Appendix B

GEOTECHICAL REPORT

November 19, 2019
File: SGL19-028

Canadian Coast Guard - Maritime & Civil Infrastructure
Fisheries & Oceans Canada
25 Huron St., Victoria, BC V8V 4V9

Attention: Mr. Clint Hoffman, M.Eng., P.Eng.

Re: Proposed Telegraph Cove (Mt. Collinson) Communications Site
Report of Geotechnical Assessment

INTRODUCTION

As requested, Simpson Geotechnical Ltd. has conducted a geotechnical assessment for the proposed Telegraph Cove communications site located on the flank of Mt. Collinson on Vancouver Island at approximately N50° 31' 42.2" W126° 47' 22.6", at an elevation of approximately 725m. The assessment was conducted in general accordance with our proposal of October 23, 2019.

We understand that the proposed building would be single-storey and constructed in accordance with the post-disaster considerations of the National Building Code of Canada (NBCC) 2015. The proposed antenna tower would be a self-supported metal lattice tower approximately 40m in height, designed and constructed in accordance with CSA S37-18 Antennas, Towers, and Antenna-Supporting Structures.

BACKGROUND

Prior to our site assessment the site had been cleared of trees and soil, then blasted to create an essentially flat and level blast rock surface at an elevation of approximately 725.75m, as shown on drawings that were provided to us. We were also provided a report (CM Rock Engineering Ltd., Oct 22, 2019, File 119-101) that indicated the blast holes had been drilled to 725.25m elevation at a 0.9m x 0.9m pattern, with fill material subsequently placed to 725.75m elevation.

The finished site topography was provided to us by the Canadian Coast Guard and is shown on Figure 1. We were also provided with pre-blasting topography, which is shown on the cross sections on Figure 2. The pre and post blasting topography indicate that substantial quantities of fill material has been located to the northern and southern sides of the site, as illustrated in the cross sections shown on Figure 2. Photographs of the stripped rock surface were also provided to us, included as Photos 1 and 3.

Online geologic mapping of the site area published by the Province of BC indicated the site area to be underlain by middle to upper Triassic basalt. Geologic faults are shown in the order of 1.5km westward of the site, generally following Beaver Cove and the Kokish River valley.

A site-specific Seismic Hazard Calculation for the site location was obtained from Natural Resources Canada. That calculation indicated a Peak Ground Acceleration of 0.288g for the 2% in 50-year probability seismic event. The Seismic Hazard Calculation is appended, which includes seismic data for other probabilities of occurrence.

SITE ASSESSMENT

The site assessment was conducted on November 8, 2019 and consisted of observations of the general setting and topography of the site, and review of bedrock exposures in the immediate vicinity of the site. A photolog is appended.

The site was essentially flat and level and located at a local topographic high point on the flank of Mt. Collinson. The site surface comprised angular grey basaltic rock pieces that ranged from gravel to boulder size. The central area of the site was surfaced with primarily smaller gravel and cobble sized particles, while larger cobble and boulder sizes were on the surface around the perimeter of the site (see Photo 2).

The fill slopes around the perimeter of the site sloped down in the order of 40 to 60 degrees from horizontal (Photo 4 and 5), in both blast rock material, as well as in organic material as was present in an infilled gully off the southwestern area of the site. That gully was up to 10m deep with a slope comprised of up to 8m thickness of organic fill and woody debris at a slope of up to 54 degrees from horizontal that we interpret as stripped material from the site, capped with up to 2.5m thickness of blast rock cobbles and boulders (Photo 6).

Immediately northwards of the site the slope continued down at approximately 70 to 80 degrees for at least 30m. The approximate crest of that slope is shown on Figure 1, and Photo 1. The undisturbed portion of that slope was vegetated in primarily low brush, while the tops of trees growing at the bottom of that slope reached to nearly the site elevation.

We were unable to access the base of the slope to the north of the site to look for evidence of historic rockfall from the steep north side slope. The slope immediately southwards of the site was relatively gentle, with the exception of the gully at the western side described above.

