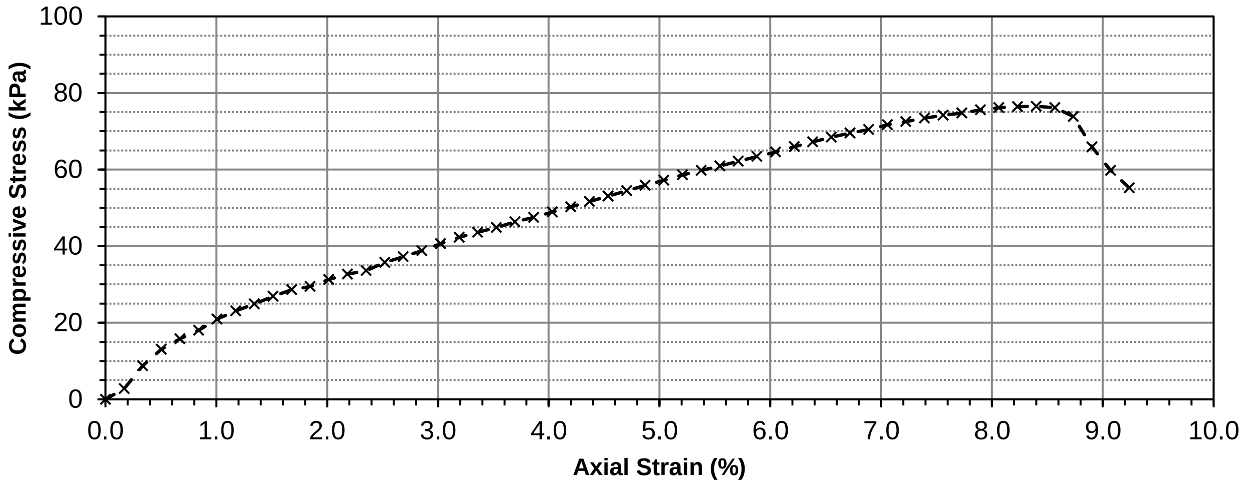
Photo:



Project 0013-040-00
Location 60 Hurst Way
Hole No. TH21-01 Sample No. T11
Depth 30-32'
Technician DJ Date 2021-10-09

Project No. 0019-013-00
Client SNC-Lavalin Inc.
Project Hurst Regional Pumping Station - Chlorine System 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	-0.06	0.0000	0.00	0.004150	0.0	0.00	0.00
10	0.17	0.2540	0.17	0.004157	11.6	2.79	1.39
20	0.66	0.5080	0.34	0.004164	36.3	8.71	4.36
30	1.02	0.7620	0.50	0.004172	54.4	13.05	6.52
40	1.25	1.0160	0.67	0.004179	66.0	15.80	7.90
50	1.44	1.2700	0.84	0.004186	75.6	18.06	9.03
60	1.68	1.5240	1.01	0.004193	87.7	20.92	10.46
70	1.86	1.7780	1.18	0.004200	96.8	23.04	11.52
80	2.02	2.0320	1.34	0.004207	104.8	24.92	12.46
90	2.19	2.2860	1.51	0.004214	113.4	26.91	13.46
100	2.34	2.5400	1.68	0.004221	121.0	28.66	14.33
110	2.41	2.7940	1.85	0.004229	124.5	29.44	14.72
120	2.57	3.0480	2.02	0.004236	132.6	31.29	15.65
130	2.69	3.3020	2.18	0.004243	138.6	32.67	16.33
140	2.77	3.5560	2.35	0.004250	142.6	33.56	16.78
150	2.96	3.8100	2.52	0.004258	152.2	35.75	17.88
160	3.09	4.0640	2.69	0.004265	158.8	37.23	18.61
170	3.23	4.3180	2.86	0.004272	165.8	38.81	19.41
180	3.39	4.5720	3.02	0.004280	173.9	40.63	20.31
190	3.54	4.8260	3.19	0.004287	181.5	42.32	21.16
200	3.66	5.0800	3.36	0.004295	187.5	43.66	21.83
210	3.77	5.3340	3.53	0.004302	193.0	44.87	22.44
220	3.90	5.5880	3.70	0.004310	199.6	46.31	23.16
230	4.01	5.8420	3.86	0.004317	205.1	47.52	23.76

Project No. 0019-013-00
Client SNC-Lavalin Inc.
Project Hurst Regional Pumping Station - Chlorine System Upgrades

Unconfined Compression Test Data (cont'd)

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)
240	4.14	6.0960	4.03	0.004325	211.7	48.95	24.47
250	4.26	6.3500	4.20	0.004332	217.7	50.26	25.13
260	4.39	6.6040	4.37	0.004340	224.3	51.68	25.84
270	4.52	6.8580	4.54	0.004348	230.8	53.10	26.55
280	4.65	7.1120	4.70	0.004355	237.4	54.51	27.25
290	4.78	7.3660	4.87	0.004363	244.0	55.91	27.96
300	4.90	7.6200	5.04	0.004371	250.0	57.20	28.60
310	5.03	7.8740	5.21	0.004378	256.6	58.59	29.30
320	5.14	8.1280	5.38	0.004386	262.1	59.75	29.88
330	5.25	8.3820	5.54	0.004394	267.6	60.91	30.45
340	5.37	8.6360	5.71	0.004402	273.7	62.18	31.09
350	5.49	8.8900	5.88	0.004410	279.7	63.44	31.72
360	5.60	9.1440	6.05	0.004418	285.3	64.58	32.29
370	5.73	9.3980	6.22	0.004426	291.8	65.94	32.97
380	5.85	9.6520	6.38	0.004433	297.9	67.19	33.59
390	5.97	9.9060	6.55	0.004441	303.9	68.43	34.22
400	6.08	10.1600	6.72	0.004449	309.5	69.55	34.78
410	6.17	10.4140	6.89	0.004457	314.0	70.45	35.22
420	6.29	10.6680	7.06	0.004466	320.1	71.67	35.84
430	6.38	10.9220	7.22	0.004474	324.6	72.56	36.28
440	6.47	11.1760	7.39	0.004482	329.1	73.44	36.72
450	6.55	11.4300	7.56	0.004490	333.2	74.20	37.10
460	6.61	11.6840	7.73	0.004498	336.2	74.74	37.37
470	6.70	11.9380	7.90	0.004506	340.7	75.61	37.81
480	6.76	12.1920	8.06	0.004515	343.7	76.14	38.07
490	6.80	12.4460	8.23	0.004523	345.8	76.45	38.22
500	6.82	12.7000	8.40	0.004531	346.8	76.53	38.27
510	6.80	12.9540	8.57	0.004539	345.8	76.17	38.08
520	6.60	13.2080	8.74	0.004548	335.7	73.81	36.91
530	5.90	13.4620	8.90	0.004556	300.4	65.93	32.97
540	5.35	13.7160	9.07	0.004565	272.7	59.74	29.87
550	4.95	13.9700	9.24	0.004573	252.5	55.22	27.61