Geotechnical Site Assessment

Sunshine Coast DFAA Sites – Flume Creek Sites
near Sechelt, BC
WSP File: VG07794.700

Prepared for:

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

Prepared by:

WSP E&I Canada Limited
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T: 604-664-4315

09 February 2023

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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 – Flume Creek Sites Project (the Project), near Sechelt, BC.

The purpose of this geotechnical report is to assist the Project team in advancing culvert replacement design at Flume Creek on Beach Avenue and Margaret 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 event occurred that caused flooding and washouts at two culvert locations for Flume Creek on Margaret Road and Beach Avenue, 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 upgrades 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 2 December 2022, WSP expects the culvert replacements to comprise:

- Side-by-side concrete box culverts of 2.7 m x 1.5 m and 2.1 m x 1.2 m dimensions.
    - Culvert top and bottom elevations nominally offset at all inlets and outlets with a singular headwall encompassing both box culvert inlets and outlets.

The depths of the concrete box culverts have not been provided; however, WSP recommends that the top elevation of the concrete box culverts be buried at least 1075 mm to 1100 mm below finished roadway surface to allow for the minimum proposed pavement structure. Reduced burial depth may be considered where geometric constraints exist that limit the additional Suitable Type D or SGSB fill recommended in Section 5.8.

3.0 Geotechnical Investigation

3.1 Drilling Investigation

WSP conducted a geotechnical investigation at the two subject sites on May 31, 2022. One borehole (BH22-01) was advanced to 4.6 m on Beach Avenue near the existing culvert and one borehole (BH22-02) was advanced to 6.1 m on Margaret Road near the existing culvert location. The boreholes were advanced using solid stem auger. 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 the approximate borehole locations.

Prior to the subsurface investigation, WSP prepared a site-specific health and safety 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, Atterberg limits, hydrometer analysis, sieve analysis and organic content) 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 – Margaret Road and Beach Avenue – 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.

Margaret Road and Beach Avenue in the area of the Project sites traverse generally north-south and east-west, respectively. Margaret Road and Beach Avenue sites are separated by approximately 125 m and are constructed on a roadway embankment that spans Flume Creek at two separate locations, both of which flow through the embankments in culverts. Both Margaret Road and Beach Avenue are generally flat with respect to vertical alignment at the Project site locations and both roads are gravel surfaced, typical of MoTI low-volume roads.

At Margaret Road the embankment stands at approximately 1 Horizontal to 1 Vertical (1H:1V) and the exterior armoring comprises cobbles and boulders (riprap), extending from the crest of the slope to creek bed for a height of approximately 2 m to 3 m. There are currently three corrugated steel culverts under the embankment at this location, stacked in a triangular formation with a two-pipe base and one pipe above. There is visual evidence of geofabric situated above the culverts. Adjacent to the culvert outlets, the exposed embankment comprises silty sand and gravel, sub-angular to sub-rounded, with organics.

At Beach Avenue the embankment stands at approximately 1H:1V and the exterior armoring comprises cobbles and boulders (riprap), extending from the crest of the slope to creek bed for a height of approximately 2 m to 3 m. There are currently four corrugated steel culverts under the embankment at this location at approximately the same elevation, with visual evidence of geofabric situated above the culverts. Exposed banks and a nearby stockpile of excavated material, indicated to be from the repair efforts, comprises silty sand and gravel, sub-rounded, with organics.

4.3 Subsurface Conditions

Based on the information obtained from the geotechnical investigation, the subsurface conditions below the roadway embankment surface at Beach Avenue and Margaret Road are described as follows:

Beach Avenue:

Fills: Sandy gravel, trace silt extending to a depth of approximately 3.2 m. Below a depth of 1.5 m, organic material consisting of rootlets and topsoil was observed in the fill material. Inferred to be loose to compact based on drilling observations.

Silt: Silt**,** non-plastic, wet, and inferred to be very loose to loose based on drilling observations. Extending from 3.2 m to 4.6 m (termination of augerhole).

Seepage: Observed at a depth of 1.5 m during drilling. May not represent stabilized groundwater level.

Margaret Road:

Fills: Sand, some gravel, trace silt extending to a depth of 0.6 m, inferred to be loose to compact based on drilling observations.

Silt: Silt, non-plastic, wet, and inferred to be very loose to loose based on drilling observations. Extending from 0.6 m to 6.1 m (termination of augerhole).

Seepage: Observed at a depth of 1.2 m during drilling. May not represent stabilized groundwater level.

4.3.1 Groundwater

Groundwater was not observed within the open boreholes during our geotechnical investigation; however, seepage was observed at depths of 1.2 m and 1.5 m. The nearby watercourse water level at the time of the investigation was estimated to be approximately 1.5 m to 2.5 m below the borehole surface. Based on these observations, it is our opinion that groundwater may be encountered at depths of about 1.2 m or deeper.

4.3.2 Chemical Analysis of Soil and Water

Based on laboratory testing of samples obtained from BH22-02 (soil) and the adjacent creek (water) the following results are provided for 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 4.83, sulfate ion content of < 0.05 %, a chloride ion content of 0.004 % and a resistivity of 41,000 ohm-cm and the creek water sample at this location has a

pH of 7.41, a sulfate ion content of 1.6 mg/L, a chloride ion content of 2.96 mg/L, a resistivity of 22,800 ohm-cm and a conductivity of 42.5 uS/cm.

5.0 Geotechnical Design Considerations

5.1 Seismic Considerations

WSP has conducted a preliminary 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 observed during drilling. The resultant Site Class has been assessed as:

- Preliminary Site Class E: Average Standard Penetration Resistance N_{60} < 15 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 (MoTI Supplement to CHBDC 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 factored 5% damped Site Class E values for the site under the design seismic conditions. Detailed seismic hazard values are provided in Appendix A.

