TREK GEOTECHNICAL Quality Engineering | Valued Relationships

April 9, 2018 File No. 0115-031-00

Mr. Chris Houston
Associated Engineering (Sask.) Ltd.
203 - Number Five Donald Street
Winnipeg, MB
R3L 2T4

RE Brandon AAFC Research Centre – Watermain Upgrades and Extension
Geotechnical Investigation Report

As requested by Associated Engineering (AE), TREK Geotechnical Inc. (TREK) has completed a geotechnical investigation for new watermains at the AAFC Brandon Research Centre located at 2701 Grand Valley Road, in Brandon, MB. The terms of reference for the investigation are included in our proposal addressed to Mr. Chris Houston of Associated Engineering (AE), dated March 2, 2018. TREK's scope or work includes a sub-surface investigation, laboratory testing, and the provision of recommendations for design and construction of the watermains.

Background Information

Two new watermains to the facility are planned for construction at the site including a new 300 mm diameter line from 18th Street and a new 250 mm diameter extension to an existing watermain at Braecrest Drive. Overall, approximately 2.5 km of new watermains are planned at the site to service to the facility. The water lines will consist of PVC pipe and will be buried 3 m below ground surface.

Field Program

Sub-Surface Investigation

A sub-surface investigation was completed on March 23, 2018 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site. Six test pits (TP18-01 to 06) were excavated to depths ranging between 2.4 and 5.2 m below ground surface using a Kobelco 260sk, track-mounted excavator equipped with a 0.6 m wide bucket. The test pits were backfilled with the excavated material and compacted with the excavator bucket. TP18-01 was discontinued at 2.4 m depth after an unknown line was exposed; it did not appear as though the line was damaged and a representative form AAFC was informed.

Sub-surface soils observed during excavation were visually classified based on the Unified Soil Classification System (USCS). Disturbed grab samples were retrieved from the bucket during

excavation at regular intervals and a relatively undisturbed Shelby tube sample was obtained. All samples retrieved during excavation were transported to TREK's soils laboratory in Winnipeg, MB 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 the Shelby tube sample. Grain size distribution, Atterberg limits, and acidity, resistivity, and water-soluble sulphate testing were also completed on select samples.

The test pit locations were selected by AE prior to the investigation and were located in the field using a handheld GPS. TP18-04 to 06 were relocated to avoid conflict with buried utility lines. The actual test pit locations are shown the Test Pit Location Plan (Figure 01) and UTM coordinates are provided on the test pit logs. Test pit elevations were not recorded. Test pit logs are attached which describe the soil units encountered and other pertinent information such as groundwater conditions and a summary of the laboratory testing results. Laboratory testing results are also attached to this letter.

Soil Stratigraphy

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

The soil stratigraphy in TP18-02 to 04 generally consists of loose, poorly graded, fine to coarse-grained sand extending to the depth of exploration (4.6 m below ground surface). In TP18-05 and 06, the stratigraphy consists of clay extending to depths of 4.3 and 3.8 m below ground surface. The upper 1.5 m of the clay contains organics and is stiff, moist, and of intermediate plasticity. Below 1.5 m, the clay is free of organics, stiff to very stiff, dry to moist, and of high plasticity. Loose, poorly graded, coarse-grained sand to coarse-grained gravel is present below the clay in TP18-05 and extends to the depth of exploration of 4.6 m below ground surface. Loose, poorly graded, fine to coarse-grained sand is present below the clay in TP18-06 and extends to the depth of exploration of 5.2 m below ground surface. In TP18-01, loose, poorly graded, fine-grained sand fill was encountered to the depth of exploration at 2.4 m below ground surface.

Groundwater Conditions

Seepage was encountered in TP18-01 and 05 at respective depths of 0.6 and 4.3 m below ground surface. Less than 100 mm of water accumulated at the bottom of these test pits immediately after excavation was completed. Sloughing and/or caving were observed below a depth of 3.4 and 3.7 m in TP18-03 and 06. These test pits remained open to depths of 4 and 4.9 m immediately after completion of test pitting.

These observations 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.

Recommendations

Temporary Excavations and Shoring

Excavations for the proposed watermain trenches are anticipated to extend approximately 3 m below the existing ground surface. Slope stability analyses were conducted to provide recommendations for slope geometry of temporary, open-cut excavations to this depth. The analyses were conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2016 software package (Geo-Slope International Ltd.) using the Morgenstern-Price method of slices to calculate factors of safety (FS) of theoretical slip surfaces identified using a grid and radius slip surface method. A static piezometric line at 3 m depth was assumed to represent groundwater levels.

The analysis was performed assuming two cases, including, 1) and an excavation entirely in stiff clay, and 2) an excavation entirely in loose sand. Effective stress shear strength parameters were assumed in the analysis and selected based on our observations and experience with similar soils. These parameters are summarized in Table 01. In order to maintain a minimum safety factor of 1.3 (considered an acceptable target for temporary excavations), open-cut excavations should be sloped at 2H:1V (2horizontal:1vertical) or flatter to 3 m depth. Slope stability outputs for each case are attached. TREK should be contacted to revise our analyses if open-cut excavations greater than 3 m deep are required.

Table 01. Soil Properties used in the Stability Analysis

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
Sand	18	0	30
Clay	17.5	5	17

Maintaining the stability of the excavation slopes for the duration of construction should be the responsibility of the Contractor. 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. 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 directed to a sump pit and pumped out of the excavation. If saturated sands are encountered, shoring or slope flattening may be required. To prevent wet 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

If temporary shoring is necessary due to space constraints, cantilevered walls will be required to support the excavations. Table 02, provides the recommended earth pressure coefficients and bulk unit weights for the clay and sand layers for calculation of lateral earth pressures. Surcharge loads

(if present) and hydrostatic water pressure (assuming a groundwater level at 3 m below ground surface) should be incorporated into the design of cantilevered walls, as well as an adequate factor of safety against instability.

