AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Memorandum

To	Marvin McDonald	Page	1
CC			
Subject	Preliminary Geotechnical Assessment- Fort Garry Interceptor Sewer Crossing at the Red River		
From	Alex Hill		
Date	December 12, 2013	Project Number	60274906 (403.9.2)

This assessment forms part of the Preliminary Geotechnical Assessment undertaken in accordance with the scope of work outlined in the AECOM Proposal (04001205.4016.035) dated July 10, 2013 in regards to the provision of Professional Engineering Services for the Repair of the Fort Garry Interceptor Sewer Crossing the Red River.

1. Introduction

1.1 General

The primary focus of the geotechnical assessment was to establish the current stability of the riverbank slope within the study area and to identify the potential for slope failure engaging the sewer pipe. Recommendations are provided as part of this Memorandum should there be a risk of slope failure and its potential to engage of the sewer pipe. Further geotechnical recommendations are provided to address erosion at toe of the riverbank slope.

1.2 Scope

The Preliminary Geotechnical Assessment included the following components:

- Visual inspection of the subject site and its boundaries;
- Review of existing reports and as-built drawings relevant to the subject site and adjacent structures, if available;
- Completion of a geotechnical field program including the undertaking of a series of test holes and the subsequent installation of groundwater monitoring instruments (i.e., standpipe piezometers);
- An evaluation of current slope stability and identification of mechanisms (where appropriate and applicable) that may contribute to potential slope instability;
- An evaluation of potential stabilisation measures should the results of the stability analysis indicate potential risk to current conditions and/or adjacent structures; and

- Provision of recommendations for remediation of the slope should the stability analysis indicate potential instability.

1.3 Background

The following sources of background information were reviewed as part of this preliminary geotechnical assessment:

Reports:

- AECOM Canada Ltd. (May 23, 2012), Technical Memorandum - *Test Hole Adjacent to Interceptor; Fort Garry to St. Vital Interceptor, East Bank of Red River at Bishop Grandin Boulevard.*
- UMA Engineering Ltd. (December 4, 2006), Functional Design Report - *St. Vital Park Riverbank Stability Study and Functional Design of Stabilization Measures.*
- Klohn Leonoff Consultants (April 5, 1976), Sub-soils Investigation- *Fort Garry - St. Vital Corridor, Winnipeg Manitoba.*

Drawings:

- Wardrop Engineering Inc. (June 23, 1997), Fort Garry Bridge (Route 165) Flood '97 Monitoring Riverbed Soundings - *Scour Investigation Plan (*B173-97-S1*).*
- Wardrop Engineering Inc. (June 23, 1997), Fort Garry Bridge (Route 165) Flood '97 Monitoring Riverbed Soundings - *Scour Investigation; Section A-A (*B173-97-S2*).*
- Wardrop Engineering Inc. (June 23, 1997), Fort Garry Bridge (Route 165) Flood '97 Monitoring Riverbed Soundings - *Scour Investigation; Section B-B (*B173-97-S3*).*
- W.L Wardrop & Associates (March 25, 1977), As-Built Drawings - *Route 165, South Bridge Soils Data* (B-5092-205).
- W.L Wardrop & Associates (March 25, 1977), As-Built Drawings - *Route 165, North Bridge Soils Data* (B-5092-206).
- W.L Wardrop &Associates (March 25, 1977), As-Built Drawings - *Route 165, Aqueduct Soils Data* (B-5092-207)..
- W.L Wardrop &Associates (March 25, 1977), As-Built Drawings - *Route 165, Water Level Data* (B-5092-207).

2. Field Program

2.1 Site Reconnaissance

A detailed site reconnaissance was conducted on November 6, 2013 by AECOM personnel to document and photograph site conditions (topography, evidence of instabilities, vegetation, etc.) and to evaluate site access for field investigation and potential construction access. The riverbank characterization described in Section 3.0 of this Memorandum is based on information collected during the site reconnaissance trip.

2.2 Surveys

Topographic surveys were not included as part of the geotechnical field program, and as such, all subsequent geotechnical analysis has been based on previous surveys conducted on the study area, specifically along the sewer alignment.

2.3 Geotechnical Investigation

To supplement soil and groundwater information obtained from previous geotechnical investigations and reports, two (2) test holes were advanced under the supervision of AECOM at the locations shown on Figure A1, enclosed within Appendix A of this Memorandum.

The geotechnical investigation was conducted on November 8 and 19, 2013, using an Acker MP-8/SS3 drill rig equipped with 125 mm diameter solid stem augers, operated by Paddock Drilling Ltd. Two (2) test holes (TH13-01 and TH13-02) were advanced to power auger refusal (within Glacial Till) at depths of 13.8 m (TH13-01) and 11.6 m (TH13-02) below ground surface. Both test holes were completed under the supervision of AECOM personnel, who visually classified and logged soils, retrieved samples for laboratory testing, and supervised in-situ soil testing, instrumentation installation, and test hole backfilling. In-situ soil testing consisted of Standard Penetration Tests (SPTs) performed at regular intervals throughout each test hole. Instrumentation installation included 25 mm diameter polyvinyl chloride (PVC) standpipe piezometers with 0.3 m casagrande tips installed in each test hole upon completion. Each test hole was backfilled with silica sand around the casagrande tip with the remaining annulus sealed with bentonite chips.

Test hole locations were measured using the Universal Transverse Mercator (UTM) coordinate system by AECOM personnel using handheld GPS, generally considered accurate to +/- 3 m. Ground elevations at each test hole were not measured. Detailed test hole logs summarizing the location and completion depths of test holes, encountered soil conditions, and seepage and sloughing conditions are presented within Appendix B of this Memorandum.

A summary of the test hole drilling is presented in Table 2-1 below.

Table 2-1: Summary of Test Holes Drilling

Test Hole	Depth to Base of Hole (m)	Soil Unit at Termination Depth
TH13-01	13.8	Glacial Till
TH13-02	11.6	Glacial Till

Notes: *- Elevations not recorded as part of the Geotechnical Investigation

2.4 Laboratory Testing

Laboratory testing was conducted on selected soil samples collected during the site investigation. The laboratory testing program included determination of moisture contents, grain size distribution (hydrometer method), Atterberg limits, unconfined compressive strengths and density testing. The laboratory test results are shown on the test hole logs in Appendix B and are also presented separately in Appendix C (Laboratory Test Results). Table 2-2 summarizes the number and type of the tests completed.

Table 2-2: Laboratory Testing Summary

Test	Number
Moisture Content	24
Hydrometer Analysis	5
Atterberg Limits	5
Unconfined Compressive Strength	2
Bulk and Dry Density	5

3. Riverbank Characterisation

3.1 General

The Fort Garry Interceptor Sewer is located in a large alluvial flood plain that extends from just south of Bishop Grandin Boulevard to approximately 1 km north of the project site. The alluvial soils that form the flood plain are comprised mainly of clay beds of silt, sand, and gravel, which were deposited either directly on glacial till or on a layer of lacustrine clay. The alluvial deposits are exposed over the full height of the subject riverbank throughout the study area.

The system of bank characterization as detailed in the City of Winnipeg Waterways Authority's *Riverbank Characterization Study* (May 2000) has been adopted for characterizing the subject riverbank slope within the project study area. Following the 2000 study, the riverbank slope associated with this project has been classified as an *Erosion Controlled Bank* based on site conditions.

3.1.1 Site Reconnaissance Observations

Photographs taken during the course of the site reconnaissance visit are presented as Appendix D enclosed with this Memorandum.

Vegetation

The east bank of the Red River within the study area largely consisted of a manicured lawn along the upper bank, a flattened mid-slope (inclusive of an asphalt walkway), and a non-maintained lower slope with overgrown mature trees and brush as vegetation cover. Directly at the toe of the slope, vegetation cover is absent due to erosion.

Instability Features

The following slope instability features were identified during the site reconnaissance visit:

- A tension crack was observed on the asphalt walkway running approximately 10 meters in both directions perpendicular to interceptor alignment. No vertical displacement within the pavement surface was noted. It was further evident that historical movement along the tension crack in the horizontal direction may have occurred, which appeared to have been partially repaired. There may be a number of mechanisms attributable to the identified pavement cracking including sub-base/sub-grade failure, seasonal swelling and shrinkage of sub-grade, and movement within the riverbank slope.

- Dislocated trees were observed along the lower slope parallel to the alignment of the interceptor. Based on the direction at which the trees leaned, it was inconclusive as to the nature of the movement within the slope. It is likely, however that tree movement may be a consequence of shallow topsoil creep or shallow subsoil movement.

- An erosional scarp was present along the complete length of the toe of slope along the study area, perpendicular to the interceptor alignment. The erosional scarp measured approximately 0.9 m (average) in vertical height, and had exposed the alluvial clays along the entire length. It was evident that in certain segments, the alluvial soils comprised of silty clays with intermittent silt and sand lenses (<25 mm thickness).

Drainage Observations

Erosion scour from land drainage sewer outfall at bridge pier of eastbound Fort Garry Bridge was observed approximately 12.0 m south of sewer interceptor pipe alignment. Rip-rap, where present at the toe of the bridge abutment slope, was relatively intact, with erosion being limited to the alluvial materials deposited on the previously placed rip-rap.

There appeared to be no clear indication of deep-seated rotational or translational movement/failure within the riverbank slope either historically or at present. Based on the erosion of the alluvial soils at the toe of the slope, the most significant driver of any slope instability would likely be the localized softening and weathering of soils due to water erosion, and the further reduction of toe weight due to erosion. A loss of materials at the toe of the slope may, in time, propagate further upslope by a process of retrogressive failure.

3.2 Erosion Controlled Bank

Based on site observations obtained via site reconnaissance, the riverbank slope within the project study area is classified as an erosion controlled bank in accordance with the criteria described in the City of Winnipeg Waterways Authority's *Riverbank Characterization Study* (May 2000). This classification is attributed to a riverbank slope where riverbank loss is primarily the result of erosion along the edge of the river at summer water levels. Bank failures typically are localized toppling of over steepened riverbank slopes created as a result of excessive toe erosion.

Shallow failures or sloughing of the bank face often follow floods or heavy precipitation which can saturate the bank and reduce the strength of the soil. There is no evidence of deep-seated or rotation failures along the subject riverbank slope, but the rate of bank loss may be accelerated following heavy precipitation or rapid drawdown events. For the most part, the lower portion of the riverbank slope is covered with semi-mature trees and tall shrubs which contribute to reducing erosion to the near-surface soils during heavy rainfall. Little or no vegetation was observed on the over-steepened bank face above the river level, leaving it vulnerable to erosion.

4. Subsurface Conditions

The following sections describe the subsurface stratigraphy directly within the area of investigation (i.e., riverbank section) based on the findings of the field investigation. Subsurface conditions can vary within the site and the information provided in this section is a summary of the findings from the field investigation and laboratory testing program.

4.1 Soil Stratigraphy

Based on the results of the test holes performed at the subject site, the general soil profile in descending order from ground surface is as follows:

- Topsoil
- Alluvial Clay
- Lacustrine Clay
- Glacial Till

Each major stratigraphic unit is discussed separately as follows:

4.1.1 Topsoil

Topsoil was encountered in the both test holes (TH13-01 and TH13-02) with a thickness ranging between 100 to 200 mm.

4.1.2 Alluvial Clay

Based on visual observations for and laboratory findings associated with the alluvial soils, it is considered suitable to separate the soils into two separate sub-units based on composition and engineering behaviour for the purposes of soil modelling.

The Alluvial Clay contained silt and sand inclusions, seams and laminations at various depths. The silt and sand seams ranged from 1 to 100 mm in thickness, whilst the laminations are less than 2 mm in thickness. The upper portion of the Alluvial Clay is generally brown with a stiff consistency becoming grey and soft with increasing depth, marking the transition into the lower sub-unit.

Upper Alluvial Clay

The Upper Alluvial Clay was encountered directly below the topsoil, with a corresponding thickness of 2.0 m as observed in test hole TH13-02. The upper alluvial unit was generally noted as a trace to silty, trace to some sand, dark brown to grey, intermediate to high plastic clay (CI-CH). The clay had a firm to stiff consistency and was also noted to be dry to moist. Trace organics and sulphates were also observed within the upper unit. Desiccation to the soil was also evident during the drilling of the test holes within the clay, likely a consequence of shrinkage.

A single SPT blow count was recorded at 9 blows per 300 mm, indicating that the intermediate to high plasticity clay was stiff. The moisture content of the clay varied from 29.3 to 32.4%. A summary of the index properties of the Upper Alluvial Clay is presented in Table 4-1 below;

Table 4-1: Summary of Index Properties of the Upper Alluvial Clay

	Minimum Value	Maximum Value	Average Value
Moisture Content (%)	29.3	32.4	30.5
	Reported Value		
SPT ‘N’ Blow Counts (uncorrected)	9		

Lower Alluvial Clay

The Lower Alluvial Clay was encountered directly beneath the Upper Alluvial Clay at a depth of 2.1 m below existing grade within one test hole (TH13-02). The lower alluvial unit was generally noted as a some to silty, trace to some sand, dark brownish grey to grey, high plastic clay (CH). The clay had a firm to stiff consistency, and was also noted to be damp to wet. Trace organics were also observed throughout the lower unit.

A single SPT blow count was recorded as 15 blows per 300 mm, indicating that the high plasticity clay was stiff to very stiff. However, based on values of undrained shear strength, generally the Lower Alluvial Clay had a soft to firm consistency (25 to 50 kPa). The moisture content of the clay varied from 32.7 to 37.2%. A summary of the index properties of the Lower Alluvial Clay is presented in Table 4-2 below;

Table 4-2: Summary of Index Properties of the Lower Alluvial Clay

	Minimum Value	Maximum Value	Average Value
Moisture Content (%)	32.7	37.2	35.0
Grain Size Analysis - Gravel (%)	0.0	0.1	0.05
Grain Size Analysis - Sand (%)	0	5.2	2.6
Grain Size Analysis - Silt (%)	39.0	44.0	41.5
Grain Size Analysis - Clay (%)	50.7	61.0	56.0
Undrained Shear Strength (kPa)	47.9	49.0	48.5
	Reported Value		
Dry Unit Weight (kN/m^3)	13.83		
Bulk Unit Weight (kN/m^3)	18.40		
SPT ‘N’ Blow Counts (uncorrected)	15		
Liquid Limit (%)	53.8		
Plastic Limit (%)	18.9		

4.1.3 Lacustrine Clay

Lacustrine Clay was encountered in both test holes (TH13-01 and TH13-02) either directly beneath the topsoil or alluvial clay deposits. The thickness of the Lacustrine Clay ranged from 4.0 to 11.7 m.

The Lacustrine Clay was noted as a greyish brown, moist to wet, soft to very stiff, high plastic silty clay. However, the results of a single grain size analysis test (by hydrometer method) indicate a predominant silt and clay (each grain size proportion exceeding 35%) soil based on the percentage passing by dry unit weight. However, this result is not believed to be a characteristic representation of the composition of the Lacustrine Clay throughout the sequence of riverbank deposits.

SPT blow counts were recorded at values between 7 and 11 blows per 300 mm, indicating that the high plasticity clay was firm to stiff in consistency. Based on values of undrained shear strength, the Lacustrine Clay had a firm (25 to 50 kPa) to very stiff (100 to 200 kPa) consistency. A summary of the index properties of the Lacustrine clay is presented in Table 4-3 below;

Table 4-3: Summary of Index Properties of the Lacustrine Clay

	Minimum Value	Maximum Value	Average Value
Moisture Content (%)	26.5	42.7	33.8
Liquid Limit (%)	62.3	76.2	68.7
Plastic Limit (%)	18.8	27.2	23.0
Dry Unit Weight (kN/m^3)	11.66	13.74	12.82
Bulk Unit Weight (kN/m^3)	16.60	18.20	17.53
SPT ‘N’ Blow Counts (uncorrected)	7.0	11.0	9.6
Grain Size Analysis - Gravel (%)	0.0	1.4	0.5
Grain Size Analysis - Sand (%)	0.0	10.6	4.2
Grain Size Analysis - Silt (%)	27.9	47.8	35.3
Grain Size Analysis - Clay (%)	50.8	69.2	60.0
Undrained Shear Strength (kPa)	35.9	133.6	82.0

4.1.4 Glacial Till

Glacial Till was encountered underlying the Lacustrine Clay at a depth of between 10.0 and 11.9 m below grade in both test holes (TH13-01 and TH13-02). The Glacial Till was predominately characterized as a silt dominated matrix, with sub-components of some gravel to gravelly, some sand to sandy, and trace to some clay. The Glacial Till was tan in colour, wet, and compact to very dense. However, the general consistency/density of the upper 0.5 m of the till was noted as a soft/loose deposit, locally referred to as putty till.

All test holes were terminated in the dense till due to power auger refusal. Moisture contents decrease from 12.3 to 9.8% over a depth of 10.0 to 13.8 m below grade. Seepage and sloughing was noted at the base of the till. A summary of the index properties of the Glacial Till is presented in Table 4-4 below;

Table 4-4: Summary of Index Properties of the Glacial Till

	Minimum Value	Maximum Value	Average Value
Moisture Content (%)	9.8	12.3	11.3
SPT 'N' Blow Counts (uncorrected)	17	>50	45

4.2 Groundwater Conditions

The measured groundwater levels (GWL) in the two standpipe piezometers are presented in Table 4-5.

Table 4-5: Summary of Standpipe Piezometer Readings

Test Hole	Soil Unit	Groundwater Observations During Drilling (m)	Depth to Groundwater Level Below Grade (m)	
			November 19, 2013	November 26, 2013
TH13-01	Glacial Till (CL)	Groundwater seepage observed at 6.7 m below grade	5.77	6.02
TH13-02	Glacial Till (CL)	Groundwater seepage observed at 4.9 m below grade.	10.29	5.97

Groundwater levels should be expected to fluctuate seasonally and in response to climatic conditions (precipitation). Groundwater levels may vary from those reported when construction commences. It is recommended to monitor the groundwater periodically prior to construction to observe seasonal fluctuations.

5. Model Construction

Computer aided numerical modelling software utilizing Slope/W (Geoslope International) was used for the slope stability analysis and the resultant stability output models are presented as part of Appendix E, enclosed within this Memorandum. The soil stratigraphy used in the analysis was based on the information contained Section 4.0.

Slope stability assessment was performed using Morgenstern-Price's general method of slices based on a limit equilibrium approach. More advanced methods (such as finite element analysis) were not used for this study

As part of the analysis, the following slip surfaces were considered of interest and are presented graphically in Figure 1 below. A Factor of Safety (FS) was assigned to each of the following:

- **Global Slip Surface (GS)**: Defined as a slip surface that largely encompasses the slope soil mass, and has an entry and exit point at or just beyond the slope crest and toe.
- **Global Slip Surface Engaging Pipe (GS+P)**: Defined as a slip surface that meets the criteria of a global slip surface and encompasses part of the buried pipe.
- **Toe Slip Surface (TS)**: Defined as a slip surface that is localised to the toe of the slope, which has a minimum depth of 0.5 m. At some locations the FS of this slip surface may be lower than the critical or global FS. Instability at the toe of the slope may reduce the FS for the global or critical slip surfaces. Retrogressive failures starting at the toe may also work towards the riverbank.

