APPENDIX A – GEOTECHNICAL INVESTIGATIONS
CONQUEST ENGINEERING LIMITED – DECEMBER 20, 2017
AMEC ENVIRONMENT & INFRASTRUCTURE MARCH 24, 2014

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Saint John
Moncton
Fredericton
Bedford

373 Baig Blvd.
Moncton New Brunswick
E1E 4H8
Phone: 506 382-7565
Fax: 506 384-8866
www.conquest-eng.com

December 20, 2017

Project No.: 071-223

Michael Mills
Crandall Engineering Ltd.
Via email: mfm@crandallengineering.ca

Mike;

Re: Geotechnical Investigation – Sewage Treatment Upgrades
Springhill Institution, Springhill, NS

As requested by Crandall Engineering Ltd., Conquest Engineering Ltd. (CEL) has performed a geotechnical investigation for a proposed blower building and pipe installation for the Sewage Treatment Upgrades at Springhill Institution in Springhill, Nova Scotia. At the time of this investigation the size and founding elevation of the building had not been finalized.

The investigation consisted of drilling four (4) boreholes including two (2) boreholes within the area of the proposed blower building (BH-01 and BH-02), one (1) borehole for the proposed pipe alignment (BH-04) and one (1) borehole over the existing berm (BH-03). The purpose of the investigation was to obtain geotechnical information at the site and to provide geotechnical recommendations for the design and construction of the proposed blower building and pipe installation.

FIELD PROCEDURES

The field work was carried out on December 14, 2017. Four (4) boreholes were drilled to depths ranging between 4.3 m and 6.3 m below the existing ground surface. The borehole locations were established in the field as per Crandall Engineering Ltd. Drawing for Project No. R.061876.001 (Rev. 0 – Dated Nov. 22, 2017). Boreholes BH-01 and BH-02 were adjusted slightly in the field by CEL personnel to avoid conflicts with existing underground services and BH-03 was relocated further north since the location was inaccessible. Ground surface elevations and coordinates (northings and eastings) are referenced to geodetic datum and were obtained and provided to us by Crandall Engineering Ltd.

A CEL engineer supervised the drilling and sample collection activities and logged the subsurface conditions encountered at each borehole. The boreholes were advanced vertically using 100 mm diameter solid stem augers. Soil samples were collected at close intervals within the overburden material using a 50 mm outside diameter split-spoon. Detailed logs of the soils encountered and the sampling and testing completed are given on the attached Borehole Records.

Standard Penetration Tests (SPT's) were performed and N-values recorded for each split-spoon sample obtained. The performance of the Standard Penetration Tests was based on the test method described in ASTM D1586-84. The determination of the compactness of granular soil strata, as indicated on the Borehole Records, is based primarily on the results of Standard Penetration Testing.

All soil samples were stored in moisture tight containers and returned to our laboratory for further classification and testing. All samples will be kept in storage for a period of two (2) months from the date of issue of this report. After this time the samples will be discarded unless we are instructed otherwise.

SOIL CONDITIONS

The soil strata encountered at the site are described in detail on the attached Borehole Records. Soil classification was based on the procedures described in ASTM D2488 (Standard Practice for Description and Identification of Soils, Visual-Manual Procedure). For an explanation of the descriptions used on the Borehole Records, reference should be made to the attached Symbols and Terms used on Borehole and Test Pit Records.

In general, the principle strata encountered at the boreholes are as follows:

1. TOPSOIL (BH-03 only);
2. Sand with silt, clay, gravel and trace of organics: FILL;
3. Reddish brown to grey to brown silty/clayey SAND with gravel;
4. Light brown to grey SANDSTONE/SILTSTONE bedrock (BH-03 only).

GROUNDWATER CONDITIONS

Groundwater was observed during the drilling operations in all boreholes except borehole BH-01, at a depth of 3.0 m below the existing ground surface. The depth to the groundwater table is shown on the attached Borehole Records. Groundwater levels should be expected to fluctuate due to site use, adjacent site use, seasonal weather trends, construction activity, and/or from the effects of a particular precipitation event.

DISCUSSION AND RECOMMENDATIONS

At the time of this report the details of the Blower Building had not been provided. We assume the structure will be a single storey building with a slab-on-grade.

Based on the soil conditions encountered at the borehole locations, the following recommendations and commentary are provided for the new building and pipe work.

BUILDING – BOREHOLES BH-01 AND BH-02

- Initially all FILL should be excavated down to competent native silty/clayey SAND with gravel and removed from within the building area. An excavation of approximately 3.4 m deep should be expected in the area of borehole BH-02.
- The entire excavated areas should be proof-rolled under the observation of a geotechnical engineer to determine if any soft or yielding areas exist prior to placement of any structural engineered fill material. The site soils have a high percentage of fines and will soften/degrade if not protected from construction traffic and/or groundwater/surface water. Any softened/yielding or frozen subgrade soils should be over-excavated and replaced with structural engineered fill as discussed herein.

- Any imported structural engineered fill placed as backfill should consist of either approved Nova Scotia Transport and Infrastructure Renewal (NSTIR) Type 2 material or 125 mm well graded granular material with less than 10% fines content such as borrow from local pits, a quarried material or other alternative material. All structural engineered fill should be tested and approved by a geotechnical engineer prior to utilization on site.
- The lift thickness must be compatible with the compaction equipment to ensure the specified density is achieved throughout the backfill. Typically placing the backfill in 300 mm lifts is appropriate. Structural engineered fill should be compacted to a minimum of 98% of the corrected maximum dry density as per ASTM D698 (standard Proctor).
- The conditions at the site indicate that a foundation system consisting of spread and/or strip footings and slab-on-grade would be practical following site work as discussed in this report. Spread and strip footings may be founded on native silty/clayey SAND with gravel or on compacted structural engineered fill as previously described.
- **Geotechnical Resistance at Serviceability Limit State (SLS):** Foundations established on the native silty/clayey SAND with gravel or on compacted structural engineered fill, placed as detailed herein, may be proportioned for a bearing pressure of 200 kPa at SLS. At this pressure, total and differential settlements are expected to be less than 25 mm and 19 mm respectively.
- **Factored Geotechnical Resistance at Ultimate Limit State (ULS):** Foundations established on the native silty/clayey SAND with gravel or on compacted structural engineered fill, placed as detailed herein, may be proportioned for a factored bearing resistance of 500 kPa at ULS. Footings must have a minimum width of 600 mm for this bearing condition.
- All exterior foundations should be provided with a minimum soil cover of 1.5 meters for frost protection.
- The proposed site can be classified as a Site Class “D” for Seismic Site Response as per the National Building Code (2010), Table 4.1.8.4.A.
- To prevent adfreezing the exterior foundation walls should be backfilled with non-frost susceptible fill. Well graded and free draining granular gravel with a maximum particle size of 80 mm and with less than 5 percent passing the 80 micron sieve (such as NSTIR Type 2 or equivalent) will suit.
- A conventional grade slab founded on structural engineered fill is practical for this site. A 150 mm thick layer of NSTIR Type 1 crushed rock is recommended below the floor slab for levelling and uniform support purposes. The crushed rock should be compacted to a minimum of 98% of the maximum dry density as per the ASTM D698 (standard Proctor). The slabs may be designed using a modulus of subgrade reaction of 60 MN/m^3, based on a 300 mm square bearing plate.
- All bearing surfaces should be inspected by qualified geotechnical personnel prior to concrete placement to confirm acceptable bearing conditions.
- Groundwater was observed within the depths of our investigation therefore dewatering equipment will likely have to be employed during the construction.
- Due to the fine-grained characteristics of the native soils at the site they are subjected to softening in the presence of moisture. Care will have to be exercised in the handling and compaction of these soils.

