



THURBER ENGINEERING LTD.

Soaring Lands Spa Geotechnical Investigation

5440 and 5450 Whitemud Road NW, Edmonton, Alberta

Client Name: Stantec
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1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Soaring Lands Spa development located at 5440 and 5450 Whitemud Road NW in Edmonton, Alberta.

The scope and requirements of the geotechnical investigation were outlined in our proposal to Ms. Yolanda Lew of Stantec dated July 5, 2024. The scope of work did not include soil and groundwater environmental assessment. Authorization to proceed with the geotechnical investigation was received via the signed agreement by Mr. Steve Arsenault of Scandinave Spa. dated July 18, 2024.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. PROPOSED DEVELOPMENT

2.1 Background

Thurber previously completed a geotechnical investigation and set-back assessment for the lots located at 5440 and 5450 Whitemud Road NW in Edmonton, Alberta in 2010. The findings of the geotechnical investigation and set-back assessment were provided in our report No. 17-160-12 dated October 12, 2010 to Maclab Enterprises and the University of Alberta.

Thurber has recently completed a set-back assessment for the above referenced lots in 2023 to check for any substantial changes to the valley slopes since issuing our 2010 report. The findings of the set-back assessment were provided in our report No. 36428 submitted to Dialog and the University of Alberta Properties Trust (UAPT) dated May 18, 2023.

A top of bank walk was completed by Mr. Thomas Vogt, P.Eng., and Mr. Robin Tweedie, P.Eng., both of Thurber and was accompanied by representatives from Stantec, UAPT, City of Edmonton and Pals Geomatics on October 19, 2023. The development setbacks had been staked at the site by Geomatics at the time of our site walk. The field review confirmed that the top of bank and the interpreted Urban Development Line (UDL) and Structure Development Line (SDL) were located on site in general accordance with the recommendations presented in our geotechnical assessment report No. 36428 dated May 18, 2023. and were presented in our letter No. 36428 dated November 17, 2023 to UAPT.

All structures at this site should be located behind the Structure Development Line, as shown on Drawing No. 11600145AB-TOB from our November 17, 2023 letter, and reproduced in Appendix A.

2.2 Spa Development

The proposed development is located at 5440 and 5450 Whitemud Road NW, in Edmonton, Alberta. An image of the site condition at the time of undertaking our field investigation is shown in Figure 2.1 below.



Figure 2.1: Site Condition Near Test Hole TH24-06

Based on the conceptual site plan drawing and information provided by Stantec, we understand that the proposed development will generally consist of the following buildings: reception, massage, sauna, steam, mechanical and two solarium buildings. The total development footprint is about 10.4 acres. A conceptual site plan drawing showing a potential building layout is included in Appendix A.

A site plan drawing showing the approximate test hole locations from the 2024 geotechnical investigation and relevant test holes from the 2010 geotechnical investigation is presented in Drawing No. 36428-1 in Appendix A.

As requested by the client, Thurber performed a geotechnical investigation at this site to assess the soil conditions and provide geotechnical recommendations for the site development and foundation design of the proposed spa development.

3. METHOD OF INVESTIGATION

3.1 Field Investigation

Twelve (12) test holes, TH24-01 through -12, were drilled on site using a truck mounted auger drill rig operated by All Service Drilling Inc. of Nisku, Alberta on August 12 and 13, 2024. The test holes were drilled to depths ranging from 4 m and 12 m below the ground surface within the proposed pavement areas and building footprints, respectively. Drawing No. 36428-1 attached in Appendix A shows the approximate test hole locations.

Prior to drilling, the test hole locations were cleared of underground utilities by the Utility Safety Partners (formerly Alberta-One Call) and a private utility locator.

Disturbed soil samples were obtained from the auger flights during drilling and Standard Penetration Tests (SPTs) were carried out at selected depths in each test hole. The undrained shear strength (C_{open} value) of cohesive soil samples was estimated using a pocket penetrometer.

Water and slough levels were noted during and immediately after completion of the drilling program, and standpipe piezometers were installed in test holes TH24-03, -04, -08, -10 and -11 to permit future monitoring of the groundwater levels. The remaining test holes were backfilled with bentonite chips and drill cuttings. Groundwater readings in the piezometers were obtained at the completion of drilling, and again on August 27, 2024, 2 weeks after drilling.

Locations of previous test holes that were drilled within the current development site in 2010 are also shown on Drawing No. 36428-1, and the test hole logs are included in Appendix B. Those test holes were extended to depths of up to 51.8 m below ground surface.

3.2 Laboratory Testing

Laboratory testing included visual classification and determination of the natural water content of all soil samples. In addition, Atterberg limits and water-soluble sulphate tests were carried out on selected representative soil samples.

The results of the geotechnical drilling and laboratory program are summarized in the test hole logs provided in Appendix B. An explanation of the symbols and terms used to describe observations in the test hole logs, and the Modified Unified Soil Classification are also provided in Appendix B.

Results of Atterberg limits and water-soluble sulphate ion content tests are summarized in Tables 3.1 and 3.2, respectively, and presented in Appendix C.

Table 3.1: Summary of Atterberg Limits Test

TEST HOLE	SAMPLE DEPTH (m)	MATERIAL	WATER CONTENT (%)	ATTERBERG LIMITS			MODIFIED USCS
				LL (%)	PL (%)	PI (%)	
TH24-03	0.30	Clay Fill	17.8	57	18	39	CH
TH24-07	0.61	Clay Fill	21.7	59	19	40	CH
TH24-09	0.46	Clay	25.3	74	28	46	CH
TH24-10	1.52	Clay	25.3	67	26	41	CH

Table 3.2: Summary of Water-Soluble Sulphate Ion Content Tests

TEST HOLE	SAMPLE DEPTH (m)	SOLUBLE SULPHATE CONTENT (%)
TH24-07	1.52	0
TH24-08	3.05	0.02
TH24-10	6.10	0.40
TH24-11	3.05	0

4. SITE DESCRIPTION

4.1 Subsurface Conditions

In general, the subsurface soils at the drilled locations consisted of the following main soil types in descending order:

- Topsoil
- Gravel Fill
- Clay Fill

- Clay
- Sand
- Silt
- Clay Till
- Empress Sand and Gravel
- Bedrock (Interbedded Clay Shale/Sandstone).

The soil conditions are generally consistent with the soil strata encountered during our 2010 geotechnical investigation. It should be noted however that the original residence on the property has been removed and it is likely that area around and under the old building areas may contain variable backfills.

Further descriptions of the main soil layers are provided in the following sections. A detailed description of subsurface conditions observed at each test hole location is presented on the test hole logs in Appendix B. The detailed descriptions in Appendix B should be used in preference to the generalized descriptions given below.

4.1.1 Topsoil

Topsoil was encountered at the surface in test holes TH10-1, -2, -4, -5, -6, -13 and TH24-06, -09, and -12. The topsoil was generally brown to black and contained some rootlets and ranged between 150 mm and 300 mm thick at the test hole locations.

It should be noted that the topsoil thickness may be greater between bore hole locations. If a more accurate determination of topsoil thickness is required for volume calculations, additional hand excavated test holes or test pitting should be carried out.

4.1.2 Gravel Fill

A gravel fill layer ranging between 400 mm and 425 mm in thickness was encountered in test holes TH10-3, TH24-05, -07, -08, and -11. The gravel was dark brown, silty, sandy and contained up to 50 mm diameter aggregate. The water content of the gravel fill ranged between six to eight percent.

4.1.3 Clay Fill

Clay fill was encountered in test holes TH24-01, -03, -05, -07, -08, and -11 at the ground surface or underlying the gravel fill and extended to depths ranging from about 1 m to 1.5 m below the ground surface. The clay fill was generally brown, silty and contained trace amounts of sand, gravel and organics. The water content of the clay fill ranged between 10 and 30 percent. SPT “N” values of the clay fill ranged from seven to 10 blows per 300 mm penetration, indicating a stiff consistency.

Atterberg limits tests on selected clay fill samples indicated liquid limits of 57 to 59 percent and plastic limits of 18 to 19 percent, indicating that the clay fill is high plastic.

4.1.4 Clay

Lacustrine silty clay was encountered at ground surface or underlying the fill or topsoil in test holes TH10-1 to -7, -10, -13 and test holes TH24-01 to -12. The clay extended between the test hole termination depths of 4.3 m and 10.5 m below ground surface.

The clay was generally brown, silty and contained trace amounts of oxides and coal. SPT “N” values in the clay layer ranged from five to 33 blows per 300 mm penetration, indicating a firm to hard consistency. The natural water content of the clay ranged from about six to 41 percent.

Atterberg limits tests conducted on selected clay samples from test holes TH24-09 and -10 yielded liquid limits ranging between 67 and 74 percent and the corresponding plastic limits between 26 and 28 percent, indicating the clay samples are high plastic.

4.1.5 Sand

Sand was encountered underlying the clay in test hole TH24-10 and extended to 8.4 m below the ground surface. The sand was generally brown and silty. The natural water content of the sand was nine percent.

4.1.6 Silt

Silt was encountered underlying the clay or sand in test holes TH24-10 to -12 and extended to 11.4 m below the ground surface. The natural water contents of the silt ranged from 24 to 32 percent. SPT “N” values in the silt ranged from five to 19 blows per 300 mm penetration, indicating a loose to compact relative density.

4.1.7 Clay Till

Glacial clay till was encountered underlying the clay in test holes TH10-1, -2, -3, -13, and TH24-07 to -12 and extended to the test hole termination depths of 11.9 m to 16.0 m below the ground surface. The clay till was generally brown becoming grey with depth, silty, sandy and contained trace amounts of gravel, coal, and oxides. The natural water content of the clay till ranged from 13 to 20 percent. SPT “N” values of the clay till ranged from 19 to 63 blows per 300 mm penetration, indicating a very stiff to very hard consistency.

It should be noted that, although not encountered during test hole drilling, the clay till frequently contains cobbles and boulders throughout.

4.1.8 Empress Sand and Gravel

Empress sand was underlying the clay till in test hole in the previous deeper 2010 test holes TH10-1, -2 and -3 and extended to depths ranging between 34 m to 37.3 m below the ground surface. The sand was generally brown, fine to medium grained and silty. The natural water content of the sand ranged from four to nine percent. SPT ‘N’ values ranged from 41 to greater than 100 blows per 300 mm penetration indicating a dense to very dense condition.

Gravel was encountered in two of the test holes (TH10-2 and TH10-3) below the sand, immediately above the bedrock contact. The thickness of the gravel ranged from 1.3 m to 1.8 m. The gravel was in general brown and silty, some clay to clayey, with trace coal seams. The natural water content of the gravel ranged from eight to 17 percent. One SPT ‘N’ value of 89 blows per 300 mm penetration indicating a very dense condition.

4.1.9 Bedrock (Interbedded Clay Shale/Sandstone)

Bedrock was encountered in all three test holes drilled at the slope crest at elevations of about 630.5 m to 630.7 m. Core recovery were typically 100 percent, and RQD values of 98 percent to 100 percent were determined for all core runs except between elevations 629.2 m and 627.1 m where the value was 87%. The bedrock was observed to be weathered over the upper 2.5 m of the unit.

The bedrock consisted of interbedded clay shale and sandstone, with some siltstone layers and coal seams. The clay shale was bentonitic between elevation 629.0 m and 629.2 m, between 622.6 m and 621.4 m, and between 621.7 m and 621.3 m. Slickensides were also observed in the clay shale between elevations 628.95 m and 627.95 m.

The results of direct shear testing on specimens obtained from the core samples of the bentonitic clay shale at 629.2 m (DS10-1) and 629.0 m (DS10-2) are provided in Appendix C. The results indicate peak strengths ranging from $\Phi_p'=20^\circ$ to $\Phi_p'=50^\circ$ at an assumed cohesion value of 50 kPa. Residual strength values of $\Phi_r'=10^\circ$ and $\Phi_r'=19^\circ$ were measured ($c'=0$ kPa).

4.2 Groundwater and Slough Conditions

Sloughing and groundwater conditions encountered in the test holes during drilling are presented in Table 4.1 and noted on the test hole logs in Appendix B. Standpipe piezometers were installed in test holes TH24-03, -04, -08, -10 and -11 to allow for future monitoring of groundwater levels. Groundwater measurements were taken again in the piezometers on August 27, 2024, two weeks after installation.

Table 4.1: Summary of Slough and Groundwater Levels

TEST HOLE	TEST HOLE DEPTH B.G.S. (m)	SLOUGH COMPLETION B.G.S. (m)	FREE WATER ON COMPLETION (ABOVE SLOUGH) B.G.S. (m)	STANDPIPE WATER LEVELS B.G.S. AUGUST 27, 2024 (m)
TH24-01	4.3	3.5	None	-
TH24-02	4.3	3.7	None	-
TH24-03	4.3	3.8	None	Dry
TH24-04	4.3	3.8	None	Dry
TH24-05	4.3	3.8	None	-
TH24-06	4.3	3.7	None	-
TH24-07	11.9	11.0	None	-
TH24-08	11.9	8.5	None	9.2
TH24-09	11.9	11.0	None	-
TH24-10	11.9	None	None	11.2
TH24-11	11.9	10.3	10.3	9.7
TH24-12	11.9	11.2	None	-

B.G.S. – Below Ground Surface

Table 4.2 presents a summary of the water levels measured in the test holes completed in 2010.

Table 4.2: Summary of Slough and Groundwater Levels in Test Holes Completed in 2010.

PIEZOMETER	Tip Depth (m)	Water Level After Installation (m)	Water Level On September 17, 2010 (m)
TH10-1	36.3 (631.6)	34.8 (633.1)	34.8 (633.1)
TH10-2(a)	35.1 (631.4)	33.5 (633.0)	33.6 (632.9)
TH10-2(b)	9.1 (657.4)	Dry	Dry
TH10-2A (Pneumatic)	37.6 (629.0)	-	34.1 (632.5)
TH10-4	8.4 (661.4)	Dry	Dry
TH10-5A	8.4 (661.2)	7.4 (662.2)	7.6 (662.0)
TH10-5B	7.0 (662.6)	Dry	Dry
TH10-6	8.4 (667.1)	Dry	Dry
TH10-7	8.2 (663.5)	Dry	Dry
TH10-13	7.4	Dry	Dry

The results of the groundwater level monitoring indicate a perched groundwater table in the upper clay and clay till at depths ranging from about 9.2 m to 11.2 m below the ground surface, and a deeper groundwater table in the sand and gravel layer and underlying bedrock at a depth of about 33 m below ground surface.

It should be noted that the groundwater table may vary between test hole locations and that seasonal fluctuations of groundwater levels may be encountered due to precipitation and other climatic factors. Hence, the actual groundwater conditions at the time of construction could vary from those recorded during this investigation.

4.3 Frost Penetration

The surficial clay soils are considered moderately frost-susceptible. The expected depths of frost penetration have been estimated using averaged thermal parameters estimated for the materials encountered at the project site and estimates of air freezing indices in the general area. The frost penetration has been estimated for both the mean annual Air Freezing Index (AFI) of 1440°C-days and the 50-year return period Air Freezing Index of 2400°C-days. The estimated frost penetration depths for the mean annual and 50-year return AFI are 1.6 m and 2.4 m, respectively.

The estimated depths of frost penetration are based on a uniform soil type with no snow/insulation cover. If the area is covered with turf or significant snow, the depth of frost penetration will be less.

The 50-year return estimated frost penetration depth is generally used for design, while the average annual value could be used for construction with some risk.

5. GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

5.1 Top of Bank Setback and Development Guidelines

As indicated in Section 2.1, Thurber completed a top of bank set back assessment in 2023 and established the Urban Development Line (UDL) and Structure Development Line (SDL) as presented in Drawing No 36428-1, in Appendix A.

All structures should be located behind the Structure Development Line (SDL) shown on the drawing. In addition, the following guidelines should be adhered to with respect to development activities close to the top of bank:

- Dumping of any type of fill, grass cuttings or construction debris adjacent to or on/over the crest of slope should not be allowed.
- The set-back areas between the top of bank and the Urban Development Set-Back Line should consist of natural vegetation. Where the natural vegetation has been removed, re-vegetation should be encouraged to protect the set-back area and upper slope. The vegetation should be native to the area with species chosen which have deep root systems that do not require extensive watering. Irrigation should only be allowed during initial growth but not after establishment of the vegetation.
- Excessive watering of lawns, trees, shrubs and other vegetation shall not be permitted close to the top of bank.
- Grading of the site should not allow any ponding of water or the focused discharge of water toward the slopes. Surface runoff shall be directed away from the slopes and into the storm drainage system where possible.
- All buried water or sewer lines should be constructed with watertight joints and connections to manholes and catch basins to ensure that excessive seepage into the ground does not occur.

- No underground sprinkler or irrigation systems or swimming pools should be installed between the Urban Development Line and Structure Line (permanent building line);
- Permanent above ground pools may be permitted provided that are essential water tight. Drainage of the pools should discharge into the storm sewer system.

Thurber should review the site grading and drainage plans once the design has been advanced.

5.2 Site Preparation

The geotechnical investigation results indicate that the project site is generally underlain by clay fill, overlying clay, overlying clay till, overlying Empress sand and gravel over bedrock. The short-term groundwater level measurements from the standpipe piezometers indicated that the groundwater table ranged from 9.2 m to 11.2 m below the ground surface.

The following general guidelines are provided for site preparation; however, these should be reviewed once further details on the design grades are available.

All topsoil, near-surface unsuitable fill and deleterious materials should be stripped and removed from under the development areas during site preparation. No site grading should be undertaken between the UDL and the top of bank.

As a general guideline, the exposed subgrade should be scarified to a depth of 150 mm and recompacted to at least 95 percent of Standard Proctor Maximum Dry Density (ASTM D698).

Fill for backfilling, or site grading purposes should generally consist of selected inorganic low to medium plasticity clay or imported granular material. Imported fill should contain no environmental contaminants or construction debris. Import and on-site fill should not contain rocks or lumps larger than 100 mm in the greatest dimension. Any new fill should be placed and compacted in lifts not exceeding 150 mm loose thickness, moisture conditioned as necessary, and compacted to the minimum compaction levels as shown in Table 5.1.

Table 5.1: Recommended Compaction Levels for Site Grading

FILL LOCATION	RECOMMENDED MINIMUM COMPACTION LEVEL
Under buildings, access roads, sidewalks or curb/gutter	98 Percent of Standard Proctor Maximum Dry Density at +/- 2 percent of Optimum Water Content (OWC)
Under paved or concrete areas not subject to truck traffic and trenches	95 Percent of Standard Proctor Maximum Dry Density at +/- 2 percent of OWC
Landscaped Areas	92 Percent of Standard Proctor Maximum Dry Density at +/- 2 percent of OWC

Care should be taken to avoid disturbance of the existing site grade during and following site stripping. Any disturbed areas within the footprint of the development should be sub-excavated and replaced or recompacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

Frozen fill, snow, ice or other deleterious material should not be included in fill materials beneath the structures.

Permanent site drainage should be developed at the early stages of construction in order to improve site trafficability and reduce future frost effects in the subgrade. It is recommended that the finished subgrade be sloped at a minimum gradient of one percent toward catch basins or adjacent roadways to drain any surface water away from the structures.

Geotechnical site inspection is recommended during subgrade preparation to confirm the subgrade conditions. In addition, the density of compacted fills should be confirmed by field density test measurements during construction.

5.3 Building Foundations

5.3.1 General

We understand that the proposed buildings will include the following: reception, massage, sauna, steam, mechanical and two solarium buildings. No details of the building layouts or loading were available at the time of report preparation, however it is expected that the buildings will generally be single storey or low rise buildings. The following foundation types are considered feasible for the proposed buildings on this site:

- Spread footings
- Cast-in-place concrete friction piles

- Cast-in-place concrete end bearing piles

It should be noted that spread footings will generally be more prone to long-term movements than pile foundations. Consequently, pile foundations are the preferred foundation type for buildings for the proposed spa development. The choice of suitable pile foundation type will depend on the design loads and other considerations.

