PARKS CANADA

BANFF CAMPGROUND GEOTECHNICAL

GEOTECHNICAL INVESTIGATION REVISION 1

MINNEWANKA DAY-USE AREA & CASTLE MOUNTAIN CAMPGROUND

BANFF, ALBERTA

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CONFIDENTIAL

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1 INTRODUCTION

Parks Canada retained WSP Canada Inc. (WSP) to complete a geotechnical investigation for washroom facility improvements at the Minnewanka Day-Use Area and Castle Mountain Campground within Banff National Park in Alberta. This document is Revision 1 of the geotechnical report. The scope of work was completed in accordance with WSP's proposal dated October 9, 2018, and included the following:

- Nine geotechnical boreholes
- Laboratory testing
- Geotechnical report

The geotechnical field investigation took place during the same mobilization as a hydrogeological / environmental / septic assessment which included field investigations at the Fenlands, Vermillion Lakes, Johnston Canyon, Tunnel Mountain and Cascade Ponds sites. The results of the hydrogeological / environmental / septic assessment are presented in a separate report. This report presents the results of the geotechnical scope only.

The objectives of this geotechnical investigation were to assess the subsoil conditions and to provide recommendations for engineering design parameters for the proposed developments on site.

The use of this report is subject to the Terms of Reference (Appendix A).

2 SITE AND PROJECT DESCRIPTION

The investigation took place at the existing Minnewanka Day-Use Area and Castle Mountain Campground.

2.1 Minnewanka Day-Use Area

Boreholes for the geotechnical investigation were completed at three sites referred to as sites A, B and C. At site A, a new vault toilet building is proposed within a restored area where a now-demolished flush washroom building existed. At sites B and C, a new vault toilet building is proposed at the location of an existing vault toilet building.

The three sites are generally flat and are surrounded by coniferous trees. Roads and small structures related to the day-use area are nearby.

2.2 Castle Mountain Campground

A new washroom building is proposed within the existing Castle Mountain Campground. The site is generally flat and surrounded by tall coniferous trees. Roads and small structures related to the campground are nearby.

2.3 Geology

Based on published surficial geology mapping[1], the Minnewanka Day-Use Area surficial geology is expected to comprise of moraine glacial till deposits consisting of a mixture of clay, silt and sand as well as minor gravel, cobbles and boulders.

The Castle Mountain Campground surficial geology is expected to comprise of both fluvial deposits consisting of poorly to well sorted sand, gravel, silt and clay as well as moraine deposits similar to the Minnewanka site.

3 METHODOLOGY

3.1 Field Investigation

WSP oversaw the drilling of nine geotechnical boreholes on October 18 and 21, 2018. The boreholes were drilled by Ernco Environmental Drilling & Coring Inc. using a track-mounted drill rig and direct push drilling technology. The borehole details are provided in Table 1. A site plan showing the borehole locations is provided in Appendix B (Figures 1 to Figure 5).

Table 1 Borehole Details

Borehole #	Completion Date	Depth (mbgs)	*Latitude	*Longitude	Descriptive Location
18BH01	Oct 21, 2018	4.8 (***Refusal)	51.248008	-115.500309	Minnewanka Site B
18BH02	Oct 21, 2018	1.8 (***Refusal)	51.248035	-115.499103	Minnewanka Site A
18BH03	Oct 21, 2018	2.6 (***Refusal)	51.248035	-115.499102	Minnewanka Site A
18BH04	Oct 21, 2018	2.0 (***Refusal)	51.248020	-115.499079	Minnewanka Site A
18BH05	Oct 21, 2018	2.1 (***Refusal)	51.248037	-115.499078	Minnewanka Site A
18BH06	Oct 21, 2018	1.5 (***Refusal)	51.250352	-115.495983	Minnewanka Site C
18BH07	Oct 21, 2018	1.5 (***Refusal)	51.250310	-115.496035	Minnewanka Site C
**18BH08	Oct 18, 2018	6.6	51.268707	-115.910908	Castle Mountain Campground
**18BH09	Oct 18, 2018	4.6	51.268571	-115.910959	Castle Mountain Campground

Notes: *As-built borehole coordinates were acquired using a handheld GPS (NAD 83). Coordinates are accurate to ±3 m

**18BH08 and 18BH09 refer to field borehole logs 18BH02 and 18BH03 respectively, which were completed at the Castle Mountain Site. The numbering system was revised to improve the legibility of this report.

***Drilling refusal was encountered in 18BH01 to 1BH 07

[1] Fenton, M.M., Waters, E.J., Pawley, S.M., Atkinson, N., Utting, D.J. and Mckay, K. (2013): Surficial geology of Alberta; Alberta Energy Regulator, AER/AGS Map 601, scale 1:1 000 000.

Standard penetration tests (SPTs) were performed at selected depth intervals and soil samples were obtained from the split-spoon sampler. Piezometers / monitoring wells were installed at selected locations across all of the Banff campground sites as a part of the hydrogeological / environmental / septic assessment. The borehole logs which describe soil stratigraphy, sampling sequences, and the field and laboratory test results are included in Appendix B.

3.2 Laboratory Testing

The following laboratory tests were completed on soil samples collected on site:

- 26 moisture content tests
- 2 Atterberg limits tests
- 2 grain size analysis tests (sieve and hydrometer)
- 1 grain size analysis test (sieve only)
- 4 soluble sulphate content tests

The laboratory test results are discussed in Section 4. The test results are shown on the borehole logs in Appendix B. The laboratory testing sheets are provided in Appendix C.

4 SUBSURFACE CONDITIONS

The general soil profile at the Minnewanka Sites A, B and C were somewhat variable; however, all sites encountered drilling refusal on inferred bedrock at depths ranging from 1.5 to 4.8 meters below ground surface (mbgs). The overburden material is consistent with moraine glacial till deposits; however, the composition varies from site to site. Fill material was encountered at the surface of all boreholes except 18BH02.

The soil profile at the Castle Mountain site generally consisted of surficial topsoil over gravel and sand till, over clay over gravel and sand till.

Groundwater conditions are summarised in Section 4.3. A description of the subsurface soil strata is provided in the following sub-sections.

4.1 Minnewanka Site (Boreholes 18BH01 to 18BH07)

4.1.1 Granular Fill

Surficial granular fill was encountered within 18BH01 and was 150 mm thick. The surficial granular fill generally comprised of sand and gravel. It was brown and dry.

4.1.2 Topsoil

Surficial topsoil was encountered in 18BH02 and was 300 mm thick. The topsoil was brown and moist.

4.1.3 Sand Fill

Surficial sand fill was encountered within 18BH03, 18BH06 and 18BH07 and ranged from 0.3 to 1.1 m thick. The sand fill contained variable amounts of gravel, silt and clay. The sand fill was dark grey and dry.

One moisture content on a sand fill sample was 5% which indicates dry to moist sand.