- Surface water from precipitation events will have to be controlled to keep any excavation dry during the construction phase. Surface drainage measures, including erosion/siltation protection using silt fences, check dams, interceptor trenches, French drains, etc., should be taken before earthworks commence. The excavation contractor should ensure adequate dewatering within excavations and backfill areas be carried out during construction to maintain conditions acceptable for backfill operations or for the casting of concrete foundations and other related activities.
- In the event of winter construction, care shall be taken to ensure that all bearing soils remain free of frost penetration prior to and following the casting of the concrete. Concrete should not be cast on rock that is below 5^{o}C. Special care and precautions should be executed when earthworks and concrete placement is undertaken during winter months or otherwise freezing temperatures. Attached are guidelines for winter construction that should be considered.
- Safe excavated slopes are the responsibility of the earthwork contractor and shall conform to the requirements of the provincial authority having jurisdiction. If an excavation cannot be properly sloped or benched, the contractor should install an engineered shoring system to safely support the temporary excavation. Excavation slopes should be checked regularly for signs of instability and flattened as required. Temporary slopes should be protected from surface erosion by means of swales or ditches around the perimeter of the excavation and by means of plastic sheeting placed over the slope.

PIPE WORK – BOREHOLE BH-04

Excavations for pipe work will be made in either FILL or native silty/clayey SAND with gravel or into bedrock depending on the final depth of the proposed pipes.

Bedding material shall be placed around new piping with a minimum thickness of 150 mm to be placed underneath the pipes and 300 mm above the top of pipes. The bedding material should primarily consist of a well graded crushed rock satisfying the gradation requirements of NSTIR Type 1 material.

If, due to groundwater migration, bedding material cannot be placed in a dry condition, we recommend that a minimum thickness of 150 mm crushed rock (drainage stone bedding material) be used along the new pipe works length. It shall be completely wrapped in non-woven geotextile filter fabric in order to hinder the migration of fine material into the bedding material. The bedding material should primarily consist of a 20 mm clear stone satisfying the gradation requirements given in Table 1 below.

Table 1: Drainage Stone Bedding Material – Gradation Limits

Sieve Size	Percent Passing
20.0 mm	100
14.0 mm	40-50
10.0 mm	20-62
5.0 mm	0-20

Excavated materials may be selectively reused as pipe backfill material provided they are free of organics or deleterious material and have a moisture content close to the optimum moisture content. If the reused material cannot be properly compacted then the material should be removed and replaced with approved backfill material.

The lift thickness used during backfilling operations must be compatible with the compaction equipment and the material type to ensure the specified density is achieved throughout the backfill. The compaction equipment must be suitably sized so as not to cause damage or displacement of the pipes. The lift thickness should not exceed 150 mm. . Pipe bedding and backfill materials should be compacted to a minimum of 95% of the maximum dry density as per the standard Proctor (ASTM D698).

CLOSING

This report has been prepared for the sole benefit of Crandall Engineering Ltd., its designates, nominees and partners. Any use or reliance on this report under any of the following conditions would render this report inapplicable:

- where there have been any change in site conditions; or
- where used for purposes not intended or delineated in this report; or
- where used by third parties without express written agreement of Conquest Engineering.

Any use of, or reliance upon, this report under such circumstances or by such parties is strictly prohibited and without risk or liability to Conquest Engineering.

Conquest Engineering used reasonable care, skill, competence and judgment in the preparation of this report. The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. The information and conclusions contained in this report are generally consistent with professional standards for individuals providing similar services at the same time, in the same locale and under like circumstances.

A field investigation is a limited and random sampling of a site. Some variation between sampling locations should be expected. The conclusions presented in this report represent the best technical judgment of Conquest Engineering based on the data obtained from the work. The conclusions are based on the site conditions observed by Conquest Engineering at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. Due to the nature of the investigation and the limited data available, Conquest Engineering cannot warrant against undiscovered environmental liabilities.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein. Further, if there are changes to the proposed work, such as adjustments in founding elevation or building loads, etc., we require that we be notified to allow for review of our recommendations.

It is strongly recommended that Conquest Engineering Ltd. be engaged during the project to enable us to confirm general conformance of the work to our recommendations for site preparation (including excavation and replacement of the unsuitable soils present at the site). Failure to engaged Conquest Engineering Ltd. during this work will relieve Conquest Engineering Ltd., its officers, directors, employees and sub-consultants against all damages, liabilities or costs arising out of, or in any way connected with, the performance of such services by other persons or entities and from any and all claims arising from modifications, clarifications, interpretations, adjustments or changes to the Contract Documents to reflect changed field or other conditions.

We trust this is the information you require at this time. If you have any questions or if we can be of any further assistance please feel free to contact us.

This report was prepared by Robert Y. Cyr, M.A.Sc., P.Eng. and reviewed by G. Ross Whitcomb, P.Eng.

Respectfully submitted,
CONQUEST ENGINEERING LTD.

Robert Y. Cyr, M.A.Sc., P. Eng.
Senior Engineer / Principal

G. Ross Whitcomb, P.Eng.
Senior Engineer / Principal

Attachments: Symbols and Terms used on Borehole Records
Borehole Records
Borehole Location Plan
Winter Construction Guidelines

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SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil	-	mixture of soil and humus capable of supporting good vegetative growth
Peat	-	fibrous aggregate of visible and invisible fragments of decayed organic matter
Till	-	unstratified glacial deposit which may range from clay to boulders
Fill	-	any materials below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure
Varved	-	composed of regular alternating layers of silt and clay
Stratified	-	composed of alternating successions of different soil types, e.g. silt and sand
Layer	-	>75 mm
Seam	-	2 mm to 75 mm
Parting	-	< 2 mm
Well Graded	-	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Uniformly Graded	-	predominantly of one grain size

Terminology describing soils on the basis of grain size and plasticity is based on the ASTM D2488 – Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The classification excludes particles larger than 76 mm (3 inches). This system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	Greater than 20%

The standard terminology to describe cohesionless soils includes the compactness (formerly "relative density"), as determined by laboratory test or by the Standard Penetration Test 'N' – value.

Relative Density	'N' Value	Compactness %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests, or occasionally by standard penetration tests.

Consistency	Undrained Shear Strength (Su)		'N' Value
	Kips/sq.ft.	KPa	
Very Soft	< 0.25	< 12.5	< 2
Soft	0.25 – 0.5	12.5 – 25	2 – 4
Firm	0.5 – 1.0	25 – 50	4 – 8
Stiff	1.0 – 2.0	50 – 100	8 – 15
Very Stiff	2.0 – 4.0	100 – 200	15 – 30
Hard	> 4.0	> 200	> 30

ROCK DESCRIPTION

Rock Quality Designation (RQD)

The classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on N-size (45 mm) core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from in situ fractures.