The recommendations for these foundation types are provided in the following sections. Additional recommended construction procedures are provided in Appendix D.

5.3.2 Spread Footings

Spread footings are considered suitable for the foundation of the proposed development and should be designed and constructed in accordance with the following recommendations:

- Exterior footings supporting heated structures should have a minimum soil cover of 1.5 m below finished grade to provide adequate protection against frost. Interior footings may be founded in the native clay at a minimum depth of 1.0 m below finished grade.
- For unheated structures, exterior and interior footings should be founded at a minimum depth of 2.4 m below the floor slab level, unless insulation is used.
- All footings should be founded on the undisturbed, inorganic, and native clay. Footings should not be supported on fill. Where local soft zones or organic pockets are encountered in the footing trenches, it may be necessary to increase the size of the footings or to remove the soft/organic material and replace it with lean concrete. Disturbed soil should not be allowed to remain in the footing trenches.
- Strip and square footings founded on the native undisturbed clay may be designed using the ultimate bearing resistance of 300 kPa for strip footings and 360 kPa for square footings. The factored ULS bearing resistance is 150 kPa for strip footings and 180 kPa for square footings, based on a Geotechnical Resistance Factor (Φ) of 0.5.
- Care should be taken to prevent excessive drying or wetting or freezing of the foundation soils during construction. Any soils in the below footings that become dried or wetted should be scarified, moisture conditioned and recompact, or sub-excavated and replaced with compacted crushed gravel or lean concrete.
- The excavated base of the foundation level should be protected from weathering and frost action to prevent the deterioration of the soil at the footing level. It should be recognized that the native clay at footing level is frost susceptible and hence may undergo frost heave

movements during winter and subsequent settlement upon thawing. Therefore, it is imperative that the footings should be protected against freezing until the building is adequately heated.

- The footing excavations should be inspected by qualified geotechnical personnel to confirm that the footings are located in the above recommended suitable native clay soil, and the bearing surfaces have been adequately prepared prior to pouring of the concrete. Additional recommended construction procedures are provided in Appendix D.

5.3.3 Cast-in-Place Concrete Piles

Cast-in-place concrete piles, may be designed and constructed in accordance with the following recommendations:

Cast in place concrete piles may be designed as straight shaft friction piles (ignoring end bearing resistance) or belled end bearing piles including both skin friction and end bearing resistance, depending on the design load requirements, as follows:

$$Q_T = Q_B + Q_s$$

Where:

$$Q_T = \text{Ultimate static pile resistance (kN)}$$

$$Q_B = \text{Ultimate end bearing resistance (kN)}$$

$$Q_s = \text{Ultimate shaft friction resistance (kN)}.$$

The factored ULS pile resistances are based on the product of the estimated ultimate pile resistance and the appropriate geotechnical resistance factors. The geotechnical resistance factors are prescribed in the National Building Code (NBC, 2020) and are dependent on the method used to determine the ultimate pile capacity, as summarized in the following table.

Table 5.2: Recommended Geotechnical Resistance Factor for Limit States Design of Deep Foundations (NBC 2020)

DESCRIPTION	GEOTECHNICAL RESISTANCE FACTOR (GRF)
(a) Resistance to axial load	
(i) semi-empirical analysis using laboratory and in-situ test data	0.4
(ii) analysis using static loading test results	0.6
(iii) analysis using dynamic monitoring results	0.5
(iv) uplift resistance by semi-empirical analysis	0.3
(v) uplift resistance using loading test results	0.4
(b) Resistance to horizontal load	0.5

Use bolded values for pile design unless static capacities are confirmed by appropriate pile load tests

Cast-in-place concrete piles should be designed and installed in accordance with the ultimate skin friction and ultimate end bearing resistances provided in Table 5.3 below:

Table 5.3: Cast-In-Place Concrete Piles – Ultimate Shaft Resistance and End Bearing Resistances

DEPTH BELOW EXISTING GROUND SURFACE (m)	SOIL TYPE	ULTIMATE SHAFT RESISTANCE (kPa)	ULTIMATE END BEARING RESISTANCE (kPa)
0 – 1.5 ¹	Clay Fill and Clay	0	0
1.5 - 10	Clay	40	600 ²
Below 10	Clay Till	65	900 ³

¹ Or depth of fill, whichever is greater

² For end bearing piles founded in stiff clay below 7 m depth

³ For end bearing piles founded at least 1.5 m into very stiff clay till below 11 m depth

- The factored ULS pile geotechnical resistances may be determined by applying a geotechnical resistance factor (GRF) of 0.4 in compression, and 0.3 in tension to the ultimate pile resistances determined using the ultimate shaft friction and ultimate end bearing resistance values presented in Table 5.3.
- Shaft adhesion should not be included in the upper 1.5 m of the pile (or to the depth of fill where greater than 1.5 m) to allow for the possibility of the soil drying and shrinking away from the pile shaft or for future fill settlement. In addition, for unheated structures, shaft adhesion should be ignored for the depth of frost penetration.

- Cast-in-place concrete straight shaft friction piles that will be subject to freezing temperatures either during construction or long-term operation should be at least 6 m long below finished grade to resist potential frost heave forces. The pile length will need to be evaluated by the structural engineer to provide resistance to other forces, such as uplift loads.
- Cast in place concrete end bearing piles may be designed as straight shaft or belled end bearing piles, using the ultimate end bearing resistances presented in Table 5.3.
- In the case of belled end bearing piles, the bell diameter to shaft diameter ratio should not exceed 3:1, and the bell should not be sloped at more than 30 degrees to the vertical.
- A minimum pile shaft diameter of 400 mm is required to facilitate pouring of the concrete and cleaning/inspection of the base. Larger pile diameters (i.e., 500 mm and greater) are generally more suitable for dealing with cobbles and boulders.
- A minimum pile spacing of three shaft diameters center to center is recommended. Piles within two bell diameters for belled piles should not be drilled or poured consecutively within the same 24-hour period to allow the concrete in the adjacent pile to be set.
- All pile excavations should be thoroughly cleaned and visually inspected by qualified geotechnical personnel prior to pouring of the concrete to ensure a satisfactory base has been achieved. No sloughing or disturbed material should be allowed to remain in the pile excavations.
- Longitudinal reinforcement is required throughout the length of the pile shaft to resist potential uplift forces on the pile due to frost action and seasonal moisture variations. If piles are designed as tension elements, the pile reinforcing should be designed to resist the anticipated uplift stresses.
- Concrete should be poured immediately after drilling the pile hole to reduce the risk of groundwater seepage and sloughing soil.
- It should be noted that the short-term groundwater level measurements indicated that the groundwater table ranges between 9.2 m and 11.2 m below the existing ground surface at the piezometer locations. Therefore, temporary steel casing should be available during pile construction and used if seepage and/or soil sloughing becomes excessive.
- It should be noted that cobbles and boulders are frequently encountered within the clay till and could hamper the installation of the piles if encountered during piling. The contractor should be suitably equipped to deal with this situation if it occurs during construction.

- The concrete materials and methods of concrete construction should be as per CSA A23.1-19/A23.2-19.

5.4 Grade Beams

Where piles are used, grade beams and pile caps may be required along the top of the piles. Precautions should be taken to prevent heaving of the grade beams due to frost penetration or swelling of the underlying soil, where the grade beams or pile caps will lie less than 1.5 m below the ground surface for heated structures or where the grade beams will lie above the seasonal frost line, for unheated structures.

The recommended construction procedures for preventing heave under the grade beams or pile caps are through the use of a crushable non-degradable void form material (such as Beaver Plastics Frost Cushion), as shown in Figure 5.1. The grade beam must be designed in accordance with the crushing strength of the void filler used, and the piles must be able to resist the resulting uplift load.

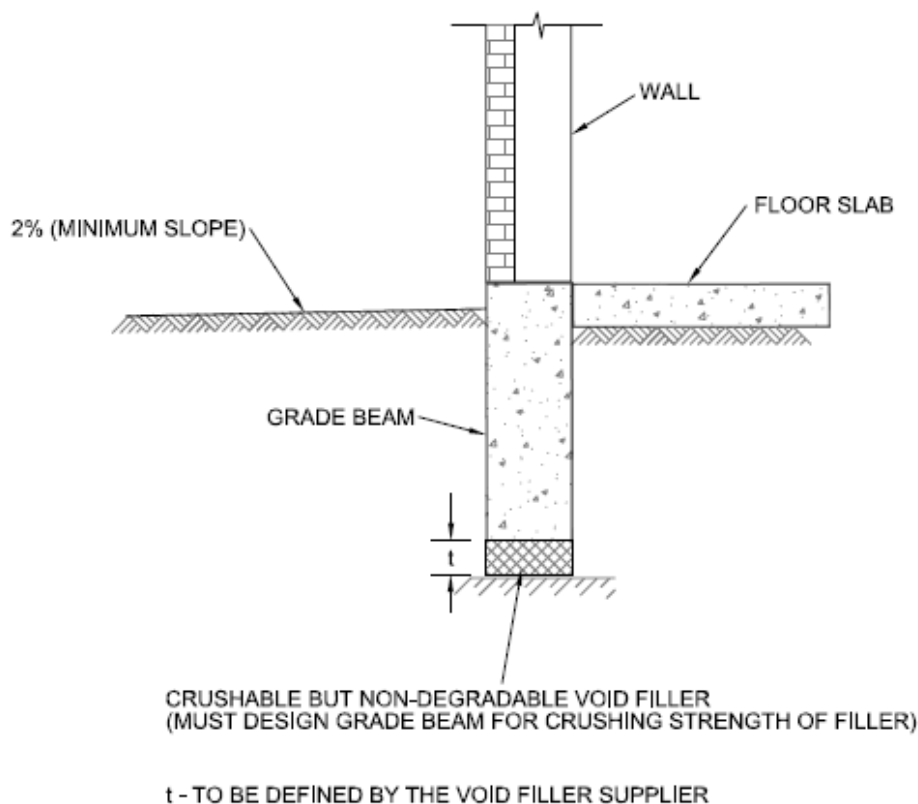


Figure 5.1: Typical Uninsulated Grade Beam

5.5 Basements

5.5.1 Excavation

No details of the requirements for basements in the various structures was provided at the time of report preparation.

If the proposed buildings include basements, it is anticipated that the basements will extend through clay fill and native clay soils depending on the basement depths and location within the proposed development.

Temporary excavation slopes through the clay fill and clay should be sloped not steeper than 1H:1.5V. Flatter slopes may be required to maintain the stability of open excavations if soft clay or water bearing silt, gravel and sand layers are encountered during excavations.

Excavated material should be kept back from the top of the excavation by at least a distance equal to the excavation depth. It is also recommended that the open excavation slopes be inspected on a daily basis for evidence of instability, such as cracking at the crest, development of any tension cracks, or slope failures. If the movement of excavation slopes occurs during construction, flatter slopes may be required.

Short-term groundwater levels in the standpipes were greater than 9 m below existing ground surface. Therefore groundwater seepage into excavations is not expected to be a significant concern at this site. If seepage into excavation occurs, it is expected to be of a magnitude that could be typically handled by a sump and pump.

It is recommended that the excavation be carried out in a timely manner and backfilled as soon as possible. The ground surface outside the excavation should be sloped at a grade of at least two percent to shed water away from the building. Consideration should be given to covering the excavated slopes with tarps to reduce erosion, raveling, and sloughing of excavation walls during periods of rain.

The above slope excavations are provided for design purposes and are not to be considered as clearance for Occupational Health and Safety requirements; therefore, at all times, the Alberta Occupational Health and Safety Regulation and Code must be followed by the prime contractor.

5.5.2 Backfill

Perimeter subdrains should be provided around the base of all exterior basement walls to provide drainage of any subsurface water entrapped in the backfill soils.

Free-draining clean granular material (less than 5 percent passing a No. 200 sieve) would be the first choice of material for backfilling against the basement walls as it compacts relatively easily and does not settle significantly with time.

The native excavated clay material is not desirable for backfilling because it remains in hard chunks and it is difficult to obtain uniform compaction resulting in nonuniform ground settlement with time. However, if necessary to use the native excavated clay soil as backfilling, it should be free of organic content and placed in lifts with light compaction and well broken down to reduce potential long-term settlements of the backfill. High plastic clay should not be used as a backfill behind basement walls. The medium plastic clay till may be used for this purpose.

The backfill should be carefully placed against the basement walls to avoid over-compaction of the material and distress to the walls, and should be capped with an impervious barrier, such as a compacted clay layer of about 300 mm thickness. A recommended typical gradation for free draining granular material is provided in Table 5.4.

Table 5.4: Typical Gradation for Free Draining Gravel

SIEVE	% PASSING
1 ½ (38,000 um)	100
3/8 (10,000 um)	65 – 100
No. 4 (5,000 um)	50 – 90
No. 10 (2,000 um)	35 – 75
No. 40 (400 um)	10 – 45
No. 100 (150 um)	0 – 20
Np. 200 (75 um)	0 – 5

Backfilling should be delayed until the concrete in the foundation wall has gained sufficient strength. Premature backfilling or backfilling with excessive force may result in distress to the foundation walls. Heavy compaction equipment should not be allowed to operate within a distance

of about 1.5 m from the face of the wall to prevent potential for overstressing of the basement walls.

5.5.3 Lateral Earth Pressures

A triangular earth pressure distribution may be utilized for the design of basement walls and retaining structures resisting earth pressures. The horizontal earth pressure p_h at depth h may be calculated as follows:

$$p_h = K \times [(W \times h) + q] \text{ (kPa)}$$

Where:

K = the coefficient of earth pressure (Table 5.5)

W = the bulk unit weight, kN/m^3

h = the depth below the backfill surface, m.

q = surcharge pressure (kPa).

Table 5.5: Long-Term Earth Pressure Coefficients For Vertical Retaining Walls Assuming Stiff Wall Good Surface Drainage And Horizontal Backslope

SOIL DESCRIPTION*	BULK UNIT WEIGHT kN/m^3	COEFFICIENTS OF PRESSURE		
		K_a ACTIVE	K_o AT-REST	K_p PASSIVE
Clay Backfill – On Site Clay Fill and Clay	20	0.40	0.58	2.4
Backfill – Gravel	21.5	0.30	0.46	3.4

*Compacted to 95 Percent of Standard Proctor Density

At-rest pressures should be used for the design of the basement walls that are restrained from movement at the tops of the walls. Active earth pressure may be used for the design of relatively low retaining walls that can be allowed to move laterally at the top at a distance of 0.01 or 0.001 times the height of the wall, for clay or gravel backfill, respectively. The passive pressure will be mobilized when the top of the wall has moved into the backfill at a distance of 0.02 times the height of the wall, for both types of materials.

Where traffic or other live loads may travel or operate near the retaining wall, the horizontal pressures due to the live load should be superimposed on the static earth pressures.

The earth pressures are governed by the soil type within a zone of mobilized soil behind the wall. The minimum thickness of backfill required to mobilize the recommended coefficients of earth pressure for gravel is shown in Figure 5.2.

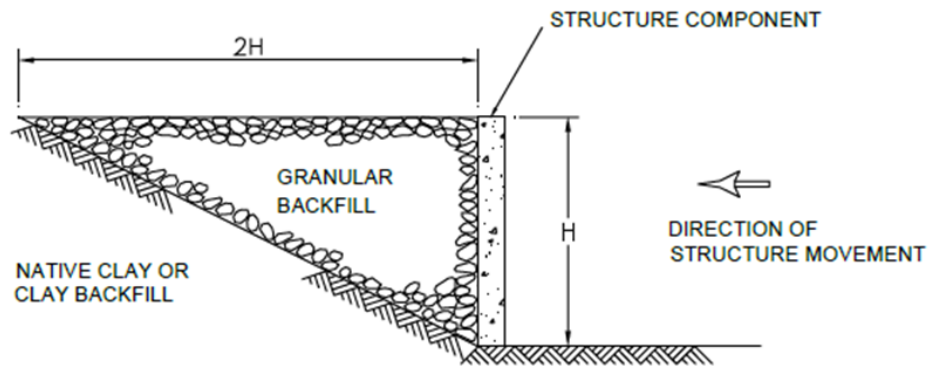
Where retaining structures will extend below the water table, either under slab drainage should be provided to maintain the groundwater level below the base of the wall, or alternatively, the earth pressures should be calculated as follows, which assumes full hydrostatic pressures:

$$p_h = [K(W - 9.8) + 9.8]h \quad (\text{kPa})$$

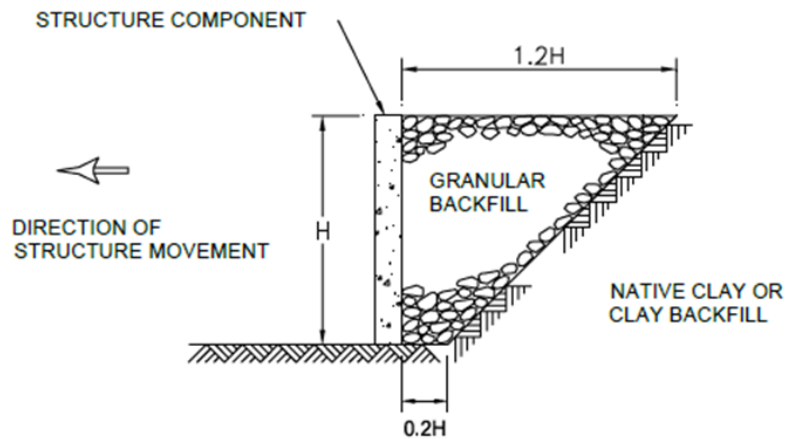
Perimeter drainage, where used, should consist of perforated drains surrounded by washed gravel and enveloped with a non-woven geotextile. Free draining sand or gravel should be placed against the wall to about 300 mm below the ground surface, and an impervious clay cap should be formed at the ground surface.

Care should be taken not to over compact the backfill; otherwise, higher earth pressure will result, which may distress the wall.

A recommended typical gradation for free draining granular material, for use behind the retaining structure is provided in Table 5.4.



(a) MINIMUM THICKNESS OF GRANULAR BACKFILL TO MOBILIZE PASSIVE EARTH PRESSURES



(b) MINIMUM THICKNESS OF GRANULAR BACKFILL TO MOBILIZE ACTIVE EARTH PRESSURES

Figure 5.2: Minimum Thickness of Granular Backfill Required To Mobilize Recommended Coefficients Of Earth Pressures For Gravel

5.6 Floor Slab

5.6.1 Concrete Floor Slab

The results of the investigation indicated the presence of high plastic clay near the surface. Such soils are prone to swelling and shrinkage in response to moisture variations caused by wetting or drying of the near surface soils. Where slabs on grade are sensitive to floor slab movements, consideration should be given to using structural slabs supported on piles.

Where slabs on grade are used, the following recommendation should be applied in an attempt to minimize the risk of future ground movement. It is important that the Client understand and accept the risks of using a slab-on-grade supported on high plastic clay.

It is expected that the main floor slab will be founded on the engineered fill replacing the topsoil and organics currently on site. All engineered fill should be placed and compacted in accordance with the recommendations presented in Section 5.2.

The following additional recommendations apply to the design and construction of concrete slabs-on-grade.

- All poor-quality soils (soft, loose, wet, and/or containing organics) should be removed below the building floor slab. The subgrade should be inspected by geotechnical personnel to verify that all poor-quality soils have been removed.
- Where high plastic clay fill and clay is present below slab-on-grade, the high plastic clay fill and clay is prone to swelling and shrinkage in response to variations in moisture. Care should be taken to avoid extreme wetting or drying of the clay fill and clay subgrade during construction. Any overdried or wetted clay fill and clay below the underside of the slab level should be excavated and replaced with imported granular fill or low to medium plastic clay fill.
- All clay fill should be compacted in lifts not exceeding 150 mm and compacted to at least 98 percent of SPMDD. within zero to +2 percent of OWC, and for gravel fill within +/- 2 percent of OWC. Free water should not be allowed to access the subgrade beneath the slab at any time during the operation of the proposed facility.
- A minimum of 500 mm of granular fill clean, (e.g. City of Edmonton Class 3 , Des 20 crushed gravel) is recommended beneath the floor slab to reduce the swelling and shrinking potential.