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

Design Seismic Event	Peak Ground Horizontal Acceleration	Sa (0.05)	Sa (0.1)	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)	0.282g	0.334g	0.483g	0.620g	0.653g	0.460g	0.244g	0.058g

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

Based on the soil and groundwater conditions anticipated within the upper 30 m depth, WSP assesses the risk of liquefaction for this site to be moderate. This liquefaction assessment is made based on experience with similar subsurface conditions and local sites – neither a simplified nor detail liquefaction assessment has been conducted due to the lack of subsurface data necessary to support calculations and due to limitations in our scope of work.

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 Suitable fill placement.

Table 2: Anticipated Geotechnical Parameters

Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Local Type D Suitable Embankment Fill	19	34	0
Silt Deposits	18	31	0
Class 50 kg Riprap	22	42	0

5.3 Material Re-Use

At Beach Avenue, the subsurface soil anticipated within excavation depth comprises sandy gravels with trace silt up to a depth of 1.5 m. Below 1.5 m this material includes organics extending to 3.2 m depth. Sandy silt was encountered below 3.2 m and extending to 4.6 m depth.

At Margaret Road, the subsurface soil anticipated within excavation depth comprises generally sand with some gravel and trace silt to 0.6 m depth. Below, a layer of silt with some sand and organics was observed extending from 0.6 m to 6.1 m depth.

The near-surface soils consisting of sandy gravel at Beach Avenue (generally extending to 1.5 m depth) and sand at Margaret Road (generally extending to 0.6 m depth) are considered acceptable for re-use as local Type D Suitable embankment fill provided that all subsurface soil containing organics (wood, roots, etc.) or deleterious material (garbage, debris, high-fines) are separated out and not utilized in the Type D fills.

Fine-grained silt layers below the above-mentioned sand and gravel soils are not considered acceptable for re-use as Type D Suitable fill within the embankment or for subgrade bearing but may be utilized as Type D material outside the embankment (for grading or landscaping). All soils containing organics and deleterious material are not acceptable for re-use as Type D Suitable 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 0.282 g (factored for Site Class E) and horizontal seismic coefficient of 0.141 g (half of the full peak ground horizontal acceleration) to simulate the pseudo-seismic loading.

WSP has conducted a stability analysis using GeoStudio SlopeW 2022.1 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 silt deposits stripped of organics, with an embankment slope of 2H:1V. Rip-rap channel armoring was utilized for basal scour protection on the inlet/outlet as shown in the design drawings. A traffic surcharge of 14.4 kN/m was utilized in the static assessment per CHBDC S6-14.

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
Flume Creek at Beach Ave	1.45	1.48	1.10	1.19
Flume Creek at Margaret Rd	1.45	1.45	1.10	1.16

Based on the results of the stability analyses, the proposed embankment configuration meets or 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°
- 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 5.1 and following Mononobe-Okabe's (1929) dynamic earth pressure theory, the active dynamic lateral earth pressure coefficient K_{ae} = 0.35 and the passive dynamic lateral earth pressure coefficient K_{pe} = 2.87.

5.6 Concrete Headwalls

Based on the 50% Design Drawings, WSP estimates the concrete headwall at Flume Creek will be at least 4.8 m wide (side-by-side 2.7 m and 2.1 m box 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 very loose to loose silt deposits. This subgrade is considered poor for bearing subgrade and a minimum thickness of 0.5 m of these deposits should be removed underlying the headwall footing, extending up from the excavation base perimeter at a 1H:1V slope, and replaced with 75 mm well-graded base (WGB) material compacted to 100% Standard Proctor Maximum Dry Density (SPMDD). The underlying silt subgrade should be 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.

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. Should the recommended 0.5 m of compacted WGB not be placed underlying the headwall footing, the bearing resistance will be significantly reduced.

5.7 Temporary Cut Slopes and Drainage

Temporary excavations greater than 1.2 m in depth and steeper than 3/4H:1V requiring worker entry must be shored or flattened in accordance with WorkSafeBC regulations. Temporary slope design is the contractor's responsibility. Should groundwater or surface water inflows soften/loosen the overburden material, flatter slopes may be required. For preliminary purposes, a typical side slope of approximately 1H:1V may be assumed in the overburden material; however, actual temporary excavation side slopes should be determined based on the depth and soil/groundwater conditions encountered and reviewed by a qualified geotechnical engineer.

Temporary site drainage may be required for excavation and should be assessed by the contractor in relation to excavation depth, construction methodology, schedule and anticipated groundwater depth and seasonal rainfall. Accumulation of surface water should be anticipated during periods of wet weather and significant inflow of groundwater should be anticipated at approximately 1.2 m depth based on the geotechnical site investigation data. Perched water may also be present within the fills and overlying the fine-grained deposits anticipated within typical excavation depths.

5.8 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 Margaret Road and Beach Avenue at the time of preparing this report however, due to the assumed low volume traffic on these roads, limited/infrequent use by heavy commercial vehicles and the roadway not leading to a subdivision, WSP recommends that the pavement design follow Type C typical pavement structure as outlined below.

Pavement Structure (from surface):

- 50 mm to 75 mm of Asphalt;
- 225 mm thickness of 25 mm Crushed Base Course (CBC); and
- 300 mm thickness of Select Granular Subbase (SGSB); and
- 500 mm thickness of Type D Suitable 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 Suitable Type D or SGSB fill be placed below the minimum 300 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 Suitable 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

Figure 1 Site Plan

Legend

As-Drilled Test Hole Location (WSP, 2022)

Note:
1. Image provided by Bing Maps Aerial - © 2022 Microsoft Corporation © 2022 Maxar ©CNES (2022) Distribution Airbus DS.

CLIENT: BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

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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
FLUME CREEK SITE

DATE:	FEBRUARY 2023
PROJECT NO.:	VG07794.700
REV. NO.:	0

FIGURE 1

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: Roberts Creek, BC

Prepared by: VG07794.700
WSP E&I Canada Inc.

