APPENDIX A

GEOTECHNICAL INVESTIGATION MEMORANDUM

KGS GROUP CONSULTING ENGINEERS

MEMORANDUM

TO: Colin Siepman, M.Eng., P.Eng.

FROM: Dami Adedapo, Ph.D., P.Eng.
Kyle Hamilton, B.Sc. (CE), E.I.T.

DATE: September 30, 2015

PROJECT NO: 15-0107-011

RE: Fort Rouge Outfall Chamber Upgrades
Geotechnical Site Investigation

1.0 INTRODUCTION

This memorandum summarizes KGS Group's geotechnical site investigation and provides excavation recommendations for the Fort Rouge Outfall Chamber Upgrades.

2.0 SCOPE OF WORK

The engineering services that have been provided for this project are identified below:

- **Geotechnical Investigation and Monitoring Program:** An on-site drilling program was completed to determine the subsurface soils and groundwater conditions in the vicinity of the proposed outfall chamber upgrade. The program consisted of one (1) test hole drilled into the underlying till using solid stem augers with installation of a Casagrande tip standpipe piezometer to monitor groundwater conditions.
- **Geotechnical Diagnostic Laboratory Testing Program:** Diagnostic laboratory index testing on select samples to identify engineering properties relevant to this project.
- **Geotechnical Engineering Evaluation:** A geotechnical evaluation of the site conditions including considerations for the deep excavation for the proposed chamber upgrade.

3.0 INVESTIGATION PROGRAM

3.1 TEST HOLE DRILLING AND SOIL SAMPLING PROGRAM

On August 18, 2015 KGS Group completed a geotechnical investigation near the existing outfall chamber. The drilling program consisted of one (1) test hole advanced using solid stem augers into the underlying till using a Mobile B37X track mounted rig. Drilling services were provided by Maple Leaf Drilling Ltd. with continuous KGS Group supervision. The approximate location of the test hole is shown on Figure 01.

FIGURE 01: TEST HOLE LOCATION

Representative soil samples were collected directly off the auger flights at 1.5 m intervals or at changes in soil strata encountered during drilling. The soil samples were visually inspected for material type and classified according to the modified Unified Soil Classification System (USCS). All clay samples were tested with a field Torvane to evaluate consistency and to estimate undrained shear strengths. Standard Penetration Tests (SPTs) were performed in the till to determine the relative in-situ density with split spoon samples collected in the till.

Upon completion of drilling, the test hole was examined for indications of sloughing, squeezing and seepage, and then backfilled to grade with sand, bentonite chips and auger cuttings. A detailed summary soil log incorporating all field observations and laboratory test results is included in Appendix A.

3.2 LABORATORY TESTING

A diagnostic laboratory testing program was performed on representative soil samples to determine the relevant engineering properties of the subsurface soils relative to the foundation design. Diagnostic testing included: eight (8) moisture contents, one (1) Atterberg Limit test and one (1) grain size analysis. All laboratory testing was completed at a local ASTM accredited laboratory. The results of the testing are shown on the test hole log included in Appendix A.

4.0 INVESTIGATION RESULTS

One (1) test hole was drilled into till northeast of the outfall chamber on the east side of the sidewalk. Upon completion of the drilling the sidewalls squeezed in the lower silt till at a depth of 12.8 m below existing grade. Groundwater infiltration from the silt till was noted in the test hole while drilling. The water level in the test hole was 7.9 m below existing grade at the completion of drilling.

4.1 STRATIGRAPHY

In general, the soil stratigraphy at the site has been interpreted by KGS Group to consist of thin topsoil layer overlaying silty clay and silt till. The till was encountered 11.6 m below existing grade at El. 219.8 m.

Silty Clay: Silty clay was encountered below the thin topsoil layer (approximately 0.3 m) to a depth of 11.6 m below existing grade. The silty clay was brown in colour, moist, stiff in consistency, of high plasticity and contained some silt nodules and trace fine grained sand. The undrained shear strength, estimated from the field Torvane, ranged from 20 kPa to 50 kPa and typically decreased with depth. The moisture content of the silty clay ranged from 30.5% to 44.5%. Atterberg Limit testing completed on a sample at a depth of 10.2 m measured a Liquid Limit of 78%, Plastic Limit of 21% and a Plasticity Index of 57%, classifying the material as CH (high plasticity clay).