Table 02 Earth Pressure Coefficients

Design Parameter	Earth Pressure Coefficients and Bulk Unit Weights	
	SAND	CLAY
Active (K_a)	0.3	0.5
At-rest (K_o)	0.5	0.7
Passive (K_p)	3.0	2.0
Bulk Unit Weight (kN/m^3)	18	17

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.

Concrete

Buried concrete structures should be designed in accordance with CSA A23.1-14 (Concrete Materials and Methods of Construction). Water soluble sulphate (SO4) testing was completed on two samples to assess the degree of exposure for concrete subjected to sulphate attack and the results are presented in Table 02.

Table 02. Water Soluble Sulphate Testing Results

Test Hole ID	Sample Depth	Sample ID	Soil Type	Water Soluble Sulphate
TP18-02	2.7 to 2.9 m	G05	Sand	<0.010 %
TP18-06	2.1 to 2.7 m	T21	Clay	<0.010 %

Based on these results, the degree of exposure for concrete subjected to sulphate attack is considered negligible as per Table 3, CSA A23.1-14 (Concrete Materials and Methods of Concrete Construction). 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.

Acidity, and Resistivity Testing

Soil samples have been submitted for acidity and resistivity testing. The testing had not been completed at the time of this letter. When the testing is complete, TREK will issue an addendum with the results and requirements for sulphate resistant cement for buried concrete structures.

Watermain Construction

Construction of the new watermains should follow City of Brandon Standard Construction Specifications Section No. 02660 *Watermains* and Section No. 02210 *Excavation, Bedding & Backfill* with the following supplemental recommendations:

1. The sub-grade (i.e. watermain foundation) should be free of organics, fill materials, and any other deleterious material such that it consists of undisturbed, native soil.
2. The sub-grade should be protected from freezing, drying, or inundation with water at all times. If any of these conditions occur, the sub-grade should be scarified, moisture conditioned as appropriate, and re-compacted to a minimum of 95% of the Standard Proctor Maximum Dry Density.

Frost related movements are not anticipated to be a factor for design since the watermains are to be installed to a depth of 3 m below ground surface, which is deeper than the anticipated maximum depth of frost penetration (2.5 m) for the area. The watermains can be placed above the depth of frost penetration (if required) provided insulation (e.g. Styrofoam Highload) is incorporated into the design to provide an equivalent frost protection depth of 2.5 m. TREK should be contacted to review the insulation design prior to construction to confirm it is adequate to reduce frost penetration to the intended depth.

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 Associated Engineering Ltd. (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.

If you have any questions or require any additional information, please contact the undersigned.

Kind Regards,

TREK Geotechnical Inc.

Per:

PROVINCE OF MANITOBA
R.E.J. BELBAS
Member
31049
REGISTERED PROFESSIONAL ENGINEER
Apr 9 / 18

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

Reviewed By:

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Senior Geotechnical Engineer

ENGINEERS GEOSCIENTISTS MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: April 9, 2018

Attach.