Logged by: SS Reviewed by: JB

Datum: UTM 10 Zone 10 Alignment: Beach Ave

Northing/Easting: 5475522 , 451436 Station/Offset: NA

Elevation: NA

Date(s) Drilled: 5/31/2022

Company: VanMars Drilling Ltd.

Driller: -

Drill Make/Model: Fraste ML

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) W_P % 20 W % 40 60 W_L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							0.0m sandy GRAVEL, fine to coarse, sub-rounded gravel, fine to medium sand, trace silt, grey-brown, moist, loose to compact. [FILL]			0
1		4.7		GS1						1
	1.5m						… below 1.5 m, rootlets, dark brown, wet	GP		
2	Solid Stem Auger	13.2		GS2					**Sieve** (Sa#GS2) G:% S:% F:3%	2
3							3.2m sandy SILT, non-plastic, fine sand, light grey, wet, very loose to loose.			3
4		26.4		GS3				ML	**Sieve** (Sa#GS3) G:0% S:28% F:72% Clay:15% Silt:58%	4
							4.6m Target depth at 4.6 m. Standing water observed in open borehole at 1.5 m depth. Sloughed to 1.5 m depth. Backfilled with bentonite chips and drill cuttings.			
5										5
6										6
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: 4.6 m
Depth to Top of Rock: NA

MOTI-SOIL-REV3 MOTI_MARGARET & BEACH (PHASE 700).GPJ MOTI_DATATEMPLATE_REV3.GDT 2/7/23

SUMMARY LOG

Drill Hole #: **BH22-02**

Ministry of Transportation and Infrastructure

Project: **Sunshine Coast DFAA Sites**

Location: Roberts Creek, BC

Prepared by: VG07794.700
WSP E&I Canada Inc.

Logged by: SS Reviewed by: JB

Datum: UTM 10 Zone 10 Alignment: Margaret Rd

Northing/Easting: 5475649 , 451477 Station/Offset: NA

Elevation: NA

Date(s) Drilled: 5/31/2022

Company: VanMars Drilling Ltd.

Driller: -

Drill Make/Model: Fraste ML

Drilling Method: Solid Stem Auger

DEPTH (m)	DRILLING DETAILS	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400 / SPT "N" (BLOWS/300 mm) W_P % 20 W % 40 60 W_L % 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate {G % S % F %}	DEPTH (m)
0							0.0m SAND, fine to medium, some fine to coarse gravel, trace silt, beige, moist, loose to compact. [FILL]	SP		0
							0.6m SILT, non-plastic, some fine sand, some fine gravel, brown-grey, with organics (rootlets and wood debris), moist, loose.			
1		23.3		GS1			... at 1.2 m, seepage observed in open hole		Note: GS1 Organic Matter: 6.3%	1
	1.2m									
2							…below 1.8 m, increase in wood debris (larger pieces)	ML		2
		45.6		GS2						
3	Solid Stem Auger									3
							3.66m SILT, non-plastic, some fine sand, light grey, wet, very loose to loose.			
4		30.9		GS3						4
5								ML		5
6							6.1m Target depth at 6.1 m. Seepage observed at 1.2 m depth. Sloughed to 1.1 m depth. Backfilled with bentonite chips and drill cuttings.			6
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: NA

MOTI-SOIL-REV3 MOTI_MARGARET & BEACH (PHASE 700).GPJ MOTI_DATATEMPLATE_REV3.GDT 2/7/23

Appendix B – Laboratory Test Results

Wood Environment & Infrastructure Solutions
#110 - 18568 - 96th Avenue
Surrey, British Columbia
Canada, V4N 3P9

wood.

MOISTURE CONTENT REPORT

Client: MOTI

Project Number: VG07794.700
Date: 6/20/2022

Project: MOTI SCR AAW - Sunshine Coast DFAA Sites
Lab no: L6787 - 3

Date Sampled : 5/31/2022
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	0.9	55.2	1166.1	4.7%	
BH22-01	G2	2.1	123.0	928.9	13.2%	
BH22-01	G3	3.7	16.2	61.3	26.4%	
BH22-02	G1	0.9	61.4	263.0	23.3%	
BH22-02	G2	2.1	128.4	281.8	45.6%	
BH22-02	G3	3.7	17.6	56.9	30.9%	

Comments:

Reported by: Wenjing Ke

Reviewed by: [signature]
Scott Forsyth, P.Eng.

Reporting of these test results constitutes a testing services only. Engineering interpretation or evaluation of these test results is provided only on written request. The data presented is for the sole use of the client stipulated above.

Wood Environment & Infrastructure Solutions
#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: VG07794.700
Date: 2022/06/15
Lab No.: L6787-3

Date Sampled: 2022/05/31
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	G2	2.1	2.9%	
-	-	-	-	-

Comments:

Reported by: Wenjing Ke

Reviewed by: Scott Forsyth

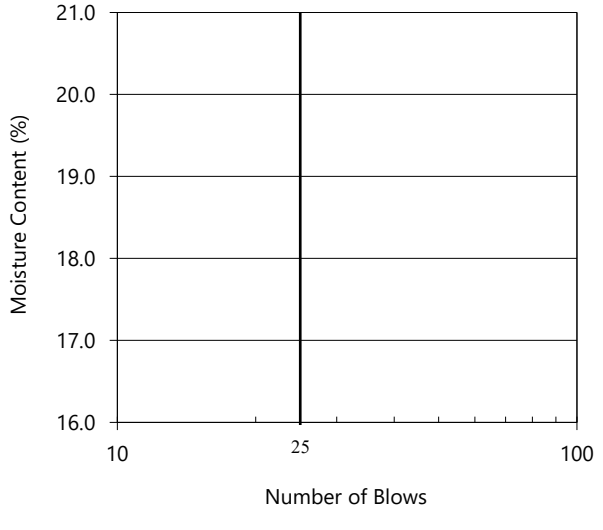
Atterberg Limits Test (ASTM D4318 - wet method)