The slopes westward and eastward of the site sloped relatively gently down from the prepared site surface. An area of bare, undisturbed, gently sloped basaltic bedrock was present to the west of the prepared site surface (Photo 5), while to the east was essentially undisturbed and vegetated with brush and small trees.

The bedrock exposed on the western side of the site showed persistent steeply inclined discontinuities that generally paralleled the north-side slope (Photo 5) at a spacing of 1 to 2m. Less persistent discontinuities formed an orthogonal and blocky structure in the rock. The bedrock discontinuities and structure suggest possible toppling block failure mechanism may occur from the steep slope immediately northwards of the prepared site area.

A small test excavation was located on the north-central area of the site, in the vicinity of the proposed antenna tower location (Photo 7). The sides of that excavation exposed 0.2m thickness angular gravel, overlying 0.6m thickness of fractured basaltic rock that retained its intact structure which we interpret as bedrock disturbed by blasting. The base of the excavation exposed angular gravel, such that the depth to intact, undisturbed bedrock at that excavation was not apparent.

The exposed bedrock was very hard and required many blows of a geologic hammer to chip, indicative of Grade R5 (very strong) rock in accordance with the Canadian Foundation Engineering Manual rock classification system. The predominant bedrock discontinuities were tight to open up to 1mm, dry, with no filler material. The rock surfaces were lightly weathered with iron stained surfaces. No water seepage from the rock discontinuities was observed at the time of our site visit.

The Rock Quality Designation (RQD) was measured by surface scanline method at approximately perpendicular orientations at N77°E and N200°E on the exposed bedrock immediately westward of the prepared site area. Those measurements resulted in an RQD that ranged from 95% to 100%, indicative of excellent quality rock in accordance with the Canadian Foundation Engineering Manual rock classification system.

LABORATORY TESTING

A sample of the basaltic rock was retained from the blasted material and tested for relative density in accordance with the ASTM C127 method. That test indicated a relative density 2.88 g/cm^3 (28.25 kN/m^3). The test report is appended.

DISCUSSION AND RECOMMENDATIONS

General

The site is considered geotechnically suitable for the proposed self-supported antenna tower, communications building, and supporting infrastructure, provided the following recommendations are implemented. We expect that the most practical foundation system for the structures would be pad or strip footings that bear directly on intact, hard, basaltic bedrock with uplift resistance provided by bonded rock anchors.

The depth to suitable intact, undisturbed bedrock foundation subgrade on the site is likely to be variable and may be more than 0.6m below the existing blast rock fill surface of the site.

Slope stability considerations are for the structures are warranted and discussed below.

Slope Stability

Due to the potential for toppling block failure from the north-side of the site and the post-disaster designation of the proposed facility, a minimum 8m geotechnical setback upland from the crest of the north-side slope is recommended for critical structures that are intended to remain functional following the major 2% in 50 year probability of occurrence design seismic event. That recommended setback and building is illustrated on Figure 1.

For preliminary site layout and planning purposes, critical structures should also be located within the blasted surface area of the site, or on the intact, undisturbed, essentially flat basaltic bedrock area westwards of the prepared blast rock site surface. That results in in the approximate preliminary recommended building area for critical structures shown cross-hatched on Figure 1.

The actual proposed structure locations should be reviewed by Simpson Geotechnical Ltd. prior to finalizing the site layout.

Antenna Tower

The self-supported communications tower foundation may consist of a combination of concrete footings bearing on approved undisturbed intact basaltic bedrock with uplift resistance provided by cementitious or plastic resin grout bonded rock anchors. The foundation design should be based on the geotechnical parameters shown below in accordance with CSA S37-18 Antennas, Towers, and Antenna-Supporting Structures.