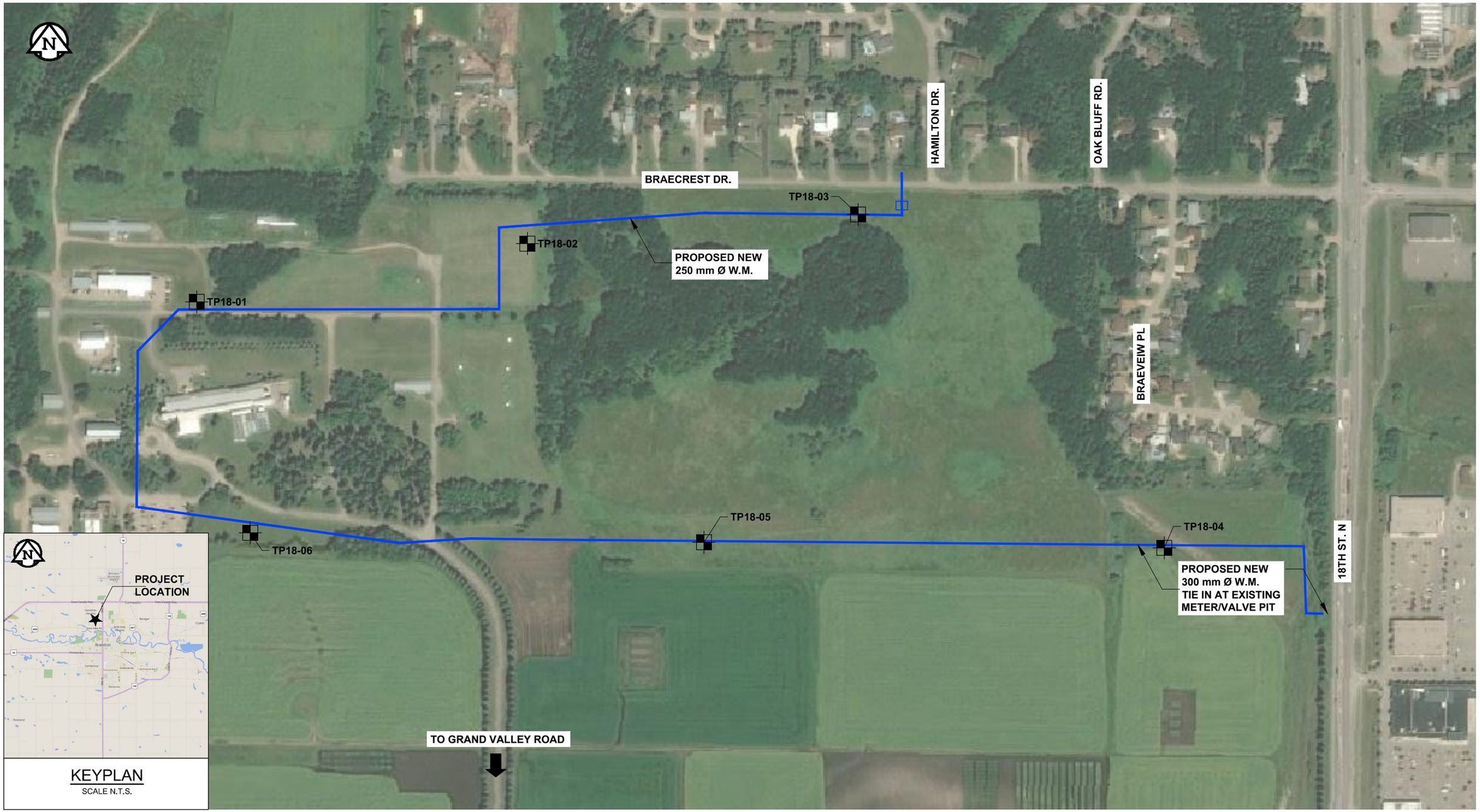
Figure

TREK GEOTECHNICAL

0115 031 00
AAFC Brandon Research Centre
Watermain Upgrade and Extensions

ANSI full bleed B (11.00 x 17.00 Inches)

Z:\Projects\0115 Associated Engineering\0115 031 00 Brandon Research Centre\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder, 4/9/2018 2:17:16 PM



KEYPLAN
SCALE N.T.S.

0 50 100 150 200 m
SCALE = 1 : 4 000 (279 mm x 432 mm)

LEGEND: TEST PIT (TREK, 2018)

NOTES:
1. IMAGE FROM BING MAPS 2018
2. TEST PIT LOCATIONS BASED ON COORDINATES PROVIDED BY HANDHELD GPS. LOCATIONS ARE APPROXIMATE

Figure 01
Test Pit Plan

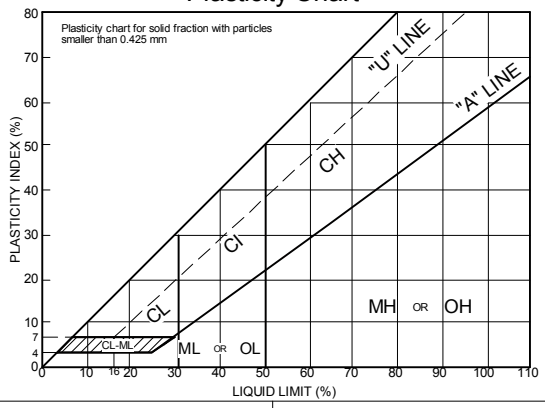
Test Pit Logs

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 Pit TP18-01
1 of 1

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524698, E-429645
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	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
0		TOPSOIL (ORGANICS)						
		SAND (FILL) - silty, trace to some gravel, trace clay - light brown - dry to moist, loose to compact - poorly graded, fine-grained		G01			●	
0.5								
1.0								
1.5				G02			●	
2.0								

END OF TEST PIT AT 2.4 m IN SAND

Notes:
1) No sloughing observed.
2) Seepage observed from ground surface to 0.6 m depth.
3) Test pit open to 2.4 m and water level measured at 2.3 m depth immediately after completion of excavating.
4) Excavating was discontinued when unidentified utility line was encountered at 2.4 m depth.
5) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Sub-Surface Log

Test Pit TP18-02
1 of 1

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524760, E-429997
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL	Undrained Shear Strength (kPa) Test Type: Torvane, Pocket Pen., Qu, Field Vane 0 50 100 150 200 250
0.0		TOPSOIL (ORGANICS) - grasses, rootlets		G03				
0.5		SAND - trace clay, trace silt, trace gravel - light brown - dry to moist, loose to compact - poorly graded, fine to medium-grained						
1.0								
1.5				G04				
2.0								
2.5								
3.0		- fine to coarse-grained sand below 2.7 m		G05				
3.5								
4.0		- moist below 3.7 m						
4.5				G06				
		END OF TEST PIT AT 4.6 m IN SAND						

Notes:
1) No sloughing or seepage observed.
2) Test pit open to 2.4 m and dry immediately after completion of excavation.
3) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Sub-Surface Log

Test Pit TP18-03
1 of 1

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524791, E-430349
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	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
0.5		SAND - silty, trace organics, trace rootlets - dark brown to black - moist, loose - poorly graded, fine-grained		G07			●	
1.0		SAND - trace clay, trace silt, trace gravel - light brown - dry to moist, loose - poorly graded, fine to coarse-grained		G08			●	
1.5								
2.0								
2.5				G09			●	
3.0								
3.5		- moist below 3.4 m						
4.0				G10			●	
4.5								

END OF TEST PIT AT 4.6 m IN SAND

Notes:
1) Sloughing observed below 3.4 m.
2) No seepage observed.
2) Test pit open to 4.0 m and dry immediately after completion of excavation.
3) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Sub-Surface Log

Test Pit TP18-04
1 of 1

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524436, E-430675
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
0.0		SAND - silty, trace organics, trace rootlets - dark brown - frozen to 1.5 m, moist and loose when thawed - poorly graded, fine sand				
0.5			G	G15		
1.0						
1.5		SAND - silty, trace to some gravel, trace clay - light brown - dry to moist, loose - poorly graded, fine to coarse-grained				
2.0			G	G16		
2.5		- moist below 2.4 m	G	G17		
3.0						
3.5						
4.0						
4.5			G	G18		

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 PIT AT 4.6 m IN SAND

Notes:
1) No sloughing or seepage observed.
2) Test pit open to 4.6 m and dry immediately after completion of excavation.
3) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Sub-Surface Log

Test Pit TP18-05
1 of 1

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524442, E-430185
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL	Undrained Shear Strength (kPa) Test Type: △ Torvane △ ✤ Pocket Pen. ✤ ☒ Qu ☒ ○ Field Vane ○ 0 50 100 150 200 250
0.5		CLAY - silty, trace sand, trace organics - dark grey - frozen to 1.5 m, moist and stiff when thawed - intermediate plasticity		G11				
1.0								
1.5		CLAY - silty, trace sand, trace oxidation - brown - moist, stiff - high plasticity - blocky		G12				
2.0								
2.5								
3.0				G13				
3.5								
4.0								
4.5		SAND and GRAVEL - trace clay, trace silt - brown, moist, compact - poorly graded, coarse-grained sand to coarse-grained gravel		G14				

