Geotechnical Report

Sunshine Coast DFAA Sites – Day Road Site
near Sechelt, BC
Project # VG07794.500

Prepared for:

BC Ministry of Transportation and Infrastructure
Suite 310 – 1500 Woolridge Street
Coquitlam, BC V3K 0B8

Prepared by:

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11 October 2022

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11 October 2022

"Effective September 21, 2022, Wood Environment & Infrastructure Solutions Canada Limited is now operating as WSP E&I Canada Limited. No other aspects of our legal entity, contractual terms or capabilities have changed in relation to this report submission."

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1.0 Introduction

WSP E&I Canada Limited (WSP) is pleased to provide this geotechnical report to the British Columbia Ministry of Transportation and Infrastructure (MoTI) in support of the Sunshine Coast DFAA Sites – Day Road Site Project (the Project), near Sechelt, BC.

The purpose of this geotechnical report is to assist the Project team in advancing culvert replacement design at Gough Creek and Clack Creek on Day Road, including adjacent roadway embankment and pavement considerations.

This report is limited to the geotechnical aspects of the Project only and does not include provision of environmental, archaeological, hydrotechnical or other disciplines that may be required for the Project.

2.0 Project Background and Site Information

2.1 Project Background

WSP understands that in November 2021 an atmospheric river event occurred that caused flooding and washouts at two culvert locations (Gough Creek and Clack Creek) on Day Road, near Sechelt, BC. The culverts were initially replaced by emergency works crews following temporary remediation procedures. MoTI is currently seeking to replace the temporary culvert and embankment with permanent structures that meet current MoTI design standards. The permanent replacement works include new realigned culvert structures and new roadway embankment and pavement structure.

Based on our understanding of the permanent culvert replacement 50% Design Drawings, as provided by MoTI dated 26 May 2022, WSP understands that the culvert replacements will comprise:

- Gough Creek: 2.7 m × 2.7 m concrete box culvert with concrete headwalls.
- Clack Creek: 2.4 m × 2.4 m and 2.4 m × 2.4 m concrete box culverts with a single-spanning concrete headwall.
  - Top of concrete box culvert elevations to match.

The depths of the concrete box culverts have not been provided; however, WSP anticipates that the top elevation of the concrete box culverts will be buried at least 875 mm below finished roadway surface to allow for the minimum proposed pavement structure.

3.0 Geotechnical Investigation

3.1 Drilling Investigation

WSP conducted a geotechnical investigation at the two culvert sites on Day Road on 1 June 2022. The investigation comprised two boreholes, BH22-01 located at Gough Creek and BH22-02 located at Clack Creek, both situated on the existing roadway embankment and drilled to depths of approximately 6.1 m and 6.9 m respectively. The boreholes were advanced using a combination of solid stem auger through the upper overburden materials and air-rotary downhole hammer (ODEX) through coarse material and bedrock. The drilling work was conducted using a truck-mounted drill rig owned and operated by VanMars Drilling Ltd. The location of each borehole was measured relative to existing site features and by hand-held GPS typically accurate to within 5 m. Figure 1 attached shows to approximate borehole locations.

Prior to the subsurface investigation, WSP prepared a site-specific health and safety plan and a traffic management plan and communicated the details of the plan with our subcontractors. WSP also prepared and submitted an H1080 "Lane Closure Permit" application form that was accepted by MoTI's local area manager for work on roadways. Furthermore, WSP conducted a BC One Call to obtain existing subsurface utility information in the area of the proposed borehole locations and retained GeoScan Subsurface Surveys Inc. to conduct an on-site verification to clear the proposed borehole locations of underground utilities using ground penetrating radar and electromagnetic methods.

All field work was conducted under the supervision of a member of WSP's geotechnical staff who managed the health and safety of the site, directed subcontractors regarding the work, visually observed and recorded the subsurface soil, rock and groundwater conditions within the boreholes and obtained representative samples for further classification and laboratory testing. Water samples from the creek were also obtained for further analytical testing. Details of the conditions encountered are provided on the Summary Logs in Appendix A.

Upon completion of drilling the boreholes were backfilled with a combination of cuttings and bentonite seal in accordance with the British Columbia Groundwater Protection Regulations. The surface of each borehole was reinstated using local granular material.

3.2 Laboratory Testing

Laboratory testing was conducted on select samples obtained from the drilling investigation for further assessment and classification. Index testing (generally comprising moisture content and sieve analyses) was conducted by WSP at our Surrey laboratory. Chemical analysis testing of soils (generally comprising pH, chloride, sulphate and resistivity) and creek water (generally comprising pH and sulphate) were conducted by a third-party laboratory, namely CARO Analytical Services Ltd. of Richmond, BC.

Select laboratory testing results are summarized on the Summary Logs in Appendix A and detailed results are provided in Appendix B.

4.0 Site Conditions

4.1 Sources of Background Information

The following information was available to WSP for use in this report:

- *"Surficial Geology and Sand and Gravel Deposits of Sunshine Coast, Powell River and Campbell River Areas"* published by Province of British Columbia, Ministry of Mines and Petroleum Resources, dated 1977.
- *"Site Inspection Reports – Day Road at Clack Creek and Gough Creek – Culvert Inspections"* issued by Urban Systems Ltd., dated 18 January 2022.

4.2 Surface Conditions

WSP personnel visited the site on 4 March 2022 to observe the surface conditions.

Day Road in the area of the Project sites traverses generally east-west. It is constructed on an embankment spanning Clack Creek and Gough Creek, both of which flow through the embankment in culverts (corrugated steel pipe). The two culvert and creek sites are separated by approximately 250 m. Day Road varies in elevation along the east-west profile, dipping/undulating at the location of the creeks by several meters. Day Road is a gravel surfaced road, typical of MoTI low-volume roads.

The embankments at the creek locations stand at approximately 1.5 Horizontal to 1 Vertical (1.5H:1V) with some sloughed/over-steepened sections, standing at up to approximately 3 m to 5 m height above the creek beds. The exterior of the embankment slopes visually appeared to comprise imported material of boulders, cobbles, gravel and sand with little fines. It is understood that the embankment and roadway in the vicinity of the culverts were reconstructed during the initial restoration efforts. Bedrock was observed on the downstream outlet at Gough Creek on the east bank.

4.3 Subsurface Conditions

Based on the information obtained from the geotechnical investigation, the subsurface conditions from roadway embankment surface at Gough Creek and Clack Creek are described as follows:

Gough Creek:

Fills: Imported gravelly sand, trace silt extending to a depth of approximately 1.5 m. Inferred to be loose based on drilling observations.

Sand and Gravel: Natural sand and gravel trace silt extending to approximately 3.4 m depth. With inclusions of wood chunks and rootlets, moist to wet. Inferred to be compact to dense based on drilling observations. Likely Capilano Deposit origin.

Bedrock: Encountered at 3.4 m depth and extended to 6.1 m depth (borehole termination).

Groundwater: Observed at 2.4 depth based on standing water within the open borehole prior to backfilling. May not represent stabilized groundwater level.

Clack Creek:

Fills: Imported gravelly sand, trace silt extending to a depth of approximately 4.7 m. Inferred to be loose based on drilling observations.

Sand and Gravel: Natural sand and gravel trace silt extending to approximately 6.4 m depth. Inferred to be compact to dense based on drilling observations. Likely Capilano Deposit origin.