Silt Till: Silt till was encountered below the silty clay at a depth of 11.6 m below existing grade. The silt till was generally tan to grey in colour, loose to very dense, with medium to coarse grained sand and some fine grained gravel. The uncorrected SPT blow count (N) per 300 mm was 9 blows at El. 218.9 m and 45 blows at El. 217.5 m (SPT refusal). Results of the SPT testing are included on the soil log in Appendix A. The moisture content in the till varied was 9.7% at El. 218.9 m and 18.9% at El. 217.5 m.

4.2 GROUNDWATER

Groundwater infiltration from the silt till was noted at the time of drilling. The water level was 7.9 m below existing grade at the completion of drilling. It should be noted that groundwater levels will fluctuate seasonally and following precipitation events

The drilling program included the installation of one (1) 25 mm diameter Casagrande tip standpipe piezometer within the silt till at Elev. 218.6 m±. The piezometric monitoring results are summarized in Table 1.

TABLE 1
PIEZOMETRIC MONITORING RESULTS

Ground Elevation (m):		**231.40**
Top of Pipe Elevation (m):		**231.25**
Tip Elevation (m):		**218.57**
Monitoring Zone:		**Till**
Date	**River Level (m)**	**Piezometric Elevation (m)**
3-Sep-15	223.71	224.20
24-Sep-15	223.76	224.15

5.0 CONSTRUCTION CONSIDERATIONS

5.1 LATERAL EARTH PRESSURE

Lateral earth pressure coefficients that may be used for preliminary design purposes are shown on Table 2.

TABLE 2
LATERAL EARTH PRESSURE COEFFICIENTS

Backfill Material	ϕ'	K_a	K_p	K_o
Glacial Till	25°	0.41	2.46	0.58
Silty Clay	18°	0.53	2.0	0.69
Well Graded Compacted Granular	35°	0.27	3.69	0.42

5.2 TEMPORARY CONSTRUCTION EXCAVATIONS AND SHORING

The excavation at the site shall comply with Manitoba Workplace Safety and Health Act and Regulation. Preliminary guidance for temporary excavations above the water table is provided in Table 3.

TABLE 3
PRELIMINARY GUIDANCE FOR TEMPORARY DRY EXCAVATIONS

Height of Excavation (m)	Minimum Recommended Side slope
0 –1.5	1H : 1V
1.5 –3.0	1.5H : 1V
3.0 – 5.0	2H : 1V
5.0 – 6.5	3H : 1V

If the excavation is to be performed below the water table or adjacent to the existing infrastructure temporary shoring or bracing should be employed. Suitable options include H-piles and timber lagging or driven steel sheet piling. Any excavation deeper than 1.5 m should be reviewed and designed by an experienced professional engineer registered in Manitoba as required by Manitoba Workplace Safety and Health Act and Regulation.

All surcharge loads such as stockpiled soil, equipment, etc. should be kept a minimum of 10 m away from the edge of excavations and all surface runoff should be directed away from excavations.

The silty clay soil may be susceptible to sloughing from wetting and drying cycles. It is recommended that the side slopes of all open excavations be covered to prevent saturation of the soil and all surface runoff should be directed away from excavations. There may be the potential for localized groundwater inflows into an excavation below the water table, which may require temporary pumping as well as potential shoring.

5.3 EXCAVATION DEPRESSURIZATION

The proposed excavation to El. 221.0 m will result in approximately 1.2 m thick layer of silty clay remaining above the glacial till (El. 219.8 m). Excavation to El. 221.0 m could result in the blow out of the bottom of the excavation under the current measured groundwater conditions. In order to prevent blow out, dewatering wells within the till may be required.

