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Talbot River Dam, Lock 39 and Talbot Canal 2013 Geotechnical Site Investigation Report

FINAL

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1.0 INTRODUCTION

1.1 BACKGROUND

KGS Group was retained by Public Works and Government Service Canada (PWGSC) to complete a geotechnical investigation for the Talbot River Dam, Lock 39 and Talbot Canal. The purpose of the investigation was to obtain geotechnical data to determine the material types and characteristics of the embankment fill and the foundations for use in the dam safety review (DSR) currently underway. Monitoring well and vibrating wire piezometers were also installed to measure the piezometric level within the embankments. The embankment material properties and the piezometric data will be incorporated into the evaluation of the geotechnical performance of the structure as part of the Dam Safety Review (DSR) being undertaken for PWGSC. Any investigations needed to complete final design of remedial measures that may be recommended from the DSR is separate and not included.

The site is located on the Talbot River near the town of Bolsover, Ontario (approximately 7 km west of Bolsover), and 1.2 km downstream from Lock 38 / Talbot Dam. The site is accessible from Canal Road from Hwy 50. The Talbot River Dam is a concrete gravity dam founded on bedrock and built in 1908 to maintain the navigation levels on the waterway and provide control of the watershed. There are two earthfill embankment structures associated with the Talbot River Dam. The Right Earthfill Embankment is 114 m long and consists of earthfill with a concrete core and an additional 14 m long end section with sheet pile core. The Left Earthfill Embankment is a part of the Northwest Earthfill Embankment of the Talbot Canal and consists of earthfill with a 12 m long concrete core wall from the concrete dam structure. Lock 39 is also a concrete gravity structure founded on timber piles and was constructed in 1908. Talbot Canal runs from Talbot River Dam to Lock 39, and includes two earth embankments (Northwest and Southeast Canal Earthfill Embankments) on either side of the nearly 1400 m long canal. The locations of the earthfill and concrete structures are shown in Figures 2.1a, 2.1b and Figure 2.1c.

Review of the existing documentation has shown that there was limited to no information on the earthfill materials used as backfill for the embankments and concrete walls. Initial / preliminary analyses of the earthfill embankments and concrete structures were completed as part of the DSR to evaluate the stability of the structures with variable assumptions on backfill materials

and piezometric levels. These analyses have shown that the stability conditions are very sensitive to the geotechnical assumptions, and this site investigation was performed to better identify the geotechnical conditions for incorporation into the DSR and better represent the actual stability conditions.

This geotechnical program was undertaken to provide key fill and foundation properties for incorporation into the DSR. However, the program was not considered extensive, and investigation activities that could be potentially required for design of any remedial work have not been included in this program.

A detailed scope of KGS Group's services is summarized below:

- Drilling of exploratory test holes, soil sampling and laboratory testing;
- Excavating test pits;
- Determination of embankment fill materials, foundation soils and their engineering characteristics;
- Assessment of the foundation conditions of the embankments;
- Installation of an automated piezometer system for monitoring the porewater pressure within the earthfill embankments.

2.0 2013 SITE INVESTIGATION PROGRAM

The 2013 site investigations program was undertaken to obtain the geotechnical data required to determine the embankment material types and engineering properties of the embankment fills and foundations, and to install monitoring wells and vibrating wire piezometers to measure the piezometric levels. The embankment material properties and the piezometric data were then incorporated into the evaluation of the geotechnical performance of the structure as part of the DSR.

The geotechnical exploratory program consisted of the following:

- Drilling of a total of fifteen (15) test holes along the crest of the embankments to the underlying bedrock and / or native soil to determine the composition and properties of the embankment fill materials and to assess the foundation conditions.
    - Six (6) test holes at Talbot River Dam: one (1) at Left (South) Earthfill Embankment and five (5) test holes at Right (North) Earthfill Embankment.
    - Two (2) test holes at the north side of the Lock 39.
    - Seven (7) test holes at the Talbot Canal Earthfill embankments: four (4) along the Northwest Canal Earthfill Embankment and three (3) test holes along the Southeast Canal Earthfill Embankment.
- Excavating four (4) test pits along the upstream side of the earthfill embankments of the Talbot Canal.
- Installation of three (3) monitoring wells (standpipes) and two (2) vibrating wire (VW) piezometers in the embankments;
    - One (1) VW piezometer and one (1) standpipe at Right (North) Earthfill Embankment of Talbot River Dam.
    - One (1) VW piezometer and one (1) standpipe at the north side of the Lock 39 structure.
    - One (1) standpipe at the Northwest Canal Earthfill Embankment at Talbot Canal.
- Completing laboratory index testing and advanced soil testing on representative embankment materials and the foundation soils.

Health and Safety and Environmental Protection Plans were prepared and submitted to PWGSC for review and approval prior to any work being conducted on site. Public Works and

Government Service Canada (PWGSC) and Parks Canada Agency (PCA) staff conducted an internal environmental assessment of the work plan, and confirmed the requirements for the field operation.

2.1 TEST HOLE DRILLING AND SAMPLING PROGRAM

The drilling services were provided by Ohlmann Geotechnical Services Inc. (OGS) of Almonte, Ontario. Laboratory testing of selected soil samples was completed at the Golder Associates Soils Laboratory in Mississauga, Ontario.

The drilling of the test holes and soil sampling was completed between June 5 and June 9, 2013 under continuous supervision and direction of KGS Group. Eight (8) test holes (TH13-105, TH13-201 and 202, and TH13-301 to 305) were readily accessible and were drilled using a bombardier mounted drill rig (CME75) equipped with continuous 200 mm diameter hollow stem augers and an automatic hammer, as shown in Photo 1. The other seven (7) test holes (TH13-101 to TH13-104, TH13-104a, and TH13-306 to 307) were not accessible by vehicle and were drilled using a standard portable-type drill rig equipped with casing-wash boring and a manual hammer, as shown in Photo 2.

All test holes were advanced to the underlying bedrock or native soils, as indicated in Table 2.1-1. The approximate locations of the test holes and test pits are shown in Figures 2.1a, 2.1b and 2.1c. Standard Penetration Tests (SPT's) were performed as part of the drilling program to estimate the in-situ density of the embankment fill and foundation soils, and disturbed soil samples were recovered from the sampler. All samples were visually classified in the field according to the Unified Soil Classification System (USCS) and representative samples were selected and bagged for laboratory testing. A Shelby tube sample of clayey soil was recovered within TH13-105 for a Consolidated Undrain Triaxial test. Detailed borehole log records that contain all field observations, soil descriptions, groundwater levels and laboratory test results are included in Appendix A.

TABLE 2.1-1
TALBOT RIVER DAM, LOCK 39 AND TALBOT CANAL - SUMMARY OF 2013 DRILLING PROGRAM

Structure	Test Hole #	Location	Total Depth Drilled (m)	Fill Thickness (m)*
Talbot River Dam	TH13-101 (Crest-D/S side)	Right Earthfill Embankment	6.55	5.5
	TH13-102 (Crest-U/S side)		6.02	5.8
	TH13-103 (Crest-D/S side)		6.02	5.8
	TH13-104 (Crest-U/S side)		2.13	2.1+
	TH13-104a (Crest-D/S side)		6.40	6.4
	TH13-105 (Crest-U/S side)	Left Earthfill Embankment	7.01	5.8
Lock 39	TH13-201 (Crest-U/S side)	North side	10.97	9.5
	TH13-202 (Crest-U/S side)		10.97	9.5
Talbot Canal	TH13-301 (Crest-U/S side)	Northwest Earthfill Embankment	6.55	±3.5
	TH13-302 (Crest-D/S side)		5.03	±3.2
	TH13-303 (Crest-U/S side)		5.03	±3.1
	TH13-304 (Crest-U/S side)		5.03	±3.3
	TH13-305	Southeast Earthfill Embankment	5.03	±3.1
	TH13-306 (Crest)		6.71	±3.0
	TH13-307 (Crest-U/S side)		4.88	±2.3

* Fill thickness was approximated based on visual inspection of the test holes and samples recovered, and was sometimes difficult to distinguish due to the similarity to the underlying native materials.

PHOTO 1
CME 75 DRILL RIG AT TH13-202

PHOTO 2
ELECTRICAL PORTABLE DRILLING EQUIPMENT AT TH13-101

FIGURE 2.1A
APPROXIMATE TEST HOLE LOCATIONS – TALBOT RIVER DAM

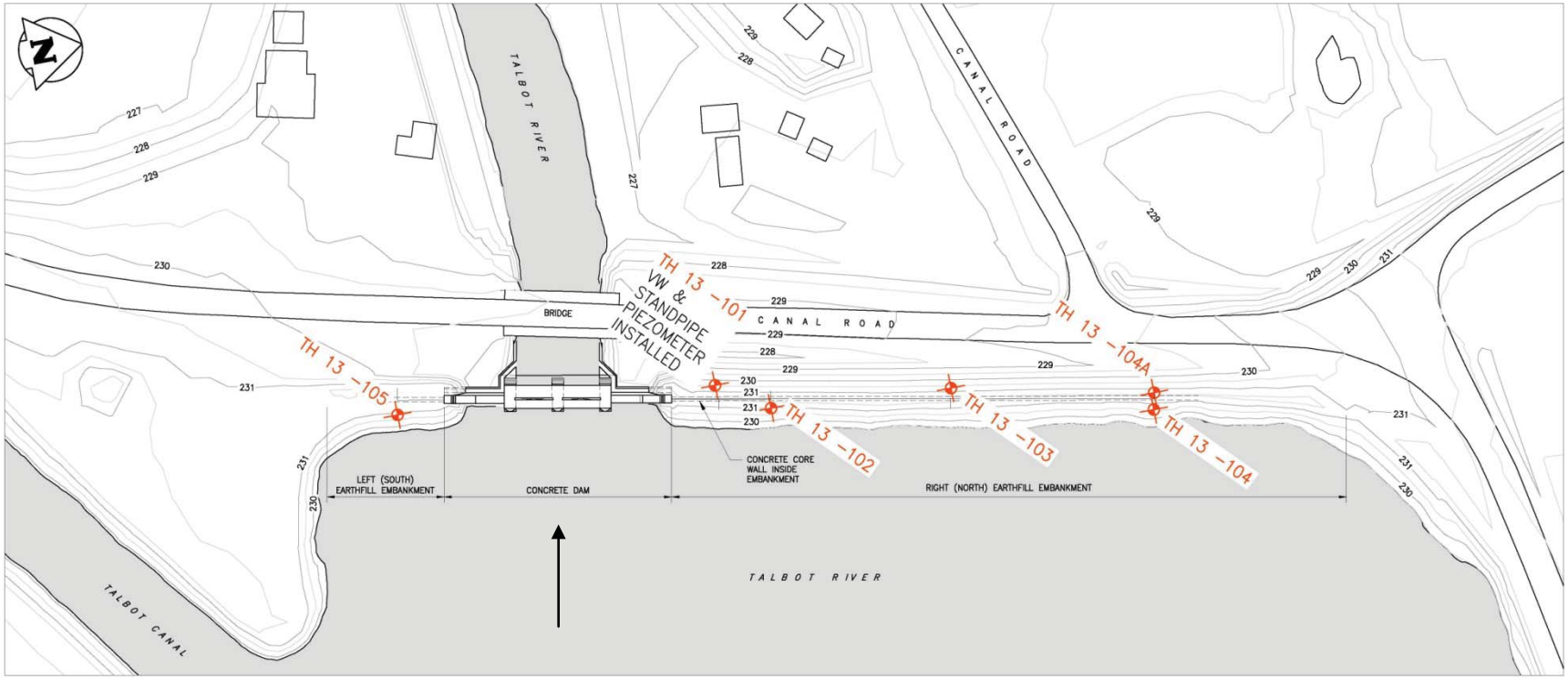


FIGURE 2.1B
APPROXIMATE TEST HOLE LOCATIONS – LOCK 39

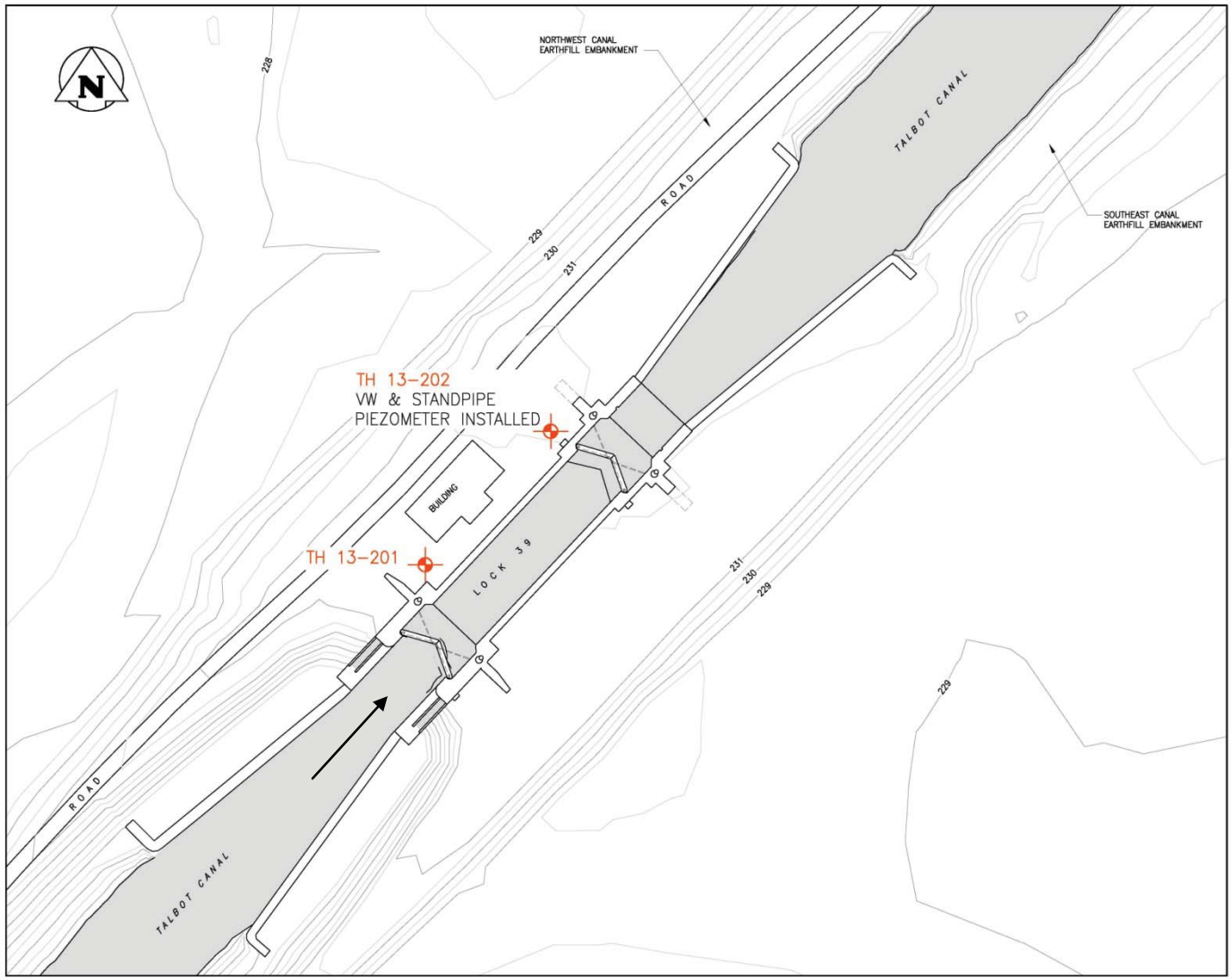
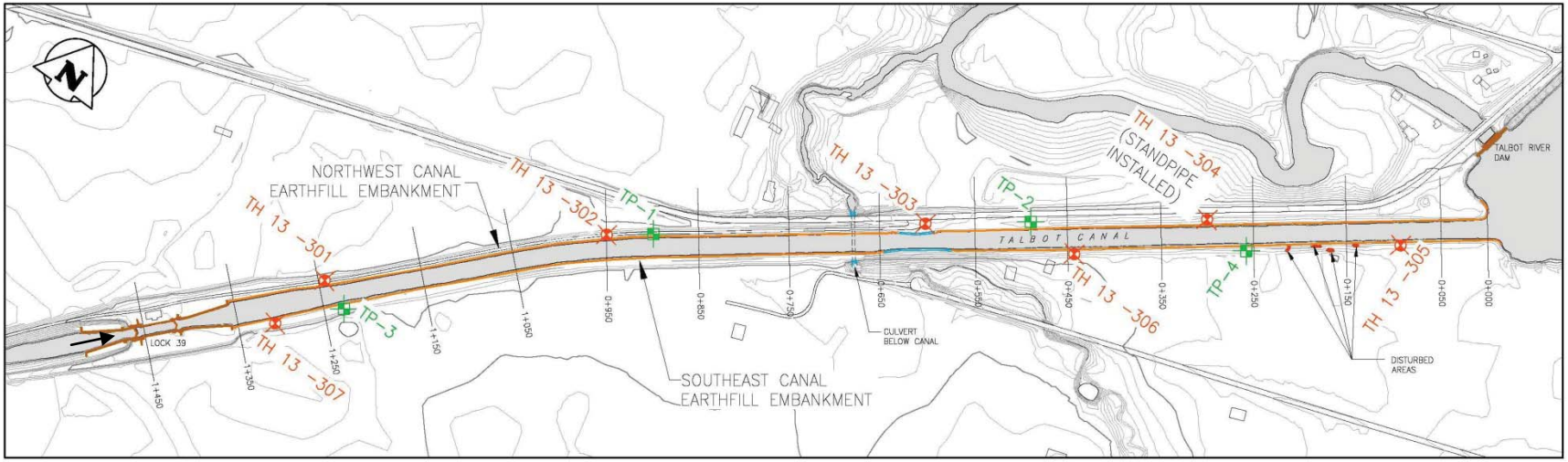


FIGURE 2.1C
APPROXIMATE TEST HOLE AND TEST PIT LOCATIONS – TALBOT CANAL



2.2 TEST PITTING

The PWGSC Terms of Reference document for the DSR noted that a steel sheet pile wall was installed along the crest of both embankments at the upstream portion, however no background documentation or drawings were available to confirm the existence of the sheet piles and PCA personal could not confirm that sheet piles were installed in these embankments. Test pitting (TP-1 to TP-4) was performed using a rubber tire backhoe at four select locations along the canal embankments to try and identify whether the sheet piles were installed. The test pit locations are shown in the Figure 2.1c.