4.1.4 Silt Fill

Silt fill was encountered in 18BH01 below the granular fill and at the surface in 18BH04 and 18BH05. The silt fill extended to depths ranging from 1.1 to 1.7 mbgs. The silt fill contained variable amounts of gravel, silt and clay. The silt fill was generally brown and dry.

Moisture contents of three samples of silt fill ranged from 6 to 12% indicating dry to moist condition.

4.1.5 Rafted Bedrock

Rafted bedrock was encountered from 1.7 to 2.4 mbgs in 18BH01 between the silt fill and sill till layers. Very little sample was recovered from the direct push. Not enough sample could be recovered to determine the type of bedrock.

4.1.6 Silt Till

Silt till was encountered in 18BH01 below the rafted bedrock and extended until 3.0 mbgs. The silt till contained some sand, some clay and some gravel and was wet, dark brown and loose.

4.1.7 Sand Till

Sand till was encountered in 18BH02, 18BH03, 18BH04, 18BH05 and 18BH07 either below the topsoil or fill material and extended to depths ranging from 0.8 to 2.1 mbgs. The sand till was generally silty, with trace clay and gravel and grey to brown.

Moisture contents of six samples of sand till ranged from 4 to 11% indicating dry to moist condition.

Two SPTs completed within the sand till had “N” values of 6 and 7 blows per 300 mm of penetration, which indicates loose sand.

One grain size analysis (i.e., sieve and hydrometer) was completed on a sample of sand till from 18BH04 at 1.5 mbgs which resulted in 8.3% gravel, 48.2% sand, 41.5% silt and 2.0% clay. A soluble sulphate content test was completed on the same sample which resulted in 0.42% sulphate content.

4.1.8 Clay Till

Clay till was encountered in 18BH06 below the sand fill and in 18BH07 below the sand till and extended to 1.5 mbgs. The clay till was silty with some sand and trace gravel. The clay till was brown with trace oxide and coal inclusions.

Moisture contents of two samples of clay till were 16 and 25% indicating moist condition.

One Atterberg limits test was completed on a sample of clay till from 18BH06 at 1.4 mbgs which resulted in plastic and liquid limits of 19% and 28% respectively which correspond to low plastic clay. A soluble sulphate content test was completed on the same sample which resulted in 0.044% sulphate content.

4.1.9 Sand and Gravel Till

Sand gravel till was encountered in 18BH01, 18BH02 and 18BH03 either below the silt till or sand till and extended to depths ranging from 1.8 to 3.0 mbgs. The sand and gravel till was generally silty with variable amounts of clay and grey to brown. Cobbles and increased gravel content was present closer to the termination depth of the borehole.

Moisture contents of four samples of sand and gravel till ranged from 2 to 9% indicating dry to moist condition.

Two SPTs completed within the sand and gravel till had “N” values of 6 and 17 blows per 300 mm of penetration, which indicates loose to compact sand and gravel.

One grain size analysis (i.e., sieve and hydrometer) was completed on a sample of sand and gravel till from 18BH01 at 3.0 mbgs which resulted in 12.5% gravel, 44.2% sand, 34.1% silt and 6.2% clay. A soluble sulphate content test was completed on the same sample which resulted in 0.076% sulphate content.

4.1.10 Inferred Bedrock

All Minnewanka boreholes encountered drilling refusal on inferred bedrock. No sample from the direct push could be recovered due to the drilling refusal which is why the bedrock is “inferred”. Since there was no sample, the bedrock type could not be classified.

The top of the inferred bedrock in the Minnewanka boreholes is summarized in Table 3.

Table 2 Top of Inferred Bedrock

Borehole #	Drilling Refusal Depth / Top of Inferred Bedrock (mbgs)	Soil Type of Layer Above Inferred Bedrock
18BH01	4.8	Sand and Gravel Till
18BH02	1.8	Sand and Gravel Till
18BH03	2.6	Sand and Gravel Till
18BH04	2.0	Sand Till
18BH05	2.1	Sand Till
18BH06	1.5	Clay Till
18BH07	1.5	Clay Till

4.2 Castle Mountain Site (Boreholes 18BH08 and 18BH09)

4.2.1 Topsoil

Surficial topsoil was encountered in both boreholes and was 150 and 300 mm thick in 18BH08 and 18BH09, respectively. The topsoil was brown and moist.

4.2.2 Sand Till

Sand till was encountered in 18BH08 below the topsoil and extended until 0.6 mbgs. The sand till was silty with trace clay and reddish brown.

A moisture content of one sample of sand till was 11% indicating moist condition.

One SPT completed within the sand till had an “N” value of 5 blows per 300 mm of penetration, which indicates loose sand.

4.2.3 Gravel and Sand Till

Gravel and sand till was encountered in 18BH08 below the sand till and in 18BH09 below the topsoil. In 18BH08 the gravel and sand till extended until borehole termination depth at 6.6 mbgs; however, it was interrupted by a layer of clay from 3.4 to 4.6 mbgs. In 18BH09, the gravel and sand till extended until the start of the clay layer at 3.0 mbgs.

The gravel and sand till was generally grey to brown and contained cobbles and boulders deeper into the layer

Moisture contents of eight samples of gravel and sand till generally ranged from 1 to 5% indicating dry condition.

Four SPTs completed within the gravel and sand till had “N” values of 41 and 76 blows per 300 mm of penetration, which indicates dense to very dense gravel and sand.

One grain size analysis (i.e., sieve only) was completed on a sample of gravel and sand till from 18BH08 at 1.5 mbgs which resulted in 58.7% gravel, 32.6% sand and 8.7% silt/clay. A soluble sulphate content test was completed on the same sample which resulted in 0.100% sulphate content.

4.2.4 Clay

Clay was encountered in both boreholes from 3.4 to 4.6 mbgs in 18BH08 and from 3.0 to 4.6 mbgs in 18BH09. The clay extended until borehole termination depth in18BH09. The clay was light beige and did not appear to contain any other inclusions.

A moisture content of one sample of clay was 22% indicating moist condition.

One SPT completed within the clay had an “N” value of 18 blows per 300 mm of penetration, which indicates very stiff clay.

One Atterberg limits test was completed on a sample of clay from 18BH08 at 3.8 mbgs which resulted in plastic and liquid limits of 22% and 35% respectively which correspond to medium plastic clay.

4.3 Groundwater and Sloughing Conditions

For a more detailed analysis of the groundwater conditions on site, please refer to the hydrogeological / environmental / septic assessment report. As it relates to construction, the following geotechnical groundwater and sloughing conditions observations are provided.

- Sloughing (i.e., borehole collapsing) was observed in all boreholes due the sandy gravelly soils that were encountered.
- Water seepage during drilling was encountered in 18BH01 at 3.0 mbgs.
- Water seepage during drilling was encountered in 18BH08 at 3.0 mbgs.