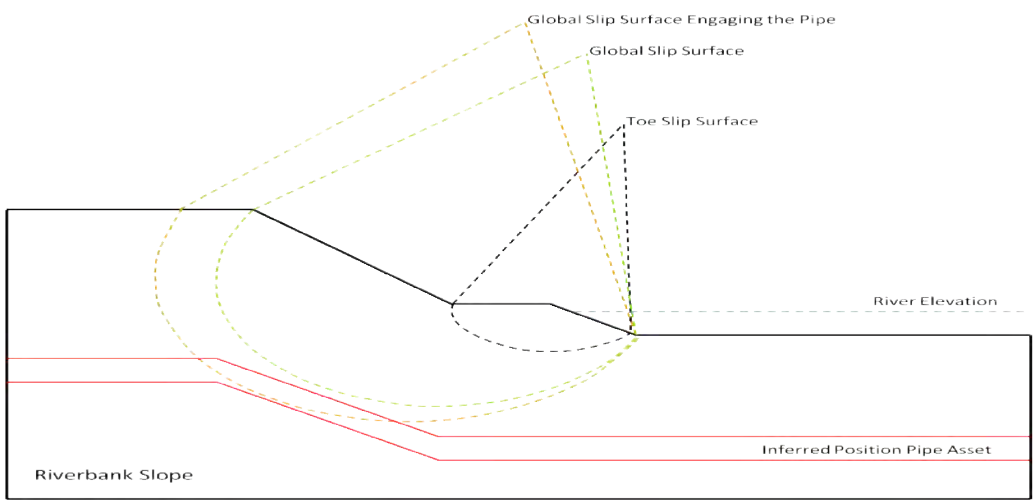

Figure 1: Assessed Slip Surfaces within Analysis

5.1.1 Groundwater Conditions

Groundwater conditions within the stability models are based upon measurements taken from the standpipe piezometers installed within test holes completed as part of the field investigation. These groundwater readings are representative of winter conditions only, and therefore, to replicate summer groundwater conditions, groundwater has been modified to reflect the increase in summer river elevations. Groundwater conditions adopted within the modelling are summarized in Table 5-1, below.

5.1.2 River Elevations

As part of the slope stability assessment, river elevations were modelled to reflect both summer and winter levels, as follows:

- Summer Water Level: 223.74 m (August 22, 2012)
- Winter Water/Ice Level: 222.02 m (December 1970)

An assessment of current slope conditions during a rapid drawdown event was also undertaken as part of the slope stability analysis to ascertain the FS following spring melt and heavy precipitation events.

5.2 Selection of Ground Model Parameters

Based on the geotechnical index properties of the soils and based on the range of values expected for Winnipeg clays, the soil strength parameters shown in Table 5-1 have been adopted for use as part of slope stability assessment.

Table 5-1: Soil Strength Parameters for Stability Analysis

Stratum	Moist Bulk Unit Weight (kN/m^3)	Internal Angle of Friction (Degrees)	Cohesion (kPa)	Groundwater Elevations (m)	
				Summer Conditions	Winter Conditions
Alluvial Clay*	18	18	5	223.74 to 227.53	222.02 to 227.53
Lacustrine Clay	18	14	5		
Glacial Till	21	30	10		

Notes: * Inclusive of upper and lower alluvial clay

These soil parameters are further validated by the work undertaken as part of the AECOM (formerly UMA) through the *St. Vital Park Riverbank Stability Study* (2006). The work undertaken by AECOM focused solely on the study of failed riverbank slopes within 1 km of the Fort Garry Sewer Interceptor Crossing predominantly composed of alluvial clays.

Fully softened shear strength values were assigned to the Lower Alluvial and Lacustrine Clays. The depth of bedrock, although not proven as part of the AECOM field investigation, was referenced from as-built drawings for use in the assessment. The bedrock was treated as an *impenetrable layer* within the analysis, and therefore not assigned a shear strength value.

5.3 Current Riverbank Stability

Based on the topographic cross-section taken along the pipe alignment and the selected ground model parameters shown in Table 5-1, the current slope stability was assessed in terms of both global stability and the probability of failure engaging the sewer pipe. The Factors of Safety derived from this assessment are presented in Table 5-2, below.

Table 5-2: Current Slope Stability of Riverbank Slope along Pipe Alignment

River Conditions	Global Slip Stability (GS)	Global Stability Engaging the Pipe (GS+P)	Toe Slip Surface (TS)	Reference
Normal Summer Water Level (NWWL)	1.41	1.41	>1.5	Figure E2, Appendix E
Normal Winter Water Level (NSWL)	1.37	1.37	> 1.5	Figure E3, Appendix E
Rapid Drawdown	1.19	1.19	> 1.5	Figure E4, Appendix E

Stability assessment was performed by analysing three different river condition scenarios as shown in Table 5-2. As illustrated by the results presented in Table 5-2, stability of the current slope generally falls within the accepted design range of 1.3 to 1.5 as discussed in Section 6.2 of this Memorandum. However, during and directly following rapid drawdown events (e.g., spring melt, transition from summer to winter river levels), the stability of riverbank slope decreases significantly towards an FS of 1.0 (or unity). As the soil remains saturated during drawdown, the hydrostatic force (i.e., river level) supporting the riverbank is lost, and therefore this results in significantly lower stability values as shown by an FS of 1.19.

Whilst it may not be considered necessary to fully remediate or strengthen the riverbank slope, under extreme conditions (i.e., rapid drawdown, heavy precipitation event) coupled with erosion of the bank toe, potential slope failure may present a risk to the integrity of the sewer pipe.

6. Riverbank Recommendations

6.1 Design Considerations

The design of bank stabilization measures requires the consideration of a number of factors including physical constraints, safety, aesthetics, preservation of mature trees and cost. The remedial work must also be acceptable from a hydraulic perspective, in particular with respect to negative impacts on river channel hydraulics.

6.1.1 Aesthetics

Once the design objectives are met for slope stability, it is desirable that the stabilization measures visually fit in with existing development. In this regard, import design considerations will be final grading contours (i.e., avoiding straight lines where possible) and site restoration (i.e., re-vegetation) where existing vegetation cover is removed.

6.1.2 Preservation of Mature Trees

It was noted that some of the existing mature trees along the mid-slope of the riverbank within the study area are either dead or dying. This may be a result of root damage or submergence during high water events (i.e., flooding). This scenario is however considered unlikely given that ground elevations at these locations exceed normal summer water levels. As a consequence of potential future construction activity, the removal of both healthy and unhealthy trees maybe unavoidable but should be limited where feasible. Where possible, the stabilization measures should be designed to minimize the loss of trees.

6.1.3 Cost

The undertaking of any remedial or repair scheme should take into consideration the overall cost required to accomplish the objectives of the design. In regards to the subject riverbank slope within the study area, to exceed a design FS of greater than 1.5 would require substantial cost and effort for limited improvement.

6.2 Design Objectives

Acceptable Factors of Safety (FS) for the design of slope stabilization measures should typically range from 1.3 to 1.5, with the consideration of lower values possible on a case by case basis. For any particular project, the selection of an appropriate FS for design against slope failure should consider the uncertainty in geotechnical parameters (soil strength, groundwater levels, etc.), the level of importance of the geotechnical asset in context to existing/proposed infrastructure, and the level of analysis undertaken and the consequences of failure. To some degree, it is also useful to visualize slopes as existing in various stages of stability when the justification of lower factors of safety is under consideration. For example, the fact that a particular bank has historically been stable might factor in the perceived urgency to provide stabilization measures and to establish priority areas for work.

When considering the potential benefits of improving the current stability of the riverbank slope within the study area through the implementation of various remedial measures (i.e., major slope regrades, shear keys, etc.), the costs of which should not be disproportional to any perceived benefits. Given that the current stability of the existing riverbank has a FS of between 1.19 and 1.41, it would be considered uneconomical to improve stability of the riverbank beyond a design FS of 1.5, as discussed in Section 6.1.3 of this Memorandum. In this regard, all future remedial activities should be focused on limiting toe erosion and localized riverbank loss.

6.3 Recommended Protection Measures

A number of alternatives for bank stabilization and erosion protection have been assessed as part of the slope stability analysis, and are summarised as follows:

- Rip-Rap Blanket
- Slope Regrading

It is recommended that monitoring of the groundwater be conducted periodically prior to construction to observe seasonal fluctuations and to provide validation of the below groundwater condition scenarios applied in the slope design models.

6.3.1 Rip Rap Blanket

A rip-rap blanket consisting of quarried limestone is recommended along the lower slope from an elevation of approximately 222.02 m, to an approximate elevation of 225 m, with a corresponding thickness of 1 m. It is anticipated that partial sub-cut into the existing riverbank slope (between NWWL and NSWL) of approximately 0.5 m will be required.

The following slope stability improvements would be achievable through use of a rip-rap erosion control blanket summarised in Table 6-1 below.

Table 6-1: Estimated Factors of Safety with Rip-Rap Blanket

River Conditions	Global Slip Stability (GS)	Global Stability Engaging the Pipe (GS+P)	Percentage Improvement	Reference
Normal Winter Water Level (NWWL)	1.45	1.45	5.0	Figure E5, Appendix E
Normal Summer Water Level (NSWL)	1.48	1.48	8.0	Figure E6, Appendix E
Rapid Drawdown	1.31	1.31	9.2	Figure E7, Appendix E

Preliminary analysis determined that adopting a design solution comprising the use of a rip-rap erosion control blanket at the toe of the slope would provide sufficient Factors of Safety for slope stability and toe protection. The greatest percentage improvement was noted during drawdown conditions. Given that drawdown conditions may be only temporary in duration, a FS of 1.3 or greater is sufficient.

Any remaining improvement in bank stability would have to be achieved through alternate measures such as a shear key or toe berm (not assessed as part of this analysis).

6.3.2 Slope Regrading

Slope regrading has been assessed in conjunction with the use of rip-rap along the toe of the riverbank. Regrading of the riverbank toe to a cut profile of 4.0(H):1.0(V) for an approximate length of 9.5 m from the edge of the existing bank toe has been assumed as part of the analysis.

The estimated Factors of Safety determined as part of this analysis are summarised in Table 6-2 below. Assessment has also be undertaken to determine the FS of the riverbank slope during temporary conditions associated with the construction phase as discussed in Sections 6.3.1 and 6.3.2 of this Memorandum. Stability of the riverbank during this period has been calculated with a FS of greater than 1.3, therefore this is considered adequate.

Table 6-2: Estimated Factors of Safety for Toe Regrading

River Conditions	Global Slip Stability (GS)	Global Stability Engaging the Pipe (GS+P)	Percentage Improvement	Reference
Normal Winter Water Level (NWWL)	1.50	1.50	8.0	Figure E8, Appendix E
Normal Summer Water Level (NSWL)	1.56	1.56	8.4	Figure E9, Appendix E
Rapid Drawdown	1.35	1.35	11.9	Figure E10, Appendix E

Based on the FS stability values presented in Table 6-2, it considered that a rip-rap blanket in conjunction with partial regrading at the toe slope produces the greatest level of improvement and performance of the riverbank slope within the study area. The precise dimensions and extents of rip-rap blanket and slope regrading may be optimised during the design phase.

6.3.3 Site Restoration

Some plantings might be installed to help reinforce the slope immediately above the rip-rap (i.e., along areas of slope regrading and excavation) should there be significant loss of vegetation and mature tree cover.

7. Closing

If we can be of further assistance, please call either Alex Hill or Zeyad Shukri directly at 204-928-8359 or 204-928-9221, respectively. Please do not hesitate to call with any further comments or questions.

Respectfully Submitted,

Alex Hill, B.Sc. (Hons), FGS
Geotechnical Engineering

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Reviewed by:

Zeyad Shukri, M.Sc.
Senior Geotechnical Engineer

8. References

- AECOM Canada Ltd (May 23, 2012), Technical Memorandum - *Test Hole Adjacent to Interceptor; Fort Garry to St. Vital Interceptor, East Bank of Red River at Bishop Grandin Boulevard.*
- UMA Engineering Ltd (December 4, 2006), Functional Design Report - *St. Vital Park Riverbank Stability Study and Functional Design of Stabilization Measures*.
- D. E. Kingerski, P. (2000) *River Stability Characterization Study for City Owned Riverbanks* City of Winnipeg, Planning, Property & Development Department, Waterways Section. May 2000.
- Klohn Leonoff Consultants (April 5, 1976), Sub-soils Investigation - *Fort Garry - St. Vital Corridor, Winnipeg Manitoba.*

APPENDIX A

TEST HOLE LOCATION PLAN

Figure: A1

AECOM

Testhole Location Plan

The Repair of the Fort Garry Interceptor Sewer Crossing

City of Winnipeg, Fort Garry Sewer Interceptor

ANSI B 279.4mm x 431.8mm
Approved:
Checked:
Designer:
Project Management Initials:
Last saved by: MAHEC (2013-12-12) Last Plotted: 2013-12-12
Filename: P:\60274906\000-CADD\GIS\MXD\G001_60274906_01V1_TESTHOLELOCATIONS.MXD

APPENDIX B

TEST HOLE LOGS

AECOM Canada Ltd.

GENERAL STATEMENT

NORMAL VARIABILITY OF SUBSURFACE CONDITIONS

The scope of the investigation presented herein is limited to an investigation of the subsurface conditions as to suitability for the proposed project. This report has been prepared to aid in the evaluation of the site and to assist the engineer in the design of the facilities. Our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of earth work, foundations and similar. In the event of any changes in the basic design or location of the structures as outlined in this report or plan, we should be given the opportunity to review the changes and to modify or reaffirm in writing the conclusions and recommendations of this report.

The analysis and recommendations presented in this report are based on the data obtained from the borings and test pit excavations made at the locations indicated on the site plans and from other information discussed herein. This report is based on the assumption that the subsurface conditions everywhere are not significantly different from those disclosed by the borings and excavations. However, variations in soil conditions may exist between the excavations and, also, general groundwater levels and conditions may fluctuate from time to time. The nature and extent of the variations may not become evident until construction. If subsurface conditions differ from those encountered in the exploratory borings and excavations, are observed or encountered during construction, or appear to be present beneath or beyond excavations, we should be advised at once so that we can observe and review these conditions and reconsider our recommendations where necessary.

Since it is possible for conditions to vary from those assumed in the analysis and upon which our conclusions and recommendations are based, a contingency fund should be included in the construction budget to allow for the possibility of variations which may result in modification of the design and construction procedures.

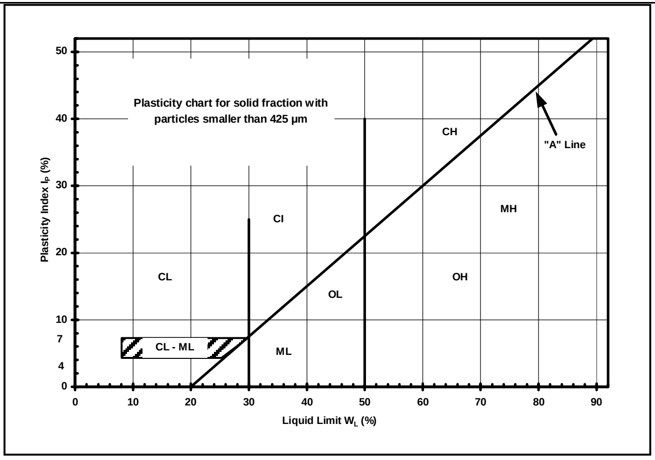
In order to observe compliance with the design concepts, specifications or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated, we recommend that all construction operations dealing with earth work and the foundations be observed by an experienced soils engineer. We can be retained to provide these services for you during construction. In addition, we can be retained to review the plans and specifications that have been prepared to check for substantial conformance with the conclusions and recommendations contained in our report.

EXPLANATION OF FIELD & LABORATORY TEST DATA

Description				AECOM Log Symbols	USCS Classification	Laboratory Classification Criteria: Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above "A" line and 4<W_P<7 $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below "A" line or W_P<4	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above "A" line or W_P<7	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below "A" line or W_P<4	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above "A" line or W_P<7	
FINE GRAINED SOILS	SILTS (Below 'A' line negligible organic content)	W_L<50	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		W_L>50	Inorganic silts of high plasticity		MH				
	CLAYS (Above 'A' line negligible organic content)	W_L<30	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		30<W_L<50	Inorganic clays and silty clays of medium plasticity		CI				
		W_L>50	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below 'A' line)	W_L<50	Organic silts and organic silty clays of low plasticity		OL				
		W_L>50	Organic clays of high plasticity		OH				
HIGHLY ORGAINIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

Symbol	Material	Symbol	Material			
	Asphalt		Till			AECOM
	Concrete		Bedrock (Undifferentiated)			
	Fill		Bedrock (Limestone)			

When the above classification terms are used in this report or test hole logs, the designated fractions may be visually estimated and not measured.