Bedrock: Encountered at 6.4 m depth and extended to 6.9 m depth (borehole termination).

Groundwater: Observed at 3.1 m depth based on standing water within the open borehole prior to backfilling. May not represent stabilized groundwater level.

4.3.1 Chemical Analysis of Soil and Water

Based on laboratory testing of samples obtained from BH22-01 (soil) and the adjacent creek (water) the following results are provided to guide other consultants and/or contractors in the concrete mix design and culvert selection for the headwalls and box culverts. Detailed results are provided in Appendix B.

The subsurface soil sample at this location has a pH of 5.15, sulfate ion content of < 0.050 %, a chloride ion content of 0.008 % and a resistivity of 62000 ohm-cm and the creek water sample at this location has a pH of 6.59, a sulfate ion content of < 1.0 mg/L, a chloride ion content of 0.48 mg/L, a resistivity of 93500 ohm-cm and a conductivity of 10.8 uS/cm.

5.0 Geotechnical Design Considerations

5.1 Seismic Considerations

WSP has conducted a site classification assessment following MoTI's Geotechnical Design Criteria (Technical Circular T-04/17) and the National Building Code of Canada (NBCC) 2015 using the subsurface soil conditions and inferred density based on drilling observations. The resultant Site Class has been assessed as:

- Site Class D: Average Standard Penetration Resistance $15 < N_{60} < 50$ in the upper 30 m of soil.

WSP obtained 2015 National Building Code of Canada (NBCC) seismic hazard values for the Project site from Natural Resources Canada's publicly available seismic hazard calculator. In accordance with MoTI's Supplement to the Canadian Highway Bridge Design Code S6-14, embankments for "other" route class are required to maintain stability during and following a 1-in-475 year seismic event.

Based on the seismic hazard values obtained, Table 1 below provides the 5% damped factored Site Class D values for the site under the design seismic conditions. Detailed seismic hazard values are provided in Appendix C for Site Class C (unfactored).

Table 1: Factored Site Class D 2015 National Building Code of Canada Seismic Hazard Values

Design Seismic Event	Peak Ground Horizontal Acceleration	Sa (0.2)	Sa (0.5)	Sa (1.0)	Sa (2.0)	Sa (5.0)
1-in-475 year (10% probability of exceedance in 50 years) – Site Class D Factored	0.209 g	0.474 g	0.498 g	0.286 g	0.169 g	0.043 g

Note:

Spectral accelerations (Sa(T)) indicate the period in which T = seconds.

Based on the soil, groundwater and bedrock conditions anticipated within the upper 30 m depth, WSP assesses the risk of liquefaction for this site to be low under typical drained conditions.

5.2 Geotechnical Parameters

Based on the subsurface conditions encountered, the geotechnical parameters for the materials to be used in design are provided in Table 2 below. The below parameters assume that any layers containing organics or deleterious material encountered below the embankment will be stripped prior to Type D fill placement.

Table 2: Anticipated Geotechnical Parameters

Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Local Type D Embankment Fill	19	34	0
Sand and Gravel Deposits	19	35	0
Class 50 kg Riprap	24	42	0

5.3 Material Re-Use

Based on the two boreholes conducted, the subsurface soil overlying bedrock (and anticipated within excavation depth) comprises generally mixed sands and gravels with trace silt. Occasional organics were observed within the native granular layer below the imported fills.

The subsurface soils are generally considered acceptable for re-use as local Type D embankment fill provided that all material containing organics (wood, roots, etc.) and/or deleterious material (garbage, debris, high-fines content soil) are separated out and not utilized in the Type D fills. All soils containing organics and/or deleterious material are not acceptable for re-use as Type D fill.

5.4 Roadway Embankments

Embankments have been assessed following the BC MoTI Supplement to CHBDC S6-14 for the following conditions:

- Degree of Understanding: Typical;
- Consequence Factor: Low; and
- Route Category: Other.

Based on the above degree of understanding, consequence factor and route category, the required factor of safety for embankments under static conditions is 1.45 and under seismic conditions is 1.10 (for 1-in-475-year ground motion). In conducting the seismic assessment, WSP utilized a peak ground horizontal acceleration of 0.209 g (factored for Site Class D) and horizontal seismic coefficient of 0.105 g (half of the full peak ground horizontal acceleration) to simulate the pseudo-seismic loading.

WSP has conducted a stability analysis using GeoStudio SlopeW 2021.3 for the typical embankment section at each creek using the 50% Design Drawings geometry, our visual field observations of site geometry and anticipated subsurface conditions/parameters. The typical sections include excavation and re-instatement of the roadway embankment using local Type D material (similar to that of the current in-situ fills encountered during the geotechnical investigation), overlying prepared subgrade comprising native sand and gravel deposits stripped of organics, with an embankment slope of 2H:1V. At the direction of the hydrotechnical consultant, a surfacing armoring of Class 50 kg Riprap of 1.5 m thickness at the at a 2H:1V slope is understood to be placed over the Type D embankment for scour protection. A robust non-woven geotextile separator should be placed over the Type D embankment and prior to riprap placement to act as a filter to mitigate soil migration.

The results of the analyses conducted are summarized in Table 3 below and detailed sections are provided in Appendix D.

Table 3: Embankment Stability Assessment Results

Culvert Location	Target Factor of Safety – Static	Design Factor of Safety – Static	Target Factor of Safety – Seismic	Design Factor of Safety – Seismic
Gough Creek	1.45	1.93	1.10	1.43
Clack Creek	1.45	1.65	1.10	1.30

Based on the results of the stability analyses, the proposed embankment configuration exceeds the required factors of safety. It is recommended that the embankments be constructed following the configuration outlined prior and be constructed in a manner consistent with the latest iteration of MoTI Standard Specifications (currently v2020), specifically SS201 – Roadway and Drainage Excavation, SS202 – Granular Surfacing, Base and Subbase and SS205 – Riprap.

5.5 Lateral Earth Pressures

Lateral earth pressures for buried structures have been calculated following Coulomb's (1776) earth pressure theory for cohesionless soils, adjusted for wall friction, non-horizontal backfill and non-vertical soil-wall interface per Mayniel (1908) and Müller-Breslau (1906).

WSP has assumed the following parameters for use in lateral earth pressure coefficient calculations:

- Φ (soil internal friction angle) = 34° (per Section 3.4);
- δ (wall-soil interface friction) = 0.5 * φ = 17° (for soil-concrete interface);
- β (backfill inclination angle) = 0°; and
- θ (camber of structure from horizontal) = 90°.

Based on the above assumptions the active static lateral earth pressure coefficient K_a = 0.26 and the passive static lateral earth pressure coefficient K_p = 3.24. The horizontal components of the earth pressure may then be calculated using the lateral earth pressure coefficients per the equations below, where z is the depth of burial in consideration and γ is the unit weight of the backfill (19 kN/m^3 per Section 3.4).

$$\sigma_a = K_a \gamma z cos\beta \text{ (active)}$$

and

$$\sigma_p = K_p \gamma z cos\beta \text{ (passive)}$$

Under seismic conditions, the dynamic lateral earth pressures may be calculated using the above formulae and K_{ae} and K_{pe} in lieu of K_a and K_p, respectively. Following the above assumptions, peak ground horizontal acceleration defined in Section 4.1 and following Mononobe-Okabe's (1929) dynamic earth pressure theory, the active dynamic lateral earth pressure coefficient K_{ae} = 0.32 and the passive dynamic lateral earth pressure coefficient K_{pe} = 2.97.