- Water seepage during drilling was encountered in 18BH09 at 3.0 mbgs.
- Water seepage was not encountered in any other boreholes.

Groundwater levels are prone to fluctuations and may be affected by seasonal fluctuations, recent rainfall, surface drainage, and infiltration, etc.

5 GEOTECHNICAL COMMENTS AND RECOMMENDATIONS

This section provides geotechnical design parameters based on WSP's interpretation of the field and laboratory testing information. The geotechnical parameters provided are intended as preliminary guidance for planning and design by qualified engineers and architects. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the implementation of the project. Parties requiring information beyond the scope or purpose of this report must contact WSP or make their own interpretation of the information provided.

5.1 Soil Design Parameters

The interpreted soil design parameters in Table 3 were developed using standard engineering techniques, as indicated in the Canadian Foundation Engineering Manual (CFEM)[2].

Table 3 Soil Design Parameters

Parameters	Existing Fill	Engineered Fill	Clay Till	Sand Till, Gravel and Sand Till
Total Unit Weight (KN/m^3)	19	20	18	19
Angle of Internal Friction (°)	25	32	25	28
Undrained Shear Strength, S_u (kPa)	n/a (cohesionless)	n/a (cohesionless)	50	n/a (cohesionless)
Coefficient of Active Earth Pressure, K_a, (Rankine)	0.41	0.31	0.41	0.36
Coefficient of At-Rest Earth Pressure, K_o, (Rankine)	0.58	0.47	0.58	0.53
Coefficient of Passive Earth Pressure, K_p, (Rankine)	2.46	3.25	2.46	2.77

The earth pressure coefficients in the table above can be considered for proposed vault toilets on site. The provided earth pressure coefficients assume a horizontal back-slope.

[2] Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, Fourth Edition.

5.2 Frost Penetration Depth

The near surface soils on site have a low to medium (i.e. category F2 – gravels and sands) frost susceptibility. The maximum seasonal frost penetration depth was calculated for the near-surface soils using the procedure described in CFEM. A mean freezing index of 1,100°C days based on a 30-year return period was used for the site. The maximum seasonal frost penetration depth is estimated to be 2.1 mbgs. The estimated frost penetration depth assumes a uniform soil type without snow cover.

Foundation elements of heated and unheated structures should have a minimum frost protection equivalent to a soil cover of at least 1.5 m and 2.1 m for frost protection purposes, respectively. Rigid insulation may be used to provide frost protection equivalent to the required soil cover. Insulation used for frost protection should be placed at a minimum depth of 0.6 m below the finished ground surface and the top 0.6 m of backfill should be ignored for equivalent frost penetration calculation purposes.

5.3 Site Preparation

Site preparation is required for the proposed washroom buildings and vault toilet buildings

From a geotechnical perspective, all existing fill material, vegetation, organic material, topsoil and other deleterious material should be removed from beneath the proposed structures. The exposed subgrade should be reviewed by WSP geotechnical engineering staff prior to placement of any new fill, foundation forms, or concrete to confirm suitability for load bearing purposes. Any soft/weak areas should be over-excavated and backfilled using properly compacted, engineered fill. Upon review by a geotechnical engineer, a proof-roll test using a loaded single-axle gravel truck (or equivalent) shall be completed. Any areas which demonstrate rutting, cracking or other deformations should be examined in detail by WSP geotechnical engineering staff and remedial action taken, as required.

To reduce differential movements within the site, it is recommended that general site preparation of the site be completed.

The subgrade should be sloped a minimum of 2% to promote drainage. No water should be allowed to pond at any time during construction. Do not allow vehicle traffic over approved subgrade as it leads to softening. Any areas that become soft and wet due to construction traffic should be remediated and re-proof rolled.

Engineered fill, associated with the proposed construction, may consist of the in-situ till or imported cohesionless material. Imported material for use as engineered fill should be approved by a geotechnical engineer before placement. All engineered fill materials must be free of oversized rocks over 100 mm in diameter, organics, roots, debris, and other deleterious materials.

Engineered fill should be placed in lifts not exceeding 150 mm loose measure, and be compacted to minimum 98% Standard Proctor Maximum Dry Density (SPMDD). The moisture content at placement should be within -3% to +1% of its Optimum Moisture Content (OMC) for compaction purposes. In areas where the engineered fill is required for structural support (i.e., structural fill), it should be compacted to 100% of SPMDD.

Subgrade surfaces should be protected from freezing. In addition, the subgrade should be protected from wetting or drying, both before and after the placement of fill. Subgrade surfaces that are allowed to dry or become wet must be scarified, moisture conditioned, and re-compacted.

5.4 Foundations

Based on the subsurface ground conditions encountered, shallow foundations in the form of spread and strip footings are considered suitable foundation systems for the proposed washroom buildings at Minnewanka Day-Use Area and Castle Mountain Campground.

The foundation design parameters provided in this report are presented in terms of Limit States Design, as per National Building Code of Canada (NBCC[3]) and CFEM.

5.4.1 Shallow Foundations

Shallow foundations in the form of spread and strip footings founded on native till are considered suitable for the soil conditions encountered at the project site. Footings must not be placed in existing fill. An unfactored ultimate bearing resistance of 375 kPa at Ultimate Limit State (ULS) should be utilized for the design of spread and strip footings with minimum embedment depth of 0.5 mbgs and width ranging from 0.5 m to 2.5 m. The embedment depth is to be measured from ground surface or from the top of adjacent slabs-on-grade, whichever is less. A resistance factor (ϕ) of 0.5 as per NBCC should be applied to determine the factored bearing resistance at ULS.

The bearing pressures at Serviceability Limit States (SLS) for strip and spread footing foundations bearing on till vary with footing size. When applying the factored geotechnical bearing resistance on footing sizes ranging from 0.5 to 2.5 metre widths, settlements are expected not to exceed 25 mm.

In calculation of the geotechnical bearing resistance and the settlement of the foundations, it was assumed that proper moisture barrier system will be employed to minimize moisture fluctuation.

The recommended geotechnical design bearing resistance and pressure have been determined for vertical, concentric loading, as described in CFEM. For footings subjected to eccentric loads, the following equivalent footing width shall be used to calculate the design values (i.e., bearing resistance and bearing pressure) of the footing:

$$B' = B - 2e$$
$$L' = L - 2e$$

Where B' is the equivalent footing width; B is the actual footing width; L' is the equivalent footing width, L is the actual footing width, and e is the eccentricity of the load. Effects of inclined loads, if any, shall also be considered as discussed in the CFEM.

The ultimate lateral resistance of footings may be calculated by considering the sliding resistance acting along the footing base and the passive earth pressure resistance of permanent soil on the side of the buried structure opposite the applied lateral load. The ultimate sliding resistance at the foundation base may be calculated multiplying the total vertical load acting on the foundation by the coefficient of friction. A coefficient of friction of 0.4 is recommended between concrete foundation base and the soil bearing surface. A geotechnical resistance factor of 0.8 should be considered for factored lateral capacity of the foundation.