- All heated utilities located beneath the slab should be insulated to reduce the potential for drying and shrinkage of the clay shale subgrade, where present.
- The slab-on-grade should be free to move from the perimeter walls or grade beam but can be tied into the grade beam at doorway locations.
- Surface slabs supported on native clay should be designed to tolerate some movement. Where slab movement cannot be tolerated, the slab should be supported on piles with a crushable void form below the slab to accommodate potential ground heave.
- Any non-load bearing walls supported on the slab-on-grade should have the provision of a gap of about 50 mm between the top plate and ceiling to accommodate potential future heave.
- Surface grading and landscaping should be designed to shed water away from the slab-on-grade area to reduce ingress of water and potential swelling.

5.6.2 Radon Mitigation System Considerations

5.6.2.1 Large Buildings

The proposed development may not meet the criteria for small building, as described in Part 9 of Division B (Housing and Small Buildings) of the 2019 National Building Code – 2019 Alberta Edition (NBC), i.e., is greater than 600 m², or is greater than 3 storey tall, or does include major occupancy. Therefore, the provisions for handling radon extraction should follow the NBC Article 6.2.1.1, which recommends following the requirements of Environmental Protection Agency's (EPA's) manual EPA 625/R-92/016.

The EPA manual specifies a minimum of 100 mm of coarse aggregate meeting Size #5 grading requirements as defined in ASTM C33/C33M be provided directly below the floor slab. We recommend that this be increased to at least 150 mm thickness for ease of placement and compaction. Care and attention are required to prevent shoving or displacement of the granular material.

The gravel layer should be enveloped by a non-woven geotextile layer above and below, and a membrane barrier system should be placed directly below the concrete slab. The radon membrane barrier system (also is the vapour barrier) is to be a minimum, 10 mil polyolefin based resin sheet membrane, meeting the requirements of ASTM E 1745. The layer of geotextile below the granular material is used to prevent the loss of granular material into the underlying subgrade and to prevent the migration of fines into the gravel layer from the subgrade. The top geotextile may be omitted if the polyolefin barrier is sufficiently robust (i.e. meets or exceeds the

recommended minimum thickness of 10 mil and wide-base rebar chair supports are used) to minimize the potential for punctures and tearing from the gravel layer. The polyolefin or bituminous barrier must also be present on walls in cases where the structure includes below grade construction, such as basements or parkades, for both dampproofing and vapour intrusion control. Slab joints should be tooled when poured and sealed with polyurethane caulking once cured.

Additional requirements, such as the use of radon suction pits, may be required by the jurisdiction having authority. Suction pits, under slab piping, and the related venting systems shall be designed by a qualified mechanical consultant accredited as a Canadian National Radon Proficiency Program (C-NRPP) Certified Mitigation Professional.

To minimize the potential for drying the subgrade, mainly if it consists of high plastic clay, which could lead to shrinkage and settlement of the subgrade, consideration should be given to install a second polyolefin barrier between the subgrade and the non-woven geotextile that overlies the granular material. If excessive slab movement cannot be tolerated, it may be necessary to consider structurally supporting the floor slab on piles.

If used, the gas-permeable layer (radon gas layer) must meet the requirements of the NBC. Where slab-on-grade construction is utilized, the gas-permeable layer may be installed directly over the prepared subgrade. Where a structurally supported floor slab is used, the gas-permeable layer should be positioned immediately beneath the void filler. In either circumstance, installation shall be in accordance with the manufacturer's specifications with separation from the sub-grade as required.

After all preparations for casting of the floor slab have been made, but prior to concrete placement, it is recommended that the air barrier be inspected by the authority having jurisdiction or a suitably qualified organization / individual to ensure any and all slab penetrations and punctures / tears to the air barrier are properly sealed or repaired as needed.

Thurber has C-NRPP accredited staff able to provide radon measurement services; we will be pleased to provide this service upon request.

5.6.2.2 Small Buildings

The 2019 National Building Code – 2019 Alberta Edition (NBC) indicates that Part 9 of Division B (Housing and Small Buildings) applies to all buildings with an area not exceeding 600 m² and height of 3 storeys or less and not used for major occupancies. The NBC requires the proposed

structure to include a radon mitigation rough-in, such as a granular depressurization layer beneath the floor slab, for possible subfloor depressurization to control radon concentrations.

A light-weight non-woven geotextile, installed in accordance with the manufacturer's recommendations, should be used as a separator between the prepared subgrade and the overlying granular depressurization layer. The NBC indicates the granular depressurization layer should be comprised of a 100 mm (minimum) thick layer of coarse gravel installed under the entire floor slab area. However, Thurber recommends that a minimum of 150 mm of clean, well-graded sand or gravel be utilized for this purpose beneath the floor slab and along the outside of footings or grade beams to also assist with leveling and drainage purposes. The granular material should meet the following criteria:

- Clean crushed aggregate containing not more than 10 percent of material passing the 4mm sieve.
- Nominal maximum aggregate size of either 20 mm or one-third of the total thickness of the layer, whichever is less.
- Minimum of 60 percent of material having two or more crushed faces.

The well-graded nature of the granular material may make it prone to shoving and displacement during subsequent construction activities.

A membrane barrier system should be placed directly below the concrete slab. The radon membrane barrier system (also is the vapour barrier) is to be a minimum, 10 mil polyolefin based resin sheet membrane, meeting the requirements of ASTM E 1745.

A non-woven geotextile material should be placed above the granular material to protect the polyolefin barrier from punctures or tears during the construction of the floor slab. The use of wide-base rebar chair supports should be considered in lieu of supports with legs and the poly barrier should be inspected for damage and repaired as required prior to the placing of concrete. The geotextile may be omitted if the polyolefin barrier is sufficiently robust (i.e. meets or exceeds the recommended minimum thickness of 10 mil and wide-base rebar chair supports are used) to minimize the potential for punctures and tearing from the gravel layer.

For buildings utilizing strip footings or grade beams that create isolated subfloor areas, piping should be installed through these features to ensure air can be extracted through the entire depressurization layer.

For below grade walls, a polyofelin or bituminous barrier is required for dampproofing and to assist with vapour intrusion control. Slab joints should be tooled when poured and sealed with polyurethane caulking once cured.

To minimize the potential for drying the subgrade, mainly if it consists of high plastic clay, which could lead to shrinkage and settlement of the subgrade, consideration should be given to install a second polyolefin barrier, underlain by non-woven geotextile, between the subgrade and the granular material. If excessive slab movement cannot be tolerated, it may be necessary to consider structurally supporting the floor slab on piles. For structurally supported floor slabs, the gravel layer should be installed immediately beneath the void filler.

Additional requirements, such as the use of radon suction pits may be required by the jurisdiction having authority. Suction pits, under slab piping, and the related venting systems shall be designed by a qualified mechanical consultant accredited as a Canadian National Radon Proficiency Program (C-NRPP) Certified Mitigation Professional.

Thurber has C-NRPP accredited staff able to provide radon measurement services; we will be pleased to provide this service upon request.

5.7 Cement Type

Four tests were conducted to determine the water-soluble sulphate ion (SO_4) content of soil samples recovered from the test holes. These tests indicated the presence of 0 to 0.40 percent water-soluble sulphate content in the soil samples. As per the guidelines of Table 3 of CSA Standard A23.1-19, the subsurface concrete at this site may be exposed to a "Severe" degree of exposure (Exposure Class S-2) to sulphate attack and would require the use of CSA Type HS or HSb Portland cement (regular or blended high sulphate-resistant hydraulic cement). Supplementary cementitious materials may be used in combination with a hydraulic cement or a blended cement, provided that the mixture of cementitious materials meets the relevant performance requirements in Table 3, for S-1, S-2, or S-3 exposure.

Following the guidelines of Table 2 of CSA A23.1-19, we recommend that such concrete should have maximum water to cementing materials ratio of 0.45 with the specified minimum 56-day compressive strength of 32 MPa, and should incorporate appropriate air entrainment. Further, such concrete should be cured as per the applicable "Curing Type" stated in Tables 2 and 19.

Please note that as per CSA A23.1-19 Clause 4.1.1.6.3, calcium chloride or any admixture formulation containing chloride ions shall not be used in the subsurface concrete, which falls under exposure classification "S-1" and "S-2" as defined in Table 3. Also, other calcium salts used

as an accelerating admixture should be avoided as they may increase the severity of the sulphate attack.

The recommendations stated above for the subsurface concrete at this site may require further additions and/or modifications due to structural, durability, service life or other considerations that are beyond the geotechnical scope.

In addition, if imported material is required to be used at the site and will be in contact with concrete, it is recommended that the fill soil be tested for sulphate content to determine whether the above-stated recommendations remain valid.

5.8 Seismicity

Based on the available geotechnical information, the site is classified as Site Class D in accordance with the site classification as per Table 4.1.8.4.-B of the National Building Code (NBCC 2020).

5.9 Pavement Design Recommendations

5.9.1 Subgrade Preparation

Clay fill, and clay soils were encountered in the test holes on this site. It is recommended that all topsoil (if present), soil with excessive amounts of organics, and any poor-quality soils be removed from the pavement areas. If required, additional excavations should be carried out to accommodate the pavement structure.

The test hole logs indicate that the exposed soils will likely consist of clay fill or clay. The exposed surfaces should be proof rolled and inspected by qualified geotechnical personnel to confirm that all deleterious materials have been removed, and to identify wet or weak areas. There is a possibility that local areas of wet or soft clay could be encountered, which should be sub-excavated to suitable soils and replaced with good-quality material. The sub-excavated depths should be decided in the field by geotechnical personnel at the time of grading. Where ground conditions at the base of the excavation are weak, a geogrid and/or a non-woven geotextile should be placed over the base of the excavation.

The water contents and consistencies of the clay fill and clay soils are variable and will require moisture conditioning in order to achieve the required compaction. Depending on the construction timing, drying of the clays may be difficult, and it may be preferable to modify the upper portions of the subgrades with Portland cement (on the order of 5 percent by dry soil mass). The benefits

of cement modification would be improved field workability, improved drying during construction and the formation of a working platform for placing and compacting the pavement materials. It is recommended that, as a minimum, the upper 150 mm of the subgrade should be modified, which would require a cement application of about 15 kg per square meter of subgrade surface. It may be necessary to increase the cement application and depth of modification in areas where weaker subgrades are present. Alternatively, wet or weak areas may be sub-excavated and replaced with drier soils or granular fill. The objective of the subgrade preparation would be to produce a stable non-yielding construction platform for the support of construction traffic and the pavement structure.

The following recommendations apply to design and construction:

- The prepared subgrade should be proof rolled to detect soft/wet zones as outlined in the recommended construction procedures in Appendix D. Wet or weak areas should be removed and replaced with good quality fill or cement modified.
- Subgrade areas that become softened or disturbed as a result of construction traffic or weather conditions should also be sub-excavated and replaced with good quality fill or cement modified.
- The exposed subgrade should be scarified to a depth of 150 mm, properly moisture conditioned, and recompact to a minimum of 95 percent of SPMDD, within +/- 2 percent of OWC.
- Fill required to raise the parking area to subgrade level should consist of low to medium plastic clay or clean granular fill. The backfill should be placed and compacted in lifts not exceeding 150 mm compacted thickness to at least 98 percent of SPMDD, within +/- 2 percent of OWC, except for the upper 150 mm, which should be compacted to 100 percent of SPMDD.

The final compacted subgrade surface should be proof rolled to confirm that surface deflections are minimal under the influence of construction traffic.

The clay and clay fill encountered on site are moderately susceptible to frost heaving. It is likely that some movement will occur in the subgrade soils during seasonal changes. Methods of reducing frost heave effects include raising the surface grades, sub-excavating the frost susceptible soils, improving the drainage, and insulating the subgrade.

Permanent site drainage should be developed at early stages of construction in order to improve site trafficability and reduce future frost effects in the subgrade. It is recommended that the

finished subgrade surface be sloped at a minimum of two percent towards catch basins or perimeter drains. The purpose of this is to drain any subsurface water from the subgrade and thereby prevent ponding of water, which could result in swelling, softening, and/or possible frost heaving.

5.9.2 Pavement Design

A soaked California Bearing Ratio (CBR) value of 3 is considered applicable for the design of the pavement structure on the types of subgrade materials encountered at this site. The design of pavement thickness will depend on the magnitude, frequency and distribution of traffic loading anticipated in the various areas of the site. In lieu of this information, the following guidelines presented in Table 5.6 below can be used for the design of the pavement structures at the proposed roadway and parking lot areas.

Table 5.6: Typical Pavement Structures

PAVEMENT TYPE	PAVEMENT STRUCTURE
Light Duty (such as parking areas for light cars and pickup trucks)	75 mm Asphaltic Concrete over 250 mm Crushed Granular Base Course over 300 mm prepared subgrade
Heavy Duty (access routes used by heavy vehicles such as garbage trucks and service vehicles)	100 mm Asphaltic Concrete over 300 mm Crushed Granular Base Course over 300 mm prepared subgrade

In areas subject to loading and unloading of heavy trucks such as garbage trucks collection areas or loading docks, consideration should be given to an adequately designed concrete pavement structure. Concrete pavement structures should be designed to satisfy CSA Exposure Class C2.

The pavement materials should be supplied and constructed in accordance with the latest edition of the City of Edmonton (COE) Complete Streets Design and Construction Standards.

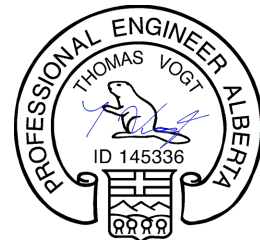
6. CONSTRUCTION INSPECTION

The performance of the structures will depend upon the quality of workmanship during construction. This is particularly important regarding earthwork and foundation installations where variations in soil conditions could occur. Therefore, it is recommended that inspection be provided by qualified geotechnical personnel during installation or earthwork to confirm that the structures are installed in soil material and stratigraphy similar to those that have been assumed for the design. Compaction testing for backfill will also be required.

7. SIGNATURES/CLOSURE

This report was issued before any final design or construction details had been prepared or issued. Therefore, differences may exist between the report recommendations and the final design, the contract documents, or conditions during construction. In such instances, Thurber Engineering Ltd. should be contacted immediately to address these differences. Designers and contractors undertaking or bidding the work should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for design and construction, and make their own interpretation of the data as it may affect their proposed scope of work, cost, schedules, safety, and equipment capabilities.

We trust this information meets your present needs. If you have any questions, please contact the undersigned at your convenience.



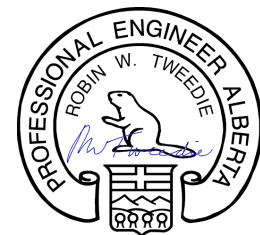
September 6, 2024

Thomas Vogt, M.Eng., P.Eng.
Geotechnical Engineer

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PERMIT NUMBER: P005186	
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)	

Date: September 6, 2024

File: 36428



September 6, 2024
ID#26519

Robin Tweedie, M.Sc., P.Eng.
Principal | Senior Geotechnical Engineer

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

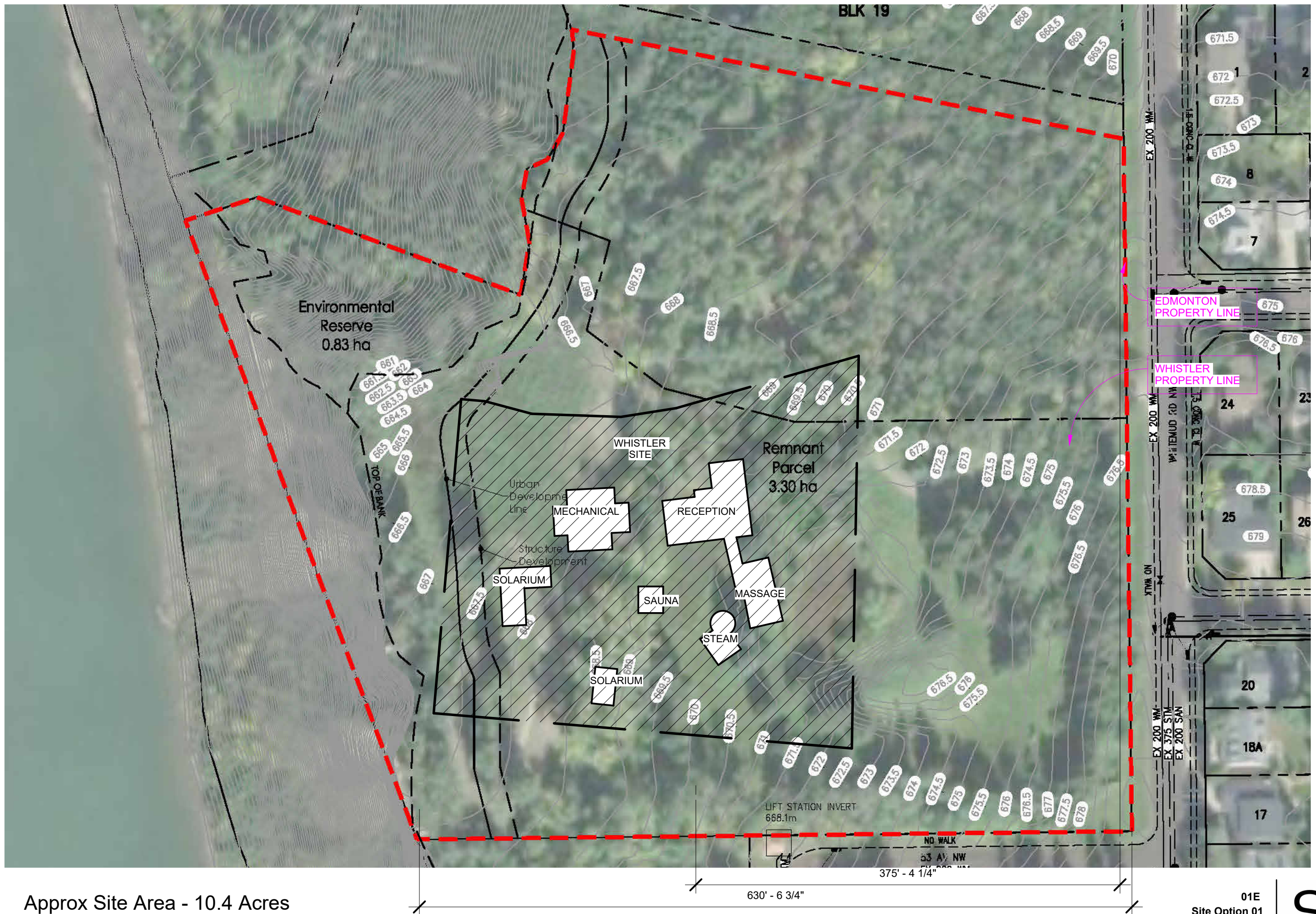
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

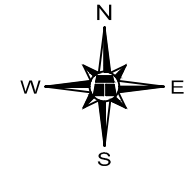
Proposed Development Layout Plan Provided by Stantec
Drawing No 36428-1 – Site Plan Showing Approximate Test Hole Locations



Approx Site Area - 10.4 Acres
(Whistler) Approx Site Area - 2.45 Acres

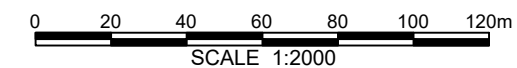
01E
Site Option 01
Scandinave

STARK



LEGEND

- | | |
|---|---------------------------------------|
|  | APPROXIMATE TEST HOLE LOCATION |
| (SP) | STANDPIPE PIEZOMETER |
|  | APPROXIMATE TEST HOLE LOCATION (2010) |
|  | ESTIMATED TOP OF BANK |
|  | URBAN DEVELOPMENT LINE (UDL) |
|  | STRUCTURE DEVELOPMENT LINE (SDL) |



2023 AIR PHOTO FROM THE CITY OF EDMONTON



**SOARING LANDS SPA
5440 AND 5450 WHITEMUD ROAD NW,
EDMONTON, ALBERTA,
GEOTECHNICAL INVESTIGATION
SITE PLAN SHOWING APPROXIMATE
TEST HOLE LOCATIONS**

DWG No. 36428-1

DRAWN BY	ML
DESIGNED BY	TGV
APPROVED BY	RWT
SCALE	1:2000
DATE	AUGUST 202
FILE No.	3642



THURBER ENGINEERING LTD.