RQD	ROCK QUALITY
90 – 100	Excellent, intact, very sound
75 – 90	Good, massive, moderately jointed or sound
50 – 75	Fair, blocky and seamy, fractured
25 – 50	Poor, shattered and very seamy or blocky, severely fractured
0 – 25	Very poor, crushed, very severely fractured

Terminology describing rock mass:

Spacing (mm)	Bedding, Laminations, Bands	Discontinuities
2000 – 6000	*Very Thick*	*Very Wide*
600 – 2000	*Thick*	*Wide*
200 – 600	*Medium*	*Moderate*
60 – 200	*Thin*	*Close*
20 – 60	*Very Thin*	*Very Close*
< 20	*Laminated*	*Extremely Close*
< 6	*Thinly Laminated*	

Strength Classification	Uniaxial Compressive Strength (MPa)
Very Weak	1 – 5
Weak	5 – 25
Medium Strong	25 – 50
Strong	50 – 100
Very Strong	100 – 250
Extremely Strong	> 250

Terminology describing weathering:

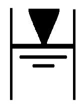
Slight - Weathering limited to the surface of major discontinuities. Typically iron stained.
Moderate - Weathering extends throughout rock mass. Rock is not friable.
High - Weathering extends throughout rock mass. Rock is friable.

STRATA PLOT

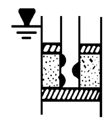
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Metamorphic Bedrock	Sedi- mentary

WATER LEVEL MEASUREMENT



Borehole or Standpipe



Piezometer

SAMPLE TYPE AND/OR FIELD TESTS

SS	Split Spoon Sample (obtained by performing the Standard Penetration Test)
ST	Shelby Tube or Thin Wall Tube
PS	Piston sample
DC	Dynamic Cone Penetration
FSV	Field Shear Vane
AS	Auger Sample
BS	Bulk Sample
WS	Wash Sample
HQ, NQ, BQ, etc.	Rock Core Samples (obtained with the use of standard size diamond drilling bits)

N- VALUE

Numbers in this column are the results of the SPT (Standard Penetration Test): the number of blows of a 140 pound (64kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and ‘N’ values cannot be presented, the abbreviation SSR (Split Spoon Refusal) will appear in place of a numerical value.

OTHER TESTS

Symbols in this column indicate that the following laboratory tests have been carried out and the results are presented separately.

S	Sieve analysis
G_s	Specific gravity of soil particles
k	Permeability
	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; Test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer
H	Hydrometer analysis
γ	Unit weight
C	Consolidation
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct shear
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Records equals $I_p(50)$; the index corrected to a reference diameter of 50 mm)
MSV	Laboratory Miniature Shear Vane

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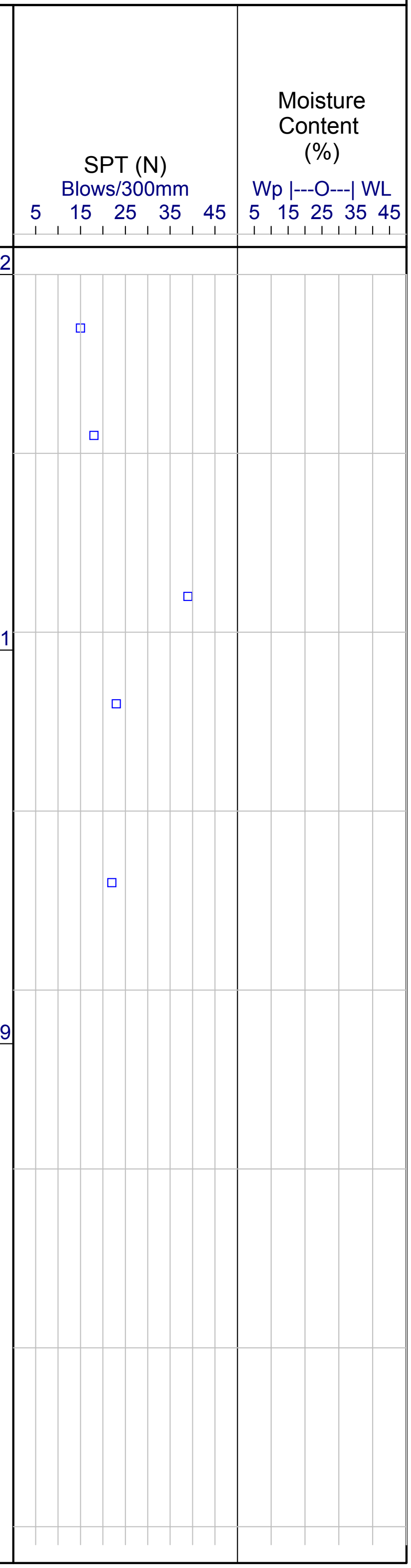
BOREHOLE RECORD

Project Name: Sewage Treatment Upgrades - Springhill Institution
Project No.: 071-223 **BH -** 01
Client: Crandall Engineering Ltd. **Page:** 1 of 1
Location: Springhill, NS **Date Drilled:** Dec.14, 2017
Water Level: Not observed at time of drilling **Datum:** Geodetic

Depth (m)	Water Level (m)	Sample Type	Sample Number	N Value or RQD %	Recovery (mm)	Symbols	SOIL AND/OR ROCK DESCRIPTION	Elevation/Depth (m)
0.0 – 2.1		SS	1	15	200		Compact to dense reddish brown to light brown sand with silt, clay, gravel and cobbles: FILL - trace of organics from surface to 0.3 m	145.2 0.0
		SS	2	18	400			
		-	-	-	-			
		SS	3	39	530			
2.1 – 4.3		SS	4	23	500		Compact to dense reddish brown to grey to brown silty/clayey SAND with gravel	143.1 2.1
		-	-	-	-			
		SS	5	22	600			
		SS	6	62	500			
4.3							End of borehole	140.9 4.3



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BOREHOLE RECORD

Project Name: Sewage Treatment Upgrades - Springhill Institution
Project No.: 071-223
Client: Crandall Engineering Ltd.
Location: Springhill, NS
Water Level: 3.0 m on December 14, 2017

BH - 02
Page: 1 of 1
Date Drilled: Dec.14, 2017
Datum: Geodetic

Depth (m)	Water Level (m)	Sample Type	Sample Number	N Value or RQD %	Recovery (mm)	Symbols	SOIL AND/OR ROCK DESCRIPTION	Elevation/Depth (m)	SPT (N) Blows/300mm	Moisture Content (%) Wp |---O---| WL
0.0							Loose to compact reddish brown to black to brown sand with silt, clay and gravel: FILL - trace of organics from surface to 0.3 m	144.9 0.0		
		SS	1	8	300					
		SS	2	6	430					
		-	-	-	-					
		SS	3	7	180					
		SS	4	26	150					
3	▼	-	-	-	-					
		SS	5	11	300					
3.4							Compact to dense reddish brown to grey to brown silty/clayey SAND with gravel	141.5 3.4		
		SS	6	26	550					
		SS	7	40	430					
4.9							End of borehole Practical refusal to further penetration of split spoon Probable bedrock	140.0 4.9		