<table>
<tr><th colspan="2" rowspan="2">FRACTION</th><th colspan="2">SEIVE SIZE (mm)</th><th colspan="2">DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS</th></tr>
<tr><th>Passing</th><th>Retained</th><th>Percent</th><th>Identifier</th></tr>
<tr><td rowspan="2">Gravel</td><td>Coarse</td><td>76</td><td>19</td><td rowspan="2">35-50</td><td rowspan="2">and</td></tr>
<tr><td>Fine</td><td>19</td><td>4.75</td></tr>
<tr><td rowspan="3">Sand</td><td>Coarse</td><td>4.75</td><td>2.00</td><td rowspan="2">20-35</td><td rowspan="2">“y” or “ey” *</td></tr>
<tr><td>Medium</td><td>2.00</td><td>0.425</td></tr>
<tr><td>Fine</td><td>0.425</td><td>0.075</td><td rowspan="2">10-20</td><td rowspan="2">some</td></tr>
<tr><td colspan="2" rowspan="2">Silt (non-plastic) or Clay (plastic)</td><td colspan="2" rowspan="2">< 0.075 mm</td></tr>
<tr><td>1-10</td><td>trace</td></tr>
<tr><td colspan="6">* for example: gravelly, sandy clayey, silty</td></tr>
<tr><td colspan="6">Definition of Oversize Material

COBBLES: 76mm to 300mm diameter
BOULDERS: >300mm diameter</td></tr>
</table>

LEGEND OF SYMBOLS

Laboratory and field tests are identified as follows:

- q_u - undrained shear strength (kPa) derived from unconfined compression testing.
- T_v - undrained shear strength (kPa) measured using a torvane
- pp - undrained shear strength (kPa) measured using a pocket penetrometer.
- L_v - undrained shear strength (kPa) measured using a lab vane.
- F_v - undrained shear strength (kPa) measured using a field vane.
- γ - bulk unit weight (kN/m^3).
- SPT - Standard Penetration Test. Recorded as number of blows (N) from a 63.5 kg hammer dropped 0.76 m (free fall) which is required to drive a 51 mm O.D. Raymond type sampler 0.30 m into the soil.
- DPPT - Drive Point Pentrometer Test. Recorded as number of blows from a 63.5 kg hammer dropped 0.76 m (free fall) which is required to drive a 50 mm drive point 0.30 m into the soil.
- w - moisture content (W_L, W_P)

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

Su (kPa)	CONSISTENCY
<12	very soft
12 – 25	soft
25 – 50	medium or firm
50 – 100	stiff
100 – 200	very stiff
200	hard

The resistance (N) of a non-cohesive soil can be related to compactness condition as follows

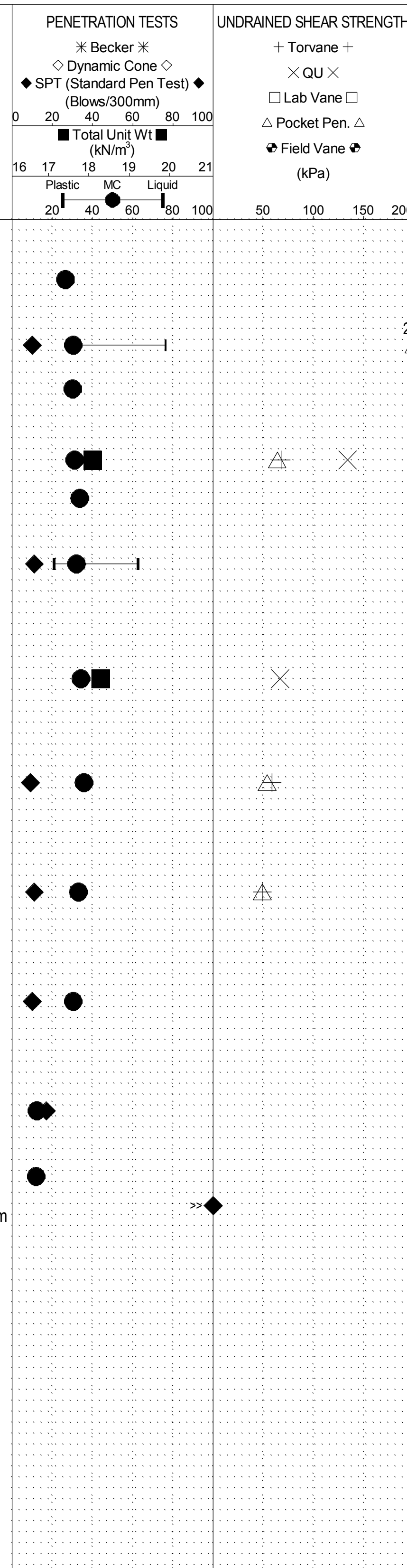
N – BLOWS/0.30 m	COMPACTNESS
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50	very dense

PROJECT: FGSV Interceptor Siphon	CLIENT: City of Winnipeg	TESTHOLE NO: **TH13-01**
LOCATION: Upper Bank of Red River, UTM: 14 U, N 5520496, E 0633705		PROJECT NO.: 60274906
CONTRACTOR: Paddock Drilling	METHOD: Truck Mounted Acker MP-8	ELEVATION (m):

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS
0	TOPSOIL and ORGANICS - some clay - brown, dry				
0.8	CLAY- silty, trace sand, trace organics, trace sulphates - brown, dry, stiff - high plasticity - moderately fissured	GRAB	G01		
1.8		SPLIT SPOON	S02	10	221 SPT Blows: 4, 5, 5 40% Recovery Gravel: 0.0 %, Sand: 0.5%, Silt: 30.3%, Clay: 69.2%
2.4		GRAB	G03		
3	CLAY and SILT - trace sand - brown, stiff, dry to moist - high plasticity	SHELBY TUBE	T04		(T04): 60% Recovery
3.9		GRAB	G05		
4.1	- mottled brown grey below 4.1 m				
4.8		SPLIT SPOON	S06	11	SPT Blows: 5, 4, 7 100% Recovery Gravel: 0.0%, Sand: 1.4%, Silt: 47.8%, Clay: 50.8%
6.4		SHELBY TUBE	T07		(TO7): 100% Recovery
6.7	- wet at 6.7 m				
7.8	- fine sand lense (25 mm thickness) at 7.8 m - grey below 7.8 m	SPLIT SPOON	S08	9	SPT Blows: 3, 4, 5 100% Recovery
9.1	- trace gravel (rounded, 20 mm) at 9.1 m	SPLIT SPOON	S09	11	SPT Blows: 3, 5, 6 100% Recovery
10.7	- fissuring at 10.7 m - trace silt, sand, and gravel below 10.7m	SPLIT SPOON	S10	10	SPT Blows: 4, 7, 3 100% Recovery
11.9	SILT (TILL) - sandy, some clay, trace gravel - tan, wet, compact	SPLIT SPOON	S11	17	SPT Blows: 3, 6, 11 100% Recovery
13.3		GRAB	G12		
13.8		SPLIT SPOON	S13	50/ 51mm	SPT Blows: 50/51mm, No Recovery



END OF TEST HOLE AT 13.8 m IN SILT (TILL)

Notes:

1. Power auger refusal at 13.8 m below ground surface.
2. Seepage noted at 6.7 m below ground surface during drilling.
3. Sloughing not observed.
4. Standpipe piezometer (SP13-01) installed upon completion with casagrande tip at 13.7 m below ground surface and 0.9 m stick-up.
5. Test hole backfilled with silica sand from 13.7m to 11.3 m, bentonite chips from 11.3 to 6.1 m, auger cuttings from 6.1 to 1.2 m, and bentonite chips from 1.2 m to surface.
6. Water levels:
- Nov 8, 2013 (install): 12.95 m
- Nov 19, 2013: 5.70 m
- Nov 26, 2013: 6.02 m

AECOM

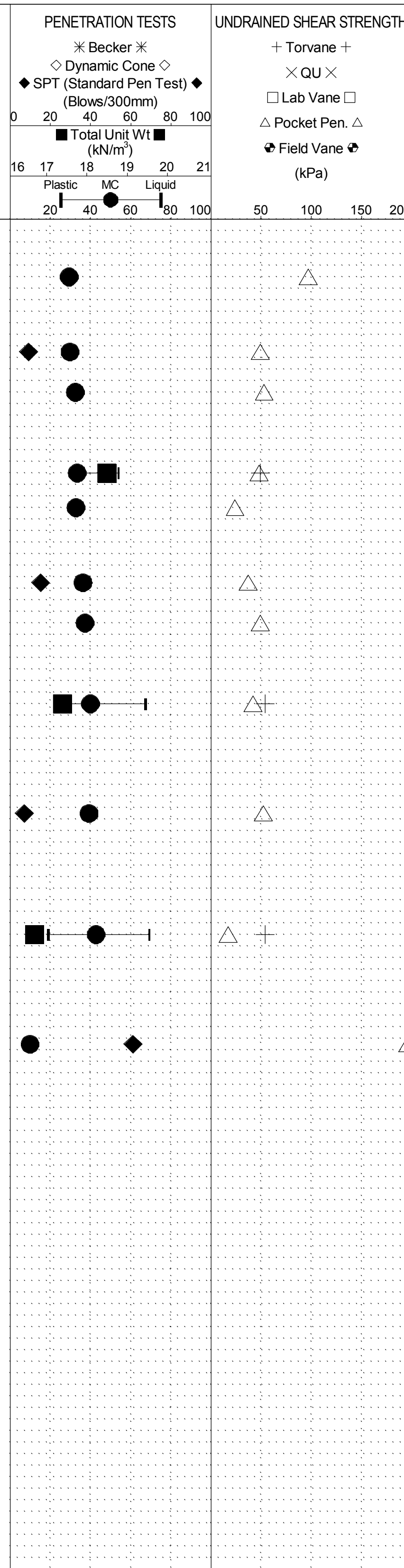
LOGGED BY: Aaron Kaluzniak	COMPLETION DEPTH: 13.76 m
REVIEWED BY: Alex Hill	COMPLETION DATE: 11/8/13
PROJECT ENGINEER: Marvin McDonald	

PROJECT: FGSV Interceptor Siphon	CLIENT: City of Winnipeg	TESTHOLE NO: **TH13-02**
LOCATION: Lower Bank of Red River, UTM: 14 U, N 5520490, E 0633691		PROJECT NO.: 60274906
CONTRACTOR: Paddock Drilling	METHOD: Truck Mounted Acker SS-3	ELEVATION (m):

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS
0	TOPSOIL and ORGANICS - some clay - brown, dry				
	CLAY- trace to some sand, trace silt, trace organics - grey-brown, dry to moist, firm to stiff - Intermediate to high plasticity	Grab	G1		
		Split spoon	S2	9	SPT Blows: 3, 4, 5 61% Recovery
2	CLAY and SILT - trace sand, trace organics - brown, firm to stiff, dry to moist - high plasticity	Grab	G3		
		Shelby tube	T4		100% Recovery
	- greyish brown below 3.5 m	Grab	G5		Gravel: 0.1 %, Sand: 5.2%, Silt: 44.0%, Clay: 50.7%
	- grey, moist, silty, below 5.0 m	Split spoon	S6	15	SPT Blows: 3, 6, 9 100% Recovery
		Grab	G7		Gravel: 0.0 %, Sand: 0.0%, Silt: 39.0%, Clay: 61.0%
6	CLAY- silty - brown to greyish brown, firm, moist - high plasticity	Shelby tube	T8		100% Recovery
	- grey, wet below 7.2 m - intermittant sand seams (<25 mm thickness) below 7.2 m	Split spoon	S9	7	SPT Blows: 3, 4, 3 100% Recovery
	- fine sand layer (<76 mm thickness) between 8.10 m and 8.20 m				
	- grey, very soft below 9.1 m	Shelby tube	T10		100% Recovery Gravel: 1.4 %, Sand: 10.6%, Silt: 27.9%, Clay: 60.1%
	- trace gravel below 9.8 m				
10	SILT (TILL) - gravelly, some sand, trace to some clay - tan, wet, compact to very dense	Split spoon	S11	61	SPT Blows: 20, 28, 33 78% Recovery
			S12		SPT Blows: 51/0 mm



END OF TEST HOLE AT 11.6 m IN SILT (TILL)

Notes:

1. Power auger refusal at 11.6 m below ground surface on suspected bedrock.
2. Seepage noted at 4.9 m below ground surface during drilling.
3. No sloughing observed.
4. Standpipe piezometer (SP13-02) installed upon completion with casagrande tip at 11.6 m below ground surface and 0.91 m stick-up.
5. Test hole backfilled with silica sand from 11.6m to 10.4 m, bentonite chips from 10.4 to ground surface.
6. Water levels:
   - Nov 19, 2013 (install): 10.29 m
   - Nov 26, 2013: 5.97 m

AECOM

LOGGED BY: Sam Oshati	COMPLETION DEPTH: 11.58 m
REVIEWED BY: Alex Hill	COMPLETION DATE: 11/19/13
PROJECT ENGINEER: Marvin McDonald	Page 1 of 1

APPENDIX C

LABORATORY REPORTS

AECOM
AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com
204 477 5381 tel
204 284 2040 fax

Memorandum

To	Alex Hill	Page	1
CC			
Subject	City of Winnipeg – FGSV Interceptor Siphon		
From	Jared Baldwin		
Date	November 20, 2013	Project Number	60274906

Please find attached the following material test result(s) on sample(s) submitted to the Winnipeg Geotechnical Laboratory:

- Ten (10) Moisture Content tests.
- Two (2) Grain Size Distribution (hydrometer method) tests.
- Two (2) Atterberg Limits (3 points) tests.
- Two (2) Torvane, Pocket Penetrometer, Unconfined Compressive Strength, Moisture Content, Bulk Density and Visual Description on a Shelby tube sample.

If you have any questions, please contact the undersigned.

Sincerely,

Jared Baldwin, M.Sc., P.Eng.
Geotechnical Engineer

Att.

MOISTURE CONTENT

JOB No.: 60274906
CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon

DATE: November 14, 2013

HOLE NO.	13-01	-	-	-	-	-
SAMPLE NO.	G01	S02	G03	G05	S06	S08
DEPTH (FT)	2.5 - 3.0	5.0 - 65	7.5 - 8.0	12.5 - 13.0	15.0 - 16.5	25.0 - 26.5
MOISTURE CONTENT %	26.5	30.4	30.1	33.6	32.0	35.7
HOLE NO.	13-01	-	-	-		
SAMPLE NO.	S09	S10	S11	S12		
DEPTH (FT)	30.0 - 31.5	35.0 - 36.5	40.0 - 41.5	44.5 - 45.0		
MOISTURE CONTENT %	33.0	30.4	12.3	11.9		
HOLE NO.						
SAMPLE NO.						
DEPTH (FT)						
MOISTURE CONTENT %						
HOLE NO.						
SAMPLE NO.						
DEPTH (FT)						
MOISTURE CONTENT %						

NOTES:

AECOM

MATERIALS LABORATORY
AECOM
99 Commerce Drive, Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

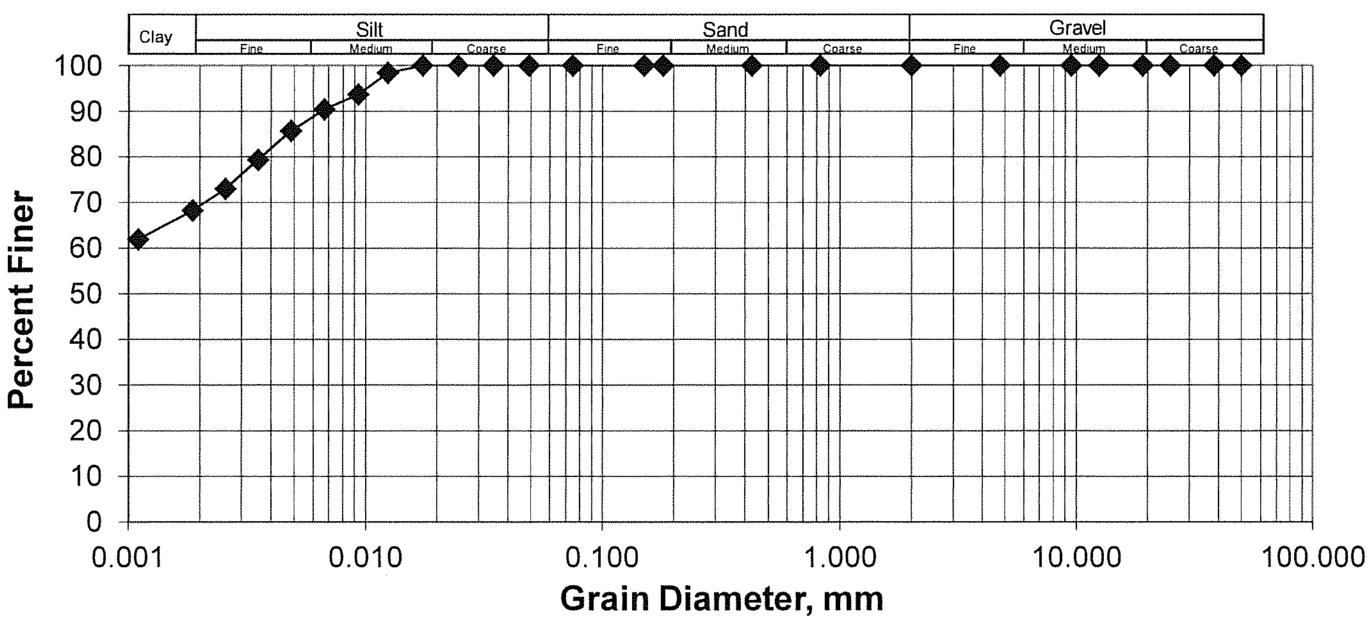
GRAIN SIZE DISTRIBUTION
(ASTM D422-63)

MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60274906	Hole No.:	13-01
Client:	City of Winnipeg	Sample No.:	S02
Project :	FGSV Interceptor Siphon	Depth:	1.5 - 2.0m
Date Tested:	18-Nov-13	Date Sampled:	8-Nov-13
Tested By:	ML	Sampled By:	AECOM (AK)

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	100.0	0.0750	100.0
38.0	100.0	0.83	100.0	0.0491	100.0
25.0	100.0	0.43	100.0	0.0347	100.0
19.0	100.0	0.18	100.0	0.0246	100.0
12.5	100.0	0.15	100.0	0.0174	100.0
9.5	100.0	0.075	100.0	0.0124	98.4
4.75	100.0			0.0093	93.6
2.00	100.0			0.0067	90.5
				0.0049	85.7
				0.0035	79.3
				0.0026	73.0
				0.0019	68.2
				0.0011	61.9

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.0%**	**Silt**	**30.3%**
Sand	**0.5%**	**Clay**	**69.2%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

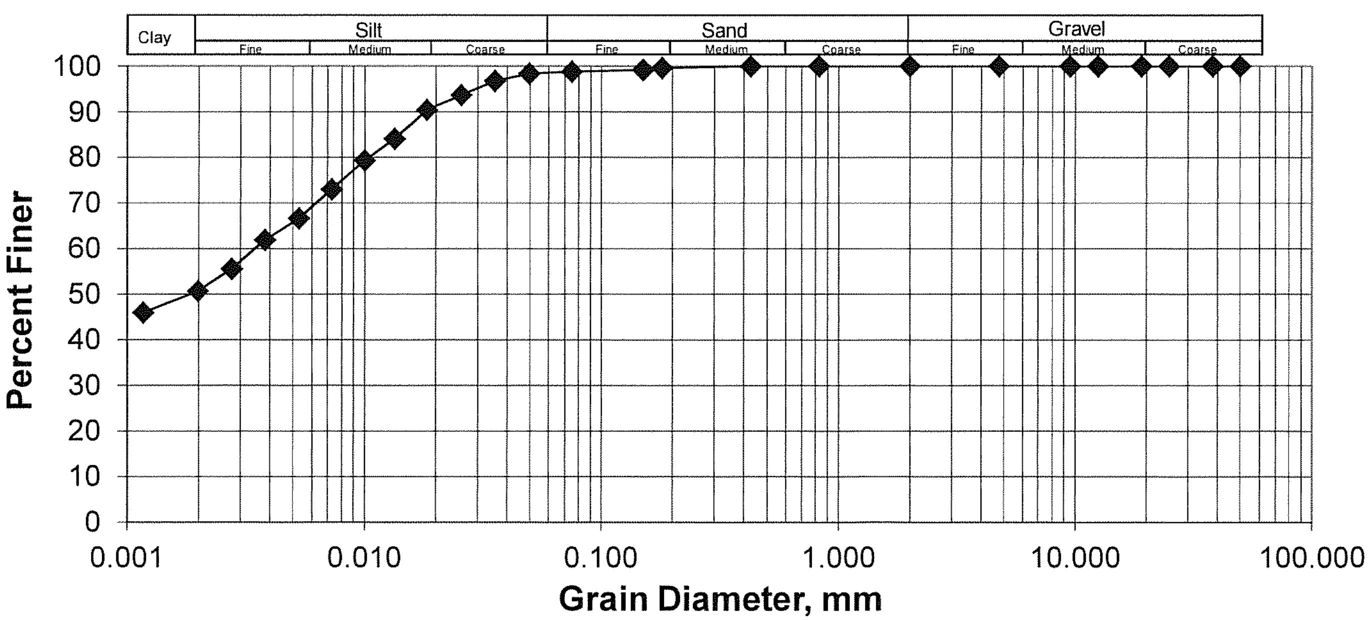
GRAIN SIZE DISTRIBUTION
(ASTM D422-63)

AECOM
MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60274906	Hole No.:	13-01
Client:	City of Winnipeg	Sample No.:	S06
Project :	FGSV Interceptor Siphon	Depth:	4.5 - 5.0m
Date Tested:	18-Nov-13	Date Sampled:	8-Nov-13
Tested By:	ML	Sampled By:	AECOM (AK)

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	100.0	0.0750	98.8
38.0	100.0	0.83	100.0	0.0496	98.4
25.0	100.0	0.43	100.0	0.0354	96.8
19.0	100.0	0.18	99.6	0.0255	93.6
12.5	100.0	0.15	99.2	0.0183	90.5
9.5	100.0	0.075	98.8	0.0134	84.1
4.75	100.0			0.0100	79.3
2.00	100.0			0.0073	73.0
				0.0053	66.6
				0.0038	61.9
				0.0028	55.5
				0.0020	50.8
				0.0012	46.0