2.3 INSTRUMENTATION - PIEZOMETER INSTALLATION

As described in Section 2.0, three (3) standpipes (in TH13-101, -202 and -304) and two (2) VW piezometers (in TH13-101 and -202) were installed to monitor the groundwater conditions within the embankments and their foundations. Installation details, including the tip elevations of the piezometers, are shown on the summary test hole logs in Appendix A.

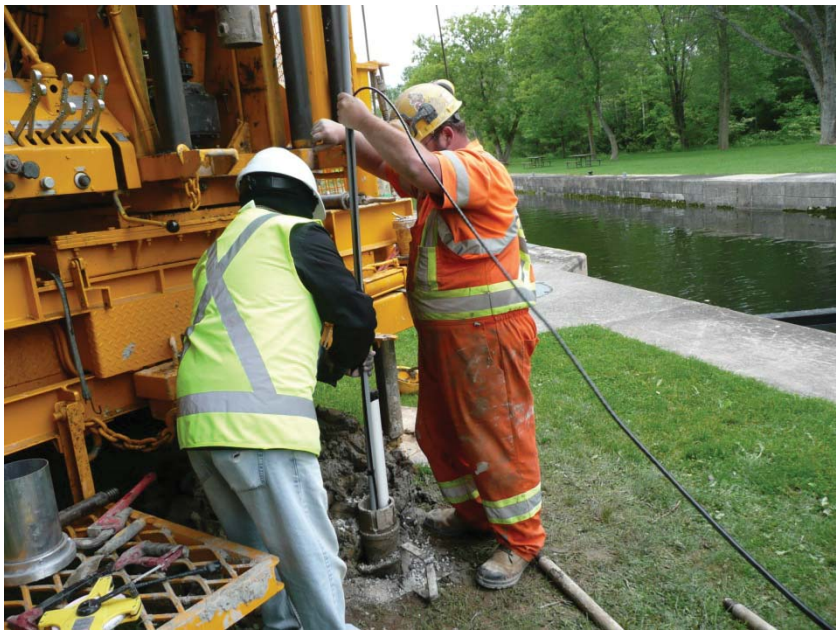
The standpipe requires manual reading to measure the groundwater level. The vibrating wire piezometers were connected to automated data loggers to continuously monitor piezometric levels and temperature within the embankment fills and the foundation soils. Detailed descriptions of the logger are provided in the following section. All piezometer readings collected to September 2013 are presented in Section 3.4.

PHOTO 3
INSTALLATION OF STANDPIPE PIEZOMETER AT TH13-202

PHOTO 4
DT 2011 VIBRATING WIRE PIEZOMETER INSTALLED AT TH13-202

PHOTO 5

INSTALLATION OF VIBRATING WIRE PIEZOMETER AT TH13-202



2.3.1 Single Channel Vibrating Wire Data Loggers

A Single Channel Data Logger Model DT2011 (Figure 2.3-1), manufactured by RST instruments, was installed on each of the piezometers in TH13-202 and TH13-105 in the earthfill embankments. The vibrating wire piezometer and battery powered data logger are economic and designed for reliable, unattended and continuous monitoring of a single vibrating wire sensor. The logger is encased in a water resistant IP 66 enclosure and connects directly to the vibrating wire piezometer via an IP68 rated sealed entry. The DT2011 loggers run on two (2) “AA” alkaline batteries and have an internal memory of 128KB that can store over 30,000 data sets of frequency and temperature. The operating temperature of the recorder is between –40°C to 60°C. Periodic battery changing and downloading of the data is typically performed two times per year.

FIGURE 2.3-1
DT2011 DATA LOGGER WITH VIBRATING WIRE PIEZOMETER

The DT2011 loggers are controlled and programmed with the Windows-based LogViewer® Software. Prior to installation, the DT2011 logger was programmed and verified in the field to ensure it was functioning properly. The vibrating wire piezometer was read with a standard readout box and readings were compared to DT2011 values for verification.

2.4 LABORATORY TESTING

Routine index and advanced laboratory testing were performed on select soil samples for use in material classification and characterization, as well as estimation of shear strength parameters. The routine index testing included moisture content testing, grain size analysis and plasticity index testing (Atterberg Limits testing). Advanced laboratory testing included Consolidated Undrained (CU) Triaxial testing for a Shelby tube sample of clayey silt fill and Consolidated Drained Direct Shear testing (DST) on reconstituted samples of sandy silt to silty sand fill obtained from the split spoon. The laboratory testing was completed at Golder Associates Ltd. Soil Laboratory in Mississauga, Ontario, with the results interpreted by KGS Group for use in the geotechnical evaluation of the DSR. The following soil testing standards of the American Society for Testing and Materials (ASTM) were used for the soil testing:

- ASTM D422 - Standard Test Method for Particle-Size Analysis of Soils;
- ASTM D1140 - Test Method for Amount of Material in Soils Finer than the No. 200 Sieve;
- ASTM D2216 - Standard Test Method for Laboratory Determination of Water (Moisture);

- ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity;
- ASTM D3080 - Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions;
- ASTM D4767 - Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.

3.0 SITE INVESTIGATION RESULTS

The site investigation program was undertaken to assess the engineering characteristics of the embankment fill materials and the foundation soils, and included drilling a total of fifteen (15) test holes and excavating four (4) shallow test pits. Soil stratigraphy and groundwater conditions encountered in each of the exploratory test holes are provided in Appendix A. The results of the laboratory tests completed on selected soil samples are presented in Table 3.5-1 and are also included in the summary logs. The soil classification and description provided herein are in accordance with the Unified Soil Classification System (USCS).

3.1 RIGHT AND LEFT EARTHFILL EMBANKMENTS - TALBOT RIVER DAM

3.1.1 Embankment Fill

The fill materials encountered within the Right and Left Earthfill Embankment consisted mainly of sandy silt to silty sand. Some clayey silt to silty clay fill materials were also encountered. The depth of the embankment fill estimated from test holes drilled along the crest varied from 5.5 to 6.4 m. The crest elevation of the embankments at the test hole locations varied between 231.15 and 231.33 m (approximate bottom of fill at El. 225.8 to 225.0 m±).

- ***Sandy Silt to Silty Sand Fill*** – Sandy silt to silty sand fill was encountered within the earthfill embankments at both the upstream and downstream sides of the Right Earthfill Embankment. The sandy silt to silty sand fill extended from the crest to depths varying between 5.5 m to 6.4 m at the downstream side and 1.8 m to over 2.1 m at the upstream side. The sandy silt to silty sand fill was generally brown, moist to wet, contained trace clay and gravel, and was in a loose to compact state with an average measured (uncorrected) SPT N-value of 5 blows per 300 mm (ranging from 1 to 24 blows per 300 mm). The moisture content ranged from 12% to 29% with an average of approximately 21% according to the laboratory testing. Grain size analyses indicated that the sand/silt fill typically consisted of approximately 50% sand (ranging from 37% to 65%) and 40% silt (ranging from 28% to 46%).
- ***Clayey Silt to Silty Clay Fill*** – Clayey silt to silty clay fill was encountered below the sandy silt to silty sand fill at the upstream side of the Right Earthfill Embankment and from the crest at the upstream side of the Left Earthfill Embankment. The clayey silt to

silty clay fill extended to depths varying between 5.5 to 5.8 m. In general, this fill was typically brown to grey, moist to very moist, very soft to soft in consistency, of intermediate plasticity, and contained trace amounts of fine-grained sand. The measured (uncorrected) SPT N-values were typically at or below 2 blows per 300 mm indicating soft to very soft in consistency. Moisture content ranged from 36% to 43% with an average value of approximately 39%. Atterberg Limits testing indicated that the clayey silt to silty clay was of intermediate plasticity (Liquid Limit from 28% to 48%, Plastic Limit from 14 to 20% and Plasticity Index from 14% to 28%). At 4 m depth in TH13-102, the in-situ moisture content was approximately at the liquid limit. Grain size analyses indicated that the clayey silt to silty clay fill consisted of approximately 42 to 56% silt and 38 to 55% clay.

3.1.2 Sandy Silt Till

The embankment fill was underlain by native soil of glacial origin consisting of sandy silt till which extended below depths varying between 5.5 to 5.8 m (or from El. 225.5 m to 225.8 m) below ground surface to bedrock. The sandy silt till was typically grey in colour, low plasticity to non plastic, moist to wet and contained a varying amount of sand and silt. The measured (uncorrected) SPT N-value of 38 blows per 300 mm to greater than 50 blows per 150 mm (exceeding the SPT refusal criteria), indicating the sandy silt till was generally in a dense to very dense state. The moisture content was about 6% from one laboratory test on one typical till sample. A grain size analysis test indicated that the till consisted of approximately 45% sand, 33% silt, 16% clay and 6% gravel.

3.1.3 Bedrock

Coring of the bedrock was performed at one test hole (TH13-101) located at the Right Earthfill Embankment, and extended approximately 250 mm into intact bedrock. Coring identified that the bedrock was grey limestone below the glacial till at El. 225 m (approximately 6.2 m below the ground surface). Power auger refusal was encountered at a depth of 7.01 m (EL. 224.1 m) at TH13-105 at the Left Earthfill Embankment on presumed sound bedrock. A suspected thin limestone layer was encountered in the SPT sampler at the bottom of the hole (depth of 6.4 m)

at the Right Earthfill Embankment (EL. 224.9 m) at TH13-104a. This also indicated the suspected limestone bedrock.

3.2 NORTH SIDE OF LOCK 39 EARTHFILL EMBANKMENT

3.2.1 Embankment Fill

The fill material encountered within the north side of Lock 39 mainly consisted of clayey silt to silty clay. The clayey silt to silty clay fill (embankment fill) extended from the ground surface to approximately 9.5 m deep to the underlying till (El. 221.9 m). The ground surface of the embankment at the test holes locations varied between 231.33 and 231.40 m. In general, the clayey silt to silty clay fill was typically brown to grey, moist to very moist, soft to very soft in consistency, of low plasticity, and contained trace amounts of fine-grained sand and trace to some topsoil at some depths. The measured (uncorrected) SPT N-values averaged at 3 blows per 300 mm and ranged from 2 to 6 blows/300mm indicating a soft to very soft in consistency. The moisture content ranged from 19% to 39% with an average value of approximately 27%. Atterberg Limits testing indicated that the clayey silt to silty clay was of low plasticity (Liquid Limit averaged at 24%, Plastic Limit averaged at 17% and Plasticity Index averaged at 7%). Grain size analyses indicated that the fill consisted of approximately 74% silt (ranging from 72% to 76%), approximately 16% clay (ranging from 15 to 18%) and approximately 10% sand (ranging from 7 to 13%).

3.2.2 Sandy Silt Till

The embankment fill was underlain by native sandy silt till which was observed at a depth of approximately 9.5 m below grade (El. 221.9 m). The sandy silt till layer extended to a depth of over 11 m below the ground surface (El. 220.4 m) where both test holes were ended. The sandy silt till was typically grey in colour, low plasticity to non plastic, moist to wet and contained a varying amount of sand and silt and wet fine grained sand layers. Sand material backed up into the hollow stem augers at an approximate depth of 11 m at TH13-201 where the drilling had to be discontinued. The measured (uncorrected) SPT N-value of 15 and 24 blows per 300 mm indicated that the sandy silt till was generally in a compact state. The moisture content ranged from 10% to 17% and averaged at approximately 14%. A grain size analysis test indicated that

the till consisted of approximately 68% silt, 13% silt and 19% clay. Bedrock was not encountered at a maximum depth of approximately 11.0 m below grade (El. 220.4 m) at the end of both test holes, TH13-201 and TH13-202.

3.3 NORTHWEST AND SOUTHEAST CANAL EARTHFILL EMBANKMENTS- TALBOT CANAL

3.3.1 Embankment Fill

The fill materials encountered within the canal embankments mainly consisted of clayey silt to silty clay fill. The thickness of the embankment fill material estimated from the test holes varied from 2.3 to 3.5 m. The crest elevation of the canal embankments at the test hole locations varied between 231.20 and 231.53 m (approximate bottom of fill at El. 228.9 to 227.9 m).

A 200 mm thick black topsoil layer or granular fill was encountered at the ground surface of the test holes (i.e. crest of embankments). The upper topsoil or granular layers were underlain by a clayey silt and silty clay fill, which was typically brown, moist to very moist and of intermediate plasticity. The clayey silt to silty clay fill contained trace amounts to some fine-grained sand and trace to some topsoil at occasional depths. A 200 to 300 mm thick black topsoil layer was encountered at the depths of 2.2 m and 3.2 m at TH13-302 and -307 respectively, and were likely the original topsoil at the base of the embankment during the construction. The uncorrected SPT N-values were typically 1 to 4 blows per 300 mm indicating a soft to very soft in consistency, but reached up to 14 blows/300 mm at the shallow depths at TH13-302, -305 and -307. The moisture content was tested and ranged from 14% to 34% with an average value of approximately 25%. Atterberg Limits testing indicated that the clayey silt was of intermediate plasticity (Liquid Limit averaged at 41%, Plastic Limit averaged at 18% and Plasticity Index averaged at 23%). A grain size analysis (TH13-306 S4) indicated that the clayey silt fill typically consisted of approximately 81% silt plus clay (approximately 10% clay) and 19% sand.

3.3.2 Native Clayey Silt to Silty Clay

Clayey silt to silty clay (native soil) was encountered below the embankment fill, and extended from the bottom of the embankment to a depth varying approximately from 4.9 m to 6.6 m below

grade at the end of the test holes (with the exception of TH13-306 where 0.2 m of silt till was encountered at the bottom of the hole, see Section 3.2.5 below). In general, the clayey silt to silty clay soil was typically brown and grey, moist to very moist and of intermediate plasticity. The clayey silt fill contained trace to some amounts of fine-grained sand. The uncorrected SPT N-values were typically 1 to 4 blows per 300 mm indicating a soft to very soft consistency, but reached up to 13 blows/300 mm at the local areas at TH13-306 and -307. Grain size indicated that the soil typically consisted of approximately 82% to 99% silt plus clay (clay content of approximately 33%), and 1% to 18% sand.

3.3.3 Sandy Silt Till

The deepest test hole TH13- 306 indicated that the clayey silt to silty clay layer was underlain by glacial sandy silt till at a depth of 6.5 m below ground surface (EL. 224.7 m). The sandy silt till was grey in colour, moist, low plasticity and very dense. Bedrock was not encountered at a maximum depth of approximately 6.7 m below grade (El. 224.6 m) at the bottom of the test holes.

3.3.4 Test Pitting

Shallow test pitting [approximately 2.5 m long by 1.0 m wide by 1.2 m deep] was performed using a rubber tire backhoe at four select locations along the upstream side of the canal embankments to try and identify whether the sheet piles were installed. Note that similar test pitting was completed at the canal embankment just upstream of Lock 40 where seepage and erosion was observed in the summer of 2013. At this location near Lock 40, the sheet piles were found near the upstream edge of the crest. The water level was high during test pitting (approximately 0.8 m below the crest), and the test pit depth and extent were limited to ensure there would be no seepage or erosion, particularly since the location and elevation of the sheet piles were not yet known. Sheet piles were not encountered within the investigated depth and extent of the test pits.

Embankment fill encountered during the test pitting within the investigated depth (±1.2 m) mainly consisted of clayey silt to silty clay fill. The clayey silt fill was typically brown, moist to very moist and of low to intermediate plasticity and contained some sand and trace to some

topsoils. The test pits were backfilled with the excavated embankment fill and compacted to a density similar to the surrounding soil using vibrating plate tamper equipment.

3.4 GROUNDWATER CONDITIONS

As described in Section 2.0, three (3) standpipes and two (2) VW piezometers were installed to monitor groundwater conditions during this site investigation. All the three standpipes were installed within the foundation soils of the embankments. Standpipe readings have been monitored two (2) times since installation to date, one in June 2013 and one in September 2013. The monitoring zone and the results of the groundwater level monitoring are summarized in Table 3.4-1. The standpipe readings indicated that the groundwater levels within the foundation soils were within 0.6 m between the readings (June and September 2013), although possible fluctuations are not known.

Two (2) VW piezometers were installed during this investigation as detailed below.

- One installed in TH13-101 (Talbot River Dam) within the sandy silt till with tip elevation at approximately El. 225.3 m.
- One installed in TH13-202 (Lock 39) within the embankment fill with tip elevation at approximately El. 222.9 m.

From June 6, 2013 to September 12, 2013 the vibrating wire piezometers were set up to collect data every 5 minutes in order to monitor groundwater levels within the embankment fills or foundation soils and to observe groundwater fluctuations during operation of the lock. The monitoring data from the installed VW piezometers are summarized in Figures 3.4a and 3.4b together with the upstream reservoir levels and Talbot Canal levels from PCA. The typical lock operation consists of lowering and refilling of approximately 6.0 m over an approximate 20 to 30 minute period. The review of piezometer data revealed that the groundwater levels during the lock operations have shown only approximately 25 to 50 mm groundwater fluctuation, indicating that there is a very slight to no impact on the piezometric levels within the embankment during the lock operation. As shown in Figures 3.4a and 3.4b, the piezometric levels measured in the Right Earthfill Embankment of Talbot River Dam varied between El. 227.9 m to El. 228.2 m during the monitoring period and between El. 227.8 m to El. 228.4 m at the north embankment of Lock 39.