END OF TEST PITS AT 4.6 m IN SAND and AND GRAVEL

Notes:
1) No sloughing observed.
2) Seepage observed below 4.3 m within SAND and GRAVEL.
3) Test pit open to 4.6 m and less than 100 mm of water measured in test pit immediately after completion of excavation.
4) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Sub-Surface Log

Test Pit TP18-06

Client:	Associated Engineering (Sask.) Ltd.	**Project Number:**	0115-031-00
Project Name:	Brandon AAFC Research Centre Watermain Upgrades	**Location:**	UTM N-5524452, E-429702
Contractor:	AW Group	**Ground Elevation:**	Not Measured
Method:	Kobelco SK260 Excavator	**Date Drilled:**	23 March 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

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	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
0.5		CLAY - silty, trace sand, trace organics - dark grey - frozen to 1.5 m, moist and stiff when thawed - intermediate plasticity		G19			●	
1.0								
1.5		CLAY - silty, trace sand, trace oxidation - brown - dry to moist, very stiff - high plasticity - blocky		G20			●	✤
2.0								
2.5				T21			● □	△ ✤
3.0				G22			●	✤
3.5		SAND - trace clay, trace silt, trace to some gravel - light brown - dry to moist, loose - poorly graded, fine to coarse-grained - moist below 4.3 m		G23			●	
4.0								
4.5				G24			●	
5.0								

END OF TEST PIT AT 5.2 m IN SAND

Notes:
1) No seepage observed.
2) Caving observed below 3.7 m depth.
3) Test pit open to 4.9 m and dry immediately after completion of excavation.
3) Test pit backfilled with excavated material and tamped with bucket to ground surface.

Logged By: Jenna Roadley **Reviewed By:** Kent Bannister **Project Engineer:** Ryan Belbas

SUB-SURFACE LOG LOGS 2018-03-26 BRANDON AAFC RESEARCH CENTRE 0_A_JSR 0115 031 00.GPJ TREK GEOTECHNICAL.GDT 9/4/18

Laboratory Testing Results

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2073943-1 TP18-02 G05 (9'-9.5')							
Sampled By: CLIENT on 23-MAR-18							
Matrix: GRAB-SOIL							
Miscellaneous Parameters							
Water Soluble Sulfate	<0.010		0.010	%	06-APR-18	06-APR-18	R4005984
L2073943-2 TP18-06 T21 (7'-9')							
Sampled By: CLIENT on 23-MAR-18							
Matrix: GRAB-SOIL							
Miscellaneous Parameters							
Water Soluble Sulfate	0.016		0.010	%	06-APR-18	06-APR-18	R4005984

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

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Moisture Content Report
ASTM D2216-10

Project No. 0115-031-00
Client Associated Engineering (Sask.) Ltd.
Project Brandon AAFC Research Centre Waterline

Sample Date 23-Mar-18
Test Date 27-Mar-18
Technician EH

Test Pit	TP18-01	TP18-01	TP18-02	TP18-02	TP18-02	TP18-02
Depth (m)	0.3 - 0.5	1.5 - 1.7	0.2 - 0.3	1.4 - 1.5	2.7 - 2.9	4.3 - 4.4
Sample #	G01	G02	G03	G04	G05	G06
Tare ID	E27	N52	C12	AC17	N106	A109
Mass of tare	8.6	8.6	8.4	6.6	8.4	8.4
Mass wet + tare	263.0	265.0	229.2	369.4	219.2	195.0
Mass dry + tare	233.4	227.0	146.8	348.8	210.2	183.4
Mass water	29.6	38.0	82.4	20.6	9.0	11.6
Mass dry soil	224.8	218.4	138.4	342.2	201.8	175.0
Moisture %	13.2%	17.4%	59.5%	6.0%	4.5%	6.6%

Test Pit	TP18-03	TP18-03	TP18-03	TP18-03	TP18-04	TP18-04
Depth (m)	0.3 - 0.5	1.1 - 1.2	2.6 - 2.7	4.1 - 4.3	0.5 - 0.6	1.7 - 1.8
Sample #	G07	G08	G09	G10	G15	G16
Tare ID	Z52	W54	AB73	K32	N22	D19
Mass of tare	8.4	8.4	6.6	8.6	8.4	8.6
Mass wet + tare	248	242.8	315.6	293	212	210
Mass dry + tare	224.6	232.6	295.8	261.2	184.2	180.4
Mass water	23.4	10.2	19.8	31.8	27.8	29.6
Mass dry soil	216.2	224.2	289.2	252.6	175.8	171.8
Moisture %	10.8%	4.5%	6.8%	12.6%	15.8%	17.2%

Test Pit	TP18-04	TP18-04	TP18-05	TP18-05	TP18-05	TP18-05
Depth (m)	2.4 - 2.6	4.3 - 4.4	0.3 - 0.5	1.5 - 1.7	2.7 - 2.9	4.4 - 4.6
Sample #	G17	G18	G11	G12	G13	G14
Tare ID	Z06	D33	N33	F14	N24	P11
Mass of tare	8.4	8.2	8.4	8.6	8.6	8.6
Mass wet + tare	208.6	220.4	281.0	292.2	405.0	228.2
Mass dry + tare	192.2	208.2	216.4	228.0	306.4	201.4
Mass water	16.4	12.2	64.6	64.2	98.6	26.8
Mass dry soil	183.8	200.0	208.0	219.4	297.8	192.8
Moisture %	8.9%	6.1%	31.1%	29.3%	33.1%	13.9%

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Moisture Content Report
ASTM D2216-10

Project No. 0115-031-00
Client Associated Engineering (Sask.) Ltd.
Project Brandon AAFC Research Centre Waterline

