Winnipeg

Water and Waste Department • Service des eaux et des déchets

WEWPCC Effluent Monitoring Station
Geotechnical Investigation Report
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Rev 00
FINAL

KGS Group 15-0107-019
June 2016

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LIST OF ABBREVIATIONS

Hwy	Highway
USCS	Unified Soil Classification System
SPT	Standard Penetration Test
TH	Testhole
CH	High plasticity clay
El.	Elevation
SPMDD	Standard Proctor Maximum Dry Density
ULS	Ultimate Limit State
SLS	Serviceability Limit State
MPa	Megapascal
kPa	Kilopascal
kN/m^3	Kilonewton Per Cubic Meter

1.0 INTRODUCTION

KGS Group was authorized by the City of Winnipeg to undertake a geotechnical investigation at the proposed location of the Effluent Monitoring Station for the West End Sewage Treatment Plant located at the South-West corner of Perimeter Highway (Hwy 100) and Wilkes Avenue (Hwy 427) intersection, as shown on Figure-1. It is understood that the proposed development consists of a new Effluent Monitoring Building, new gravel access roads and parking pad. The purpose of the investigation was to characterize the subsurface soil and assess the groundwater conditions at the site in order to provide geotechnical recommendations for the design and construction of the proposed Effluent Monitoring Station structure. The results of the geotechnical investigation are summarized in this report.

2.0 GEOTECHNICAL INVESTIGATION

On April 19, 2016 KGS Group completed a geotechnical investigation at the proposed site. The investigation program consisted of the following:

- One (1) testhole was advanced to power auger refusal in the underlying glacial till. This deep testhole was used for the design of the proposed building foundation as well as shoring design for the construction excavations.
- Three (3) shallow testholes were completed to a depth of 3.0 m (10 feet) within the vicinity of the access road.

The approximate locations of the testholes are shown on Figure-1.

All testholes were completed with solid stem augers using an Acker SX truck mounted rig. The drill rig was provided and operated by Paddock Drilling, under the continuous guidance and direction of KGS Group personnel.

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 Unified Soil Classification System (USCS). All cohesive samples were tested with a field Torvane to evaluate consistency and estimate undrained shear strength. Standard Penetration Tests (SPTs) were performed in the till to determine the relative insitu density.

Upon completion of drilling, the testholes were examined for indications of sloughing and seepage. One (1) casagrande standpipe was installed at the silt till (approximately 7.5 m) with a stick-up height of 1.0 m above the ground at the deep testhole (TH16-01) location. This hole was backfilled with silica sand to approximately 6.9 m below grade and bentonite chips to the grade. The shallow holes were backfilled with auger cutting to 0.6 m below grade and bentonite chips to grade.

Diagnostic laboratory testing program was performed on representative soil samples to determine index properties of the subsurface soils. Diagnostic testing includes moisture content and Atterberg Limit testing. The soil samples were submitted to the laboratory of Stantec

Consulting Ltd. for diagnostic testing. Testing included six (6) Moisture Content tests, and two (2) Atterberg Limit tests.

Detailed soil logs incorporating all field observations, field test results, instrumentation installation details, and material testing results are provided in Appendix A.

3.0 INVESTIGATION RESULTS

3.1 STRATIGRAPHY

In general, the soil stratigraphy at the site has been interpreted by KGS Group to consist of silty clay overlying silt/clay till. The till was found at a depth of 6.2 m below existing grade (approx. El. 231.9 m).

Topsoil – An approximately 0.1 m thick layer of topsoil was encountered in all testholes. The topsoil was mainly organic clay, black in colour, damp to moist and contained trace rootlets.

Silty Clay (CH) – Silty clay was encountered underneath the topsoil in all of the testholes. The depth of silty clay was extended to 6.2 m below grade (approx. El. 231.9 m) at TH16-01 location. All other holes were terminated in this layer. The clay was damp to moist, greyish brown to brown in colour, stiff in consistency becoming firm with increasing depth, of high plasticity, and contained occasional sand seam, trace silt nodules and trace medium to coarse grained sand. Moisture content of the clay ranged approximately from 35 to 50 percent. Atterberg limit testing performed on two samples of the clay indicated that the average liquid limit was approximately 92 percent and the average plasticity index was found to be approximately 66 percent, resulting in material being classified as high plasticity clay (CH). The undrained shear strength of the clay deposit, determined from the field Torvane on disturbed auger cutting samples, ranged from 30 to 85 kPa.

Clay Till – An approximately 0.5 m thick transition layer of clay till was encountered in between silty clay and silt till at TH16-01 location. It was grey in colour, moist, of low plasticity and contained some medium to coarse grained sand, trace fine grained sand and trace fine to coarse grained gravel.

Silt Till – Silt till was encountered at a depth of 6.7 m below grade (approx. El. 231.4 m) at TH16-01 location. The silt till was tan in colour, loose to compact, and contained some fine to coarse grained sand and some fine to coarse grained gravel.

