Submitted to: **SNC Lavalin Inc.**

GEOTECHNICAL INVESTIGATION – KEEWATIN PUMP STATION
15 PARK LANE AVENUE, WINNIPEG, MANITOBA

OCTOBER 2020

FILE NO.: 20-050-01

ENG-TECH CONSULTING LIMITED

"Engineering and Testing Solutions That Work for You"

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Figure 1 – Site and Test Hole Location Plan
Soil Classification Sheet
Test Hole Summary Logs (1)
Particle Size Analysis (2)

1.0 INTRODUCTION

ENG-TECH Consulting Limited (ENG-TECH) completed the geotechnical investigation for the proposed building addition to the Keewatin Pump Station with no basement. ENG-TECH understands that the addition is heated such that the building temperature in the winter will be maintained above 15ºC as all times. The purpose of the investigation was to assess the soil conditions near the proposed pump house addition in order to provide recommendations with respect to the foundation, drainage, and concrete durability.

1.1 Scope of Work

ENG-TECH completed the following scope of work:

- Conducted a test hole drilling and soil sampling program consisting of drilling one (1) test hole.
- Completed a laboratory testing program.
- A survey of the test hole UTM coordinates by means of GPS survey equipment.
- Prepared a report summarizing the findings of the field program and providing recommendations as outlined in the introduction.

2.0 FIELD PROGRAM AND LABORATORY TESTING

ENG-TECH supervised the drilling of one (1) test hole at the site on September 4th, 2020. The drilling was conducted by Paddock Drilling Ltd. using a truck mounted Acker MP8 drill rig equipped with 125-mm solid stem augers. The test hole (TH1) was drilled to a depth of 13.7 metres below grade (mbg). The test hole was backfilled with auger cuttings and bentonite upon completion of drilling. Test hole UTM coordinates and were measured using GPS equipment.

The soil stratigraphy was visually classified at the time of drilling using the modified Unified Soil Classification System (USCS). Soil samples were collected off the auger flights at regular depths during drilling. The soil stratigraphy was recorded at the time of drilling and the consistencies of the cohesive soils were assessed in field using a Pocket Pen and Torvane. All soil samples collected were retained for testing in ENG-TECH's Winnipeg laboratory.

Moisture contents were determined on all collected soil samples (16) while one (1) Atterberg Limits tests and two (2) Particle Size Analysis tests, and two (2) unconfined compression strength tests were completed on select samples. The moisture contents, Atterberg Limits, and unconfined compression test results are presented on the test hole summary logs, while the Particle Size Analysis is presented on a separate attachment.

3.0 STRATIGRAPHY

The stratigraphy consists of topsoil followed by sand, then clay, followed by clay till. The following summarizes the general soil profile at the Site:

- Topsoil was observed from the surface to 25 mm below grade.
- The stratigraphy consists of lacustrine clay from the topsoil to the depth explored.

- Below the topsoil the sand is brown, damp, fine to coarse, poorly graded and contains trace silt and gravel to 2.4 mbg.
- Below the sand the clay is medium brown, stiff, moist, and high plasticity to 12.2 mbg.
- Below 12.2 mbg to the end of the test hole at 13.7 mbg, is clay till.

Upon the completion of drilling seepage was observed at 8.8 mbg, whereas no sloughing was encountered. Further detailed stratigraphy descriptions are outlined on the attached test hole summary logs.

4.0 RECOMMENDATIONS

4.1 General

Based on the soil conditions observed during drilling, deep foundations such as cast-in-place concrete friction piles is the most suitable foundation type to limit settlements and differential movements. Other deep foundations such as pre-cast driven concrete piles may be considered as alternatives, although this foundation type may not be as economical to install. Shallow foundations may also be an option; however, the potential for total settlement and differential movement makes this option less desirable. In any scenario, concrete specifications, and drainage are significant to the performance of the foundation.

4.2 Cast-in-Place Concrete Friction Piles

Cast-in-place concrete friction piles were assessed using a geotechnical resistance factor of 0.4 to obtain the Ultimate Limit States (ULS) and Serviceability Limit States (SLS) values that can be used in design, as outlined in Table 1 below for downward vertical resistance:

Table 1
ULS and SLS Downward Skin Friction Static Resistances for Cast-in-Place Concrete Piles

Depth Range (m)	ULS Skin Friction Resistance	SLS Skin Friction Resistance
	kPa	
The greater of 2.5 m below existing grade or 1.0 m below the grade beam	0	0
Between the above and 6 m below existing grade	13	11
Between the above and 10.0 m below existing grade	10	8

The following recommendations also apply to the use of cast-in-place concrete friction piles:

- The piles should be spaced at least 2.5 pile diameters apart, as measured from center to center in order to have the piles act independently.