Sample Date 23-Mar-18
Test Date 27-Mar-18
Technician EH

Test Pit	TP18-06	TP18-06	TP18-06	TP18-06	TP18-06	
Depth (m)	0.5 - 0.6	1.5 - 1.7	2.9 - 3.0	3.7 - 3.8	4.7 - 4.9	
Sample #	G19	G20	G22	G23	G24	
Tare ID	W96	N25	E103	Z130	W14	
Mass of tare	8.6	8.6	8.4	8.4	8.4	
Mass wet + tare	203.4	236.2	258.8	245.8	259.2	
Mass dry + tare	168.6	193.6	197.4	223.6	246.2	
Mass water	34.8	42.6	61.4	22.2	13.0	
Mass dry soil	160.0	185.0	189.0	215.2	237.8	
Moisture %	21.8%	23.0%	32.5%	10.3%	5.5%	

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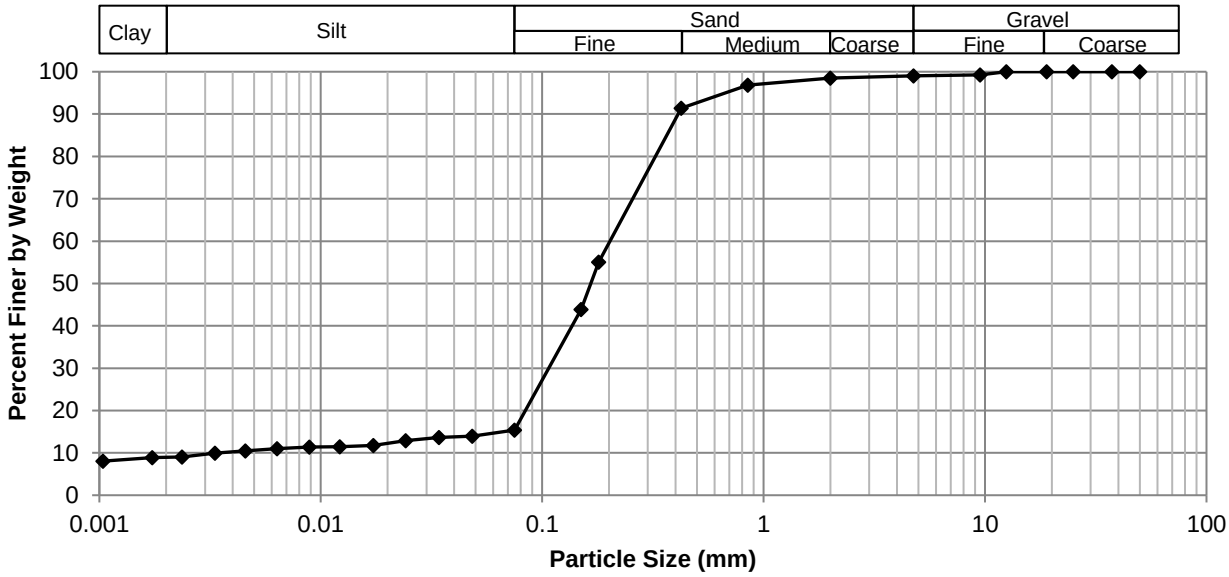
Grain Size Analysis (Hydrometer Method)
ASTM D422

Project No.	0115-031-00
Client	Associated Engineering (Sask.) Ltd.
Project	Brandon AAFC Research Centre Waterline
Test Hole	TP18-02
Sample #	G04
Depth (m)	1.4 - 1.5
Sample Date	23-Mar-18
Test Date	2-Apr-18
Technician	EH

Gravel	1.0%
Sand	83.6%
Silt	6.4%
Clay	8.9%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	98.99	0.0750	15.38
37.5	100.00	2.00	98.50	0.0484	13.96
25.0	100.00	0.850	96.81	0.0342	13.65
19.0	100.00	0.425	91.38	0.0242	12.86
12.5	100.00	0.180	55.08	0.0173	11.77
9.50	99.23	0.150	43.84	0.0122	11.48
4.75	98.99	0.075	15.38	0.0089	11.35
				0.0063	11.03
				0.0046	10.46
				0.0033	9.93
				0.0024	9.04
				0.0017	8.86
				0.0010	8.05

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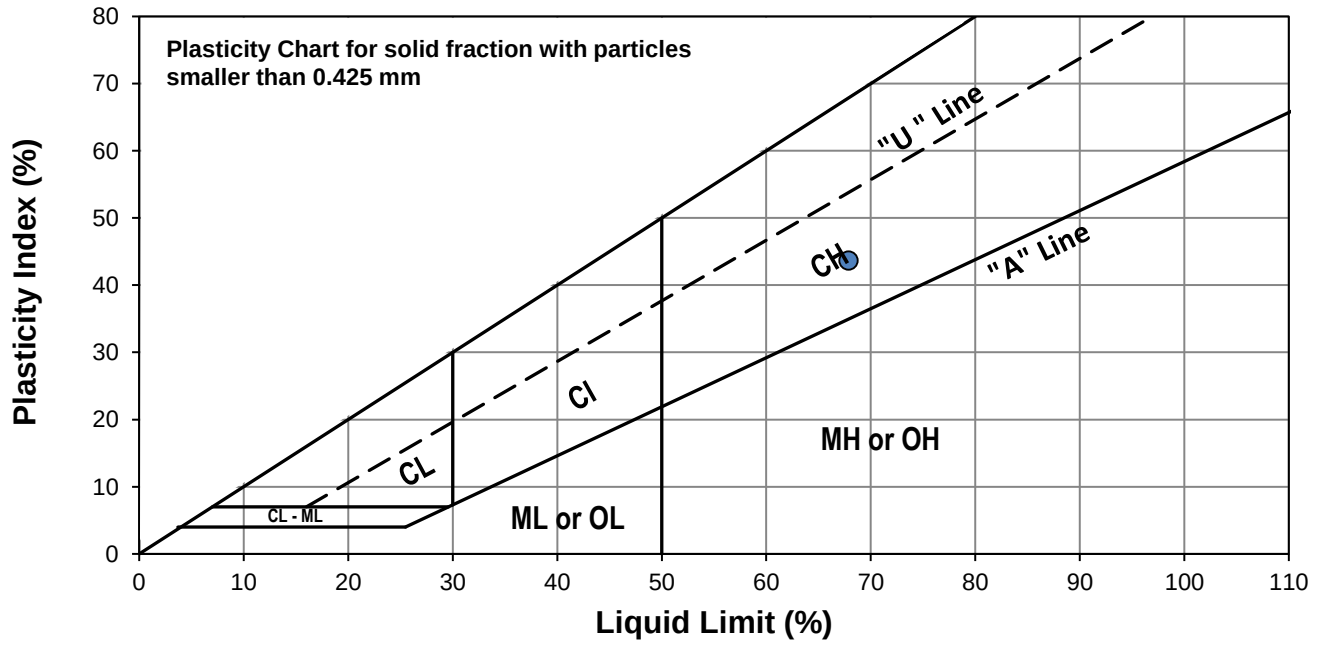
Atterberg Limits
ASTM D4318-10e1