3.2 SEEPAGE, SLOUGHING, AND GROUNDWATER CONDITIONS

No significant squeezing or sloughing was encountered in the testholes. All the testholes remained open after drilling. The shallow holes typically remained dry after drilling except TH16-04 which was full of water due to wet location. Approximately 0.23 m of water was noticed at the bottom of the deep testhole (TH16-01) right after drilling. However, the water level was measured at 4.28 m below grade in the standpipe 2 hours after installation of the standpipe. The groundwater was further monitored on May 03, 2016. The groundwater monitoring data is given in Table-1.

It must be noted that groundwater level may fluctuate seasonally, or after periods of extended precipitation or drought, and as such may differ at other times.

TABLE 1
GROUNDWATER MONITORING DATA

Testhole:	**TH16-01**
Ground Elevation (m):	**238.14**
Instrumentation Type	**Standpipe**
Top of Pipe Elevation (m):	**239.15**
Tip Elevation (m):	**230.57**
Monitoring Zone:	**Silt Till**
Date	**Groundwater Elevation (m)**
19-Apr-16	233.86
3-May-16	234.81

Note: 1. April 19, 2016 reading was taken 2 hours after installation.

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

KGS Group has reviewed the preliminary drawings for the proposed construction and relevant available information. It is understood that the Effluent Monitoring Building consists of two levels including an underground chamber. The floor slab for the chamber will be approximately 5 m below grade. A reinforced concrete mat slab or raft foundation is recommended for the building. Detail geotechnical recommendations related to construction excavation, shoring, foundation, permanent wall, and backfilling are given below.

4.1 EXCAVATION AND CONSTRUCTION DEWATERING

The composition and consistencies of the lacustrine clay soils encountered at the site are such that conventional hydraulic excavators should be able to remove these materials. Construction excavations should be in accordance with good practice and comply with the requirements of the responsible regulatory agencies.

It is anticipated that shoring will be utilized for the proposed excavation. The shoring should be designed by a qualified professional engineer. The design and construction procedures should be submitted to KGS Group for review.

No surface surcharges should be placed closer to the edge of the excavation than a distance equal to the depth of the excavation, unless the excavation support system has been designed to accommodate such surcharge. Attention should be paid to underground buried service lines close to the excavation.

Based on the observation during drilling and monitored ground water condition, ground water inflow into the excavation should be expected. It is anticipated that water inflow may be controlled by conventional high capacity pumping equipment. The foundation contract should include provisions for the control and removal of groundwater.

4.2 TEMPORARY SHORING

The shoring design and construction excavation procedures should consider the following:

- The lateral earth pressure of the native soils, groundwater pressures, surcharge load from construction equipment, and any surcharge load from nearby existing structure buildings. The approximate lateral earth pressure coefficients for different native soils encountered at the site are given in Table 2.
- Potential for basal heave due to highest possible pore pressures during construction (**may be other pore pressures then those presented in this report**) at the base of the excavation.
- Minimizing potential lateral and vertical ground movements during the removal of temporary shoring and backfilling between the existing ground and the new foundation.

TABLE 2
LATERAL EARTH PRESSURE COEFFICIENTS

Material	Friction Angle (degrees)	Unit Weight (kN/m^3)	Earth Pressure Coefficient		
			Active	At-Rest	Passive
Silty Clay	20	19	0.49	0.65	2.0
Silt Till	30	20	0.33	0.50	3.0
Granular Fill	38	21	0.24	0.38	4.2

4.3 FOUNDATION CONSIDERATIONS

Reinforced concrete mat slab or raft foundations should be considered for the proposed Effluent Monitoring Building. The foundation can be designed on the basis of a factored Serviceability Limit States (SLS) bearing capacity of 80 kPa (SLS) and a factored Ultimate Limit State (ULS) value of 100 kPa. A Geotechnical Resistance Factor of 0.4 has been applied. Typically the Modulus of Subgrade Reaction is required for raft foundation design. Table-3 shows the estimated Vertical Modulus of Subgrade Reaction based on the findings of the geotechnical investigation and recommendations from the Canadian Foundation Engineering Manual.

TABLE 3
MODULUS OF SUBGRADE REACTION

Foundation Soil Type	Vertical Modulus of Subgrade Reaction, k_{v1} (MPa/m)*
Undisturbed Silty Clay	5

*k_{v1} is for 1 ft (0.3 m) x 1 ft (0.3 m) plate
Modulus for actual footing with width of b (in m) and length of nb (in m),
$k_{vb}= k_{v1}/3.28b*((n+0.5)/1.5n)$

The following recommendations should be considered for the proposed raft foundation to alleviate potential settlement concerns:

- The bearing surface should be examined and approved by qualified geotechnical personnel immediately after completion of excavation and prior to placement of reinforcement and concrete. Bearing soils which have become frozen, dried, or softened should be removed and replaced with granular base course material compacted to 100% of Standard Proctor Maximum Dry Density (SPMDD).
- The bearing surfaces should be protected against disturbance and degradation by applying a lean concrete mix over the exposed surface immediately following excavation.
- Raft areas should be protected from meteorological elements including freezing temperatures and water.