TABLE 3.4-1
GROUNDWATER MONITORING DATA – STANDPIPE READINGS

Operating Level	**Talbot River Dam @ El. 230.44 m**	**Lock 39 @ El. 230.44 m**	**Talbot Canal @ El. 230.44 m**
Ground Elevation	**El. 231.26 m**	**El. 231.40 m**	**El. 231.60 m**
Piezometer	**Standpipe**	**Standpipe**	**Standpipe**
Test Hole Number	**TH13-101**	**TH13-202**	**TH13-304**
Tip Elevation	**El. 224.96 to El. 225.42**	**El. 220.52 to El. 220.98 m**	**El. 226.56 to El. 227.02 m**
Monitoring Zone	**Till**	**Till**	**Clayey Silt/Silty Clay**
Date	**Total Measured Pressure Head (m)**	**Total Measured Pressure Head (m)**	**Total Measured Pressure Head (m)**
15-Jun-13	227.36	227.53	229.47
12-Sep-13	227.96	227.12	-
13-Sep-13	-	-	229.34

FIGURE 3.4A
GROUNDWATER LEVEL MEASUREMENTS - NORTH EMBANKMENT OF TALBOT RIVER DAM

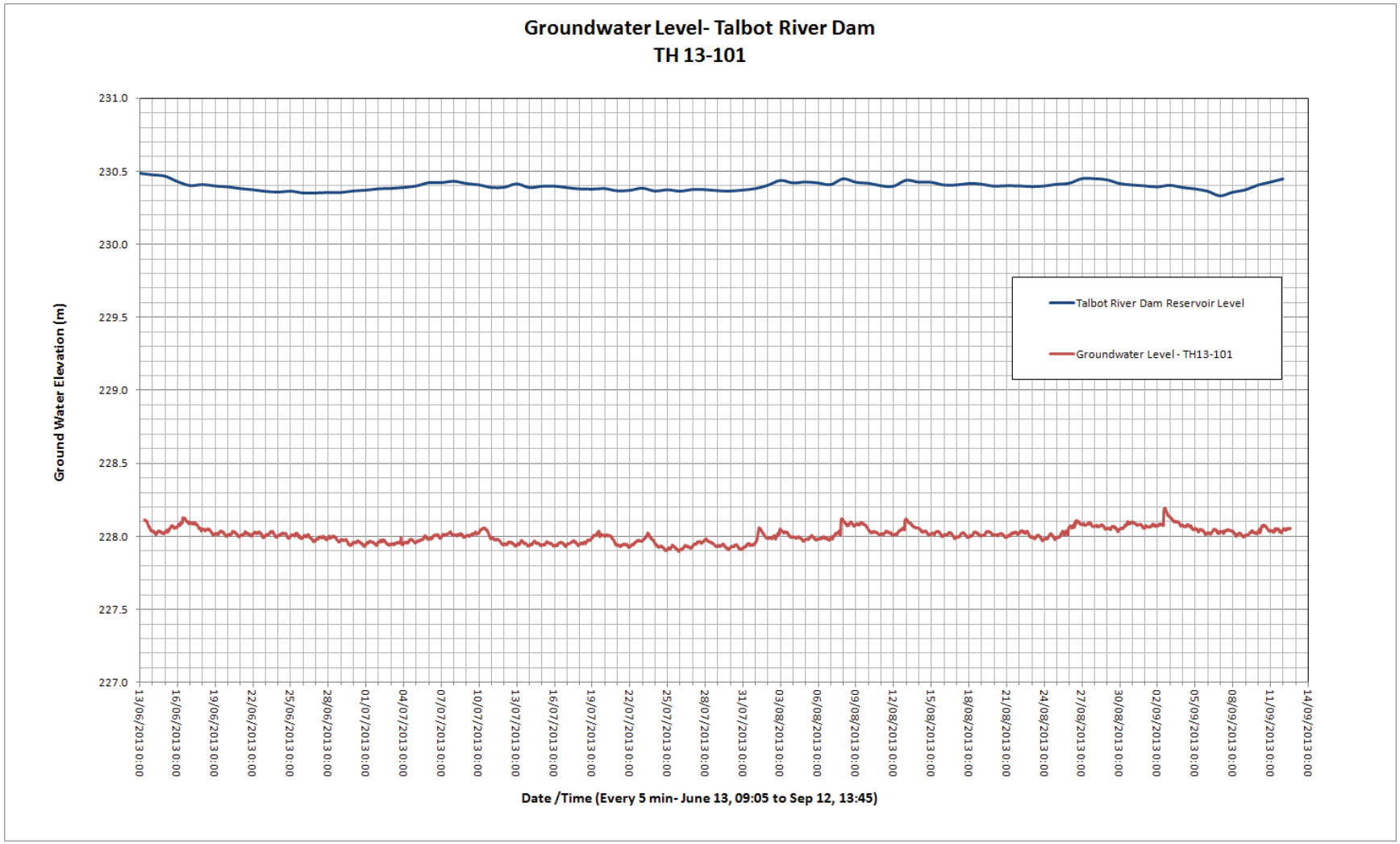
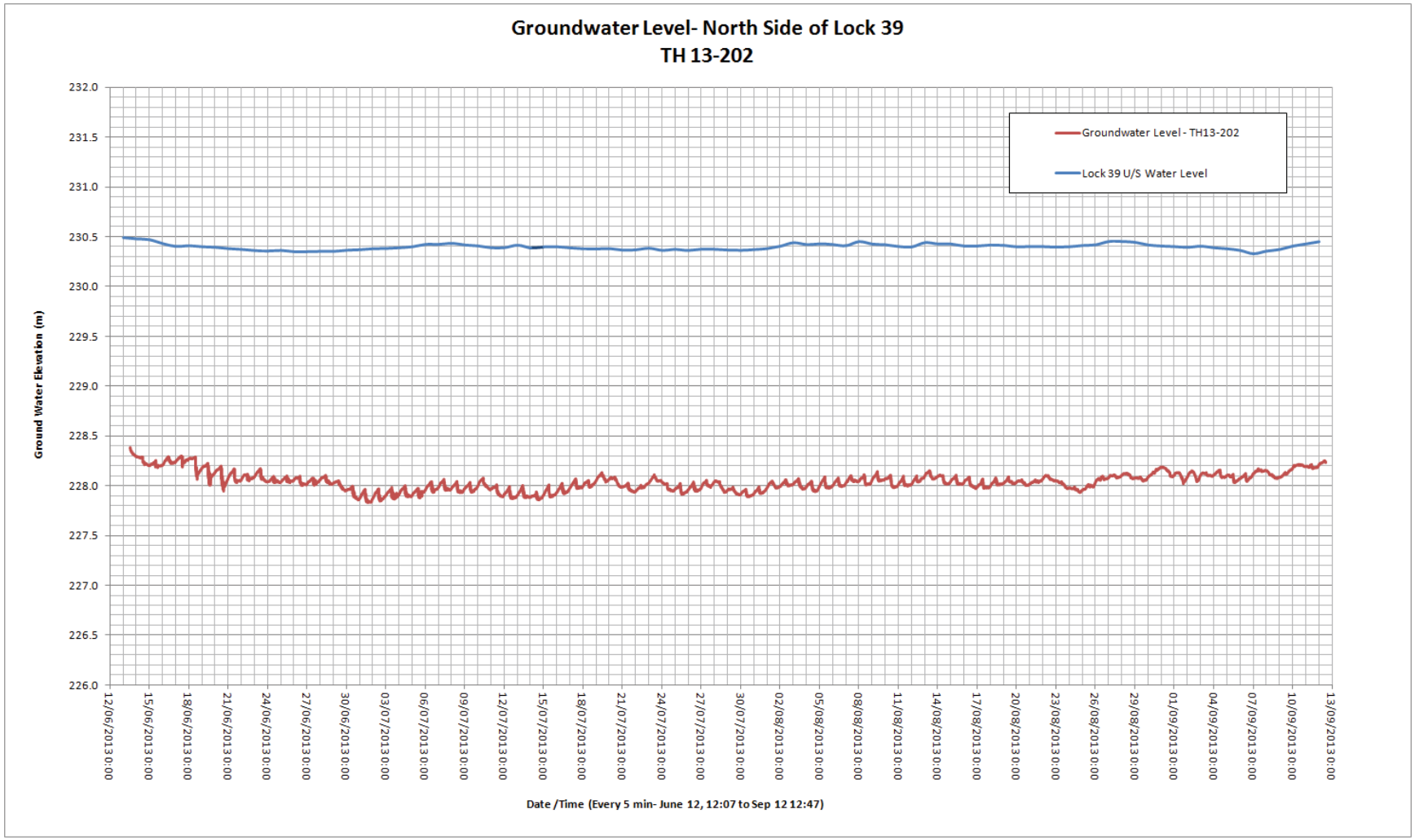


FIGURE 3.4B
GROUNDWATER LEVEL MEASUREMENTS - NORTH EMBANKMENT OF LOCK 39



3.5 LABORATORY TESTING RESULTS

3.5.1 Routine Index Testing

The results of routine index testing on the soils, including moisture content, grain size analysis (sieve and hydrometer testing) and Atterberg Limits testing, are summarized in Table 3.5-1 according to test hole number and sample depth, as well as on the detailed borehole logs presented in Appendix A. The results were also discussed in Sections 3.1 to 3.3.

TABLE 3.5-1
TALBOT RIVER DAM, LOCK 39 AND TALBOT CANAL: INDEX CHARACTERISTICS OF SOIL SAMPLES

Test Hole #	Sample Depth (m)	Moisture Content (%)	Plasticity (%)			Grain Size Distribution (%)						
			LL	PL	PI	Gravel	Sand				Silt (<0.075 to 0.002 mm)	Clay (<0.002 mm)
							Coarse (<4.75 to 2.0 mm)	Medium (<2.0 to 0.425 mm)	Fine (<0.425 to 0.075 mm)	Sand Total		
TH13-101	0.90	14	-	-	-	-	-	-	-	-	-	-
	2.44	-	-	-	-	0.7	0.4	3.5	60.6	64.5	28.0	6.8
	2.75	12	-	-	-	-	-	-	-	-	-	-
	4.27	-	-	-	-	0.0	0.0	0.0	50.4	50.4	44.2	5.4
	4.58	27	-	-	-	-	-	-	-	-	-	-
	5.20	29	-	-	-	-	-	-	-	-	-	-
TH13-102	0.61	-	-	-	-	0.0	0.0	0.3	47.8	48.1	44.1	7.8
	0.91	22	-	-	-	-	-	-	-	-	-	-
	3.66	-	-	-	-	0.2	0.0	0.1	6.6	6.7	55.7	37.4
	3.70	35.7	35	17	18	-	-	-	-	-	-	-
	5.90	33	-	-	-	-	-	-	-	-	-	-
TH13-103	5.49	-	-	-	-	5.4	3.0	6.9	27.1	37.0	45.5	12.1
TH13-104	-	-	-	-	-	-	-	-	-	-	-	-
TH13-104a	0.90	13	-	-	-	-	-	-	-	-	-	-
	2.13	22	-	-	-	-	-	-	-	-	-	-
	3.36	22	-	-	-	-	-	-	-	-	-	-
	4.58	22	-	-	-	-	-	-	-	-	-	-
	5.80	23	-	-	-	-	-	-	-	-	-	-
TH13-105	3.05	-	28	14	14	-	-	-	-	-	-	-
	3.80	42.8	48	20	28	-	-	-	-	-	-	-
	3.81	-	-	-	-	0.0	0.0	0.5	3.1	3.6	41.8	54.6
	6.01	-	-	-	-	5.8	5.4	11.9	28.2	45.5	33.0	15.7
	6.32	6	-	-	-	-	-	-	-	-	-	-
TH13-201	0.99	23	-	-	-	-	-	-	-	-	-	-
	3.28	27	-	-	-	-	-	-	-	-	-	-
	6.10	-	-	-	-	0.0	0.0	0.3	5.9	6.2	75.4	18.4
	6.31	28	25	17	8	-	-	-	-	-	-	-
	7.85	39	-	-	-	-	-	-	-	-	-	-
	9.38	10	-	-	-	-	-	-	-	-	-	-
TH13-202	3.29	19	23	17	6	-	-	-	-	-	-	-
	4.57	-	-	-	-	0.2	0.0	0.3	12.8	13.1	71.5	15.2
	4.80	27	-	-	-	-	-	-	-	-	-	-
	6.33	29	-	-	-	-	-	-	-	-	-	-
	7.85	24	-	-	-	-	-	-	-	-	-	-
	10.67	-	-	-	-	0.2	0.6	1.8	10.4	12.8	68.0	19.0
	10.90	17	-	-	-	-	-	-	-	-	-	-

TABLE 3.5-1 - CONTINUED
TALBOT RIVER DAM AND LOCK 39: INDEX CHARACTERISTICS OF SOIL SAMPLES

Test Hole #	Sample Depth (m)	Moisture Content (%)	Organic Content (%)	Plasticity (%)			Grain Size Distribution (%)						
				LL	PL	PI	Gravel	Sand				Silt (<0.075 to 0.002 mm)	Clay (<0.002 mm)
TH13-301	1.85	27	-	-	-	-	-	-	-	-	-	-	-
	3.35	14	-	-	-	-	-	-	-	-	-	-	-
	4.90	50.2	-	44	19	25	0.0	0.0	0.4	1.1	1.5	43.7	54.8
TH13-302	1.82	22	-	-	-	-	-	-	-	-	-	-	-
	4.88	28	-	-	-	-	-	-	-	-	-	-	-
TH13-303	1.82	27	-	-	-	-	-	-	-	-	-	-	-
	3.36	51	-	-	-	-	-	-	-	-	-	-	-
	4.90	34	-	-	-	-	-	-	-	-	-	-	-
TH13-304	1.82	34	-	-	-	-	-	-	-	-	-	-	-
	3.40	34.2	-	31	17	14	0.0	0.0	0.2	0.8	1.0	65.4	33.6
	4.88	38	-	-	-	-	-	-	-	-	-	-	-
TH13-305	1.82	28	-	-	-	-	-	-	-	-	-	-	-
	3.40	43.1	-	48	19	30	-	-	-	-	-	-	-
	4.88	31	-	-	-	-	-	-	-	-	-	-	-
TH13-306	0.90	20	-	-	-	-	-	-	-	-	-	-	-
	2.10	-	-	-	-	-	0.0	0.0	1.2	17.4	18.6	71.1	10.3
	3.37	49	-	-	-	-	-	-	-	-	-	-	-
	4.58	28	-	-	-	-	-	-	-	-	-	-	-
	5.80	43	-	-	-	-	-	-	-	-	-	-	-
TH13-307	0.90	25	-	-	-	-	-	-	-	-	-	-	-
	2.14	29	-	-	-	-	-	-	-	-	-	-	-
	3.40	29	-	-	-	-	0.0	0.0	0.1	18.1	18.2	71.9	9.9
	4.58	46	-	-	-	-	-	-	-	-	-	-	-

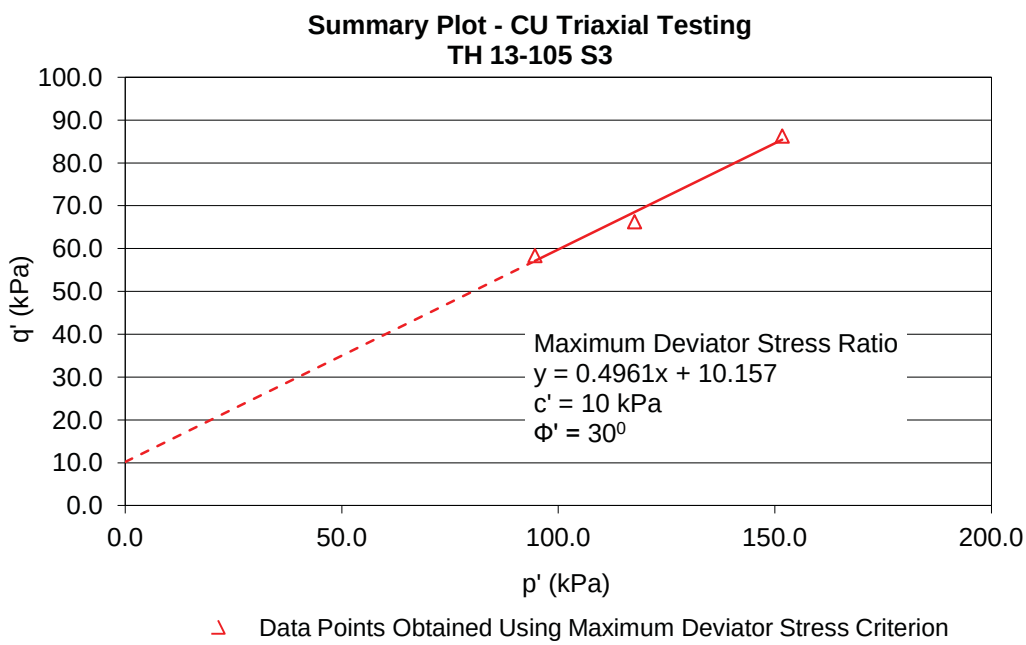
3.5.2 Consolidated Undrain Triaxial Tests

The Consolidated Undrained (CU) Triaxial tests were undertaken to estimate the effective shear strength parameters of the cohesive soil. Three (3) staged Consolidated Undrained Triaxial tests with pore pressure measurements were performed on the relatively undisturbed Shelby tube sample of clayey silt to silty clay fill from TH13-105 S3 (depth from 3.05 m to 3.81 m below grade). The test was carried out at the confining pressures of 70 kPa, 120 kPa and 170 kPa. The plot of p-q using maximum deviator stress criterion is shown in Figure 3.5-1 from the test. The estimated clayey silt to silty clay fill effective shear strength interpreted from CU Triaxial tests are listed below and representative of the intact strengths and not previously sheared or residual strengths:

Effective friction angle of clayey silt to silty clay fill Φ'= 30 degree

Effective Cohesion of clayey silt to silty clay fill c'= 10 kPa.

FIGURE 3.5-1
PLOT OF P-Q USING MAXIMUM DEVIATOR STRESS CRITERION



3.5.3 Direct Shear Tests

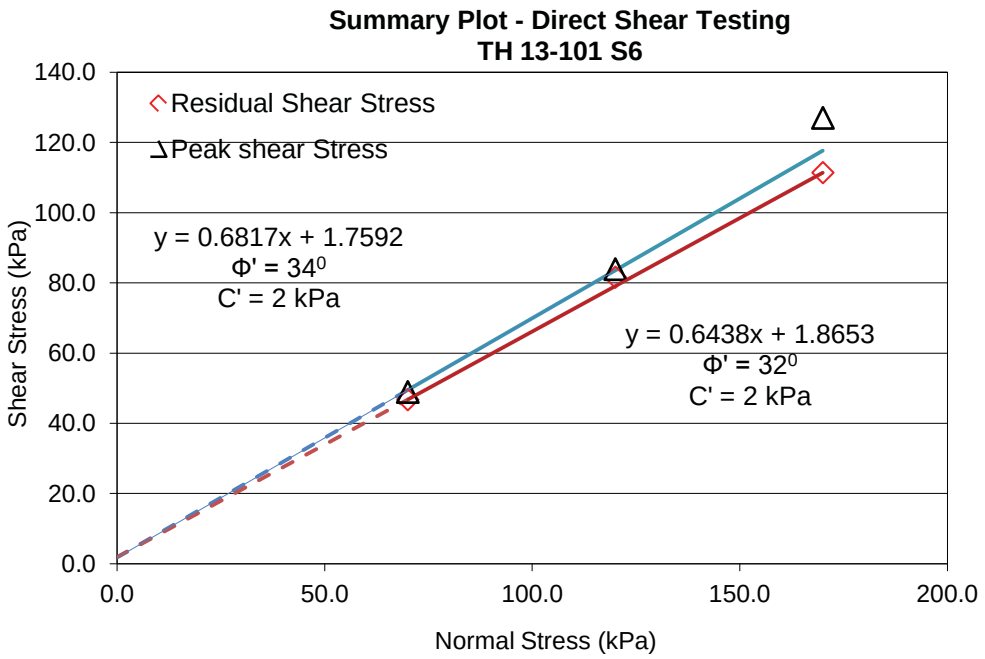
Direct shear tests were undertaken to estimate the effective shear strength parameters of relatively cohesionless soil. Three (3) Consolidated Drained Direct Shear Tests were performed (DST) on the disturbed split spoon sample of sandy silt to silty sand fill at the normal stresses of 70 kPa, 120 kPa and 170 kPa, representative of the in-situ normal stress state at the embankments. The sample was obtained from TH13-101 S6 at depths from 3.05 m to 3.66 m below grade. The direct shear test sample was prepared at the wet density of 19.5 kN/m^3 with 15% moisture content. Note that the sample was reconstituted to a density considered reasonably representative of the existing state to provide an approximation of the in-situ conditions. However, some variability can be expected and should be considered within the DSR analysis.