Project No.	0115-031-00
Client	Associated Engineering (Sask.) Ltd.
Project	Brandon AAFC Research Centre Waterline
Test Hole	TP18-05
Sample #	G13
Depth (m)	2.7 - 2.9
Sample Date	23-Mar-18
Test Date	29-Mar-18
Technician	EH

Liquid Limit	68
Plastic Limit	24
Plasticity Index	44

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	18	25	33		
Mass Wet Soil + Tare (g)	23.115	25.169	24.746		
Mass Dry Soil + Tare (g)	19.396	20.743	20.584		
Mass Tare (g)	14.095	14.258	14.234		
Mass Water (g)	3.719	4.426	4.162		
Mass Dry Soil (g)	5.301	6.485	6.350		
Moisture Content (%)	70.157	68.250	65.543		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	20.206	21.116			
Mass Wet Soil + Tare (g)	19.035	19.749			
Mass Dry Soil + Tare (g)	14.121	14.186			
Mass Water (g)	1.171	1.367			
Mass Dry Soil (g)	4.914	5.563			
Moisture Content (%)	23.830	24.573			

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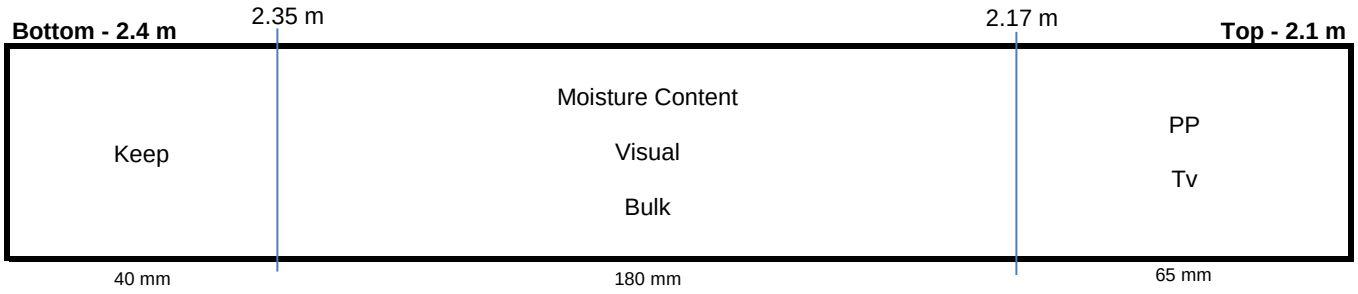
Shelby Tube Visual

Project No.	0115-031-00
Client	Associated Engineering (Sask.) Ltd.
Project	Brandon AAFC Research Centre Waterline
Test Hole	TP18-06
Sample #	T21
Depth (m)	2.1 - 2.7
Sample Date	23-Mar-18
Test Date	27-Mar-18
Technician	EH

Tube Extraction

Recovery (mm) 285



Visual Classification

Material	Clay
Composition	silty
trace silt inclusions (<15 mm ø)	
trace oxidation	
trace rootlets	
Color	grey
Moisture	damp
Consistency	very stiff
Plasticity	high plasticity
Structure	
Gradation	

Torvane

Reading	0.63
Vane Size (s,m,l)	s
Undrained Shear Strength (kPa)	154.5

Pocket Penetrometer

Reading	**1**	3.90
	2	3.70
	3	3.70
	Average	3.77
Undrained Shear Strength (kPa)		184.7

Moisture Content

Tare ID	N62
Mass tare (g)	8.6
Mass wet + tare (g)	312.7
Mass dry + tare (g)	237.9
Moisture %	32.6%

Unit Weight

Bulk Weight (g)		1092.3
Length (mm)	**1**	142.23
	2	141.91
	3	142.20
	4	142.37
Average Length (m)		0.142
Diam. (mm)	**1**	71.75
	2	72.23
	3	72.01
	4	72.47
Average Diameter (m)		0.072
Volume (m^3)		5.81E-04
Bulk Unit Weight (kN/m^3)		18.4
Bulk Unit Weight (pcf)		117.4
Dry Unit Weight (kN/m^3)		13.9
Dry Unit Weight (pcf)		88.5

Slope Stability Outputs

Tabloid (279mm x 432mm)

