Attachment A – Geotechnical Investigation Report

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October 3, 2017
File: 121620920

Attn: Mr. Steven Greeley, P.Eng
SNC-Lavalin Inc.
1133 Topsail Road
Mount Pearl, NL, Canada, A1N 5G2

Dear Mr. Greeley,

Reference: Geotechnical Investigation
St. Anthony Maintenance Garage Rehabilitation
St Anthony Airport

Acting on the request and authorization of SNC-Lavalin Inc. (the Client), Stantec Consulting Ltd. (Stantec) completed a borehole investigation at the location of a proposed extension to the Combined Services Building at St. Anthony Airport, Newfoundland and Labrador. This letter provides the findings of the field investigation and recommendations.

The scope of work was in accordance our proposal dated June 23, 2017 and consisted of drilling two (2) boreholes for the Combined Services Building (CSB) extension with each to extend a minimum of 6 metres into bedrock. The objective is to investigate subsurface conditions associated with the proposed extension and provide geotechnical engineering recommendation for planning and design.

The field was completed on September 6, 2017 and consisted of drilling the two boreholes 5.9 and 6.2 m into the bedrock using a truck mount CME 75 drill provided by Logan Geotech Inc. Borehole locations were selected by the Client and laid out in the field using a survey tape and the existing building by a Stantec and SNC representative. The borehole locations are shown on the attached Drawing No. SK1, Borehole Location Plan, provided by the client.

SITE CONDITIONS:

Conditions encountered at the boreholes are provided in detail on the attached Borehole Records and summarized in the Table below.

Borehole No.	Asphalt *Depth: From – To (m)*	Fill Material *Depth: From – To (m)*	Till *Depth: From – To (m)*	Groundwater *Depth (m)*	*Bedrock Depth (m)*	*Total Depth of Borehole (m)*
BH 1	0.0 – 0.08	0.08 – 0.15	0.15 – 1.68	N/E	1.68 – 7.54	7.54
BH 2	0.0 – 0.08	0.08 – 2.01	N/E	1.98	2.01 – 8.18	8.18

Based on the conditions encountered at the borehole locations, no evidence of a near surface fault filled with soil was encountered. However, in BH1 a clay seam and loss of core recovery was

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encountered at 7.53 m depth. In some cases, these type conditions when encountered in bedrock can be interpreted as representative of a geological fault zone, however based on the foundation loading and building size, these fractured zones will not have any impact on foundation performance. Photographs of the core recovered in the boreholes are attached to this report.

COMMENTS AND RECOMMENDATIONS:

The existing undisturbed glacial till and bedrock which underlie the site are satisfactory bearing strata to support moderate foundation loads as understood for the proposed structure. Conventional shallow foundations with spread and strip footings will be suitable.

General recommendations are presented below for site preparation, foundation design and earthworks. We would be pleased to provide additional geotechnical consultation as the project proceeds.

Site Preparation

- The water table was encountered at a depth of 1.98 m in BH 2. Site development and planned earthworks must consider the groundwater conditions encountered at the site.

- All existing asphalt and fill must be removed from the building footprint and if required due to design grades backfilled with engineered fill. The lateral limits of excavation should be sufficient to accommodate the proposed replacement structural fill at acceptable slope angles. This would normally be approximately 1H:1V for well-graded rockfill, and 1.5H:1V for select granular soil fills, though flatter slopes may be required in certain cases. These limits are necessary both to ensure that the influence zone for foundations loads is contained entirely within the structural fill, as well as to ensure that the replacement structural fill can be placed with stable slopes.

- Structural fill for grading beneath the building should consist of approved, well graded granular material such as pit run sand and gravel or a well graded blasted rockfill. Maximum particles sizes for the structural fill should not exceed 150 mm and the fines content should not exceed 8%. Use of rockfill is recommended in areas such as excavation bases if wet conditions are encountered. Structural fill should be placed in lifts and compacted to 100 percent of Standard Proctor (ASTM D698) maximum dry density. For rockfill verification of the field density by visual inspection during compaction by experienced geotechnical personnel is required. Lift thicknesses must be compatible with the compaction equipment used to assure required density is achieved throughout.

Foundation Design:

- Bearing capacity analysis for a 2 m x 2 m size spread footing or a 1 m x 10 m size strip footing founded at depth of 1.2 m is as follows:

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- Footings founded on undisturbed compact to dense glacial till:
  - Factored geotechnical bearing resistance at ultimate limit states = 375 kPa.
  - For a serviceability contact pressure of 250 kPa, a maximum settlement of less than 25 mm is estimated.
- Footings founded on compact structural fill:
  - Factored geotechnical bearing resistance at ultimate limit states = 225 kPa.
  - For a serviceability contact pressure of 150 kPa, a maximum settlement of less than 25 mm is estimated.
- Footings founded on compact bedrock:
  - Factored geotechnical bearing resistance at ultimate limit states = 750 kPa.
  - Settlement of footings on bedrock will be negligible.