- A minimum embedment depth of 6.5 m below grade must be used for all the piles supporting the house in heated areas, and 7.5 m for the piles located in unheated areas.

- The piles may be treated as supported columns throughout their length below final grade.

- The weight of the embedded portion of the pile may be neglected in the design when determining the load on a pile.

- Each pile must be reinforced to at least 6 m, with reinforcement to resist up-lift pressures due to structural forces as determined by the structural engineer. Vertical reinforcement may also be required in unheated areas to resist breaking of the upper portion of the piles as a result of up-lift forces due to frost action against piles in unheated areas. The use of a Sonatube wrapped with a layer of 4 mil poly and inserted in the upper 2.5 m of the boreholes prior to placement of concrete will aid to reduce the potential of uplift pressures on the piles due to frost.

- The piles should be poured immediately after the completion of drilling to reduce the potential for seepage, sloughing, swelling and squeezing of the boreholes, and should be poured in accordance with Clause 7.5.7 of the Canadian Standards Association A23.1-19 (Concrete Materials and Methods of Concrete Construction). Steel sleeving varying in length (including full length) may be required for some piles, while pumping may be required to remove water from some boreholes prior to pouring the concrete. Sleeves and pumps should be available on site and used as required.

- A minimum compressible void form of 150 mm should be maintained under all pile caps, grade beams, and structures supported on piles to prevent damage due to uplift pressures and potential swelling of the underlying soils, should it occur.

4.3 Concrete Slab-on-Grade Floors

ENG-TECH cautions that some movement of the slab-on-grade floors for the pump station should be expected and is typical for all slab-on-grade floors. The above can be minimized by proper sub-grade preparation, the use of a well-graded compacted base material and proper site drainage. If typical movements are not acceptable to the owner, a floor structurally supported on piles must be used. Based on the above and providing the owner is willing to accept the possibility of movement of the floor slabs in the order of 50 mm, the floor slabs could be constructed as follows:

- Remove all organic topsoil, soft soil, silt and silty soils from the surface to their full depth. Continue to excavate as required in order to achieve a minimum depth of 150 mm below the base of the slab design elevations. The exposed sub-grade at the pump station addition area will consist of sand.

- Uniformly compact the upper 200 mm of the sub-grade to 98% of the material's maximum dry density (MMD) at +/- 2% of optimum moisture content (OMC). If soft or weak spots or silt or silty soils are encountered, sub-excavate 300 mm and backfill using "GBC I" or "GBC II" granular base in a single lift and compact the lift to 100% of the soil's MDD near OMC.

- Place a 150 mm of "GBC I" or "GBC II" granular base in a single lift base immediately below the bottom of the slab and then compact the base material to 100% of the material's MDD near the soils OMC to the underside of the slab design elevations.

- Place a vapour barrier consisting of a minimum of 10 mm poly directly below the base of the

slab prior to pouring the concrete.

- The floor slabs should be continuously reinforced and should be provided with joints at regular intervals to control and reduce random cracking and to prevent faulting.

- All partition walls or equipment founded on the slab should have a minimum 75 mm thick void space at the top to prevent damage if the slab should heave. The floor slab should be structurally separated from the grade beams and columns.

4.4 Drainage

Proper surface drainage is essential to reduce the potential of frost action and to reduce excess moisture adjacent the foundation of the building. Medium to highly plastic clay soils should be used to raise the site adjacent to the pump station addition's footprint in landscaped areas in order to achieve proper drainage away from the proposed structure. Surface drainage should be controlled by ensuring a minimum grade away from the proposed building of 5% for well-compacted surface soils and 2% for paved surfaces for a minimum distance of 3 m. Runoff from the pump station addition should be directed a minimum distance of 3 m from the perimeter of the proposed addition to reduce the potential of excessive moisture near the foundation.