5.6 Concrete Headwalls

Based on the 50% Design Drawings, WSP estimates the concrete headwall at Gough Creek will be at least 3.3 m wide (2.7 m box culvert plus 0.3 m per side) and the concrete headwall at Clack Creek will be at least 5.7 m wide (2 x 2.4 box culverts with 0.3 m per side and between culverts). For calculation purposes, WSP assumed that the concrete headwalls will have a minimum length of 2.0 m (estimated from the 50% Design Drawing section details).

Based on the results of the geotechnical investigation, it is anticipated that the concrete headwalls will be situated on inferred compact to dense sand and gravel with little fines. This subgrade is considered competent for bearing subgrade assuming it is suitably prepared (e.g. stripped of organics, undisturbed, unsaturated, etc.) in accordance with the Standard Specifications. Deeper stripping may be required should organics or deleterious material (saturated, high-fines, debris or other) be encountered at this depth.

For levelling purposes, it may be necessary to over-excavate approximately 0.3 m and replace with 75 mm well-graded base (WGB) material compacted to 100% Standard Proctor Maximum Dry Density (SPMDD).

The preliminary soil bearing resistance has been assessed following the CHBDC S6-14 methods using a typical degree of understanding and the subsequent shallow foundation bearing resistance factor of 0.5. The resultant factored allowable bearing resistance of the subgrade is 100 kPa.

5.7 Pavement Structure

WSP has assessed the pavement structure requirements following MoTI Technical Circular T-01/15 *"Pavement Structure Design Guidelines"*. Traffic data was not available for Day Road at the time of preparing this report however, due to the assumed low volume traffic on Day Road, limited/infrequent use by heavy commercial vehicles and the roadway not leading to a subdivision, WSP recommends that the pavement design follow Type D typical pavement structure as outlined below.

Pavement Structure (from surface):

- Graded Aggregate Seal or High Fines Gravel Surface;
- 225 mm thickness of 25 mm Well-Graded Base Course (WGB); and
- 150 mm thickness of Select Granular Subbase (SGSB); and
- 500 mm thickness of Type D or SGSB.

Near-surface concrete box culverts underlying pavement structure tend to exacerbate transverse cracking of the surface course. This is due to the immediate transition between low stiffness subgrade and high stiffness concrete within the embankment, in which the soil immediately adjacent to the box culvert compresses under load and the concrete box culvert does not compress, resulting in a differential ground movement that propagates to surface. To mitigate this issue and for longevity of the pavement surface, it is recommended that an additional minimum thickness of 500 mm local Type D or SGSB fill be placed below the minimum 150 mm thick SGSB layer which will allow the pavement surface to compress or "flex" in better uniformity when traversing the concrete box culvert. Additional thickness of Type D or SGSB material below the SGSB will assist in improving the long-term performance and should be included where possible based on geometric constraints.

6.0 Closure

This report is subject to the attached limitations in Appendix E.

Recommendations and assessments presented herein are based on limited subsurface information.

This report has been prepared for the exclusive use of BC Ministry of Transportation and Infrastructure, for the specific application described herein. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. WSP E&I Canada Limited accepts no responsibility for damages suffered by any third party as a result of decisions made or actions based on this report.

Sincerely,

WSP E&I Canada Limited

Prepared by:

James Brunswick, P.Eng.
Senior Geotechnical Engineer

Reviewed by:

John Laxdal, P.Eng.
Principal Geotechnical Engineer

PERMIT TO PRACTICE
WSP E&I Canada Limited
Authorized By: James Brunswick
Signature:
Date: 11-Oct-2022
PERMIT NUMBER: 1004452
Engineers and Geoscientists
British Columbia

Figure 1 Site Plan

Legend

As-Drilled Borehole Location (Wood, 2022)

Note:
1. Stream network provided by BC Fresh Water Atlas.
2. Image provided by Bing Maps Aerial - © 2022 Microsoft Corporation © 2022 Maxar ©CNES (2022) Distribution Airbus DS.

CLIENT: BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

WSP E&I Canada Limited
111 Dunsmuir Street Suite 400
Vancouver, BC, CANADA V6B 5W3
Main: +1 604 664 4315

DWN BY: BB
CHK'D BY: JB
DATUM: NAD 83
PROJECTION: UTM Zone 10
SCALE: 1:2 000

TITLE: SITE PLAN

PROJECT: SUNSHINE COAST DFAA SITES
DAY ROAD SITE

DATE: JULY 2022
PROJECT NO.: VG07794.500
REV. NO.: 0

FIGURE 1

S:\External\VG07794-MoTI-SunshineCoast-DFAASite-CAD\VG07794.500-DayRoadSite-Fig1-SitePlan.dwg – 1 – Jul. 26, 2022 4:56pm – benjamin.brown2

This drawing was originally produced in colour.

Appendix A – Summary Logs

SUMMARY LOG

Drill Hole #: **BH22-01**

Ministry of Transportation and Infrastructure

Project: **Sunshine Coast DFAA Sites**

Location: Intersection of Gough Creek and Day Road

Prepared by: VG07794.500
WSP E&I Canada Ltd.

Logged by: SS Reviewed by: JB

Datum: UTM 10 Zone 10 Alignment: Day Road

Northing/Easting: 5476758 , 453816 Station/Offset:

Elevation:

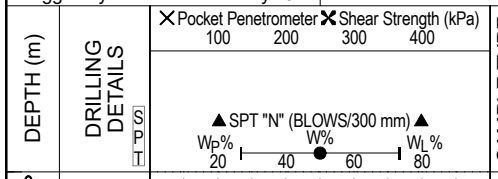
Date(s) Drilled: 6/1/2022

Company: VanMars Drilling Ltd.

Driller:

Drill Make/Model: Fraste ML

Drilling Method: Solid Stem Auger/ODEX



DEPTH (m)	DRILLING DETAILS	SPT	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION		CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
0		6.5		GS1			**(SP) SAND**, fine to medium grained, poorly graded, gravelly (fine to coarse, subrounded), trace silt, grey-brown, moist, loose [FILL]	0.0m	SP	Borehole was advanced using solid stem auger from ground surface to 3.2 m, and ODEX from 3.2 to 6.1 m.	0
1		6		GS2			...below 0.9 m, fine gravel, subangular				1
								1.5m			
2							**(SP) SAND & GRAVEL**, fine to medium grained, poorly graded, fine to coarse subrounded gravel, some silt, wood chunks, rootlets, brown, moist to wet, compact		SP-SM		2
	2.4m	10.1		GS3			…below 2.1 m, wet			**Sieve** (Sa#GS3) G:% S:% F:6%	
3							…at 3.4 m, auger refusal, switch to ODEX				3
								3.4m			
4				GS4			**BEDROCK** … below 3.4 m, slower drilling, small fractured angular rock chips and fine particles in ODEX cuttings, light brown		BR		4
5				GS5							5
6								6.1m			6
							End of borehole at 6.1 m. Following the extraction of ODEX casing, borehole was open to 5.3 m and ground water was 2.4 m below ground surface. Backfilled with bentonite chips from 5.3 to 0.9 m, and drill cuttings from 0.9 m to surface.				
7											7
8											8
9											9
10											

Legend Sample Type:
A-Auger, **B**-Becker, **C**-Core, **G**-Grab, **V**-Vane, **L#**-Lab Sample, **S**-Split Spoon, **O**-Odex (air rotary), **W**-Wash (mud return), **T**-Shelby Tube

Final Depth of Hole: 6.1 m
Depth to Top of Rock: 3.4 m

MOTI-SOIL-REV3 MOTI_DAY ROAD (PHASE 500).GPJ MOTI_DATATEMPLATE_REV3.GDT 6/21/22

SUMMARY LOG

Drill Hole #: **BH22-02**

Ministry of Transportation and Infrastructure

Project: **Sunshine Coast DFAA Sites**

Location: Intersection of Clack Creek and Day Road

Prepared by: VG07794.500
WSP E&I Canada Ltd.