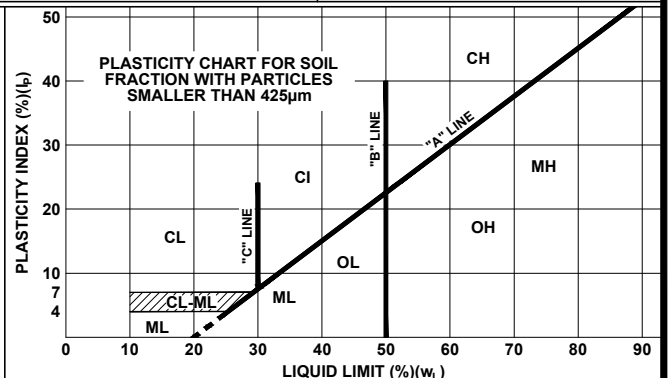
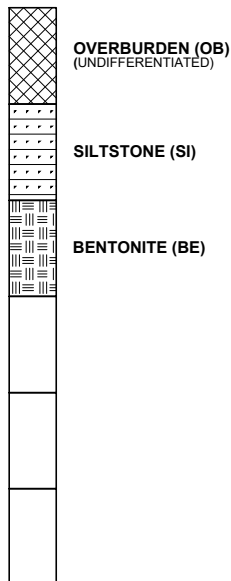
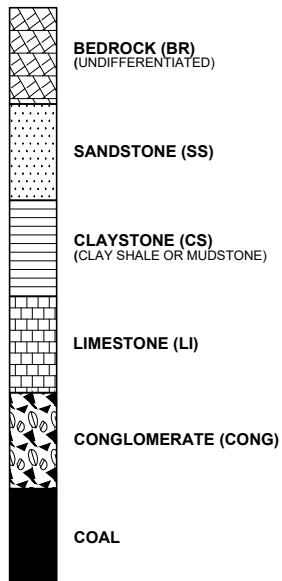
APPENDIX B

Modified Unified Soils Classification
Symbols and Terms Used on Test Hole Logs
Test Hole Logs

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

(MODIFIED BY PFRA, 1985)

MAJOR DIVISION			GROUP SYMBOL	THURBER LOG SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of gravel and sand from grain size curve. Depending on percentages of fines (fraction smaller than 75µm) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC Borderline cases requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
			GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7
	SANDS MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY-SANDS, LITTLE OR NO FINES		$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		SAND WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)	
		$w_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30\% < w_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS		
		$w_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$w_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY		
		$w_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS		
	HIGHLY ORGANIC SOILS		Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS		STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE



MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS
(MODIFIED BY PFRA, 1985)

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. VISUAL TEXTURAL CLASSIFICATION OF MINERAL SOILS

<u>CLASSIFICATION</u>	<u>APPARENT PARTICLE SIZE</u>	<u>VISUAL IDENTIFICATION</u>
Boulders	Greater than 200 mm	Greater than 200 mm
Cobbles	75 mm to 200 mm	75 mm to 200 mm
Gravel	4.75 mm to 75 mm	5 mm to 75 mm
Sand	0.075 mm to 4.75 mm	Visible particles to 5 mm
Silt	0.002 mm to 0.075 mm	Non-Plastic particles, not visible to the naked eye
Clay	Less than 0.002 mm	Plastic particles, not visible to the naked eye

2. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

<u>DESCRIPTIVE TERM</u>	<u>APPROXIMATE UNDRAINED SHEAR STRENGTH</u>	<u>APPROXIMATE SPT * 'N' VALUE</u>
Very Soft	Less than 10 kPa	Less than 2
Soft	10 - 25 kPa	2 to 4
Firm	25 - 50 kPa	4 to 8
Stiff	50 - 100 kPa	8 to 15
Very Stiff	100 - 200 kPa	15 to 30
Hard	200 - 300 kPa	Greater than 30
Very Hard	Greater than 300 kPa	

Modified from
National Building
Code

* SPT 'N' Value Standard Penetration Test 'N' Value - refers to the number of blows from a 63.5 kg hammer free falling a height of 0.76m to advance a standard 50mm outside diameter split spoon sampler for 0.3m depth into the undrilled portion of the test hole.

3. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

<u>DESCRIPTIVE TERM</u>	<u>STANDARD PENETRATION TEST (SPT) (Number of Blows per 300 mm)</u>
Very Loose	0 - 4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	Over 50

Modified from
National Building
Code

4. LEGEND FOR TEST HOLE LOGS

SYMBOL FOR SAMPLE TYPE

 Shelby Tube	 SPT	 No Recovery	 A-Casing	 Grab	 Core
---	---	---	--	--	--

SYMBOLS USED FOR TEST HOLE LOGS

●	WC - Water Content (% by weight) of soil sample
▼	Water Level
■ SPT	Standard Penetration Test 'N' Value (Blows/300mm)
▲ CPen	Shear Strength determined by pocket penetrometer
CVane	Shear Strength determined by pocket vane
Cu	Undrained Shear Strength determined by unconfined compression test
SO ₄ %	Percent (%) of water soluble sulphate ions

TERMS DESCRIBING QUANTITIES

'and'	35% to 50% of each size group
'sandy'	20% to 35%
'some'	10% to 20%
'trace'	Less than 10%
'mixture'	Soils containing three or more size groups within 20% of each other and each group greater than 10%



THURBER ENGINEERING LTD.

CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-01																																										
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930053 m, Easting: 328647 m			ELEVATION:																																										
SAMPLE TYPE: Grab Sample Standard Penetration Test																																																
BACKFILL TYPE:																																																
<table><tr><td rowspan="4">DEPTH (m)</td><td rowspan="4">SAMPLE TYPE</td><td rowspan="4">SAMPLE ID SPT (N)</td><td colspan="2">▲ C_{pen} (kPa) ▲</td><td rowspan="4">REMARKS</td><td rowspan="4">MUSCS / ISRM</td><td rowspan="4">SOIL SYMBOL</td><td rowspan="4">DESCRIPTION</td><td rowspan="4">DEPTH (m)</td></tr><tr><td>50</td><td>100</td><td>150</td><td>200</td></tr><tr><td colspan="2">■ SPT (N) Blows/300 mm ■</td></tr><tr><td>10</td><td>20</td><td>30</td><td>40</td></tr><tr><td colspan="3"></td><td colspan="2">PL WC (%) LL</td><td colspan="3"></td><td colspan="2"></td></tr><tr><td colspan="3"></td><td colspan="2">10 20 30 40</td><td colspan="3"></td><td colspan="2"></td></tr></table>									DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C _{pen} (kPa) ▲		REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)	50	100	150	200	■ SPT (N) Blows/300 mm ■		10	20	30	40				PL WC (%) LL										10 20 30 40						
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C _{pen} (kPa) ▲		REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION				DEPTH (m)																																				
			50	100									150						200																													
			■ SPT (N) Blows/300 mm ■																																													
			10	20					30	40																																						
			PL WC (%) LL																																													
			10 20 30 40																																													
0		G-1				CI-OL		CLAY (FILL), stiff, brown and black, silty, some sand, trace gravel, trace organics	0																																							
1		SPT-2 5-5-5 (10)				CH		CLAY, brown, silty	1																																							
		G-3				CH			2																																							
2																																																
		SPT-4 10-16-17 (33)				CI-CH		- hard																																								
3		G-5				CI-CH			3																																							
4		SPT-6 10-14-15 (29)				CI-CH		- very stiff, trace oxides, trace coal	4																																							
5								END OF HOLE at 4.3 m - no water - slough at 3.5 m - backfilled with drill cuttings and bentonite chips at surface	5																																							
6									6																																							
7									7																																							
8									8																																							
9									9																																							
10									10																																							



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 4.3 m

COMPLETION DATE: 2024-08-13

Page 1 of 1

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-02			
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930034 m, Easting: 328629 m		ELEVATION:			
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test							
BACKFILL TYPE:							
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40 <td>REMARKS</td> <td>MUSCS / ISRM SOIL SYMBOL</td> <td>DESCRIPTION</td> <td>DEPTH (m)</td>	REMARKS	MUSCS / ISRM SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0		G-1			CI-OL	CLAY, brown, silty	0
1		SPT-2 4-6-8 (14)			CH	- stiff	1
2		G-3		>>▲ Cpen > 216 kPa	CH		2
3		SPT-4 5-6-3 (9)		>>▲ Cpen > 216 kPa	CH	- trace silt pockets	3
4		G-5			CH		4
5		SPT-6 8-10-10 (20)			CL-ML	- very stiff, sandy	5
6						END OF HOLE at 4.3 m - no water - slough at 3.7 m - backfilled with drill cuttings and bentonite chips at surface	6
7							7
8							8
9							9
10							10



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 4.3 m

COMPLETION DATE: 2024-08-13

Page 1 of 1

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-03			
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5929965 m, Easting: 328623 m		ELEVATION:			
SAMPLE TYPE: Grab Sample		Standard Penetration Test					
BACKFILL TYPE: Bentonite		Drill Cuttings Slough					
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM SOIL SYMBOL	DEPTH (m)	
0		G-1			CH	CLAY (FILL), brown, silty, trace sand	0
1		SPT-2 4-4-4 (8)		C _{pen} > 216 kPa	CH	- stiff, trace silt partings	1
2		G-3			CH	CLAY, stiff, brown, silty, trace oxides, trace silt lenses	2
3		SPT-4 4-6-7 (13)			CH	- trace coal	3
4		G-5			CI		4
5		SPT-6 4-5-5 (10)			CH		5
6						END OF HOLE at 4.3 m	6
7						- no water	7
8						- slough at 3.8 m	8
9						- standpipe piezometer installed	9
10						- backfilled with drill cuttings and bentonite chips at surface	10
			WATER LEVEL BELOW GROUND SURFACE:				
			- August 13, 2024 = Dry				
			- August 27, 2024 = Dry				
DRILLING CO.: All Service Drilling Inc.			COMPILED BY: TGV				
RIG TYPE: M10			REVIEWED BY: RWT				
DRILL METHOD: Solid Stem Auger			COMPLETION DATE: 2024-08-13				
INSPECTOR: NNM			Page 1 of 1				

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-04					
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930014 m, Easting: 328604 m		ELEVATION:					
SAMPLE TYPE: Grab Sample		Standard Penetration Test							
BACKFILL TYPE: Bentonite		Drill Cuttings Slough							
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM SOIL SYMBOL DESCRIPTION	DEPTH (m)			
0		G-1			CI	CLAY, brown, silty, trace coal	0		
1		SPT-2 4-4-6 (10)			CH	- stiff	1		
2		G-3			CH	- trace oxides, trace silt pockets	2		
3		SPT-4 5-6-8 (14)			CH	- trace coal	3		
4		G-5			CH		4		
5		SPT-6 3-3-3 (6)			CI	- firm, trace sand partings	5		
6						END OF HOLE at 4.3 m - no water - slough at 3.8 m - standpipe piezometer installed - backfilled with drill cuttings and bentonite chips at surface WATER LEVEL BELOW GROUND SURFACE: - August 13, 2024 = Dry - August 27, 2024 = Dry	6		
7							7		
8							8		
9							9		
10							10		
THURBER ENGINEERING LTD.			DRILLING CO.: All Service Drilling Inc. RIG TYPE: M10 DRILL METHOD: Solid Stem Auger INSPECTOR: NNM				COMPILED BY: TGV REVIEWED BY: RWT COMPLETION DATE: 2024-08-13		COMPLETION DEPTH: 4.3 m

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-05				
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930068 m, Easting: 328526 m		ELEVATION:				
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test								
BACKFILL TYPE:								
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ ■ SPT (N) Blows/300 mm ■ PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0		G-1			GM		GRAVEL (FILL), dark brown, sandy	0
1		SPT-2 3-5-5 (10)			CH		CLAY (FILL), stiff, brown, silty, some sand, trace gravel	1
2		G-3			CH		CLAY, brown, silty, trace coal, trace silt pockets	2
3		SPT-4 3-5-5 (10)			CH		- stiff, trace oxides, trace silt lenses	3
4		G-5			CH			4
5		SPT-6			CI		END OF HOLE at 4.3 m - no water - slough at 3.8 m - backfilled with drill cuttings and bentonite chips at surface	5
6								6
7								7
8								8
9								9
10								10

DRILLING CO.: All Service Drilling Inc.
RIG TYPE: M10
DRILL METHOD: Solid Stem Auger
INSPECTOR: NNM

COMPILED BY: TGV
REVIEWED BY: RWT

COMPLETION DEPTH: 4.3 m
COMPLETION DATE: 2024-08-13

Page 1 of 1

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-06			
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5929990 m, Easting: 328623 m		ELEVATION:			
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test							
BACKFILL TYPE:							
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0		G-1			CH	TOPSOIL CLAY, brown, silty	0
1		SPT-2 4-5-6 (11)			CH	- stiff, trace oxides, trace silt partings	1
2		G-3			CH	- trace coal	2
3		SPT-4 3-4-5 (9)			CH		3
4		G-5			CI		4
5		SPT-6 4-5-6 (11)			CI	END OF HOLE at 4.3 m - no water - slough at 3.7 m - backfilled with drill cuttings and bentonite chips at surface	5
6							6
7							7
8							8
9							9
10							10



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 4.3 m

COMPLETION DATE: 2024-08-13

Page 1 of 1

CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-07		
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930001 m, Easting: 328542 m			ELEVATION:		
SAMPLE TYPE:			Grab Sample Standard Penetration Test					
BACKFILL TYPE:								
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0		G-1a	</					

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-07				
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930001 m, Easting: 328542 m		ELEVATION:				
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test								
BACKFILL TYPE:								
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
10		SPT-14 5-7-7 (14)			CL		CLAY (continued)	10
11		G-15			CI		CLAY TILL, greyish brown, some sand, trace gravel, trace coal	11
12		SPT-16 7-10-11 (21)			CI		- very stiff, silty	12
13							END OF HOLE at 11.9 m - no water - slough at 11.0 m - backfilled with drill cuttings and bentonite chips at surface	13
14								14
15								15
16								16
17								17
18								18
19								19
20								20



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

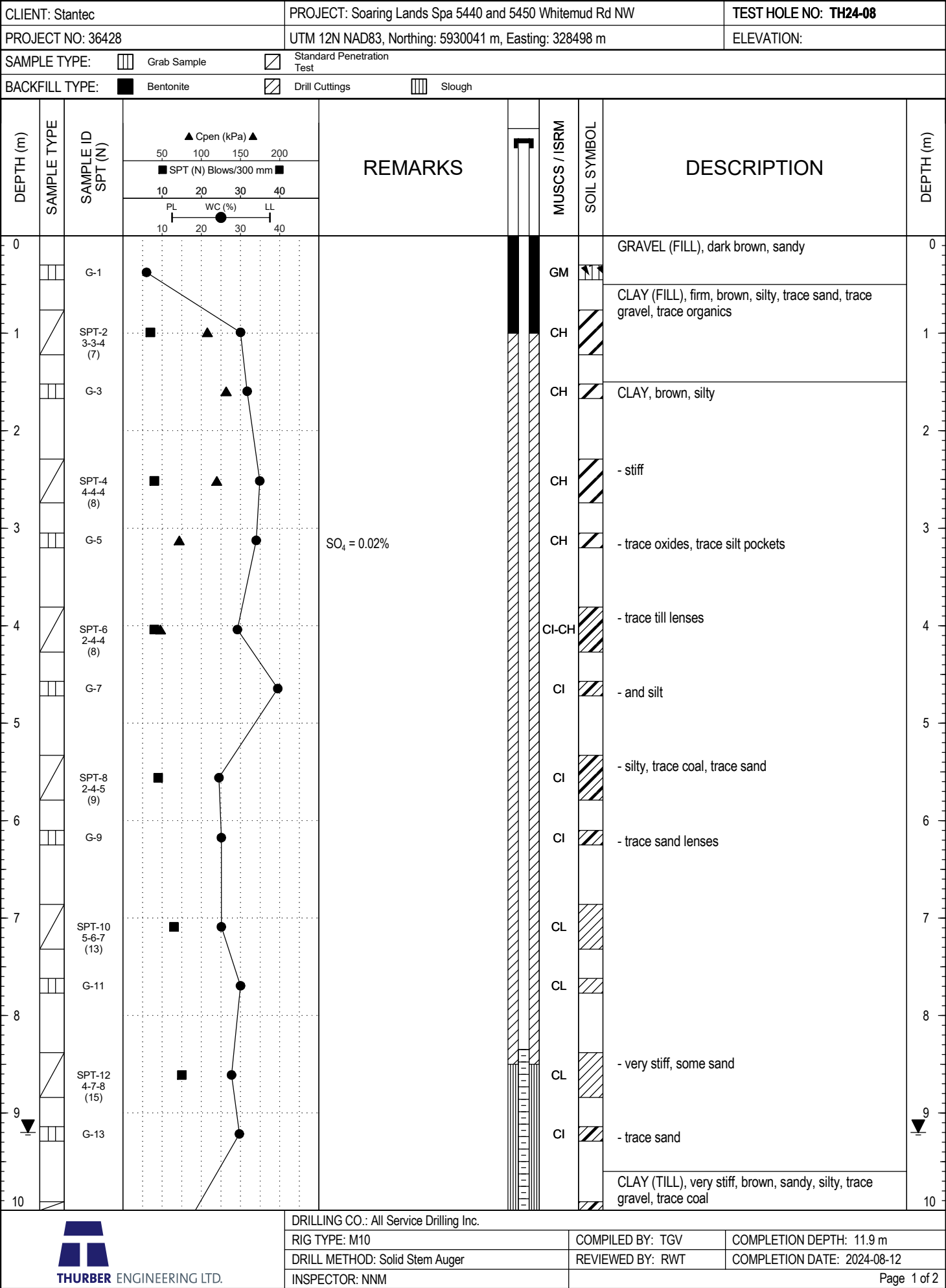
COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 11.9 m

COMPLETION DATE: 2024-08-12

Page 2 of 2



CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-08			
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930041 m, Easting: 328498 m			ELEVATION:			
SAMPLE TYPE: Grab Sample			Standard Penetration Test						
BACKFILL TYPE: Bentonite			Drill Cuttings Slough						
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	STANDPIPE	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
10		SPT-14 7-8-10 (18)				CI		CLAY (TILL) (continued)	10
11		G-15				CI			11
12		SPT-16 9-10-11 (21)				CI		END OF HOLE at 11.9 m - no water - slough at 8.5 m - standpipe piezometer installed - backfilled with drill cuttings and bentonite chips at surface WATER LEVEL BELOW GROUND SURFACE: - August 13, 2024 = 10.2 m - August 27, 2024 = 9.2 m	12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20

THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

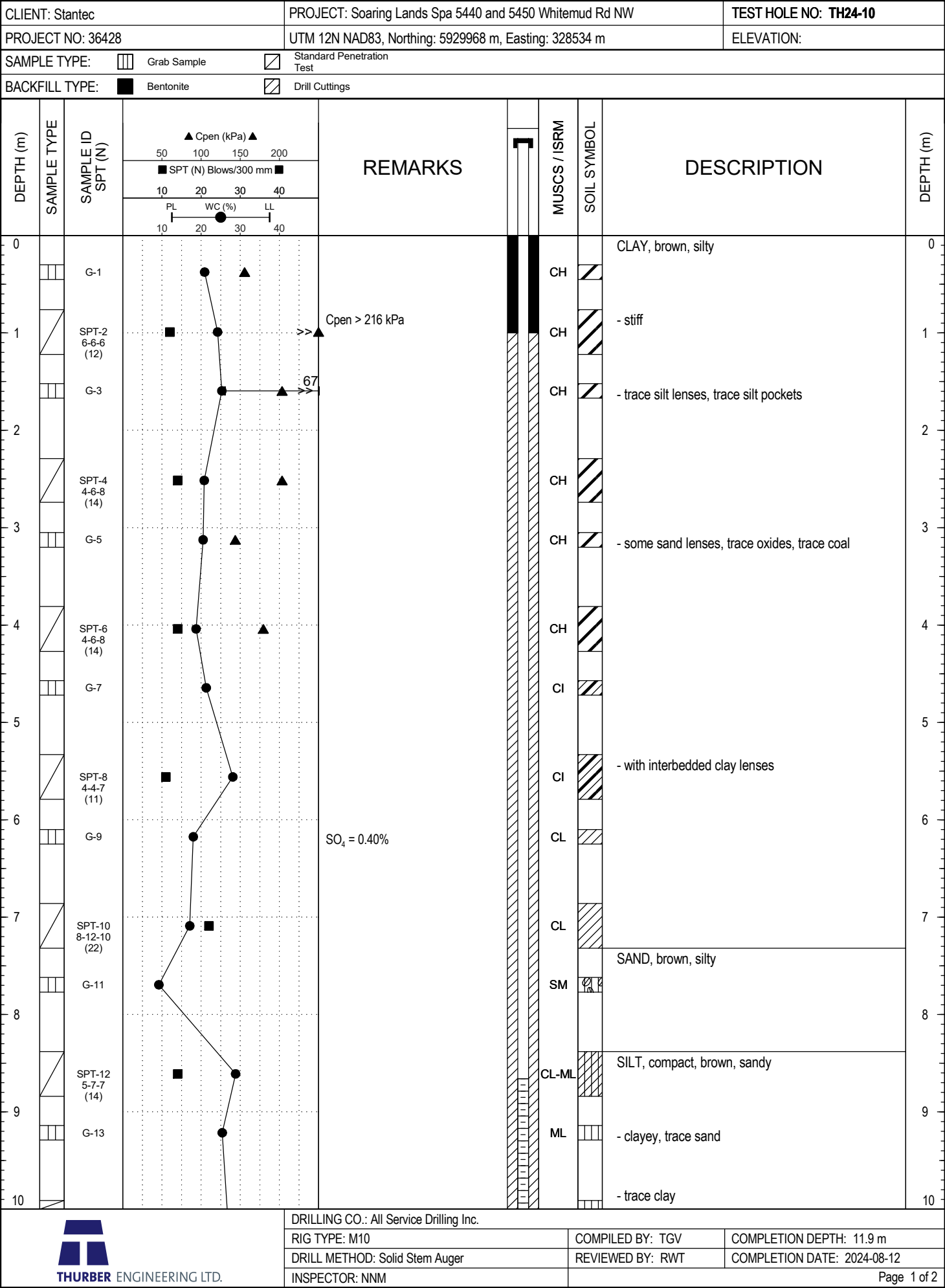
COMPLETION DEPTH: 11.9 m

COMPLETION DATE: 2024-08-12

Page 2 of 2

CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-09		
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930004 m, Easting: 328506 m			ELEVATION:		
SAMPLE TYPE:			Grab Sample Standard Penetration Test					
BACKFILL TYPE:								
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0							TOPSOIL	0
		G-1	</					

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-09				
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930004 m, Easting: 328506 m		ELEVATION:				
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test								
BACKFILL TYPE:								
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)		MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)	
10		SPT-14 4-4-4 (8)	▲ C_{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40				10	
11		G-15			CL		CLAY (continued) CLAY (TILL), brown, sandy, silty, trace gravel, trace coal	11
12		SPT-16 6-9-10 (19)			CI		- very stiff	12
13						END OF HOLE at 11.9 m - no water - slough at 11.0 m - backfilled with drill cuttings and bentonite chips at surface	13	
14							14	
15							15	
16							16	
17							17	
18							18	
19							19	
20							20	
 THURBER ENGINEERING LTD.			DRILLING CO.: All Service Drilling Inc.					
			RIG TYPE: M10		COMPILED BY: TGV		COMPLETION DEPTH: 11.9 m	
			DRILL METHOD: Solid Stem Auger		REVIEWED BY: RWT		COMPLETION DATE: 2024-08-12	
			INSPECTOR: NNM		Page 2 of 2			



CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-10					
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5929968 m, Easting: 328534 m		ELEVATION:					
SAMPLE TYPE: Grab Sample		Standard Penetration Test							
BACKFILL TYPE: Bentonite		Drill Cuttings							
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	STANDPIPE	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
10		SPT-14 5-8-11 (19)				ML		SILT (continued)	10
		G-15				ML			
11									
		SPT-16 9-15-15 (30)		>>▲ Cpen > 216 kPa		CI		CLAY (TILL), hard, brown, sandy, silty, trace gravel, trace coal	
12								END OF HOLE at 11.9 m	12
								- no water	
								- no slough	
								- standpipe piezometer installed	
								- backfilled with drill cuttings and bentonite chips at surface	
								WATER LEVEL BELOW GROUND SURFACE:	
								- August 13, 2024 = 11.4 m	
								- August 27, 2024 = 11.2 m	
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20

THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 11.9 m

COMPLETION DATE: 2024-08-12

Page 2 of 2

CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-11													
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930027 m, Easting: 328547 m			ELEVATION:													
SAMPLE TYPE:			Grab Sample Standard Penetration Test																
BACKFILL TYPE:			Bentonite Drill Cuttings Slough																
<table><tr><td rowspan="4">DEPTH (m)</td><td rowspan="4">SAMPLE TYPE</td><td rowspan="4">SAMPLE ID SPT (N)</td><td> ▲ C_{pen} (kPa) ▲ 50 100 150 200 </td><td rowspan="4">REMARKS</td><td rowspan="4"> MUSCS / ISRM SOIL SYMBOL </td><td rowspan="4">DESCRIPTION</td><td rowspan="4">DEPTH (m)</td></tr><tr><td> ■ SPT (N) Blows/300 mm ■ 10 20 30 40 </td></tr><tr><td> PL WC (%) LL 10 20 30 40 </td></tr><tr><td></td></tr></table>									DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200	REMARKS	MUSCS / ISRM SOIL SYMBOL	DESCRIPTION	DEPTH (m)	■ SPT (N) Blows/300 mm ■ 10 20 30 40	PL WC (%) LL 10 20 30 40	
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200	REMARKS	MUSCS / ISRM SOIL SYMBOL	DESCRIPTION	DEPTH (m)												
			■ SPT (N) Blows/300 mm ■ 10 20 30 40																
			PL WC (%) LL 10 20 30 40																
0		G-1		C _{pen} > 216 kPa	CI	GRAVEL (FILL)	0												
1		SPT-2 5-5-5 (10)			CI	CLAY (FILL), brown, silty, some sand	1												
		G-3			CH	- stiff, trace oxides													
2						CLAY, brown, silty, trace silt lenses	2												
		SPT-4 5-5-7 (12)			CH	- stiff, trace silt partings													
3		G-5		SO ₄ = 0.00%	CH	- trace oxides	3												
4		SPT-6 4-5-6 (11)			CH		4												
		G-7			CI	- trace coal	5												
5						- and silt lenses, firm													
		SPT-8 2-3-2 (5)			CI		6												
6		G-9			CI	- some silt lenses	6												
7		SPT-10 9-9-9 (18)			CL-ML	SILT, compact, brown, some clay	7												
		G-11			CL-ML	- trace sand lenses	8												
8																			
		SPT-12 4-5-6 (11)			CL-ML		9												
9		G-13			CL-ML		9												
10				Seepage at 9.9 m		- loose, some sand	10												



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.		COMPILED BY: TGV	COMPLETION DEPTH: 11.9 m
RIG TYPE: M10		REVIEWED BY: RWT	COMPLETION DATE: 2024-08-12
DRILL METHOD: Solid Stem Auger			
INSPECTOR: NNM			

Page 1 of 2

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-11					
PROJECT NO: 36428		UTM 12N NAD83, Northing: 5930027 m, Easting: 328547 m		ELEVATION:					
SAMPLE TYPE: ☐ Grab Sample ☒ Standard Penetration Test									
BACKFILL TYPE: ☒ Bentonite ☒ Drill Cuttings ☐ Slough									
DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ Cpen (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	STANDPIPE	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
10		SPT-14 2-2-3 (5)	■			CL-ML		SILT (continued)	10
11		G-15				CL-ML			11
12		SPT-16 9-15-10 (25)	● ■ ▲			CI		CLAY (TILL), very stiff, dark brown, sandy, silty, trace gravel, trace oxides, trace coal	12
13								END OF HOLE at 11.9 m - water at 10.3 m - slough at 10.3 m - standpipe piezometer installed - backfilled with drill cuttings and bentonite chips at surface WATER LEVEL BELOW GROUND SURFACE: - August 13, 2024 = 9.7 m - August 27, 2024 = 9.7 m	13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
			DRILLING CO.: All Service Drilling Inc.						
			RIG TYPE: M10		COMPILED BY: TGV		COMPLETION DEPTH: 11.9 m		
			DRILL METHOD: Solid Stem Auger		REVIEWED BY: RWT		COMPLETION DATE: 2024-08-12		
			INSPECTOR: NNM						

CLIENT: Stantec			PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW			TEST HOLE NO: TH24-12		
PROJECT NO: 36428			UTM 12N NAD83, Northing: 5930020 m, Easting: 328515 m			ELEVATION:		
SAMPLE TYPE:			Grab Sample Standard Penetration Test					
BACKFILL TYPE:								



THURBER ENGINEERING LTD.

DRILLING CO.: All Service Drilling Inc.

RIG TYPE: M10

DRILL METHOD: Solid Stem Auger

INSPECTOR: NNM

COMPILED BY: TGV

REVIEWED BY: RWT

COMPLETION DEPTH: 11.9 m

COMPLETION DATE: 2024-08-12

Page 1 of 2

CLIENT: Stantec		PROJECT: Soaring Lands Spa 5440 and 5450 Whitemud Rd NW		TEST HOLE NO: TH24-12																																																																																																																															
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DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	▲ C_{pen} (kPa) ▲ 50 100 150 200 ■ SPT (N) Blows/300 mm ■ 10 20 30 40 PL WC (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM				SOIL SYMBOL						DESCRIPTION	DEPTH (m)																																																																																																																			
10		SPT-14 4-5-5 (10)			CL-ML		SILT (continued)	10																																																																																																																											
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		SPT-16 9-11-11 (22)			CI		CLAY (TILL), very stiff, brown, sandy, silty, trace coal																																																																																																																												
12							END OF HOLE at 11.9 m - no water - slough at 11.2 m - backfilled with drill cuttings and bentonite chips at surface	12																																																																																																																											
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THURBER ENGINEERING LTD.			DRILLING CO.: All Service Drilling Inc.																																																																																																																																
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			DRILL METHOD: Solid Stem Auger		REVIEWED BY: RWT		COMPLETION DATE: 2024-08-12																																																																																																																												
			INSPECTOR: NNM																																																																																																																																

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-1				
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 12, 2010		PROJECT NO: 17-160-12				
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 667.89 (m)				
SAMPLE TYPE ☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY								
BACKFILL TYPE ☒ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SLOUGH								
DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
0			-Flush - mount cap				TOPSOIL, brown	
1		12	>>>▲Cpen > 215kPa			CI	CLAY stiff, brown, silty	667
			>>>▲Cpen > 215kPa			CH	-trace gravel	
2			>>>▲Cpen > 215kPa			CH		666
		28	>>>▲Cpen > 215kPa			CH	-very stiff, fissured, thin silt layering	
3						CI	-clayey silt layer, mottled brown	665
4		14				CH	-stiff, mottled brown	664
			>>>▲Cpen > 215kPa			CH	-very stiff, brown, sandy	
5						CH		663
		16				CH	-slightly mottled, trace fine sand	662
6						CI-CH	-trace coal pockets	
7		24	>>>▲Cpen > 215kPa			CI		661
			>>>▲Cpen > 215kPa			CL	-brown - light brown, fine sandy, trace sand seams	660
8			-Switched to hollow stem augers					
9		32						659
10								658



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 37.6 m

COMPLETION DATE: 12/8/10

Page 1 of 4

BOREHOLE LOG: 17-160-12 GPJ THPBR AB.GDT 12/10/10- REGULAR LIBRARY WITH WELL ID.GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-1	
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 12, 2010		PROJECT NO: 17-160-12	
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 667.89 (m)	
SAMPLE TYPE		☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY			
BACKFILL TYPE		☒ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SLOUGH			

DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40			REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
10		20	●	■	▲			Cl		CLAY (TILL) - CONTINUED very stiff, grey, slightly mottled brown, silty, trace to some sand, trace coal pockets and gravel	657
11											
12		18	●	■	▲			Cl		-sandy, dark grey	656
13		63	●	■		>>■		Cl		-very hard, brown - grey, light grey layering, sandy, trace coal pockets	655
14										-dark grey, silty, sandy, trace to some gravel	654
15		45	●	■	▲	■ - Cpen > 215kPa		Cl			653
16		68	●	■		>>■		SM		SAND very dense, brown, fine to medium grained, trace silt	652
17											651
18		115	●	■		>>■		SM		-some cemented layering	650
19		68	●	■		>>■		SC		-occasional cemented layering	649
20											648

THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS	FIELD LOGGED BY: AGW	COMPLETION DEPTH: 37.6 m
	PREPARED BY: MMM	COMPLETION DATE: 12/8/10
	REVIEWED BY: DJL	Page 2 of 4

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-1					
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 12, 2010		PROJECT NO: 17-160-12					
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 667.89 (m)					
SAMPLE TYPE ☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY									
BACKFILL TYPE ☒ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SLOUGH									
DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)	
		▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40							
20							SAND - CONTINUED		
21		55	>>■		SC		-trace to some silt	647	
22		66	>>■		SC		-brown - light brown	646	
23								645	
24		54	>>■		SC		-brown, fine grained	644	
25		54	>>■		SM			643	
26								642	
27		59	>>■		SM		-occasional coal and clay seams	641	
28								640	
29		41	■		SC		-dense, thin clay layering, occasional oxidation	639	
30		59	>>■		SM		-very dense, some silt, trace coal seams	638	

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID: GLB



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

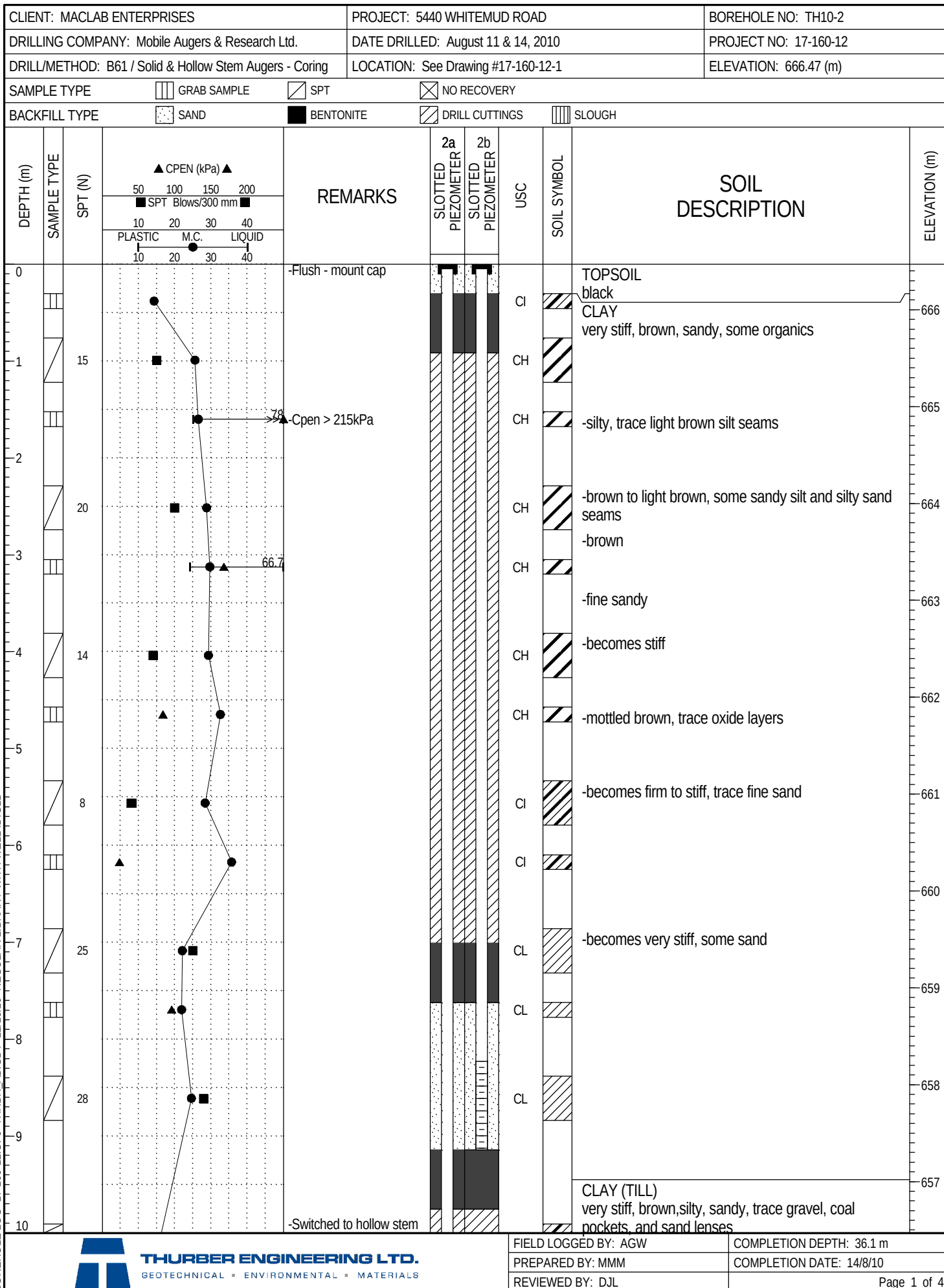
FIELD LOGGED BY: AGW	COMPLETION DEPTH: 37.6 m
PREPARED BY: MMM	COMPLETION DATE: 12/8/10
REVIEWED BY: DJL	Page 3 of 4

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-1	
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 12, 2010		PROJECT NO: 17-160-12	
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 667.89 (m)	
SAMPLE TYPE		☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY			
BACKFILL TYPE		☒ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SLOUGH			

DEPTH (m)	SAMPLE TYPE	SPT (N)	CPEN (kPa) ▲			REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
			SPT Blows/300 mm ■								
			10	20	30						
			PLASTIC	M.C.	LIQUID						
30									SAND - CONTINUED		
31										637	
32		52					SC		-reddish brown, medium to fine grained, trace to some silt, occasional coal and clay layering	636	
33		51					SC		-brown, oxidized, fine grained, coal seam	635	
34										634	
35		52					SM		-reddish brown, fine to medium grained	633	
36		50/127					SM		-brown, some gravel, trace silt	632	
37										631	
38		60/152					CH		CLAY SHALE (BEDROCK), very hard, grey	630	
39									END OF TEST HOLE AT 37.6m UPON COMPLETION: Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -August 16, 2010 = 34.8m -September 17, 2010 = 34.8m	629	
40										628	

 THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS		FIELD LOGGED BY: AGW PREPARED BY: MMM REVIEWED BY: DJL	COMPLETION DEPTH: 37.6 m COMPLETION DATE: 12/8/10
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BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10 - REGULAR LIBRARY WITH WELL ID GLB



CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2	
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 11 & 14, 2010		PROJECT NO: 17-160-12	
DRILL/METHOD: B61 / Solid & Hollow Stem Augers - Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.47 (m)	
SAMPLE TYPE		☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY			
BACKFILL TYPE		☒ SAND ☐ BENTONITE ☒ DRILL CUTTINGS ☐ SLOUGH			

DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40			REMARKS	2a SLOTTED PIEZOMETER	2b SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
10		19				augers			Cl		CLAY (TILL) - CONTINUED	656
11												
12		31							Cl		-becomes very stiff to hard	655
13												
14		29				>>▲Cpen > 215kPa			Cl		-brown - grey, trace sand / quartz pockets	654
15												
16		34										
17												
18		53				>>■			SM-SC		SAND very dense, brown, silty, fine to medium grained, some clay to clayey, trace gravel	653
19												
20		62				>>■			SM-SC		-trace silt and coal seams	652
21												
22		54				>>■			SC			651
23												
24												
25												
26												
27												
28												
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THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS	FIELD LOGGED BY: AGW	COMPLETION DEPTH: 36.1 m
	PREPARED BY: MMM	COMPLETION DATE: 14/8/10
	REVIEWED BY: DJL	Page 2 of 4

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10 - REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2							
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 11 & 14, 2010		PROJECT NO: 17-160-12							
DRILL/METHOD: B61 / Solid & Hollow Stem Augers - Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.47 (m)							
SAMPLE TYPE ☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY											
BACKFILL TYPE ☒ SAND ☐ BENTONITE ☒ DRILL CUTTINGS ☐ SLOUGH											
DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS		2a	2b	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)	
					SLOTTED	SLOTTED					
					PIEZOMETER	PIEZOMETER					
		▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40									
20									SAND - CONTINUED	646	
21		59		>>■			SM-SC			645	
22											
23											
24		62		>>■			SM-SC			644	
25											
26											
27		54		>>■			SM-SC			643	
28											
29											
30		70		>>■			SM-SC		-brown - light brown	642	
31											
32											
33											
34											
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39											
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41											
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CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2	
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 11 & 14, 2010		PROJECT NO: 17-160-12	
DRILL/METHOD: B61 / Solid & Hollow Stem Augers - Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.47 (m)	
SAMPLE TYPE		☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY			
BACKFILL TYPE		☒ SAND ☐ BENTONITE ☒ DRILL CUTTINGS ☐ SLOUGH			

DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS			2a	2b	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
						SLOTTED	SLOTTED				
						PIEZOMETER	PIEZOMETER				
30									SAND - CONTINUED	636	
31											
32		56						SM	-reddish brown, trace silt, fine to medium grained	635	
33		52			-Trace seepage			SM	-brown, medium grained, trace gravel	634	
34											
35		89			-Standpipe 25mm Ø PVC -Casagrande tip			GC GC	GRAVEL grey - brown, some clay, trace coal pockets	633	
36		50						CS	CLAY SHALE (BEDROCK) -dark grey, weathered	632	
37									END OF AUGER TEST HOLE TH10-2 AT 36.1m UPON COMPLETION: Two standpipe piezometers installed (2a and 2b) WATER LEVEL BELOW GROUND SURFACE: -August 13, 2010 = 33.5m (2a) -August 13, 2010 = Dry (2b) -August 16, 2010 = 34.3m (2a) -August 16, 2010 = Dry (2b) -September 17, 2010 = 33.6m (2a) -September 17, 2010 = Dry (2b) Cored TH10-2A on August 14, 2010 using wet rotary -Start coring at 36.0m	631	
38											
39											
40											

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10 - REGULAR LIBRARY WITH WELL ID GLB



THURBER ENGINEERING LTD.
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FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 36.1 m

COMPLETION DATE: 14/8/10

Page 4 of 4

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2A				
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 14, 2010		PROJECT NO: 17-160-12				
DRILL / METHOD: B61 / Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.65 (m)				
SAMPLE TYPE ☒ CORE								
BACKFILL TYPE ☒ BENTONITE ☐ GROUT ☐ SAND								
DEPTH (m)	SAMPLE TYPE	RQD/REC	▲ RECOVERY % ▲ 20 40 60 80 ■ RQD % ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80		DISCONTINUITIES DESCRIPTION	032654 PNEUMATIC PIEZOMETER	SOIL / ROCK DESCRIPTION	ELEVATION (m)
0					-Flush - mount cap		SEE TH10-2 FOR AUGER LOG DETAILS	666
1								665
2								664
3								663
4								662
5								661
6								660
7								659
8								658
9								657
10								

THURBER ENGINEERING LTD.
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LOGGED BY: AGW
 PREPARED: MMM
 REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
 COMPLETION DATE: 8/14/2010

Page 1 of 6

BOREHOLE LOG: 17-160-12-1-B-REGULAR LUB-ROCK WITH WELL ID.GPJ THRRB AB.GDT 12/10/10

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2A				
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 14, 2010		PROJECT NO: 17-160-12				
DRILL / METHOD: B61 / Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.65 (m)				
SAMPLE TYPE ☒ CORE								
BACKFILL TYPE ☒ BENTONITE ☐ GROUT ☐ SAND								
DEPTH (m)	SAMPLE TYPE	RQD/REC	▲ RECOVERY % ▲ 20 40 60 80 ■ RQD % ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80		DISCONTINUITIES DESCRIPTION	PNEUMATIC PIEZOMETER	SOIL / ROCK DESCRIPTION	ELEVATION (m)
10							CONTINUED	656
11								655
12								654
13								653
14								652
15								651
16								650
17								649
18								648
19								647
20								

THURBER ENGINEERING LTD.
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LOGGED BY: AGW
 PREPARED: MMM
 REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
 COMPLETION DATE: 8/14/2010

BOREHOLE LOG: 17-160-12-1-B-REGULAR LUB-ROCK WITH WELL ID.GPJ THRRB AB.GDT 12/10/10

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2A				
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 14, 2010		PROJECT NO: 17-160-12				
DRILL / METHOD: B61 / Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.65 (m)				
SAMPLE TYPE ☒ CORE								
BACKFILL TYPE ☒ BENTONITE ☐ GROUT ☐ SAND								
DEPTH (m)	SAMPLE TYPE	RQD/REC	▲ RECOVERY % ▲ 20 40 60 80 ■ RQD % ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80		DISCONTINUITIES DESCRIPTION	032654 PNEUMATIC PIEZOMETER	SOIL / ROCK DESCRIPTION	ELEVATION (m)
20							CONTINUED	646
21								645
22								644
23								643
24								642
25								641
26								640
27								639
28								638
29								637
30								

THURBER ENGINEERING LTD.
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LOGGED BY: AGW
 PREPARED: MMM
 REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
 COMPLETION DATE: 8/14/2010

Page 3 of 6

BOREHOLE LOG: 17-160-12-1-B-REGULAR LUB-ROCK WITH WELL ID.GPJ THRRB AB.GDT 12/10/10

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2A						
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 14, 2010		PROJECT NO: 17-160-12						
DRILL / METHOD: B61 / Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.65 (m)						
SAMPLE TYPE ☒ CORE										
BACKFILL TYPE ☒ BENTONITE ☐ GROUT ☐ SAND										
DEPTH (m)	SAMPLE TYPE	RQD/REC	RECOVERY %		DISCONTINUITIES DESCRIPTION	PNEUMATIC PIEZOMETER	SOIL / ROCK DESCRIPTION	ELEVATION (m)		
			20	40					60	80
			RQD %							
			20	40					60	80
			PLASTIC	M.C.	LIQUID					
			20	40	60	80				
30							CONTINUED			
31								636		
32								635		
33								634		
34								633		
35								632		
36								631		
37		100/100					CLAY SHALE (BEDROCK), hard to very hard, grey -horizontal coal seam at 36.1m SANDSTONE, grey, weathered, some silt CLAY SHALE, dark grey, slightly weathered	630		
38							SANDSTONE, grey, slightly weathered, some silt CLAY SHALE dark grey, slightly weathered -fissured angles to 45° -dark grey - green, medium plastic -bentonitic shale from 37.5m to 37.6m	629		
39		87/100					SANDSTONE grey, fine to medium grained, fresh, some silt	628		
40							CLAY SHALE dark grey, medium plastic	627		

BOREHOLE LOG: 17-160-12-LIB-REGULAR LIB-ROCK WITH WELL ID.GPJ THRRB AB.GDT 12/10/10



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

LOGGED BY: AGW
PREPARED: MMM
REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
COMPLETION DATE: 8/14/2010

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-2A																	
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 14, 2010			PROJECT NO: 17-160-12																	
DRILL / METHOD: B61 / Coring			LOCATION: See Drawing #17-160-12-1			ELEVATION: 666.65 (m)																	
SAMPLE TYPE			CORE																				
BACKFILL TYPE			BENTONITE		GROUT		SAND																
DEPTH (m)			SAMPLE TYPE			RQD/REC			DISCONTINUITIES DESCRIPTION			PNEUMATIC PIEZOMETER			SOIL / ROCK DESCRIPTION			ELEVATION (m)					
						▲ RECOVERY % ▲																	
						20 40 60 80																	
						■ RQD % ■																	
						20 40 60 80																	
						PLASTIC M.C. LIQUID																	
						20 40 60 80																	
40																		CLAY SHALE - CONTINUED					
																		SANDSTONE					
																		grey, fine to medium grained, fresh, some silt					
																		-thin coal seams from 40.3m to 40.6m			626		
																		-coal seam at 40.7m					
41			98/100																				
																		-Machine break					
																					625		
42																							
																		-Machine break					
																		-Machine break					
																		-Machine break					
																		-RUN#4 from 42.6m to 45.0m			624		
43																							
																		CLAY SHALE, dark grey, fresh, medium plastic					
																		-brown coal layer from 43.4m to 43.6m					
																		-black coal seam at 43.4m			623		
44			100/100																				
																		-black coal seam from 43.89m to 43.94m					
																		-bentonitic shale from 44.0m to 44.2m					
																		-bentonitic shale from 44.5m to 44.7m, some coal seams at 44.6m			622		
45																							
																		-RUN#5 from 45.0m to 47.4m					
																		-Natural break					
																		-grey, high plastic, some medium plastic clay shale zones					
																		-bentonitic shale from 45.0m to 45.6m			621		
46			100/100																				
																		-coal seam at 45.8m					
																		-coal seam at 45.9m					
																		-coal seam at 46.4m					
																		-pink pockets from 46.4m to 46.6m			620		
47																							
																		CLAY SHALE					
																		dark grey, fresh					
																					619		
48																							
																		SILTSTONE, light grey					
																		CLAY SHALE, dark grey, fresh					
																		SILTSTONE					
																		CLAY SHALE					
																		SANDSTONE			618		
49			100/100																				
																		grey, medium to fine grained, fresh, some silt					
																		-thin coal seams in sandstone from 49.1m to 49.5m					
																		-Machine break					
																					617		
50																							
																		-Machine break					
																		-Occasional machine break through run					

THURBER ENGINEERING LTD.

GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

LOGGED BY: AGW

PREPARED: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m

COMPLETION DATE: 8/14/2010

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THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

LOGGED BY: AGW
PREPARED: MMM
REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
COMPLETION DATE: 8/14/2010

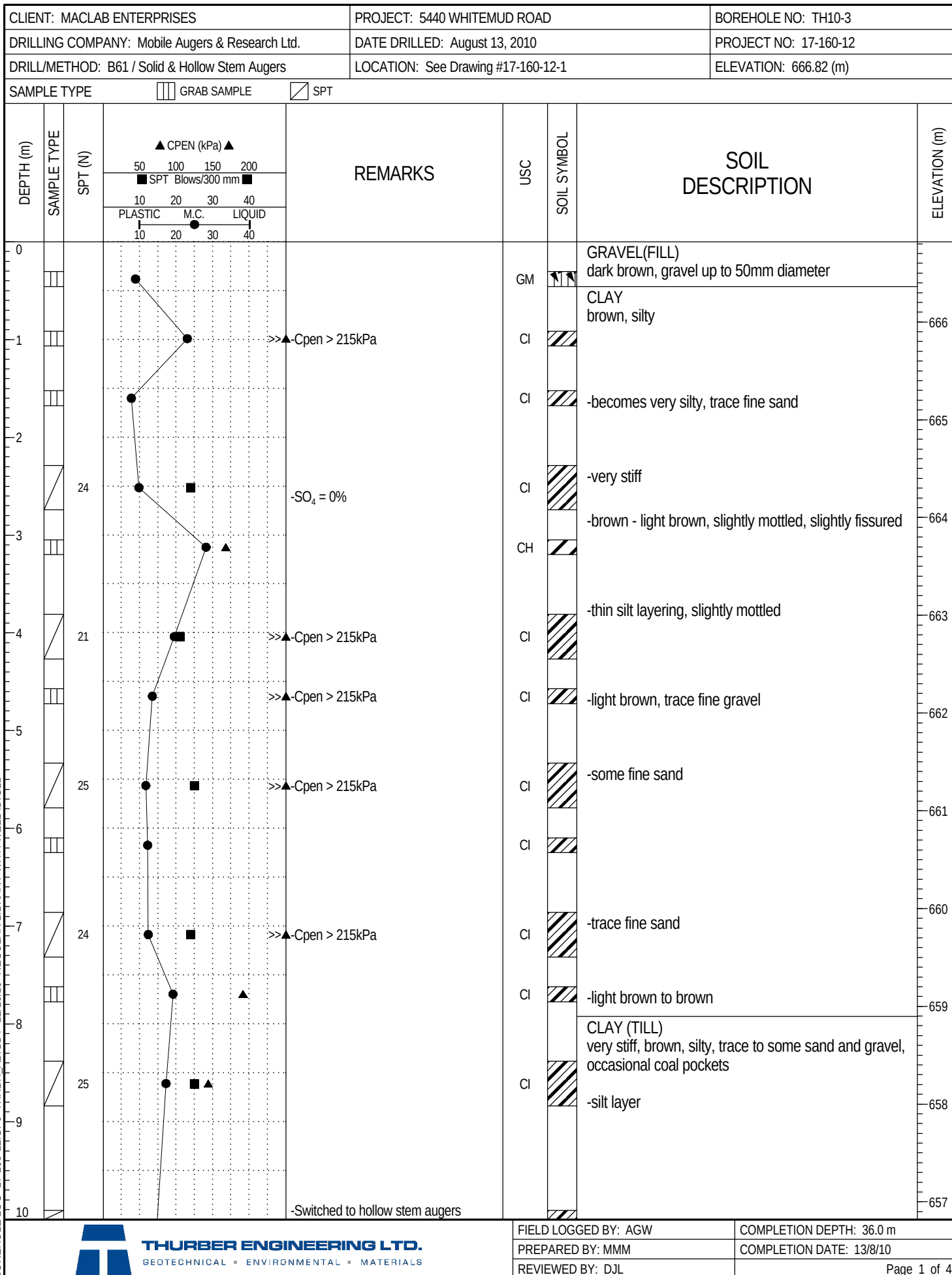
CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-2A						
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 14, 2010		PROJECT NO: 17-160-12						
DRILL / METHOD: B61 / Coring		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.65 (m)						
SAMPLE TYPE ☒ CORE										
BACKFILL TYPE ☒ BENTONITE ☐ GROUT ☐ SAND										
DEPTH (m)	SAMPLE TYPE	RQD/REC	RECOVERY %		DISCONTINUITIES DESCRIPTION	PNEUMATIC PIEZOMETER	SOIL / ROCK DESCRIPTION	ELEVATION (m)		
			RQD %							
			M.C.							
			PLASTIC	LIQUID						
50			20	40	60	80	-RUN#7 from 49.9m to 51.8m	032654	SANDSTONE - CONTINUED	616
51		100/100							SILTSTONE, light grey SANDSTONE grey, some silt and coal seams	615
52									END OF TEST HOLE AT 51.8m UPON COMPLETION: Pneumatic piezometer (#032654) installed Tip at 37.6m WATER LEVEL BELOW GROUND SURFACE: -September 17, 2010 = 34.1m	614
53										613
54										612
55										611
56										610
57										609
58										608
59										607
60										

THURBER ENGINEERING LTD.
 GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

LOGGED BY: AGW
 PREPARED: MMM
 REVIEWED BY: DJL

COMPLETION DEPTH: 51.8 m
 COMPLETION DATE: 8/14/2010

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BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-3		
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 13, 2010			PROJECT NO: 17-160-12		
DRILL/METHOD: B61 / Solid & Hollow Stem Augers			LOCATION: See Drawing #17-160-12-1			ELEVATION: 666.82 (m)		
SAMPLE TYPE			☐ GRAB SAMPLE ☒ SPT					
DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40	REMARKS	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
10		52	● ▲	>>■ SPT hit on a rock	Cl		CLAY (TILL) - CONTINUED -sand seams	656
11								
12		39	● ■	>>▲ Cpen > 215kPa	Cl		-hard, dark brown - grey, trace coal pockets	655
13								654
14		38	● ■	>>▲ Cpen > 215kPa	Cl		-some sand, trace to some gravel	653
15								
16		37	● ■	>>▲ Cpen > 215kPa	Cl		-more gravel	652
17								651
18		87	● ■	>>■	SC-CL		SAND very dense, brown, medium to fine grained, clayey, thin clay layering, some coal clay cemented seams	650
19								649
20		68	● ■	>>■	SM		-silty, no clay layering	648
								647
THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS					FIELD LOGGED BY: AGW		COMPLETION DEPTH: 36.0 m	
					PREPARED BY: MMM		COMPLETION DATE: 13/8/10	
					REVIEWED BY: DJL		Page 2 of 4	

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-3			
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 13, 2010		PROJECT NO: 17-160-12			
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.82 (m)			
SAMPLE TYPE ☐ GRAB SAMPLE ☒ SPT							
DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
		▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40					
20						SAND- CONTINUED	
21							646
22		79	>>■	SM		-fine grained	645
23							644
24							643
25		55	>>■	SM		-medium to fine grained, trace to some silt, trace coal seams, occasional thin clay and silt layers	642
26							641
27							640
28		68	>>■	SM		-occasional thin clay and silt layers	639
29							638
30							637
THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS				FIELD LOGGED BY: AGW		COMPLETION DEPTH: 36.0 m	
				PREPARED BY: MMM		COMPLETION DATE: 13/8/10	
				REVIEWED BY: DJL		Page 3 of 4	

BOREHOLE LOG: 17-160-12 GPJ THPBR AB.GDT 12/10/10- REGULAR LIBRARY WITH WELL ID.GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-3			
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 13, 2010		PROJECT NO: 17-160-12			
DRILL/METHOD: B61 / Solid & Hollow Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 666.82 (m)			
SAMPLE TYPE ☐ GRAB SAMPLE ☒ SPT							
DEPTH (m)	SAMPLE TYPE	SPT (N)	REMARKS	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
30						SAND- CONTINUED	
31							636
32		80		SM		-reddish brown, some coal and clay seams	635
33							634
34							633
35		50/102		GM		GRAVEL very dense, brown, silty, sandy, up to 20mm diameter, trace coal seams	632
36		60/152		CL		SANDSTONE (BEDROCK) very dense, grey, some silt	631
37						END OF TEST HOLE AT 36.0m UPON COMPLETION: Backfilled with drill cuttings and bentonite chips at surface	630
38							629
39							628
40							627



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GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 36.0 m

COMPLETION DATE: 13/8/10

Page 4 of 4

BOREHOLE LOG: 17-160-12 GPJ TH10-3 AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID: GLB

