TREK GEOTECHNICAL

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City of Winnipeg

Bickerton Street Pipe Crossing under Canadian National Rail Bridge, Winnipeg, MB

Geotechnical Investigation Report

Prepared for:
Tyler Phillips, EIT
Engineering Services, Water and Waste Department
City of Winnipeg
510 Main Street
Winnipeg, MB
R3B 1B9

Project Number: 0015-026-00

Date: October 10, 2018

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TREK GEOTECHNICAL Quality Engineering | Valued Relationships

October 10, 2018 Our File No. 0015-026-00

Tyler Phillips, EIT
Engineering Services, Water and Waste Department
City of Winnipeg
510 Main Street
Winnipeg, MB
R3B 1B9

RE: Bickerton Street Pipe Crossing under Canadian National Rail Bridge, Winnipeg, MB
Geotechnical Investigation Report

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

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

Nelson John Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer, Principal

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	JR	August 9, 2018	Final Report
0	JR	October 10, 2018	Revised Report

Authorization Signatures

Prepared By:

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Geotechnical Engineering Intern

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Oct. 10, 2018
REGISTERED PROFESSIONAL ENGINEER

Nelson Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

Reviewed By:

ENGINEERS GEOSCIENTISTS MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Oct. 10, 2018

Steven Harms, M.Sc., P.Eng.
Geotechnical Engineer

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This report summarizes the results of the geotechnical investigation completed by TREK Geotechnical Inc. (TREK) for the new watermain and sewer crossing under the Canadian National (CN) Rail Bridge at Bickerton Street, Winnipeg MB. The terms of reference for the investigation are included in our proposal to the City of Winnipeg dated June 18, 2018. The scope of work includes a subsurface investigation, laboratory testing, and provision of geotechnical recommendations for the design and construction of new underground utilities in compliance with CN Rail crossing requirements. We have also included a proposed construction monitoring program to monitor abutment and pier displacements to determine if movements are within CN Rail's tolerable limits.

2.0 Project Understanding and Site Conditions

The proposed underground utilities include a watermain and a waste water sewer to be installed under CN's rail bridge (CN Redditt route) along Bickerton Street in Winnipeg, MB. The waste water sewer line and the watermain will be entirely new installations. The CN rail bridge spans Bickerton Street in an east/west orientation and the proposed utilities will be located within the roadway of Bickerton Street. Bickerton Street runs in a north/south orientation between the rail bridge east pier and east abutment.

The watermain construction will consist of installing a 250 mm diameter (285 mm O.D.) PVC pipe within a 450 mm diameter (457 mm O.D.) steel casing. The casing will be installed to an obvert elevation of approximately 228.5 m (approximately 2.5 m below the existing roadway beneath the rail bridge). The new waste water sewer line will consist of a 250 mm diameter PVC pipe installed lower than the watermain to an obvert elevation between 227.0 m to 227.5 m (approximately 4.0 m below the existing roadway beneath the rail bridge). The new lines will run will be offset approximately a minimum 5 m east and 5 m west of the rail bridge pier and abutment, respectively, as shown on Figure 1. In the vicinity of the bridge, the watermain's steel casing and PVC sewer line will be installed using horizontal directional drilling techniques (trenchless method) over a distance of approximately 38 m between sending and receiving pits.

2.1 Crossing Requirements

CN rail has specific protocols and requirements to mitigate the risk of track settlement or heave associated with installation of pipeline crossings under their rail lines. As part of their requirements, a form (Geo Form 1) is to be completed by the Engineer of record. This form only provides a general description of the steps to be taken into consideration for design and construction. The form does not include any specific protocols regarding subsurface investigations, recommendations and construction monitoring.

Track and rail movement or settlement thresholds based on CN requirements are:

- Ground settlements of 5 mm are to be reported to CN Rail immediately;

- Ground settlements of 10 mm or greater, all works stop immediately.

These thresholds requirements are intended for installations under rail embankments; however, similar tolerances can be applied to other support structures such as bridge abutments or piers. Other considerations for the new utility installations would be determining if the proposed alignment offset is at sufficient distance as to not induce load on or decrease the resistance of the existing foundations due to the installation.

3.0 Subsurface Investigation

3.1 Drilling Program

A subsurface investigation was undertaken on July 16, 2018 under the supervision of TREK personnel to evaluate the subsurface conditions at the site. Two test holes (TH18-01, TH18-02) were drilled to a depth of 6.1 m using a Geoprobe track-mounted drill rig equipped with 125 mm diameter solid stem augers. Test holes TH18-01 and TH18-02 are located approximately 12 m north and 12 m south of the extents of CN's rail bridge, respectively.

Subsurface soils encountered during drilling were visually classified based on the Unified Soil Classification System (USCS). Samples retrieved during drilling included disturbed (auger cuttings) and undisturbed (Shelby tube) samples. All samples retrieved during drilling were transported to TREK's soils laboratory in Winnipeg, Manitoba for further testing and classification. Laboratory testing consisted of water content determination on all samples as well as bulk unit weight measurements and unconfined compression testing on select Shelby tube samples. Soils laboratory testing results are included in Appendix A.

The test hole locations were initially determined by measuring an offset from the abutment and coordinates were confirmed using a handheld GPS. Elevations were surveyed using a rod and level relative to the centre bolt on the pier west of Bickerton Street which was assigned a temporary benchmark elevation of 100.00 m. Test hole logs are attached which describe the soil units encountered and other pertinent information such as test hole locations, elevation, groundwater conditions and a summary of the laboratory testing results. The test hole locations are shown in plan on Figure 01.

3.2 Subsurface Conditions

3.2.1 Soil Stratigraphy

A brief description of the soil units encountered at the test hole locations 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 logs.

The soil stratigraphy at the site generally consists of a layer of sand and gravel fill as part of the pavement structure underlain by silty clay fill and native clay. The sand and gravel fill varies in thickness from 0.3 m to 1.1 m and is silty, grey, dry to moist, compact and well-graded. The silty clay

fill also varies in thickness from 0.3 m to 1.3 m, contains trace sand and trace gravel, is dark grey, moist, stiff and of intermediate plasticity. Silty clay was encountered at 1.5 m to the maximum depth of exploration (6.1 m) and is generally brown, moist, stiff becoming softer with depth and of high plasticity. In TH18-02, a silt layer was encountered between the clay fill and the silty clay at a depth of 1.3 m and is 0.3 m thick. The silt is clayey, light brown, moist, soft and of low plasticity.