Rock anchors for uplift resistance should be designed by a Professional Engineer experienced in rock anchor design. The uplift resistance may be determined as shown on Figure 3, based on a maximum cone apex angle of 90 degrees (45 degrees each side of the long axis of the anchor). The apex of the inverted cone should be located no deeper than the midpoint of the anchor bond length. Anchors located laterally closer than 1.2 x T (where T is the anchor depth) should be considered to as act as a group.

Local topography may truncate the uplift cone when uplift rock anchors are located laterally closer to a slope than that anchor depth into the bedrock. The reduction in uplift cone volume by truncation of the uplift cone by local topography should be considered in the tower location, anchor design and installation.

Recommended Geotechnical Foundation Design Parameters for Proposed Klemtu MCTS Antenna Tower (In accordance with CSA S37-18)

Parameter	Value
Bedrock type	Basaltic
Design depth to sound bedrock (including weathered rock)	Varies and may be >0.6m
Ultimate, unfactored, bearing resistance (bearing on approved, undisturbed, intact, level basaltic bedrock)	2000 KPa
Serviceability bearing resistance (mx. 15mm settlement)	400 KPa
Ultimate, unfactored compressive strength of intact basaltic bedrock	100 MPa
Ultimate unfactored tensile strength of rock mass on surface of cone based on excellent quality rock mass with minimum RQD=95%	200 kPa
Bulk unit weight of basaltic rock mass	25.9 KN/m^3
Ultimate, unfactored grout to rock bond stress (cementitious or plastic resin grout)	4.2 MPa
Recommended design depth to groundwater	>6m
Rock Quality Designation (RQD)	95%
Design cone apex angle	maximum 90 degrees
Seismic site class (NBCC 4.1.8.4)	A

Geotechnical resistance factors (Φ) of 0.5 for bearing and 0.4 for uplift resistance of rock anchors are recommended. In no case should the allowable (working) grout to rock bond design strength be greater than 1.4 MPa. The actual grout to rock bond strength should be verified on site with a sacrificial test anchor prior to installation and grouting of production anchors.

Plain bars should not be considered to develop bonding with the grout. The required grout strength and development length for bar to grout bond should be determined in accordance with the recommendations of the Canadian Portland Cement Association.

Rock anchor grout should be mixed and utilized in accordance with the grout manufacturer's directions. Grout strength should be verified by field testing in accordance with CSA A23.2. All drilled holes should be completely filled with grout following proof testing of the anchor bonds. All rock anchors should be proof loaded to 110% of the factored load under the review of Simpson Geotechnical Ltd. Although groundwater is not anticipated to be encountered during rock anchor installation, wet conditions may be encountered in the rock anchor drill holes from perched surface water, especially during periods of wet weather. Plastic resin grout should not be used in wet drill holes.

The prepared foundation subgrade and rock anchor proof loading should be reviewed by Simpson Geotechnical Ltd. prior to the placement of foundation concrete to verify conformance to the intent of the recommendations provided.

Communications Building

The building foundations should bear directly on approved, clean, essentially level, undisturbed and intact, basaltic bedrock. Footings bearing directly on a suitable bedrock surface may be designed in accordance with NBCC 2015 based on the geotechnical parameters provided below.

For Limit States Design, foundations may be designed based on an Ultimate (unfactored) Limit State (ULS) bearing resistance of 2000 KPa. A Serviceability Limit State (SLS) bearing resistance of 400 KPa may be used for the building, based on limiting total and differential settlement to less than 15mm.

Sliding resistance may be based on a friction angle of 32° between cast-in-place concrete footings and clean, sound, basaltic bedrock. Geotechnical resistance factors (Φ) of 0.5 for bearing and 0.8 for sliding are recommended. Additional sliding resistance, if needed, should be provided with reinforcing steel dowels grouted into the bedrock with a high strength non-shrink anchor grout to at least 300mm depth into the intact bedrock.

The site may be considered Site Class A in accordance with the 2015 National Building Code of Canada Section 4.1.8.4.