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.0%**	**Silt**	**47.8%**
Sand	**1.4%**	**Clay**	**50.8%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

AECOM

AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

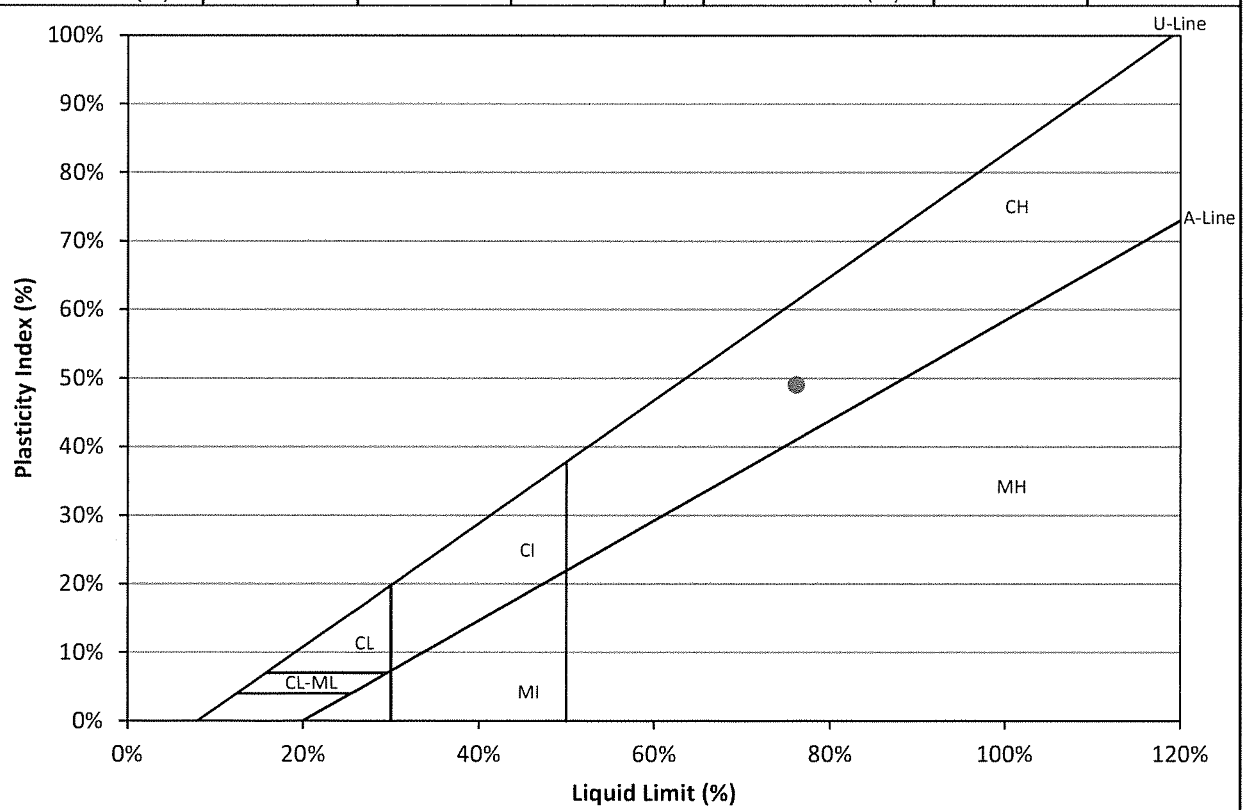
Project Name:	FGSV Interceptor Siphon	Supplier:	N/A
Project Number:	60274906	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	AKaluzniak
Sample Location:	TH13-01	Sample Date:	September 9, 2013
Sample Depth:	1.5 - 2.0m	Lab Technician:	MLotecki
Sample Number:	S02	Date Tested:	November 18, 2013

Atterberg Limits

ASTM D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	18	24	35
Wet Sample (g)	11.8	10.2	11.7
Dry Sample (g)	6.7	5.8	6.7
Water Content (%)	77.9%	76.2%	74.3%

Plastic Limit		
Trial	1	2
Wet Sample (g)	7.0	6.5
Dry Sample (g)	5.5	5.1
Water Content (%)	27.2%	27.1%



Liquid Limit (%): 76.2%	Plastic Limit (%): 27.2%	Plasticity Index (%): 49.0%

AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

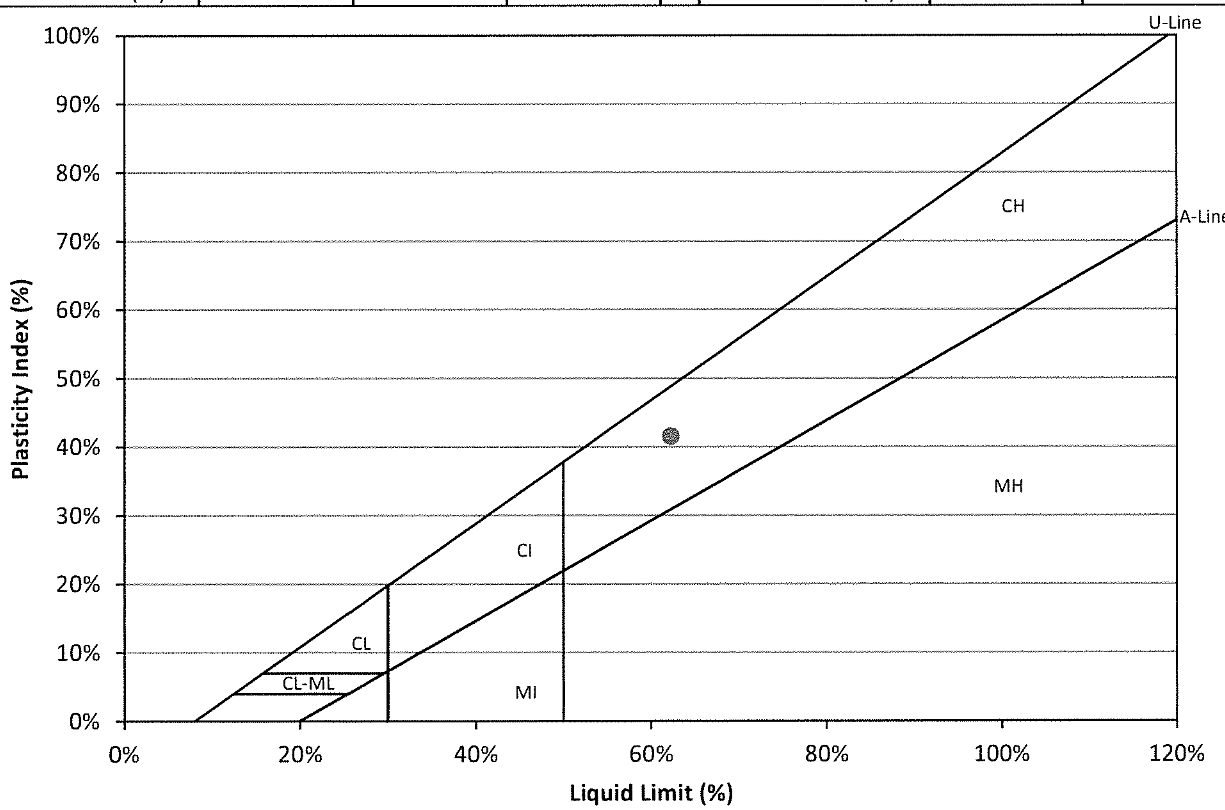
Project Name:	FGSV Interceptor Siphon	Supplier:	N/A
Project Number:	60274906	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	AKaluzniak
Sample Location:	TH13-01	Sample Date:	November 8, 2013
Sample Depth:	4.5 - 5.0m	Lab Technician:	MLotecki
Sample Number:	S06	Date Tested:	November 18, 2013

Atterberg Limits

ASTM D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	18	27	35
Wet Sample (g)	12.6	14.2	10.5
Dry Sample (g)	7.7	8.7	6.5
Water Content (%)	64.1%	62.1%	60.2%

Plastic Limit		
Trial	1	2
Wet Sample (g)	11.1	8.4
Dry Sample (g)	9.2	7.0
Water Content (%)	20.8%	20.7%



Liquid Limit (%): 62.3%	Plastic Limit (%): 20.7%	Plasticity Index (%): 41.5%

AECOM - SOILS LABORATORY
SHEAR STRENGTH, MOISTURE CONTENT & DENSITY CALCULATIONS

AECOM

CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon
JOB NO.: 60274906

TEST HOLE NO.:	**TH13-01**
SAMPLE NO.:	**T07**
SAMPLE DEPTH:	20 - 22'
DATE TESTED:	8-Oct-13
SHEAR STRENGTH TESTS	
TORVANE	
Reading	0.65
Vane Size (S, M, L)	M
Undrained Shear Strength (kPa)	**63.8**
Undrained Shear Strength (ksf)	1.33
POCKET PENETROMETER	
Reading - Qu (tsf)	1.25
Undrained Shear Strength (kPa)	**59.9**
Reading - Qu (tsf)	1.25
Undrained Shear Strength (kPa)	**59.9**
Reading - Qu (tsf)	1.25
Undrained Shear Strength (kPa)	**59.9**
UNCONFINED COMPRESSIVE STRENGTH TEST	
Unconfined compressive strength (kPa)	**68.8**
Unconfined compressive strength (ksf)	**1.4**
Undrained Shear Strength (kPa)	**34.4**
Undrained Shear Strength (ksf)	**0.719**
MOISTURE CONTENT	
Tare Number	M12
Wt. Sample wet + tare (g)	399.6
Wt. Sample dry + tare (g)	300.0
Wt. Tare (g)	8.6
Moisture Content %	**34.2**
BULK DENSITY	
Sample Wt. (g)	1185.8
Diameter 1 (cm)	7.28
Diameter 2 (cm)	7.29
Diameter 3 (cm)	7.29
Avg. Diameter (cm)	**7.29**
Length 1 (cm)	15.34
Length 2 (cm)	15.34
Length 3 (cm)	15.36
Avg. Length (cm)	**15.35**
Volume (cm^3)	640.0
Moisture content (%)	34.2
Bulk Density (g/cm^3)	1.853
Bulk Density (kN/m^3)	**18.2**
Bulk Density (pcf)	**115.7**
Dry Density (kN/m^3)	**13.54**

AECOM - SOILS LABORATORY
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS (ASTM D2166)

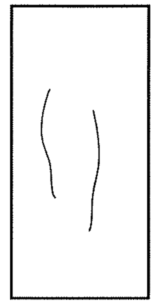
AECOM

CLIENT:	City of Winnipeg
PROJECT:	FGSV Interceptor Siphon
JOB NO.:	60274906

TEST HOLE NO.:	TH13-01
SAMPLE NO.:	T07
SAMPLE DEPTH:	20 - 22'
SAMPLE DATE:	17-Sep-13
TEST DATE:	8-Oct-13

SOIL DESCRIPTION:	
CLAY; silty, trace sand, trace till inclusions, brown, moist, crumbly, medium to high plasticity, homogeneous	
MOISTURE CONTENT:	34.2

SAMPLE DIAM.(Do):	72.87	(mm)	INITIAL AREA, Ao:	4170.1	(mm^2)
SAMPLE LENGTH, (Lo):	153.47	(mm)	PISTON RATE:	0.051	(inches / minute)
L / D RATIO:	2.1	(2 < L/D < 2.5)	AXIAL STRAIN RATE, R:	0.84	(0.5<R<2 % / minute)



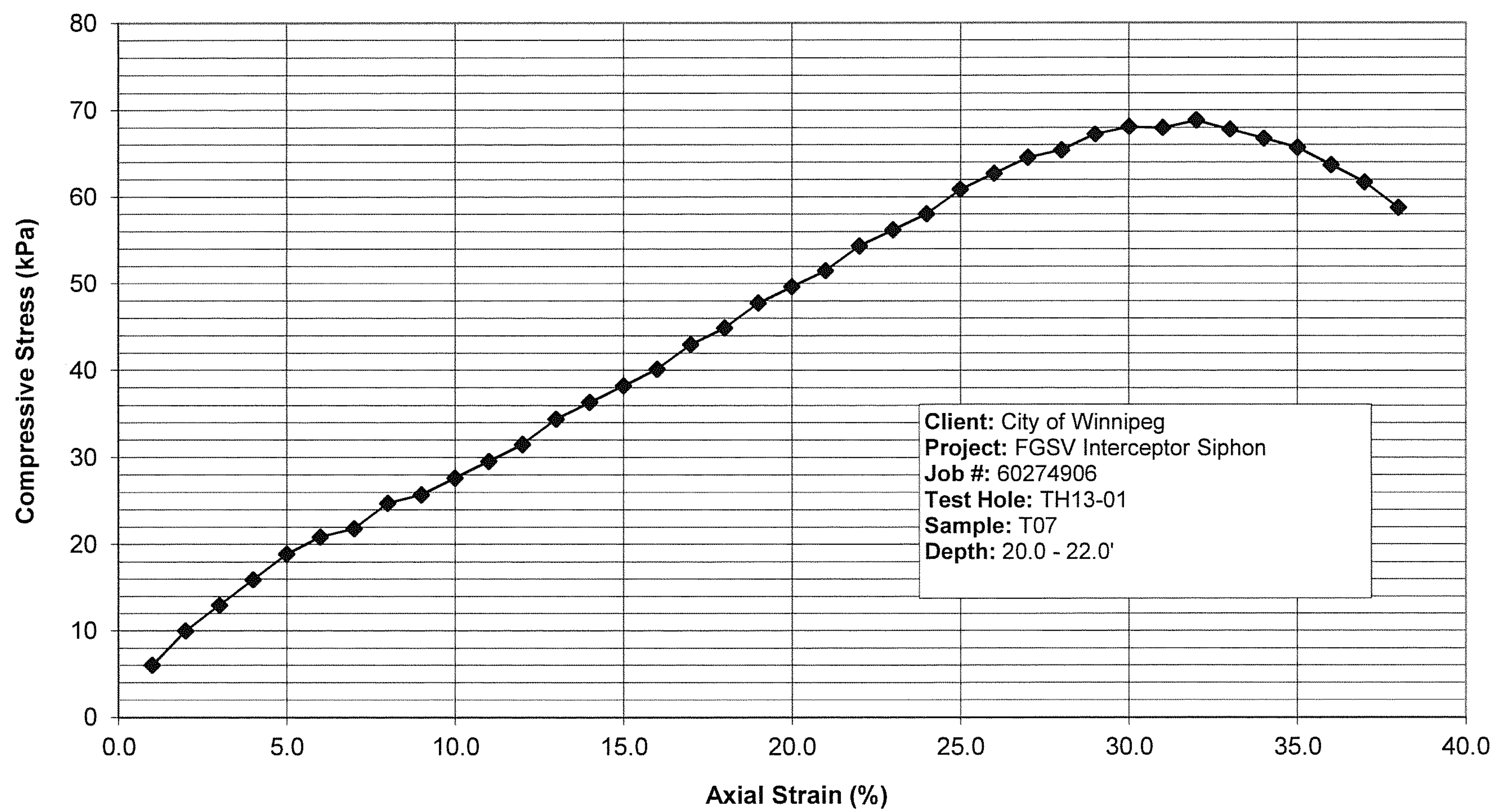
FAILURE SKETCH

TEST DATA - DIAL READINGS							
AXIAL COMPRESSION	PROVING RING	TOTAL AXIAL STRAIN, E_1	AVERAGE CROSS-SECTIONAL AREA, A	APPLIED AXIAL LOAD, P	COMPRESSIVE STRESS, σ_c		
(inches)	(inches)	(%)	(inches2)	(lbs)	(psi)	(ksf)	(kPa)
0.01	0.0006	0.00	6.46	5.62	0.87	0.125	6.0
0.02	0.0010	0.14	6.47	9.37	1.45	0.208	10.0
0.03	0.0013	0.28	6.48	12.18	1.88	0.271	13.0
0.03	0.0016	0.42	6.49	14.99	2.31	0.333	15.9
0.04	0.0019	0.56	6.50	17.80	2.74	0.394	18.9
0.05	0.0021	0.70	6.51	19.68	3.02	0.435	20.8
0.06	0.0022	0.84	6.52	20.61	3.16	0.455	21.8
0.07	0.0025	0.98	6.53	23.43	3.59	0.517	24.7
0.08	0.0026	1.13	6.54	24.36	3.73	0.537	25.7
0.09	0.0028	1.27	6.55	26.24	4.01	0.577	27.6
0.09	0.0030	1.41	6.56	28.11	4.29	0.617	29.6
0.10	0.0032	1.55	6.57	29.98	4.57	0.658	31.5
0.11	0.0035	1.69	6.57	32.80	4.99	0.718	34.4
0.12	0.0037	1.83	6.58	34.67	5.27	0.758	36.3
0.13	0.0039	1.97	6.59	36.54	5.54	0.798	38.2
0.14	0.0041	2.11	6.60	38.42	5.82	0.838	40.1
0.14	0.0044	2.25	6.61	41.23	6.23	0.898	43.0
0.15	0.0046	2.39	6.62	43.10	6.51	0.937	44.9
0.16	0.0049	2.53	6.63	45.91	6.92	0.997	47.7
0.17	0.0051	2.67	6.64	47.79	7.20	1.036	49.6
0.18	0.0053	2.81	6.65	49.66	7.47	1.075	51.5
0.19	0.0056	2.95	6.66	52.47	7.88	1.134	54.3
0.20	0.0058	3.10	6.67	54.35	8.15	1.173	56.2
0.20	0.0060	3.24	6.68	56.22	8.42	1.212	58.0
0.21	0.0063	3.38	6.69	59.03	8.82	1.271	60.8
0.22	0.0065	3.52	6.70	60.91	9.09	1.309	62.7
0.23	0.0067	3.66	6.71	62.78	9.36	1.347	64.5
0.24	0.0068	3.80	6.72	63.72	9.48	1.366	65.4
0.25	0.0070	3.94	6.73	65.59	9.75	1.404	67.2
0.26	0.0071	4.08	6.74	66.53	9.87	1.422	68.1
0.26	0.0071	4.22	6.75	66.53	9.86	1.420	68.0
0.27	0.0072	4.36	6.76	67.46	9.98	1.437	68.8
0.28	0.0071	4.50	6.77	66.53	9.83	1.415	67.8
0.29	0.0070	4.64	6.78	65.59	9.68	1.393	66.7
0.30	0.0069	4.78	6.79	64.65	9.52	1.371	65.7
0.31	0.0067	4.92	6.80	62.78	9.23	1.330	63.7
0.31	0.0065	5.06	6.81	60.91	8.95	1.288	61.7
0.32	0.0062	5.21	6.82	58.09	8.52	1.227	58.7

UNCONFINED COMPRESSIVE STRENGTH, q_u:	68.82	kPa
(based on maximum q_u value)	1.437	ksf
UNDRAINED SHEAR STRENGTH, S_u:	34.41	kPa
(based on maximum q_u value)	0.719	ksf

NOTES:

AECOM
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS
(ASTM D2166)