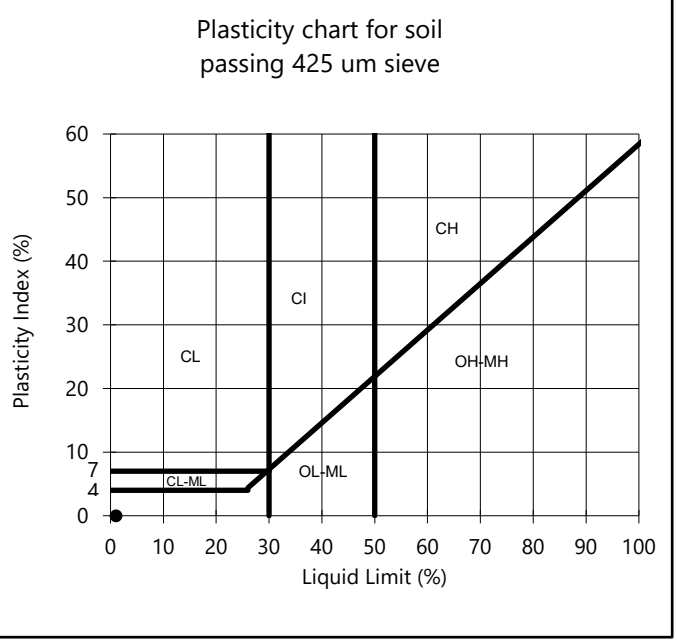
Wood Environment & Infrastructure Solutions

a Division of Wood Canada Limited

Client: MoTI
Project No: VG07794-700
Project: MoTI SCR AAW - Sunshine Coast DFAA Sites
Sample ID: BH22-01, G3 @ 12'-13'
Date: 15-Jun-22
Technician: WK

Liquid Limit Test				Plastic Limit Test		
# of Blows	-	-	-		-	-
Tare #	-	-	-	Tare #	-	-
Wet Wt + Tare	-	-	-	Wet Wt + Tare	-	-
Dry Wt + Tare	-	-	-	Dry Wt + Tare	-	-
Wt of Tare	-	-	-	Wt of Tare	-	-
% Moisture	-	-	-	% Moisture	-	-





Liquid Limit : - **Plastic Limit :** - **Plasticity Index :** -

Classification : Non-Plastic **Reviewed By :** Scott Forsyth

GRAIN SIZE DISTRIBUTION

ASTM D7928

Client: BC Ministy of Transportation and Infratucture
1500 Woolridge St.
Coquitlam, BC

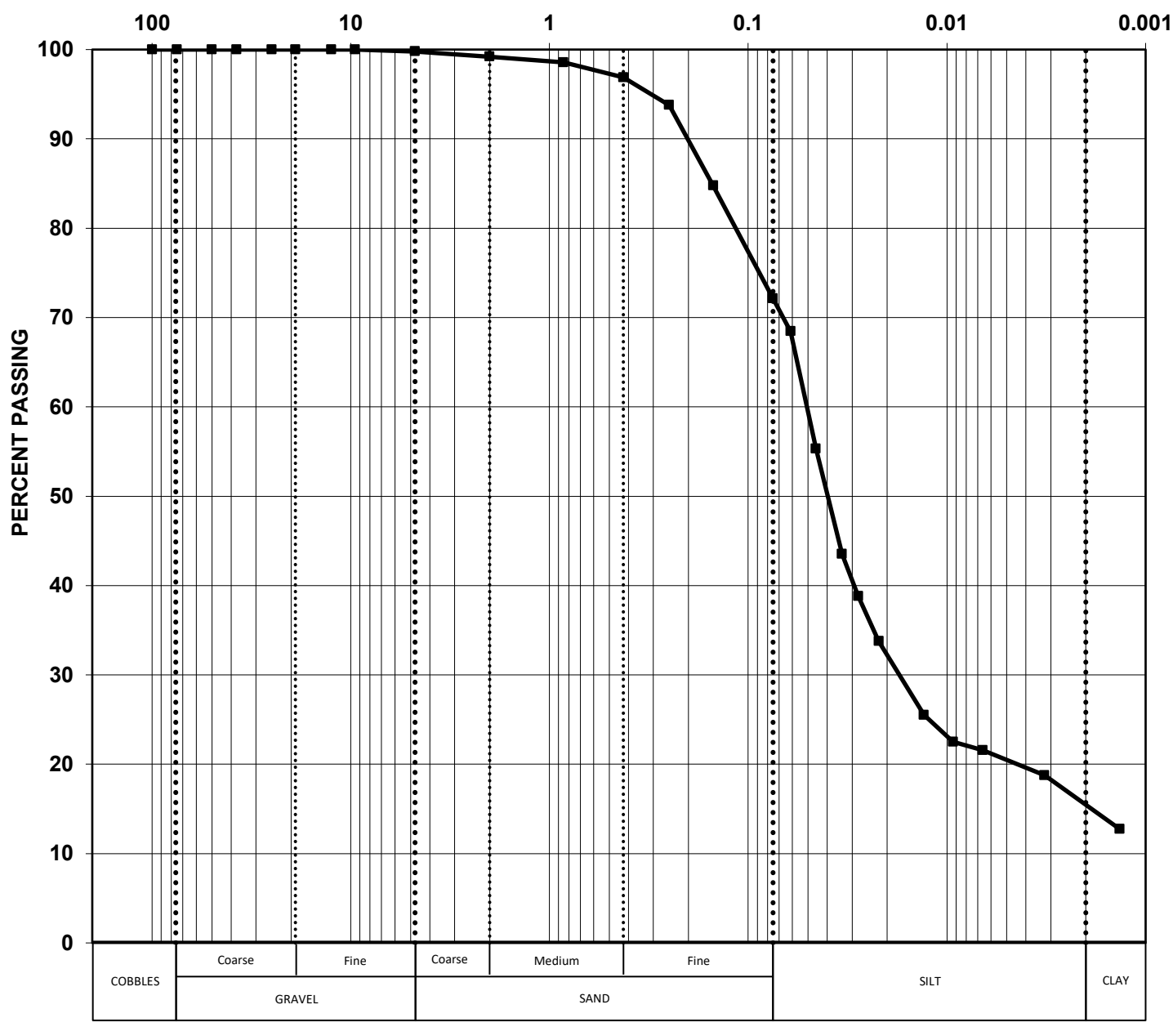
PROJECT: VG07794.700
OFFICE: Surrey, BC
TECHNICIAN: Wenjing Ke
DATE: 2022-06-15