4.4 UPLIFT

The proposed Effluent Monitoring Building should be of sufficient weight and embedment within soil or otherwise anchored to resist the maximum anticipated hydrostatic uplift forces.

4.5 PERMANENT WALL PRESSURES

Permanent walls should be designed to resist lateral earth pressures, in the at rest condition, and may be designed using the following expression, which assumes a triangular pressure distribution:

$$P_o = K_o (\gamma H + q)$$

Where:

P_o = Lateral earth pressure at rest condition where no movements of walls occur at a given depth (kPa).
K_o = Coefficient of earth pressure at rest condition (see Table-2).
H = Depth below final grade (m).
q = Any surcharge pressure at ground level.
γ = Unit weight (kN/m^3)

The above noted expression assumes native material or backfill material compacted to approximately 95% of SPMDD and flat ground behind the permanent wall. If the ground surface slopes upwards away from the wall, design wall pressures should be re-evaluated.

Backfill around the permanent wall should not commence before the concrete walls have reached a minimum two-thirds of its 28-day strength and first floor framing and lower floor slab are in place. Only hand operated compaction should be employed within 600 mm of the concrete permanent walls.

4.6 BACKFILL MATERIALS AND COMPACTION

Backfill around the proposed new structure walls should be a clean granular material with less than 5% fines (passing the #200 sieve). The granular backfill should be compacted uniformly in maximum 150 mm lifts to a density of at least 98% of SPMDD. The top meter of the backfill should consist of well compacted clayey soils to reduce surface runoff infiltration. In addition, the base of the walls should be provided with a filter protected drainage system to prevent hydrostatic pressure build up against walls. Where drainage is not provided, the hydrostatic pressure against wall should be assumed with a groundwater level to be at the surface.

4.7 ACCESS ROAD OR PAD CONSIDERATIONS

The following is recommended for the construction of access road and parking pad at the site:

- Sub-excavate the surficial soils to the subgrade design elevation and perform proof-roll compaction of the silty clay subgrade. Scarify and re-compact the top 150 mm of subgrade to 98% of SPMDD. Areas that exhibit unsuitable deflection should be sub-excavated an additional 600 mm and replaced with compacted granular subbase.
- A minimum of 300 mm of granular subbase and 100 mm of granular base is recommended with a minimum of 75 mm traffic gravel.
- A light weight non-woven geotextile should be placed as a separator on top of the subgrade soil prior to placing subbase and base courses.

5.0 SUMMARY

- Based on drilling of four testholes at the site, the stratigraphy is interpreted to consist of silty clay underlain by clay/silt till. The silty clay extended to approximately 6.2 m below existing grade (approx. El. 231.9 m).

- Based on limited ground water monitoring data, the ground water level ranged between El. 233.9 m and El. 234.8 m. Actual groundwater level should be verified prior to commencement of construction.

- Temporary shoring will be required for the construction of the building and should be designed by a qualified professional engineer. The design and construction procedures should be submitted to KGS Group for review.

- Reinforced concrete mat slab/raft type of foundation is recommended for the Effluent Monitoring Building with a Vertical Modulus of Subgrade Reaction (k_{v1}) of 5 MPa/m (Modulus of actual footing should be calculated based on foundation dimension).

- The bearing surfaces for mat slabs should be approved by a qualified professional engineer and protected against disturbance and degradation by applying a lean concrete mix over the exposed surface immediately following excavation. Mat slab areas should be protected from meteorological elements including freezing temperatures and water.

- The access road and parking pad can be founded on the insitu clay subgrade prepared by proof-roll compaction and separated from the granular subbase using a non-woven geotextile.

6.0 STATEMENT OF LIMITATIONS AND CONDITIONS

6.1 THIRD PARTY USE OF REPORT

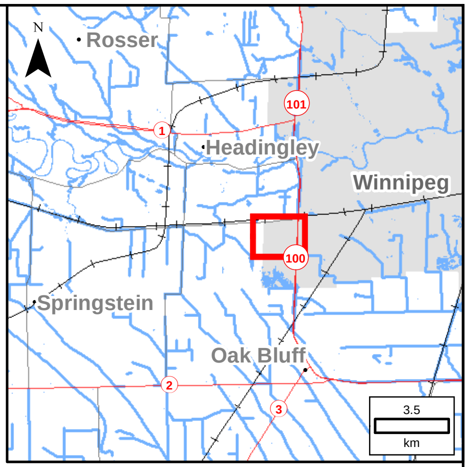
This report has been prepared for the City of Winnipeg to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

6.2 GEOTECHNICAL INVESTIGATION STATEMENT OF LIMITATIONS

The geotechnical investigation findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. The findings and recommendations are based on the results of field and laboratory investigations, combined with an interpolation of soil and groundwater conditions found at and within the depth of the testholes drilled by KGS Group at this site. If conditions encountered during construction appear to be different from those shown by the testholes drilled by KGS Group or if the assumptions stated herein are not in keeping with the design, this office should be notified in order that the recommendations can be reviewed and modified if necessary.