The plot of shear stress vs normal stress is shown in Figure 3.5-2 from the test. The estimated sandy silt to silty sand fill effective shear strength interpreted from Direct Shear tests are listed below:

Effective residual friction angle of sandy silt to silty sand Φ'= 32 degree
Effective residual cohesion of sandy silt to silty sand c'= 2 kPa.

Effective Peak friction angle of sandy silt to silty sand Φ'= 34 degree
Effective Peak cohesion of sandy silt to silty sand c'= 2 kPa.

FIGURE 3.5-2
PLOT OF SHEAR STRESS VS NORMAL STRESS



4.0 GEOTECHNICAL ENGINEERING ASSESSMENTS

4.1 ENGINEERING PARAMETERS FOR THE EMBANKMENT MATERIALS

Representative engineering properties of the embankment fills and foundation soils for Talbot River Dam, north side of Lock 39 embankment and Talbot Canal embankments are presented on Table 4.1-1. The soil strength parameters of the embankment fill and foundation soils were estimated from in situ Standard Penetration Tests (SPT) and laboratory index testing using empirical correlations and the interpretation of the advanced laboratory testing results, as well as previous experience with similar soil materials. Ranges of shear strengths have been provided to represent the variations observed from the investigations. Some cohesion was measured in the silty clay / clayey silt from the CU triaxial test (10 kPa). Cohesion within the non-plastic materials was assumed to be zero.

TABLE 4.1-1
EFFECTIVE SHEAR STRENGTH PARAMETERS FOR EARTHFILL EMBANKMENTS

Material	Representative Lower and Upper Bounds, Φ'	Consistency based on SPT	Cohesion, c' (kPa)	Estimated Unit Weight, γ_{sat} (kN/m^3)
North and South Embankments of Talbot River Dam				
Sandy Silt to Silty Sand Fill	30° to 32°	Loose to Compact	0	19.5
Clayey Silt to Silty Clay Fill	27° to 30°	Soft to Firm	0	18.0
Sandy Silt Till	38° to 40°	Dense to Very Dense	0	21.0
North of Lock 39 Embankments				
Clayey Silt to Silty Clay Fill	27° to 30°	Soft to Very Soft	0	18.0
Sandy Silt Till	38° to 40°	Compact	0	21.0
Northwest and Southeast Canal Embankments of Talbot Canal				
Clayey Silt to Silty Clay Fill	27° to 30°	Soft to Very Soft	0	18.0
Clayey Silt to Silty Clay	27° to 30°	Soft to Very Soft	0	18.0
Sandy Silt Till	38° to 40°	Very Dense	0	21.0

5.0 CLOSURE

1. This geotechnical program was undertaken to provide in-situ properties of the fill and foundation materials necessary to carry out the DSR. Any additional or more detailed investigation activities that could be potentially required for design of any remedial work have not been included in this investigation program.

2. A total of fifteen (15) test holes were drilled during the exploratory program to investigate the embankment fill materials and foundation soils of the earthfill embankments. Three (3) monitoring wells (standpipe piezometers) and two (2) vibrating wire piezometers were installed in the test holes to monitor the groundwater level within the earthfill embankments or their foundation soils.

3. The fill materials encountered within all the embankments at the site mainly consisted of sandy silt and/or clayey silt to silty clay. The sandy silt fill was loose to compact, had low to no plasticity, was moist to wet and contained varying amounts of topsoil and clay. The clayey silt to silty clay fill was firm to very soft, low to intermediate plasticity and contained trace to some amounts of fine-grained sand and contained varying amounts of topsoil.

4. The native soil encountered at the site consisted of clayey silt to silty clay and/or sandy silt till. The clayey silt to silty clay was soft to very soft, intermediate plasticity and contained trace to some amounts of fine-grained sand. The sandy silt till was compact to very dense.

5. The piezometric data revealed that there was only a very slight to no impact on groundwater level within the left embankment during the lock operation.

6. The soils strength parameters of the embankment fill were estimated based on the field testing results, the laboratory testing results and previous experience with similar materials.

6.0 STATEMENT OF LIMITATIONS AND CONDITIONS

6.1 THIRD PARTY USE OF REPORT

This report has been prepared for the Client 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 test holes drilled by KGS at this site

APPENDICES

APPENDIX A1

TEST HOLE LOGS

KGS GROUP — SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH 13-101**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.26 m
SITE	Talbot River Dam- Right Wing Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Crest of Dam, 10 m N of North Abutment of concrete dam (D/S side)	WATER ELEV.	
		DATE DRILLED	07/06/2013
DRILLING METHOD	Casing and Washboring, Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m) / **DEPTH (m) (ft)** / **GRAPHICS** / **DESCRIPTION AND CLASSIFICATION** / **PIEZ. LOG** / **DEPTH (m)** / **SAMPLE TYPE** / **NUMBER** / **RECOVERY %** / **SPT (N) blows/0.15 m ▲** / **DYNAMIC CONE (N) blows/ft △** / **Cu POCKET PEN (kPa) ★** / **Cu TORVANE (kPa) ◆** / **PL MC LL %**

EMBANKMENT FILL (0.0 - 5.49 m)

Sandy Silt to Silty Sand Fill (0.0 - 3.66 m) - Brown, moist, compact, low plasticity to non plastic, trace clay.

- Varying sand and silt content.
- Loose below 1.22 m.
- Compact below 1.83 m.
- Grading to more sandy, loose, and very moist below 2.44 m.
- Grain Size Distribution: Gravel (0.7%), Sand (64.5%), Silt (28.0%), and Clay (6.8%) at 2.44 m.

Silty Sand Fill (3.66 - 5.49 m) - Brown, wet, compact to loose, low plasticity to non plastic, with fine-grained sand.

- 0.15 m thick black topsoil layer at 3.81 m.
- Grading to more silty, brown/grey, and wet below 4.27 m.
- Grain Size Distribution: Gravel (0.0%), Sand (50.4%), Silt (44.2%), and Clay (5.4%) at 4.27 m.
- Wet, loose below 4.88 m.

SANDY SILT TILL - Grey, very moist, very dense, low plasticity to non plastic.

LIMESTONE BEDROCK Light grey, fine grained, competant.

END OF HOLE ON BEDROCK AT 6.55 m.

Notes:
1. Test hole completed on June 8, 2013.
2. Installed a flushmount piezometer to a depth of 6.25 m.
3. Installed a vibrating wire (SN 12-9209) to a depth of 5.95 m.
4. Test hole backfilled with grout.

Elevation (m)	Depth (m)	Depth (ft)
231		
230	1	5
229	2	
228	3	10
227	4	15
226	5	
225.8		
225.0	6	20
225		
224.7		
224	7	25
223	8	
222	9	30

Sample	Number	Recovery %	SPT (N) blows/0.15 m	Dynamic Cone (N) blows/ft
S1	42		3, 6, 6, 7	
S2	8		12, 15, 6, 7	
S3	100		2, 2, 1, 1	
S4	71		2, 4, 6, 5	
S5	75		2, 2, 1, 1	
S6	67		1, 1, 2, 14	
S7	62		4, 11, 4, 3	
S8	75		2, 2, 2, 3	
S9	62		1, 2, 1, 2	
S10	17		1	50, 50 /(50 mm penetration)

Piezometer: VW at 5.9 m; 5.9 m; 6.6 m

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH 13-102**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.28 m
SITE	Talbot River Dam- Right Wing Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Crest of Dam, 21 m N of North Abutment of concrete dam (U/S side)	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	Continuous Split Spoon, Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL (0.0 - 5.79 m)** **Sandy Silt Fill (0.0 - 1.83 m)** - Brown, moist, soft, low plasticity to non plastic, trace clay.		S1	62	2, 1, 1, 3	
				- Very moist to wet below 0.61 m. - Grain Size Distribution: Gravel (0.0%), Sand (48.1%), Silt (44.1%), and Clay (7.8%) at 0.61 m.		S2	71	1, 2, 3, 3	
230	1	5		- Wet, very soft below 1.22 m.		S3	58	0, 1, 2, 2	
229	2			**Clayey Silt to Silty Clay Fill (1.83 - 5.79 m)** - Grey/brown, very moist, very soft, intermediate plasticity.		S4	75	0, 0, 0, 1	
				- Topsoil mixed between 1.83 and 2.44 m.		S5	54	0, 1, 1, 1	
228	3	10		- Very soft below 3.1 m.		S6	50	0, 0, 0, 2	
	4			- Grain Size Distribution: Gravel (0.2%), Sand (6.7%), Silt (55.7%), and Clay (37.4%) at 3.66 m.		S7	54	0, 1, 1, 2	
227		15				S8	22	1, 1, 1, 1	
	5			- Sampler sank to 5.18 m on last blow from 4.87 m.					
226				- Very soft, very moist to wet below 5.4 m.		S9	58	0, 0, 0, 1	
225.5								5	
225.3	6	20		**SANDY SILT TILL** - Grey, very moist, very dense, low plasticity to non plastic.		S10	56	▲ 50 (75 mm penetration)	
225				**END OF HOLE IN TILL AT 6.02 m.**					
	7			Notes: 1. Water level at 1.22 m below grade upon completion of drilling. 2. Test hole completed on June 8, 2013. 3. Test hole backfilled with bentonite chips.					
224		25							
223	8								
222	9	30							

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH 13-103**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.33 m
SITE	Talbot River Dam- Right Wing Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Crest of Dam, 59 m N of North Abutment of concrete dam (D/S side)	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	Continuous Split Spoon, Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL (0.0 - 5.79 m)** **Sandy Silt Fill (0.0 - 1.83 m)** - Brown, moist, compact, low plasticity to non plastic, trace clay.		S1	42	2, 3, 4, 8, 7, 6	
	1					S2	50	3, 4, 2, 1	
230		5		- Loose below 1.22 m.		S3	42	2, 2, 1, 1	
	2			**Sandy Silt to Silty Sand Fill (1.83 - 5.79 m)** - Brown, very moist to wet, loose, low plasticity to non plastic.		S4	50	1, 0, 1	
229				- Varying sand and silt content.					
				- Loose and very moist to wet below 2.8 m.		S5	58	8 (Rock encountered), 1, 1	
	3	10				S6		2, 1, 2, 1, 1	
228				- Brown/grey, wet, and loose below 3.66 m.		S7		2, 2, 2, 3	
	4					S8		2, 1, 1, 1	
227		15		- Varying sand and silt content.					
	5					S9		4, 7, 3, 2	
226				- Compact below 5.18 m.					
225.5				- Grain Size Distribution: Gravel (5.4%), Sand (37.0%), Silt (45.5%), and Clay (12.1%) at 5.49 m.		S10		18	
225.3	6	20		**SANDY SILT TILL** - Grey, moist, very dense, low plasticity to non plastic.				50 (75 mm penetration)	
225				**END OF HOLE IN TILL AT 6.02 m.**					
	7								
224		25							
	8								
223									
	9	30							
222									

Notes:
1. Test hole completed on June 8, 2013.
2. Water level at 4.2 m below grade upon completion of drilling.
3. Test hole backfilled with bentonite chips.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH 13-104**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.29 m
SITE	Talbot River Dam- Right Wing Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Crest of Dam, 102 m N of North Abutment of concrete dam (U/S side)	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	Continuous Split Spoon, Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL (0.0 - 2.13 m)** **Sandy Silt Fill (0.0 - 2.13 m)** - Brown, moist, loose, low plasticity to non plastic trace clay.		S1	42	1, 6, 1, 2, 3	
	1					S2	62	1, 1, 4	
230		5		- Very moist to wet below 1.22 m.		S3	75	2, 1, 1, 1, 1	
229.2	2					S4	67	50 (Concrete Corewall)	
229				**END OF HOLE ON CONCRETE CORE WALL AT 2.13 m.**					
	3	10							
228									
	4								
227		15							
	5								
226									
	6	20							
225									
	7								
224		25							
	8								
223									
	9	30							
222									

Notes:
1. Concrete corewall encountered at 1.22 m. Test hole moved to downstream side of embankment (TH 13-104a).
2. No free water in the test hole upon completion of drilling.
3. Test hole backfilled with bentonite chips.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH 13-104a**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.29 m
SITE	Talbot River Dam	TOP OF PVC ELEV.	
LOCATION	102 m N of North Abutment of concrete dam (D/S side)	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	Continuous Split Spoon, Portable Rig (Manual Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL (0.0 - 6.40 m)**					
				Sandy Silt to Silty Sand Fill (0.0 - 6.40 m) - Brown, moist, compact, low plasticity to non plastic, trace clay.		S1	50	2, 4, 5, 9	
				- Varying sand and silt content.				6, 3	
				- Loose below 0.76 m.		S2	67	4	
	1							2, 2, 2	
230		5				S3	75	2, 2, 1	
	2							3	
				- Compact below 2.13 m.		S4	75	4, 6, 5	
229				- Very moist, some topsoil, some clay below 2.44 m.				9	
						S5	83	5, 4	
	3	10		- Very moist to wet, trace clay below 3.05 m.				0	
228				- Presumed limestone pieces at 3.05 m.		S6	75	5, 19, 5	
				- Brown/grey, wet, some topsoil at 3.66 m.				9, 5	
	4			- Loose below 3.96 m.		S7	83	2, 2, 0	
227		15				S8	75	2, 2, 1, 0	
	5					S9	83	1, 0, 1, 1, 1	
226						S10	75	1, 1 (50 mm penetration)	
	6	20		- Some gravel, some topsoil below 6.10 m.		S11	42	3, 50 (No penetration)	
225 / 224.9				**AUGER REFUSAL PRESUMABLY ON BEDROCK AT 6.40 m.**					
	7			Notes: 1. Test hole completed on June 8, 2013. 2. Water level at 4.0 m below grade at the completion of drilling. 3. Test hole backfilled with bentonite chips. 4. Test hole located 2 m west (downstream) of TH 13-104.					
224		25							
	8								
223									
	9	30							
222									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-105**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.15 m
SITE	Talbot River Dam- Left Wing Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	10 m S of South Abutment of concrete dam (U/S side)	WATER ELEV.	
DRILLING METHOD	200 mm Hollow Stem Auger, CME 75 (Automatic Hammer)	DATE DRILLED	07/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL (0.0 - 5.79 m)** **Clayey Silt to Silty Clay Fill (0.0 - 5.79 m)** - Brown, moist, firm, intermediate plasticity.					
230	1	5		- Soft, increase in clay content below 1.52 m.	S1		72	▲ 2, 4, 4	
229	2				S2		83	▲ 0, 0, 1	
228	3	10			S3				
227	4			- Grain Size Distribution: Gravel (0.0%), Sand (3.6%), Silt (41.8%), and Clay (54.6%) at 3.81 m.	S4			▲ 0, 0, 1	
226	5	15		- Very soft below 4.6 m.	S5		56	▲ 0, 0, 1	
225.4				- Some subangular gravel (5 to 10 mm) at 5.64 m.	S6		100	▲ 0, 1, 14	
225	6	20		**SANDY SILT TILL** - Grey, moist, dense, low plasticity to non plastic. - Grain Size Distribution: Gravel (5.8%), Sand (45.5%), Silt (33.0%), and Clay (15.7%) at 6.01 m.	S7		78	▲ 10, 16, 22	
224.1	7			**AUGER REFUSAL PRESUMABLY ON BEDROCK AT 7.01 m.**					
224		25							
223	8								
222	9	30							

Notes:
1. Test hole completed on June 7, 2013.
2. Groundwater level at 1.4 m below grade at the completion of drilling.
3. Test hole backfilled with bentonite chips.