Logged by: SS Reviewed by: JB

Datum: UTM 10 Zone 10 Alignment: Day Road

Northing/Easting: 5476758 , 454053 Station/Offset:

Elevation:

Date(s) Drilled: 6/1/2022

Company: VanMars Drilling Ltd.

Driller:

Drill Make/Model: Fraste ML

Drilling Method: Solid Stem Auger/ODEX

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); Wp% 20, W% 40 60, WL% 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							**(SP) SAND**, fine to medium grained, poorly graded, gravelly (subrounded), trace silt, brown, moist, loose [FILL]		Borehole was advanced using solid stem auger from ground surface to 1.7 m, and ODEX from 1.7 to 6.9 m.	0
1		5.3		GS1					**Sieve** (Sa#GS1) G:% S:% F:3%	1
2		8.1		GS2			…at 1.7 m, auger refusal, switch to ODEX … from 1.7 to 1.8 m, suspected cobble, slower drilling and angular rock chips …below 1.8 m, compact	SP		2
3	3.1m ▼						…below 3.0 m, increase in gravels, seepage			3
4		12.2		GS3						4
4.7m										
5		13.1		GS4			**(GP-GM) GRAVEL**, fine to coarse grained, poorly graded, sandy (fine to medium), some silt, brown-grey, wet, dense	GP-GM	**Sieve** (Sa#GS4) G:32% S:60% F:8% Note: GS4 sample is not representative of in-situ conditions	5
6										6
6.4m							**BEDROCK** … below 6.4 m, slower drilling, small fractured angular rock chips and fine particles in ODEX cuttings, light brown	BR		
6.9m							**End of borehole at 6.9 m**. Following the extraction of ODEX casing, borehole was open to 1.2 m. Backfilled with bentonite chips from 1.2 to 0.3 m, and drill cuttings from 0.3 m to surface.			7
7										
8										8
9										9
10										

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 6.9 m
Depth to Top of Rock: 6.4 m

MOTI-SOIL-REV3 MOTI_DAY ROAD (PHASE 500).GPJ MOTI_DATATEMPLATE_REV3.GDT 6/21/22

Appendix B – Laboratory Test Results

WSP E&I Canada Ltd.
#110 - 18568 - 96th Avenue
Surrey, British Columbia
Canada, V4N 3P9

MOISTURE CONTENT REPORT

Client: MOTI

Project Number: VG07794.500
Date: 6/20/2022

Project: MOTI SCR AAW - Sunshine Coast DFAA Sites
Lab no: L6787 - 1

Date Sampled : 6/1/2022
Sampled by: Soheil Sayedinazad

Date Tested : 6/13/2022
Tested by: Wenjing Ke

Hole #	Grab Sample	Depth (m)	Mass of Water (g)	Mass Dry Sample (g)	Moisture Content (%)	Remarks
BH22-01	G1	0.5	59.7	924.4	6.5%	
BH22-01	G2	1.1	17.4	290.2	6.0%	
BH22-01	G3	2.3	123.9	1231.7	10.1%	
BH22-02	G1	0.9	39.5	751.4	5.3%	
BH22-02	G2	2.1	22.1	272.5	8.1%	
BH22-02	G3	4.0	38.8	318.1	12.2%	
BH22-02	G4	5.2	49.8	379.8	13.1%	

Comments:

Reported by: Wenjing Ke

Reviewed by: [signature]
Scott Forsyth

WSP E&I Canada Ltd.
#110 - 18568 - 96th Avenue
Surrey, British Columbia
Canada, V4N 3P9

Materials Finer than 75-µm Sieve by Wash (ASTM C117)

Client: **MoTI**
Project: **MoTI SCR AAW - Sunshine Coast DFAA Sites**

Project Number: VG07794.500
Date: 2022/06/15
Lab No.: L6787-1

Date Sampled: 2022/06/01
Sampled by: Soheil Sayedinazad

Date Tested: 2022/06/13
Tested by: Wenjing Ke

Hole #	Grab Sample	Depth (m)	Material Finer than 75 µm (%)	Remarks
BH22-01	G3	2.3	6.2%	
BH22-02	G1	0.9	3.2%	
-	-	-	-	-

Comments:

Reported by: Wenjing Ke

Reviewed by: Scott Forsyth

Sieve Analysis

Report Date: June 21, 2022

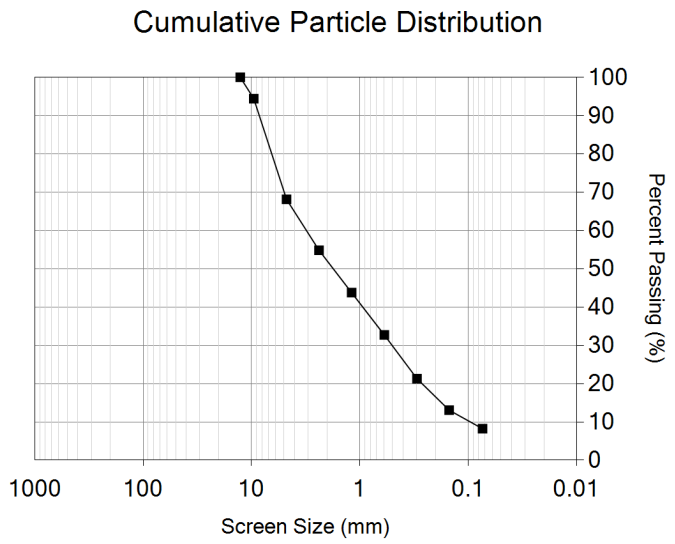
Client

Name: BC Ministry Of Transportation and Infrastructure
Address: 310 - 1500 Woolridge Street Coquitlam, BC V3K 0B8
Attention: Salem Bahamdun
PO Number:
Sample Date: 6/1/2022 by Soheil Sayedinazad
Source: BH22-02 G4 17'-18'

Project

Name: (VG07794) South Coast As and When
Address: 1500 Woolridge St, Coquitlam, BC
Phase: .500 **Task:**
Manager: Eric Mohlmann
Lab/Ref. #: BH22-02, G4

Type of Specification: No project specification was provided.



Sieve Analysis: (ASTM C117-17/C136-19)

200 Wash Procedure: A

Sieve Size	Passing	Specification Min	Specification Max
12.5mm	100%		
9.5mm	94%		
4.75mm	68%		
2.36mm	55%		
1.18mm	44%		
600µm	33%		
300µm	21%		
150µm	13%		
75µm	8.2%		

Moisture Content (%): 13.1% **(ASTM D2216-19)**

Particle Size (bold indicates value was interpolated)							
Over 3" / 76mm	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0%	0.0%	32.0%	**17.0%**	**25.0%**	**17.8%**	8.2%	

Remarks:

Distribution: Surrey, Wood

Reviewed By: Scott Forsyth, P.Eng.