Bearing surfaces should be protected from ingress of free water, typically resulting in softening of soils. Footings must not be placed on any uncontrolled fill, organic, disturbed, or frozen soil. Bearing soil that becomes frozen, dried, or softened must be removed and replaced with concrete, or the footings should be extended to reach soil in an unaffected condition. It is also essential that the foundation soil not be allowed to freeze after the concrete

[3] National Building Code of Canada, 13th Edition 2010, National Research Council

for the footing has been poured. If freezing of the soil below the constructed footing is suspected, the soil and the foundation must be inspected by WSP geotechnical engineering staff prior to continuing construction. It is essential that the foundation soil not be allowed to freeze at any time before or after pouring of concrete. It is also recommended that all foundation bearing soils be inspected by WSP geotechnical engineering staff to confirm the soil conditions and associated bearing capacity.

5.5 Slab-On-Grade Construction

A slab-on-grade is considered suitable, provided that the subgrade soils underneath slab-on-grade areas are prepared as outlined in Section 5.3 of this report. It is important that the subgrade surface be protected from moisture changes and freezing temperatures both during and after construction in order to minimize the potential of frost heave/thaw and softening action on the subgrade soils.

A layer of granular material (such as 25 mm crushed gravel or approved equivalent) of at least 200 mm in thickness should be placed immediately beneath slab-on-grade for levelling and support purposes. This material should be compacted to 100% SPMDD at moisture content within -3% to +1% of OMC.

Slabs-on-grade should float independently of all load-bearing walls and columns to minimize the potential for damage from small differential settlement between these elements.

5.6 Subsurface Structures Wall

The walls of any subsurface structures will likely be restrained from moving, and therefore should be designed to resist at-rest lateral earth pressures. The at-rest earth pressure coefficient for design purposes may be taken as the values presented in Table 3. The total pressure on the walls will consist of the cumulative loading imposed by earth pressure, water pressure, and surcharge due to surface or foundation loads.

The lateral earth pressure distribution (p) may be assumed to increase with depth according to:

$$p = K(\gamma z + q)$$

Where:	p	=	lateral earth pressure (kPa)
	K	=	coefficient of lateral earth pressure
	γ	=	unit weight of soil
	z	=	depth from top of wall (m)
	q	=	surcharge load (kPa)

It is recommended to backfill temporary excavation around the building perimeter with clean, well graded granular material, compacted to 95% SPMDD.

The above design values assume horizontal ground conditions at the top of the wall. If sloping ground exists, these values would increase as described in CFEM. Lateral pressures due to irregular surface loads, traffic loads or foundation loads should be added where applicable.

5.7 Temporary Excavations

Temporary excavations at the site should be sloped or shored for worker and foundation protection. Construction must conform to good practice and comply with regulations, such as the Alberta Construction Safety Regulations. According to the Occupational Health and Safety Code Part 32[4]., the soil is to be classified as “soft, sandy or loose”; therefore, excavation walls must be sloped 45° from the base of the excavation. WSP should be given the opportunity to review the proposed excavation layout and to provide further guidance if steeper cut slopes are desired.

Excavations must not undermine the foundations of existing buildings that are to be left in place.

Excavations of more than 3.0 meter depths should be subject to a detailed slope stability analysis to determine minimum slope angles or other means to provide a safe temporary work environment.

Excavations must be protected from rain, snow, or any ingress of free water. Prolonged exposure of excavated areas should be avoided to prevent deterioration of exposed soil with resultant slope instability. Similarly, excavated materials should be stockpiled away from the excavations to avoid any slope instability and to prevent materials from falling into excavations. Temporary surcharge loads, such as stock of material or heavy equipment, should be kept back from excavation faces a distance equal to at least one-half the excavation depth.

Based on conditions encountered during drilling and the measured groundwater levels, seepage is not anticipated in excavations up to 2.5 m in depth. Dewatering of excavations will be dependent upon weather conditions and the time of year of construction. If seepage is encountered during construction, groundwater may be controlled by sump and pumping methods. The groundwater level should be maintained a minimum of 0.5 m below excavation grade at all times. During construction, the prepared subgrade surface should be shaped to prevent ponding of water on the site. Excess water should not be allowed to pond and should be drained or pumped from within the building footprint and areas subject to surface improvements as quickly as possible.

5.8 Permanent Dewatering and Site Drainage

WSP recommends installing a perimeter drainage system (i.e. weeping tile) comprising of a minimum 100 mm diameter slotted or perforated PVC pipe, surrounded by minimum 150 mm of free draining gravel. The gravel should be wrapped in a non-woven geotextile to mitigate migration of fines and extend the life of the system.

It is recommended that the final grading of the site be designed such that surface water is directed away from all structures. Site grading within 2 m of building perimeters should be sloped at no less than 2% away from any building structures. Surface water should not be permitted to pond or flow adjacent to foundations and roof and other drains should discharge away from the structures.

5.9 Seismic Site Classification

Available information was reviewed to assess the seismic classification of the project site. The reviewed information included the Borehole Records, the National Building Code of Canada (NBCC)[5] and CFEM.

The site classification for Seismic Site Response is provided in Sections 4.1.8.4 of NBCC and in Chapter 6 of CFEM and is determined using the expected shear wave velocity, Standard Penetration Resistance N-value and

[4] Occupational Health and Safety Act, Occupational Health and Safety Code 2009, Government of Alberta, 2009
[5] National Research Council; 2015; National Building Code of Canada

undrained shear strength within the top 30 m. Based on the available information, the average ground properties in the upper 30 m at the site are inferred to stiff soil, corresponding to Class C as per Table 6.1A, CFEM.

5.10 Water Soluble Sulphate

The results from the soluble sulphate content laboratory tests are summarized in Sections 4.1.7, 4.1.8, 4.1.9 and 4.2.3.

One test result (i.e. Castle Mountain 18BH08) indicated a moderate degree of exposure (class S-3) to sulphate attack on concrete in contact with the soil as per degree CSA A23.1-14[6]. The remainder of the tests had a negligible degree of sulphate exposure. Any imported soils should be tested for water soluble sulphate concentration and associated sulphate exposure classification.

Concrete properties should be specified by the structural engineer to meet structural requirements and exposure to freeze and thawing and/or chlorides.

6 CLOSURE

This report has been prepared for the sole benefit of Parks Canada and is not intended for use by others. This report may not be reproduced without the prior written consent of WSP. Contractors undertaking the work must draw their own interpretations of the factual information provided in this report as they affect the construction costs, procedures, and scheduling.

As boreholes are a localized representation of the total study area, subsurface conditions may vary between and/or beyond the borehole locations. If conditions encountered at the site vary significantly from that reported herein, WSP should be notified immediately so that our interpretation and recommendations can be reviewed and revised, if necessary.