FIGURES

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



LEGEND:

▚	Testhole
◎	Testhole / Standpipe Piezometer
—	Highway
—	Provincial Road
┼	Railway

NOTES:

1. Testhole locations were surveyed by KGS Group, April 2016.
2. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, Zone 14 Elevations are in metres above sea level (MSL)

100 0 100 200 300

Metres

SCALE: 1:7,500 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
00	16/06/07	ISSUED WITH FINAL REPORT	KMR	MSW

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

WEST END SEWAGE TREATMENT PLANT
EFFLUENT MONITORING STATION

TESTHOLE LOCATION SITE PLAN

JUNE 2016

FIGURE 1

REV: 00

FileName: P:\Projects\2015\15-0107-019\Dwg\GIS\MXDs\Rev0\15-0107-019_Fig1_Rev0.mxd
11"x17" PLOT SCALE 1:1

APPENDIX A

TESTHOLE LOG RECORD

KGS GROUP

SUMMARY LOG

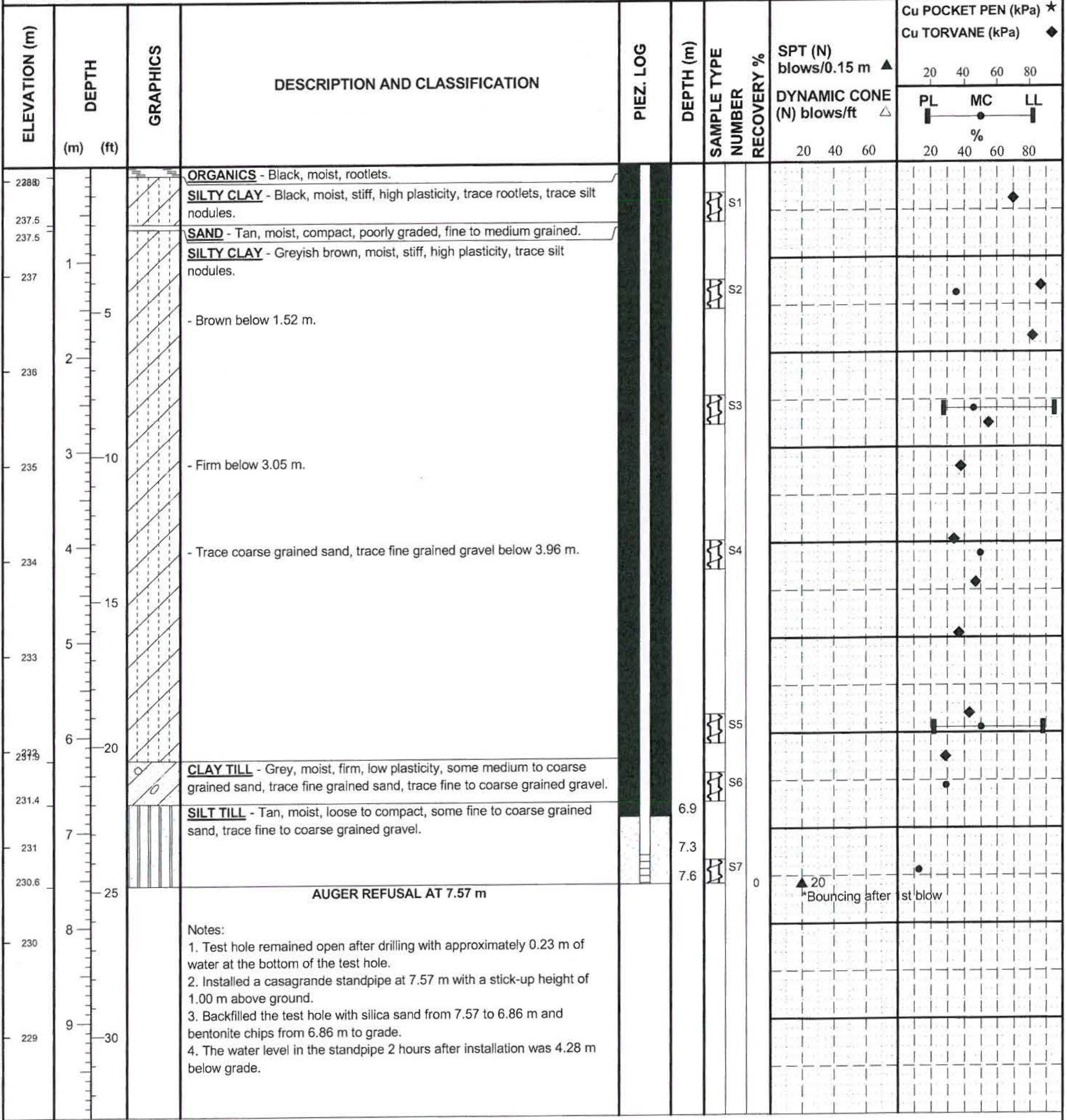
REFERENCE NO.