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BOREHOLE RECORD

Project Name: Sewage Treatment Upgrades - Springhill Institution
Project No.: 071-223 **BH -** 03
Client: Crandall Engineering Ltd. **Page:** 1 of 1
Location: Springhill, NS **Date Drilled:** Dec.14, 2017
Water Level: 3.0 m on December 14, 2017 **Datum:** Geodetic

Depth (m)	Water Level (m)	Sample Type	Sample Number	N Value or RQD %	Recovery (mm)	Symbols	SOIL AND/OR ROCK DESCRIPTION	Elevation/Depth (m)
0.0–0.3		SS	1	11	350		Reddish brown sand with silt and clay: TOPSOIL	145.0 / 0.0
0.3–4.2		SS	2	18	400		Loose to compact reddish brown to black to brown sand with silt, clay, gravel and trace of organics: FILL	144.7 / 0.3
		-	-	-	-			
		SS	3	16	350			
		SS	4	14	550			
	3.0 (▼)	-	-	-	-			
		SS	5	4	150			
		SS	6	8	200			
4.2–4.8		-	-	-	-		Compact reddish brown silty/clayey SAND with gravel	140.8 / 4.2
		SS	7	SSR	230			
4.8–6.3		-	-	-	-		Inferred light brown to grey SANDSTONE / SILTSTONE bedrock	140.2 / 4.8
		SS	8	SSR	150			
6.3							End of borehole	138.7 / 6.3

SPT (N) Blows/300mm: 5 15 25 35 45

Moisture Content (%) Wp |---O---| WL: 5 15 25 35 45

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BOREHOLE RECORD

Project Name: Sewage Treatment Upgrades - Springhill Institution
Project No.: 071-223 — **BH -** 04
Client: Crandall Engineering Ltd. — **Page:** 1 of 1
Location: Springhill, NS — **Date Drilled:** Dec.14, 2017
Water Level: 3.0 m on December 14, 2017 — **Datum:** Geodetic

Depth (m)	Water Level (m)	Sample Type	Sample Number	N Value or RQD %	Recovery (mm)	SOIL AND/OR ROCK DESCRIPTION	Elevation/Depth (m)
0.0						Very loose to loose grey to brown sand with silt, clay, gravel and trace of organics: FILL	142.6 / 0.0
		SS	1	7	100		
		SS	2	3	500		
		-	-	-	-		
1.4						Dense reddish brown to grey silty/clayey SAND with gravel	141.2 / 1.4
		SS	3	32	500		
		SS	4	44	400		
3.0	▼	-	-	-	-		
		SS	5	31	200		
		SS	6	43	300		
4.3						End of borehole	138.3 / 4.3

SPT (N)
Blows/300mm
5 15 25 35 45

Moisture Content (%)
Wp |---O---| WL
5 15 25 35 45

LEGEND

BOREHOLE LOCATION

BOREHOLE LOCATION PLAN
SEWAGE TREATMENT UPGRADES
SPRINGHILL INSTITUTION
SPRINGHILL, NS

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Saint John
Moncton
Fredericton
Bedford

DATE:	SCALE:
2017–12–19	NTS
PROJECT No.:	FIGURE:
071–223	1

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GEOTECHNICAL RECOMMENDATIONS WINTER CONSTRUCTION

The following are general geotechnical recommendations for earthworks for building areas in winter conditions.

General

- Earthworks conducted during freezing conditions are suspect. Special procedures and precautions must be exercised to minimize the risk of future problems.

- A site meeting should be held at project start-up to discuss the schedules of the various contractors in relation to the following geotechnical recommendations.

Excavation

- The rootmat/topsoil layer and any overlying snow will reduce the frost penetration. Conducting only the excavation work required for each day of work is recommended to minimize freezing of the soil in the foundation areas.

- Excavated material to be used as structural fill should not be stockpiled, but should be placed and compacted immediately after excavation.

Fill Placement

Based on our experience, it is generally impractical to place well-graded gravel, sand, or fine-grained soils in temperatures lower than about -5 degrees Celsius. On very cold days, loose material starts to freeze within about 15 minutes. At temperatures below -5 degrees Celsius, clear gravel or clear rockfill is recommended but subject to design considerations governing the work.

The following provides recommendations for all structural fill types.

- Structural fill placement should be conducted in small areas. Depending on the temperature, this may allow for continuous placement of fill lifts during the work day without the requirement for excavation of frozen material prior to placement of the next lift.

- Material containing snow or ice should not be incorporated in the work. During snow events, fill placement should be stopped. When the earthwork restart, all snow and ice should be removed from the fill surface prior to subsequent fill placement. In order to remove all snow and/or ice after a snow event, some of the underlying fill may have to be removed and wasted.

- For intermediate fill lifts, frost protection (e.g.; straw, insulated tarp, etc) should be provided at the end of the work day, or alternatively, fill that freezes overnight should be removed in the morning. Also, any snow or ice should also be removed. Fill surfaces should be sloped to prevent ponding of water during milder weather.

- The final fill surface, the base of footing excavations and slab subgrade should be protected from freezing. If the final fill surface is exposed to freezing temperatures, heat will be required to thaw the soil. Test pits and temperature readings could be completed to determine if the soil is above freezing. Consideration should also be given to the installation of thermocouples in the fill during placement, as a means of reading temperatures at depth. The areas that were frozen should be proof-rolled.

- The moisture content of fill materials should be approximately 2% below optimum. Fill materials with moisture contents above the optimum should not be used.

- Loose edges of the structural fill lifts should be avoided to reduce frost penetration. Edges of fill lifts should be tapered and compacted.

- Regular checks of the temperature of the fill should be made. The soil temperature should be greater than +2°C to allow for compaction to the specified degree.

Footing Construction

- Footings should not be placed on frozen material.

- Where the footing elevation is within approved finer-grained materials, we recommend over-excavation by at least 6 inches and placement of nominal 1 inch stone or other clean gravel. This will reduce disturbance of the bearing surface.

- Following construction of footings, temporary frost protection must be provided to avoid freezing of the bearing surface and for protection of the concrete during curing.

- Consideration should be given to specifying that the footing depth for interior foundations be 1.2 m below slab subgrade for frost protection during construction; or alternatively, fill could be temporary bermed over interior footings to provide insulation.

- Foundations should be backfilled with a free-draining granular material and drainage provided to prevent adfreeze of foundations, particularly during construction.

- Cast-in-place concrete should be protected during colder weather conditions as per CSA A23.1-2009.

Geotechnical Inspection and Testing

The information herein should be reviewed by geotechnical personnel and customized to the specific geotechnical aspects and design considerations of a site. Full-time inspection and testing by experience geotechnical personnel is particularly important during earthworks in winter conditions and is strongly recommended.