- Foundations on soil or structural fill should have a minimum soil cover of 1,800 mm or equivalent insulation for frost protection. In general, bedrock is not considered frost susceptible. However, depending upon the rock quality, a nominal soil cover for frost protection may be required. Based on our experience, a 600 mm cover for exterior footing walls founded on bedrock is recommended.

- To reduce the potential for ad-freezing, backfill material used around foundation walls should be free of organics and deleterious material, free draining and classed as non-frost susceptible.

- We understand that the existing building does not have a weeping tile around the perimeter footings and to date the structure has performed satisfactorily and there have been no issues related to foundation drainage. In addition, we understand that installing a standard weeping tile around the exterior footings for the building extension is not feasible due to site grading and drainage details. Therefore, a weeping tile will not be installed.

- Based on the subsurface conditions noted during the investigation, and the recommendations outlined in Table 6.1A of the Canadian Foundation Engineering Manual, 4th edition (copy of Table 4.1.8.4.A in NBCC 2005), the site classification for seismic site response is "B".

- Engineering parameters are based on empirical correlations for soil materials like the native soils encountered at the site and the soils being placed and compacted to a relative density of 35 to 65% (i.e. compact). Verification of these values is required once the details of the foundation design, planned earthworks, and source materials to be used for construction are known, have been sampled and tested in the laboratory.
  - Assumed internal friction angle = 32°.
  - Coefficient of earth pressure at rest, Ko = 0.47
  - Coefficient of active earth pressure, Ka = 0.31
  - Coefficient of passive earth pressure, Kp = 3.25
  - Dry unit weight for compacted material = 18.0 kN/m^3
  - Saturated unit weight for compacted Material = 21.5 kN/m^3
  - Submerged unit weight for compacted material = 11.7 kN/m^3

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Closure:

We trust the information presented in this letter report meets your current requirements. Use of the information provided herein is subject to the Statement of General Conditions, attached. It is the responsibility of SNC-Lavalin Inc. who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these not be satisfied. The Statement of General Conditions addresses the following: use of the report; basis of the report; standard of care; interpretation of site conditions; varying or unexpected site conditions; and planning, design, or construction.

This report has been prepared by the undersigned. Should any additional information be required, please do not hesitate to contact our office at your convenience.

Regards,

STANTEC CONSULTING LTD.

Paul D. Deering, P.Eng., P.Geo.
Senior Principal, Geotechnical Engineering
Paul.Deering@stantec.com

Attachments: Statement of General Conditions
Symbols and Terms Used on Borehole and Test Pit Records
Borehole Records
Bedrock Core Photographs
Drawing No. SK1, Borehole Location Plan

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Rootmat	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization 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 in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4th Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

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

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT 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

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality*
25-50	*Poor Quality*
50-75	*Fair Quality*
75-90	*Good Quality*
90-100	*Excellent Quality*

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	*Crushed*
Severely Fractured	*Shattered or Very Blocky*
Fractured	*Blocky*
Moderately Jointed	*Sound*
Intact	*Very Sound*

RQD (Rock Quality Designation) denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

SCR (Solid Core Recovery) denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

Fracture Index (FI) is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

Terminology describing rock with respect to discontinuity and bedding spacing:

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

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders Cobbles Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Igneous Bedrock | Meta-morphic Bedrock | Sedi-mentary Bedrock

SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

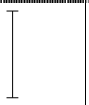
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

	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

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BOREHOLE RECORD

BOREHOLE No. **BH 1**
PAGE **1** of **1**

CLIENT **SNC-Lavalin**
PROJECT **Geotechnical Investigation, St. Anthony Maintenance Garage Rehabilitation**
LOCATION **St. Anthony Airport, NL**
DATES (mm-dd-yy): BORING **9-6-17** WATER LEVEL **N/A**

PROJECT No. **121620920**
DRILLING METHOD **Wash Bore**
SIZE **H**
DATUM

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY OR TCR(%)	SAMPLES N-VALUE OR RQD (%)	OTHER TESTS
							mm		
0		ASPHALT							
		Compact, brown, well-graded GRAVEL with sand (GW): FILL			SS	1	457	74	
1		Very dense, brown, silty SAND with gravel (SM); occasional cobbles: TILL			SS	2	508	68	
					SS	3	152	69/152	
2		Poor to fair quality, grey, medium strong, Siltstone with Quartz veins: BEDROCK			HQ	4	100%	43%	
3					HQ	5	100%	72%	
4									
5					HQ	6	100%	72%	
6									
7		- Clay seam observed at 7.53 m depth			HQ	7	67%	38%	
		End of Borehole							
8									
9									