HOLE NO. **TH16-01**

SHEET 1 of 1

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT EFFLUENT MONITORING STATION
SITE West End Sewage Treatment Plant
LOCATION ~8 m South of Effluent Outfall Pipe at Toe of Slope
DRILLING METHOD 125 mm ø Solid Stem Auger, Acker SX

JOB NO. 15-0107-019
GROUND ELEV. 238.14
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 4/19/2016
UTM (m) N 5,520,925
E 619,059



ORGANICS - Black, moist, rootlets.

SILTY CLAY - Black, moist, stiff, high plasticity, trace rootlets, trace silt nodules.

SAND - Tan, moist, compact, poorly graded, fine to medium grained.

SILTY CLAY - Greyish brown, moist, stiff, high plasticity, trace silt nodules.

- Brown below 1.52 m.

- Firm below 3.05 m.

- Trace coarse grained sand, trace fine grained gravel below 3.96 m.

CLAY TILL - Grey, moist, firm, low plasticity, some medium to coarse grained sand, trace fine grained sand, trace fine to coarse grained gravel.

SILT TILL - Tan, moist, loose to compact, some fine to coarse grained sand, trace fine to coarse grained gravel.

AUGER REFUSAL AT 7.57 m

Notes:
1. Test hole remained open after drilling with approximately 0.23 m of water at the bottom of the test hole.
2. Installed a casagrande standpipe at 7.57 m with a stick-up height of 1.00 m above ground.
3. Backfilled the test hole with silica sand from 7.57 to 6.86 m and bentonite chips from 6.86 m to grade.
4. The water level in the standpipe 2 hours after installation was 4.28 m below grade.

SAMPLE TYPE 🝖 Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN		6/2/16

KGS GROUP

SUMMARY LOG

REFERENCE NO.