SAMPLE TYPE ☒ Split Spoon ▥ Shelby Tube

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS Inc.	C.H. / S.G.	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-201**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.33 m
SITE	Lock 39- North side of Lock 39	TOP OF PVC ELEV.	
LOCATION	Top of Embankment, Northwest corner at Lock 39	WATER ELEV.	
		DATE DRILLED	05/06/2013
DRILLING METHOD	200 mm ø Hollow Stem Auguer - CME 75 (Automatic Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL** **CLAYEY SILT TO SILTY CLAY FILL (0-9.45)** - Brown, moist, soft, low plasticity, trace sand, topsoil inclusions, rootlets.					
230	1	5		- Very moist, trace clay below 1.52 m.	☒	S1	78	▲ 2 2 2	
229	2				☒	S2	78	▲ 0 1 1	
228	3	10		- Brown/grey, moist, soft, with topsoil, some wood pieces below 3.05 m.	☒	S3	78	▲ 0 1 2	
227	4	15		- With lumps of topsoil below 4.57 m.	☒	S4	100	▲ 0 1 2	
226	5								
225	6	20		- Very moist, soft, some clay below 6.10 m. - Grain Size Distribution: Gravel (0.0%), Sand (6.2%), Silt (75.4%), and Clay (18.4%) at 6.10 m.	☒	S5	100	▲ 0 1 1	
224	7	25							
223	8			- Trace gravel at 7.92 m.	☒	S6	100	▲ 0 1 3	
222	9	30			☒	S7	33	▲ 1 6 ▲ 23	
221	10			**SANDY SILT TILL** - Grey, moist, compact to dense, non plastic. - with sand layers. - Augered without sampling.					
220.4	11	35		- 900 mm sand backup into the auger at +/- 10.97 m and unable to sample at +/- 10.97 m.					
220				**END OF HOLE AT 10.97 m.**					
219	12	40							
218	13	45							

Notes:
1. Test hole completed on June 6, 2013.
2. Water level at 7.5 m below grade upon completion of drilling.
3. Backfilled TH13-201 with bentonite chips.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	CH/SG	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-202**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	TALBOT RIVER DAM AND LOCK 39	GROUND ELEV.	231.40 m
SITE	Lock 39- North side of Lock 39	TOP OF PVC ELEV.	
LOCATION	Top of Embankment, Northeast corner at Lock 39	WATER ELEV.	
DRILLING METHOD	200 mm ø Hollow Stem Auguer - CME 75 (Automatic Hammer)	DATE DRILLED	05/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231			**EMBANKMENT FILL** **CLAYEY SILT TO SILTY CLAY FILL (0-9.45 m)** - Brown, moist, soft, low plasticity, trace sand, some topsoil, rootlets.							
	1					S1		44	1, 3, 3	
230		5	- Very moist below 1.52 m.			S2		67	1, 1, 1	
	2									
229										
	3	10				S3		2.8	0, 1, 1	
228										
	4									
227		15	- Grain Size Distribution: Gravel (0.2%), Sand (13.1%), Silt (71.5%), and Clay (15.2%) at 4.57 m.			S4		67	0, 1, 1	
	5									
226										
	6	20	- Brown/grey below 6.10 m.			S5			1, 1, 1	
225										
	7									
224		25								
	8		- Wood pieces at 8.02 m.			S6		100	0, 1, 2	
223				VW	8.4 8.7					
	9	30								
222.0			**SANDY SILT TILL** - Grey, very moist to wet, compact, non plastic.			S7		67	4, 5, 10	
	10		-With sand layers.							
221		35	- Grain Size Distribution: Gravel (0.2%), Sand (12.8%), Silt (68.0%), and Clay (19.0%) at 10.67 m.		10.4 10.9	S8		100	9, 14, 10	
220.3	11		**END OF HOLE AT 11.13 m.**							
220			Notes: 1. Water level at 7.76 m below grade upon completion of drilling. 2. Test hole completed on June 6, 2013. 3. Installed a flushmount 75 mm diameter standpipe piezometer to a depth of 10.88 m. 4. Installed a vibrating wire piezometer (SN 12-9170) to a depth of 8.54 m. 5. Backfilled test hole with silica sand from 10.88 m to 10.42 m, bentonite chips from 10.42 m to 8.86 m, silica sand from 8.68 m to 8.38 m and bentonite from 8.28 m to grade.							
	12	40								
219										
	13									
218		45								

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	CH/SG	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-301**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.53 m
SITE	Talbot Canal - Northwest Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 40 m from Lock 39 (north side) - upstream side of the crest	WATER ELEV.	
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	DATE DRILLED	06/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231.4				**TOPSOIL** Black, moist.					
231				**EMBANKMENT FILL** **Clayey Silt to Silty Clay Fill (0.15 - 3.68 m)** - Brown, moist, soft, low plasticity, trace sand, trace gravel.					
	1				☒	S1	72	▲ 2, 2, 1	
230		5		- Very soft below 1.68 m.	☒	S2	100	▲ 0, 1, 1	●
	2								
229									
	3	10			☒	S3	100	▲ 2, 1, 1	●
228				- Soft below 3.35 m.					
227.9				**CLAYEY SILT TO SILTY CLAY** - Grey, very moist, soft, intermediate plasticity, trace gravel.					
	4								
227		15			☒	S4	100	▲ 0, 1, 2	●
	5			- Grain Size Distribution: Gravel (0.0%), Sand (1.5%), Silt (43.7%), Clay (54.8%) at 4.9 m.					
226									
	6	20			☒	S5	100	▲ 0, 0, 1	
225.0				**END OF HOLE AT 6.55 m.**					
	7			Notes: 1. Open hole to 6.10 m. 2. Backfilled with bentonite chips. 3. Completed on June 06, 2013. 4. No free water in test hole upon completion of drilling.					
224		25							
	8								
223									
	9	30							
222									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-302**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.50 m
SITE	Talbot Canal - Northwest Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 450 m from Lock 39 (north side) - downstream side of the crest	WATER ELEV.	
		DATE DRILLED	07/06/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231				**EMBANKMENT FILL** **GRANULAR FILL(0.0-200 mm)** **Clayey Silt to Silty Clay Fill (0.20 - 3.20 m)** - Brown, moist, soft, low plasticity, trace sand, some topsoil.					
	1			- Some topsoil.		S1	72	1, 2, 2	
230		5		- Moist to wet, some sand below 1.52 m. - Stiff		S2	72	1, 5, 6	
	2								
229									
	3	10		- Trace gravel below 3.05 m.		S3	89	0, 1, 2	
228.3				**TOPSOIL** - Black, moist to very moist.					
228.1				**CLAYEY SILT TO SILTY CLAY** - Brown, soft, intermediate plasticity, trace gravel.					
228									
	4								
227		15				S4	100	0, 1, 1	
226.5	5			**END OF HOLE AT 5.03 m.**					
226				Notes: 1. Open hole to 4.57 m. 2. 0.46 m of water at the bottom of the test hole upon completion of drilling. 3. Backfilled with bentonite chips. 4. Completed on June 07, 2013.					
	6	20							
225									
	7								
224		25							
	8								
223									
	9	30							
222									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-303**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.50 m
SITE	Talbot Canal - Northwest Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 750 m from Lock 39 (north side) - upstream side of the crest	WATER ELEV.	
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	DATE DRILLED	07/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231.3				**TOPSOIL** - Black, moist.					
231				**EMBANKMENT FILL** **Clayey Silt to Silty Clay Fill (0.150 - 3.05 m)** - Brown, moist, soft, low plasticity, trace sand.					
	1					S1	78	2, 2, 2	
230		5		- Some topsoil at 1.52 m.					
	2					S2	89	0, 1, 2	
229									
228.5	3	10		**CLAYEY SILT TO SILTY CLAY** - Brown, very moist, soft, intermediate plasticity.		S3	100	1, 2, 2	
228									
	4								
227		15				S4	100	0, 2, 2	
226.5	5			**END OF HOLE AT 5.03 m.**					
226				Notes: 1. Open hole to 4.57 m. 2. No free water in test hole upon completion of drilling. 3. Backfilled with bentonite chips. 4. Completed on June 07, 2013.					
	6	20							
225									
	7								
224		25							
	8								
223									
	9	30							
222									

SAMPLE TYPE ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-304**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.47 m
SITE	Talbot Canal - Northwest Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 1.25 km from Lock 39 (north side) - upstream side of the crest	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	UTM (m)	N E

ELEVATION (m) | DEPTH (m) (ft) | GRAPHICS | DESCRIPTION AND CLASSIFICATION | PIEZ. LOG | DEPTH (m) | SAMPLE TYPE | NUMBER | RECOVERY % | SPT (N) blows/0.15 m ▲ | DYNAMIC CONE (N) blows/ft △ | Cu POCKET PEN (kPa) ★ | Cu TORVANE (kPa) ◆ | PL MC LL %

TOPSOIL - Black, moist.

EMBANKMENT FILL

Clayey Silt to Silty Clay Fill (0.150 - 1.52 m) - Brown, moist, soft, low plasticity, some topsoil, some sand.

Sandy Silt Fill (1.52 - 1.83 m) - Brown, very moist to wet, loose, some clay.

Clayey Silt to Silty Clay (1.83 - 3.05 m) - Brown, soft, intermediate plasticity, trace sand, trace gravel.

CLAYEY SILT TO SILTY CLAY (3.05 to 5.03 m) - Brown, soft, intermediate plasticity, trace sand, trace gravel.
- Grain Size Distribution: Gravel (0.0%), Sand (1.0%), Silt (65.4%), Clay (33.6%) at 3.4 m.

END OF HOLE AT 5.03 m.

Notes:
1. Open hole to 4.57 m.
2. Water level at 2.0 m below grade upon completion of drilling
3. Installed a 25 mm diameter standpipe piezometer to a depth of 4.57 m.
4. Completed on June 08, 2013.
5. Backfilled test hole with silica sand from 4.57 m to 3.66 m and bentonite chips from 3.66 m to grade.

Sample	Depth (m)	Number	Recovery %	SPT (N) blows/0.15 m	Dynamic Cone (N) blows/ft
S1			67	2, 2, 2	
S2			67	1, 1, 1	
S3	3.7		100	1, 1, 1	
S4	4.6		100	0, 0, 2	

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-305**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.50 m
SITE	Talbot Canal - Southeast Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 1.3 km from Lock 39 (south side) - upstream side of the crest	WATER ELEV.	
		DATE DRILLED	08/06/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, CME 75 (Automatic Hammer)	UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
231.3				**TOPSOIL** - Black, moist.					
231				**EMBANKMENT FILL** **Clayey Silt to Silty Clay Fill (0.150 - 2.44 m)** - Brown, very moist, soft, low plasticity, some topsoil, some sand. - Varying sand content.					
	1				☒	S1	67	▲ 0, 1, 3	
230		5		- Wet, very soft at 1.52 m.	☒	S2	83	▲ 0, 0, 1	●
	2								
229									
228.5	3	10		**CLAYEY SILT TO SILTY CLAY** - Brown, very moist, intermediate plasticity, trace gravel.	☒	S3	100	▲ 0, 2, 1	▌●▌
228									
	4								
227		15		- Soft at 4.57 m.	☒	S4		▲ 0, 1, 2	●
226.5	5			**END OF HOLE AT 5.03 m.**					
226				Notes: 1. Open hole to 4.57 m. 2. Water at depth of 1.67 m below grade upon completion of drilling. 3. Backfilled with bentonite chips. 4. Completed on June 08, 2013.					
	6	20							
225									
	7								
224		25							
	8								
223									
	9	30							
222									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-306**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.26 m
SITE	Talbot Canal - Southeast Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 910 m from Lock 39 (south side) - on the crest	WATER ELEV.	
DRILLING METHOD	Portable Rig - Continuous Split Spoon, Manual Hammer	DATE DRILLED	09/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION
231.1			**TOPSOIL** - Black, moist, organic matters.
231			**EMBANKMENT FILL**
			Clayey Silt to Silty Clay Fill (0.15 - 2.44 m) - Brown, moist, stiff, low plasticity.
			- Trace sand at 0.61 m.
	1		
230		5	
	2		- Soft below 1.83 m.
229			- Grain Size Distribution: Gravel (0.0%), Sand (18.6%), Silt (71.1%), Clay (10.3%) at 2.1 m.
228.2	3	10	
228			**CLAYEY SILT TO SILTY CLAY** - Brown, very moist, soft, intermediate plasticity, some sand, trace gravel.
			- Stiff between 3.66 and 4.27 m.
	4		
227		15	
	5		
226			
	6	20	
225			
224.7			
224.6			**SILT TILL** - Grey, moist, dense, low plasticity.
			END OF HOLE AT 6.71 m.
	7		
224		25	
	8		
223			
	9	30	
222			

Notes:
1. Open hole to 6.71 m.
2. Backfilled with bentonite chip.
3. Completed on June 09, 2013.
4. 0.3 m of water measured at bottom of test hole upon completion of drilling.

SAMPLE TYPE	NUMBER	RECOVERY %
	S1	29
	S2	25
	S3	8
	S4	92
	S5	79
	S6	100
	S7	88
	S8	83
	S9	100
	S10	100
	S11	

SPT (N) blows/0.15 m ▲ — DYNAMIC CONE (N) blows/ft △ — 20 40 60

Cu POCKET PEN (kPa) ★ — Cu TORVANE (kPa) ◆ — 20 40 60 80

PL — MC — LL — % — 20 40 60 80

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-307**

CLIENT	PWGSC	JOB NO.	12-0006-028
PROJECT	Talbot River Dam and Lock 39	GROUND ELEV.	231.20 m
SITE	Talbot Canal - Southeast Canal Earthfill Embankment	TOP OF PVC ELEV.	
LOCATION	Approx. 20 m from Lock 39 (south side) - on the U/S side of the crest	WATER ELEV.	
DRILLING METHOD	Portable Rig - Continuous Split Spoon, Manual Hammer	DATE DRILLED	09/06/2013
		UTM (m)	N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION
231.0				**TOPSOIL** - Black, moist, organic matters.
231				**EMBANKMENT FILL**
				Clayey Silt to Silty Clay Fill (0.150 - 2.29 m) - Brown, moist, stiff, low plasticity, trace sand.
				- Trace gravel, some topsoil at 0.61 m.
	1			
230				- Soft below 1.22 m.
		5		
	2			
229				
228.9				**TOPSOIL** - Black, moist.
228.6				**CLAYEY SILT TO SILTY CLAY** - Brown, very moist, firm, intermediate plasticity, trace sand.
	3	10		
228				- Grain Size Distribution: Gravel (0.0%), Sand (18.2%), Silt (71.9%), Clay (9.9%) at 3.4 m.
				- Soft, trace gravel at 3.66 m.
	4			
227				- Very moist below 4.27 m.
		15		
226.3				
	5			**END OF HOLE AT 4.88 m.**
226				
	6	20		
225				
	7			
224				
		25		
	8			
223				
	9			
222		30		

Notes:
1. Open hole to 4.88 m.
2. 0.30 m of water measured at bottom of the test hole upon completion of drilling.
3. Backfilled with bentonite chip.
4. Completed on June 09, 2013.

SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △
	S1	63	3, 4, 6, 4
	S2	75	2, 3, 2, 3
	S3	63	1, 2, 2, 2, 2, 2
	S4		2, 2, 3, 5
	S5	75	5, 8, 7
	S6	71	3, 1, 2, 3
	S7	75	1, 1, 1
	S8	100	2, 1, 1, 2, 4

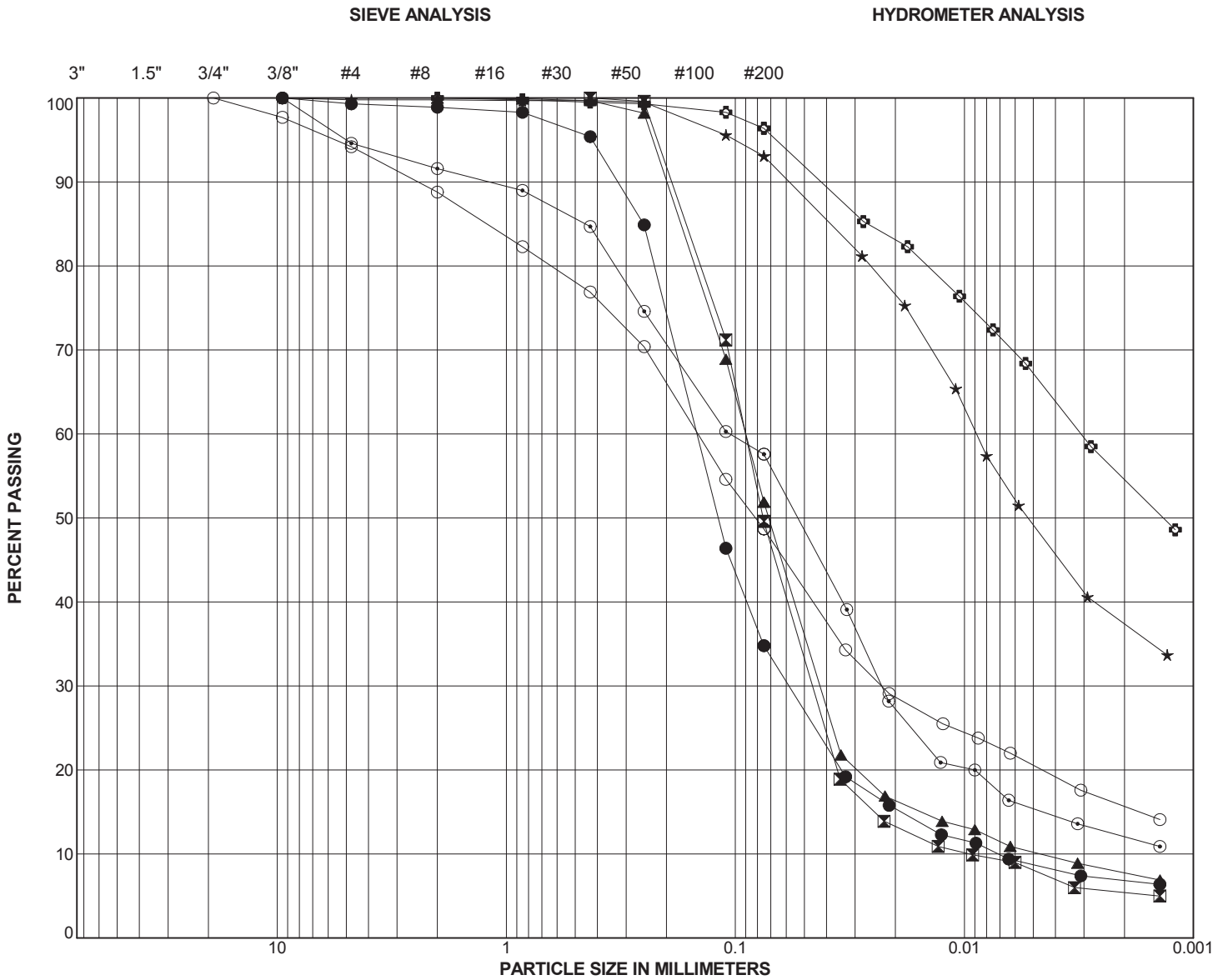
Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
OGS INC.	SG/CH	MJ	9/4/15

APPENDIX A2

GRAIN SIZE PLOTS



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	TH 13-101	2.4	S5	0.7	64.5	28.0	6.8	34.8	20.7	3.3	
⊠	TH 13-101	4.3	S8	0.0	50.4	44.2	5.4	49.6	9.5	2.5	
▲	TH 13-102	0.6	S2	0.0	48.1	44.1	7.8	51.9	19.4	4.4	
★	TH 13-102	3.7	S7	0.2	6.7	55.7	37.4	93.1			CI
⊙	TH 13-103	5.5	S10	5.4	37.0	45.5	12.1	57.6			
✿	TH13-105	3.8	S4	0.0	3.6	41.8	54.6	96.4			CI
○	TH13-105	6.1	S7	5.8	45.5	33.0	15.7	48.7			