4.5 Concrete Durability

General

All concrete should be designed, specified, and constructed in accordance with CSA Standard A23.1-19, Concrete Materials and Methods of Concrete Construction using the Performance Specification Alternative as outlined in Table 5 of CSA A23.1-19.

Under the performance alternative, the concrete supplier shall assume responsibility for the performance of the concrete as delivered and the contractor shall assume responsibility for the concrete in place. The owner shall specify performance requirements including: the required structural criteria and concrete strength at age, the concrete exposure class for durability, and any other properties that may be required to meet the owner's performance requirements such as colour, architectural requirements, and special surface finishes. The owner reserves the right to request the supplier provide satisfactory documentation that the proposed mix design will achieve the strength, durability, and performance requirements specified by the owner, and that the mix design satisfies the requirements of CSA A23.1-19. In addition, the owner may request the contractor to submit documentation demonstrating the owner's performance requirements have been met during construction and placement.

Based on Tables 1, 2, 3, and 4 of CSA A23.1-19, the concrete in contact with the local soils can be classified as an S-2 exposure class for the piles and pile caps since they will be in contact with clay soils, an F-2 exposure class for the grade beams, a N exposure class for the heated floor slab. The concrete design can be selected as structurally required; however, the concrete must be designed to meet the minimum specifications outlined below for durability.

Piles and Pile Caps (S-2)
56 day minimum compressive strength of 32 MPa
Maximum water/cementing materials ratio of 0.45
Maximum nominal aggregate size of 20 mm
Type HS or HSb cement
Air content of 4-7%

Grade Beams (F-2)
28 day minimum compressive strength of 25 MPa
Maximum water/cementing materials ratio of 0.55
Maximum nominal aggregate size of 20 mm
Type Gu or Gub cement
Air content of 4-7%

Slabs in Heated Areas (N)
28 day minimum compressive strength of 25 MPa
Maximum water/cementing materials ratio of 0.55
Maximum nominal aggregate size of 20 mm
Type Gu or Gub cement
Natural Air content

5.0 INSPECTION AND TESTING

The following inspection and testing by ENG-TECH will aid to ensure quality control during construction and that recommendations herein are being met:

- Sub-grade

  The upper layer of the soil at the site can vary and there is a potential of encountering a soft layer. Inspection will help to identify the soft soils and provide recommendations to deal with this potential concern on site as required.

- Pile Inspection

  Soil conditions can vary with depth, therefore pile inspection will aid to ensure the soil conditions can carry the loads as outlined herein.

- Density Testing

  Density testing on the sub-grade and base materials will confirm the densities specified herein are met.

- Concrete Testing

  Testing of the concrete used in construction will aid to ensure the concrete strengths specified are being met.

6.0 THIRD PARTY USE AND STATEMENT OF LIMITATIONS

This report has been prepared for the Client. Any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third party. ENG-TECH accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

The findings and recommendations presented in this report were based on the scope of work outlined for the purpose of the geotechnical investigation and were prepared in accordance with generally accepted principles and practices. The findings and recommendations were based on the results of field and laboratory investigations, combined with the soil and groundwater conditions encountered. Other materials or compounds not investigated or addressed or beyond the scope of work could be present at the Site. If conditions encountered during construction appear to be different from that reported by ENG-TECH or if the assumptions stated herein are not in keeping

with the design, this office should be notified in order that the recommendations can be reviewed and modified if necessary.

7.0 CLOSURE

This report was based on the scope of work outlined for the purpose of the investigation, and was prepared in accordance with acceptable professional engineering principles and practices. If you have any questions, please contact the undersigned.

Sincerely,
ENG-TECH Consulting Limited

Brianna Landrie, B.Sc, EIT
Engineering Department

Clark Hryhoruk, M.Sc., P. Eng.
Principal, Geotechnical Engineer

CDH/bl

ENGINEERS GEOSCIENTISTS MANITOBA
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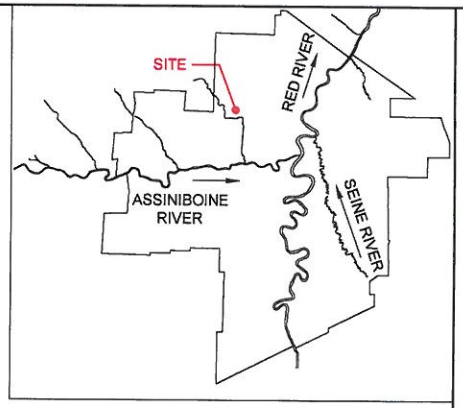
No.2475