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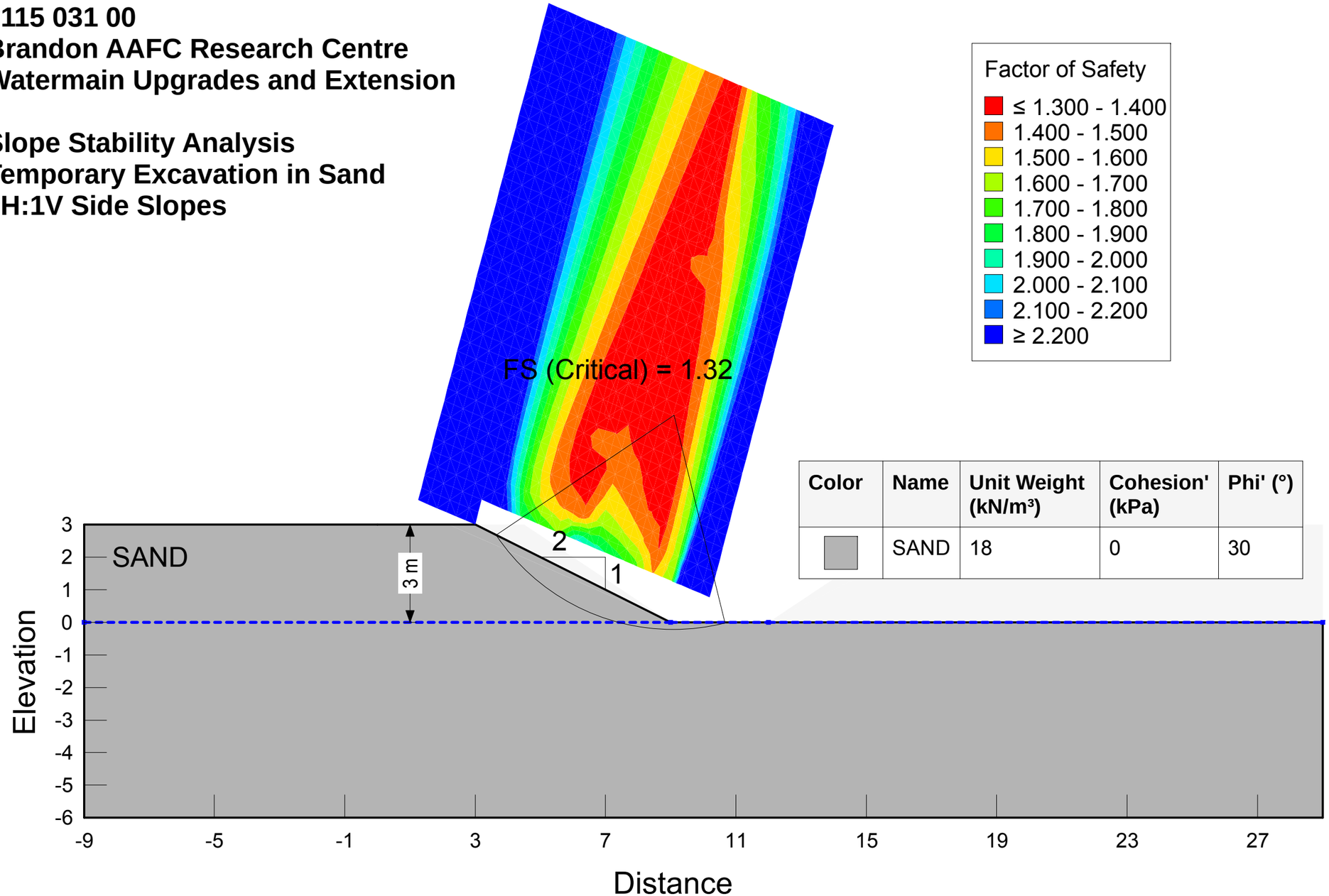
0115 031 00
Brandon AAFC Research Centre
Watermain Upgrades and Extension

Slope Stability Analysis
Temporary Excavation in Sand
2H:1V Side Slopes



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	SAND	18	0	30

SCALE: 1:130 (279mm x 432mm)

FILE PATH: Z:\Projects\0115 Associated Engineering\0115 031 00 Brandon Research Centre\2 Design\2.7 Modelling\M001 - SAND.gsz