[6] Canadian Standards Association; 2014; Concrete Materials and Methods of Concrete Construction, Canadian Standards Association International; CSA A23.1-14

APPENDIX

A TERMS OF REFERENCE

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC.

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The information, observations, findings, suggestions, recommendations and opinions contained in the Report, or any component forming the Report, are for the sole use and benefit of the Client and the team of consultants selected by the Client for the specific project that the Report was provided. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION OR COMPONENT WITHOUT THE WRITTEN CONSENT OF WSP. WSP will consent to any reasonable request by the Client to approve the use of this Report by other parties designated by the Client as the "Approved Users". As a condition for the consent of WSP to approve the use of the Report by an Approved User, the Client must provide a copy of these Terms of Reference to that Approved User and the Client must obtain written confirmation from that Approved User that the Approved User will comply with these Terms of Reference, such written confirmation to be provided separately by each Approved User prior to beginning use of the Report. The Client will provide WSP with a copy of the written confirmation from an Approved User when it becomes available to the Client, and in any case, within two weeks of the Client receiving such written confirmation.

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TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC. (continued)

5. INTERPRETATION OF THE REPORT

a. **Nature and Exactness of Descriptions**: The classification and identification of soils, rocks and geological units, as well as engineering assessments and estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1 above. The classification and identification of these items are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations or assessments utilizing the standards of Paragraph 1 involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to changes over time and the parties making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or when the Client has special considerations or requirements, the Client must disclose them to WSP so that additional or special investigations may be undertaken, which would not otherwise be within the scope of investigations made by WSP or the purposes of the Report.

b. **Reliance on information**: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to WSP. WSP has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, WSP cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. **Additional Involvement by WSP**: To avoid misunderstandings, WSP should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by WSP. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, WSP should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by WSP. Any reduction from the level of services recommended by WSP will result in WSP providing qualified opinions regarding adequacy of the work.

6. ALTERNATE REPORT FORMAT

When WSP submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon WSP. The hard copy versions submitted by WSP shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by WSP shall be deemed to be the overall originals for the Project.

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The Client recognizes and agrees that WSP prepared and submitted electronic files using specific software or hardware systems, or both. WSP makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that WSP is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by WSP. The Client further agrees that should the Client, an Approved User or a third party require WSP to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by WSP, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay WSP for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless WSP, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against WSP, whether in contract or in tort, arising or related to the provision or use or any specific software or hardware provided by WSP.

APPENDIX

B SITE PLAN AND BOREHOLE LOGS

wsp

Site Plan
Banff Campground Geotechnical Investigation
Lake Minnewanka, AB

SOURCE	CLIENT NAME	PROJECT NUMBER
Imagery Provided by Parks Canada	Parks Canada	181-13597-12

DRAWN	CHECK	APPR.	EPSG	DATE	SCALE	FIGURE NUMBER	REV.
SB	JL	-	-	21/01/2019	-	Figure 1	0

Site Plan
Banff Campground Geotechnical Investigation
Lake Minnewanka, AB

SOURCE	CLIENT NAME	PROJECT NUMBER
Imagery Provided by Parks Canada	Parks Canada	181-13597-12

DRAWN	CHECK	APPR.	EPSG	DATE	SCALE	FIGURE NUMBER	REV.
SB	JL	-	-	21/01/2019	-	Figure 2	0

Site Plan
Banff Campground Geotechnical Investigation
Lake Minnewanka, AB

SOURCE	CLIENT NAME	PROJECT NUMBER
Imagery Provided by Parks Canada	Parks Canada	181-13597-12

DRAWN	CHECK	APPR.	EPSG	DATE	SCALE	FIGURE NUMBER	REV.
SB	JL	-	-	21/01/2019	-	Figure 3	0

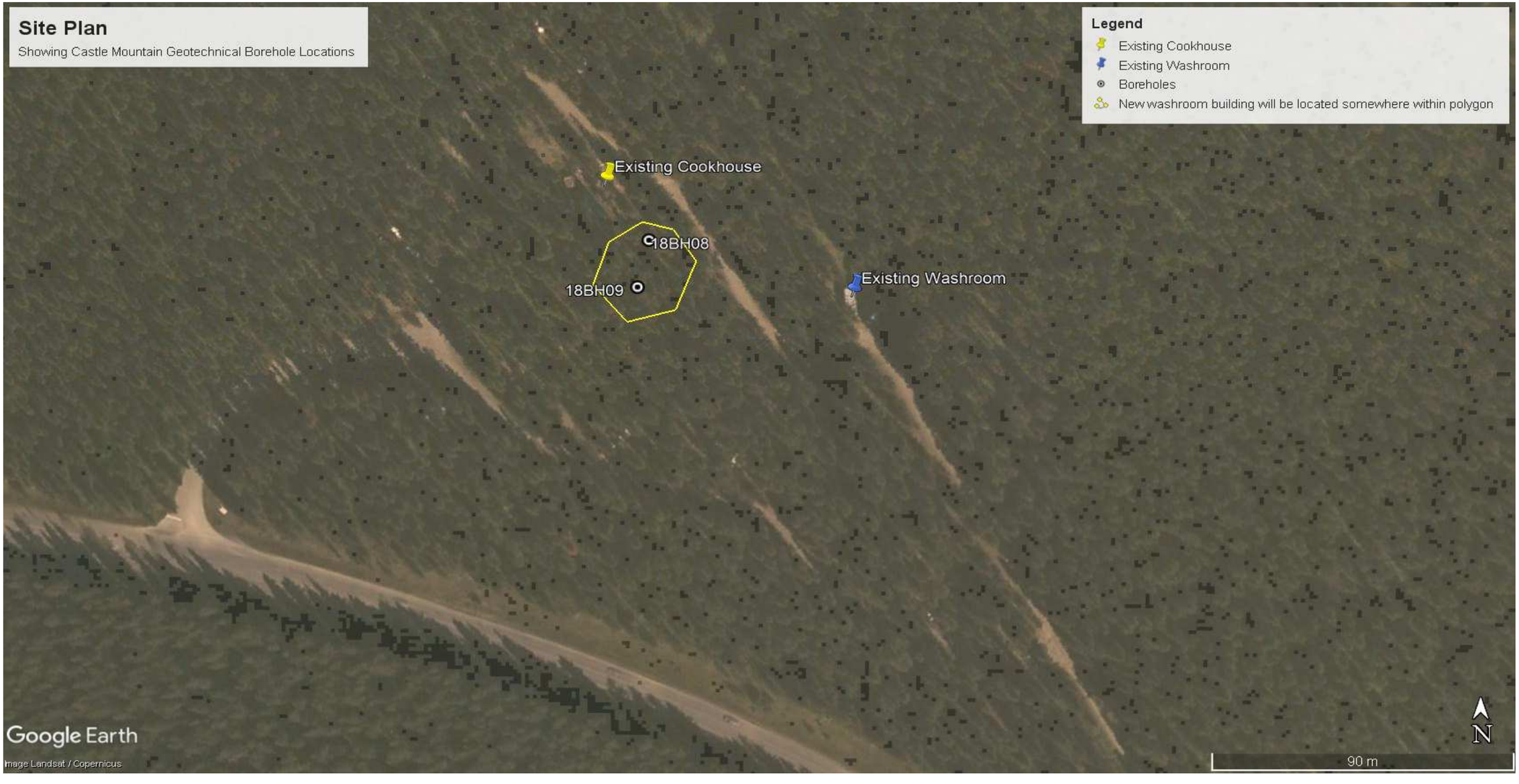
Site Plan
Banff Campground Geotechnical Investigation
Lake Minnewanka, AB