PROVINCE OF MANITOBA
C. D. HRYHORUK
Oct 8/20
REGISTERED PROFESSIONAL ENGINEER

1999 20 2019
YEARS OF EXCELLENCE

GPS COORDINATES OF TEST HOLES		
TEST HOLE	COORDINATE DATUM: WSG84	
	UTM	14U
TH1	5531818	629500



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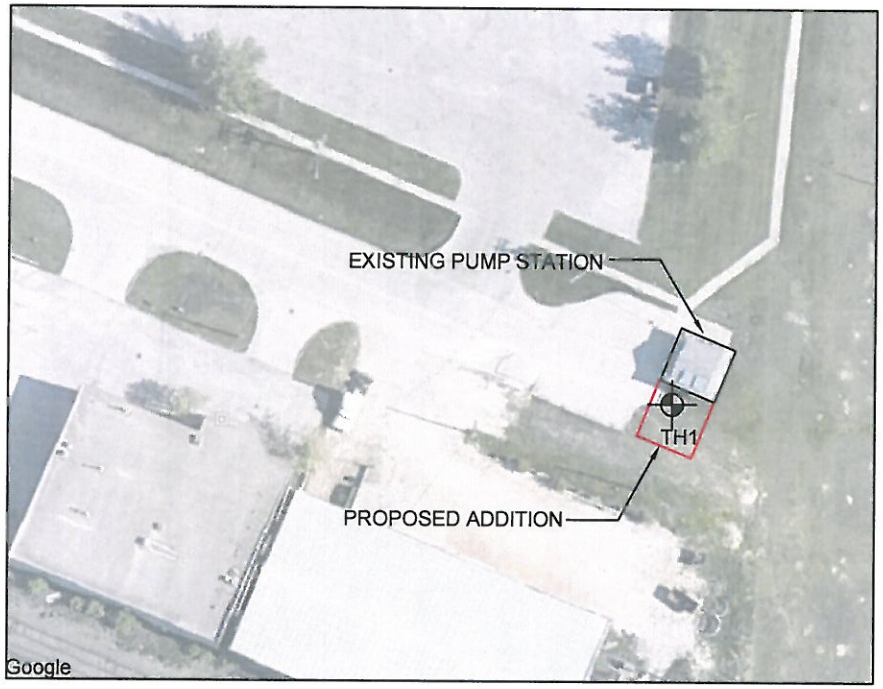

LEGEND

TH1 — TEST HOLE

NO.	DATE	ISSUE / REVISION
0	OCT 2020	REPORT

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ENGINEERS GEOSCIENTISTS MANITOBA
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No.2475

CLIENT:
SNC LAVALIN INC.

PROJECT:
GEOTECHNICAL INVESTIGATION - KEEWATIN PUMP STATION,
15 PARK LANE AVE, WINNIPEG, MB

DWG DESCRIPTION:
SITE AND TEST HOLE LOCATION PLAN

SCALE:
1:1000

DRAWN BY:	DATE:
BL	OCTOBER 2020
FILE No.: 20-050-01	CLIENT DWG/FIG. No.:
ENG-TECH DWG/FIG. No.: 1	NO.: 0

P:\2020\050(SNC Lavalin)\01(Keewatin Pump Station)\Drawings\20-050-01 Figure 1 Site Plan.dwg

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ TO 3
			GP	POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE AND P.I. MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75 mm	CLEAN SANDS (TRACE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ TO 3
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE AND P.I. MORE THAN 7
FINE GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	LL ≤ 50%	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHTY PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		LL > 50%	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	LL ≤ 30%	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		30% < LL ≤ 50%	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		LL > 50%	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE	LL < 50%	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
		LL > 50%	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