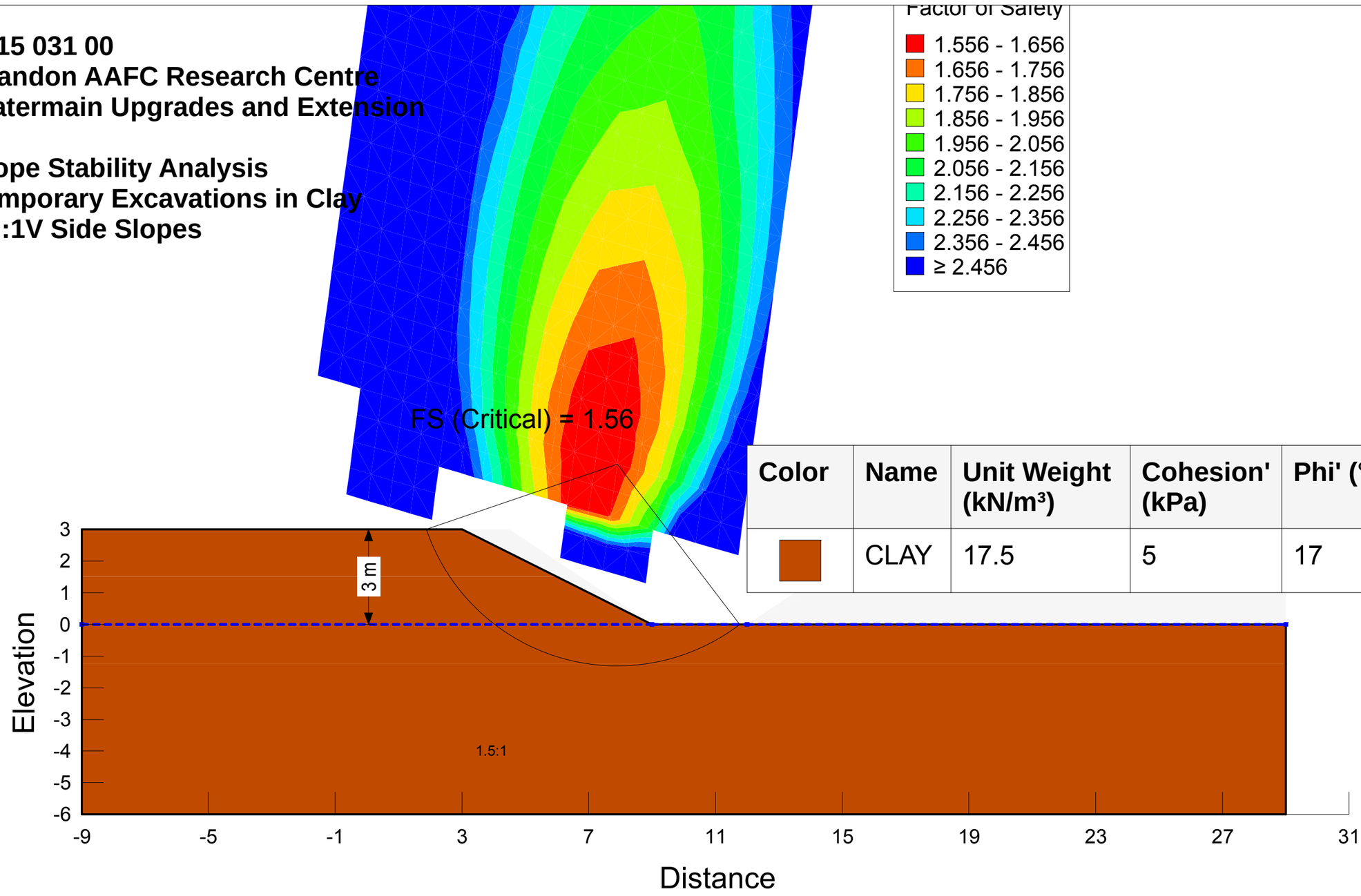
TREK GEOTECHNICAL

Tabloid (279mm x 432mm)

SAVED: 09/04/2018 4:05:45 PM

0115 031 00
Brandon AAFC Research Centre
Watermain Upgrades and Extension

Slope Stability Analysis
Temporary Excavations in Clay
2H:1V Side Slopes



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	CLAY	17.5	5	17

SCALE: 1:130 (279mm x 432mm)

FILE PATH: Z:\Projects\0115 Associated Engineering\0115 031 00 Brandon Research Centre\2 Design\2.7 Modelling\M002 - CLAY.gsz

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

April 12, 2018 File No. 0115-031-00

Mr. Chris Houston
Associated Engineering (Sask.) Ltd.
203 - Number Five Donald Street
Winnipeg, MB
R3L 2T4

RE Brandon AAFC Research Centre – Watermain Upgrades and Extension
Geotechnical Investigation Report Addendum No. 1 – Laboratory Testing Results

This letter is an addendum to the geotechnical report issued by TREK on April 9, 2018 to Associated Engineering (Sask.) Ltd. for the proposed watermains at the AAFC Brandon Research Centre. The addendum provides results of laboratory testing that was not completed at the time the report was issued.

Two soil samples (G05 from TP18-02 and G13 from TP18-02) were tested by ALS Environmental (ALS) for resistivity, conductivity, and acidity (pH). A summary of the results is provided in the table below and the laboratory testing report provided by ALS is attached.

Test Hole ID	Sample Depth	Sample ID	Soil Type	Resistivity	Conductivity	Acidity (pH)
TP18-02	2.7 to 2.9 m	G05	Sand	14,300 ohm·cm	0.0699 mS/cm	7.95
TP18-05	2.7 to 2.9 m	G13	Clay	3,190 ohm·cm	0.313 mS/cm	7.86

If you have any questions or require any additional information, please contact the undersigned.

Kind Regards,

TREK Geotechnical
Per:

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

Attach.

TREK Geotechnical Inc.
ATTN: JENNA ROADLEY
1712 St. James Street
Winnipeg MB R3H 0L3

Date Received: 05-APR-18
Report Date: 11-APR-18 12:20 (MT)
Version: FINAL

Client Phone: 204-975-9433

Certificate of Analysis

Lab Work Order #: L2076421

Project P.O. #: 0115-031-00
Job Reference: 0115-031-00
C of C Numbers:
Legal Site Desc:

Craig Riddell, B.Sc.Ag
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2076421-1 TP18-02 G05 (9.0'-9.5')							
Sampled By: CLIENT on 23-MAR-18							
Matrix: Soil - GRAB							
Miscellaneous Parameters							
% Moisture	4.11		0.10	%	10-APR-18	10-APR-18	R4007957
Resistivity	14300		1.0	ohm*cm		11-APR-18	
Conductivity	0.0699		0.0040	mS/cm		11-APR-18	R4008146
pH	7.95		0.10	pH units		10-APR-18	R4007517
L2076421-2 TP18-02 G13 (9.0'-9.5')							
Sampled By: CLIENT on 23-MAR-18							
Matrix: Soil - GRAB							
Miscellaneous Parameters							
% Moisture	24.4		0.10	%	10-APR-18	10-APR-18	R4007957
Resistivity	3190		1.0	ohm*cm		11-APR-18	
Conductivity	0.313		0.0040	mS/cm		11-APR-18	R4008146
pH	7.86		0.10	pH units		10-APR-18	R4007517

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
EC-WT	Soil	Conductivity (EC)	MOEE E3138

A representative subsample is tumbled with de-ionized (DI) water. The ratio of water to soil is 2:1 v/w. After tumbling the sample is then analyzed by a conductivity meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

MOISTURE-WT	Soil	% Moisture	Gravimetric: Oven Dried
PH-WT	Soil	pH	MOEE E3137A

A minimum 10g portion of the sample is extracted with 20mL of 0.01M calcium chloride solution by shaking for at least 30 minutes. The aqueous layer is separated from the soil and then analyzed using a pH meter and electrode.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	APHA 2510 B

Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.

RESISTIVITY-CALC-WT	Soil	Resistivity Calculation	MOECC E3138

Resistivity are calculated based on the conductivity using APHA 2510B where Conductivity is the inverse of Resistivity.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.