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-4		
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 17, 2010			PROJECT NO: 17-160-12		
DRILL/METHOD: M4A Track / Solid Stem Augers			LOCATION: See Drawing #17-160-12-1			ELEVATION: 669.84 (m)		
SAMPLE TYPE			GRAB SAMPLE SPT					
BACKFILL TYPE			DRILL CUTTINGS BENTONITE SAND SLOUGH					



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FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 8.8 m

COMPLETION DATE: 17/8/10

Page 1 of 1

CLIENT: MACLAB ENTERPRISES				PROJECT: 5440 WHITEMUD ROAD				BOREHOLE NO: TH10-5			
DRILLING COMPANY: Mobile Augers & Research Ltd.				DATE DRILLED: August 17, 2010				PROJECT NO: 17-160-12			
DRILL/METHOD: M4A Track / Solid Stem Augers				LOCATION: See Drawing #17-160-12-1				ELEVATION: 669.64 (m)			
SAMPLE TYPE		☐ GRAB SAMPLE		☒ SPT							
BACKFILL TYPE		☒ DRILL CUTTINGS		☐ BENTONITE		☐ SAND		☐ SLOUGH			
DEPTH (m) SAMPLE TYPE SPT (N) ▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40 REMARKS 5a SLOTTED PIEZOMETER 5b SLOTTED PIEZOMETER USC SOIL SYMBOL SOIL DESCRIPTION ELEVATION (m)											
0 -Flush - mount cap CI TOPSOIL, dark brown 1 12 CI CLAY stiff, brown, silty, trace sand 669 2 CI-CH -brown - light brown 668 3 7 CI -firm, brown, slightly mottled, thin silt layering, some fine sand, trace oxidation 667 4 CH -mottled brown, trace sand 666 5 CH -brown, slightly mottled 6 CI -trace coal seams 665 7 9 CI -stiff 664 8 CL -very stiff 9 CL -till like, sandy, thin silt layering 663 10 17 CL 662 11 CL 661 12 15 CL 660 13 END OF TEST HOLE AT 8.8m UPON COMPLETION: Two standpipe piezometers installed (5a and 5b) WATER LEVEL BELOW GROUND SURFACE: -August 18, 2010 = 7.4m (5a) -August 18, 2010 = Dry (5b) 660											
THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS				FIELD LOGGED BY: AGW				COMPLETION DEPTH: 8.8 m			
				PREPARED BY: MMM				COMPLETION DATE: 17/8/10			
				REVIEWED BY: DJL				Page 1 of 1			



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 8.8 m

COMPLETION DATE: 17/8/10

Page 1 of 1

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10 - REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES		PROJECT: 5440 WHITEMUD ROAD		BOREHOLE NO: TH10-6	
DRILLING COMPANY: Mobile Augers & Research Ltd.		DATE DRILLED: August 18, 2010		PROJECT NO: 17-160-12	
DRILL/METHOD: M5 / Solid Stem Augers		LOCATION: See Drawing #17-160-12-1		ELEVATION: 675.48 (m)	
SAMPLE TYPE		☐ GRAB SAMPLE ☒ SPT			
BACKFILL TYPE		☒ DRILL CUTTINGS ☐ BENTONITE ☐ SAND ☐ SLOUGH			

DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40			REMARKS	SLOTTED PIEZOMETER	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
0						-Flush - mount cap				TOPSOIL, brown	675
								CI		CLAY stiff, brown, silty	
1		10						CI-CH		-light brown pockets	
								CI			674
2								CI			
		11						CI		-trace gravel	
3								CI			673
								CI		-firm to stiff, brown	
4								CI			672
		22						CI		-very stiff, sandy, thin silt layering	
5								CI			671
								CI			
6								CI			670
		18						CI			
7								CI			669
								CI			
8								CI			668
		21						CI		-trace fine sand	
9								CI			667
								CI		-trace coal pockets	
10		20						CI			666
										END OF TEST HOLE AT 8.8m UPON COMPLETION: Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -August 18, 2010 = Dry -September 17, 2010 = Dry	

 THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS	FIELD LOGGED BY: AGW	COMPLETION DEPTH: 8.8 m
	PREPARED BY: MMM	COMPLETION DATE: 18/8/10
	REVIEWED BY: DJL	Page 1 of 1

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-7			
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 16, 2010			PROJECT NO: 17-160-12			
DRILL/METHOD: M10 / Solid Stem Augers			LOCATION: See Drawing #17-160-12-1			ELEVATION: 671.74 (m)			
SAMPLE TYPE			GRAB SAMPLE SPT						
BACKFILL TYPE			DRILL CUTTINGS BENTONITE SAND SLOUGH						
DEPTH (m) SAMPLE TYPE SPT (N) ▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40 REMARKS SLOTTED PIEZOMETER USC SOIL SYMBOL SOIL DESCRIPTION ELEVATION (m)									
0 -Flush - mount cap <									



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FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 8.8 m

COMPLETION DATE: 16/8/10

Page 1 of 1

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-10		
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 16, 2010			PROJECT NO: 17-160-12		
DRILL/METHOD: M10 / Solid Stem Augers			LOCATION: See Drawing #17-160-12-1			ELEVATION: 668.42 (m)		
SAMPLE TYPE			☐ GRAB SAMPLE ☒ SPT ☒ NO RECOVERY					
DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40	REMARKS	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
0					GC		GRAVEL AND SAND (FILL), some silt	
							ORGANIC SILT AND GRAVEL MIXTURE, black	668
1		11		>>>▲-Cpen > 215kPa	CI		CLAY stiff, dark brown, silty, sandy -mottled brown	667
2					CH		-brown - dark brown, trace to some gravel, occasional light brown pockets	667
		20		>>>▲-Cpen > 215kPa	CH-CI		-very stiff, brown - light brown, slightly mottled, occasional fine sand partings	666
3					CI		-brown, trace gravel	665
4		15			CI		-mottled brown	664
					CI			664
5								
		6			CI		-firm, brown	663
6					CI		-slightly mottled, some fine sand	662
7		16			CI		-very stiff, sandy	661
					CI			661
8								
		16			CI			660
9							END OF TEST HOLE AT 8.8m UPON COMPLETION: (Below ground surface) -Water at 6.7m Backfilled with drill cuttings and surface bentonite seal	659
10								



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FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 8.8 m

COMPLETION DATE: 16/8/10

Page 1 of 1

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10- REGULAR LIBRARY WITH WELL ID GLB

CLIENT: MACLAB ENTERPRISES			PROJECT: 5440 WHITEMUD ROAD			BOREHOLE NO: TH10-13		
DRILLING COMPANY: Mobile Augers & Research Ltd.			DATE DRILLED: August 16, 2010			PROJECT NO: 17-160-12		
DRILL/METHOD: M10 / Solid Stem Augers			LOCATION: See Drawing #17-160-12-1			ELEVATION: 635.30 (m)		
SAMPLE TYPE			☐ GRAB SAMPLE ☒ SPT					
BACKFILL TYPE			☒ DRILL CUTTINGS ☐ BENTONITE ☐ SAND ☐ SLOUGH					
DEPTH (m)	SAMPLE TYPE	SPT (N)	▲ CPEN (kPa) ▲ 50 100 150 200 ■ SPT Blows/300 mm ■ 10 20 30 40 PLASTIC M.C. LIQUID 10 20 30 40	REMARKS	USC	SOIL SYMBOL	SOIL DESCRIPTION	ELEVATION (m)
0				-Stick - up = 0.9m			TOPSOIL	635
					CI		CLAY	
					CI		reddish brown, sandy, trace roots	
					CI		-light brown, silty	
1		14		>>>▲Cpen > 215kPa	CI		-stiff, brown, some sand	
					CI		-reddish brown	634
					CI		-light brown, sandy, occasional silt layering	
2					CI		-becomes very stiff	633
		22			CI			
3					SC		CLAY AND SAND (INTERBEDDED)	632
					SC		brown, fine grained clayey sand, oxidized sand layers, trace gravel	
4		9			SC		-loose, brown - light brown, thin silt layering, trace coal seams	631
					CL		-reddish brown, silty clay, some silt layering	
5					CI		-stiff, occasional fine to medium grained sand seams	630
		15		-Standpipe 25mm Ø PVC	SC			629
6					SC			
7		16		-Casagrande tip	SC		-compact, brown, fine to medium grained, trace silt	628
					CI		CLAY (TILL)	
					CI		brown, silty, gravelly, trace sand and gravel	
8					CH		CLAY SHALE (BEDROCK)	627
					CH		very hard, grey	
9		50/152			CH		END OF TEST HOLE AT 8.7m UPON COMPLETION: Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -August 18, 2010 = Dry -September 17, 2010 = Dry	626
10								



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FIELD LOGGED BY: AGW

PREPARED BY: MMM

REVIEWED BY: DJL

COMPLETION DEPTH: 8.7 m

COMPLETION DATE: 16/8/10

Page 1 of 1

BOREHOLE LOG: 17-160-12 GPJ THPBR AB GDT 12/10/10 - REGULAR LIBRARY WITH WELL ID GLB

APPENDIX C

Laboratory Test Results



ATTERBERG LIMITS
ASTM D4318

Client: Stantec
Project: Soaring Lands Spa
Project No: 36428
Test Hole: TH24-3
Sample No: G1
Depth: 0.3 m

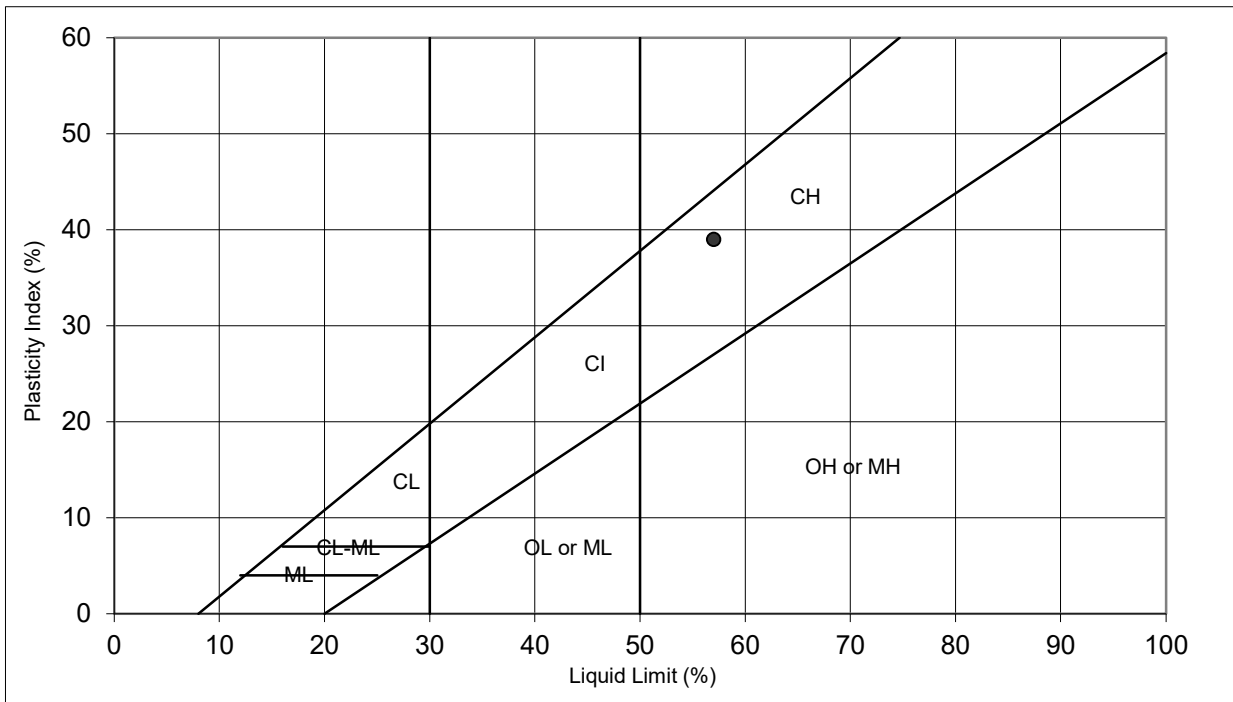
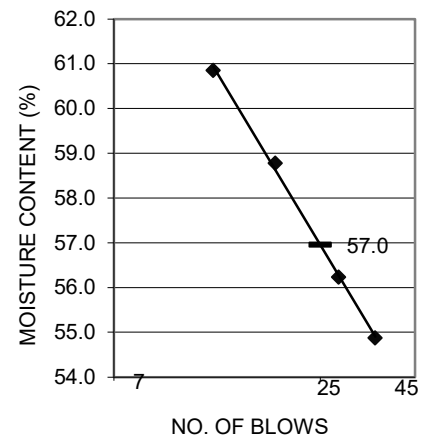
Date Tested: 30-Aug-24
Tested By: LLK
Checked By: TGV

LIQUID LIMIT

Trial No:	1	2	3	4
No of Blows:	35	28	19	13
Container No.	1	2	3	4
Wet Soil + Container	26.05	25.20	25.15	26.09
Dry Soil + Container	16.82	16.13	15.84	16.22
Wt. Of Container	0	0	0	0
Moisture Content	54.9	56.2	58.8	60.9

PLASTIC LIMIT

	1	2	AVERAGE
Container No.	5	6	
Wet Soil + Container	27.61	27.37	
Dry Soil + Container	26.3	26.06	
Wt. Of Container	19.05	18.77	
Moisture Content	18.1	18.0	18.0



REMARKS

Liquid Limit: 57
Plastic Limit: 18
Plasticity Index: 39
USC Classification: CH



ATTERBERG LIMITS
ASTM D4318

Client: Stantec
Project: Soaring Lands Spa
Project No: 36428
Test Hole: TH24-7
Sample No: G1b
Depth: 0.61 m

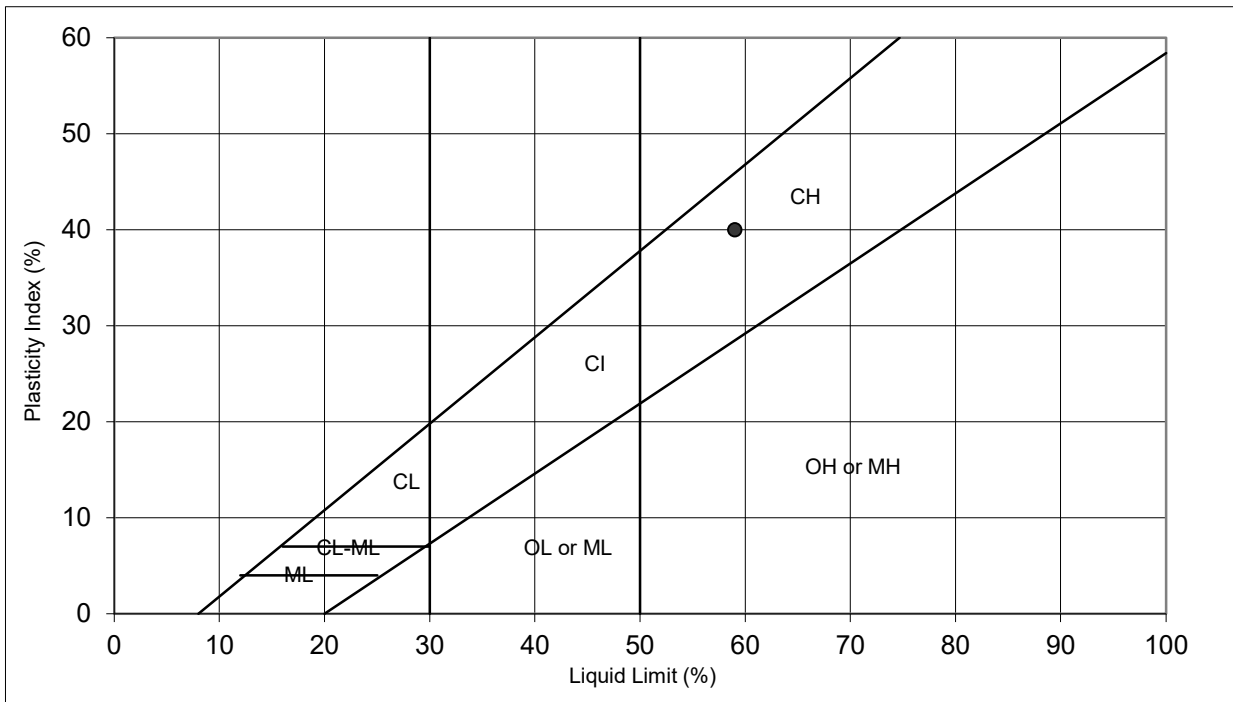
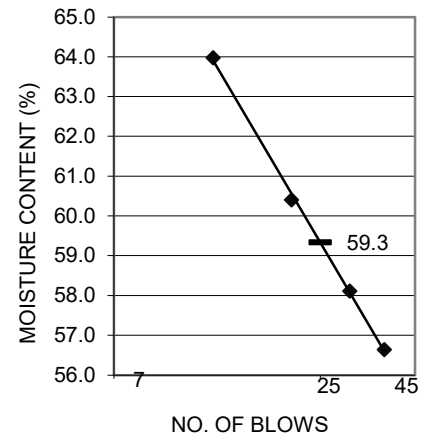
Date Tested: 30-Aug-24
Tested By: LLK
Checked By: TGV

LIQUID LIMIT

Trial No:	1	2	3	4
No of Blows:	37	30	21	13
Container No.	1	2	3	4
Wet Soil + Container	24.67	25.06	23.9	25.17
Dry Soil + Container	15.75	15.85	14.9	15.35
Wt. Of Container	0	0	0	0
Moisture Content	56.6	58.1	60.4	64.0

PLASTIC LIMIT

	1	2	AVERAGE
Container No.	5	6	
Wet Soil + Container	28.27	28.26	
Dry Soil + Container	26.79	26.79	
Wt. Of Container	18.96	18.94	
Moisture Content	18.9	18.7	18.8



REMARKS

Liquid Limit: 59
Plastic Limit: 19
Plasticity Index: 40
USC Classification: CH



ATTERBERG LIMITS
ASTM D4318

Client: Stantec
Project: Soaring Lands Spa
Project No: 36428
Test Hole: TH24-9
Sample No: G1
Depth: 0.46 m