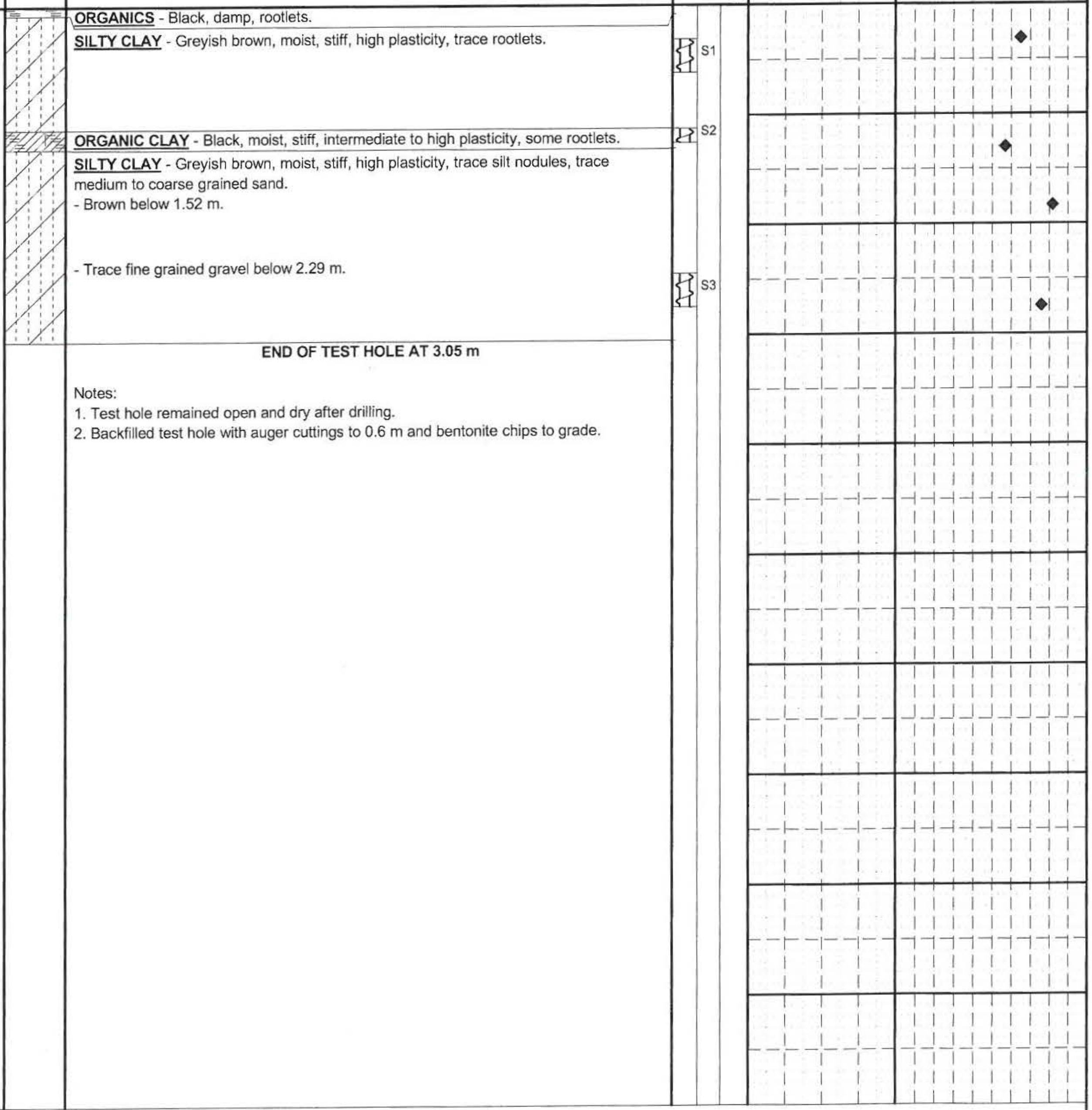
HOLE NO. **TH16-02**

SHEET 1 of 1

CLIENT	CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT	JOB NO.	15-0107-019
PROJECT	EFFLUENT MONITORING STATION	GROUND ELEV.	238.70
		TOP OF PVC ELEV.	
SITE	West End Sewage Treatment Plant	WATER ELEV.	
LOCATION	~2.5 m East of Fenceline	DATE DRILLED	4/19/2016
		UTM (m)	N 5,521,137
DRILLING METHOD	125 mm ø Solid Stem Auger, Acker SX		E 619,052

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER
238.6		ORGANICS - Black, damp, rootlets.		
		SILTY CLAY - Greyish brown, moist, stiff, high plasticity, trace rootlets.	Auger Grab	S1
237.6		ORGANIC CLAY - Black, moist, stiff, intermediate to high plasticity, some rootlets.	Auger Grab	S2
237.4		SILTY CLAY - Greyish brown, moist, stiff, high plasticity, trace silt nodules, trace medium to coarse grained sand. - Brown below 1.52 m. - Trace fine grained gravel below 2.29 m.	Auger Grab	S3
235.7	3	END OF TEST HOLE AT 3.05 m		

Notes:
1. Test hole remained open and dry after drilling.
2. Backfilled test hole with auger cuttings to 0.6 m and bentonite chips to grade.



SAMPLE TYPE Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN		6/2/16

GEOTECHNICAL-SOIL LOG U:\FMS\15-0107-019\WEWPCC EFFLUENT MONITORING STATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH16-03**

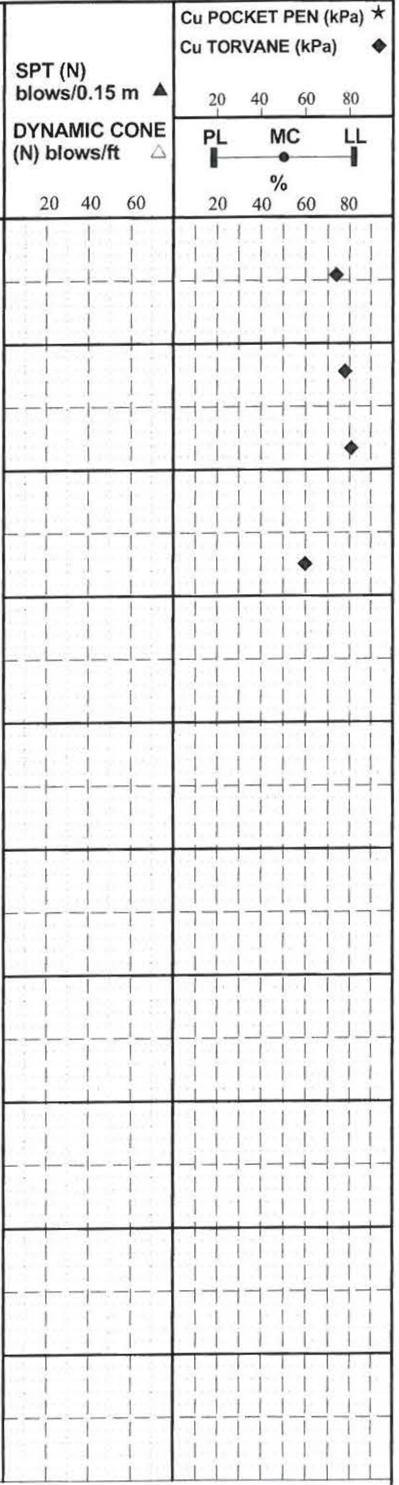
SHEET 1 of 1

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT EFFLUENT MONITORING STATION
SITE West End Sewage Treatment Plant
LOCATION ~2 m East of Fenceline in line with North Lagoon Limit
DRILLING METHOD 125 mm ø Solid Stem Auger, Acker SX

JOB NO. 15-0107-019
GROUND ELEV. 238.40
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 4/19/2016
UTM (m) N 5,521,467
E 619,066

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER
238.3		**ORGANICS** - Black, damp, rootlets.		
		SILTY CLAY - Greyish brown, moist, stiff, high plasticity, trace rootlets.		
			Auger Grab	S1
		- No rootlets below 1.22 m.		
		- Brown, trace silt nodules below 1.52 m.	Auger Grab	S2
			Auger Grab	S3
235.4	3	END OF TEST HOLE AT 3.05 m		

Notes:
1. Test hole remained open and dry after drilling.
2. Backfilled test hole with auger cuttings to 0.6 m and bentonite chips to grade.