All footings should be located so that the smallest lateral clear distance between footings will be at least equal to the difference in their bearing elevations. A foundation drainage system is not considered to be warranted with the footings bearing directly on exposed and intact bedrock, unless required to prevent rainwater or snowmelt ingress into the building . Uplift resistance for the communications building, if required, should be provided with bonded rock anchors designed in accordance with geotechnical parameters provided above for the self-supported antenna tower.

SGL can assist in approving foundation subgrade and in determining rock anchor embedment length, if required.

MISCELLANEOUS

Ongoing creep and local instability of the fill material side slopes around the site should be expected, due to over-steep slopes, the unquantifiable potential for buried organic material to create low friction interfaces within the fill mass, and decay of organics in the fill mass reducing the volume of the fill mass over time. Consequently, the uncontrolled fill around the perimeter of the site should not be used for support of structures.

The well graded blast rock material free of organics may be used as levelling fill for the helipad when placed atop clean bedrock, provided that minor settlement of the fill is acceptable. Blast rock fill material for the helipad should be selected to be well graded, inorganic, and placed to create a tight-knit mass. Permanent side-slopes for blast rock fill material should be no steeper than 1:1 (45°).

CLOSURE

We appreciate the opportunity to provide our services on this project. Should you have any questions, please do not hesitate to contact us.

This report was prepared in accordance with our terms of engagement for the exclusive use of Canadian Coast Guard, Maritime and Civil Infrastructure and their appointed agents for the proposed Telegraph Cove (Mt. Collinson) site described above. Any use or reliance made on this report by an unauthorized third party is the responsibility of that third party. Contractors should make their own assessment of the property for the purposes of bidding on and performing work on the site.

This report has been prepared in accordance with standard geotechnical engineering practice. No other warranty is provided, either expressed or implied.

Yours truly,

Simpson Geotechnical Ltd.

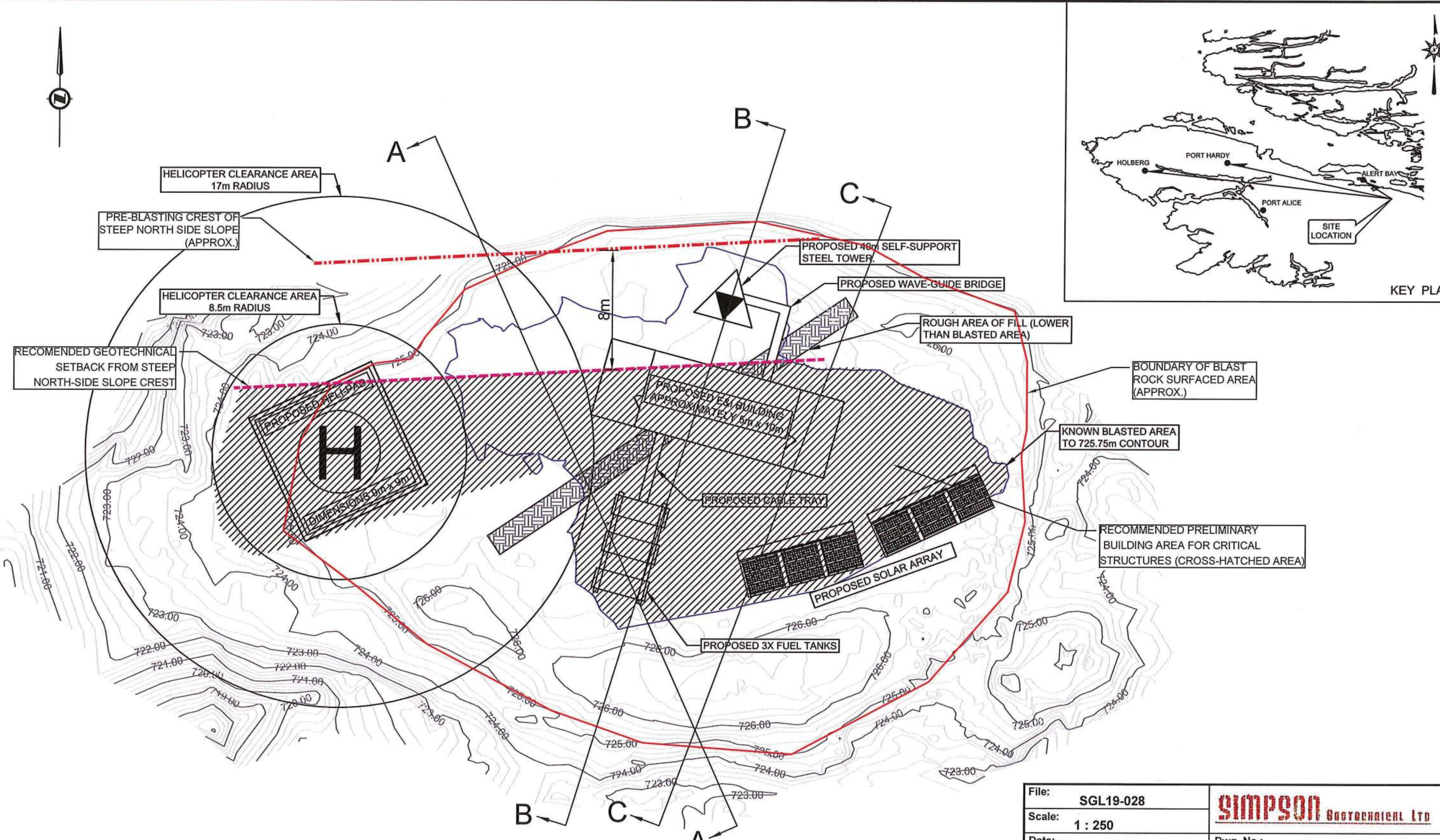
Per:

Richard Simpson, P.Eng. Nov 19, 2019

Attachments: Figure 1 – Site Location
Figure 2 – Topographic Site Plan
Figure 3 – Rock Anchor Uplift Capacity
Photo log
Seismic Hazard Calculation
ASTM C127 Relative Density Test Report

CAD PRODUCED DRAWING
PRODUIT PAR DAO

REPORT ANY ERRORS OR OMISSIONS TO ILS MANAGER
SIGNALER LES ERREURS OU LES OMISSIONS AU GESTIONNAIRE SLI



File: SGL19-028
Scale: 1 : 250
Date: November 19, 2019

SIMPSON GEOTECHNICAL LTD

Dwg. No.: Figure 1

Fisheries and Oceans Canada / Pêches et Océans Canada
Canadian Coast Guard / Garde côtière Canadienne

designed - conception	date	checked - vérifié	date
drawn - dessiné: BMR	2019-10-28	approved - approuvé	date
CCG ref. no. - no. réf. GCC: 19004 - 8B200 OPP		scale - échelle: AS SHOWN	

rev	description	by / par	Date
A	FOR REVIEW	BMR	2019-10-28

Asset - Actif
TELEGRAPH COVE (MT COLLINSON)
PROPOSED MCTS TOWER SITE

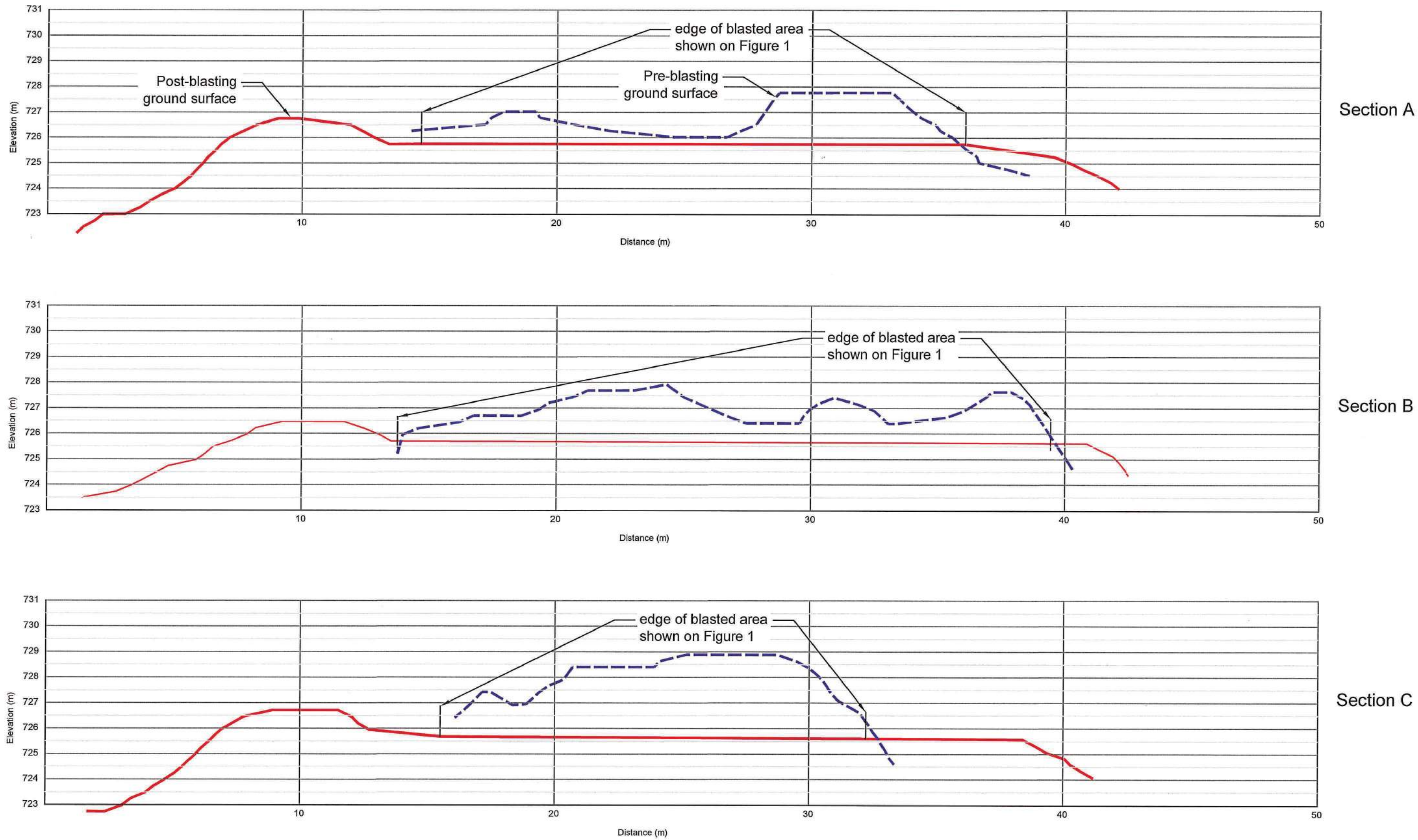
Drawing - Dessin
TELEGRAPH COVE (MT COLLINSON)
SITE LAYOUT PLAN - OPTION 1