KGS GROUP

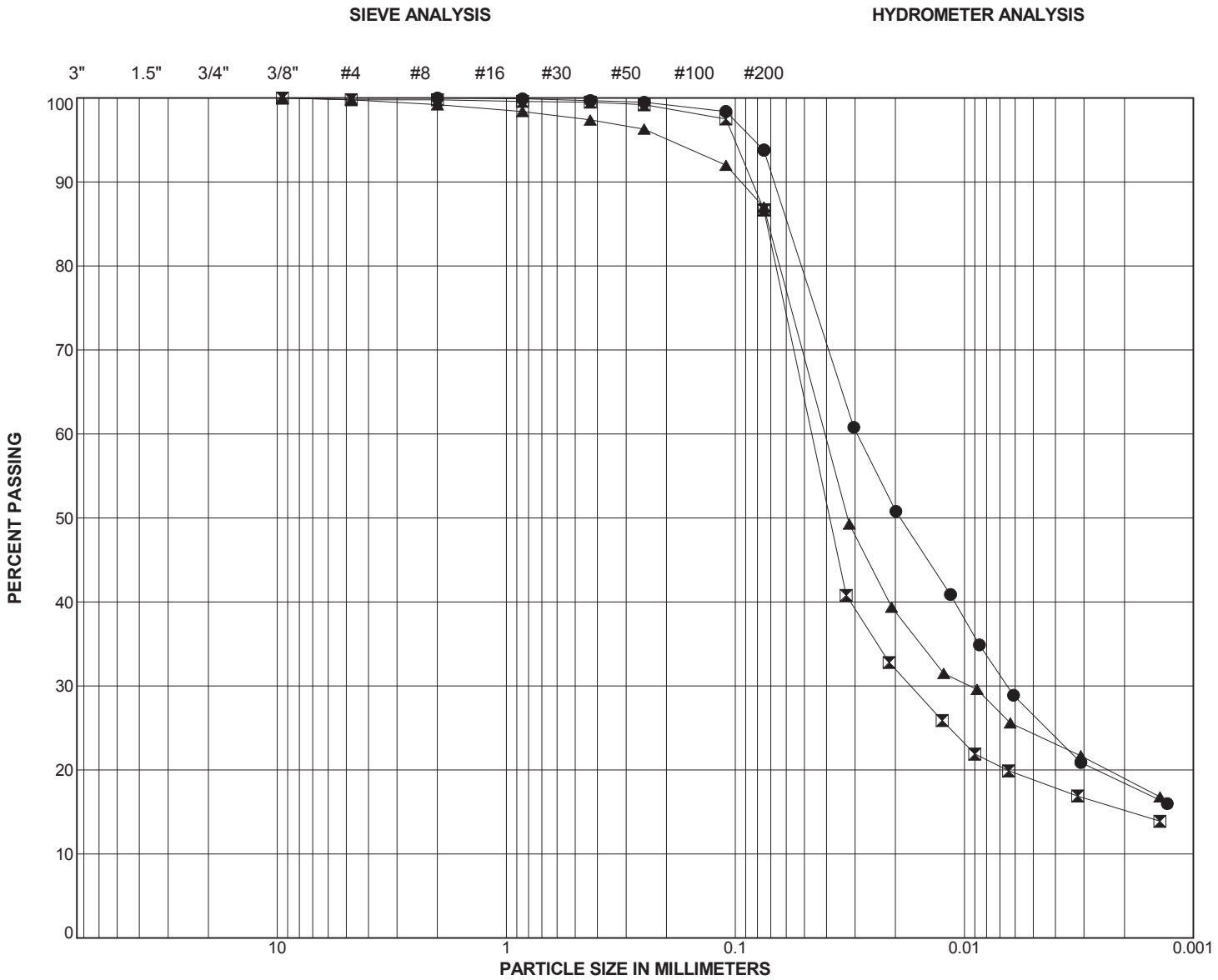
PWGSC

TALBOT RIVER DAM AND LOCK 39

GRAIN SIZE ANALYSES

August 2014	Figure 02	Page 1 of 1

SIEVE ANALYSIS P:\PROJECTS\2012\12-0006-028\DESIGN\GEO\LOGS\TALBOT GINT _SN\TALBOT RIVER DAM LOGS.GPJ



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	*TH13-201*	*6.1*	*S5*	*0.0*	*6.2*	*75.4*	*18.4*	*93.8*			*CL*
⊠	*TH13-202*	*4.6*	*S4*	*0.2*	*13.1*	*71.5*	*15.2*	*86.7*			
▲	*TH13-202*	*10.7*	*S8*	*0.2*	*12.8*	*68.0*	*19.0*	*87.0*			

KGS GROUP

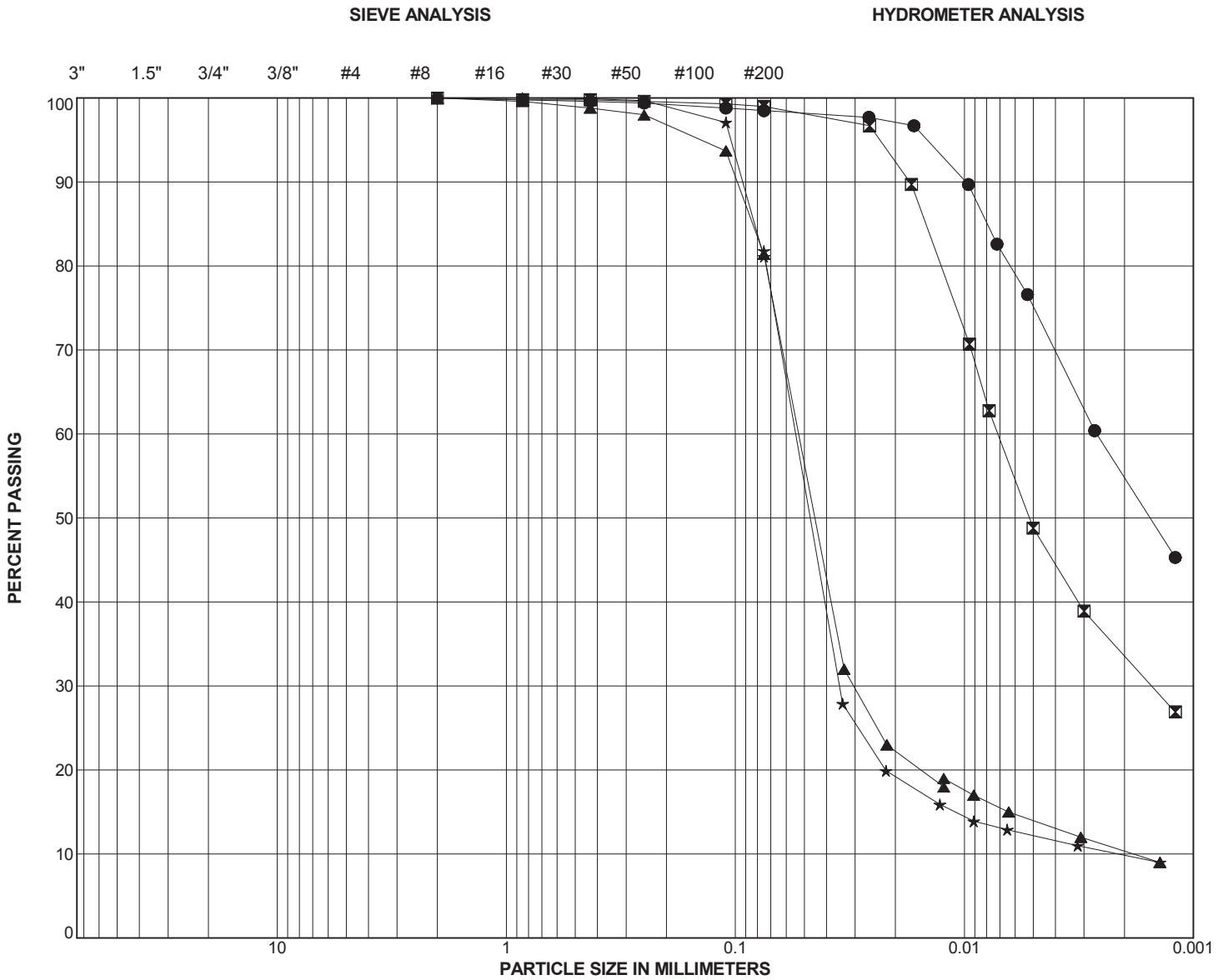
PWGSC

TALBOT RIVER DAM AND LOCK 39

GRAIN SIZE ANALYSES

August 2014	Figure 03	Page 1 of 1

SIEVE ANALYSIS P:\PROJECTS\2012\12-0006-028\DESIGN\GEO\LOGS\TALBOT GINT _SN\LOCK 39.GPJ



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	TH13-301	4.9	S4	0.0	1.5	43.7	54.8	98.5			
⊠	TH13-304	3.4	S3	0.0	1.0	65.4	33.6	99.0			
▲	TH13-306	2.1	S4	0.0	18.6	71.1	10.3	81.4	29.0	9.6	
★	TH13-307	3.4	S6	0.0	18.2	71.9	9.9	81.8	25.9	10.6	

KGS GROUP

PWGSC

Talbot River Dam and Lock 39

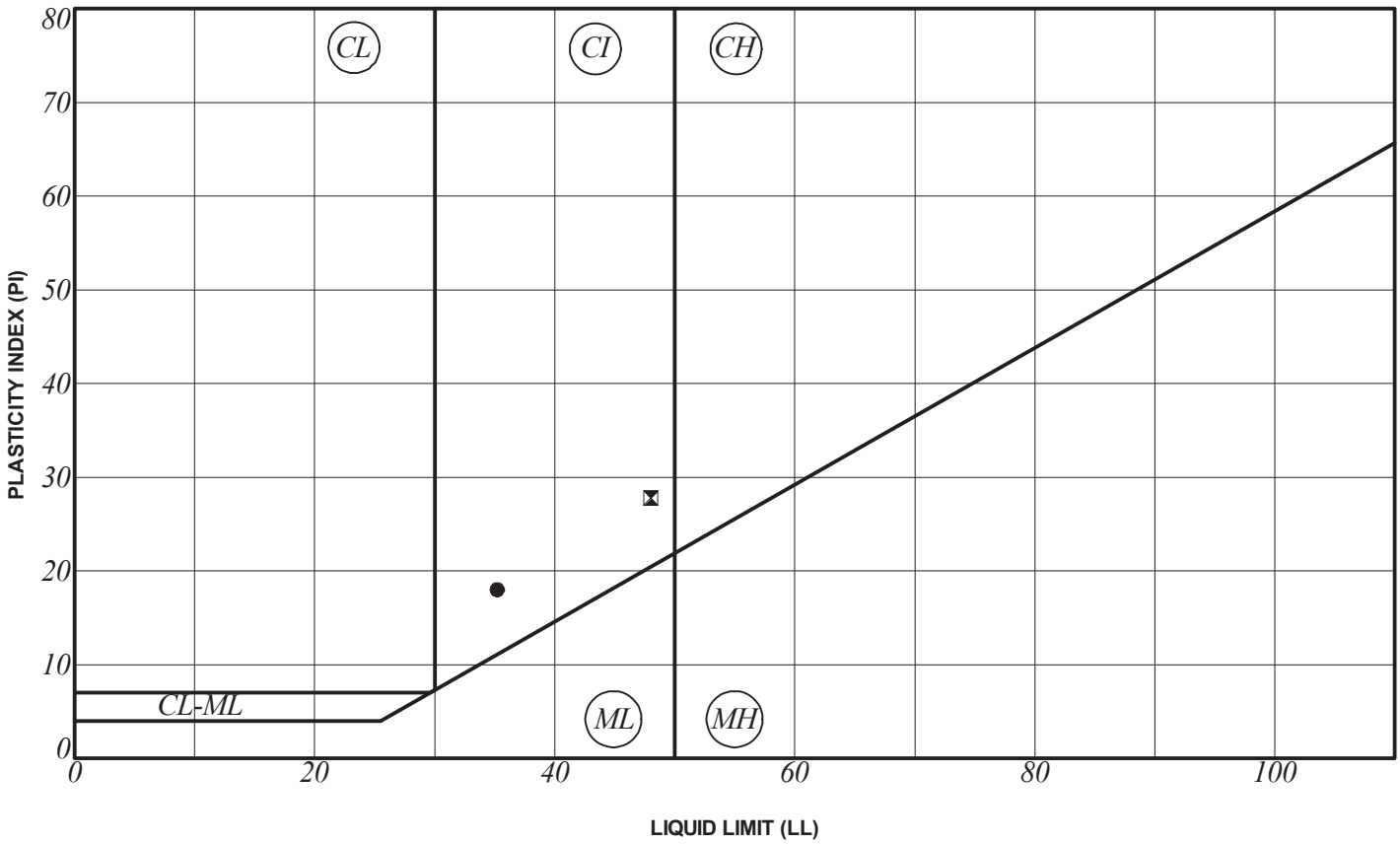
GRAIN SIZE ANALYSES

August 2014	Figure 06	Page 1 of 1

SIEVE ANALYSIS P:\PROJECTS\2012\12-0006-028\DESIGN\GEO\LOGS\TALBOT GINT _SN\TALBOT CANAL LOGS.GPJ

APPENDIX A3

A-LINE PLOTS



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH 13-102	3.7	S7	35	17	18	6.7	55.7	37.4	35.7	CI
⊠	TH13-105	3.8	S4	48	20	28	3.6	41.8	54.6	42.8	CI

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

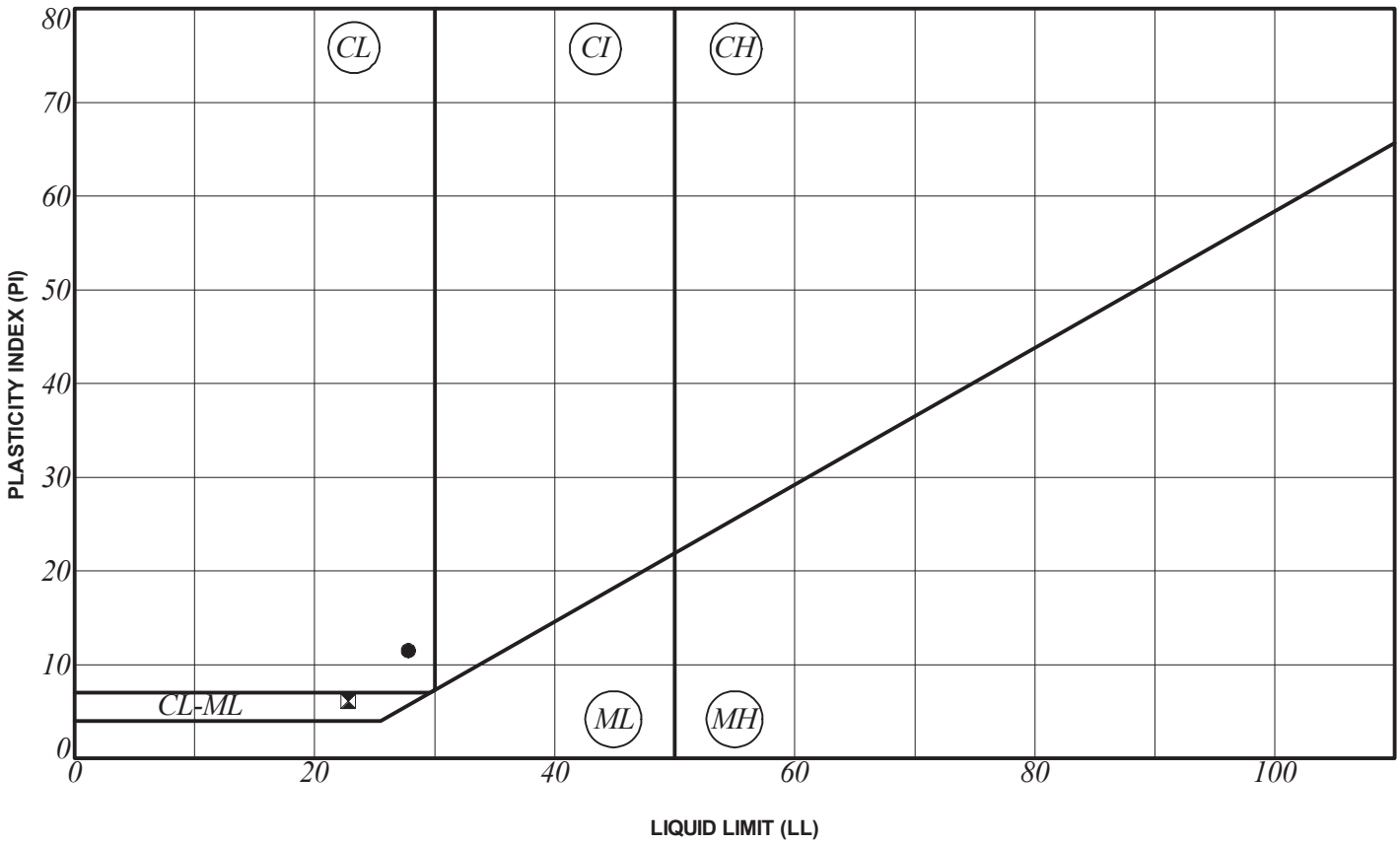
PWGSC

TALBOT RIVER DAM AND LOCK 39

A-LINE PLOT

August 2014	Figure 01	Page 1 of 1

A-LINE PLOT P:\PROJECTS\2014\14-0008-026\DESIGN\GEOLOGS\TALBOT GIN_SN\TALBOT RIVER DAM LOGS.GPJ



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH13-201	6.1	S5	28	16	12	6.2	75.4	18.4	24.7	CL
⧗	TH13-202	3.0	S3	23	17	6				18.7	CL-ML