SAMPLE TYPE Auger Grab

CONTRACTOR Paddock Drilling Ltd.
INSPECTOR C. FRIESEN
APPROVED
DATE 6/2/16

GEOTECHNICAL-SOIL LOG U:\FMS\15-0107-019\WEWPCC EFFLUENT MONITORING STATION.GPJ

KGS GROUP

SUMMARY LOG

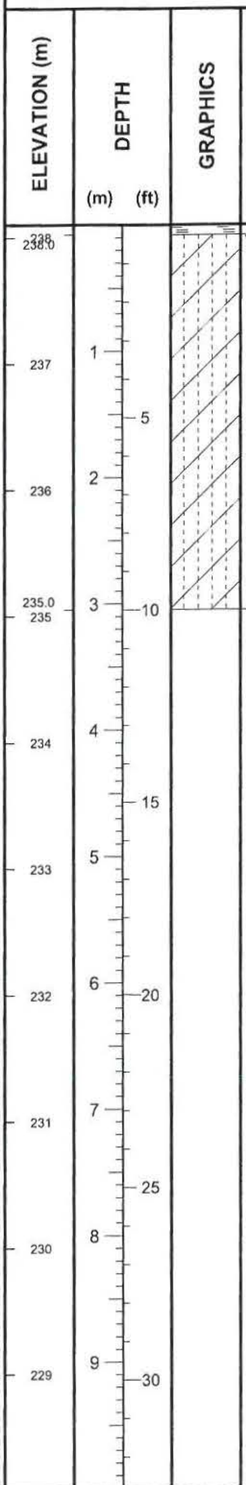
REFERENCE NO.

HOLE NO. **TH16-04**

SHEET 1 of 1

CLIENT	CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT	EFFLUENT MONITORING STATION
SITE	West End Sewage Treatment Plant
LOCATION	~2.5 m South of Fenceline
DRILLING METHOD	125 mm ø Solid Stem Auger, Acker SX

JOB NO.	15-0107-019
GROUND ELEV.	238.10
TOP OF PVC ELEV.	
WATER ELEV.	
DATE DRILLED	4/19/2016
UTM (m)	N 5,521,485 E 619,340



DESCRIPTION AND CLASSIFICATION

ORGANICS - Black, moist, rootlets.

SILTY CLAY - Greyish brown, moist, firm, high plasticity, trace rootlets.

- Stiff below 0.61 m.

- No rootlets below 1.22 m.

- Brown, trace silt nodules below 1.52 m.

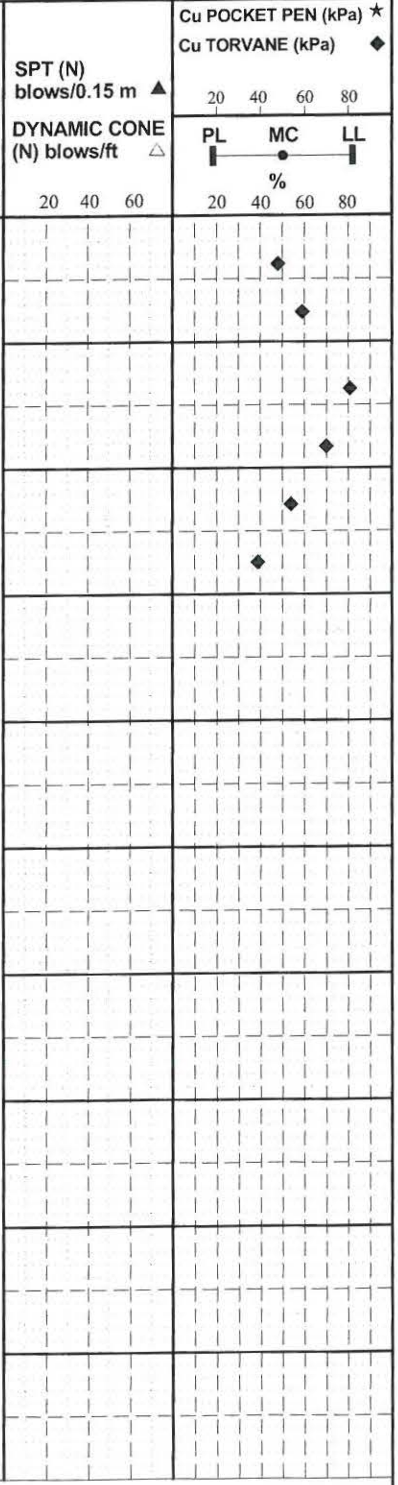
- Firm below 2.44 m.