It is anticipated that excavation depressurization to control groundwater levels and pressures may be required to facilitate the chamber excavation. Shoring should be carefully designed to take the groundwater conditions into consideration to prevent blow out / basal heave.

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Geotechnical Engineer-In-Training

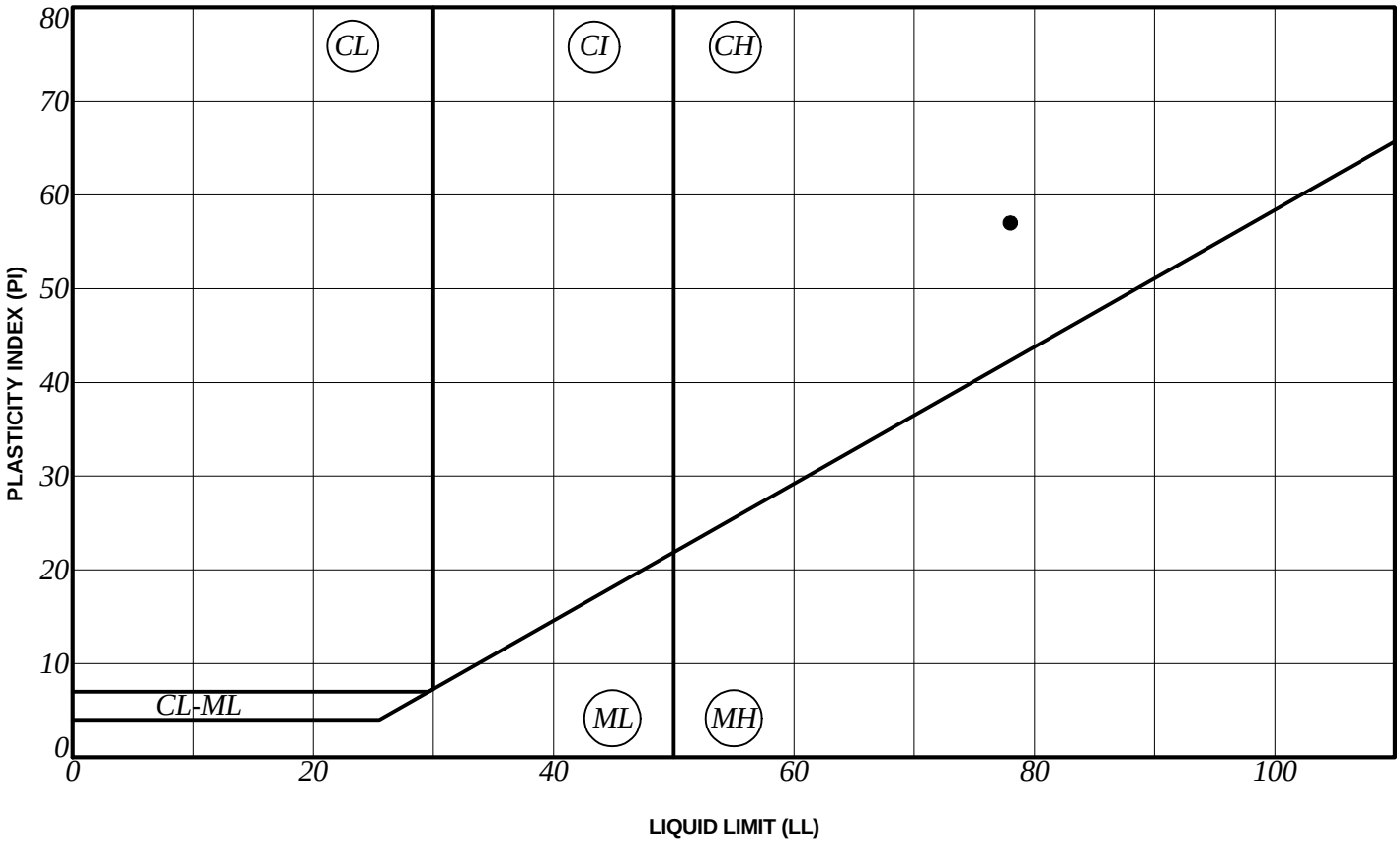
Approved By:

Dami Adedapo, P.Eng.
Senior Geotechnical Engineer

KWH/jr
Attachments

APPENDIX A

GEOTECHNICAL TEST HOLE LOG AND LABORATORY TEST RESULTS



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH15-01	10.2	S13	78	21	57	4.1			42.5	CH

Notes:
ML - Low Plasticity Silt
MH - High Plasticity Silt
CL-ML - Silty Clay
CL - Low Plasticity Clay
CI - Intermediate Plasticity Clay
CH - High Plasticity Clay
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
MC - Moisture Content
NP - Non-Plastic

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CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT

Fort Rouge Outfall Chamber Upgrades

A-LINE PLOT

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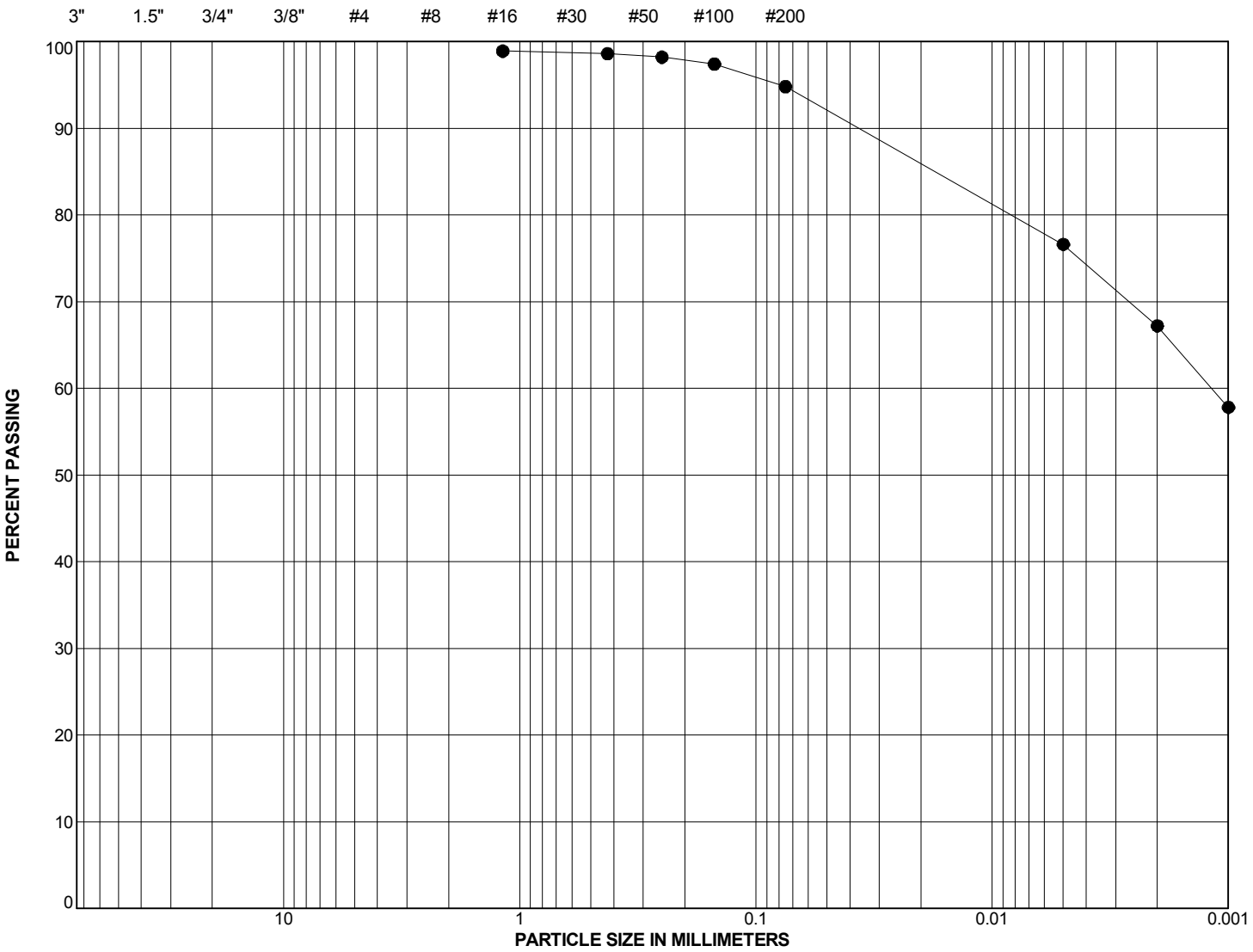
A-LINE PLOT U:\FMS\15-0107-011\15-0107-011.GPJ