GEOTECHNICAL INVESTIGATION
SPRINGHILL INSTITUTION WASTEWATER IMPROVEMENTS
SPRINGHILL, NOVA SCOTIA

Submitted to:

AMEC Power & Process
130 Eileen Stubbs Ave, Suite 201
Dartmouth, Nova Scotia B3B 2C4

Submitted by:

AMEC Environment & Infrastructure
50 Troop Avenue, Unit 300
Dartmouth, Nova Scotia B3B 1Z1

25 March 2014

TV143002

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

AMEC Environment & Infrastructure (AMEC), at the request of Mr. Glenn Clements, P.Eng. of AMEC Power & Process, carried out a geotechnical investigation at the site of the proposed Wastewater Improvements at Springhill Institution in Springhill, Nova Scotia.

The purpose of this investigation was to obtain information on subsurface conditions necessary for the design of the foundation of the proposed building for debris removal from wastewater. This report, prepared specifically and solely for the proposed project described herein, contains all of our findings and includes recommendations for foundation design and site preparation.

This report was prepared with the condition that the design will be in accordance with applicable standards and codes, regulations of authorities having jurisdiction, and good engineering practices.

AMEC recommends there be an ongoing liaison with AMEC during both the design and construction phases of the project to ensure that the recommendations in this report have been interpreted and implemented correctly.

This report deals strictly with the geotechnical issues of this project and does not encompass environmental issues that may be present on the site.

2.0 PROJECT AND SITE DESCRIPTION

The site of the proposed project is located at the Springhill Institution site in Springhill, Nova Scotia. This project will consist of constructing a small one-storey building for debris removal from wastewater. It is understood that part of the building will have a slab on grade. The footings design grades of the building will be approximately 1.5 m below grade. The building size is approximately 8.5 m by 8.5 m.

The site is presently covered with small to medium size trees. As a result, the boreholes were drilled near the two front corners of the building where the locations are clear from trees. The ground surface slopes gradually down in a southeast direction, toward the existing sewage lagoon. The proposed location of the building is shown on the attached plan in Appendix C.

3.0 INVESTIGATION PROCEDURE

The field work for the investigation was carried out under the supervision of AMEC personnel on March 14, 2014. Two boreholes (BH1 and BH2) were drilled at the site. The borehole depths were 5.8 m and 6.1 m and were advanced using solid stem augers.

The soils encountered were sampled at continuous to close intervals using a 50mm O.D. split spoon sampler. In order to assess the relative density and/or consistency of the subsoils, a Standard Penetration Test (SPT) was carried out for each sample attempt.

During drilling of the boreholes, the soils encountered were visually classified. Representative samples were placed in moisture-tight containers and taken to our laboratory for classification and testing.

The boreholes locations and elevations were surveyed by Alderney Survey Limited. Elevations of the borehole are referenced to Geodetic Datum.

4.0 SUBSURFACE CONDITIONS

Details of the soils conditions encountered at the borehole locations are provided on the borehole logs in Appendix A. The following sections summarize the soils conditions and describe them in accordance with the Unified Soil Classification System (USC).

It should be noted that stratigraphic boundaries indicated on the borehole logs typically represent a transition from one soil type to another and do not necessarily indicate an exact plane of geologic change. Subsurface conditions may vary between and beyond the borehole locations.

4.1 Rootmat

A layer of rootmat was encountered at ground surface at both boreholes. The thickness of this layer was approximately 0.2 m.

4.2 Fill

Fill was encountered below the rootmat in both boreholes. The fill consisted of brown to reddish brown clayey sand with gravel. The thickness of the fill was 2.3 m in BH1 and 2.6 m in BH2.

Measured 'N' values in the fill ranged between 4 and 34, indicating a very loose to dense relative density.

4.3 Clayey Sand with Gravel Till

Grey, clayey sand with gravel (SC) till deposit was encountered below the fill in both boreholes. The thickness of this layer was 1.4 m in BH2 and 2.1 m in BH1.

Grain size analysis (curve appended in Appendix B) performed on one sample of the clayey sand with gravel till from BH1 indicated the material to contain 16% gravel, 45% sand and 39% clay & silt sizes.

The in situ water content from the same sample was found to be 10.7 percent.

An Atterberg limit test performed on the same sample of the clayey sand with gravel till material indicated the material to be of low plasticity, with a liquid limit of 23 and a plasticity index of 9. The test results are presented on the logs in Appendix A and on the sieve sheet in Appendix B.

Measured 'N' values in this till layer ranged between 32 and greater than 50, indicating a dense to very dense relative density. The high N values were recorded close to bedrock surface.

4.4 Bedrock

Inferred bedrock was encountered underlying the till in both boreholes. The depth to bedrock below ground surface was 4.1 m in BH2 and 4.5 m in BH1. The bedrock was augured in BH1 and BH2 for 1.2 m and 2.0 m depth, respectively.

4.5 Groundwater Conditions

The boreholes were not monitored for a sufficient period of time to allow the groundwater to achieve equilibrium. Groundwater was observed during the drilling of both boreholes at 3.1 m below ground surface. The groundwater level can be expected to fluctuate seasonally with precipitation and climatic conditions.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

It should be noted that the recommendations for this project are provided for the guidance of the designers. The contractors bidding on or undertaking the work should make their own assessment of the site and interpretation of the factual information provided as it affects their construction procedures and scheduling.

5.2 Site Preparation

It is recommended that al vegetation, rootmat, fill and any other unsuitable materials be removed from within the proposed building area. Thus, the excavation will extend to the underlying clayey sand with gravel till layer.

Low areas of the site can be raised to the required subgrade level using structural fill. Pit run sand and gravel or crushed rock would be acceptable for use as structural fill, provided that the moisture contents are suitable to permit compaction. Oversize material (150 mm or larger in diameter) must be removed. Due to the high fines content in the site soils, it will be very difficult to use the existing soils for structural fill below the foundations or for backfilling.

Structural fill placed in the building areas should be placed in uncompacted maximum lifts of 300 mm and compacted to a minimum 100% Standard Proctor Maximum Dry Density (SPMDD).

Excavation of unsuitable materials and replacement of structural fill to be used as bearing stratum should extend outward from the footing perimeter a distance equal to the depth of fill placed below the footings.

The nature of the till soils renders it susceptible to softening when wetted or disturbed. Consequently, any disturbed material should be removed prior to structural fill placement. A geotextile layer should be placed between the till and the structural fill.

Provision for temporary construction hauling roads should be made, using adequate fill material.

It should be noted that the excavations may extend below groundwater level. Effective dewatering during excavation is very important to prevent disturbance of the in situ soil. Control of groundwater within the excavations can be accomplished through the use of pumps. Surface water should be directed away from excavated areas.

If construction is carried out during the winter, it should be noted that all earthworks performed during freezing weather are suspect to frost and special measures are required. Any frozen material must be removed from the building areas. All bearing surfaces, footings and foundation walls must be protected against freezing. It should be noted that the site materials are frost susceptible.

It is recommended that construction inspection be provided by geotechnical personnel during site grading operations and foundation preparation.