ADDITIONAL SYMBOLS

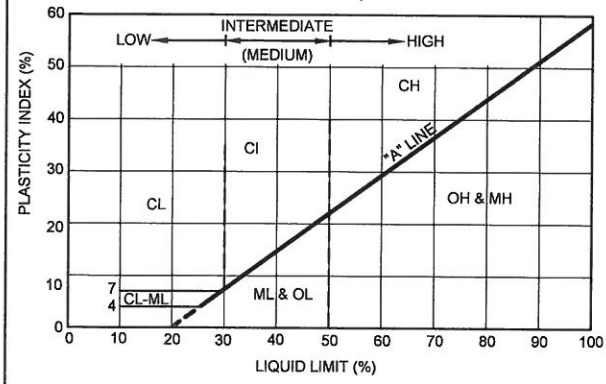
TILL, FILL, TOPSOIL, CONCRETE, SHALE, LIMESTONE, SANDSTONE, GRANITE

PLASTIC SOILS

MOISTURE	PLASTICITY	INTRUSIONS	CONSISTENCY	POCKET PEN (TSF)	(N)
DRY	LOW	ROOTLETS	VERY SOFT		< 2
DAMP	MEDIUM	OXIDES	SOFT	0 - 0.5	2 - 4
MOIST	HIGH	MICA	FIRM	0.5 - 1.0	4 - 8
WET		GYPSUM	STIFF	1.0 - 2.0	8 - 15
		ETC.	VERY STIFF	2.0 - 4.0	15 - 30
			HARD	> 4.0	> 30

TSF x 95.8 = kPa (q_U) $S_U = \frac{1}{2} \times q_U$

PLASTICITY CHART FOR SOILS PASSING 425 µm SIEVE



SOIL DESCRIPTIONS

TRACE:	0 - 10%	BOULDERS:	> 200 mm	COARSE SAND:	2 - 4.75 mm
SOME:	10 - 20%	COBBLES:	75 - 200 mm	MEDIUM SAND:	0.425 - 2 mm
WITH:	20 - 35%	COURSE GRAVEL:	19 - 75 mm	FINE SAND:	0.075 - 0.425 mm
AND:	35 - 50%	FINE GRAVEL	4.75 - 19 mm	FINES:	< 0.075 mm

GRANULAR SOILS

MOISTURE	DENSITY	GRADATION	INTRUSIONS	SPT (N)
DRY	VERY LOOSE	POORLY	ROOTLETS	0 - 4
DAMP	LOOSE	WELL	OXIDES	4 - 10
MOIST	MED. DENSE		MICA	10 - 30
WET	DENSE		FINES	30 - 50
	VERY DENSE		ETC.	> 50

DEFINITIONS

LL = LIQUID LIMIT
P.I. = PLASTICITY INDEX
C_U = COEFFICIENT OF UNIFORMITY
q_U = UNCONFINED COMPRESSIVE STRENGTH
S_U = UNDRAINED SHEAR STRENGTH
C_C = COMPRESSION INDEX
PL = PLASTIC LIMIT

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Engineering And Testing Solutions That Work For You

Test Hole #: TH1

Client: SNC Lavalin Inc.

Site: 15 Park Lane Ave, Winnipeg, Manitoba

Location: See Figure 1

Project: Geotechnical Investigation - Keewatin Pump Station

File No.: 20-050-01

Date Drilled: September 4, 2020

Grade Elevation: 100.0 m

Water Elevation: --

SUBSURFACE PROFILE				SAMPLE DATA					SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%) PL I--------X--------I LL 20 40 60 80	P. Pen	Torvane	UC
0.0		Ground Surface	100.0								
		Topsoil (25 mm) - grass covered with organics		S1		6.4					
1.0		***Sand*** - brown, damp, fine to coarse, poorly graded, trace silt, trace gravel. - below 2.1 m trace clay.	99.0	S2		4.8					
				S3		4.5					
2.0			98.0	S4		18.6					
3.0		***Clay (CH)*** - medium brown, high plasticity, stiff, moist, trace to some silt.	97.0	S5		53.3			60		
4.0			96.0	S6		52.8					
5.0			95.0	S7		51.2					30
6.0			94.0	S8		54.5			48	40	
7.0		- below 7.6 m soft, with silt.	93.0								
8.0			92.0	S9		53.9			24	20	
				S10		41.4			24		21
9.0			91.0	S11		34.7			24	25	
10.0			90.0								
11.0			89.0	S12		56.1			24	25	
12.0			88.0								
		Silt Till - grey, medium plasticity, moist, very stiff, and sand, some gravel, trace clay. - below 13.7 m hard		S13		11.5					
13.0			87.0	S14		8.0	19				
				S15		24.4					
14.0		***End of Test Hole*** - auger refusal at 13.7 m below grade. - seepage encountered at 8.8 m below grade. - no sloughing observed. - test hole backfilled with soil auger cuttings and bentonite upon completion of drilling.	86.0	S16		8.3	60				
15.0			85.0								
16.0			84.0								
17.0			83.0								