SIEVE ANALYSIS

HYDROMETER ANALYSIS



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	*TH15-01*	*10.2*	*S13*	*0.0*	*4.1*			*94.8*			*CH*

SIEVE ANALYSIS U:\FMS\15-0107-011\15-0107-011.GPJ

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Fort Rouge Outfall Chamber Upgrades

GRAIN SIZE ANALYSES

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-01**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT Fort Rouge Outfall Chamber Upgrades
SITE Fort Rouge Park
LOCATION East of Bench, North of Sidewalk
DRILLING METHOD 125 mm ø Solid Stem Flighted Auger, Track Mounted Mobile B37X

JOB NO. **15-0107-011**
GROUND ELEV. **231.40**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **8/18/2015**
UTM (m) N **5,527,064**
E **633,522**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆
231.1	0	0		**TOPSOIL** - Black, damp, trace rootlets.		0.1					
231				**SILTY CLAY** - Brown, damp, stiff, high plasticity, some silt nodules, trace fine grained sand.		0.2		S01			
	1	5				0.3		S02			
230						1.8					
	2							S03			
229											
	3	10		- With silt nodules below 3.05 m.							
228						3.7		S04			
	4			- Firm below 4.27 m.							
227		15						S05			
	5							S06			
226											
	6	20		- Damp to moist below 6.10 m.				S07			
225											
	7							S08			
224		25		- Grey below 7.32 m.				S09			
	8										
223								S10			
	9	30						S11			
222								S12			
	10							S13			
221		35		- Grain size distribution at 10.21 m: Gravel (0%), Sand (5%), Silt (28%), Clay (67%).		10.7					
	11							S14			
219.8				**SILT TILL** - Tan to grey, moist, loose, some medium to coarse grained sand, trace fine grained gravel.				S15			
	12	40				12.5		S16	67	▲ 4 4	
219						12.8		S17		▲ 5	
	13										
218											
217.4		45									
	14			- Dense to very dense, with medium to coarse grained sand, some fine grained gravel below 13.72 m.		14.0		S18	100	▲ 13 ▲ 32	
217				**END OF TEST HOLE IN SILT TILL AT 13.98 m**							
	15	50									
216											
	16										
215		55									
	17										
214											
	18	60									
213											
	19										
212		65									

Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ — 20 40 60 80
PL MC LL — % — 20 40 60 80
SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ — 20 40 60

Notes:
1. Bouncing on suspected cobbles or boulders after 2nd set of 2nd Standard Penetration Test.
2. Test hole remained open after drilling to 12.83 m.
3. Approximately 4.88 m of water at the bottom of the test hole 5 minutes after drilling.
4. Installed 0.3 m long casagrande tipped piezometer at 12.83 m.
5. Backfilled test hole with sand from 12.83 m to 10.67 m, bentonite from 10.67 m to 3.66 m, cuttings from 3.66 m to 1.83 m, bentonite from 1.83 m to 0.30 m, sand from 0.30 m to 0.20 m.
6. Flush mount cover installed.
7. All excess cuttings removed from site.
8. Elevations approximated using existing gate chamber manhole rim elevation.

SAMPLE TYPE Auger Grab ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. Hamilton	AMH	9/30/15

GEOTECHNICAL-SOIL LOG U:\FMS\15-0107-011\15-0107-011.GPJ