Wood Environment & Infrastructure Solutions - #110 - 18568 - 96th Avenue - Surrey, BC - V4N 3P9 Canada
phone: (604) 219-1674

CERTIFICATE OF ANALYSIS

REPORTED TO	Wood Plc. (Vancouver) 400-111 Dunsmuir Street Vancouver, BC V6B 5W3		
ATTENTION	James Brunswick	**WORK ORDER**	22F1773
PO NUMBER	VE249979	**RECEIVED / TEMP**	2022-06-10 11:00 / 19.5°C
PROJECT	VG07794.500	**REPORTED**	2022-06-21 14:55
PROJECT INFO	Day Road	**COC NUMBER**	No #

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO/IEC 17025:2017 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at TeamCaro@caro.ca

Authorized By:

Team CARO
Client Service Representative

TEST RESULTS

REPORTED TO	Wood Plc. (Vancouver)	**WORK ORDER**	22F1773
PROJECT	VG07794.500	**REPORTED**	2022-06-21 14:55

Analyte	Result	RL	Units	Analyzed	Qualifier
BH22-01 Day Road (22F1773-01) | Matrix: Soil | Sampled: 2022-06-01					
General Parameters					
pH (1:1 H2O Solution)	**5.15**	0.10	pH units	2022-06-15	
Sulfate, Water-Soluble	< 0.050	0.050	%	2022-06-15	
Chloride, Water-Soluble	**0.008**	0.002	%	2022-06-17	
Resistivity	**62000**	100	ohm-cm	2022-06-20	
BH22-01 Day Road (22F1773-02) | Matrix: Water | Sampled: 2022-06-01					
Anions					
Chloride	**0.48**	0.10	mg/L	2022-06-15	
Sulfate	< 1.0	1.0	mg/L	2022-06-15	
General Parameters					
Conductivity (EC)	**10.8**	2.0	µS/cm	2022-06-18	
pH	**6.59**	0.10	pH units	2022-06-18	HT2
Resistivity	**93500**	10	ohm-cm	2022-06-21	

Sample Qualifiers:

HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Wood Plc. (Vancouver)	**WORK ORDER**	22F1773
PROJECT	VG07794.500	**REPORTED**	2022-06-21 14:55

Analysis Description	Method Ref.	Technique	Accredited	Location
Anions in Water	SM 4110 B (2017)	Ion Chromatography	✓	Kelowna
Chloride, Water Soluble in Soil	ASTM C1218-17	Hot Water Extraction / Hot Water Extraction		Richmond
Conductivity in Water	SM 2510 B (2017)	Conductivity Meter	✓	Kelowna
pH in Soil	AASHTO T289-91	1:1 Soil/Water Slurry / 1:1 Soil to Water Extraction, pH Meter		Richmond
pH in Water	SM 4500-H+ B (2017)	Electrometry	✓	Kelowna
Resistivity in Soil	AASHTO T288-91	Resistivity Meter		Sublet
Resistivity in Water	SM 2510 B (2017)	Conductivity Meter		Kelowna
Sulfate, Water-Soluble in Soil	CSA A23.2-3B / CSA A23.2-2B	Extraction (HCl) / Gravimetry (Barium Sulfate Precipitation)		Richmond

Glossary of Terms:

RL	Reporting Limit (default)
%	Percent
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
ohm-cm	Ohms-centimetre
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
AASHTO	American Association of State Highway and Transportation Officials, Methods of Sampling and Testing
ASTM	ASTM International Test Methods
CSA	Canadian Standards Association Chemical Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued or once samples expire, whichever comes first. Longer hold is possible if agreed to in writing.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:TeamCaro@caro.ca

Please note any regulatory guidelines applied to this report are added as a convenience to the client, at their request, to help provide some initial context to analytical results obtained. Although CARO makes every effort to ensure accuracy of the associated regulatory guideline(s) applied, the guidelines applied cannot be assumed to be correct due to a variety of factors and as such CARO Analytical Services assumes no liability or responsibility for the use of those guidelines to make any decisions. The original source of the regulation should be verified and a review of the guideline(s) should be validated as correct in order to make any decisions arising from the comparison of the analytical data obtained to the relevant regulatory guideline for one's particular circumstances. Further, CARO Analytical Services assumes no liability or responsibility for any loss attributed from the use of these guidelines in any way.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Wood Plc. (Vancouver)	**WORK ORDER**	22F1773
PROJECT	VG07794.500	**REPORTED**	2022-06-21 14:55

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B2F1783										
Blank (B2F1783-BLK1)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	< 0.10	0.10	mg/L							
Sulfate	< 1.0	1.0	mg/L							
Blank (B2F1783-BLK2)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	< 0.10	0.10	mg/L							
Sulfate	< 1.0	1.0	mg/L							
Blank (B2F1783-BLK3)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	< 0.10	0.10	mg/L							
Sulfate	< 1.0	1.0	mg/L							
LCS (B2F1783-BS1)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	16.1	0.10	mg/L	16.0		100	90-110			
Sulfate	15.9	1.0	mg/L	16.0		100	90-110			
LCS (B2F1783-BS2)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	16.0	0.10	mg/L	16.0		100	90-110			
Sulfate	15.9	1.0	mg/L	16.0		99	90-110			
LCS (B2F1783-BS3)				Prepared: 2022-06-15, Analyzed: 2022-06-15						
Chloride	16.0	0.10	mg/L	16.0		100	90-110			
Sulfate	15.8	1.0	mg/L	16.0		99	90-110			
General Parameters, Batch B2F1024										
Blank (B2F1024-BLK1)				Prepared: 2022-06-14, Analyzed: 2022-06-14						
Sulfate, Water-Soluble	< 0.050	0.050	%							
General Parameters, Batch B2F1882										
Blank (B2F1882-BLK1)				Prepared: 2022-06-15, Analyzed: 2022-06-17						
Chloride, Water-Soluble	< 0.002	0.002	%							
Duplicate (B2F1882-DUP1)				**Source: 22F1773-01**		Prepared: 2022-06-15, Analyzed: 2022-06-17				
Chloride, Water-Soluble	0.008	0.002	%		0.008					

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Wood Plc. (Vancouver)	**WORK ORDER**	22F1773
PROJECT	VG07794.500	**REPORTED**	2022-06-21 14:55

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B2F1933										
General Parameters, Batch B2F2356										
Reference (B2F2356-SRM1)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
pH	7.01	0.10	pH units	7.01		100	98-102			
Reference (B2F2356-SRM2)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
pH	7.00	0.10	pH units	7.01		100	98-102			
General Parameters, Batch B2F2387										
Blank (B2F2387-BLK1)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	< 2.0	2.0	µS/cm							
Blank (B2F2387-BLK2)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	< 2.0	2.0	µS/cm							
Blank (B2F2387-BLK3)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	< 2.0	2.0	µS/cm							
LCS (B2F2387-BS4)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	1350	2.0	µS/cm	1410		96	95-105			
LCS (B2F2387-BS5)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	1370	2.0	µS/cm	1410		97	95-105			
LCS (B2F2387-BS6)				Prepared: 2022-06-18, Analyzed: 2022-06-18						
Conductivity (EC)	1380	2.0	µS/cm	1410		98	95-105			