3.2.2 Groundwater Conditions

Groundwater seepage and sloughing was not observed during drilling; the test hole remained dry and open immediately after drilling.

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 of time to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities.

4.0 Installation Assessment and Recommendations

Based on the proposed installation methods and distance away from the abutment and the pier, the potential of impacting the existing foundation and structure is considered minimal. In this regard, the installations are considered to be low risk for either rail movements, or changes to loading or capacity of the bridge foundations.

The installation method (HDD) has minimal impact to ground disturbance beyond the area of work in the stiff clay encountered at this site. Conservatively, ground disturbance up to a couple of meters beyond the work area could occur, although this is unlikely. Given the proposed minimum offset distance of 5 m from the alignments to the pier and the recommendations provided above, ground disturbance is not expected at the abutment or the pier.

The type and layout of the foundation system is not known, but it would be expected that the bridge is likely supported using a piled foundation including battered piles. The battered piles may be situated closer to the installation (ie. less than 5 m offset) at the obvert elevation, depending on their orientation and batter. Typically, piles for bridges can be battered as steep as 6V:1H which would encroach about 1 m closer to the new utilities, thus reducing the offset to 4 m which is deemed to be at a sufficient distance from the installation to prevent disturbance to the foundation elements. A pile battered at 1V:1H would be required in order for the new utility installations to be of concern, which is unlikely. However, as a precautionary measure, soft washing along the abutment, close to the pipe alignments could be undertaken to confirm battered piles are not present near the installations. This would be undertaken using a hydrovac truck where either a trench or multiple holes could be excavated parallel to the alignments to the depth of proposed invert for the two installations.

5.0 Construction Monitoring Program

To further manage the risk to CN Rail's infrastructure, TREK recommends a monitoring program be implemented during construction. Although CN Rail does not have any specific requirements for a monitoring program, we recommend that the bridge abutment and pier be monitored to determine if displacements are occurring.

TREK recommends survey monitoring points mounted in pairs be installed at the base and mid-height of both the east abutment and pier. All monitoring points should be surveyed every 12 hours beginning a minimum of 1 day before construction commences and finishing a minimum of three days after construction is complete. The survey method should capture movements in 3 dimensions to an accuracy less than 5 mm. As per CN Rail requirements, there will be two displacement thresholds (Warning and Critical) that will trigger response measures as described below.

Level 1: Warning

The warning level is 5 mm of displacement. If 5 mm of displacement has been observed at the abutment or the pier monitoring points, construction must be put on hold until the direction and magnitude of displacement can be determined and assessed. CN Rail will be notified if this occurs. Work may commence depending on the outcome of the assessment and discussions with and approval from CN Rail.

Level 2: Critical

The critical level is 10 mm of displacement. If the critical displacement is measured at the abutment or the pier monitoring points construction must be halted.

- CN Rail will be notified immediately.
- A detailed assessment to determine the cause of the displacements will be undertaken
- Additional field investigations and survey may be undertaken

Work may commence depending on the outcome of the assessment and discussions with and approval from CN Rail.

6.0 Excavations and Shoring

All temporary excavations such as those required for the sending and receiving pits must be carried out in compliance with the appropriate regulation(s) under the Manitoba Workplace Safety and Health Act. Any open-cut excavations greater than 3 m deep must be designed and sealed by a professional engineer and should be reviewed by the geotechnical engineer of record (TREK).

Stockpiles of excavated material and heavy equipment should be kept away from the edge of the excavation by a distance equal to or greater than the depth of excavation. The excavation should be kept free of water at all times and surface water should be diverted away from the excavation.

Where open excavations are made, flattening of side slopes may be required. If seepage conditions warrant other dewatering methods (e.g. well points), TREK should be contacted to review the dewatering plan prior to implementation.

Cantilevered (un-braced or braced) walls will be required for deep excavations or physically constrained areas where temporary shoring is necessary. Based on the sub-surface stratigraphy and maximum depth of excavation at the site, earth pressure coefficients for silty clay should be used. Table 2 provides the recommended earth pressure coefficients and bulk unit weights for the silty clay layer for calculation of lateral earth pressures. Surcharge loads and hydrostatic water pressure should be incorporated into the design of cantilevered walls, as well as an adequate factor of safety against instability.

Table 1. Recommended Design Parameters for Shoring

Design Parameters for Silty Clay	Value
Active (K_a)	0.5
At-rest (K_o)	0.7
Passive (K_p)	1.8
Bulk Unit Weight, Y (kN/m³)	18

An undrained shear strength of 30 kPa for the clay and silt can be used for the design of shoring. The undrained shear strengths were selected based on the measured undrained shear strength profile from all test types. Lateral earth pressures from surcharge loads (if applicable), or from heavy compaction equipment (if used) should be accounted for in design.

An active earth pressure coefficient (K_a) should be used to calculate lateral loads from soils against retaining structures which are free to translate horizontally away from the retained soil by more than 0.2% of the retaining wall height. A passive earth pressure coefficient (K_p) should be used if the wall is free to translate horizontally towards the retained soil by more than 2% of the retaining wall height. An at-rest earth pressure coefficient (K_o) should be used if the walls undergo less than 2% strain during movement towards the retained soil and less than 0.2% during movement away from the retained soil.

A certain amount of ground movement behind the shoring will occur and is largely unavoidable. The amount of movement that will occur cannot be accurately predicted, mainly because the movement is as much a function of installation procedures and workmanship as it is a function of theoretical considerations. It is anticipated that the design of temporary shoring will be the responsibility of the contractor. Once the proposed shoring design is complete, it should be reviewed by TREK prior to construction to ensure the design is appropriate and to assess the need for groundwater control. Performance of the excavation system should be monitored from the onset of installation to removal of the shoring system.

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 the City of Winnipeg (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.