PROJECT NAME: MoTI SCR AAW - Sunshine Coast DFAA Sites

LAB NUMBER: L6787-3
SAMPLED BY: Soheil Sayedinazad

SAMPLE NUMBER: G3
DATE SAMPLED: 2022-05-31

SAMPLE LOCATION: Flume Creek, BH22-01, 12'-13'
DATE TESTED: 2022-06-14



SUMMARY

Grain size (mm)	Passing (%)
100.0	100.0
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
12.50	100.0
9.50	100.0
4.75	99.8
2.00	99.2
0.850	98.6
0.425	96.9
0.250	93.8
0.150	84.8
0.075	72.1
0.0612	68.5
0.0456	55.3
0.0337	43.5
0.0279	38.8
0.0220	33.8
0.0131	25.5
0.0093	22.5
0.0066	21.6
0.0032	18.8
0.0014	12.8

GRAVEL=	**0.2%**
SAND =	**27.7%**
SILT =	**57.6%**
CLAY =	**14.6%**

Moisture =	**4.5%**

COMMENTS:

D10 =	**N/A**
D30 =	**0.017**
D60 =	**0.051**

Reported by: Wenjing Ke

Reviewed by: Scott Forsyth

CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Wood Environment & Infrastructure Solutions
#110 - 18568 - 96th Avenue
Surrey British Columbia
Canada, V4N 3P9

Organic Content Report
ASTM D 2974

Project No:	VG07794.700	**Project:**	MoTI SCR AAW - Sunshine Coast DFAA Sites
Client:	MoTI	**Report Date:**	6/15/2022
Date Sampled:	5/31/2022	**Source:**	Flume Creek
Tested by:	Wenjing Ke	**Date Tested:**	6/14/2022

Test Hole	**BH22-02**	-
Sample I.D	G1	-
Depth (m)	0.9	-
% Moisture Content	23.3	-
% Ash Content	93.7	-
% Organic Matter	6.3	-

Comments:
- Organic content tests were conducted in accordance with ASTM D 2974, Test Method A.
- Oven temperature for moisture content was 110 °C and for organic matter was 440 °C.
- Ash Content is the percentage by dry weight of materials remaining after an oven dry organic soil or peat is burned by a prescribed method.

Reported by: Wenjing Ke

Reviewed by: Scott Forsyth

CERTIFICATE OF ANALYSIS

REPORTED TO	Wood Plc. (Vancouver) 400-111 Dunsmuir Street Vancouver, BC V6B 5W3		
ATTENTION	James Brunswick	**WORK ORDER**	22F1771
PO NUMBER	VE249979	**RECEIVED / TEMP**	2022-06-10 11:00 / 19.5°C
PROJECT	VG07794.700	**REPORTED**	2022-06-21 14:56
PROJECT INFO	Flume Creek	**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**	22F1771
PROJECT	VG07794.700	**REPORTED**	2022-06-21 14:56

Analyte	Result	RL	Units	Analyzed	Qualifier
BH22-02 Flume Creek (22F1771-01) | Matrix: Soil | Sampled: 2022-06-10					
General Parameters					
pH (1:1 H2O Solution)	**4.83**	0.10	pH units	2022-06-15	
Sulfate, Water-Soluble	< 0.050	0.050	%	2022-06-15	
Chloride, Water-Soluble	**0.004**	0.002	%	2022-06-17	
Resistivity	**41000**	100	ohm-cm	2022-06-20	
BH22-02 Flume Creek (22F1771-02) | Matrix: Water | Sampled: 2022-06-10					
Anions					
Chloride	**2.96**	0.10	mg/L	2022-06-15	
Sulfate	**1.6**	1.0	mg/L	2022-06-15	
General Parameters					
Conductivity (EC)	**42.5**	2.0	µS/cm	2022-06-18	
pH	**7.41**	0.10	pH units	2022-06-18	HT2
Resistivity	**22800**	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**	22F1771
PROJECT	VG07794.700	**REPORTED**	2022-06-21 14:56

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**	22F1771
PROJECT	VG07794.700	**REPORTED**	2022-06-21 14:56

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	%							
General Parameters, Batch B2F1933										

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Wood Plc. (Vancouver)	**WORK ORDER**	22F1771
PROJECT	VG07794.700	**REPORTED**	2022-06-21 14:56

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
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: 49.430N 123.670W **User File Reference:** Flume Creek 2022-06-14 21:10 UT

Requested by: Wood Environment& Infrastructure Solutions

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)	0.452	0.314	0.225	0.097
Sa (0.1)	0.689	0.479	0.345	0.148
Sa (0.2)	0.852	0.600	0.433	0.186
Sa (0.3)	0.862	0.611	0.440	0.186
Sa (0.5)	0.770	0.537	0.382	0.153
Sa (1.0)	0.441	0.300	0.205	0.077
Sa (2.0)	0.269	0.177	0.118	0.042
Sa (5.0)	0.086	0.050	0.029	0.010
Sa (10.0)	0.031	0.018	0.010	0.004
PGA (g)	0.372	0.262	0.188	0.080
PGV (m/s)	0.568	0.384	0.263	0.095