5.3 Spread Footing Foundations

Spread footings placed on structural fill prepared as outlined above may be designed using a net allowable bearing pressure of 150 kPa (3 ksf). With this allowable bearing pressure, the depth of the footings should be a minimum of 1.2 m below finished grade, for confinement. Footing width should be a minimum of 600 and 900 mm for strip and spread footings respectively. Maximum toe pressure under horizontal loading is recommended at 150 kPa. Associated total and differential settlements under full design loads should be less than 25 and 19 mm, respectively.

Normally, foundation details such as foundation elevation, depth of embedment, type and dimensions of footings are required in order to determine the bearing resistance in term of the Limit State Design (LSD) approach. However, the following are LSD values for assumed footing sizes at an assumed minimum burial depth of 1.2 m (frost depth for exterior footings) and groundwater at footings level.

For design purposes, the factored geotechnical resistance at the ultimate limit states (ULS) for a 0.9 m wide strip footing would be 180 kPa. The geotechnical resistance at the serviceability limit states (SLS), assuming an allowable total settlement of 25 mm, for the 0.9 m wide strip footing would be 170 kPa.

The factored geotechnical resistance at ULS and the SLS values for square footings are shown in the table below.

Foundation Analyses

Footing Size, m	Factored Geotechnical Resistance at ULS, kPa	Geotechnical Resistance at SLS, kPa	Vertical Displacement at SLS, mm
1.0 by 1.0	180	170	Less than 25
2.0 by 2.0	200	160	Less than 25
3.0 by 3.0	220	150	Less than 25

A Geotechnical Resistance Factor of 0.5 has been applied to the ULS calculation. If foundation details are different from the assumptions made here, the geotechnical resistance values will need to be re-evaluated.

Load inclinations and eccentricities must be considered separately from the values given above.

All footings, which will be subjected to freezing conditions, should have a minimum soil cover of 1.2 m, for protection against frost action. Foundation walls should be designed for the possible affects of backfill adfreezing.

All bearing materials must be inspected by qualified personnel prior to concrete placement.

5.4 Floor Slabs

Floor slabs may be constructed on the structural fill prepared as outlined above. A granular layer should be provided below the entire floor slab areas. The granular layer should be compacted to 100 percent SPMDD.

Interior columns should be isolated from the floor slab in order to allow minor movement to take place without cracking of the floor slab.

Interior foundation wall backfill should be carefully compacted in thin lifts of 150 mm. If non-frost susceptible materials not used for backfill, a bond breaker should be used on both sides of the foundation walls.

The floor slab constructed as recommended above may be designed using a soil modulus of subgrade reaction of 40 MPa/m (150 pci).

Where the floor slab will be below final exterior grade, perimeter drains with a positive discharge should be provided at those locations.

5.5 Earthquake Considerations

For earthquake design, in conformance to the criteria in Table 4.1.8.4A, Part 4, Division B of the National Building Code (NBC 2010), the site soil is classified as Site Class “D – Stiff Soil”. The four values of the spectral response acceleration S_a (T) for different periods and the Peak Ground Acceleration (PGA) can be obtained from Table C-2 in Appendix C, Division B of the NBC (2010). The design values of F_a and F_v for Site Class “D” should be selected in accordance to Table 4.1.8.4 B and C.

5.6 Retaining Wall

Retaining walls, if applicable, should be placed on undisturbed till or structural fill prepared as outlined above. Any anticipated surcharge from structures, water pressure, vehicles, equipment, etc., which may act on the retained soil should be included in the wall design. Retaining walls should be backfilled with well graded rock fill material such as clean crushed rock with a maximum size of 100 mm. Total and submerged unit weight of 21.5 kN/m^3 (2200 kg/m^3) and 11.5 kN/m^3 (1200 kg/m^3), respectively, may be assigned to such a material. This rock fill material must extend up from the base of the wall footing at a slope of 1H:1.5V, or flatter. Backfills should be placed in lifts compatible with the compaction equipment that can be used in potentially confined spaces. Compaction of material adjacent to the wall should be carried out with light equipment in order to limit horizontal stress build up on the wall.

The following parameters may be used for design of retaining walls with a horizontal backfill surface:

Coefficient of Sliding - Ultimate

Concrete/Till or Structural Fill	0.35
Factor of Safety	1.5 recommended

Lateral Earth Pressure Coefficient

	Earth Pressure at Rest (Wall Restrained)	Active Earth Pressure (Wall Unrestrained)
Rock Fill backfill	0.50	0.30
Site Till backfill	0.58	0.38

The earth pressure coefficients should be modified to account for sloping backfill, if applicable.

6.0 CLOSURE

A geotechnical investigation provides only a limited sampling of a site. The recommendations contained in this report are based solely on the conditions encountered at the borehole locations. Should any conditions be encountered which differ from those at the borehole locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied. The limitations of this report are expressed in Appendix C. Any use which a third party makes of this information, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Sincerely,

AMEC Environment & Infrastructure
a division of AMEC Americas Limited

Reviewed by:

Joseph Fakhri, M.A.Sc., P.Eng.
Senior Geotechnical Engineer

Paul S. Belyea, M.Sc., P.Eng.
Senior Geotechnical Engineer

JF/

APPENDIX A

BOREHOLE LOGS

GENERAL REPORT NOTES

STANDARD PENETRATION TEST—SPT

The standard penetration values are recorded on the Borehole Records as N values. The N values are the number of blows required to advance a standard, 50 mm diameter, split spoon sampler a distance of 305 mm into the soil using a 63.5 kg hammer freely falling a distance of 760 mm.

DYNAMIC CONE PENETRATION TEST----DCPT

This is a similar procedure to that used in driving a standard 50 mm split spoon sampler except that a cone is driven rather than a soil sampler. A variety of cones can be used. Often the cones are 51 mm diameter with a 60 degree taper from the tip.

SAMPLE TYPE ABBREVIATION USED ON BOREHOLE LOGS

S.S.	Split spoon	S. H.	Shelby tube	W.S.	Wash sample
A.S.	Auger sample	R. C.	Rock Core	P.	Sample pushed

SOIL DESCRIPTION

The standard terminology to describe cohesionless soils includes the compactness condition as generally determined by the SPT.

The standard terminology to describe cohesive soils includes the consistency, which is based on various methods of determining undrained shear strength, and by SPT

Cohesionless Soils.		**Cohesive Soils**		
Compactness Condition	N Values	Consistency	N Values	Undrained Shear Strength, kPa
Very loose	0 – 4	Very soft	0 – 2	< 12.5
Loose	4 – 10	Soft	2 – 4	12.5 - 25
Compact	10 – 30	Firm	4 – 8	25 – 50
Dense	30 – 50	Stiff	8 – 15	50 - 100
Very Dense	> 50	Very stiff	15 – 30	100 – 200
		Hard	>30	>200

NOTE

The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon samples recovered during the field work. Soils are heterogeneous materials, and, consequently, variations may be encountered at site locations away from where the samples were obtained. During construction, competent, qualified personnel should verify that no significant variations exist from those described in the report.