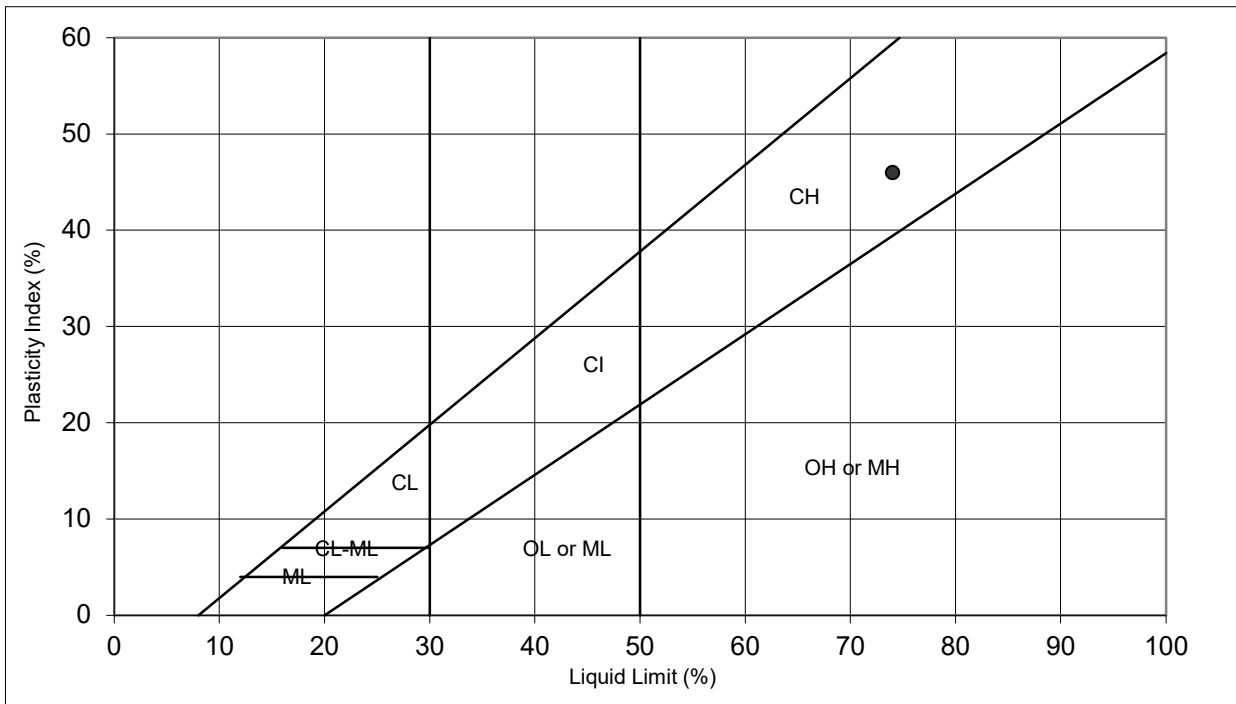
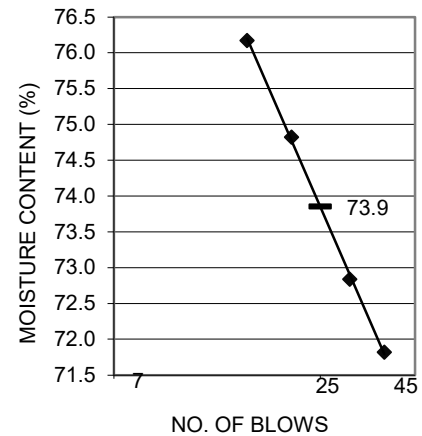
Date Tested: 30-Aug-24
Tested By: NM
Checked By: TGV

LIQUID LIMIT

Trial No:	1	2	3	4
No of Blows:	37	30	21	16
Container No.	1	2	3	4
Wet Soil + Container	12.56	12.98	12.15	14.27
Dry Soil + Container	7.31	7.51	6.95	8.1
Wt. Of Container	0	0	0	0
Moisture Content	71.8	72.8	74.8	76.2

PLASTIC LIMIT

	1	2	AVERAGE
Container No.	5	6	
Wet Soil + Container	28.31	28.89	
Dry Soil + Container	26.23	26.70	
Wt. Of Container	18.77	18.85	
Moisture Content	27.9	27.9	27.9



REMARKS

Liquid Limit: 74
Plastic Limit: 28
Plasticity Index: 46
USC Classification: CH



ATTERBERG LIMITS ASTM D4318

Client: Stantec
Project: Soaring Lands Spa
Project No: 36428
Test Hole: TH24-10
Sample No: G3
Depth: 1.52 m

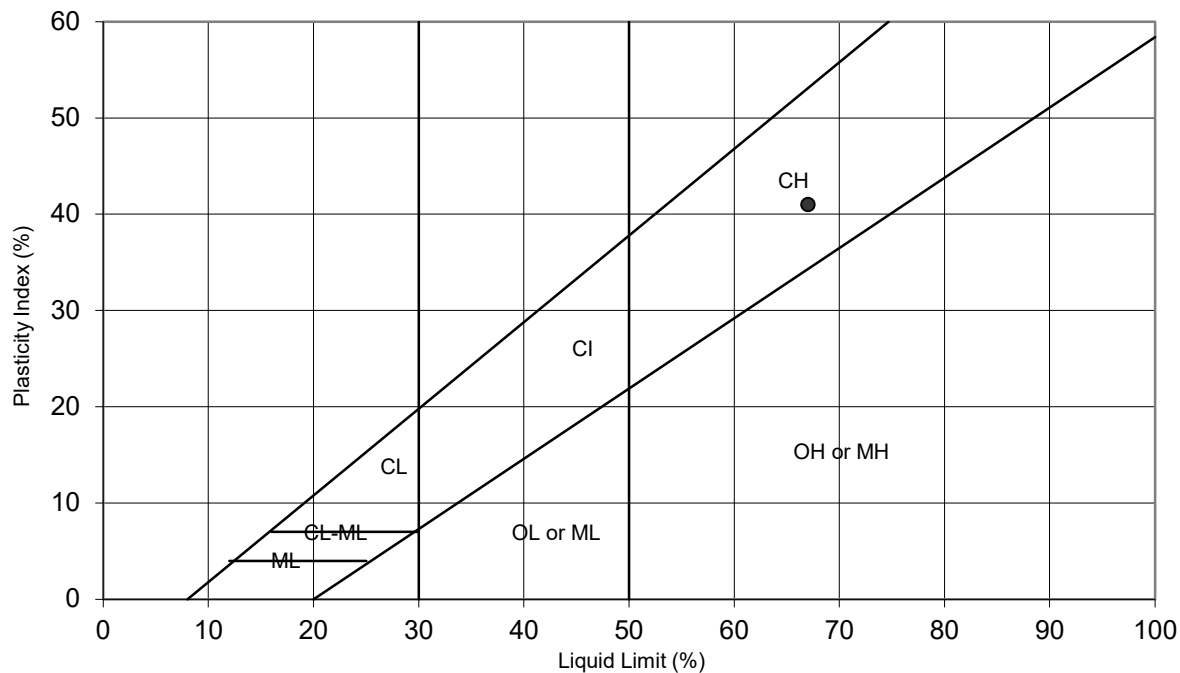
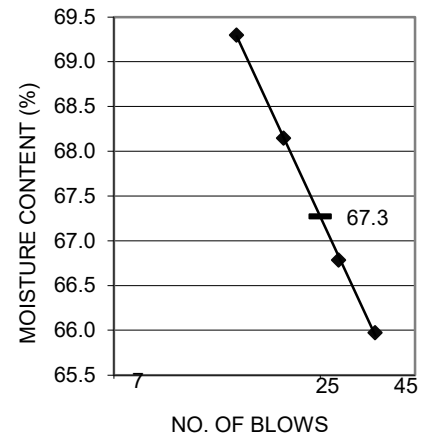
Date Tested: 30-Aug-24
Tested By: NM
Checked By: TGV

LIQUID LIMIT

Trial No:	1	2	3	4
No of Blows:	35	28	20	15
Container No.	1	2	3	4
Wet Soil + Container	12.73	14.36	12.88	13.29
Dry Soil + Container	7.67	8.61	7.66	7.85
Wt. Of Container	0	0	0	0
Moisture Content	66.0	66.8	68.1	69.3

PLASTIC LIMIT

	1	2	AVERAGE
Container No.	5	6	
Wet Soil + Container	28.31	28.94	
Dry Soil + Container	26.34	26.89	
Wt. Of Container	18.81	19.05	
Moisture Content	26.2	26.1	26.2



REMARKS

Liquid Limit: 67
Plastic Limit: 26
Plasticity Index: 41
USC Classification: CH



THURBER ENGINEERING LTD.

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Edmonton, Alberta T6B 3S5
Phone (780) 438-1460 | Fax (780) 437-7125

Job No:	36428		
Client:	Stantec		
Project:	Soaring Lands Spa		
HOLE/PIT:	TH24-7	SAMPLE:	G3
DEPTH:	1.52 m	TECH:	LLK
DATE:	29-Aug-24	CHECKED BY:	TGV

SULPHATE TEST ON SOILS USING PFRA METHOD

BEAKER NO: G2 / 3 CRUCIBLE NO: _____

- 1- Add 100 g of oven dried soil, passing No. 40 sieve.
- 2- Add 500 mL of distilled water - or ratio of 20 g of soil to 100 g of water.
- 3- Add 3 drops of concentrated HCL acid.
- 4- Place mixture in oven (110C, 250F) for 1 hour or allow to sit overnight.
- 5- Draw off or filter 100 mL clear liquid from mixture into 250 mL beaker.
- 6- Add 100 mL distilled water on 5 mL concentrated HCL acid.
- 7- Heat in oven for 1 hour.
- 8- Add 10 mL of 10% BACL2 solution, mix thoroughly, observe reaction.

X	Clear Solution No Reaction		Slightly Milky No Precipitate		Milky Solution With Precipitate
---	-------------------------------	--	----------------------------------	--	------------------------------------

- 9- Filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven

Wt of Crucible + BaSO ₄ (ppt) (oven dried)	_____ g
Wt of Crucible Empty	_____ g
Wt of BaSO ₄ (ppt)	0 g
Wt of Soil Used (passing No. 40 sieve)	100.02 g

CALCULATIONS

Gravimetric Factor

$$\text{Wt of Sulphate} = \frac{\text{Wt BaSO}_4 \text{ (ppt) gms}}{\text{Gravimetric Factor}} = \frac{0}{2.60} = 0.000 \text{ g}$$

$$\text{Percent Sulphate} = \frac{\text{Wt of SO}_4 \times 100\%}{\text{Wt of Soil Used (g)}} = \frac{0.00}{20.004} = 0.00 \%$$

☐	0-0.1%	Clear Solution, No reaction
☐	0.1-0.5%	Slightly Milky, No Precipitation Dangerous if Water Table is Too High
☐	>0.5%	Milky with Precipitate Dangerous, use HS Cement



THURBER ENGINEERING LTD.

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Edmonton, Alberta T6B 3S5
Phone (780) 438-1460 | Fax (780) 437-7125

Job No:	36428		
Client:	Stantec		
Project:	Soaring Lands Spa		
HOLE/PIT:	TH24-8	SAMPLE:	G5
DEPTH:	3.05 m	TECH:	LLK
DATE:	29-Aug-24	CHECKED BY:	TGV

SULPHATE TEST ON SOILS USING PFRA METHOD

BEAKER NO: 9 / 9 CRUCIBLE NO: M1

- 1- Add 100 g of oven dried soil, passing No. 40 sieve.
- 2- Add 500 mL of distilled water - or ratio of 20 g of soil to 100 g of water.
- 3- Add 3 drops of concentrated HCL acid.
- 4- Place mixture in oven (110C, 250F) for 1 hour or allow to sit overnight.
- 5- Draw off or filter 100 mL clear liquid from mixture into 250 mL beaker.
- 6- Add 100 mL distilled water on 5 mL concentrated HCL acid.
- 7- Heat in oven for 1 hour.
- 8- Add 10 mL of 10% BACL2 solution, mix thoroughly, observe reaction.

☐	Clear Solution No Reaction	☒	Slightly Milky No Precipitate	☐	Milky Solution With Precipitate
--------------------------	-------------------------------	-------------------------------------	----------------------------------	--------------------------	------------------------------------

- 9- Filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven

Wt of Crucible + BaSO ₄ (ppt) (oven dried)	<u>26.16</u> g
Wt of Crucible Empty	<u>26.15</u> g
Wt of BaSO ₄ (ppt)	<u>0.01</u> g
Wt of Soil Used (passing No. 40 sieve)	<u>100.01</u> g

CALCULATIONS

Gravimetric Factor

$$\text{Wt of Sulphate} = \frac{\text{Wt BaSO}_4 \text{ (ppt) gms}}{\text{Gravimetric Factor}} = \frac{0.01}{2.60} = 0.004 \text{ g}$$

$$\text{Percent Sulphate} = \frac{\text{Wt of SO}_4 \times 100\%}{\text{Wt of Soil Used (g)}} = \frac{0.38}{20.002} = 0.02 \%$$

☒	0-0.1%	Clear Solution, No reaction
☐	0.1-0.5%	Slightly Milky, No Precipitation Dangerous if Water Table is Too High
☐	>0.5%	Milky with Precipitate Dangerous, use HS Cement



THURBER ENGINEERING LTD.

4127 Roper Road
Edmonton, Alberta T6B 3S5
Phone (780) 438-1460 | Fax (780) 437-7125

Job No:	36428		
Client:	Stantec		
Project:	Soaring Lands Spa		
HOLE/PIT:	TH24-10	SAMPLE:	G9
DEPTH:	6.10 m	TECH:	NM
DATE:	29-Aug-24	CHECKED BY:	TGV

SULPHATE TEST ON SOILS USING PFRA METHOD

BEAKER NO: 3 / D1 CRUCIBLE NO: Y3

- 1- Add 100 g of oven dried soil, passing No. 40 sieve.
- 2- Add 500 mL of distilled water - or ratio of 20 g of soil to 100 g of water.
- 3- Add 3 drops of concentrated HCL acid.
- 4- Place mixture in oven (110C, 250F) for 1 hour or allow to sit overnight.
- 5- Draw off or filter 100 mL clear liquid from mixture into 250 mL beaker.
- 6- Add 100 mL distilled water on 5 mL concentrated HCL acid.
- 7- Heat in oven for 1 hour.
- 8- Add 10 mL of 10% BACL2 solution, mix thoroughly, observe reaction.

☐	Clear Solution No Reaction	☒	Slightly Milky No Precipitate	☐	Milky Solution With Precipitate
--------------------------	-------------------------------	-------------------------------------	----------------------------------	--------------------------	------------------------------------

- 9- Filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven

Wt of Crucible + BaSO ₄ (ppt) (oven dried)	<u>25.79</u>	g
Wt of Crucible Empty	<u>25.58</u>	g
Wt of BaSO ₄ (ppt)	<u>0.21</u>	g
Wt of Soil Used (passing No. 40 sieve)	<u>100.01</u>	g

CALCULATIONS

Gravimetric Factor

$$\text{Wt of Sulphate} = \frac{\text{Wt BaSO}_4 \text{ (ppt) gms}}{\text{Gravimetric Factor}} = \frac{0.21}{2.60} = 0.081 \text{ g}$$

$$\text{Percent Sulphate} = \frac{\text{Wt of SO}_4 \times 100\%}{\text{Wt of Soil Used (g)}} = \frac{8.08}{20.002} = 0.40 \%$$

☐	0-0.1%	Clear Solution, No reaction
☒	0.1-0.5%	Slightly Milky, No Precipitation Dangerous if Water Table is Too High
☐	>0.5%	Milky with Precipitate Dangerous, use HS Cement



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Job No:	36428		
Client:	Stantec		
Project:	Soaring Lands Spa		
HOLE/PIT:	TH24-11	SAMPLE:	G5
DEPTH:	3.05 m	TECH:	NM
DATE:	29-Aug-24	CHECKED BY:	TGV

SULPHATE TEST ON SOILS USING PFRA METHOD

BEAKER NO: B22 / D6 CRUCIBLE NO: _____

- 1- Add 100 g of oven dried soil, passing No. 40 sieve.
- 2- Add 500 mL of distilled water - or ratio of 20 g of soil to 100 g of water.
- 3- Add 3 drops of concentrated HCL acid.
- 4- Place mixture in oven (110C, 250F) for 1 hour or allow to sit overnight.
- 5- Draw off or filter 100 mL clear liquid from mixture into 250 mL beaker.
- 6- Add 100 mL distilled water on 5 mL concentrated HCL acid.
- 7- Heat in oven for 1 hour.
- 8- Add 10 mL of 10% BACL2 solution, mix thoroughly, observe reaction.

X	Clear Solution No Reaction		Slightly Milky No Precipitate		Milky Solution With Precipitate
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- 9- Filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven

Wt of Crucible + BaSO ₄ (ppt) (oven dried)	_____ g
Wt of Crucible Empty	_____ g
Wt of BaSO ₄ (ppt)	0 g
Wt of Soil Used (passing No. 40 sieve)	100.02 g

CALCULATIONS

Gravimetric Factor

$$\text{Wt of Sulphate} = \frac{\text{Wt BaSO}_4 \text{ (ppt) gms}}{\text{Gravimetric Factor}} = \frac{0}{2.60} = 0.000 \text{ g}$$

$$\text{Percent Sulphate} = \frac{\text{Wt of SO}_4 \times 100\%}{\text{Wt of Soil Used (g)}} = \frac{0.00}{20.004} = 0.00 \%$$

	0-0.1%	Clear Solution, No reaction
	0.1-0.5%	Slightly Milky, No Precipitation Dangerous if Water Table is Too High
	>0.5%	Milky with Precipitate Dangerous, use HS Cement

APPENDIX D

Recommended Construction Procedures

RECOMMENDED CONSTRUCTION PROCEDURES

The following construction procedures are considered to represent good practice and are to be read in conjunction with the text of this report.

1. EXCAVATED FOUNDATIONS

- 1.1. Excavation close to foundation level should be done carefully to avoid disturbance of the soil. It is essential to prevent the soil at foundation level from deterioration due to excessive drying or becoming wet from surface or seepage water. Good drainage both during and after construction is essential.
- 1.2. Sumps, if required, should be located well away from the foundation area. Softened or overdried soil must be removed and replaced by lean mix concrete or by extending the foundations.
- 1.3. The foundation must be kept from freezing both during and after construction. Foundation concrete should not be placed on or against frozen soil.

2. PROOF ROLLING

- 2.1. Proof rolling is a method of detecting soft areas in a subgrade for fill, pavement, floors or foundations. The intent is to detect softened areas not revealed by the test holes or visual examination of the site surface, and is used where normal scarification and compacting procedures would not be successful in detecting and eliminating soft areas. It is usually accomplished with the use of heavy 130 to 220 kN (15-25 ton) compaction equipment with high contact wheel pressures on independent axles, although heavily loaded single axle trucks will provide the equivalent result.
- 2.2. The procedure requires 2 complete passes with the heavy equipment in one direction and then a second series of 2 passes made at right angles to the first series.
- 2.3. While the passes are being made, any softened, rutted or displaced areas detected should be examined and either recompact with additional fill or the existing material removed and replaced with better quality material.

3. BACKFILLING

- 3.1. Backfill around foundations should be placed in such a manner so as to prevent settlement and to be relatively impervious near the surface so that water does not pond against foundations nor be allowed to seep into the soil.
- 3.2. Backfill should not be placed until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction.

- 3.3. All backfill around grade beams, foundation walls, etc. must be carefully and uniformly compacted. The backfill should be placed in even layers and no frozen nor organic material should be incorporated into the fill. All lumps of material must be broken down or squeezed together during placing and compaction.
- 3.4. The final grade (allowing for some settlement of the backfill) should shed water away from the structure.
- 3.5. During construction, precautions should be taken to prevent water ponding in grade beam excavations thereby acting as a source of water to soften the soil under the floor slab area or providing a source of water for frost action if the building is not heated during freezing weather.

4. BORED CAST-IN-PLACE CONCRETE PILES

- 4.1. If there is evidence of water bearing and/or sloughing soil, casing should be used to seal off the water or prevent the sloughing of the sides of the hole. The concrete and reinforcing steel should be on hand and placed as soon as the pile hole has been completed and approved.
- 4.2. Pile bells, if used, should be formed entirely in self-supporting soil and it may be necessary in some cases to extend the pile bell if caving occurs at the location of the bell.
- 4.3. Water should not be left ponded on the pile base and should be removed, or dried by the use of dry cement when permitted by the engineer.
- 4.4. Concrete should be placed without segregation and carefully vibrated throughout the full length of the pile to ensure that voids do not exist in the pile shaft. The concrete slump should be between 75 and 125 mm with a minimum compressive strength at 28 days of 21 MPa (3000 psi). Higher compressive strengths may be required for structural or durability reasons, and higher slumps may be necessary for closely spaced reinforcing bars or where concrete is to be tremied under water.
- 4.5. Steel reinforcing should be tied into the grade beam reinforcing steel. This recommendation is important where the soil below grade beam can swell from a change in moisture content or by frost action before the building is heated.
- 4.6. Piles closer than 2 1/2 diameters should not be drilled and poured consecutively unless permitted by the engineer and depending upon soil conditions. Where the drilling operation might affect the concrete in the adjacent pile, the drilling should not be carried out until the concrete has at least 24 hours to set, or before the concrete has reached its initial set.