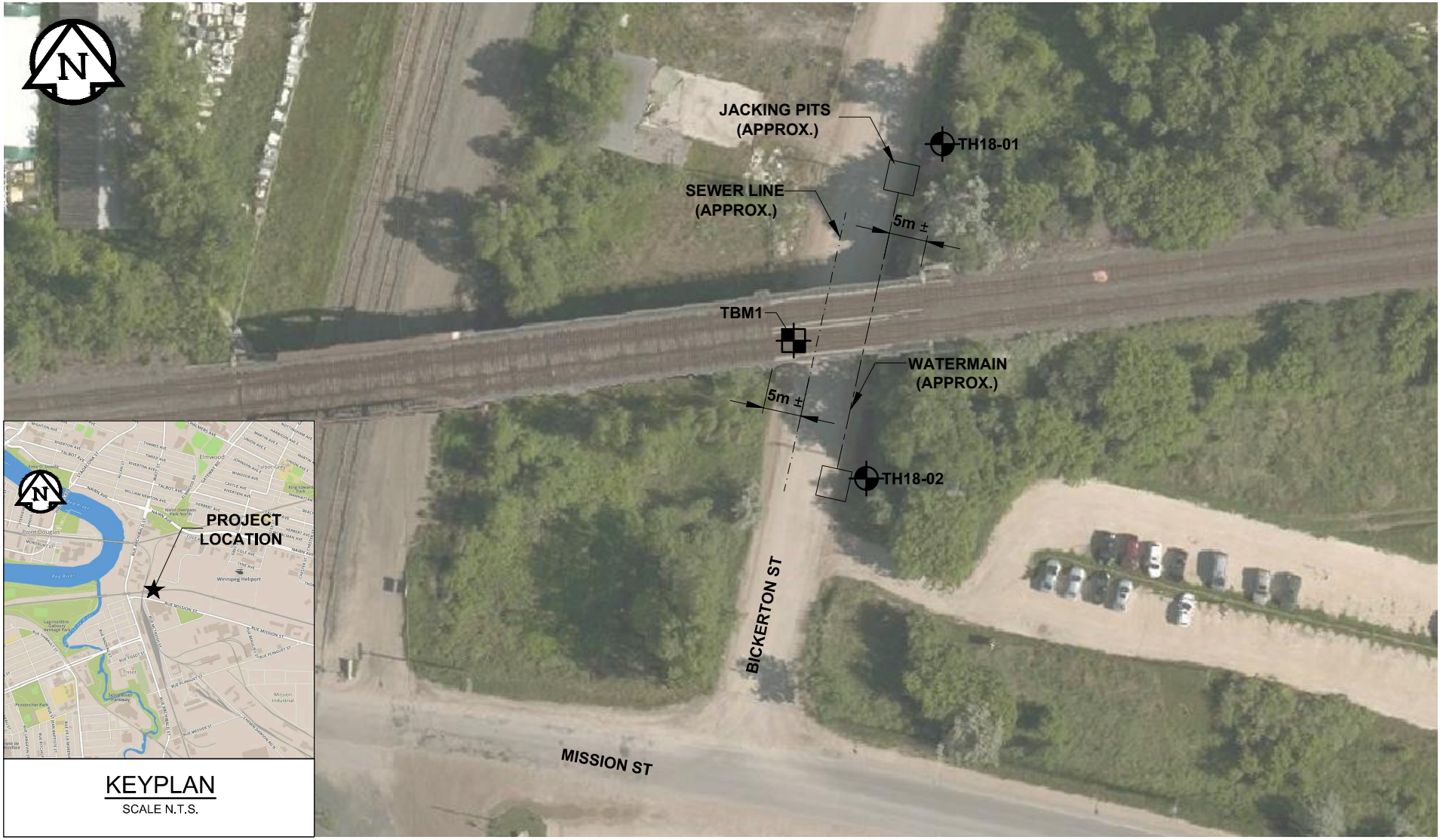
Figures

TREK GEOTECHNICAL

0015 026 00
City of Winnipeg
Bickerton Street Rail Crossing

ANSI full bleed A (11.00 x 8.50 Inches)

FIG.001 2018-07-23 Bickerton Street Rail Crossing 0_B_SL 0015 026 00.dwg, 8/7/2018 2:57:42 PM



0 10 20 30 m
SCALE = 1 : 750 (216 mm x 279 mm)

LEGEND:
TEST HOLE (TREK, 2018)
TEMPORARY BENCHMARK TBM1

NOTES:
1. IMAGE FROM GOOGLE EARTH AUGUST 24, 2015
2. TBM CENTRE BOLT ON BOTTOM BEAM OF PIER WEST OF RAIL BRIDGE OF BICKERTON STREET

Figure 01
Test Hole Location Plan

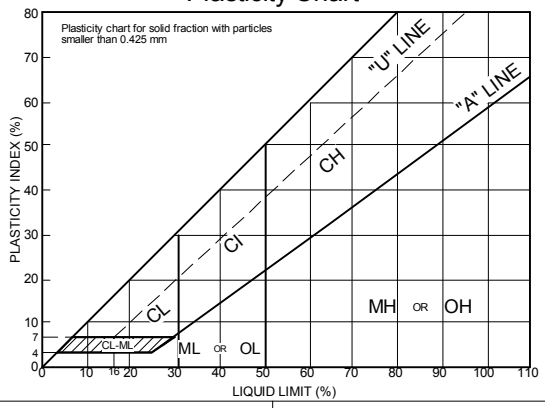
Test Hole Logs

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United 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*
			GP		Poorly-graded gravels, gravel-sand mixtures, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
		Gravel with fines (Appreciable amount of fines)	GM		Silty gravels, gravel-sand-silt mixtures	Not meeting all gradation requirements for GW
			GC		Clayey gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4 / Atterberg limits above "A" line or P.I. greater than 7 / Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
	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 / Atterberg limits above "A" line or P.I. greater than 7 / Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures	
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



Particle Size	Material	ASTM Sieve sizes	mm
	Sand		
	Coarse	#10 to #4	2.00 to 4.75
	Medium	#40 to #10	0.425 to 2.00
	Fine	#200 to #40	0.075 to 0.425
	Silt or Clay	< #200	< 0.075

Particle Size	Material	ASTM Sieve Sizes	mm
	Boulders	> 12 in.	> 300
	Cobbles	3 in. to 12 in.	75 to 300
	Gravel		
	Coarse	3/4 in. to 3 in.	19 to 75
	Fine	#4 to 3/4 in.	4.75 to 19

* 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

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

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 TH18-01
1 of 1

Client:	City of Winnipeg	**Project Number:**	0015-026-00
Project Name:	Bickerton Rail Crossing	**Location:**	UTM N-5529190, E-636130
Contractor:	Maple Leaf Drilling	**Ground Elevation:**	100.10 m
Method:	125 mm Solid Stem Augers, Geoprobe 782207 Track Mount	**Date Drilled:**	16 July 2018