LOG OF BOREHOLE BH1

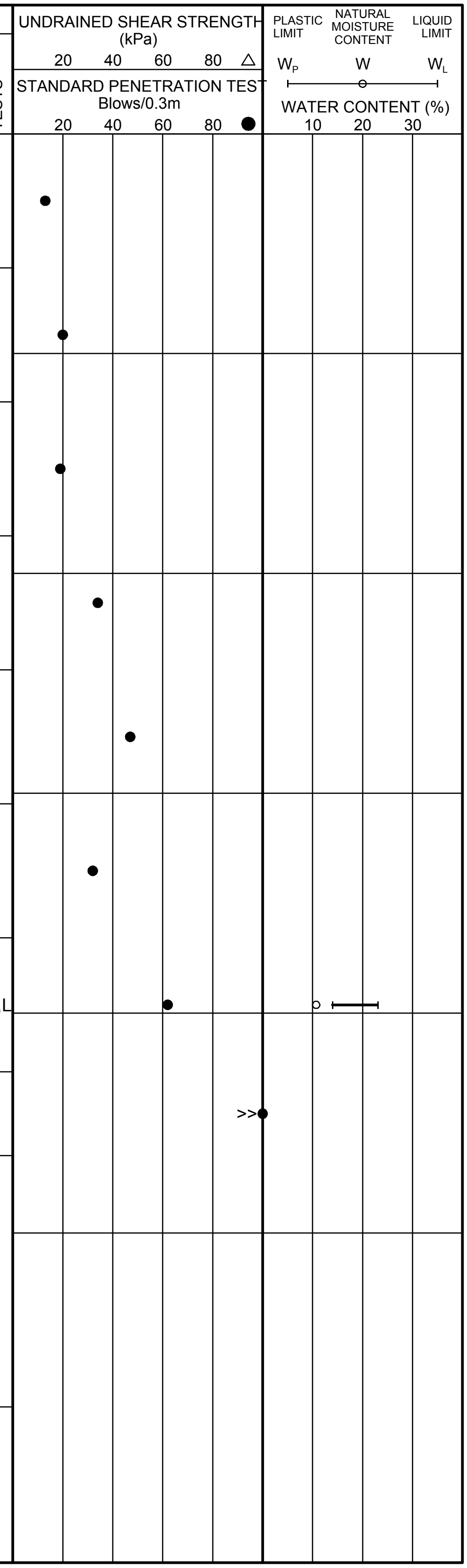
PROJECT No.:	**TV143002**	ELEVATION:	**148.87 m**
CLIENT:	**Public Works and Government Services Canada**	DATUM:	**Geodedic**
PROJECT NAME:	**Springhill Institution Wastewater Improvements**	METHOD:	**SS / Auger**
LOCATION:	**Spinghill, NS**	DIAMETER:	**100 mm**
DATE DRILLED:	**14-3-14**	WATER LEVEL:	**3.05 m**
LOGGED BY:	**G. Shupe**	CONTRACTOR:	**Logan Geotech**

DEPTH (m)	ELEVATION (m)	STRATIGRAPHIC DESCRIPTION
0	148.87	
	148.72	Loose, brown, ROOTMAT
		Compact to dense, reddish brown, clayey SAND with gravel: FILL
	146.43	Dense to very dense, grey, clayey SAND with gravel(SC): TILL
	144.30	INFERRED BEDROCK
	143.08	End of Borehole @ 5.8 m

Water level ▽ at 3.05 m

SAMPLES

TYPE	NUMBER	RECOVERY (mm)	N-VALUE or RQD%	OTHER TESTS
SS	1	550	13	
SS	2	525	20	
SS	3	600	19	
SS	4	600	34	
SS	5	600	47	
SS	6	450	32	
SS	7	300	62	S,M,L
SS	8	375	93 / 375mm	
AU				



LOG OF BOREHOLE BH2

PROJECT No.:	**TV143002**	ELEVATION:	**148.18 m**
CLIENT:	**Public Works and Government Services Canada**	DATUM:	**Geodedic**
PROJECT NAME:	**Springhill Institution Wastewater Improvements**	METHOD:	**SS / Auger**
LOCATION:	**Spinghill, NS**	DIAMETER:	**100 mm**
DATE DRILLED:	**14-3-14**	WATER LEVEL:	**3.05 m**
LOGGED BY:	**G. Shupe**	CONTRACTOR:	**Logan Geotech**

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DEPTH (m)	ELEVATION (m)	STRATIGRAPHIC DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE or RQD%	OTHER TESTS
0	148.18						
	148.03	Brown ROOTMAT	AU				
		Very loose to compact, brown clayey SAND with gravel: FILL	SS	1	500	13	
1			AU				
			SS	2	250	4	
2			SS	3	450	6	
	145.44	Dense to very dense, grey, clayey SAND with gravel: TILL	AU				
3			SS	4	425	33	
4			SS	5	375	73	
	144.06	INFERRED BEDROCK	AU				
5							
6	142.08	End of Borehole @ 6.1 m					

UNDRAINED SHEAR STRENGTH (kPa) 20 40 60 80 △

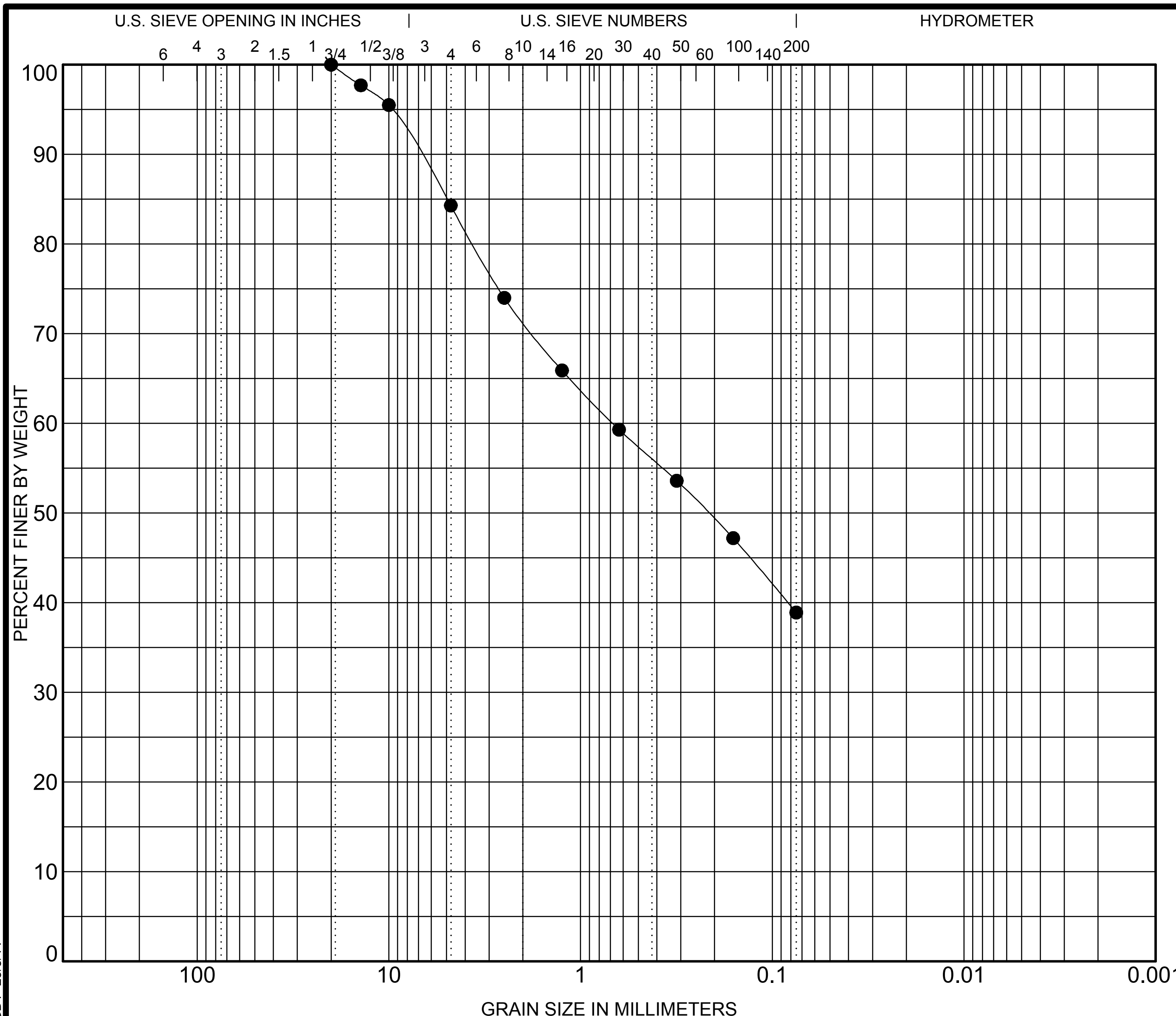
STANDARD PENETRATION TEST Blows/0.3m 20 40 60 80 ●