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

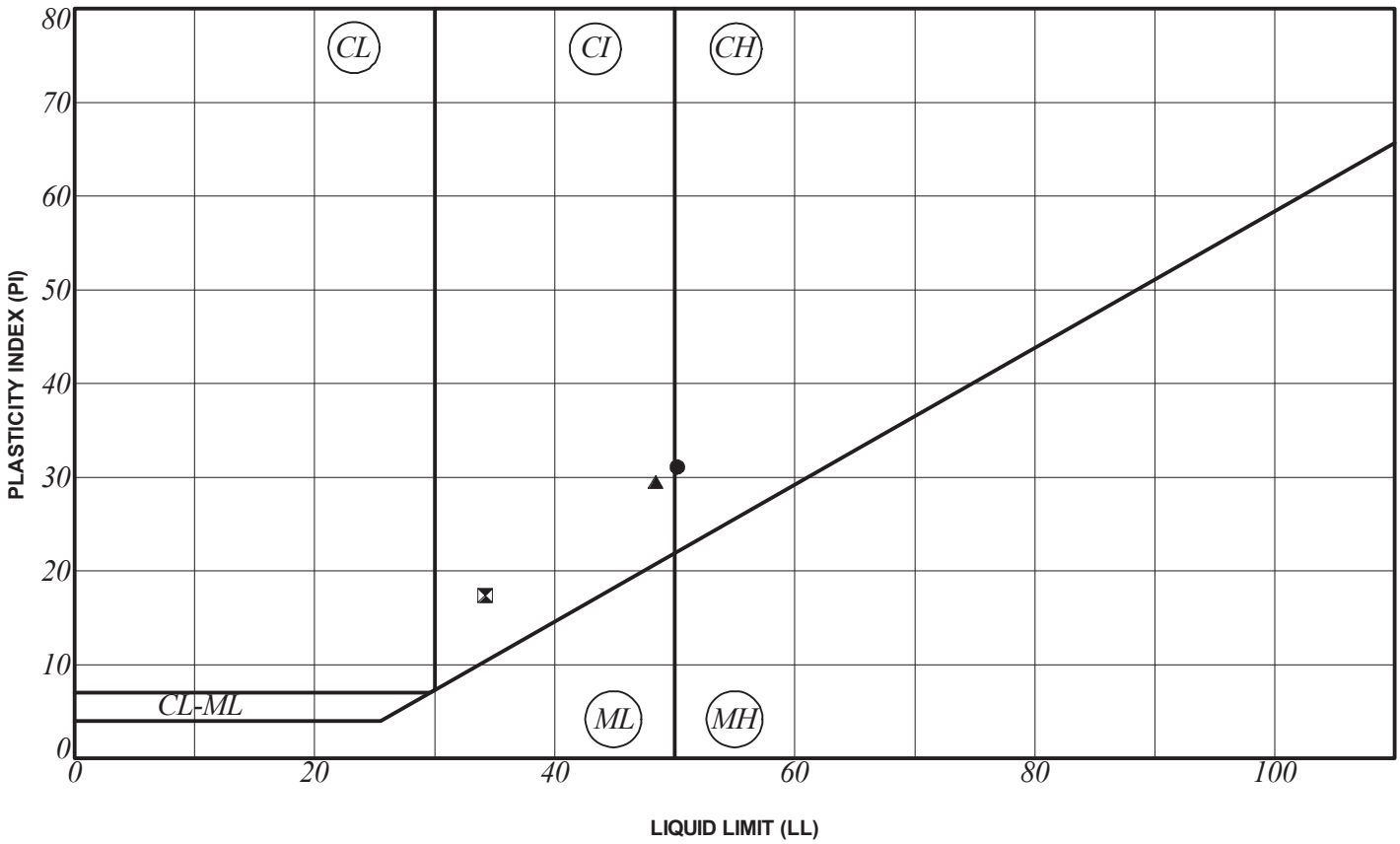
PWGSC

TALBOT RIVER DAM AND LOCK 39

A-LINE PLOT

August 2014	Figure 04	Page 1 of 1

A-LINE PLOT P:\PROJECTS\2014\14-0008-026\DESIGN\GEOLOGS\TALBOT GIN_SINLOCK 39.GPJ



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH13-301	4.9	S4	50	19	31	1.5	43.7	54.8	43.9	
⊠	TH13-304	3.4	S3	34	17	17	1.0	65.4	33.6	31.0	
▲	TH13-305	3.4	S3	48	19	30				43.1	

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

PWGSC

Talbot River Dam and Lock 39

A-LINE PLOT

August 2014	Figure 05	Page 1 of 1

A-LINE PLOT P:\PROJECTS\2014\14-0008-026\DESIGN\GEOLOGS\TALBOT GIN_SN\TALBOT CANAL LOGS.GPJ

APPENDIX B

RECOVERED SAMPLE PHOTOS

Photo 1: Right Earthfill Embankment
(TH13-103, S8, and depth 14'-16')
Note: sandy silt to silty sand

Photo 2: Right Earthfill Embankment
(TH13-101, Bedrock Core and depth 21.0')
Note: limestone bedrock

Photo 3: Lock 39 Earthfill Embankment
(TH13-201, S5, and depth 20'-21.5')
Note: clayey silt to silty clay

Photo 4: Lock 39 Earthfill Embankment
(TH13-201, S6, and depth 25'-26.5')
Note: clayey silt to silty clay

Photo 5: Lock 39 Earthfill Embankment
(TH13-202, S4 and depth 15'-16.5')
Note: clayey silt to silty clay

Photo 6: Lock 39:Earthfill Embankment
(TH13-202, S6,and depth 25'-26.5')
Note: clayey silt to silty clay

Photo 7: Northwest Canal Embankment
(TH13-302, S1, and depth 2.5'-4.0')
Note: clayey silt to silty clay

Photo 9: Northwest Canal Embankment
(TH13-302, S4, and depth 15'-16.5')
Note: clayey silt to silty clay

APPENDIX C

ADVANCED LABORATORY TESTING REPORT BY GOLDER ASSOCIATES LTD., MISSISSAUGA, ON

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 1 OF 3				FIGURE
TEST STAGE	A	B	C	D
BOREHOLE NUMBER	TP-01	TP-01	TP-01	TP-01
SAMPLE	S3	S3	S3	S3
SAMPLE DEPTH, (m)	1.68-1.98	1.68-1.98	1.68-1.98	1.68-1.98
SAMPLE HEIGHT, (mm)	30.00	30.00	30.00	30.00
SAMPLE LENGTH, (mm)	60.00	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	10.2	10.2	10.2	10.5
NORMAL (CONSOLIDATION) STRESS, (kPa)	100	300	500	700
WATER CONTENT, AFTER TEST, (%)	18.1	17.3	16.7	-
DISPLACEMENT RATE, mm/min	0.06	0.06	0.06	0.06
TIME TO FAILURE, hours	0.5	0.5	0.7	0.8
PEAK SHEAR STRESS, (kPa)	89.2	236.9	448.0	668.8
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.7	1.7	2.4	3.0
RESIDUAL SHEAR STRESS, (kPa)	57.2	153.3	329.2	572.2
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	16.4	13.8	12.8	14.1
DRY DENSITY, initial, Mg/m^3	1.78	1.78	1.78	1.77
WET DENSITY, initial, Mg/m^3	1.96	1.96	1.96	1.96

TEST NOTES:

- Specimens prepared as per clients request: target dry density1.77 Mg/m3 and 10.5% water content.
- Normal stresses asigned by the client
- Tests performed on -4.75mm material

PRELIMINARY

Date: 1/30/2014

Project No. 13-1183-0132

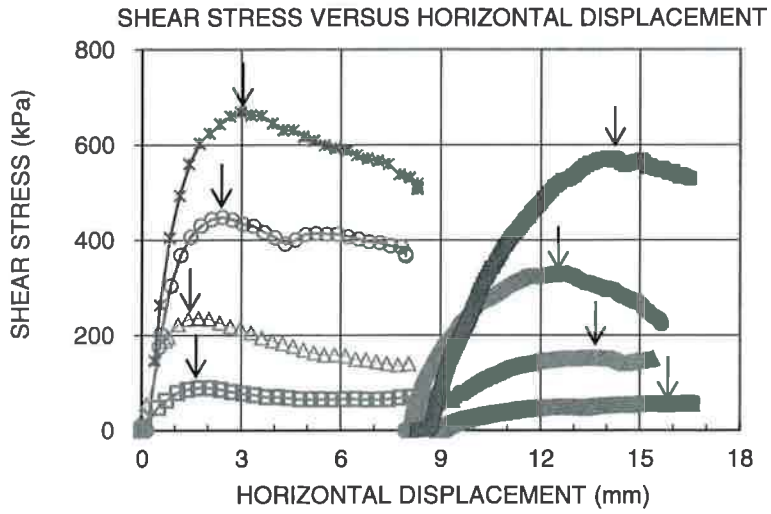
Golder Associates

Prepared By: LH

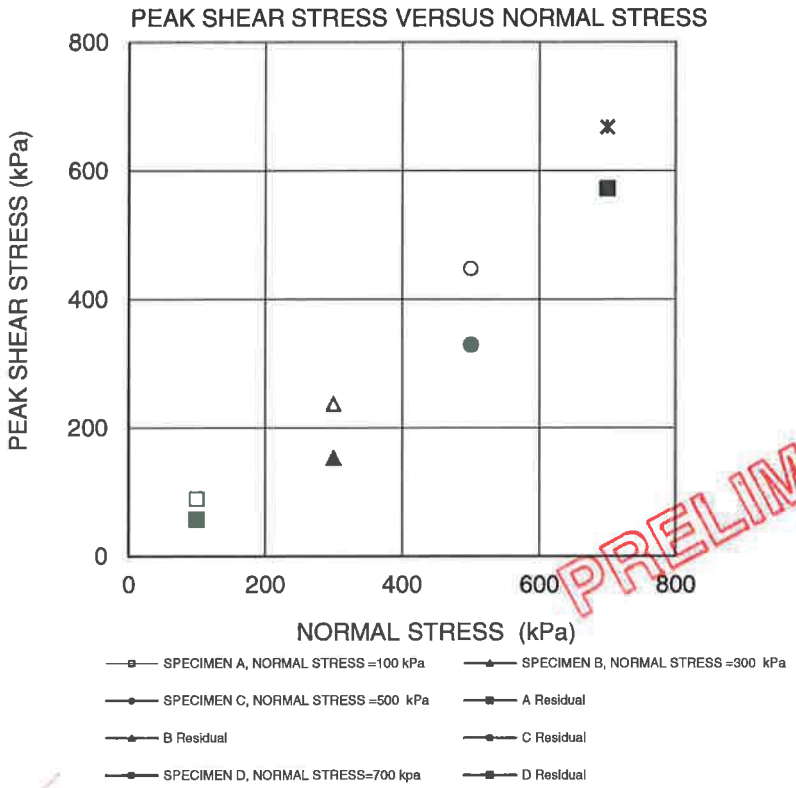
Checked By: LH

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 2 OF 3	FIGURE

BH TP-01 SA S3



BH TP-01 SA S3



PRELIMINARY

Date: 1/30/2014

Project No. 13-1183-0132

Golder Associates

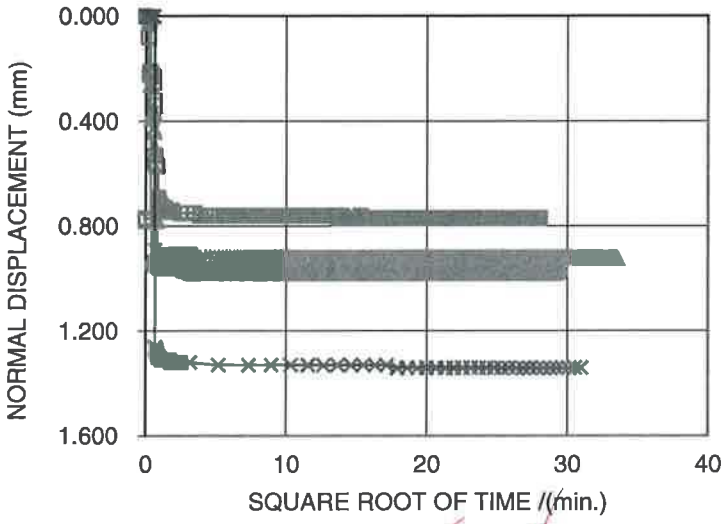
Prepared By: LH

Checked By: R

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE

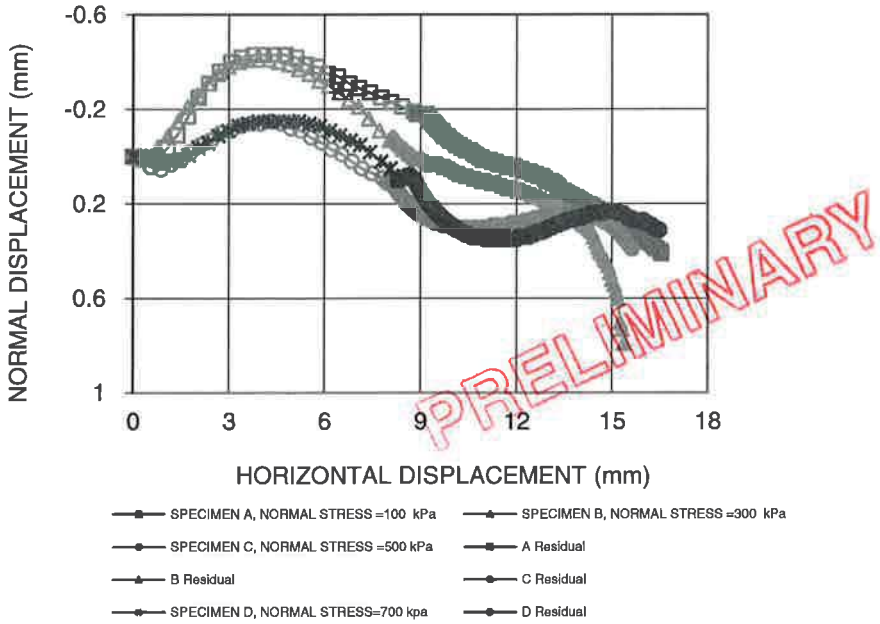
BH TP-01 SA S3

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BH TP-01 SA S3

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



PRELIMINARY

Date:	1/30/2014	Prepared By:	LH
Project No.	13-1183-0132	Checked By:	RO

Golder Associates

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 1 OF 4			FIGURE
TEST STAGE	A	B	C
BOREHOLE NUMBER	-	-	-
SAMPLE	TH 13-105	TH 13-105	TH 13-105
DEPTH, m	3.05-3.81	3.05-3.81	3.05-3.81
SPECIMEN DIAMETER, cm	5.00	5.01	5.00
SPECIMEN HEIGHT, cm	10.06	10.07	10.13
NATURAL WATER CONTENT, %	33.3	38.9	36.2
DRY DENSITY, Mg/m^3	1.43	1.32	1.37
WATER CONTENT AFTER SATURATION, %	33.6	40.2	36.5
CELL PRESSURE, σ_3, kPa	135.0	325.0	305.0
BACK PRESSURE, kPa	65.0	205.0	135.0
PORE PRESSURE PARAMETER "B"	0.96	0.97	0.99
CONSOLIDATION PRESSURE, σc, kPa	70.0	120.0	170.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	5.5	7.9	8.6
WATER CONTENT AFTER CONSOLIDATION, %	29.7	34.2	30.2
AVERAGE RATE OF STRAIN, %/hr	0.5	0.5	0.5
TIME TO FAILURE, HOURS	29.6	29.8	19.8
WATER CONTENT AFTER TEST, %	29.5	33.4	29.4
MAX. DEVIATOR STRESS, $(\sigma_1-\sigma_3)$, kPa	116.8	132.5	172.5
AXIAL STRAIN AT $(\sigma_1-\sigma_3)$ maximum, %	14.8	14.9	9.9
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1/σ'_3) maximum	4.5	3.6	3.7
DEVIATOR STRESS AT (σ'_1/σ'_3) maximum, kPa	100.5	122.1	169.8
AXIAL STRAIN AT (σ'_1/σ'_3) maximum, %	5.7	6.8	7.8
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1-\sigma_3)$ maximum	0.29	0.52	0.61
PORE PRESSURE PARAMETER, Af, AT (σ'_1/σ'_3) maximum	0.41	0.61	0.63
FILTER DRAINS USED, y/n	y	y	y

TEST NOTES:

Consolidation pressures are assigned by the client.
Specimen A taken 26-39 cm from bottom of tube.
Specimen B taken 13-26 cm from bottom of tube.
Specimen C taken 0-13 cm from bottom of tube.

FAILURE PLANE NUMBER	-	-	1.0
ANGLE OF FAILURE, DEGREES	Bulged	Bulged	60.0

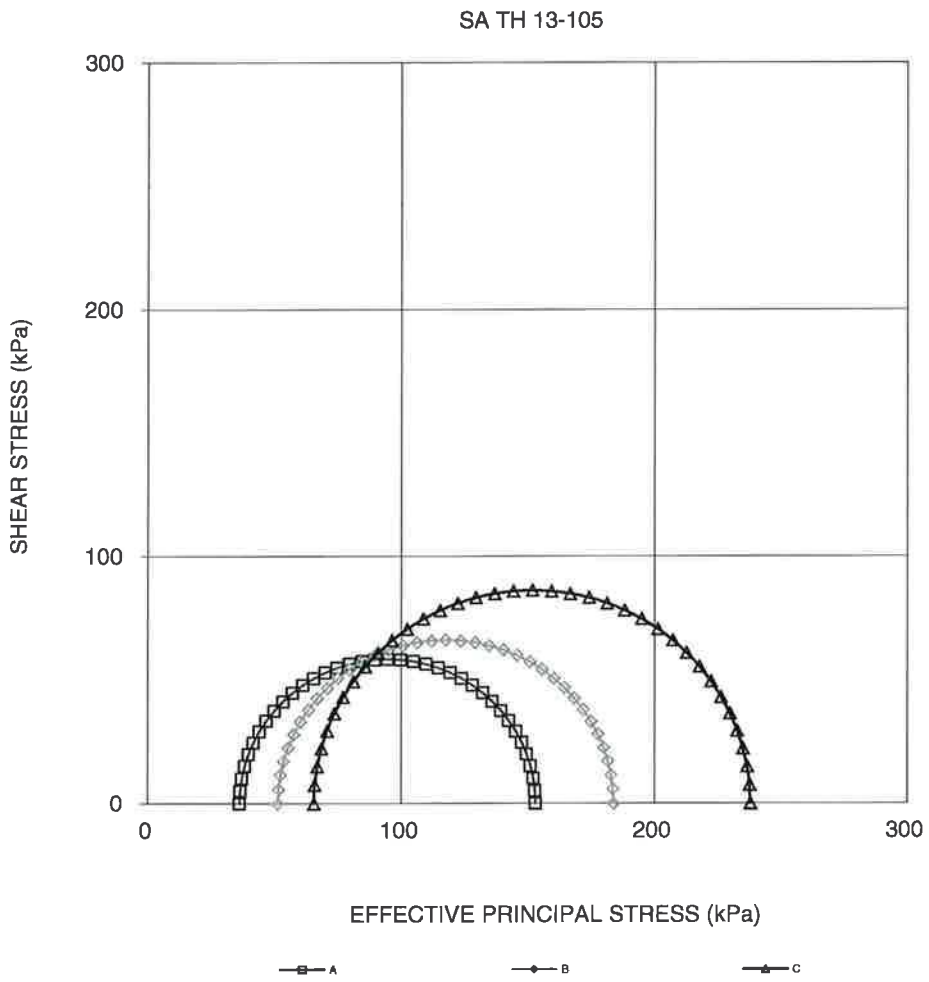
PRELIMINARY

Date: 10/20/2013
Project No. 13-1183-0110

Golder Associates

Prepared By: LH
Checked By: [illegible]