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
	0		SAND and GRAVEL (Limestone) - silty, 20 mm down - grey - dry to moist, compact - well-graded		G01
99.0	1.0				
98.9	1.1		CLAY (Fill) - silty, trace sand, trace gravel, dark grey, moist, soft to firm, intermediate plasticity		G02
	1.5		CLAY - silty - brown - moist, stiff - high plasticity		G03
	2.0				
	2.5				G04
	3.0				
	3.5				T05
	4.0				
	4.5				G06
	5.0				
	5.5				
94.0	6.0				G07

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21

Particle Size (%): 0 20 40 60 80 100

PL MC LL: 0 20 40 60 80 100

Undrained Shear Strength (kPa)

Test Type: △ Torvane △ ✤ Pocket Pen. ✤ ☒ Qu ☒ ○ Field Vane ○

0 50 100 150 200 250

END OF TEST HOLE AT 6.1 m IN CLAY

Notes:
1) No seepage or sloughing observed.
2) Test hole open to 6.1 m and dry immediately after drilling.
3) Test hole backfilled with auger cuttings and bentonite to surface.
4) Test hole elevation recorded relative to temporary benchmark.

Logged By: Jenna Roadley **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

SUB-SURFACE LOG LOGS 2018-07-17 BICKERTON XING 0_A_JSR 0015-026-00.GPJ TREK GEOTECHNICAL.GDT 7/8/18

Sub-Surface Log

Test Hole TH18-02
1 of 1

Client:	City of Winnipeg	**Project Number:**	0015-026-00
Project Name:	Bickerton Rail Crossing	**Location:**	UTM N-5529160, E-636123
Contractor:	Maple Leaf Drilling	**Ground Elevation:**	99.88 m
Method:	125 mm Solid Stem Augers, Geoprobe 782207 Track Mount	**Date Drilled:**	16 July 2018

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | 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	0		SAND and GRAVEL (Limestone) - silty, 20 mm down, grey, dry to moist, compact, well-graded		G08
	0.5		CLAY (Fill) - silty, trace sand, trace gravel - dark grey - moist, soft to firm - intermediate plasticity		G09
98.7	1.0				
98.4	1.5		SILT - clayey - light brown, moist, soft, low plasticity		G10
	2.0		CLAY - silty - brown - moist, stiff - high plasticity		
	2.5				
	3.0				G11
	3.5				
	4.0		- trace precipitates below 3.7 m (<15 mm diameter)		G12
	4.5				
	5.0				T13
	5.5				
93.8	6.0				G14

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21
Particle Size (%): 0 20 40 60 80 100
PL MC LL: 0 20 40 60 80 100
Undrained Shear Strength (kPa): 0 50 100 150 200 250
Test Type: △ Torvane △ | ✤ Pocket Pen. ✤ | ☒ Qu ☒ | ○ Field Vane ○

END OF TEST HOLE AT 6.1 m IN CLAY

Notes:
1) No seepage or sloughing observed.
2) Test hole open to 6.1 m and dry immediately after drilling.
3) Test hole backfilled with auger cuttings and bentonite to surface.
4) Test hole elevation recorded relative to temporary benchmark.

Logged By: Jenna Roadley **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

SUB-SURFACE LOG LOGS 2018-07-17 BICKERTON XING 0_A_JSR 0015-026-00.GPJ TREK GEOTECHNICAL.GDT 7/8/18

Appendix A

CN Rail Geotechnical Protocols

GEO FORM 2

THE APPLICANT MUST COMPLETE THIS FORM, AND SUBMIT WITH UTILITY APPLICATIONS FOR PIPES WITH AN OUTSIDE DIAMETER OF 10" OR GREATER.

ONCE COMPLETED, PRINT, AND SIGN THIS FORM.

Note must be added to all plans for installations 10" or greater in outside diameter:

provided construction recommendations that the Contractor shall implement as per the Geotechnical Report.

"Geotechnical Engineer evaluation has been completed and the Geotechnical Engineer has ~~determined that based on the soil conditions, there will be no adverse effects to CN operation and property~~. Engineer must be on site during construction."

Installations 10" or greater in outside diameter:

1. A Geotechnical study must be conducted to ensure there are no known or suspected problems with the installation due to soil conditions at the location. Please provide confirmation that a monitoring and mitigation plan is in place to mitigate potential stability issues with the proposed installation. Review the below requirements and initial indicating compliance and acceptance. see attached geotechnical Report
   a. Construction Methodology relative to soil conditions will be reviewed and identified by the Geotechnical Engineer as a safe and appropriate method of installation. NJF
   b. Communicate & Rectify potential adverse effects to CN Operations and property. NJF
   c. The expected extent and magnitude of ground movement over time is expected to be less than the critical threshold in the monitoring plan. NJF
   d. Set up a contingency plan in the event problems arise during construction at the site and communicate this plan to all parties involved in construction. NJF
   e. Ground surface and subsurface monitoring in place. NJF
   f. Vibration limits for communication cables will be considered and will be protected as necessary. If applicable. n/a
   g. Placed required "note" on application drawing along with stamp and signature. NJF
   To with modifications
2. A Geotechnical Engineer must be onsite during installation. Please provide the following:

   Firm name: Name of Geotechnical Firm TREK GEOTECHNICAL Inc.
   Name of Engineer assigned to project: Name of Geotechnical Engineer Nelson John Ferreira
   Contact number of Engineer assigned to project: Contact phone number 204. 792. 5784
   Email address of Engineer assigned to project: Email address of Engineer
   nferreira@trekgeotechnical.ca

3. During construction Engineer must monitor 24hrs a day, 7days a week:
    a. Ground surface and subsurface movements or settlements
        - Core Main Line
        i. ANY SETTLEMENTS OF 5MM IS TO BE REPORTED TO CN IMMEDIATELY
        ii. ANY SETTLEMENTS OF 10MM OR GREATER, WORK IS TO STOP IMMEDIATELY
        - Branch Line
        i. ANY SETTLEMENTS OF 8MM IS TO BE REPORTED TO CN IMMEDIATELY
        ii. ANY SETTLEMENTS OF 16MM OR GREATER, WORK IS TO STOP IMMEDIATELY

    b. Ensure sufficient measures are taken to preserve the safety of rail operations and structural integrity of the track grade. NJF