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

APPENDIX B

LAB TEST RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH1	3.96 m	**CLAYEY SAND with GRAVEL(SC)**	**23**	**14**	**9**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	BH1	3.96 m	**20**	**0.677**			**15.7**	**45.4**	**38.9**	

	Specimen Identification		Moisture Content, %
●	BH1	3.96 m	**10.7**

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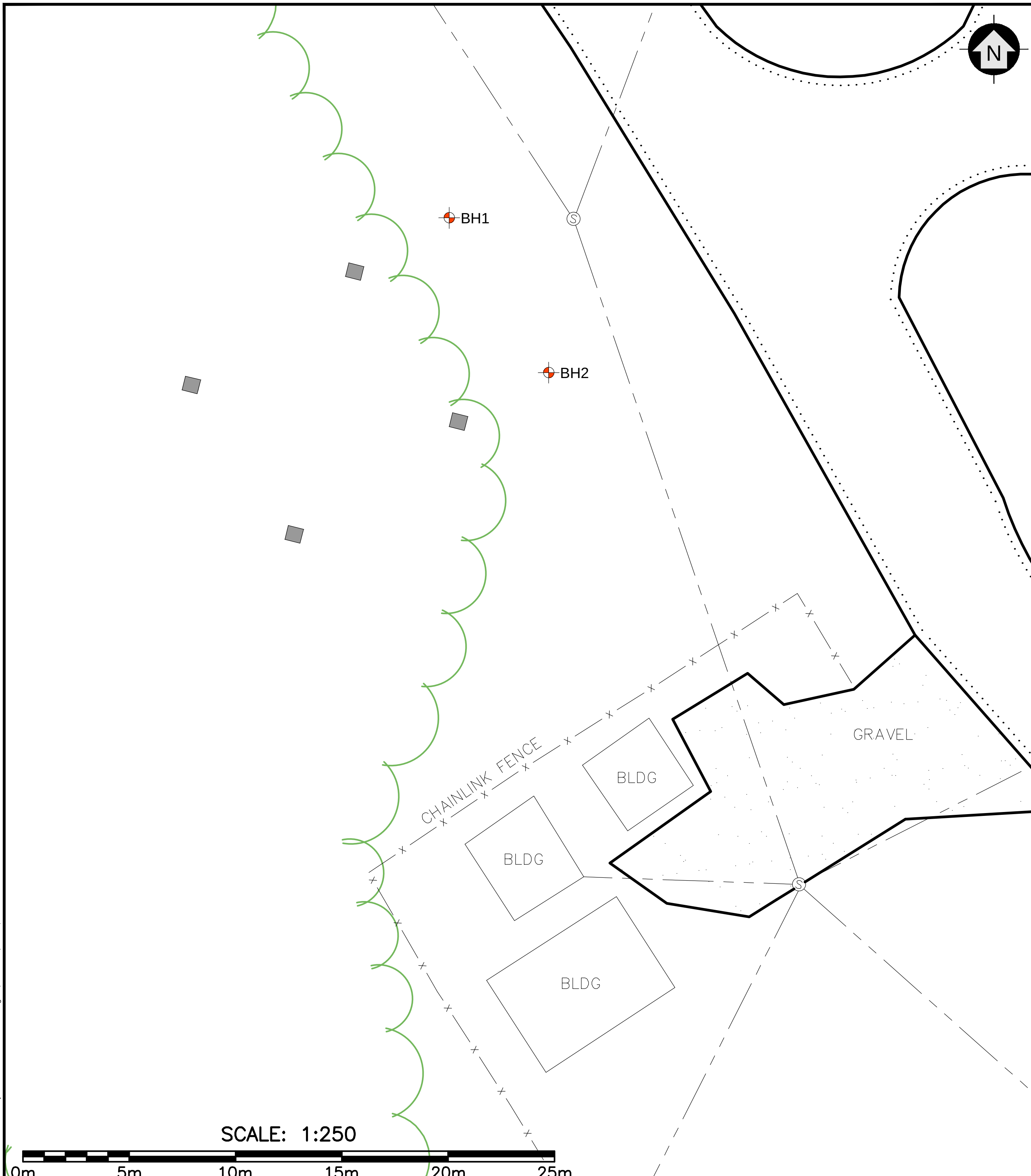
GRAIN SIZE DISTRIBUTION

Project No.: TV143002
Client: Public Works and Government Services Canada
Project Name: Springhill Institution Wastewater Improvements
Location: Spinghill, NS

APPENDIX C

BOREHOLE LOCATION PLAN
REPORT LIMITATIONS



AMEC Environment & Infrastructure 50 Troop Avenue, Unit 300 Dartmouth, N.S., B3B 1Z1 (P) 902-468-2848 (F) 902-468-1314	amec	CLIENT Public Works and Government Services Canada

PROJECT Geotechnical Investigation Springhill Institution Wastewater Improvements Springhill, Nova Scotia	DWN BY: DS CHK'D BY: JF	PROJECTION: UTM Zone 20 DATUM: NAD83	DATE: March 2014 PROJECT NO: TV143002
TITLE Borehole Location Plan	REV. NO.: N/A	SCALE: 1:250	FIGURE No. 1

\\hfx1-fs1\projectf$\5300 PROJECTS\2014\TV143002 Springhill Institution Wastewater Improvement\Cad\TV143002.dwg ; 9/23/2013 ; Schulz, Derrick M

REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the test holes.

The design recommendations given in this report are applicable only to the project described in the test, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

The elevations mentioned in this report were obtained strictly for use by this office in the geotechnical design of the project. They should not be used by any other party for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AMEC Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.