drawing no. - no. dessin: WM-697-1001
sheet-feuille: 01/01
rev: A

WM-697-1001

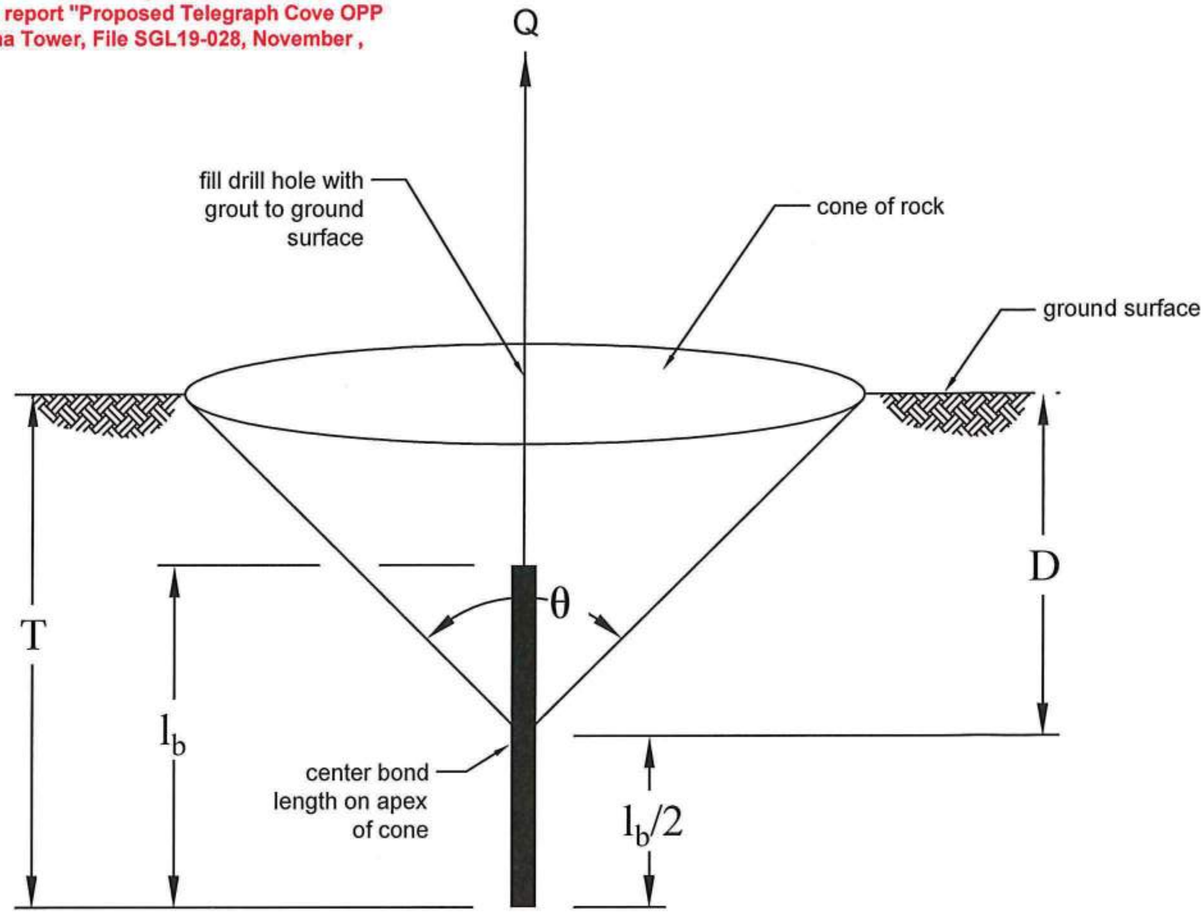
ANSI B

File / Fichier: WM-697-1001 TELEGRAPH COVE (MT COLLINSON) SITE LAYOUT PLAN.DWG - Printed / Imprimé: 2019/10/28 3:27



Project: Telegraph Cove MCTS (Mt. Collinson) Geotechnical Assessment	**File:** SGL19-028	SIMPSON GEOTECHNICAL LTD	Cross sections based on topography provided by Canadian Coast Guard.
Title: Cross Sections	**Scale:** 1 : 150		
Client: Canadian Coast Guard	**Date:** November 19, 2019	**Dwg. No.:** Figure 2	rev / description / by / date

This drawing is to be read in conjunction with Simpson Geotechnical Ltd. report "Proposed Telegraph Cove OPP Radar Site Antenna Tower, File SGL19-028, November , 2019