AECOM - SOILS LABORATORY
SHEAR STRENGTH, MOISTURE CONTENT & DENSITY CALCULATIONS

AECOM

CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon
JOB NO.: 60274906

TEST HOLE NO.:	**TH13-01**
SAMPLE NO.:	**T04**
SAMPLE DEPTH:	10 - 12'
DATE TESTED:	8-Oct-13
SHEAR STRENGTH TESTS	
TORVANE	
Reading	1.00
Vane Size (S, M, L)	M
Undrained Shear Strength (kPa)	**98.1**
Undrained Shear Strength (ksf)	2.05
POCKET PENETROMETER	
Reading - Qu (tsf)	2.75
Undrained Shear Strength (kPa)	**131.7**
Reading - Qu (tsf)	2.50
Undrained Shear Strength (kPa)	**119.7**
Reading - Qu (tsf)	2.50
Undrained Shear Strength (kPa)	**119.7**
UNCONFINED COMPRESSIVE STRENGTH TEST	
Unconfined compressive strength (kPa)	**133.6**
Unconfined compressive strength (ksf)	**2.8**
Undrained Shear Strength (kPa)	**66.8**
Undrained Shear Strength (ksf)	**1.395**
MOISTURE CONTENT	
Tare Number	M12
Wt. Sample wet + tare (g)	359.0
Wt. Sample dry + tare (g)	275.8
Wt. Tare (g)	8.2
Moisture Content %	**31.1**
BULK DENSITY	
Sample Wt. (g)	1161.2
Diameter 1 (cm)	7.23
Diameter 2 (cm)	7.24
Diameter 3 (cm)	7.25
Avg. Diameter (cm)	**7.24**
Length 1 (cm)	15.36
Length 2 (cm)	15.35
Length 3 (cm)	15.35
Avg. Length (cm)	**15.35**
Volume (cm^3)	632.1
Moisture content (%)	31.1
Bulk Density (g/cm^3)	1.837
Bulk Density (kN/m^3)	**18.0**
Bulk Density (pcf)	**114.7**
Dry Density (kN/m^3)	**13.74**

AECOM - SOILS LABORATORY
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS (ASTM D2166)

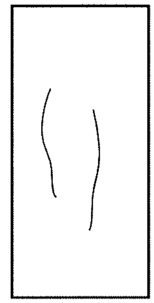
AECOM

CLIENT:	City of Winnipeg
PROJECT:	FGSV Interceptor Siphon
JOB NO.:	60274906

TEST HOLE NO.:	TH13-01
SAMPLE NO.:	T04
SAMPLE DEPTH:	10 - 12'
SAMPLE DATE:	17-Sep-13
TEST DATE:	8-Oct-13

SOIL DESCRIPTION:
CLAY; silty, trace till inclusions, brown, moist, firm, medium to high plasticity, homogeneous

MOISTURE CONTENT: 31.1



FAILURE SKETCH

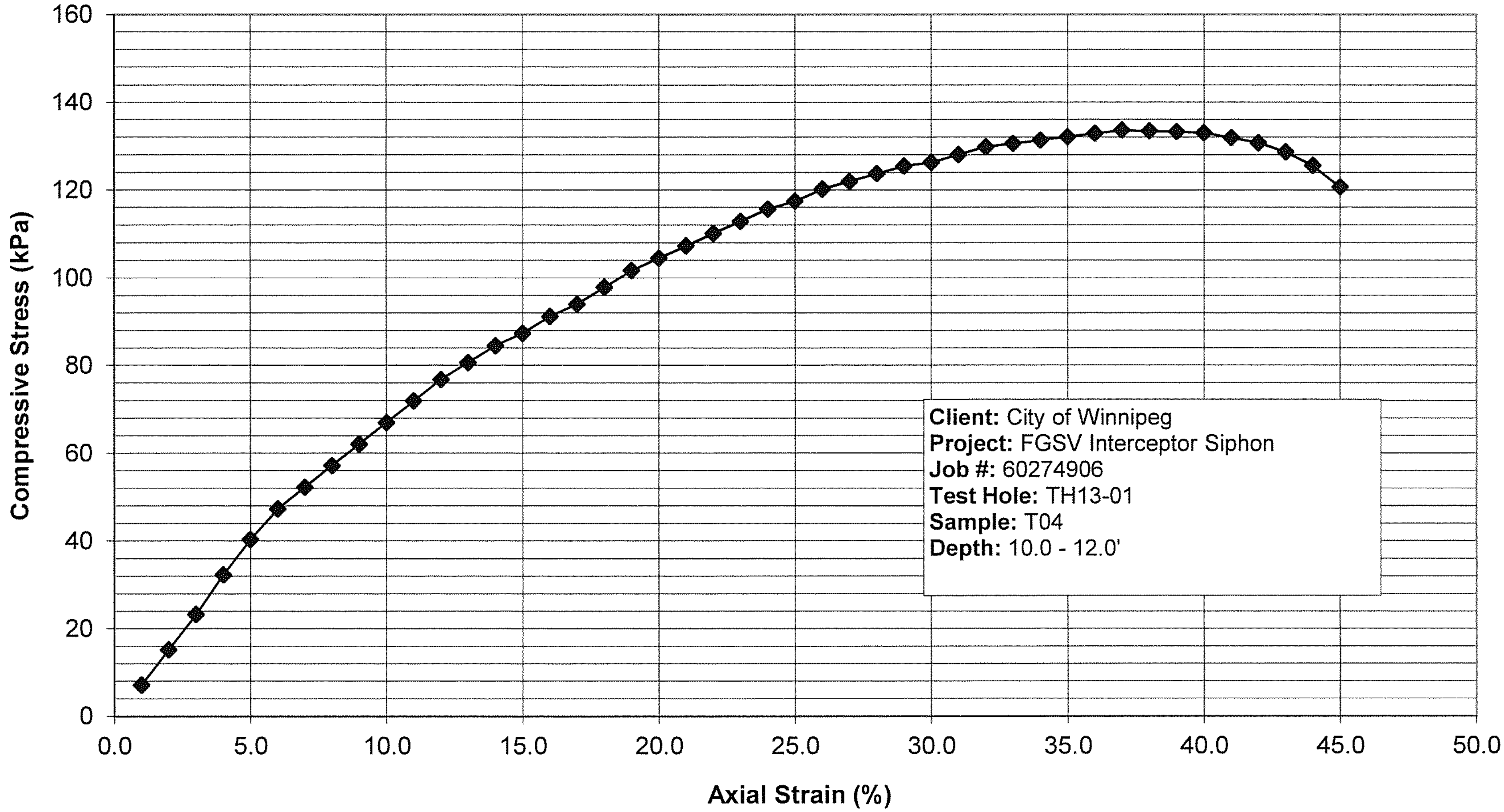
SAMPLE DIAM.(Do):	72.40	(mm)	INITIAL AREA, Ao:	4116.9	(mm^2)
SAMPLE LENGTH, (Lo):	153.53	(mm)	PISTON RATE:	0.051	(inches / minute)
L / D RATIO:	2.1	(2 < L/D < 2.5)	AXIAL STRAIN RATE, R:	0.84	(0.5<R<2 % / minute)

TEST DATA - DIAL READINGS							
AXIAL COMPRESSION	PROVING RING	TOTAL AXIAL STRAIN, E_1	AVERAGE CROSS-SECTIONAL AREA, A	APPLIED AXIAL LOAD, P	COMPRESSIVE STRESS, σ_c		
(inches)	(inches)	(%)	(inches2)	(lbs)	(psi)	(ksf)	(kPa)
0.01	0.0007	0.00	6.38	6.56	1.03	0.148	7.1
0.02	0.0015	0.14	6.39	14.06	2.20	0.317	15.2
0.03	0.0023	0.28	6.40	21.55	3.37	0.485	23.2
0.03	0.0032	0.42	6.41	29.98	4.68	0.674	32.3
0.04	0.0040	0.56	6.42	37.48	5.84	0.841	40.3
0.05	0.0047	0.70	6.43	44.04	6.85	0.987	47.2
0.06	0.0052	0.84	6.44	48.72	7.57	1.090	52.2
0.07	0.0057	0.98	6.44	53.41	8.29	1.193	57.1
0.08	0.0062	1.12	6.45	58.09	9.00	1.296	62.1
0.09	0.0067	1.27	6.46	62.78	9.71	1.399	67.0
0.09	0.0072	1.41	6.47	67.46	10.42	1.501	71.9
0.10	0.0077	1.55	6.48	72.15	11.13	1.603	76.8
0.11	0.0081	1.69	6.49	75.90	11.69	1.684	80.6
0.12	0.0085	1.83	6.50	79.65	12.25	1.764	84.5
0.13	0.0088	1.97	6.51	82.46	12.67	1.824	87.3
0.14	0.0092	2.11	6.52	86.20	13.22	1.904	91.2
0.14	0.0095	2.25	6.53	89.02	13.64	1.964	94.0
0.15	0.0099	2.39	6.54	92.76	14.19	2.043	97.8
0.16	0.0103	2.53	6.55	96.51	14.74	2.123	101.6
0.17	0.0106	2.67	6.56	99.32	15.15	2.181	104.4
0.18	0.0109	2.81	6.57	102.13	15.56	2.240	107.2
0.19	0.0112	2.95	6.58	104.94	15.96	2.298	110.0
0.20	0.0115	3.09	6.58	107.76	16.36	2.356	112.8
0.20	0.0118	3.23	6.59	110.57	16.77	2.414	115.6
0.21	0.0120	3.37	6.60	112.44	17.03	2.452	117.4
0.22	0.0123	3.52	6.61	115.25	17.43	2.509	120.1
0.23	0.0125	3.66	6.62	117.13	17.68	2.546	121.9
0.24	0.0127	3.80	6.63	119.00	17.94	2.583	123.7
0.25	0.0129	3.94	6.64	120.87	18.20	2.620	125.5
0.26	0.0130	4.08	6.65	121.81	18.31	2.637	126.2
0.26	0.0132	4.22	6.66	123.68	18.57	2.673	128.0
0.27	0.0134	4.36	6.67	125.56	18.82	2.710	129.7
0.28	0.0135	4.50	6.68	126.50	18.93	2.726	130.5
0.29	0.0136	4.64	6.69	127.43	19.04	2.742	131.3
0.30	0.0137	4.78	6.70	128.37	19.16	2.758	132.1
0.31	0.0138	4.92	6.71	129.31	19.27	2.774	132.8
0.31	0.0139	5.06	6.72	130.24	19.38	2.790	133.6
0.32	0.0139	5.20	6.73	130.24	19.35	2.786	133.4
0.33	0.0139	5.34	6.74	130.24	19.32	2.782	133.2
0.34	0.0139	5.48	6.75	130.24	19.29	2.778	133.0
0.35	0.0138	5.62	6.76	129.31	19.12	2.754	131.9
0.36	0.0137	5.77	6.77	128.37	18.96	2.730	130.7
0.37	0.0135	5.91	6.78	126.50	18.65	2.686	128.6
0.37	0.0132	6.05	6.79	123.68	18.21	2.622	125.6
0.38	0.0127	6.19	6.80	119.00	17.49	2.519	120.6

UNCONFINED COMPRESSIVE STRENGTH, q_u:	133.60	kPa
(based on maximum q_u value)	2.790	ksf
UNDRAINED SHEAR STRENGTH, S_u:	66.80	kPa
(based on maximum q_u value)	1.395	ksf

NOTES:

AECOM
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS
(ASTM D2166)



AECOM
AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com
204 477 5381 tel
204 284 2040 fax

Memorandum

To	Alex Hill	Page	1
CC			
Subject	City of Winnipeg – FGSV Interceptor Siphon		
From	Jared Baldwin		
Date	December 3, 2013	Project Number	60274906

Please find attached the following material test result(s) on sample(s) submitted to the Winnipeg Geotechnical Laboratory:

- Eight (8) Moisture Content tests.
- Three (3) Grain Size Distribution (hydrometer method) tests.
- Three (3) Atterberg Limits (3 points) tests.
- Three (3) Torvane, Pocket Penetrometer, Moisture Content, Bulk Density and Visual Description without Unconfined Compressive Strength, on Shelby tube samples.

If you have any questions, please contact the undersigned.

Sincerely,

Jared Baldwin, M.Sc., P.Eng.
Geotechnical Engineer

Att.

MOISTURE CONTENT

JOB No.: 60274906
CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon

DATE: November 25, 2013

HOLE NO.	13-02	-	-	-	-	-
SAMPLE NO.	G1	S2	G3	G5	S6	G7
DEPTH (FT)	2.5	5.0	7.5	12.5	15.0	17.5
MOISTURE CONTENT %	29.3	29.7	32.4	32.7	36.2	37.2

HOLE NO.	13-02	-				
SAMPLE NO.	S9	S11				
DEPTH (FT)	25.0	35.0				
MOISTURE CONTENT %	39.2	9.8				

HOLE NO.						
SAMPLE NO.						
DEPTH (FT)						
MOISTURE CONTENT %						

HOLE NO.						
SAMPLE NO.						
DEPTH (FT)						
MOISTURE CONTENT %						

NOTES:

AECOM

MATERIALS LABORATORY
AECOM
99 Commerce Drive, Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

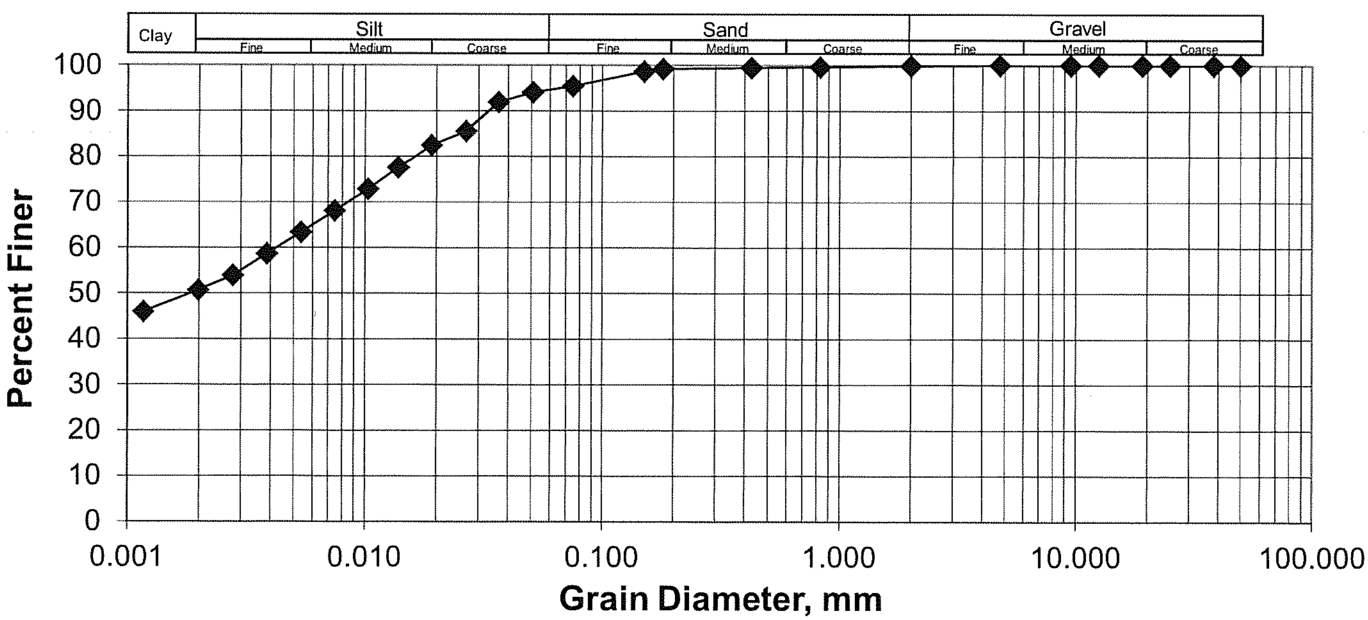
GRAIN SIZE DISTRIBUTION
(ASTM D422-63)

AECOM
MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60274906	Hole No.:	13-02
Client:	City of Winnipeg	Sample No.:	G5
Project :	FGSV Interceptor Siphon	Depth:	15.0 - 16.5'
Date Tested:	27-Nov-13	Date Sampled:	8-Nov-13
Tested By:	ML	Sampled By:	AECOM (SO)

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	99.9	0.0750	95.5
38.0	100.0	0.83	99.7	0.0508	94.2
25.0	100.0	0.43	99.5	0.0363	91.9
19.0	100.0	0.18	99.3	0.0266	85.6
12.5	100.0	0.15	98.7	0.0191	82.4
9.5	100.0	0.075	95.5	0.0138	77.7
4.75	100.0			0.0103	72.9
2.00	99.9			0.0074	68.2
				0.0054	63.4
				0.0039	58.6
				0.0028	53.9
				0.0020	50.7
				0.0012	45.9

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.1%**	**Silt**	**44.0%**
Sand	**5.2%**	**Clay**	**50.7%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

GRAIN SIZE DISTRIBUTION

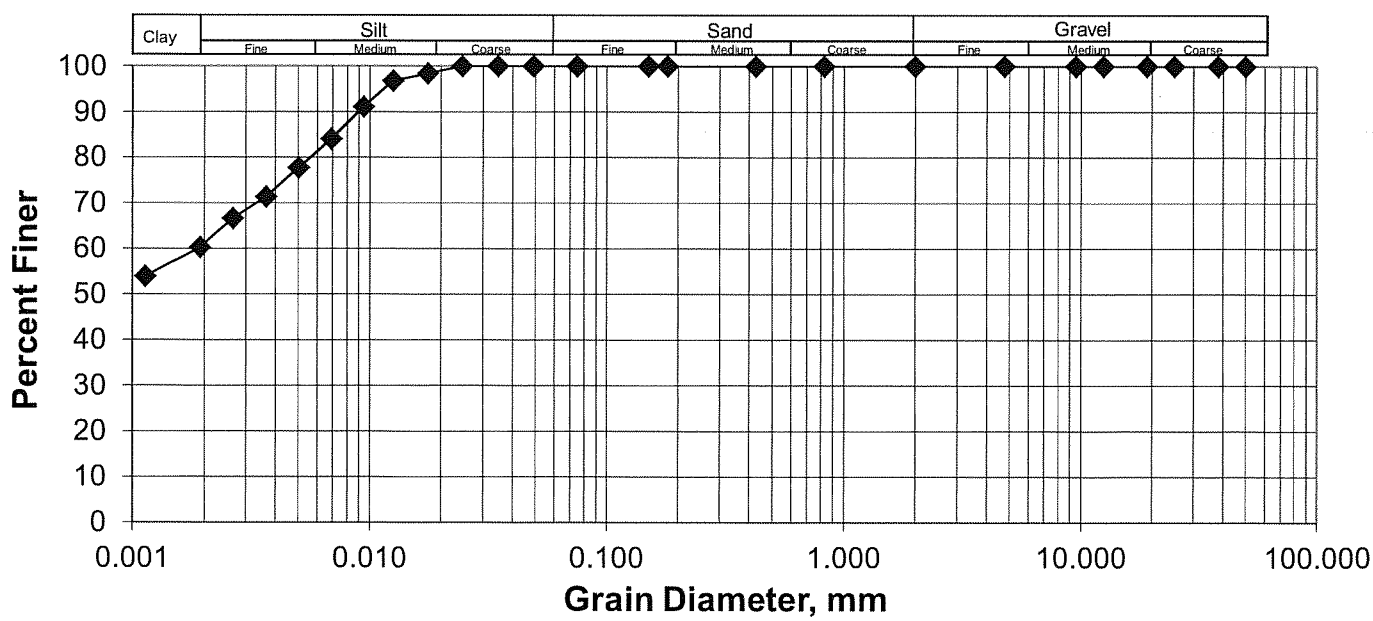
(ASTM D422-63)

MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60274906	Hole No.:	13-02
Client:	City of Winnipeg	Sample No.:	G7
Project :	FGSV Interceptor Siphon	Depth:	25.0 - 26.5'
Date Tested:	27-Nov-13	Date Sampled:	8-Nov-13
Tested By:	ML	Sampled By:	AECOM (SO)

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	100.0	0.0750	100.0
38.0	100.0	0.83	100.0	0.0491	100.0
25.0	100.0	0.43	100.0	0.0347	100.0
19.0	100.0	0.18	100.0	0.0246	100.0
12.5	100.0	0.15	100.0	0.0175	98.4
9.5	100.0	0.075	100.0	0.0125	96.8
4.75	100.0			0.0094	91.1
2.00	100.0			0.0069	84.1
				0.0050	77.8
				0.0037	71.4
				0.0026	66.6
				0.0019	60.3
				0.0011	53.9

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.0%**	**Silt**	**39.0%**
Sand	**0.0%**	**Clay**	**61.0%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

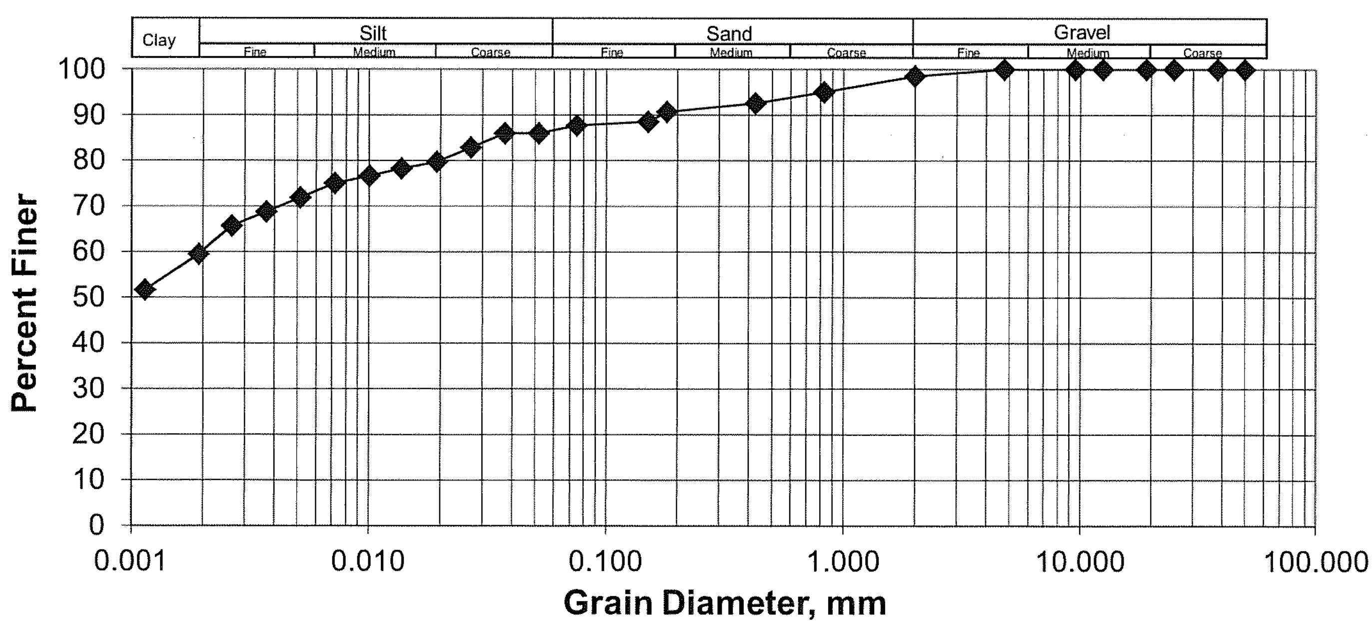
GRAIN SIZE DISTRIBUTION
(ASTM D422-63)

AECOM
MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60274906	Hole No.:	13-02
Client:	City of Winnipeg	Sample No.:	T10
Project :	FGSV Interceptor Siphon	Depth:	40.0 - 41.5'
Date Tested:	27-Nov-13	Date Sampled:	8-Nov-13
Tested By:	ML	Sampled By:	AECOM (SO)

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	98.6	0.0750	87.7
38.0	100.0	0.83	95.0	0.0518	86.0
25.0	100.0	0.43	92.7	0.0373	86.0
19.0	100.0	0.18	90.7	0.0268	82.9
12.5	100.0	0.15	88.5	0.0192	79.8
9.5	100.0	0.075	87.7	0.0137	78.2
4.75	100.0			0.0101	76.7
2.00	98.6			0.0072	75.1
				0.0052	72.0
				0.0037	68.8
				0.0026	65.7
				0.0019	59.4
				0.0011	51.6

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**1.4%**	**Silt**	**27.9%**
Sand	**10.6%**	**Clay**	**60.1%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

AECOM

AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

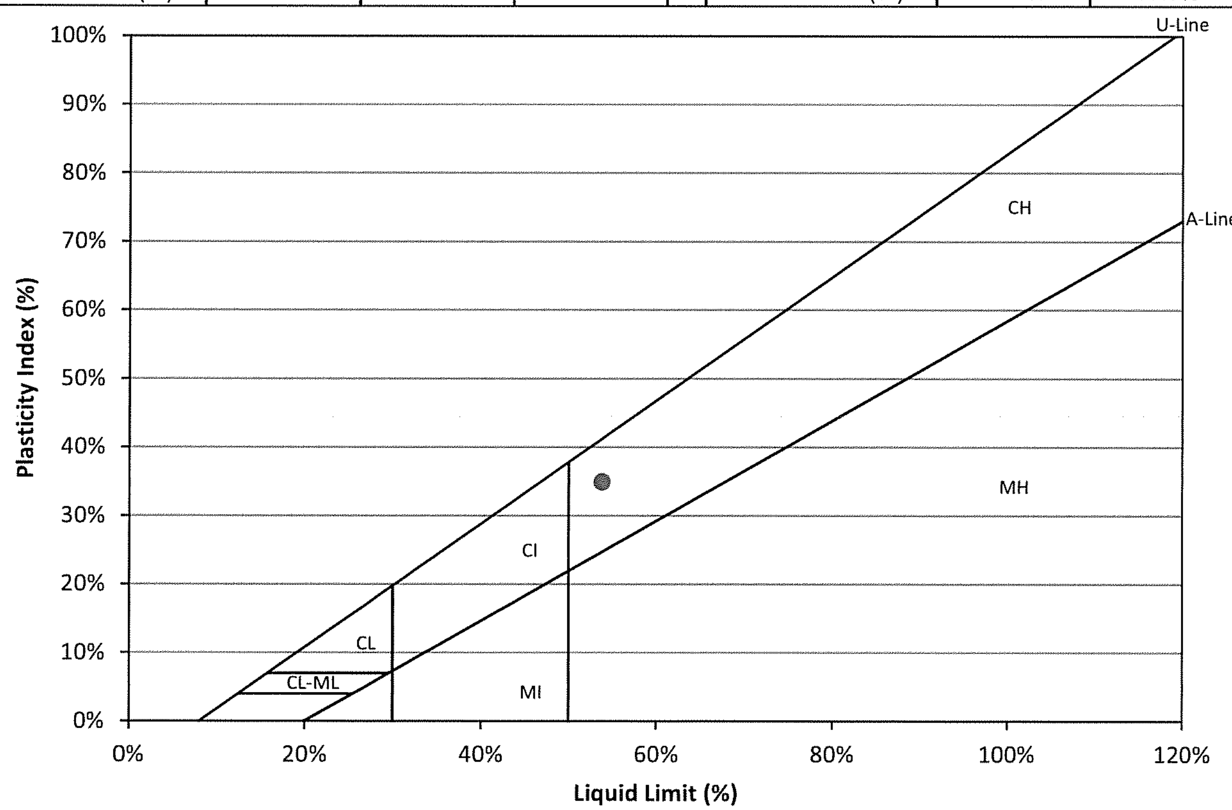
Project Name:	FGSV Interceptor Siphon	Supplier:	N/A
Project Number:	60274906	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	SOshati
Sample Location:	TH13-02	Sample Date:	September 9, 2013
Sample Depth:	3.0 - 3.6m	Lab Technician:	MLotecki
Sample Number:	T4	Date Tested:	November 26, 2013

Atterberg Limits

ASTM D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	18	25	31
Wet Sample (g)	12.7	13.3	12.9
Dry Sample (g)	8.1	8.6	8.5
Water Content (%)	55.6%	53.9%	52.9%

Plastic Limit		
Trial	1	2
Wet Sample (g)	9.4	12.1
Dry Sample (g)	7.9	10.1
Water Content (%)	18.9%	19.0%



Liquid Limit (%): 53.8%	Plastic Limit (%): 18.9%	Plasticity Index (%): 34.9%

AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

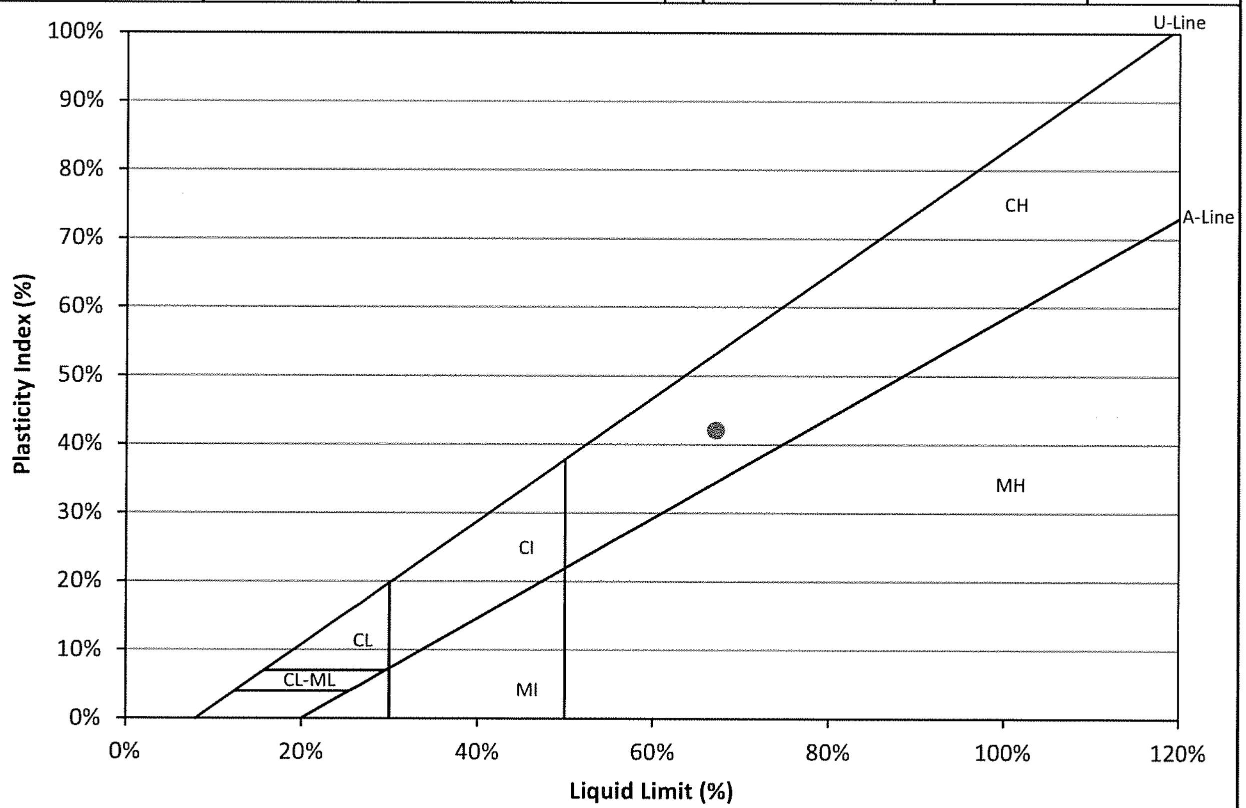
Project Name:	FGSV Interceptor Siphon	Supplier:	N/A
Project Number:	60274906	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	SOshati
Sample Location:	TH13-02	Sample Date:	September 9, 2013
Sample Depth:	9.1 - 9.6m	Lab Technician:	MLotecki
Sample Number:	T8	Date Tested:	November 26, 2013

Atterberg Limits

ASTM D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	16	28	31
Wet Sample (g)	13.3	11.4	12.3
Dry Sample (g)	7.8	6.8	7.4
Water Content (%)	69.7%	66.7%	65.8%

Plastic Limit		
Trial	1	2
Wet Sample (g)	8.5	8.0
Dry Sample (g)	6.8	6.4
Water Content (%)	25.1%	25.2%



Liquid Limit (%): 67.2%	Plastic Limit (%): 25.1%	Plasticity Index (%): 42.0%

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Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

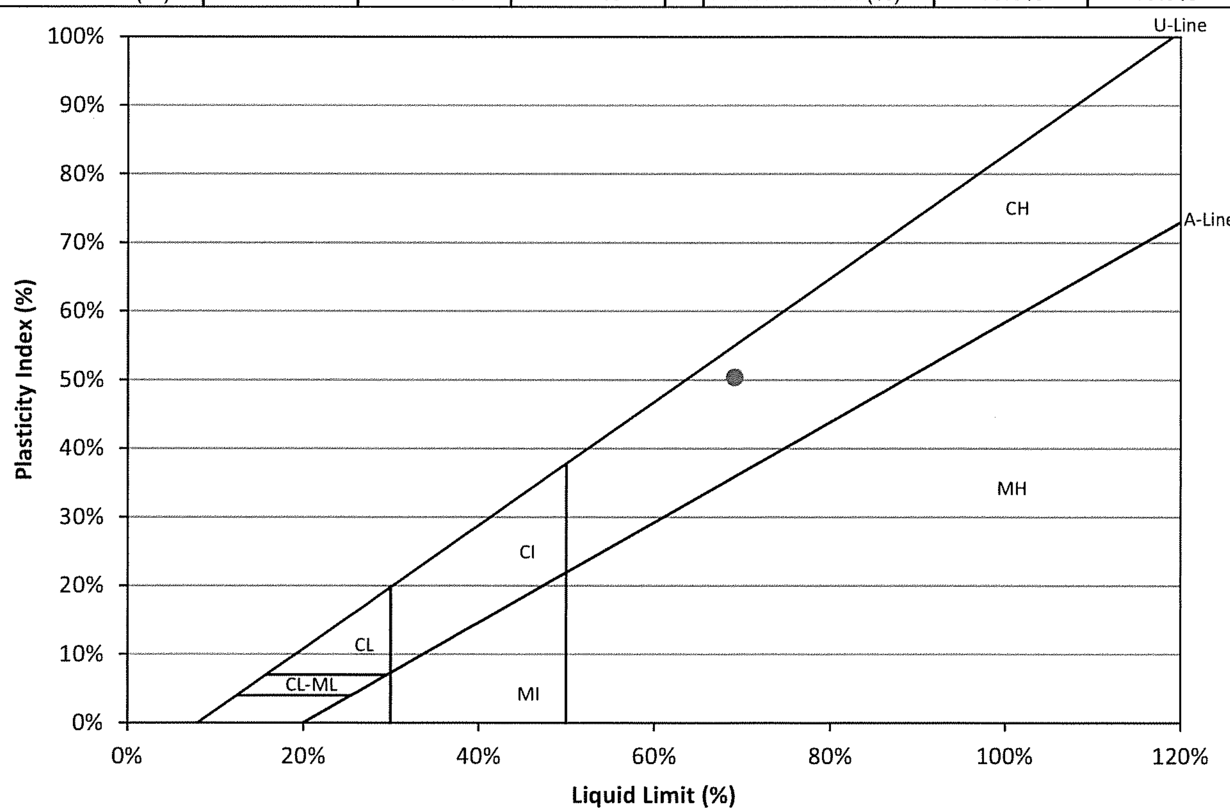
Project Name:	FGSV Interceptor Siphon	Supplier:	N/A
Project Number:	60274906	Specification:	N/A
Client:	City of Winnipeg	Field Technician:	SOshati
Sample Location:	TH13-02	Sample Date:	September 9, 2013
Sample Depth:	12.1 - 12.9m	Lab Technician:	MLotecki
Sample Number:	T10	Date Tested:	November 26, 2013

Atterberg Limits

ASTM D4318: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit			
Blows	24	26	35
Wet Sample (g)	11.1	11.5	10.9
Dry Sample (g)	6.6	6.8	6.5
Water Content (%)	69.7%	68.4%	66.4%

Plastic Limit		
Trial	1	2
Wet Sample (g)	10.3	10.5
Dry Sample (g)	8.6	8.8
Water Content (%)	18.6%	18.9%



Liquid Limit (%): 69.2%	Plastic Limit (%): 18.8%	Plasticity Index (%): 50.4%

AECOM - SOILS LABORATORY
SHEAR STRENGTH, MOISTURE CONTENT & DENSITY CALCULATIONS

CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon
JOB NO.: 60274906

TEST HOLE NO.:	**TH13-02**
SAMPLE NO.:	**T4**
SAMPLE DEPTH:	10.0 - 12.0
DATE TESTED:	26-Nov-13
SHEAR STRENGTH TESTS	
TORVANE	
Reading	0.50
Vane Size (S, M, L)	M
Undrained Shear Strength (kPa)	**49.0**
Undrained Shear Strength (ksf)	1.02
POCKET PENETROMETER	
Reading - Qu (tsf)	1.00
Undrained Shear Strength (kPa)	**47.9**
Reading - Qu (tsf)	1.00
Undrained Shear Strength (kPa)	**47.9**
Reading - Qu (tsf)	1.00
Undrained Shear Strength (kPa)	**47.9**
UNCONFINED COMPRESSIVE STRENGTH TEST	
Unconfined compressive strength (kPa)	**N/A**
Unconfined compressive strength (ksf)	**N/A**
Undrained Shear Strength (kPa)	**N/A**
Undrained Shear Strength (ksf)	**N/A**
MOISTURE CONTENT	
Tare Number	M12
Wt. Sample wet + tare (g)	426.1
Wt. Sample dry + tare (g)	321.7
Wt. Tare (g)	8.4
Moisture Content %	**33.3**
BULK DENSITY	
Sample Wt. (g)	1185.6
Diameter 1 (cm)	7.23
Diameter 2 (cm)	7.24
Diameter 3 (cm)	7.24
Avg. Diameter (cm)	**7.24**
Length 1 (cm)	15.35
Length 2 (cm)	15.34
Length 3 (cm)	15.32
Avg. Length (cm)	**15.34**
Volume (cm^3)	630.8
Moisture content (%)	33.3
Bulk Density (g/cm^3)	1.879
Bulk Density (kN/m^3)	**18.4**
Bulk Density (pcf)	**117.3**
Dry Density (kN/m^3)	**13.83**

AECOM - SOILS LABORATORY
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS (ASTM D2166)

AECOM

CLIENT:	City of Winnipeg
PROJECT:	FGSV Interceptor Siphon
JOB NO.:	60274906

TEST HOLE NO.:	TH13-02
SAMPLE NO.:	T4
SAMPLE DEPTH:	10.0 - 12.0
SAMPLE DATE:	19-Nov-13
TEST DATE:	26-Nov-13

SOIL DESCRIPTION:	
CLAY; silty, trace sand, trace oxidation, brown, moist, firm, medium to high plasticity, homogeneous	
MOISTURE CONTENT:	33.3