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 2 OF 4	FIGURE



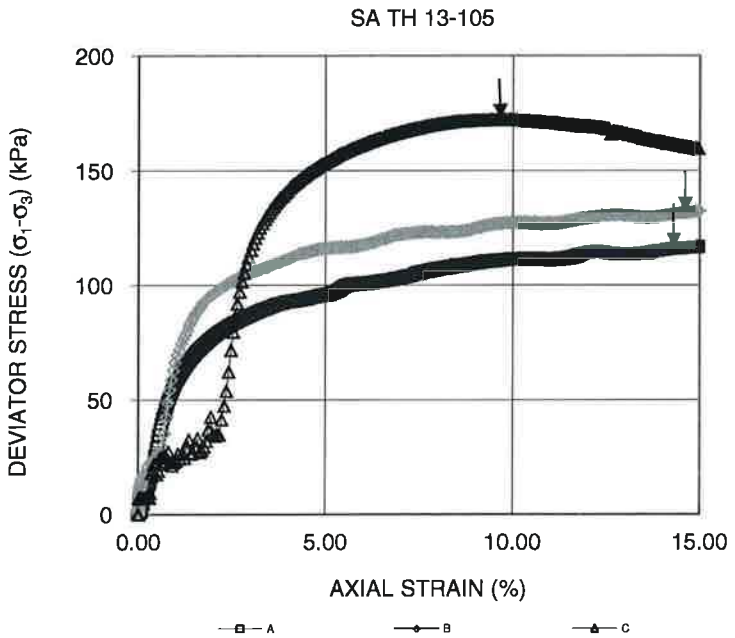
PRELIMINARY

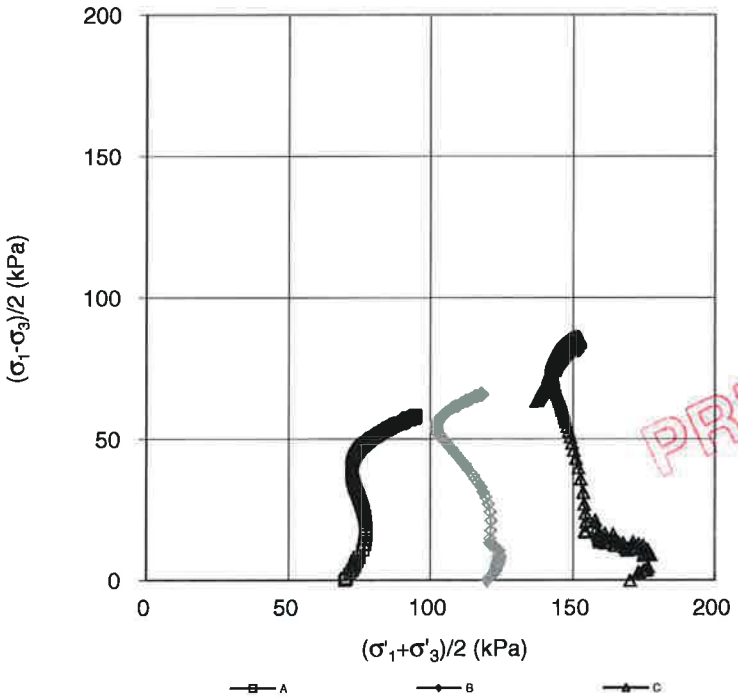
Date: 10/20/2013
Project No. 13-1183-0110

Golder Associates

Prepared By: LH
Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 3 OF 4	FIGURE



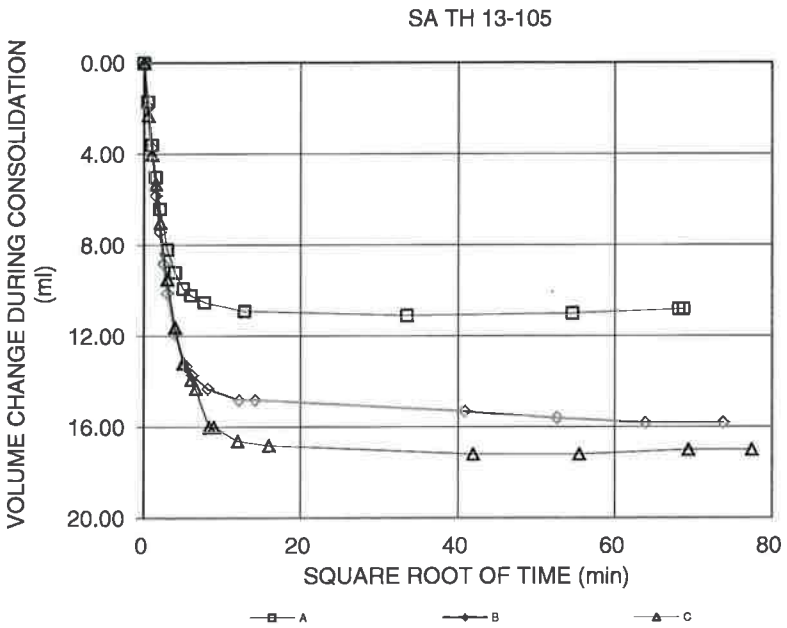


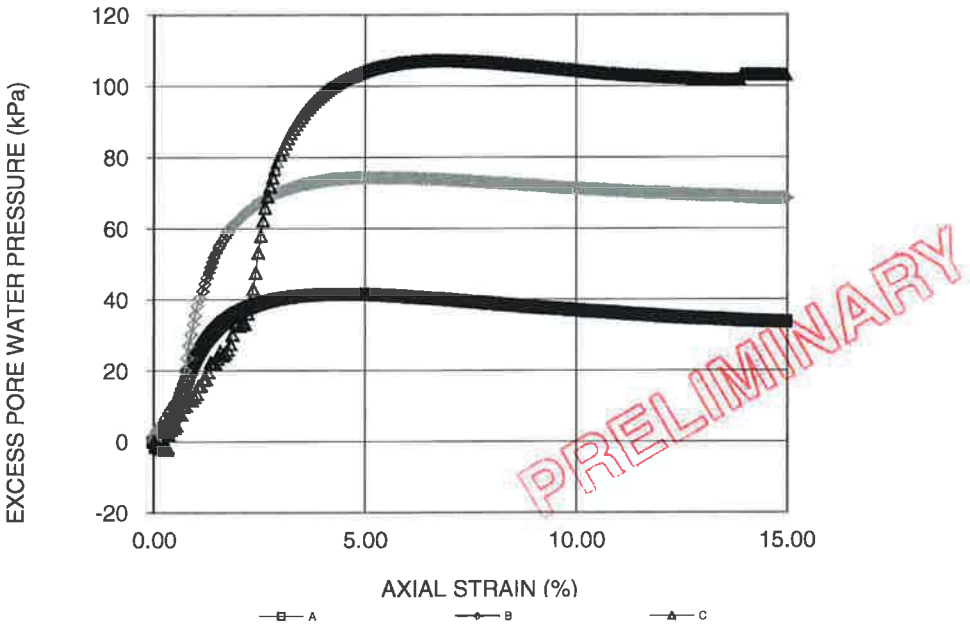
Date: 10/20/2013
Project No. 13-1183-0110

Golder Associates

Prepared By: LH
Checked By: MC

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 4 OF 4	FIGURE





Date: 10/20/2013

Project No. 13-1183-0110

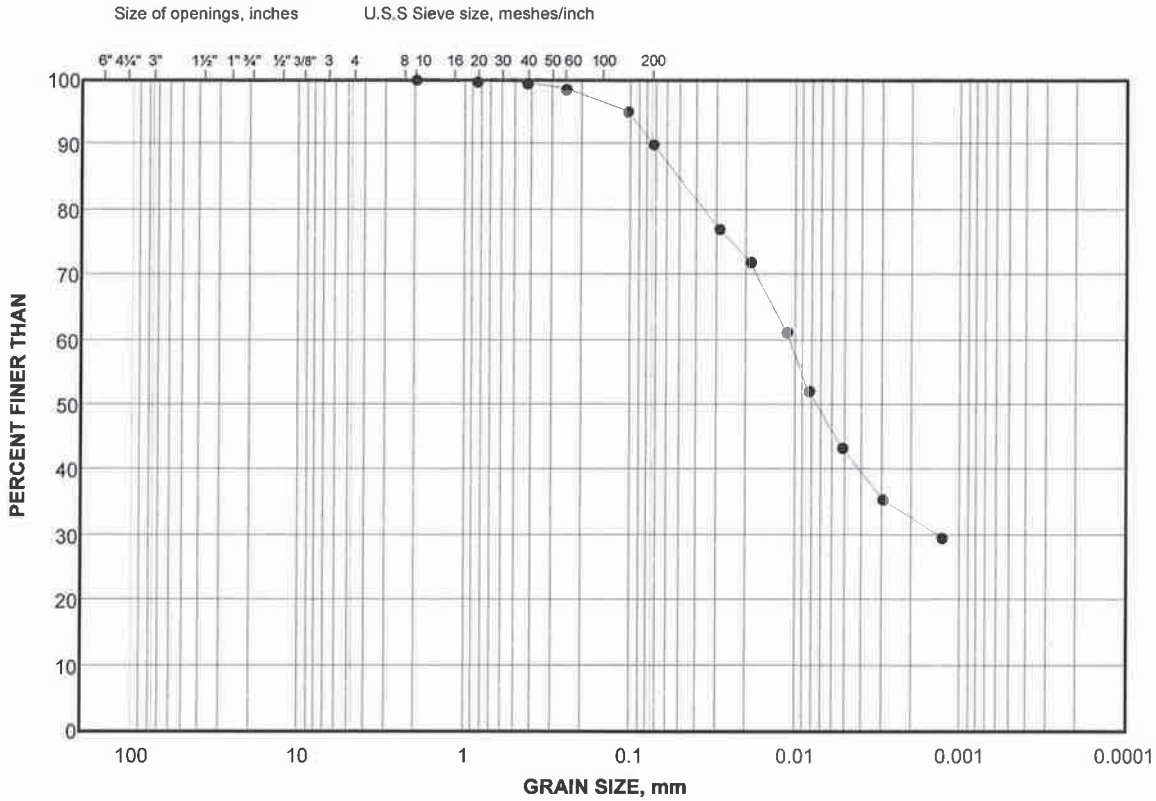
Golder Associates

Prepared By: LH

Checked By: [illegible]

GRAIN SIZE DISTRIBUTION

FIGURE



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

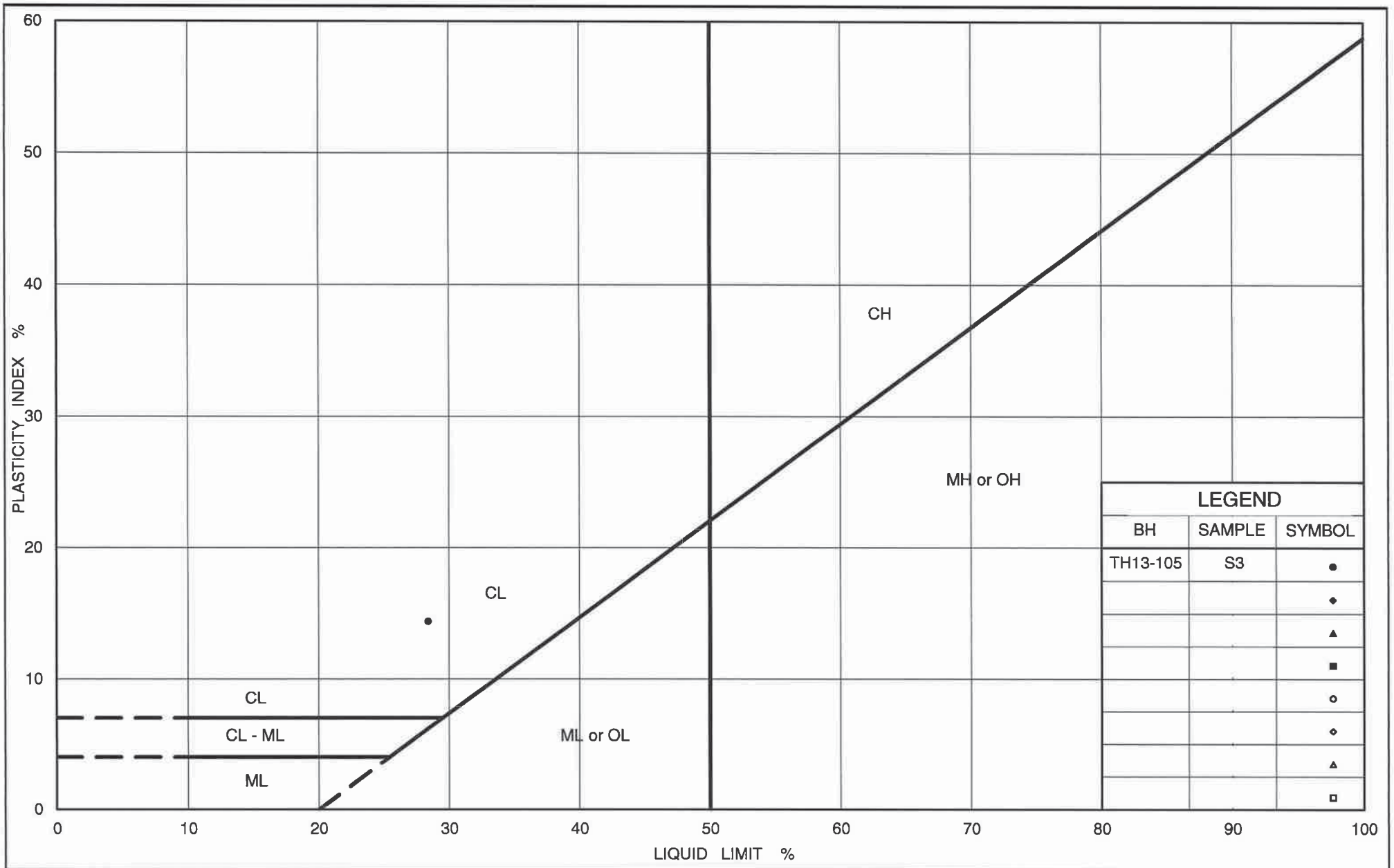
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	TH13-105	S3	3.00 - 3.80

Project Number: 13-1183-0110

Checked By: _____

Golder Associates

Date: 21-Oct-13



Golder Associates

PLASTICITY CHART

Figure No.

Project No. 13-1183-0110

Checked By: MU

SUMMARY OF ATTERBERG LIMITS DETERMINATION

ASTM D 4318-05

PROJECT NUMBER	13-1183-0110
PROJECT NAME	KGS Group / Testing / 13-0006-028
DATE TESTED	October, 2013

Borehole No.	Sample No.	Depth (ft)	Depth (m)	Atterberg Limits LL, PL, PI
TH13-105	S3	10.0-12.5	3.05-3.81	LL=28.4, PL=14.0. PI=14.4

Checked By:

Golder Associates

APPENDIX D

CALIBRATION CERTIFICATES

VW Piezometer Calibration Certificate

Serial #: 12-9170
Range : 350 kPa
Cable Length: 15 m
Date of Calibration: 11/13/2012

Part #: 52611028
Cable Part # : 50613524
Calibrated by: KB
Note:

ABC Calibration Factors

	A	B	C
kPa	-1.336052E-4	-6.303506E-2	1.248100E+3
psi	-1.937780E-5	-9.142463E-3	1.810216E+2

Pressure in kPa/psi = $(A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

TI Calibration Factors

	C0	C1	C2	C3	C4	C5
kPa	1.242617E+3	-6.033918E-2	7.514429E-2	-1.342518E-4	5.495633E-5	-1.294475E-3
psi	1.802200E+2	-8.751150E-3	1.089837E-2	-1.947089E-5	7.970461E-6	-1.877411E-4

Pressure in kPa/psi = $C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

Summary of Test Results at 15°C

Thermistor reading is 14.3 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

Applied (kPa)	Equivalent (psi)	Frequency (Hz)	Calculated (kPa)	Calculated (psi)	Error (%FS)
0.0	0.00	2829.6	0.0	0.00	0.00
35.0	5.08	2786.6	35.0	5.07	0.00
70.0	10.15	2743.0	69.9	10.14	0.02
105.0	15.23	2698.6	105.0	15.23	-0.01
140.0	20.31	2653.7	140.0	20.30	0.01
175.0	25.38	2608.0	175.0	25.38	0.01
210.0	30.46	2561.5	210.0	30.46	0.00
245.0	35.53	2514.3	245.0	35.53	0.00
280.0	40.61	2466.2	280.0	40.62	-0.01
315.0	45.69	2417.3	315.0	45.69	-0.01
350.0	50.76	2367.5	350.0	50.76	0.00

VW Piezometer Calibration Certificate

Serial #: 12-9209
Range : 350 kPa
Cable Length: 15 m
Date of Calibration: 11/13/2012

Part #: 52611028
Cable Part # : 50613524
Calibrated by: KB
Note:

ABC Calibration Factors

	A	B	C
kPa	-1.131269E-4	-2.125272E-3	9.497409E+2
psi	-1.640767E-5	-3.082447E-4	1.377483E+2

Pressure in kPa/psi = $(A \times Hz^2) + (B \times Hz) + C$, where Hz is frequency in Hertz.

TI Calibration Factors

	C0	C1	C2	C3	C4	C5
kPa	9.526539E+2	-2.303526E-3	-2.366613E-1	-1.132229E-4	4.806036E-5	-9.667822E-4
psi	1.381659E+2	-3.340864E-4	-3.432361E-2	-1.642102E-5	6.970321E-6	-1.402150E-4

Pressure in kPa/psi = $C0 + (C1 \times Hz) + (C2 \times T) + (C3 \times Hz^2) + (C4 \times Hz \times T) + (C5 \times T^2)$

Where Hz is the frequency reading in Hertz and T is the Thermistor reading in degrees C.
TI factors are calculated from temperatures at 5.0, 15.0 and 25.0 degrees C.
Applied pressure and temperature are NIST traceable.

Summary of Test Results at 15°C

Thermistor reading is 14.3 °C.

Applied Pressure is referenced to 1 atm. Calculated Pressure uses ABC Calibration factors.

Applied (kPa)	Equivalent (psi)	Frequency (Hz)	Calculated (kPa)	Calculated (psi)	Error (%FS)
0.0	0.00	2888.1	0.0	0.00	0.00
35.0	5.08	2834.2	35.0	5.08	0.00
70.0	10.15	2779.3	70.0	10.15	0.00
105.0	15.23	2723.2	105.0	15.23	-0.01
140.0	20.31	2666.0	140.0	20.31	-0.01
175.0	25.38	2607.6	175.0	25.38	0.00
210.0	30.46	2547.8	210.0	30.46	0.00
245.0	35.53	2486.5	245.0	35.54	-0.01
280.0	40.61	2423.7	280.1	40.62	-0.01
315.0	45.69	2359.3	315.0	45.69	-0.01
350.0	50.76	2293.1	350.0	50.76	0.00