Where:

$$Q = \frac{f_{(r)} + w_C}{FS} \qquad f_{(r)} = \frac{\sigma_t \pi D^2}{\cos\frac{\theta}{2}} \qquad w_c = \frac{\pi}{3} D^3 \gamma_r$$

* reduce cone volume accordingly when uplift cone is truncated by local topography

$$T = D + \frac{l_b}{2} \qquad l_b = \frac{Q}{\pi d \tau_a}$$

- Q = vertical uplift capacity of rock anchor (kN)
- T = total depth of rock anchor (m)
- $f_{(r)}$ = resisting tensile force on surface of cone (kN)
- W_c = weight force of rock cone (kN)
- D = depth to apex of cone (m)
- θ = apex angle of cone (degrees)
- σ_t = working tensile strength on surface of cone (kPa)
- γ_r = unit weight of rock (kN/m³)
- l_b = bond length of anchor (m)
- τ_a = grout to rock working bond stress (kPa)
- d = drillhole diameter (m)
- FS = factor of safety applied to the load (minimum FS = 1.5 recomended)

Project: Proposed Telegraph Cove OPP Radar Site Antenna Tower			SIMPSON GEOTECHNICAL LTD
Title: Rock Anchor Uplift Capacity			
Client: Canadian Coast Guard			
File: SGL19-028	Drawn by: RRS	Scale: NTS	Date: November 19, 2019 — Dwg. No.: Figure 3

Photo 1 – Provided photo of site during clearing. General outline of bedrock surface can be seen, as well as crest of steep north-side slope. Stripped organics are being pushed into gully to southwest of cleared bedrock.

Photo 2 – Finished site surface looking westwards.

Photo 3 – Provided photo of steep bedrock slope on northern side of site currently covered with blast rock fill

Photo 4 – Similar location to Photo 3 (northwestern area of site) showing fill over crest of bedrock slope.

Photo 5 – Looking eastwards along northern side of site. Persistent bedrock discontinuities that generally parallel northern slope face are visible, as well as probable wedge of fill on north side slope crest.

Photo 6 – Gully at southwest corner of site filled with organics and capped with blast rock.

Photo 7 – Test excavation on north-central area of site showing over-blast (fractured bedrock that retains its intact structure) to at least 0.7m depth

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 50.528N 126.790W **User File Reference:** Mt Collinson, Telegraph Cove 2019-11-15 16:30 UT

Requested by: Simpson Geotechnical Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.308	0.230	0.176	0.088
Sa (0.1)	0.485	0.355	0.267	0.130
Sa (0.2)	0.625	0.464	0.354	0.178
Sa (0.3)	0.659	0.482	0.362	0.178
Sa (0.5)	0.629	0.446	0.324	0.145
Sa (1.0)	0.440	0.302	0.210	0.086
Sa (2.0)	0.278	0.183	0.120	0.043
Sa (5.0)	0.095	0.061	0.038	0.013
Sa (10.0)	0.034	0.021	0.014	0.005
PGA (g)	0.288	0.213	0.162	0.078
PGV (m/s)	0.528	0.361	0.248	0.090

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

SIMPSON GEOTECHNICAL LTD **ASTM C127 Relative Density**

Project Telegraph Cove MCTS (Mt. Collinson) **Project No.** SGL19-028

Client Canadian Coast Guard **Date** 14-Nov-19

Sample Location Site blast rock

Sample Description Basaltic

Pan No. F

Drying Start Time	Nov 12, 2019 0820hrs
Drying Stop Time	Nov 13, 2019 0910hrs
Sample Dry, 110° (**A**) g	1846.1 g
Soak Start Time	Nov 13, 2019 0917hrs
Soak Stop Time	Nov 14, 2019 1317hrs
Saturated Surface Dry 24 hour soak (**B**) g	1851.1 g
Water Temperature	23.3 ° C
Submerged Weight at 23° g (**C**)	1209.8 g
Relative Density (specific gravity) = A/(B-C)	2.88 g/cm^3
Absorption (%) = (B-A)/Ax100	0.27 %