SAMPLE DIAM.(Do):	72.37	(mm)	INITIAL AREA, Ao:	4113.1	(mm^2)
SAMPLE LENGTH, (Lo):	153.37	(mm)	PISTON RATE:	0.051	(inches / minute)
L / D RATIO:	2.1	(2 < L/D < 2.5)	AXIAL STRAIN RATE, R:	0.84	(0.5<R<2 % / minute)

FAILURE SKETCH

TEST DATA - DIAL READINGS							
AXIAL COMPRESSION	PROVING RING	TOTAL AXIAL STRAIN, E_1	AVERAGE CROSS-SECTIONAL AREA, A	APPLIED AXIAL LOAD, P	COMPRESSIVE STRESS, σ_c		
(inches)	0.5	(%)	(inches2)	(lbs)	(psi)	(ksf)	(kPa)

UNCONFINED COMPRESSIVE STRENGTH, q_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf
UNDRAINED SHEAR STRENGTH, S_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf

NOTES:

AECOM

SHEAR STRENGTH, MOISTURE CONTENT & DENSITY CALCULATIONS

CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon
JOB NO.: 60274906

TEST HOLE NO.:	**TH13-02**
SAMPLE NO.:	**T8**
SAMPLE DEPTH:	30.0 - 31.5
DATE TESTED:	26-Nov-13
SHEAR STRENGTH TESTS	
TORVANE	
Reading	0.70
Vane Size (S, M, L)	M
Undrained Shear Strength (kPa)	**68.7**
Undrained Shear Strength (ksf)	1.43
POCKET PENETROMETER	
Reading - Qu (tsf)	1.75
Undrained Shear Strength (kPa)	**83.8**
Reading - Qu (tsf)	1.50
Undrained Shear Strength (kPa)	**71.8**
Reading - Qu (tsf)	1.50
Undrained Shear Strength (kPa)	**71.8**
UNCONFINED COMPRESSIVE STRENGTH TEST	
Unconfined compressive strength (kPa)	**N/A**
Unconfined compressive strength (ksf)	**N/A**
Undrained Shear Strength (kPa)	**N/A**
Undrained Shear Strength (ksf)	**N/A**
MOISTURE CONTENT	
Tare Number	M12
Wt. Sample wet + tare (g)	426.6
Wt. Sample dry + tare (g)	307.4
Wt. Tare (g)	8.3
Moisture Content %	**39.9**
BULK DENSITY	
Sample Wt. (g)	1111.5
Diameter 1 (cm)	7.23
Diameter 2 (cm)	7.23
Diameter 3 (cm)	7.25
Avg. Diameter (cm)	**7.24**
Length 1 (cm)	15.35
Length 2 (cm)	15.34
Length 3 (cm)	15.34
Avg. Length (cm)	**15.34**
Volume (cm^3)	631.1
Moisture content (%)	39.9
Bulk Density (g/cm^3)	1.761
Bulk Density (kN/m^3)	**17.3**
Bulk Density (pcf)	**110.0**
Dry Density (kN/m^3)	**12.35**

AECOM - SOILS LABORATORY
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS (ASTM D2166)

AECOM

CLIENT:	City of Winnipeg
PROJECT:	FGSV Interceptor Siphon
JOB NO.:	60274906

TEST HOLE NO.:	TH13-02
SAMPLE NO.:	T8
SAMPLE DEPTH:	30.0 - 31.5
SAMPLE DATE:	19-Nov-13
TEST DATE:	26-Nov-13

SOIL DESCRIPTION:	
CLAY; silty, trace sand, brown with grey, moist, firm, medium to high plasticity, homogeneous	
MOISTURE CONTENT:	39.9

SAMPLE DIAM.(Do):	72.37	(mm)	INITIAL AREA, Ao:	4113.1	(mm^2)
SAMPLE LENGTH, (Lo):	153.43	(mm)	PISTON RATE:	0.051	(inches / minute)
L / D RATIO:	2.1	(2 < L/D < 2.5)	AXIAL STRAIN RATE, R:	0.84	(0.5<R<2 % / minute)

FAILURE SKETCH

TEST DATA - DIAL READINGS							
AXIAL COMPRESSION	PROVING RING	TOTAL AXIAL STRAIN, E_1	AVERAGE CROSS-SECTIONAL AREA, A	APPLIED AXIAL LOAD, P	COMPRESSIVE STRESS, σ_c		
(inches)	0.7	(%)	(inches2)	(lbs)	(psi)	(ksf)	(kPa)

UNCONFINED COMPRESSIVE STRENGTH, q_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf
UNDRAINED SHEAR STRENGTH, S_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf

NOTES:

AECOM - SOILS LABORATORY
SHEAR STRENGTH, MOISTURE CONTENT & DENSITY CALCULATIONS

AECOM

CLIENT: City of Winnipeg
PROJECT: FGSV Interceptor Siphon
JOB NO.: 60274906

TEST HOLE NO.:	**TH13-02**
SAMPLE NO.:	**T10**
SAMPLE DEPTH:	40.0 - 41.5
DATE TESTED:	26-Nov-13
SHEAR STRENGTH TESTS	
TORVANE	
Reading	0.75
Vane Size (S, M, L)	M
Undrained Shear Strength (kPa)	**73.6**
Undrained Shear Strength (ksf)	1.54
POCKET PENETROMETER	
Reading - Qu (tsf)	0.75
Undrained Shear Strength (kPa)	**35.9**
Reading - Qu (tsf)	0.75
Undrained Shear Strength (kPa)	**35.9**
Reading - Qu (tsf)	0.75
Undrained Shear Strength (kPa)	**35.9**
UNCONFINED COMPRESSIVE STRENGTH TEST	
Unconfined compressive strength (kPa)	**N/A**
Unconfined compressive strength (ksf)	**N/A**
Undrained Shear Strength (kPa)	**N/A**
Undrained Shear Strength (ksf)	**N/A**
MOISTURE CONTENT	
Tare Number	M12
Wt. Sample wet + tare (g)	390.2
Wt. Sample dry + tare (g)	275.9
Wt. Tare (g)	8.2
Moisture Content %	**42.7**
BULK DENSITY	
Sample Wt. (g)	1072
Diameter 1 (cm)	7.23
Diameter 2 (cm)	7.25
Diameter 3 (cm)	7.25
Avg. Diameter (cm)	**7.24**
Length 1 (cm)	15.35
Length 2 (cm)	15.32
Length 3 (cm)	15.32
Avg. Length (cm)	**15.33**
Volume (cm^3)	631.7
Moisture content (%)	42.7
Bulk Density (g/cm^3)	1.697
Bulk Density (kN/m^3)	**16.6**
Bulk Density (pcf)	**105.9**
Dry Density (kN/m^3)	**11.66**

AECOM - SOILS LABORATORY
UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOILS (ASTM D2166)

AECOM

CLIENT:	City of Winnipeg
PROJECT:	FGSV Interceptor Siphon
JOB NO.:	60274906

TEST HOLE NO.:	TH13-02
SAMPLE NO.:	T10
SAMPLE DEPTH:	40.0 - 41.5
SAMPLE DATE:	19-Nov-13
TEST DATE:	26-Nov-13

SOIL DESCRIPTION:	
CLAY; silty, trace till inclusions, trace sand, trace silt inclusions, trace stones (5mm), brown, moist, firm, medium to high plasticity, homogeneous	
MOISTURE CONTENT:	42.7

SAMPLE DIAM.(Do):	72.43	(mm)	INITIAL AREA, Ao:	4120.7	(mm^2)
SAMPLE LENGTH, (Lo):	153.30	(mm)	PISTON RATE:	0.051	(inches / minute)
L / D RATIO:	2.1	(2 < L/D < 2.5)	AXIAL STRAIN RATE, R:	0.85	(0.5<R<2 % / minute)

FAILURE SKETCH

TEST DATA - DIAL READINGS							
AXIAL COMPRESSION	PROVING RING	TOTAL AXIAL STRAIN, E_1	AVERAGE CROSS-SECTIONAL AREA, A	APPLIED AXIAL LOAD, P	COMPRESSIVE STRESS, σ_c		
(inches)	(inches)	(%)	(inches2)	(lbs)	(psi)	(ksf)	(kPa)
	N/A						
	N/A						
	N/A						
	N/A						

UNCONFINED COMPRESSIVE STRENGTH, q_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf
UNDRAINED SHEAR STRENGTH, S_u:	0.00	kPa
(based on maximum q_u value)	0.000	ksf

NOTES:

APPENDIX D

PHOTOGRAPHS

Photo 1: Cracking along the existing asphalt access road, mid-slope facing north.

Photo 2: Erosion of riverbank toe, facing east.

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Photo 3: Exposed alluvial soils within eroded riverbank toe (highly weathered and softened), facing east.

Photo 4: Rip-rap blanket placed below eastbound Bishop Grandin Bridge, facing south.

Photo 5: River elevations (November 2013), facing northwest.

Photo 6: Erosion of riverbank toe, facing north.

APPENDIX E

SLOPE STABILTY OUTPUTS

Current Slope Conditions (Summer River Elevations)

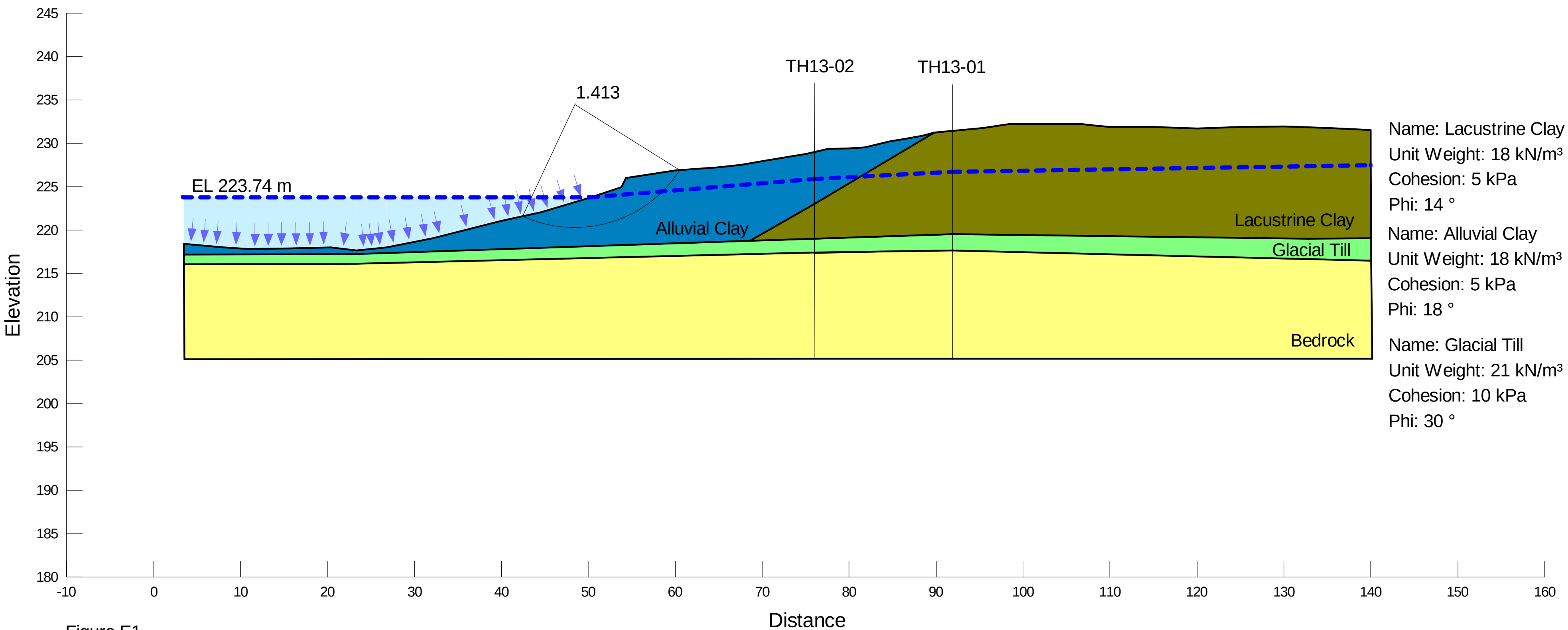


Figure E1

Current Slope Conditions (Winter River Elevations)

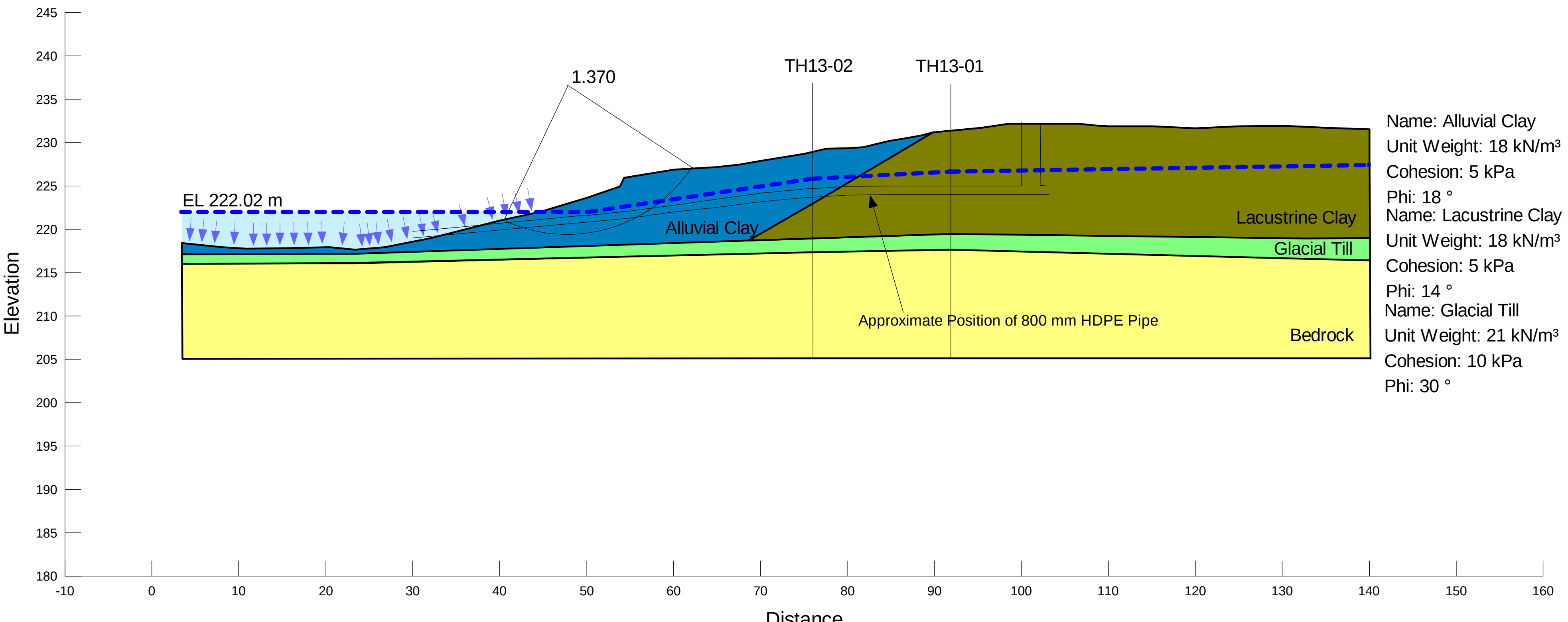


Figure E2

Current Slope Conditions (Rapid Drawdown)

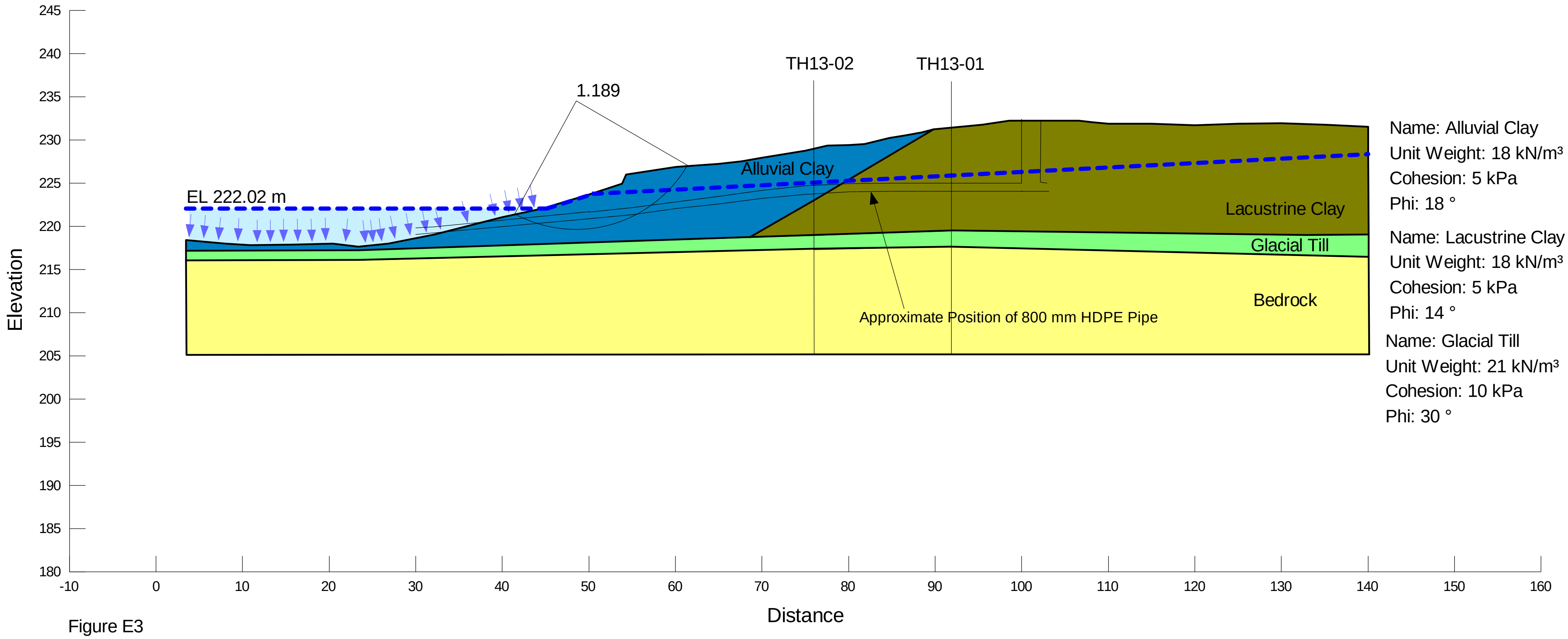


Figure E3

Riverbank Protection Measures- Rip Rap Erosion Control Blanket (Winter Elevations)

