Stantec Consulting Ltd.
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May 22, 2018
File: 121621787

Department of Fisheries and Oceans
Canadian Coast Guard
Marine and Civil Infrastructure
P.O. Box 5667
St. John's NL A1C 5X1

Reference: Proposed New Communication Tower - Project F6839-175605
Chebucto Head Lighthouse, Duncan's Cove, Nova Scotia
Geotechnical Investigation Report

INTRODUCTION

As requested, Stantec Consulting Ltd. has conducted a geotechnical investigation in support of the proposed communication tower noted above. Our work consisted of logging two boreholes near the planned tower base location and preparation of this report. This report contains all our findings and recommendations for site preparation, foundation design, and applicable rock engineering parameters. The work was conducted in accordance with our proposal of February 2, 2018.

SITE DESCRIPTION

The planned location of the new tower is the Canadian Coast Guard facility at Chebucto Head Road, Duncan's Cove, Nova Scotia. The facility and planned tower site are situated at the end of the road. The facility currently consists of multiple communication towers, a lighthouse, and an operations building.

The planned new tower location is southwest of the operations building/lighthouse. At the time we were on site, the tower location was clear of trees. Based on geological mapping, the site is situated over granitic bedrock of the Liscomb Complex, and overburden consists of a thin sandy till veneer.

FIELD PROCEDURES

The field program was conducted on March 29, 2018 and consisted of two boreholes, BH1 and BH2, near the tower base, supervised and logged by experienced Stantec geotechnical personnel. Detailed records of the conditions encountered, and samples obtained are attached.

The boreholes were put down at locations selected by Canadian Coast Guard personnel. The borehole locations were surveyed by Stantec personnel referencing site features.

SUBSURFACE CONDITIONS

The subsurface conditions encountered in the boreholes are described in detail on the borehole records and are summarized in the following paragraphs. All soil descriptions are in accordance with ASTM D-2487 and D-2488, using the Unified Soil Classification system.

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A layer of rootmat and topsoil, 0.2 metres thick, was encountered at the surface of both boreholes. At borehole BH02, the topsoil/rootmat was underlain by a 1 metre thick layer of brown silty clayey sand with gravel. Bedrock was encountered beneath the topsoil at borehole BH01and beneath the silty sand at BH02. The bedrock consisted of slightly weathered, fair to very good quality, white to pink granite with RQDs ranging from 40 to 97%.

No groundwater seepage was observed in the boreholes at the time of drilling. Groundwater levels will fluctuate seasonally, in response to precipitation events, and as a result of construction or grading activities.

DISCUSSION AND RECOMMENDATIONS

We currently understand the proposed communication tower will consist of a self-supported structure. Based on information from Canadian Coast Guard personnel and the conditions encountered, we expect the tower will be supported by concrete blocks or piers founded on, and anchored into, bedrock. Recommendations for site preparation and foundation design are provided in the following sections.

The tower foundation preparation will consist of stripping the overburden (rootmat, topsoil, silty clayey sand) down to bedrock, and excavating to the design bearing elevations. Temporary dewatering of excavations may be necessary if groundwater levels, at the time of construction, have risen to above proposed bearing elevations. Surface water should be directed away from excavations by means of diversionary ditches or swales. Bedrock removal will require the use of suitable hydraulic rock breaking equipment and/or blasting.

To provide a level working base for foundation formwork, consideration may be given to placing mudslabs at the foundation pier/block locations.

Spread footings on clean intact bedrock may be designed for a factored geotechnical bearing resistance at ULS of 1,500 kPa; associated settlement would be negligible.

Foundation bases should be provided with a minimum of 1.2 metres of soil cover, or the insulation equivalent, for frost protection. A reduced frost cover could be considered for foundations placed directly on clean intact bedrock, free of all loose fragments and soil seams which typically requires high pressure air/water system to achieve.

Foundation bases should be inspected, prior to formwork installation or concrete placement, by experienced geotechnical personnel to verify the design bearing pressures.

For anchors grouted into the granite bedrock, the upper 1.2 metres of rock should not be included in the calculation of anchor/socket length. We recommend a factored geotechnical resistance (tension) at ultimate limit states (ULS) of 600 kPa, which includes a resistance factor of 0.3, be used for the bond stress between the bedrock and the concrete or grout.

For uplift loading, it will also be necessary to check the total pullout resistance of the anchors. The pullout resistance can be calculated as the weight of rock within a theoretical cone with a 60 degree apex at the bottom of the socket. A factor of 1.3 should be applied to the weight of cone analysis. Where theoretical cones of adjacent anchors overlap, the overlapping portion should be ignored in resistance calculations. A submerged unit weight of 15 kN/m^3 may be used for the bedrock.

CLOSURE

Use of this report is subject to the attached Statement of General Conditions. It is the responsibility of the Canadian Coast Guard, who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. 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
- Planning, design or construction

This report was prepared by Mark Bochmann, P.Eng., and reviewed by Brian Grace, P.Eng. We trust that the information contained in this report is adequate for your present purposes. If you have any questions about the contents of the report or if we can be of any other assistance, please contact us at your convenience.

Yours truly,

STANTEC CONSULTING LTD.

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Attachments: Statement of General Conditions
Symbols and Terms Used on Borehole and Test Pit Records
Borehole Records BH01 and BH02
Figure No. 1, Borehole Locations

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

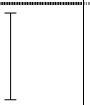
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals 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

BH01

CLIENT **CANADIAN COAST GUARD** PROJECT No. **121621787**

LOCATION **CHEBUCTO HEAD, NOVA SCOTIA** BH SIZE **NQ**

DATES: BORING **2018/04/06** WATER LEVEL **Not Observed** DATUM **-**

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N-VALUE OR-RQD %	OTHER TESTS
							mm		
0		TOPSOIL							
		Poor to good quality, slightly weathered, white to pink GRANITE bedrock -stainining and weathering on fracture surfaces			NQ	1	79%	RQD 49%	
1									
					NQ	2	100%	82%	
2									
					NQ	3	100%	40%	
3									
					NQ	4	100%	90%	
4									
5									
6		End of borehole							
7									

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 90

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BOREHOLE RECORD

BH02

CLIENT **CANADIAN COAST GUARD** PROJECT No. **121621787**

LOCATION **CHEBUCTO HEAD, NOVA SCOTIA** BH SIZE **NQ**

DATES: BORING **2018/04/16** WATER LEVEL **Not Observed** DATUM **-**

DEPTH(m)	ELEVATION(m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N-VALUE OR-RQD %	OTHER TESTS
							mm		
0		TOPSOIL							
		Very loose brown silty, clayey SAND with gravel			SS	1	150	4	
1		Excellent quality, fresh to slightly weathered, white to pink GRANITE bedrock -stainining and weathering on fracture surfaces			NQ	2	100%	RQD 92%	
2					NQ	3	97%	97%	
3									
4					NQ	4	100%	93%	
5					NQ	5	100%	95%	
6		End of borehole							
7									

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 90

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2018/05/22 9:26 AM By: Pinnell, Brian

ORIGINAL SHEET - ISO A3

APR. 2018
121621787.400

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Legend

BOREHOLE

0 10 20 40m

BAR SCALE
1:1000

Notes

AERIAL IMAGE FROM ZOOM EARTH.

Client/Project
CANADIAN COAST GUARD, PROPOSED VHF TOWERS
DUNCAN'S COVE, NOVA SCOTIA
CCG COMMUNICATIONS FACILITY (CHEBUCTO HEAD ROAD)

Figure No.
1

Title
BOREHOLE LOCATIONS