SOURCE	CLIENT NAME	PROJECT NUMBER
Imagery Provided by Parks Canada	Parks Canada	181-13597-12

DRAWN	CHECK	APPR.	EPSG	DATE	SCALE	FIGURE NUMBER	REV.
SB	JL	-	-	21/01/2019	-	Figure 4	0

Site Plan

Showing Castle Mountain Geotechnical Borehole Locations



wsp				Site Plan Banff Campground Geotechnical Investigation Castle Mountain Campground, AB				
SOURCE Imagery Provided by Parks Canada				CLIENT NAME Parks Canada		PROJECT NUMBER 181-13597-14		
DRAWN SB	CHECK JL	APPR. -	EPSG -	DATE 21/01/2019	SCALE -	FIGURE NUMBER Figure 5		REV. 0

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Banff Campground Geotechnical
Parks Canada

18BH01 (Minnewanka Site B)

Project No: 181-13597-12
Lat: 51.24801 Long: -115.50031

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		brown, **GRANULAR FILL** , sand and gravel, dry				
		brown, **SILT FILL** , sandy, trace clay, dry				
	2				G	
	4					
	6	completely weathered, extremely weak, brown, **(rafted) BEDROCK** , moist		14	SPT	
2	8				G	
		loose, dark brown, **SILT TILL** , some sand, some clay, some gravel, wet				
	10	at 3.0 m - water seepage				
		loose, greyish brown, **SAND & GRAVEL TILL** , silty, clayey, wet, bedrock fragments at 3.0 m - 12.5% gravel, 44.2% sand, 34.1% silt and 6.2% clay based on lab test at 3.0 m - 0.076% sulphate based on lab test		6	SPT	
	12				G	
4	14					
		at 4.5 m - more bedrock fragments		refusal	SPT	
	16	at 4.8 m - refusal on infered intact bedrock End of borehole at 4.8 m due to refusal.				
	18					
6	20					
	22					

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
Logged by: AB
Checked by: SB

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Banff Campground Geotechnical
Parks Canada

18BH02 (Minnewanka Site A)

Project No: 181-13597-12
Lat: 51.24804 Long: -115.49910

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark brown, **TOPSOIL (300 mm thick)**, moist				
	2	compact, reddish brown, **SAND TILL** , and silt, some clay, dry				
		loose, greyish brown, **SAND & GRAVEL TILL** , silty, cobbles, dry			G	
	4				G	
	6	from 1.5 - increase cobbles, dense, increased gravel				
2		at 1.8 m - refusal on inffered intact bedrock End of borehole at 1.8 m due to refusal.				
	8					
	10					
	12					
4						
	14					
	16					
	18					
6						
	20					
	22					

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
Logged by: AB
Checked by: SB

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Banff Campground Geotechnical
Parks Canada

18BH03 (Minnewanka Site A)

Project No: 181-13597-12
Lat: 51.24804 Long: -115.49910

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark grey, **SAND FILL** , and silt, some clay, some gravel, dry				
	2	loose, reddish brown, **SAND TILL** , and silt, trace clay, trace gravel, moist, trace coal, trace oxides			G	
	4	compact, greyish brown, **SAND & GRAVEL TILL** , silty, dry				
	6			17	SPT	
2						
	8	from 2.3 m - bedrock fragments, increased gravel, cobbles			G	
		at 2.6 m - refusal on infered intact bedrock		refusal	SPT	
		End of borehole at 2.6 m due to refusal.				
	10					
	12					
4						
	14					
	16					
	18					
6						
	20					
	22					

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
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Checked by: SB

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18BH04 (Minnewanka Site A)

Project No: 181-13597-12
Lat: 51.24802 Long: -115.49908

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark brown, **SILT FILL** , gravelly, clayey, some sand, dry			G	
		loose, reddish brown, **SAND TILL** , and silt, trace clay, trace gravel, dry, trace oxides				
		from 1.5 m - brown at 1.5 m - 8.3% gravel, 48.2% sand, 41.5% silt and 2.0% clay based on lab test at 1.5 m - 0.042% sulphate based on lab test		6	SPT	
2		at 2.0 m - refusal on infered intact bedrock End of borehole at 2.0 m due to refusal.		refusal	SPT	

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
Logged by: AB
Checked by: SB

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18BH05 (Minnewanka Site A)

Project No: 181-13597-12
Lat: 51.24804 Long: -115.49908

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark brown, **SILT FILL** , gravelly, clayey, some sand, dry			G	
		loose, reddish brown, **SAND TILL** , and silt, trace clay, trace gravel, dry, trace oxides				
		from 1.5 m - silty, brown		7	SPT	
		at 2.1 m - refusal on infered intact bedrock		refusal	SPT	
		End of borehole at 2.1 m due to refusal.				

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
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18BH06 (Minnewanka Site C)

Project No: 181-13597-12
Lat: 51.25035 Long: -115.49598

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark brown, **SAND FILL** , gravelly, some clay, moist			G	
		firm, brown, **CLAY TILL** , silty, some sand, trace gravel, moist to wet, trace oxides, trace coal				
		at 1.4 m - 0.044% sulphate based on lab test		refusal	G SPT	
		at 1.5 m - refusal on infered intact bedrock End of borehole at 1.5 m due to refusal.				

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
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Banff Campground Geotechnical
Parks Canada

18BH07 (Minnewanka Site C)

Project No: 181-13597-12
Lat: 51.25031 Long: -115.49604

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
0	0	dark brown, **SAND FILL** , gravelly, some clay, moist				
0.6	2	loose, grey, **SAND TILL** , silty, some gravel, moist to wet, trace oxides			G	
1.2	4	firm, brown, **CLAY TILL** , silty, some sand, trace gravel, moist to wet, trace oxides, trace coal		refusal	G SPT	
1.5	6	at 1.5 m - refusal on infered intact bedrock End of borehole at 1.5 m due to refusal.				