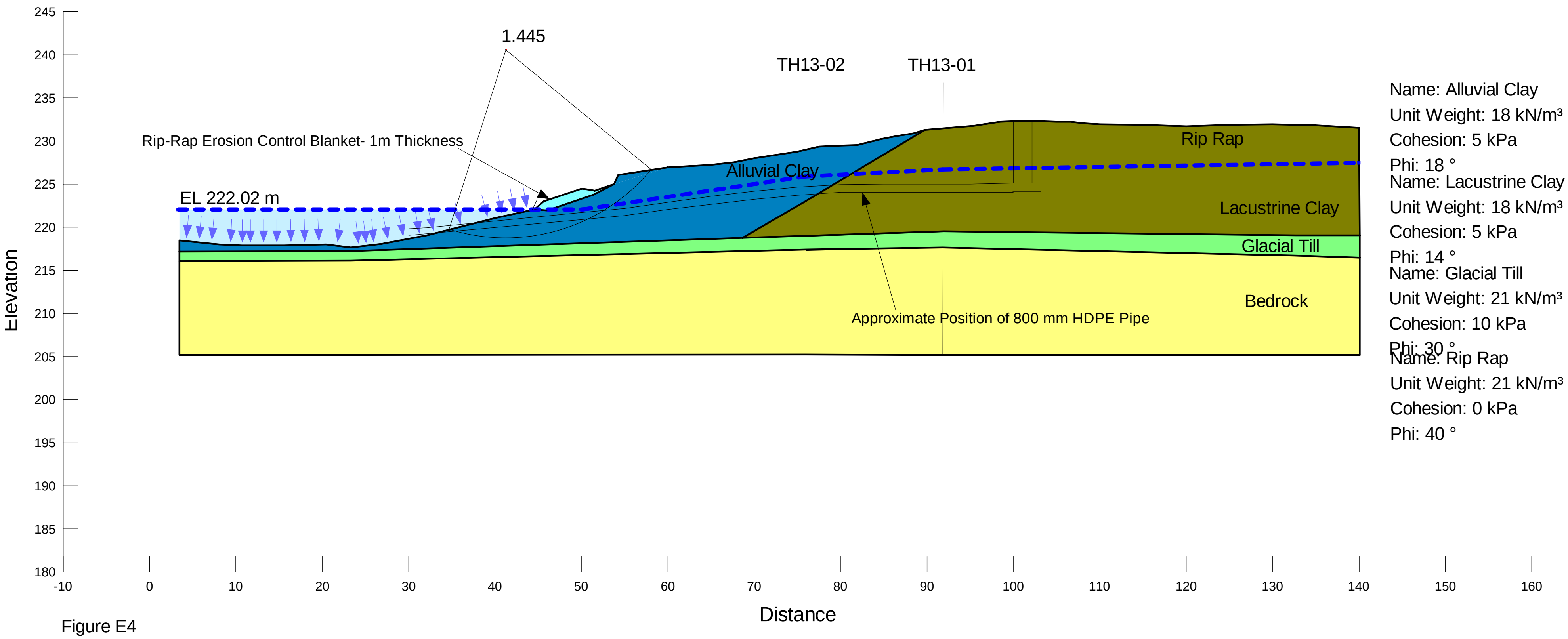
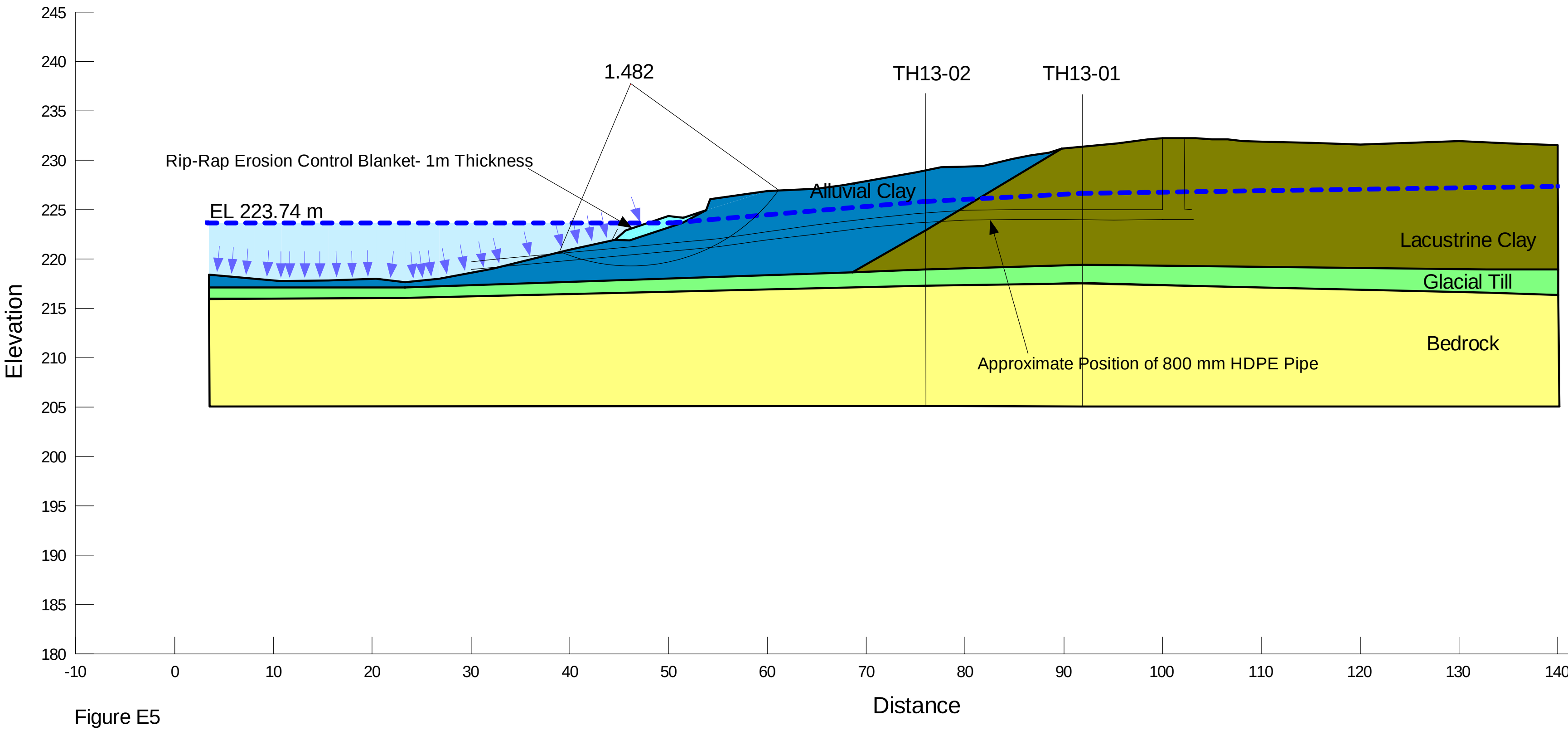


Figure E4

Riverbank Protection Measures- Rip Rap Erosion Control Blanket (Summer Elevations)



Name: Lacustrine Clay
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Glacial Till
Unit Weight: 21 kN/m³
Cohesion: 10 kPa
Phi: 30 °

Name: Alluvial Clay
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 18 °

Name: Bedrock

Name: Rip Rap
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 40 °

Figure E5

Riverbank Protection Measures- Rip Rap Erosion Control Blanket (Rapid Drawdown)

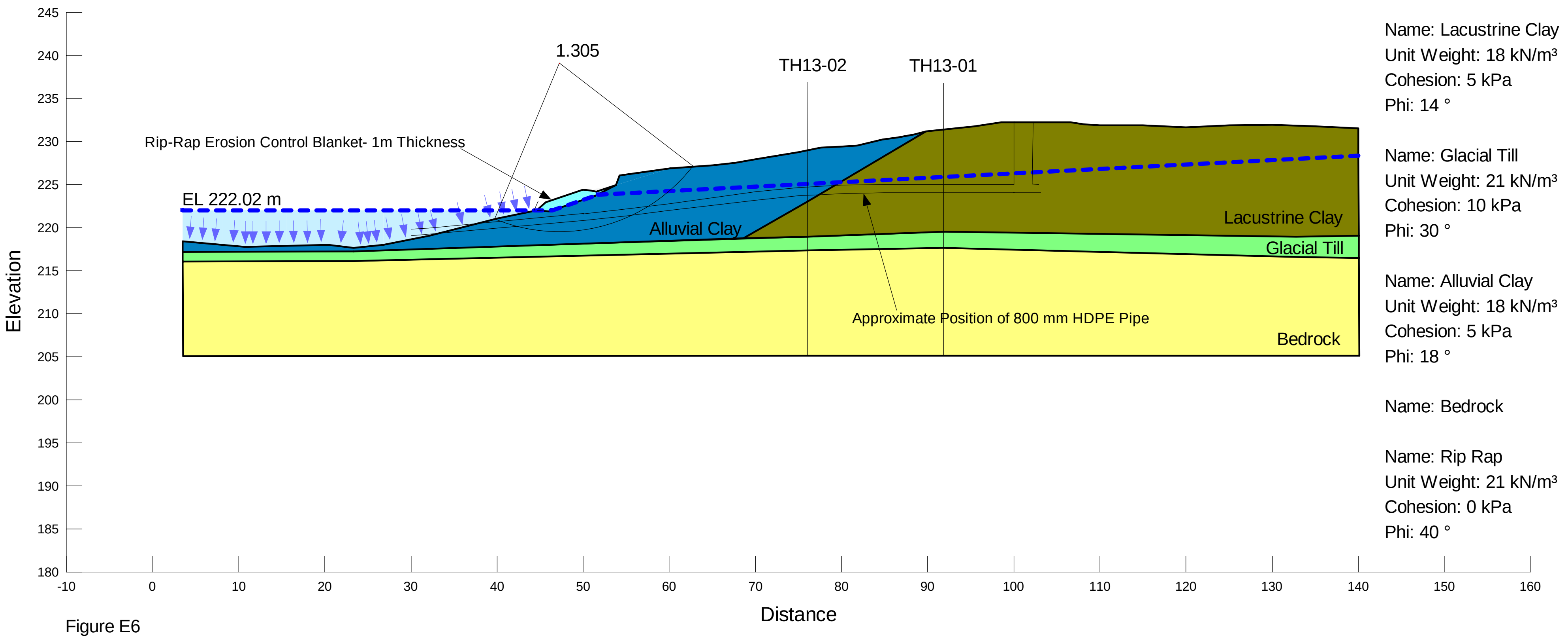


Figure E6

Riverbank Protection Measures- Rip Rap Erosion Control Blanket and Toe Regrade (Winter Elevations)

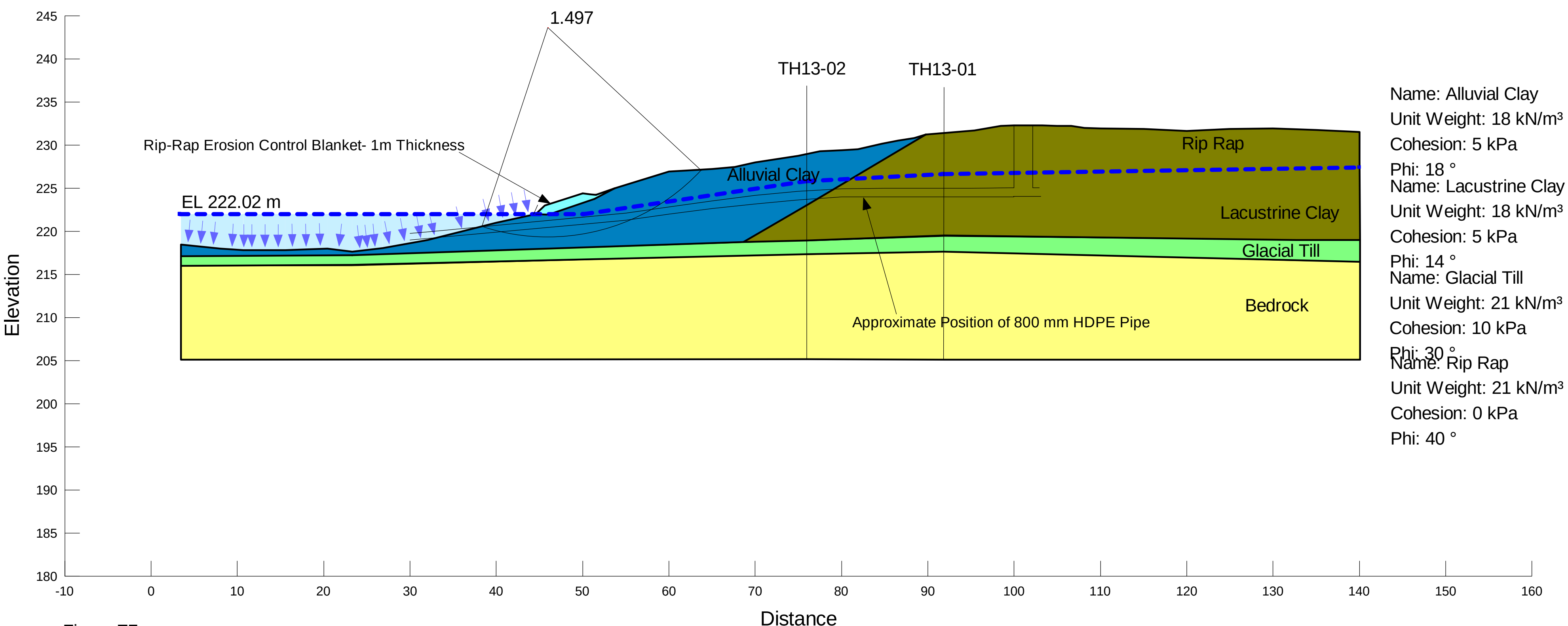


Figure E7

Riverbank Protection Measures- Rip Rap Erosion Control Blanket and Toe Regrade (Summer Elevations)

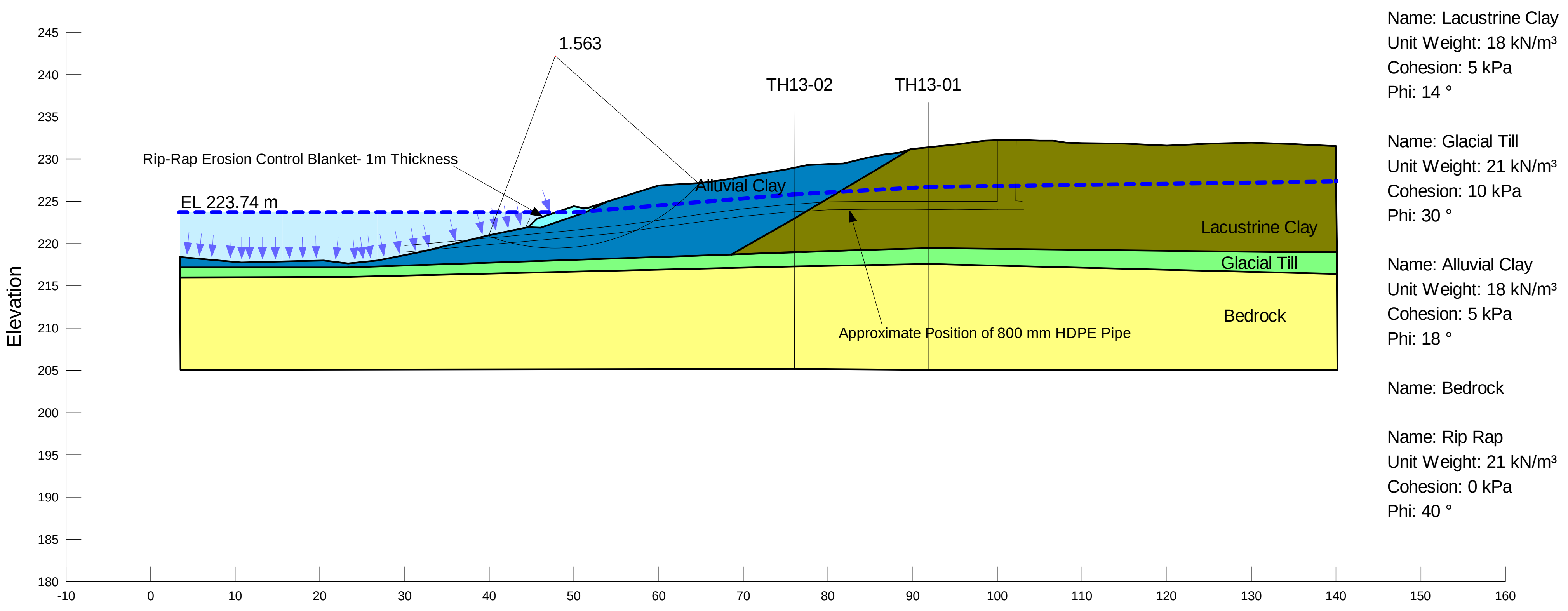


Figure E8

Riverbank Protection Measures- Rip Rap Erosion Control Blanket and Toe Regrade (Rapid Drawdown)

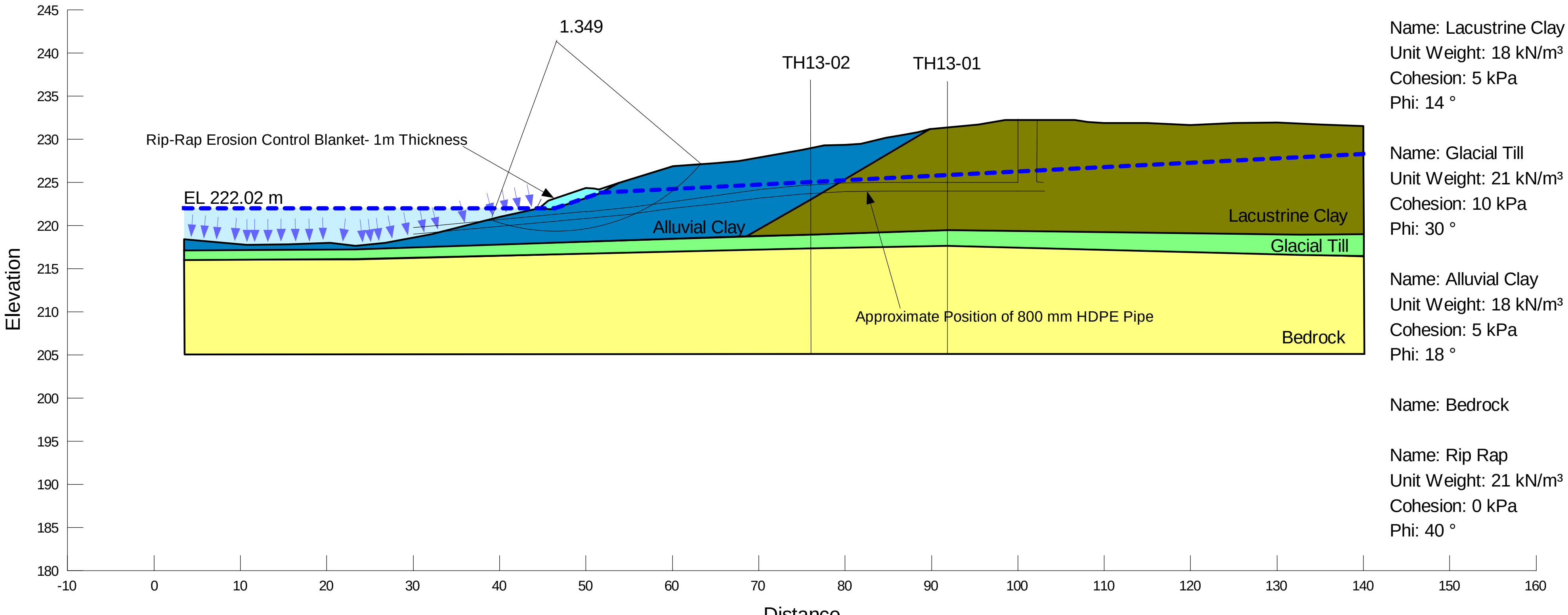


Figure E9