Appendix C – 2015 National Building Code of Canada Seismic Hazard Calculation

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: 49.442N 123.637W **User File Reference:** Day Road 2022-04-26 21:45 UT

Requested by: Wood E&IS

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)	0.446	0.309	0.221	0.095
Sa (0.1)	0.680	0.472	0.339	0.146
Sa (0.2)	0.840	0.591	0.426	0.183
Sa (0.3)	0.849	0.600	0.433	0.183
Sa (0.5)	0.757	0.527	0.376	0.151
Sa (1.0)	0.433	0.294	0.202	0.076
Sa (2.0)	0.264	0.174	0.116	0.041
Sa (5.0)	0.085	0.049	0.029	0.009
Sa (10.0)	0.030	0.017	0.010	0.004
PGA (g)	0.367	0.258	0.185	0.078
PGV (m/s)	0.558	0.378	0.259	0.094

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

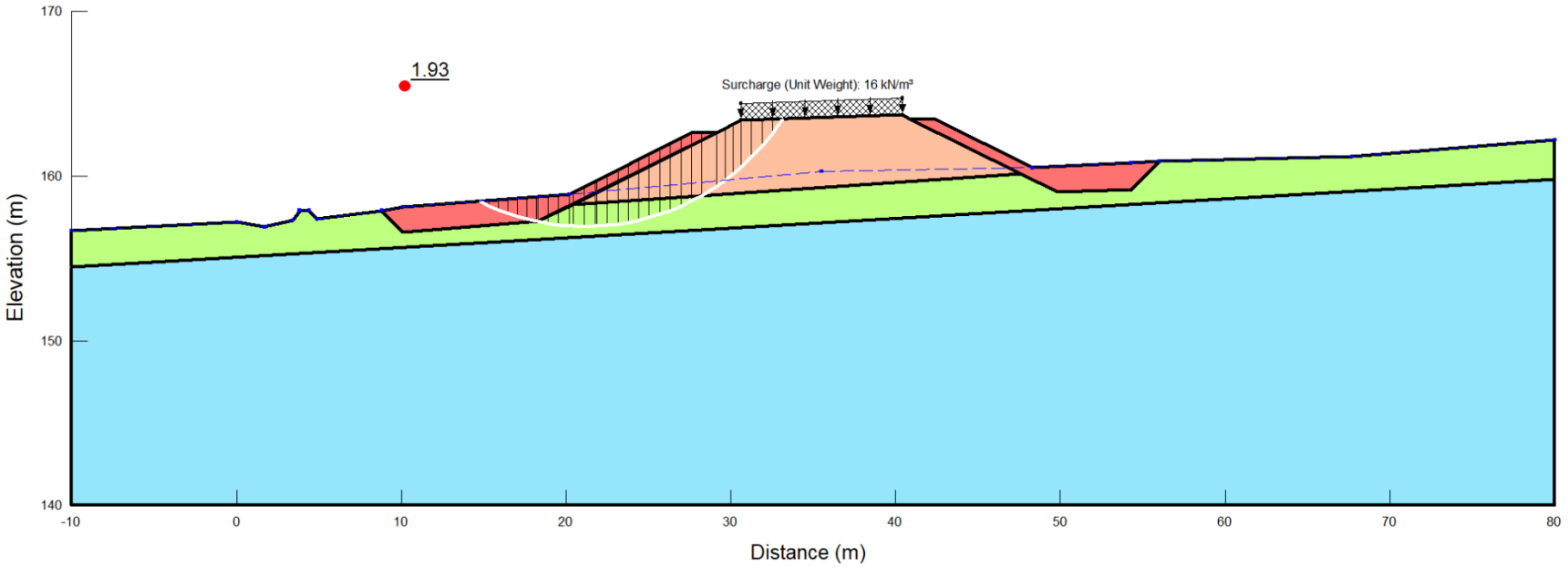
National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

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

Appendix D – Slope Stability Sections



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Class 50 kg Riprap	24	0	42
	Local Type D Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	35

CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

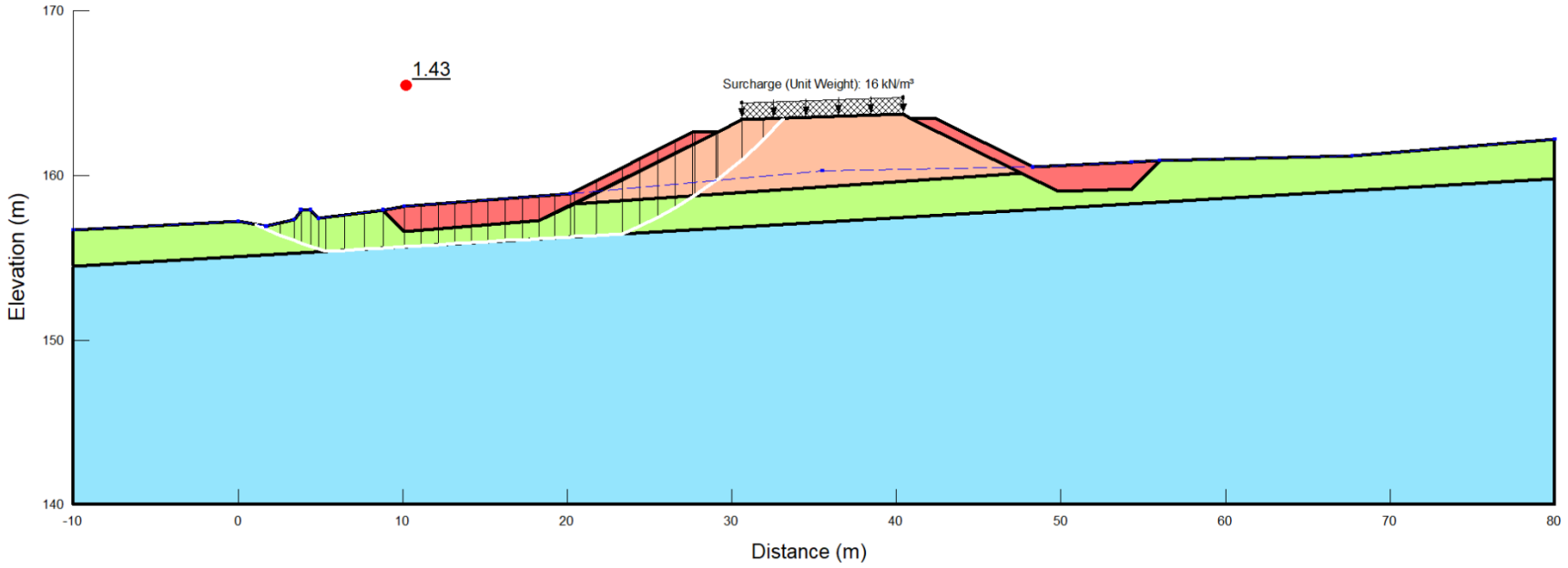
CONSULTANT
wsp

YYYY-MM-DD	2022-07-22
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

PROJECT
SUNSHINE COAST DFAA SITES – DAY ROAD

TITLE
CRITICAL SLOPE STABILITY MODEL
GOUGH CREEK – STATIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	500	0	D1



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Class 50 kg Riprap	24	0	42
	Local Type D Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	35

CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

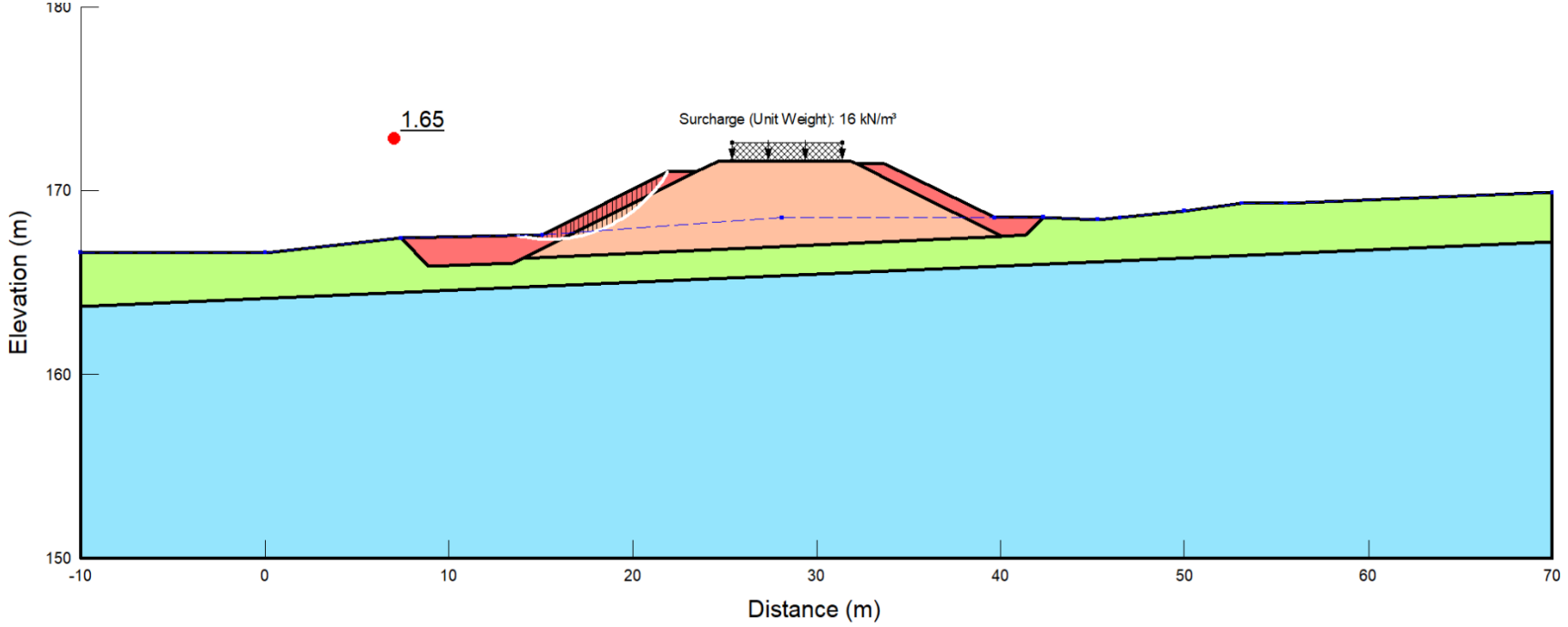
CONSULTANT
wsp

YYYY-MM-DD	2022-07-22
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

PROJECT
SUNSHINE COAST DFAA SITES – DAY ROAD

TITLE
CRITICAL SLOPE STABILITY MODEL
GOUGH CREEK – SEISMIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	500	0	D2



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Class 50 kg Riprap	24	0	42
	Local Type D Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	35

CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

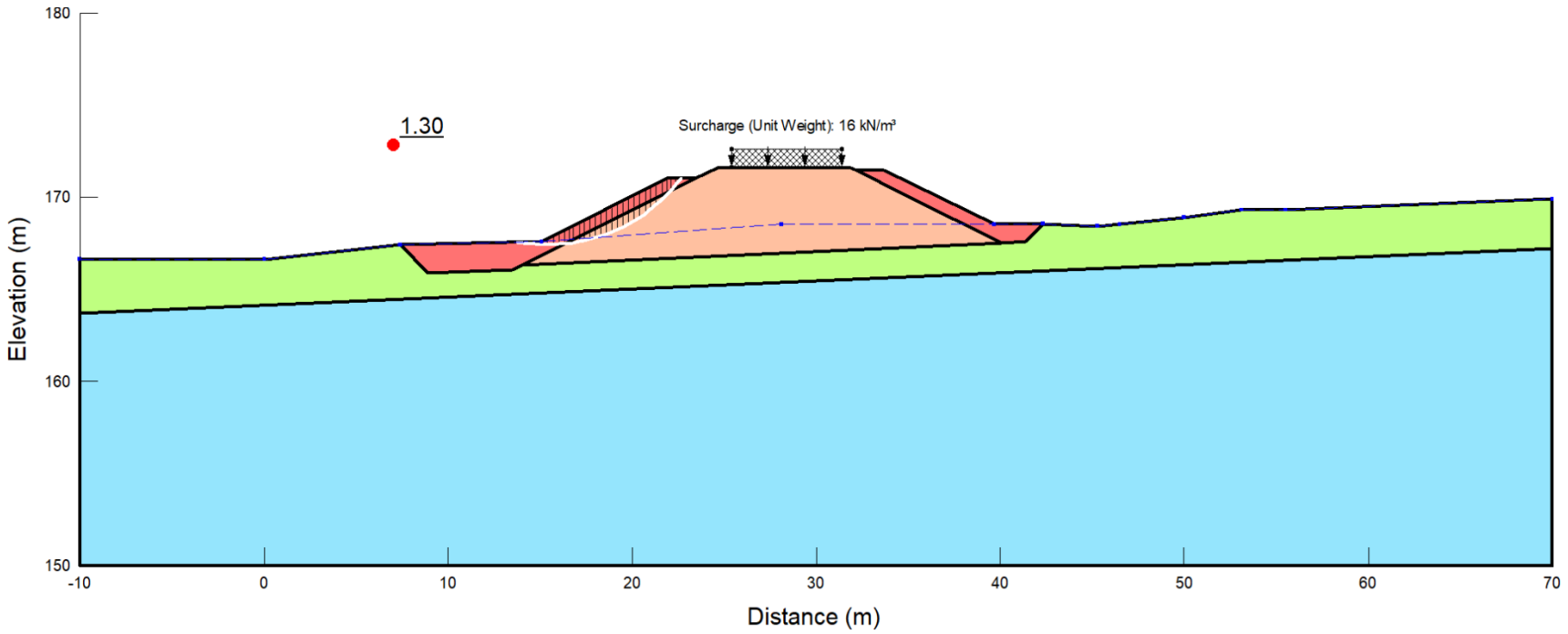
CONSULTANT
wsp

YYYY-MM-DD	2022-07-22
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

PROJECT
SUNSHINE COAST DFAA SITES – DAY ROAD

TITLE
CRITICAL SLOPE STABILITY MODEL
CLACK CREEK – STATIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	500	0	D3



Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock			
	Class 50 kg Riprap	24	0	42
	Local Type D Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	35

CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

CONSULTANT
wsp

YYYY-MM-DD	2022-07-22
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

PROJECT
SUNSHINE COAST DFAA SITES – DAY ROAD

TITLE
CRITICAL SLOPE STABILITY MODEL
CLACK CREEK – SEISMIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	500	0	D4

Appendix E – Limitations

Limitations

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:
   a) The contract between WSP and the Client, including any subsequent written amendment or Change Order duly signed by the parties (hereinafter together referred as the "Contract");
   b) Any and all time, budgetary, access and/or site disturbance, risk management preferences, constraints or restrictions as described in the contract, in this report, or in any subsequent communication sent by WSP to the Client in connection to the Contract; and
   c) The limitations stated herein.
2. **Standard of care:** WSP has prepared this report in a manner consistent with the level of skill and are ordinarily exercised by reputable members of WSP's profession, practicing in the same or similar locality at the time of performance, and subject to the time limits and physical constraints applicable to the scope of work, and terms and conditions for this assignment. No other warranty, guaranty, or representation, expressed or implied, is made or intended in this report, or in any other communication (oral or written) related to this project. The same are specifically disclaimed, including the implied warranties of merchantability and fitness for a particular purpose.
3. **Limited locations:** The information contained in this report is restricted to the site and structures evaluated by WSP and to the topics specifically discussed in it, and is not applicable to any other aspects, areas, or locations.
4. **Information utilized:** The information, conclusions and estimates contained in this report are based exclusively on: i) information available at the time of preparation, ii) the accuracy and completeness of data supplied by the Client or by third parties as instructed by the Client, and iii) the assumptions, conditions, and qualifications/limitations set forth in this report.
5. **Accuracy of information:** No attempt has been made to verify the accuracy of any information provided by the Client or third parties, except as specifically stated in this report (hereinafter "Supplied Data"). WSP cannot be held responsible for any loss or damage, of either contractual or extra-contractual nature, resulting from conclusions that are based upon reliance on the Supplied Data.
6. **Report interpretation:** This report must be read and interpreted in its entirety, as some sections could be inaccurately interpreted when taken individually or out-of-context. The contents of this report are based upon the conditions known and information provided as of the date of preparation. The text of the final version of this report supersedes any other previous versions produced by WSP.
7. **No legal representations:** WSP makes no representations whatsoever concerning the legal significance of its findings, or as to other legal matters touched on in this report, including but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel.
8. **Decrease in property value:** WSP shall not be responsible for any decrease, real or perceived, of the property or site's value or failure to complete a transaction, as a consequence of the information contained in this report.
9. **No third-party reliance:** This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or Contract. Any use or reproduction which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. WSP does not represent or warrant the accuracy, completeness, merchantability, fitness for purpose or usefulness of

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10. **Assumptions:** Where design recommendations are given in this report, they apply only if the project contemplated by the Client is constructed substantially in accordance with the details stated in this report. It is the sole responsibility of the Client to provide to WSP changes made in the project, including but not limited to, details in the design, conditions, engineering, or construction that could in any manner whatsoever impact the validity of the recommendations made in the report. WSP shall be entitled to additional compensation from Client to review and assess the effect of such changes to the project.
11. **Time dependence:** If the project contemplated by the Client is not undertaken within a period of 18 months following the submission of this report, or within the time frame understood by WSP to be contemplated by the Client at the commencement of WSP's assignment, and/or, if any changes are made, for example, to the elevation, design or nature of any development on the site, its size and configuration, the location of any development on the site and its orientation, the use of the site, performance criteria and the location of any physical infrastructure, the conclusions and recommendations presented herein should not be considered valid unless the impact of the said changes is evaluated by WSP, and the conclusions of the report are amended or are validated in writing accordingly.

    Advancements in the practice of geotechnical engineering, engineering geology and hydrogeology and changes in applicable regulations, standards, codes or criteria could impact the contents of the report, in which case, a supplementary report may be required. The requirements for such a review remain the sole responsibility of the Client or their agents.

    WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.
12. **Limitations of visual inspections:** Where conclusions and recommendations are given based on a visual inspection conducted by WSP, they relate only to the natural or man-made structures, slopes, etc. inspected at the time the site visit was performed. These conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in WSP's opinion, for direct observation.
13. **Limitations of site investigations:** Site exploration identifies specific subsurface conditions only at those points from which samples have been taken and only at the time of the site investigation. Site investigation programs are a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions.

    The data derived from the site investigation program and subsequent laboratory testing are interpreted by trained personnel and extrapolated across the site to form an inferred geological representation and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite this investigation, conditions between and beyond the borehole/test hole locations may differ from those encountered at the borehole/test hole locations and the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

    Final sub-surface/bore/profile logs are developed by geotechnical engineers based upon their interpretation of field logs and laboratory evaluation of field samples. Customarily, only the final bore/profile logs are included in geotechnical engineering reports.

Bedrock, soil properties and groundwater conditions can be significantly altered by environmental remediation and/or construction activities such as the use of heavy equipment or machinery, excavation, blasting, pile-driving or draining or other activities conducted either directly on site or on adjacent terrain. These properties can also be indirectly affected by exposure to unfavorable natural events or weather conditions, including freezing, drought, precipitation and snowmelt.

During construction, excavation is frequently undertaken which exposes the actual subsurface and groundwater conditions between and beyond the test locations, which may differ from those encountered at the test locations. It is recommended that WSP be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered at the test locations, that construction work has no negative impact on the geotechnical aspects of the design, to adjust recommendations in accordance with conditions as additional site information is gained, and to deal quickly with geotechnical considerations if they arise.

Interpretations and recommendations presented herein may not be valid if an adequate level of review or inspection by WSP is not provided during construction.

14. **Factors that may affect construction methods, costs and scheduling:** The performance of rock and soil materials during construction is greatly influenced by the means and methods of construction. Where comments are made relating to possible methods of construction, construction costs, construction techniques, sequencing, equipment or scheduling, they are intended only for the guidance of the project design professionals, and those responsible for construction monitoring. The number of test holes may not be sufficient to determine the local underground conditions between test locations that may affect construction costs, construction techniques, sequencing, equipment, scheduling, operational planning, etc.

    Any contractors bidding on or undertaking the works should draw their own conclusions as to how the subsurface and groundwater conditions may affect their work, based on their own investigations and interpretations of the factual soil data, groundwater observations, and other factual information.

15. **Groundwater and Dewatering:** WSP will accept no responsibility for the effects of drainage and/or dewatering measures if WSP has not been specifically consulted and involved in the design and monitoring of the drainage and/or dewatering system.

16. **Environmental and Hazardous Materials Aspects:** Unless otherwise stated, the information contained in this report in no way reflects on the environmental aspects of this project, since this aspect is beyond the Scope of Work and the Contract. Unless expressly included in the Scope of Work, this report specifically excludes the identification or interpretation of environmental conditions such as contamination, hazardous materials, wild life conditions, rare plants or archeology conditions that may affect use or design at the site. This report specifically excludes the investigation, detection, prevention or assessment of conditions that can contribute to moisture, mould or other microbial contaminant growth and/or other moisture related deterioration, such as corrosion, decay, rot in buildings or their surroundings. Any statements in this report or on the boring logs regarding odours, colours, and unusual or suspicious items or conditions are strictly for informational purposes.

17. **Sample Disposal:** WSP will dispose of all uncontaminated soil and rock samples after 30 days following the release of the final geotechnical report. Should the Client request that the samples be retained for a longer time, the Client will be billed for such storage at an agreed upon rate. Contaminated samples of soil, rock or groundwater are the property of the Client, and the Client will be responsible for the proper disposal of these samples, unless previously arranged for with WSP or a third party.