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
Shear strength in kPa (Unconfined)
Shear strength in kPa (Field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 21/10/2018
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18BH08 (Castle Mtn 18BH02)

Banff Campground Geotechnical
Parks Canada

Project No: 181-13597-12

Lat: 51.26871 Long: -115.91091

Depth (m)	Depth (ft)	Description	Piezo 1	C	N	Type/ Sample #	Water Level
		dark brown, **TOPSOIL (150 mm thick)**, moist					
		compact, reddish brown, **SAND TILL** , silty, trace clay, moist			5	SPT	
	2	compact, grey to brown, **GRAVEL & SAND TILL** , dry				G	
	4						
		from 1.5 m - cobbles, boulders at 1.5 m - 58.7% gravel, 32.6% sand, 8.7% silt/clay based on lab test at 1.5 m - 0.100% sulphate based on lab test			76	SPT	
2	6						
	8					G	
	10				18	SPT	
		at 3.0 m - water seepage					
	12	very stiff, light beige, **CLAY** , medium plastic, wet				G	
4	14						
		dense to very dense, grey to brown, **GRAVEL & SAND TILL** , cobbles, boulders			41	SPT	
	16						
	18					G	
6	20						
					67	SPT	
	22	End of borehole at 6.6 m.					

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
X Shear strength in kPa (Unconfined)
⊗ Shear strength in kPa (Field vane)
⊠ Remolded strength in kPa
Percent Passing # 200 sieve

Bentonite/Grout Plug
Solid Pipe
Cuttings
Slotted Pipe
Sand/Pea-Gravel

Drill Method: Sonic
Date Drilled: 18/10/2018
Logged by: AB
Checked by: SB

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Banff Campground Geotechnical
Parks Canada

18BH09 (Castle Mtn 18BH03)

Project No: 181-13597-12
Lat: 51.26857 Long: -115.91096

Depth (m)	Depth (ft)	Description	C	N	Type/ Sample #	Water Level
		dark brown, **TOPSOIL (300 mm thick)**, moist				
		compact, grey to brown, **GRAVEL & SAND TILL** , dry			G	
	2					
	4				G	
	6					
2					G	
	8					
	10	at 3.0 m - water seepage			G	
		very stiff, light beige, **CLAY** , medium plastic, wet				
	12					
4					G	
	14					
		End of borehole at 4.6 m.			G	
	16					
	18					
6						
	20					
	22					

10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:
DYNAMIC CONE PENETRATION TEST

Plastic Limit (%) Liquid Limit (%)
Moisture Content (%)
Ground Water Level
Shear strength in kPa (Torvane)
PP Pocket Penetrometer (compressive strength in kPa)
X Shear strength in kPa (Unconfined)
⊗ Shear strength in kPa (Field vane)
⊠ Remolded strength in kPa
■ Percent Passing # 200 sieve

Drill Method: Sonic
Date Drilled: 18/10/2018
Logged by: AB
Checked by: SB

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APPENDIX

C LABORATORY TEST RESULTS

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MOISTURE CONTENT
(ASTM D2216)

TRN: 18-050

Client:	Parks Canada	Sampled By:	AB
Project:	Banff Campground Geotechnical	Tested By:	DH
Job No.:	181-13597-12	Sample Date:	October 18, 2018
Report Date:	December 3, 2018	Test Date:	November 14, 2018

BH No. (Site B)	**BH18-01**	**BH18-01**	**BH18-01**	**BH18-01**	**BH18-01**	**BH18-01**	
Depth in meter	0.75	1.50	2.25	3.00	3.75	4.50	
Tare No.	# 726	# 1326	# 107	# 504	# 836	# 1016	
Wt. Tare, g	11.3	11.2	11.4	11.5	11.5	11.6	
Wt. Wet Soil + Tare, g	466.6	380.4	467.2	536.1	542.8	457.2	
Wt. Dry Soil + Tare, g	416.4	342.6	439.8	501.8	509.0	418.6	
Wt. Water, g	50.2	37.8	27.4	34.3	33.8	38.6	
Wt. Dry Soil, g	405.1	331.4	428.4	490.3	497.5	407.0	
Moisture Content (%)	**12.4**	**11.4**	**6.4**	**7.0**	**6.8**	**9.5**	
BH No. (Site A)	**BH18-03**	**BH18-03**	**BH18-03**	**BH18-03**			
Depth in meter	0.75	1.5	2.25	2.6			
Tare No.	# 208	# 1021	# 358	M-113			
Wt. Tare, g	11.3	11.5	11.5	11.4			
Wt. Wet Soil + Tare, g	359.9	453.7	494.9	545.9			
Wt. Dry Soil + Tare, g	323.4	444.6	479.9	541.5			
Wt. Water, g	36.5	9.1	15.0	4.4			
Wt. Dry Soil, g	312.1	433.1	468.4	530.1			
Moisture Content (%)	**11.7**	**2.1**	**3.2**	**0.8**			
BH No. (Site A)	**BH18-04**	**BH18-04**	**BH18-04**	**BH18-04**			
Depth in meter	0.75	1.5	2.0	3.5			
Tare No.	M-480	# 679	747	# 728			
Wt. Tare, g	11	11.4	11.1	11.8			
Wt. Wet Soil + Tare, g	436.5	370.1	337.0	572.1			
Wt. Dry Soil + Tare, g	388.2	357.1	324.0	561.1			
Wt. Water, g	48.3	13.0	13.0	11.0			
Wt. Dry Soil, g	377.2	345.7	312.9	549.3			
Moisture Content (%)	**12.8**	**3.8**	**4.2**	**2.0**			

Per: Stephen Bernier

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MOISTURE CONTENT
(ASTM D2216)

TRN: 18-050

Client:	Parks Canada	Sampled By:	AB
Project:	Banff Campground Geotechnical	Tested By:	DH
Job No.:	181-13597-12	Sample Date:	October 18, 2018
Report Date:	December 3, 2018	Test Date:	November 14, 2018

BH No. (Site A)	**BH18-05**	**BH18-05**	**BH18-05**
Depth in meter	0.75	1.50	2.10
Tare No.	# 794	# 582	# 825
Wt. Tare, g	11.4	11.4	11.5
Wt. Wet Soil + Tare, g	430.1	374.7	289.6
Wt. Dry Soil + Tare, g	407.7	354.1	273.0
Wt. Water, g	22.4	20.6	16.6
Wt. Dry Soil, g	396.3	342.7	261.5
Moisture Content (%)	**5.7**	**6.0**	**6.3**
BH No. (Site C)	**BH18-06**	**BH18-06**	**BH18-06**
Depth in meter	0.75	1.0	1.50
Tare No.	# 811	# 1314	# 1420
Wt. Tare, g	11.5	11	11.7
Wt. Wet Soil + Tare, g	460.6	450.0	25.6
Wt. Dry Soil + Tare, g	439.6	361.8	25.1
Wt. Water, g	21.0	88.2	0.5
Wt. Dry Soil, g	428.1	350.8	13.4
Moisture Content (%)	**4.9**	**25.1**	**3.7**
BH No. (Site C)	**BH18-07**	**BH18-07**	
Depth in meter	0.75	1.5	
Tare No.	# 363	# 497	
Wt. Tare, g	11.1	11.6	
Wt. Wet Soil + Tare, g	399.5	448.7	
Wt. Dry Soil + Tare, g	379.7	385.8	
Wt. Water, g	19.8	62.9	
Wt. Dry Soil, g	368.6	374.2	
Moisture Content (%)	**5.4**	**16.8**	