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

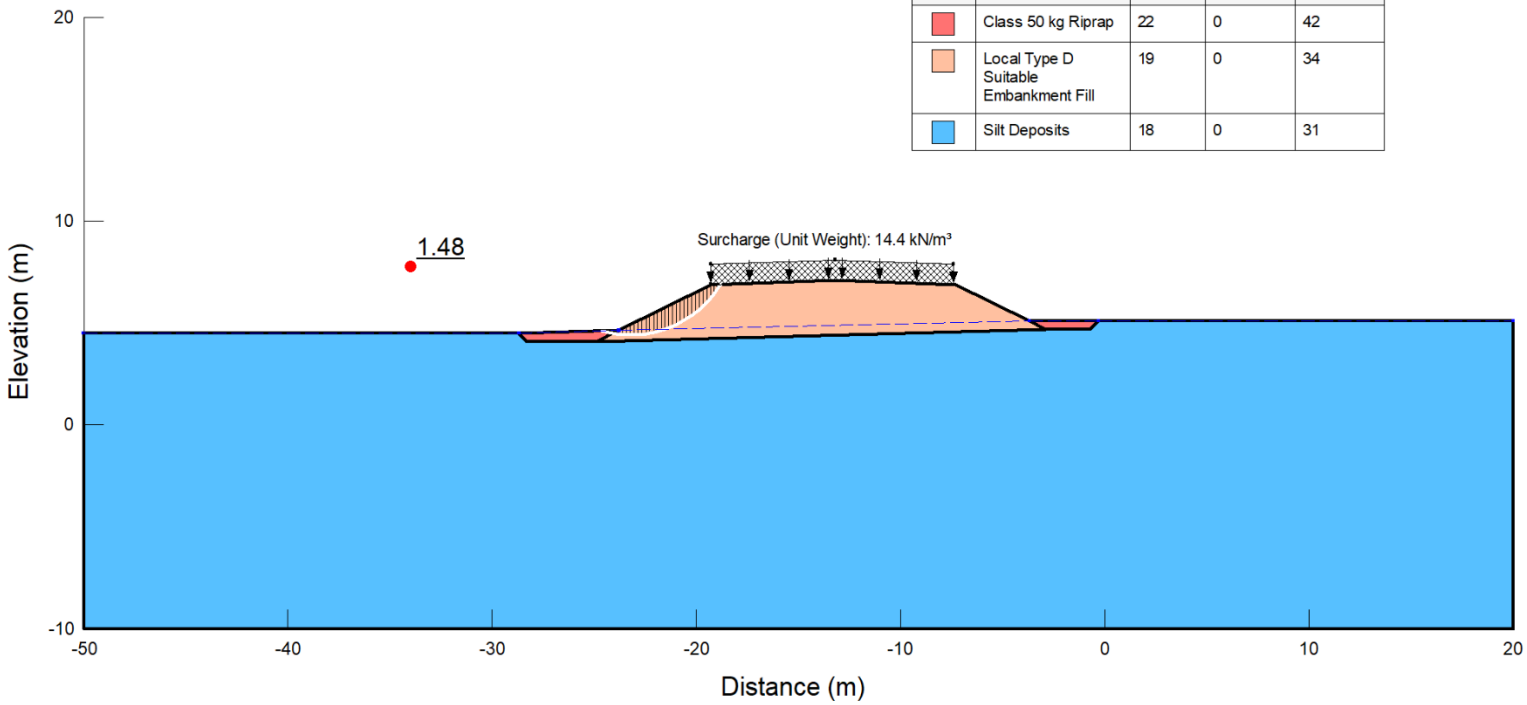
Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

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 (°)
	Class 50 kg Riprap	22	0	42
	Local Type D Suitable Embankment Fill	19	0	34
	Silt Deposits	18	0	31



CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

PROJECT
SUNSHINE COAST DFAA SITES – FLUME CREEK

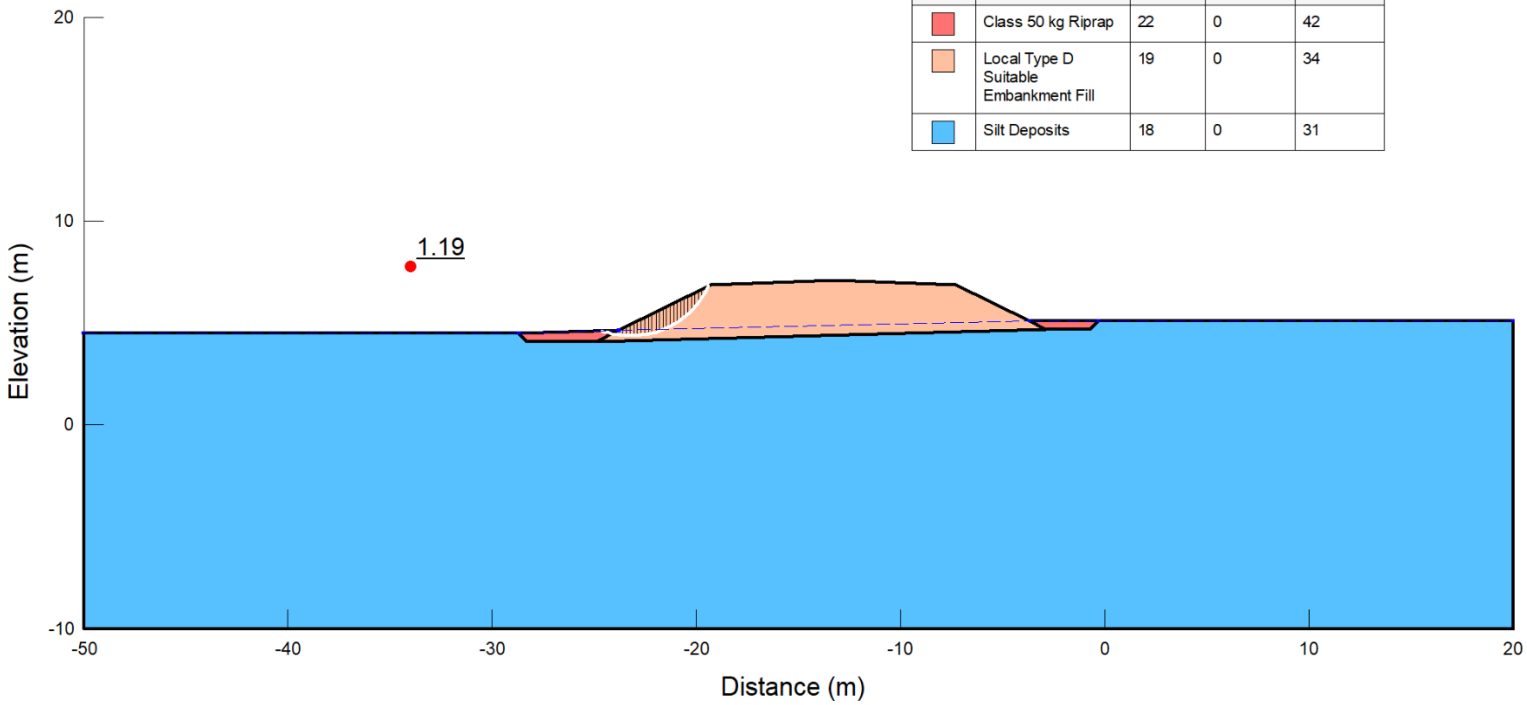
CONSULTANT
wsp

YYYY-MM-DD	2023-02-08
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

TITLE
CRITICAL SLOPE STABILITY MODEL
BEACH AVENUE – STATIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	700	0	D1

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Class 50 kg Riprap	22	0	42
	Local Type D Suitable Embankment Fill	19	0	34
	Silt Deposits	18	0	31



CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

PROJECT
SUNSHINE COAST DFAA SITES – FLUME CREEK

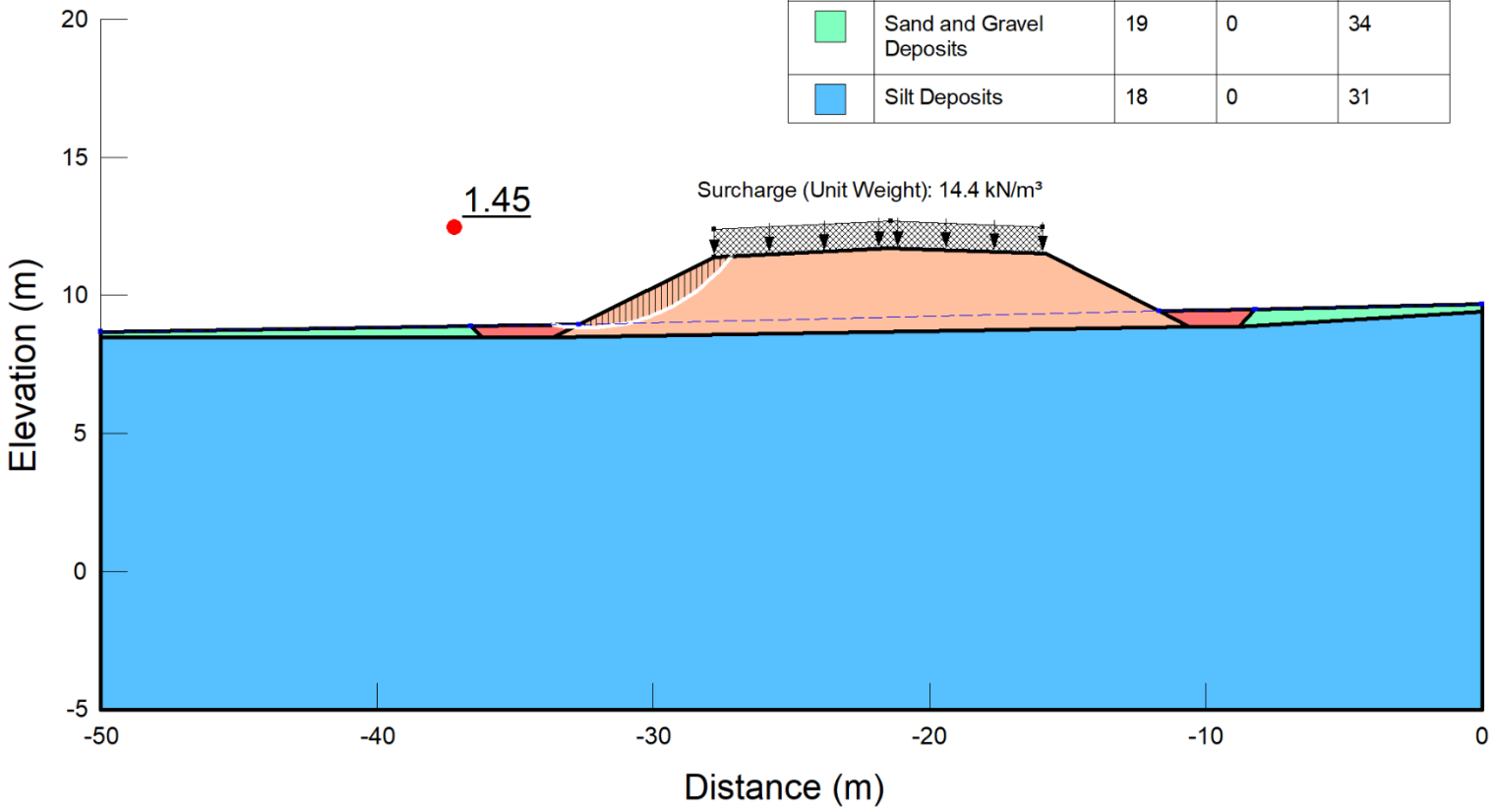
CONSULTANT

YYYY-MM-DD	2023-02-08
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

TITLE
CRITICAL SLOPE STABILITY MODEL
BEACH AVENUE – SEISMIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	700	0	D2

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Class 50 kg Riprap	22	0	42
	Local Type D Suitable Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	34
	Silt Deposits	18	0	31



CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

PROJECT
SUNSHINE COAST DFAA SITES – FLUME CREEK

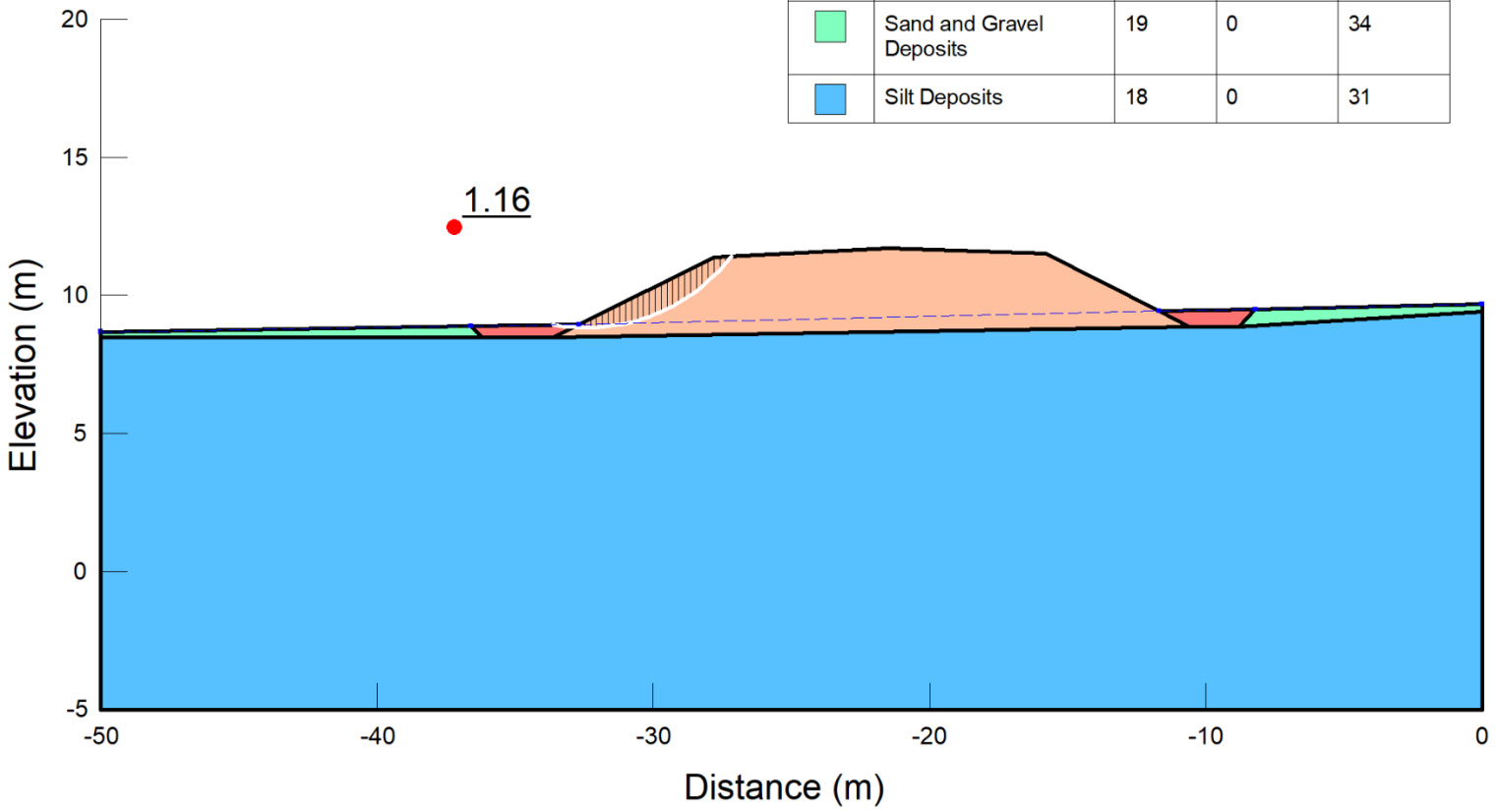
CONSULTANT

YYYY-MM-DD	2023-02-08
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

TITLE
CRITICAL SLOPE STABILITY MODEL
MARGARET ROAD – STATIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	700	0	D3

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Class 50 kg Riprap	22	0	42
	Local Type D Suitable Embankment Fill	19	0	34
	Sand and Gravel Deposits	19	0	34
	Silt Deposits	18	0	31



CLIENT
BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

PROJECT
SUNSHINE COAST DFAA SITES – FLUME CREEK

CONSULTANT

YYYY-MM-DD	2023-02-08
PREPARED	J.BRUNSWICK
DESIGN	J.BRUNSWICK
REVIEW	J.LAXDAL
APPROVED	J.LAXDAL

TITLE
CRITICAL SLOPE STABILITY MODEL
MARGARET ROAD – SEISMIC CONDITIONS

PROJECT No.	Phase	Rev	FIGURE
VG07794	700	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.
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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.
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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

this document, or any information contained in this document, for use or consideration by any third party. WSP accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on this report or anything set out therein. including without limitation, any indirect, special, incidental, punitive, or consequential loss, liability or damage of any kind.

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.