ENG- TECH Consulting Limited

Logged by: BL

Reviewed by: SDT

Drilled By: Paddock Drilling Ltd

Drill Rig: Acker MP8

Auger Size: 125 mm Solid Stem

Completion Depth: 13.7 m

Completion Elevation: 86.3 m

Sheet: 1 of 1

SAMPLE TYPE: SPLIT BARREL | SHELBY TUBE | AUGER CUTTINGS | SPLIT SPOON

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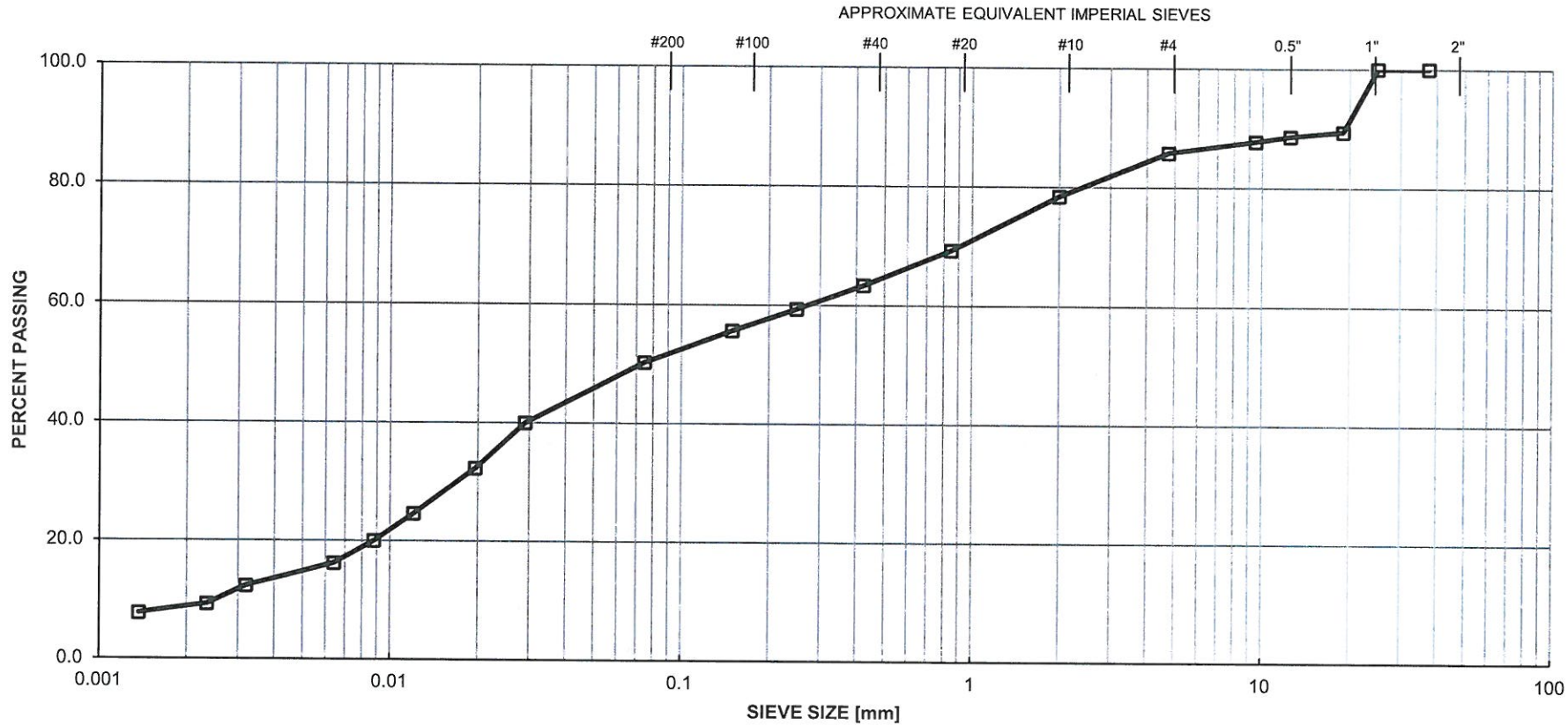
File No.: 20-050-01