UNDRAINED SHEAR STRENGTH - kPa
20 40 60 80
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50 60 70 80

△ Unconfined Compression Test
□ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◥ Torvane

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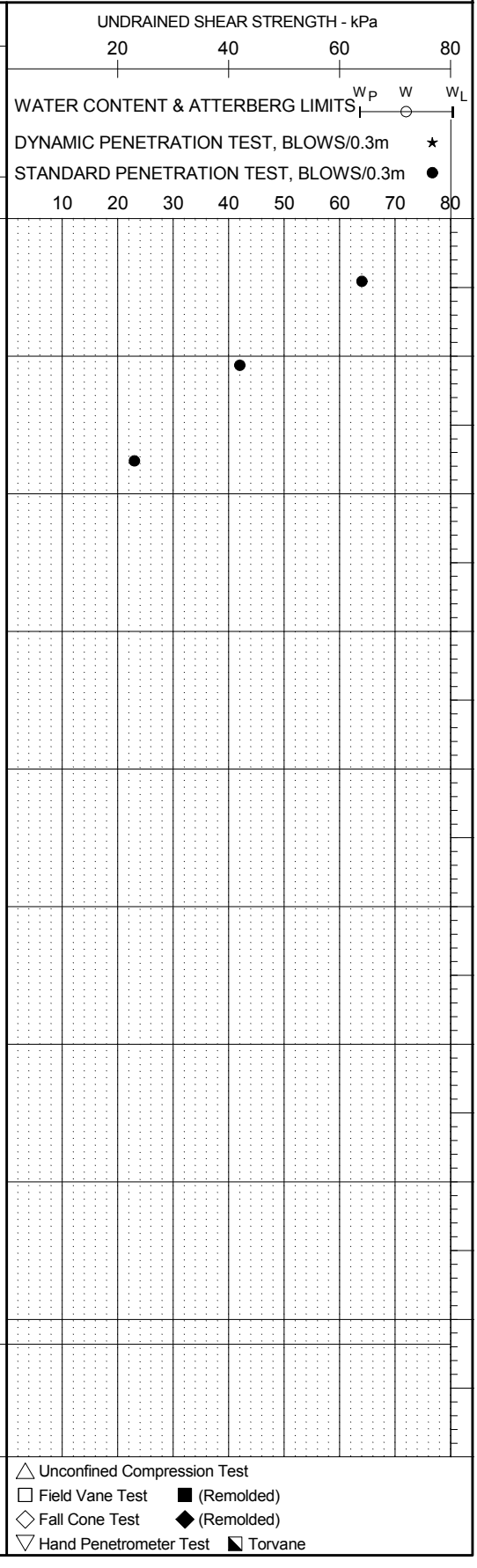
BOREHOLE RECORD