4. Post Installation the following is to be done:
    a. Engineer to provide confirmation in writing that the work was conducted in accordance with the detailed plans accepted by CN. This will include the submission of as-constructed plans with an engineer's stamp.
    b. Engineer to report on the results of the ground monitoring and confirm that there are no expected problems due to installation

Please initial here as understanding of the above requirements. Initial NJF

Applicant: Nelson John Ferreira Signature: Nel F

Date Signed: July 15, 2019 Title: Senior Geotechnical Engineer

Appendix B

Laboratory Results

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Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 0015-026-00
Client City of Winnipeg
Project Bickerton Rail Crossing

Sample Date July 16 2018
Test Date July 17 2018
Technician KM

Test Pit	TH18-01	TH18-01	TH18-01	TH18-01	TH18-01	TH18-01
Depth (m)	0.3 - 0.5	1.1 - 1.2	1.4 - 1.5	2.3 - 2.4	4.4 - 4.6	5.9 - 6.1
Sample #	G01	G02	G03	G04	G06	G07
Tare ID	Z50	K20	H60	F17	E56	H34
Mass of tare	8.4	9.0	8.6	8.6	9.0	9.4
Mass wet + tare	210.2	218.0	211.8	207.2	229.6	223.6
Mass dry + tare	184.2	174.2	158.0	147.4	154.0	151.8
Mass water	26.0	43.8	53.8	59.8	75.6	71.8
Mass dry soil	175.8	165.2	149.4	138.8	145.0	142.4
Moisture %	14.8%	26.5%	36.0%	43.1%	52.1%	50.4%

Test Pit	TH18-02	TH18-02	TH18-02	TH18-02	TH18-02	TH18-02
Depth (m)	0.0 - 0.2	0.8 - 0.9	1.4 - 1.5	2.9 - 3.0	3.8 - 4.0	5.9 - 6.1
Sample #	G08	G09	G10	G11	G12	G14
Tare ID	AB11	AC07	F63	AA10	AB90	F1
Mass of tare	6.6	7.0	8.4	6.8	6.8	8.8
Mass wet + tare	221	225.2	232.2	213.6	236.4	224
Mass dry + tare	197.4	169.6	187.0	151.2	157.8	157.8
Mass water	23.6	55.6	45.2	62.4	78.6	66.2
Mass dry soil	190.8	162.6	178.6	144.4	151.0	149.0
Moisture %	12.4%	34.2%	25.3%	43.2%	52.1%	44.4%

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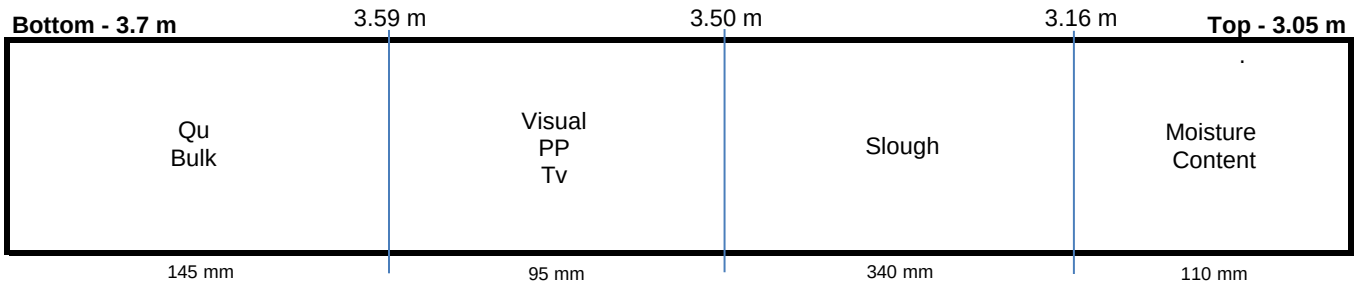
Shelby Tube Visual

Project No.	0015-026-00
Client	City of Winnipeg
Project	Bickerton Rail Crossing
Test Hole	TH18-01
Sample #	T05
Depth (m)	3.0 - 3.7
Sample Date	16-Jul-18
Test Date	17-Jul-18
Technician	KM

Tube Extraction

Recovery (mm) 690



Visual Classification

Material	Clay
Composition	silty
gravel inclusions (<15 mm ø)	
Color	greenish brown
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	homogeneous
Gradation	-

Torvane

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

Pocket Penetrometer

Reading	**1**	0.90
	2	0.70
	3	0.70
	Average	0.77
Undrained Shear Strength (kPa)		37.6

Moisture Content

Tare ID	N56
Mass tare (g)	8.6
Mass wet + tare (g)	188.5
Mass dry + tare (g)	128.4
Moisture %	50.2%

Unit Weight

Bulk Weight (g)		934.7
Length (mm)	**1**	140.01
	2	140.07
	3	139.06
	4	138.91
Average Length (m)		0.140
Diam. (mm)	**1**	71.75
	2	71.35
	3	72.70
	4	72.19
Average Diameter (m)		0.072
Volume (m^3)		5.68E-04
Bulk Unit Weight (kN/m^3)		16.1
Bulk Unit Weight (pcf)		102.7
Dry Unit Weight (kN/m^3)		10.7
Dry Unit Weight (pcf)		68.4

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Unconfined Compressive Strength

ASTM D2166

Project No.	0015-026-00
Client	City of Winnipeg
Project	Bickerton Rail Crossing
Test Hole	TH18-01
Sample #	T05
Depth (m)	3.0 - 3.7
Sample Date	16-Jul-18
Test Date	17-Jul-18
Technician	KM

Unconfined Strength

	kPa	ksf
Max q_u	78.3	1.6
Max S_u	39.2	0.8

Specimen Data

Description Clay - silty, gravel inclusions (<15 mm Ø), greenish brown, moist, firm, high plasticity, homogeneous

Length	139.5	(mm)	**Moisture %**	50%	
Diameter	72.0	(mm)	**Bulk Unit Wt.**	16.1	(kN/m^3)
L/D Ratio	1.9		**Dry Unit Wt.**	10.7	(kN/m^3)
Initial Area	0.00407	(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