END OF TEST HOLE AT 3.05 m

Notes:

1. Test hole remained open after drilling and mostly full of water due to wet location.
2. Backfilled test hole with auger cuttings to 0.6 m and bentonite chips to grade.

SAMPLE TYPE	NUMBER	RECOVERY %
Auger Grab	S1	
Auger Grab	S2	
Auger Grab	S3	



SAMPLE TYPE Auger Grab

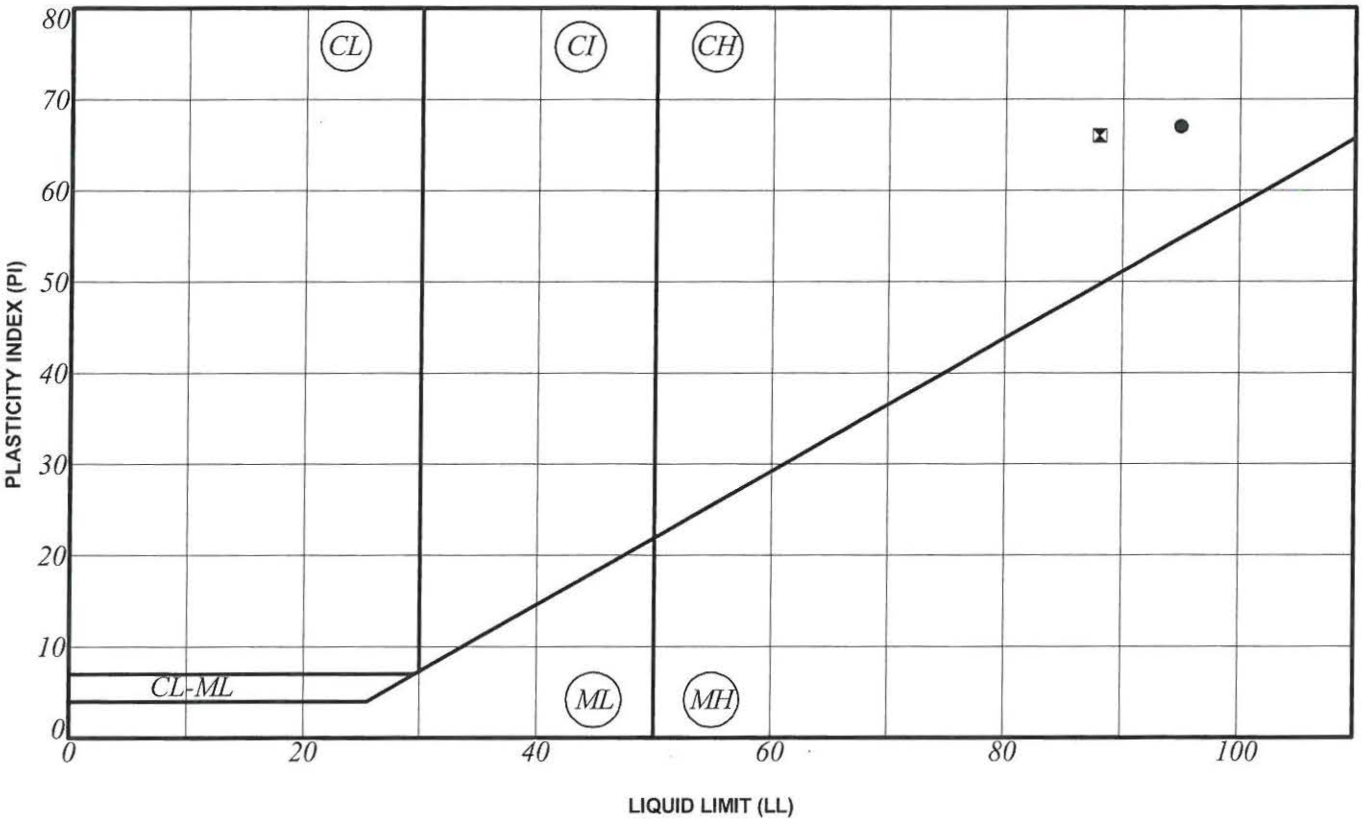
CONTRACTOR Paddock Drilling Ltd.

INSPECTOR C. FRIESEN

APPROVED

DATE 6/2/16

GEOTECHNICAL-SOIL LOG U:\FMS\15-0107-019\WEWPCC EFFLUENT MONITORING STATION.GPJ



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH16-01	2.4	S3	95	28	67				45.7	CH
☒	TH16-01	5.8	S5	88	22	66				50.2	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

KGS GROUP

CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT

EFFLUENT MONITORING STATION

A-LINE PLOT

June 2016	**Figure 1**	**Page 1 of 1**

A-LINE PLOT U:\FMS\15-0107-019\WEWPCC EFFLUENT MONITORING STATION.GPJ