BOREHOLE No. **BH 2**
PAGE **1** of **1**
PROJECT No. **121620920**
DRILLING METHOD **Wash Bore**
SIZE **H**
DATUM

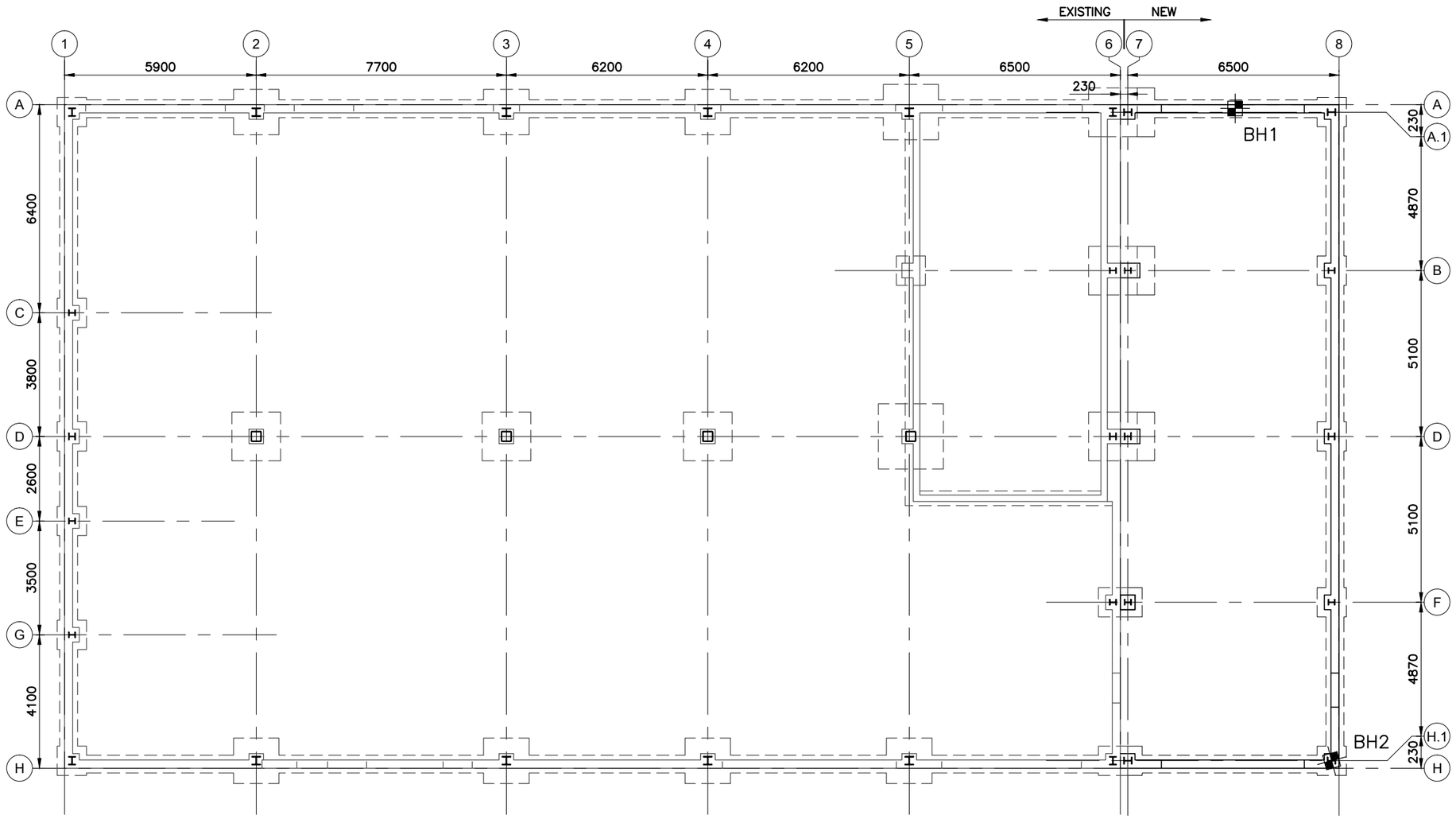
CLIENT **SNC-Lavalin**
PROJECT **Geotechnical Investigation, St. Anthony Maintenance Garage Rehabilitation**
LOCATION **St. Anthony Airport, NL**
DATES (mm-dd-yy): BORING **9-6-17** WATER LEVEL **1.98m** **9-6-17**

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY OR TCR(%)	N-VALUE OR RQD (%)	OTHER TESTS
							mm		
0		ASPHALT							
		Compact, brown, well-graded GRAVEL with sand (GW): FILL			SS	1	0.48	64	
1		Compact to very dense, brown, silty SAND with gravel (SM); trace rootlets: FILL			SS	2	0.41	42	
					SS	3	0.41	23	
2				▽	HQ	4	100%	0%	
		Very poor to excellent quality, grey, medium strong, Siltstone with Quartz veins: BEDROCK			HQ	5	88%	29%	
3					HQ	6	98%	60%	
4					HQ	7	100%	71%	
5					HQ	8	100%	100%	
6					HQ	9	100%	100%	
7									
8					HQ	10	100%	100%	
		End of Borehole							
9									



BH 1 Core

BH 2 core



BORE HOLE LOCATION PLAN

SCALE : 1:150

0m 5m 10m 15m

Public Works and Government Services Canada / Travaux Publics et Services gouvernementaux Canada

LEGEND

– BORE HOLE (LOCATION APPROXIMATE)

C01	ISSUED FOR INFORMATION	08/31 2017
revisions		date

project / projet

COMBINED SERVICES BUILDING REHABILITATION
ST. ANTHONY AIRPORT
NEWFOUNDLAND

drawing / dessin

BORE HOLE LOCATION PLAN

designed / conçu: M.GEHUE
date: 2017/08/31

drawn / dessiné: J.VINCENT
date: 2017/08/31

approved / approuvé
date

Tender / Soumission

PWGSC Project Manager / Administrateur de projets TPSGC

project number / no. du projet: R.077269.001

drawing no. / no. du dessin: SK1

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E–DRM/GDD–E: 547190 Version 1