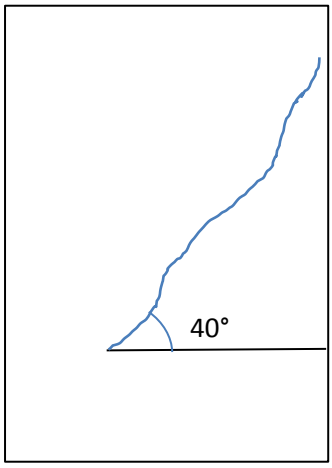
Vane Size
m

Pocket Penetrometer

	Reading	Undrained Shear Strength	
	tsf	**kPa**	**ksf**
	0.90	44.1	0.92
	0.70	34.3	0.72
	0.70	34.3	0.72
Average	**0.77**	**37.6**	**0.79**

Failure Geometry

Sketch:



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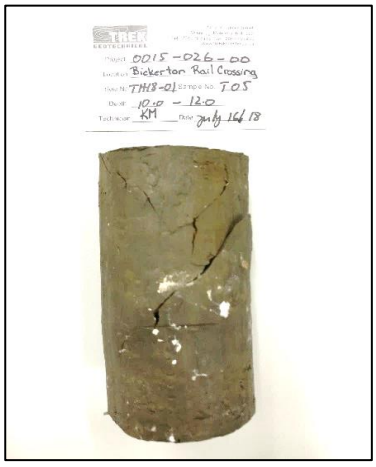

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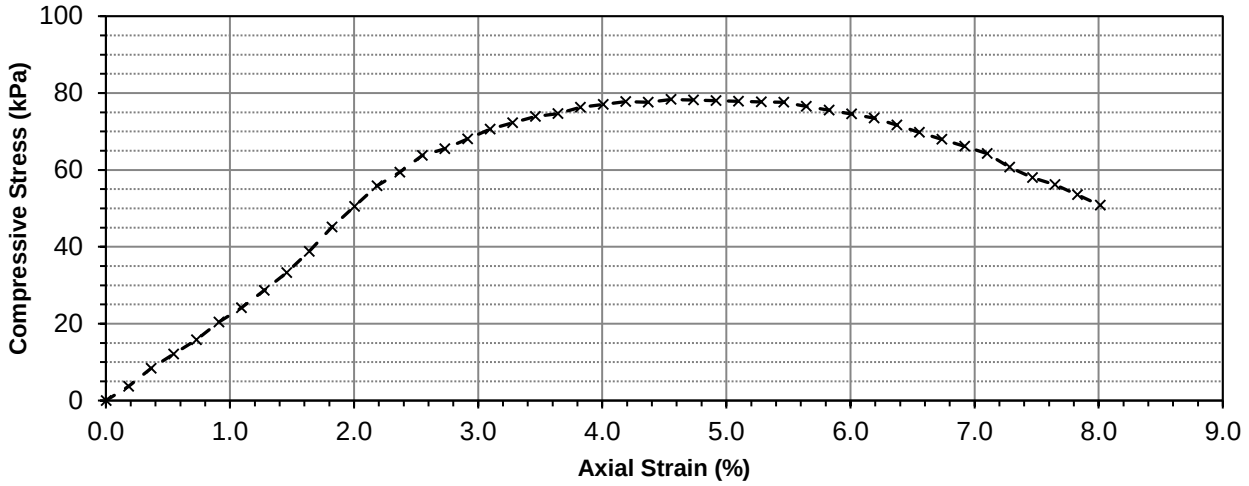
Unconfined Compressive Strength

ASTM D2166

Project No. 0015-026-00
Client City of Winnipeg
Project Bickerton Rail Crossing

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	0.004071	0.0	0.00	0.00
10	4	0.2540	0.18	0.004079	14.9	3.66	1.83
20	9	0.5080	0.36	0.004086	34.1	8.33	4.17
30	13	0.7620	0.55	0.004094	49.4	12.06	6.03
40	17	1.0160	0.73	0.004101	64.7	15.77	7.89
50	22	1.2700	0.91	0.004109	83.8	20.40	10.20
60	26	1.5240	1.09	0.004116	99.1	24.08	12.04
70	31	1.7780	1.27	0.004124	118.3	28.68	14.34
80	36	2.0320	1.46	0.004131	137.4	33.26	16.63
90	42	2.2860	1.64	0.004139	160.4	38.75	19.37
100	49	2.5400	1.82	0.004147	187.2	45.14	22.57
110	55	2.7940	2.00	0.004154	209.9	50.52	25.26
120	61	3.0480	2.18	0.004162	232.5	55.87	27.93
130	65	3.3020	2.37	0.004170	247.6	59.39	29.69
140	70	3.5560	2.55	0.004178	266.5	63.80	31.90
150	72	3.8100	2.73	0.004186	274.1	65.48	32.74
160	75	4.0640	2.91	0.004193	285.4	68.06	34.03
170	78	4.3180	3.10	0.004201	296.6	70.60	35.30
180	80	4.5720	3.28	0.004209	304.1	72.25	36.12
190	82	4.8260	3.46	0.004217	311.6	73.88	36.94
200	83	5.0800	3.64	0.004225	315.3	74.63	37.32
210	85	5.3340	3.82	0.004233	322.8	76.26	38.13
220	86	5.5880	4.01	0.004241	326.5	76.99	38.50
230	87	5.8420	4.19	0.004249	330.3	77.73	38.86

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Unconfined Compressive Strength

ASTM D2166

Project No. 0015-026-00
Client City of Winnipeg
Project Bickerton Rail Crossing

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	87	6.0960	4.37	0.004257	330.3	77.58	38.79
250	88	6.3500	4.55	0.004265	334.0	78.31	39.15
260	88	6.6040	4.73	0.004274	334.0	78.16	39.08
270	88	6.8580	4.92	0.004282	334.0	78.01	39.01
280	88	7.1120	5.10	0.004290	334.0	77.86	38.93
290	88	7.3660	5.28	0.004298	334.0	77.71	38.86
300	88	7.6200	5.46	0.004306	334.0	77.56	38.78
310	87	7.8740	5.64	0.004315	330.3	76.55	38.27
320	86	8.1280	5.83	0.004323	326.5	75.53	37.77
330	85	8.3820	6.01	0.004331	322.8	74.52	37.26
340	84	8.6360	6.19	0.004340	319.1	73.52	36.76
350	82	8.8900	6.37	0.004348	311.6	71.66	35.83
360	80	9.1440	6.55	0.004357	304.1	69.80	34.90
370	78	9.3980	6.74	0.004365	296.6	67.95	33.97
380	76	9.6520	6.92	0.004374	289.1	66.11	33.05
390	74	9.9060	7.10	0.004382	281.6	64.26	32.13
400	70	10.1600	7.28	0.004391	266.5	60.70	30.35
410	67	10.4140	7.46	0.004400	255.2	58.00	29.00
420	65	10.6680	7.65	0.004408	247.6	56.18	28.09
430	62	10.9220	7.83	0.004417	236.3	53.50	26.75
440	59	11.1760	8.01	0.004426	225.0	50.84	25.42