PARTICLE SIZE ANALYSIS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



Test Hole:	Sample:	Depth:	Reference No.:	Components:
1	14	12 m	20-50-1-4	Gravel (14.2 %), Sand (35.5 %), Silt (41.5 %), Clay (8.8 %)

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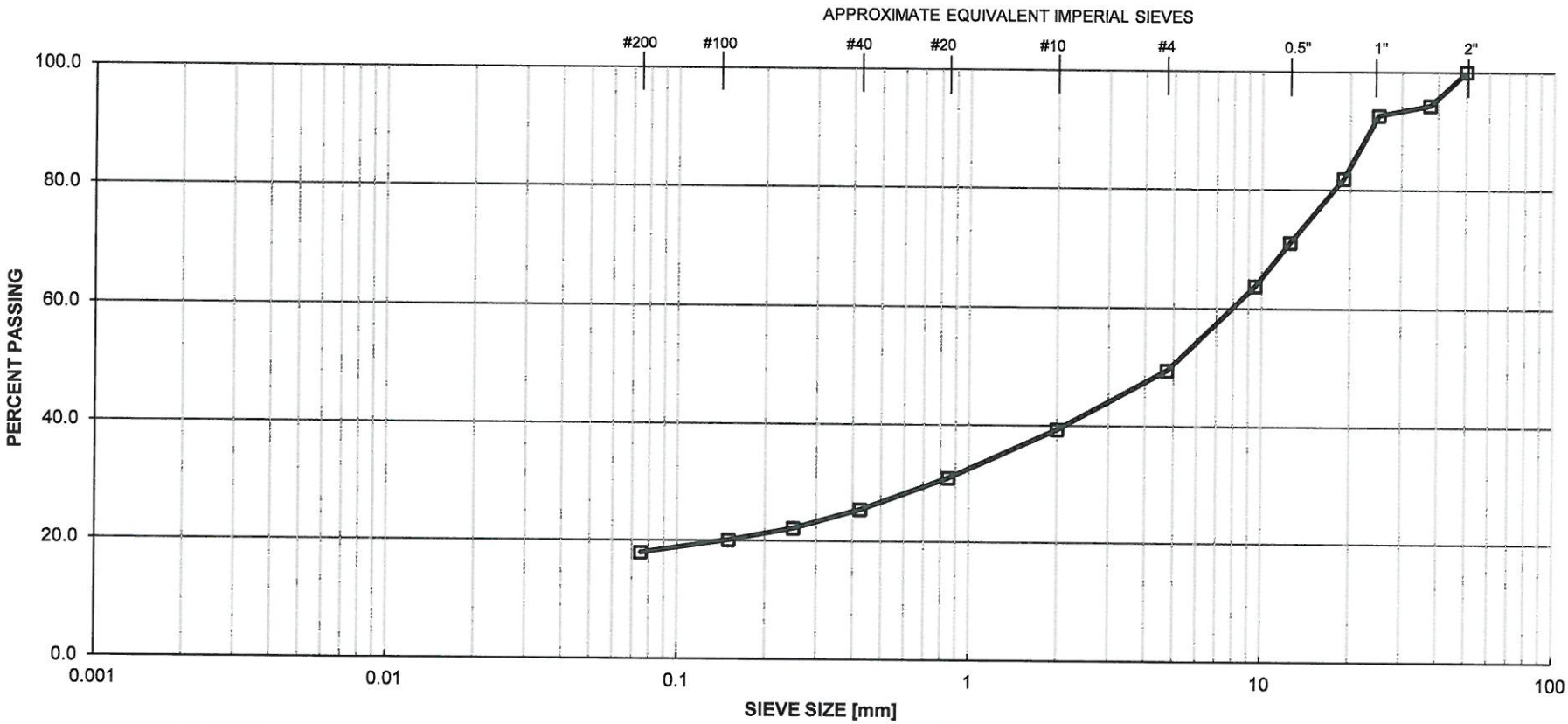
Page No.: 1 of 1

SIEVE SIZE ANALYSIS

CLAY & SILT	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE



Test Hole:	Sample:	Depth:	Reference No.:	Sample Type:
TH1	S3	5.0 ft.	20-50-1-1	-