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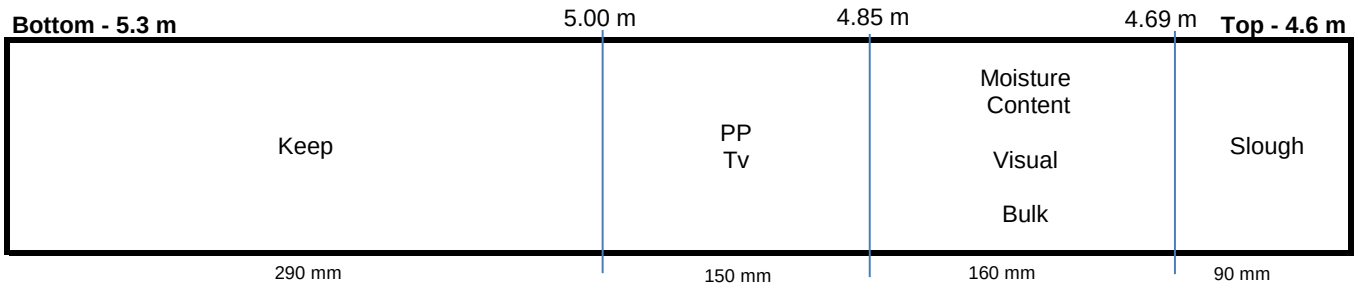
Shelby Tube Visual

Project No.	0015-026-00
Client	City of Winnipeg
Project	Bickerton Rail Crossing
Test Hole	TH18-02
Sample #	T13
Depth (m)	4.6 - 5.2
Sample Date	16-Jul-18
Test Date	17-Jul-18
Technician	KM

Tube Extraction

Recovery (mm) 690



Visual Classification

Material	Clay
Composition	silty
some silt inclusions (<10 mm ø)	
Color	brown
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	homogeneous
Gradation	-

Torvane

Reading	0.54
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	53.0

Pocket Penetrometer

Reading	**1**	0.90
	2	1.00
	3	1.00
	Average	0.97
Undrained Shear Strength (kPa)		47.4

Moisture Content

Tare ID	H33
Mass tare (g)	8.5
Mass wet + tare (g)	250.8
Mass dry + tare (g)	169.6
Moisture %	50.4%

Unit Weight

Bulk Weight (g)		1042.7
Length (mm)	**1**	151.43
	2	150.69
	3	149.83
	4	150.31
Average Length (m)		0.151
Diam. (mm)	**1**	72.56
	2	72.77
	3	73.40
	4	72.83
Average Diameter (m)		0.073
Volume (m^3)		6.28E-04
Bulk Unit Weight (kN/m^3)		16.3
Bulk Unit Weight (pcf)		103.6
Dry Unit Weight (kN/m^3)		10.8
Dry Unit Weight (pcf)		68.9

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Unconfined Compressive Strength

ASTM D2166

Project No.	0015-026-00
Client	City of Winnipeg
Project	Bickerton Rail Crossing
Test Hole	TH18-02
Sample #	T13
Depth (m)	4.6 - 5.2
Sample Date	16-Jul-18
Test Date	17-Jul-18
Technician	KM

Unconfined Strength

	kPa	ksf
Max q_u	63.8	1.3
Max S_u	31.9	0.7

Specimen Data

Description Clay - silty, some silt inclusions (<10 mm Ø), brown, moist, firm, high plasticity, homogeneous

Length	150.6	(mm)	**Moisture %**	50%	
Diameter	72.9	(mm)	**Bulk Unit Wt.**	16.3	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	10.8	(kN/m^3)
Initial Area	0.00417	(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
0.54	53.0	1.11

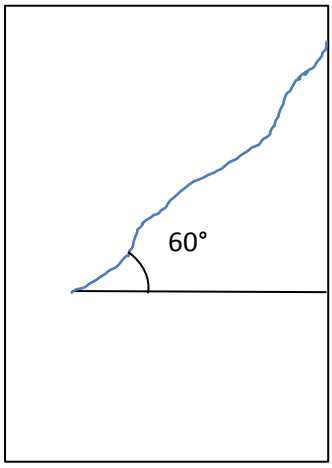
Vane Size
m

Pocket Penetrometer

	Reading	Undrained Shear Strength	
	tsf	kPa	ksf
	0.90	44.1	0.92
	1.00	49.1	1.02
	1.00	49.1	1.02
Average	**0.97**	**47.4**	**0.99**

Failure Geometry

Sketch:



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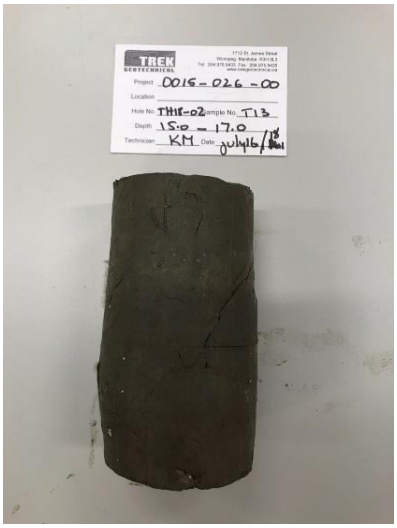

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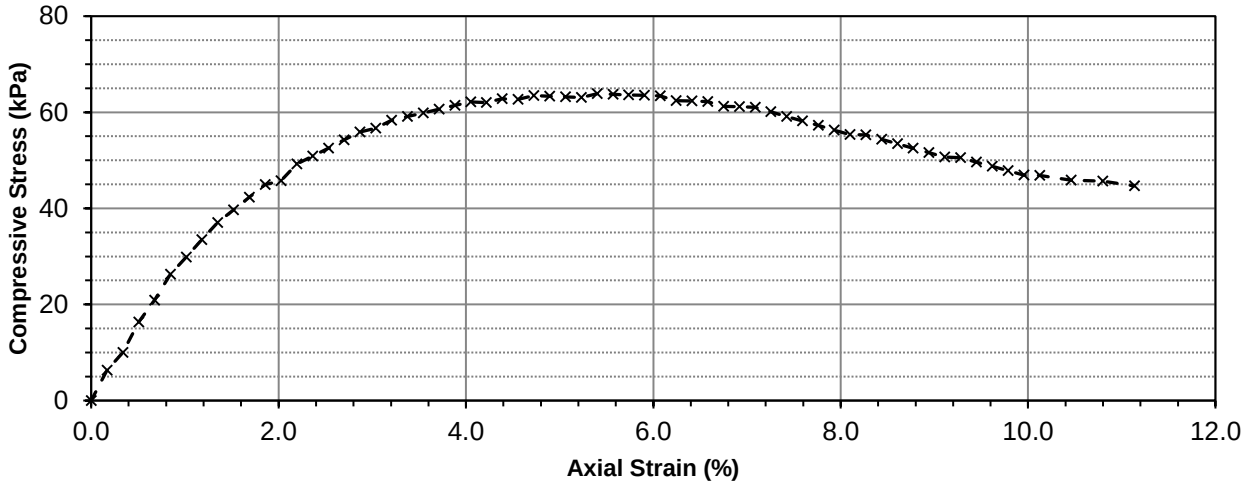
Unconfined Compressive Strength

ASTM D2166

Project No. 0015-026-00
Client City of Winnipeg
Project Bickerton Rail Crossing

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	0.004173	0.0	0.00	0.00
10	7	0.2540	0.17	0.004180	26.4	6.32	3.16
20	11	0.5080	0.34	0.004187	41.7	9.96	4.98
30	18	0.7620	0.51	0.004194	68.5	16.33	8.17
40	23	1.0160	0.67	0.004201	87.6	20.86	10.43
50	29	1.2700	0.84	0.004208	110.6	26.28	13.14
60	33	1.5240	1.01	0.004215	125.9	29.87	14.94
70	37	1.7780	1.18	0.004223	141.2	33.45	16.72
80	41	2.0320	1.35	0.004230	156.5	37.01	18.51
90	44	2.2860	1.52	0.004237	168.0	39.66	19.83
100	47	2.5400	1.69	0.004244	179.5	42.29	21.15
110	50	2.7940	1.86	0.004252	191.0	44.92	22.46
120	51	3.0480	2.02	0.004259	194.8	45.73	22.87
130	55	3.3020	2.19	0.004266	209.9	49.19	24.60
140	57	3.5560	2.36	0.004274	217.4	50.88	25.44
150	59	3.8100	2.53	0.004281	225.0	52.55	26.28
160	61	4.0640	2.70	0.004289	232.5	54.22	27.11
170	63	4.3180	2.87	0.004296	240.1	55.89	27.94
180	64	4.5720	3.04	0.004303	243.9	56.67	28.33
190	66	4.8260	3.21	0.004311	251.4	58.32	29.16
200	67	5.0800	3.37	0.004318	255.2	59.09	29.55
210	68	5.3340	3.54	0.004326	259.0	59.86	29.93
220	69	5.5880	3.71	0.004334	262.7	60.63	30.31
230	70	5.8420	3.88	0.004341	266.5	61.39	30.70

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Unconfined Compressive Strength

ASTM D2166

Project No. 0015-026-00
Client City of Winnipeg
Project Bickerton Rail Crossing

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	71	6.0960	4.05	0.004349	270.3	62.15	31.08
250	71	6.3500	4.22	0.004357	270.3	62.04	31.02
260	72	6.6040	4.39	0.004364	274.1	62.80	31.40
270	72	6.8580	4.55	0.004372	274.1	62.69	31.34
280	73	7.1120	4.72	0.004380	277.8	63.44	31.72
290	73	7.3660	4.89	0.004387	277.8	63.33	31.66
300	73	7.6200	5.06	0.004395	277.8	63.22	31.61
310	73	7.8740	5.23	0.004403	277.8	63.10	31.55
320	74	8.1280	5.40	0.004411	281.6	63.85	31.92
330	74	8.3820	5.57	0.004419	281.6	63.73	31.87
340	74	8.6360	5.74	0.004427	281.6	63.62	31.81
350	74	8.8900	5.90	0.004435	281.6	63.51	31.75
360	74	9.1440	6.07	0.004443	281.6	63.39	31.70
370	73	9.3980	6.24	0.004451	277.8	62.43	31.21
380	73	9.6520	6.41	0.004459	277.8	62.32	31.16
390	73	9.9060	6.58	0.004467	277.8	62.20	31.10
400	72	10.1600	6.75	0.004475	274.1	61.25	30.62
410	72	10.4140	6.92	0.004483	274.1	61.14	30.57
420	72	10.6680	7.09	0.004491	274.1	61.03	30.51
430	71	10.9220	7.25	0.004499	270.3	60.08	30.04
440	70	11.1760	7.42	0.004507	266.5	59.13	29.57
450	69	11.4300	7.59	0.004516	262.7	58.19	29.09
460	68	11.6840	7.76	0.004524	259.0	57.25	28.62
470	67	11.9380	7.93	0.004532	255.2	56.31	28.15
480	66	12.1920	8.10	0.004540	251.4	55.37	27.69
490	66	12.4460	8.27	0.004549	251.4	55.27	27.64
500	65	12.7000	8.43	0.004557	247.6	54.34	27.17
510	64	12.9540	8.60	0.004566	243.9	53.41	26.71
520	63	13.2080	8.77	0.004574	240.1	52.49	26.24
530	62	13.4620	8.94	0.004583	236.3	51.57	25.78
540	61	13.7160	9.11	0.004591	232.5	50.65	25.33
550	61	13.9700	9.28	0.004600	232.5	50.56	25.28
560	60	14.2240	9.45	0.004608	228.8	49.64	24.82
570	59	14.4780	9.62	0.004617	225.0	48.73	24.37
580	58	14.7320	9.78	0.004625	221.2	47.83	23.91
590	57	14.9860	9.95	0.004634	217.4	46.92	23.46
600	57	15.2400	10.12	0.004643	217.4	46.83	23.42
620	56	15.7480	10.46	0.004660	213.7	45.85	22.92
640	56	16.2560	10.80	0.004678	213.7	45.67	22.84
660	55	16.7640	11.13	0.004696	209.9	44.70	22.35