Per: Stephen Bernier

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MOISTURE CONTENT
(ASTM D2216)

TRN: 18-050

Client:	Parks Canada	Sampled By:	AB
Project:	Banff Campground Geotechnical	Tested By:	DH
Job No.:	181-13597-12	Sample Date:	October 18, 2018
Report Date:	December 3, 2018	Test Date:	November 14, 2018

BH No.	**BH18-08**	**BH18-08**	**BH18-08**	**BH18-08**	**BH18-08**	**BH18-08**	**BH18-08**
Depth in feet	0.2	3.0	5.0	7.5	10.0	12.5	15.0
Tare No.	# 512	# 1559	639	# 397	# 585	M-538	# 801
Wt. Tare, g	11.6	11.6	12.3	11.3	11.6	11.7	11.7
Wt. Wet Soil + Tare, g	373.3	529.3	437.2	711.2	515.4	459.6	517.0
Wt. Dry Soil + Tare, g	336.0	510.9	435.3	706.4	465.9	377.1	500.7
Wt. Water, g	37.3	18.4	1.9	4.8	49.5	82.5	16.3
Wt. Dry Soil, g	324.4	499.3	423.0	695.1	454.3	365.4	489.0
Moisture Content (%)	**11.5**	**3.7**	**0.4**	**0.7**	**10.9**	**22.6**	**3.3**
BH No.	**BH18-08**	**BH18-08**					
Depth in feet	17.5	20.0					
Tare No.	# 1309	# 393					
Wt. Tare, g	11.0	11.2					
Wt. Wet Soil + Tare, g	410.6	446.6					
Wt. Dry Soil + Tare, g	394.4	435.8					
Wt. Water, g	16.2	10.8					
Wt. Dry Soil, g	383.4	424.6					
Moisture Content (%)	**4.2**	**2.5**					
BH No.							
Depth in meter							
Tare No.							
Wt. Tare, g							
Wt. Wet Soil + Tare, g							
Wt. Dry Soil + Tare, g							
Wt. Water, g							
Wt. Dry Soil, g							
Moisture Content (%)							

Per: Stephen Bernier

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ATTERBERG LIMITS
(ASTM D4318)

TRN: 18-050

Client:	Parks Canada Minnewanka	Sampled By:	AB
Project:	Banff Campground Geotechnical	Tested By:	KB
Job No.:	181-13597-12	Sample Date:	October 18 & 21, 2018
Report Date:	December 4, 2018	Test Date:	November 24th, 2018

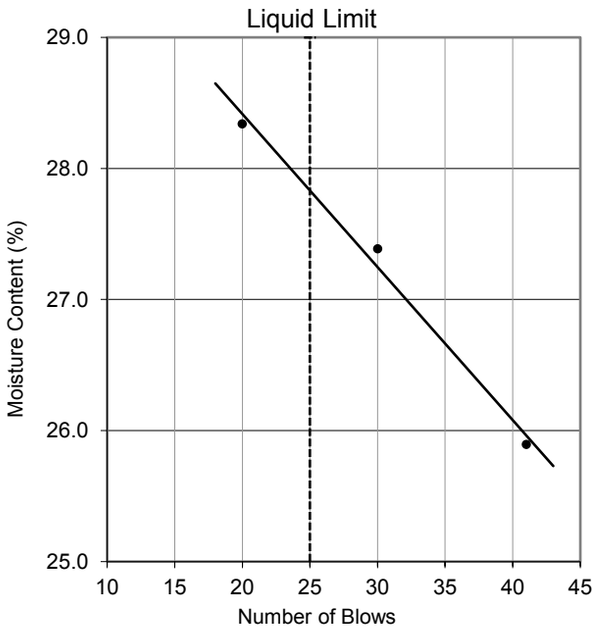
Bore Hole No.: BH-6 **Depth:** 1 m

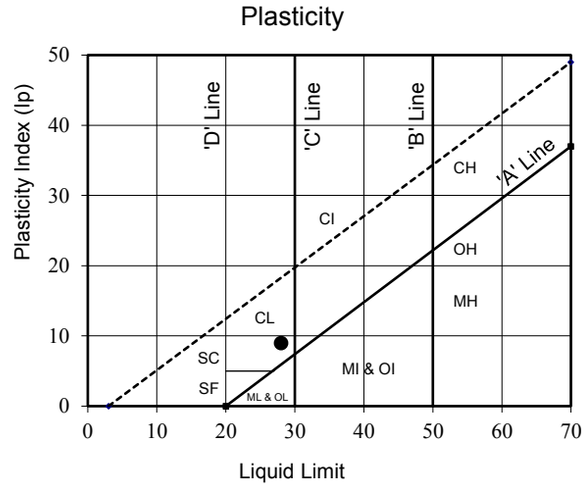
Liquid Limit Test

Trial	A	B	C
No. of Blows	20	30	41
Tare Number	LV-16	L-33	RP-11
Wt. of Tare, g	15.99	15.72	16.13
Wt. Wet Soil + Tare, g	23.19	27.86	25.61
Wt. Dry Soil + Tare, g	21.60	25.25	23.66
Wt. of Water, g	1.59	2.61	1.95
Wt. of Dry Soil, g	5.61	9.53	7.53
Moisture Content (%)	28.3	27.4	25.9

Plastic Limit Test

Trial	A	B
Tare Number	L-23	L-37
Wt. of Tare, g	17.89	19.15
Wt. Wet Soil + Tare, g	18.40	19.53
Wt. Dry Soil + Tare, g	18.32	19.47
Wt. of Water, g	0.08	0.06
Wt. of Dry Soil, g	0.43	0.32
Moisture Content (%)	18.6	18.8





USCS Symbol	CL
Liquid Limit (%)	28
Plastic Limit (%)	19
Plasticity Index (%)	9

Soil Description: Low Plastic Clay

Per: Stephen Bonnier

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ATTERBERG LIMITS
(ASTM D4318)

TRN: 18-050

Client:	Parks Canada	Sampled By:	AB
	Castle Mountain		
Project:	Banff Campground Geotechnical	Tested By:	KB
Job No.:	181-13597-12	Sample Date:	October 18 & 21, 2018
Report Date:	December 4, 2018	Test Date:	November 24th, 2018

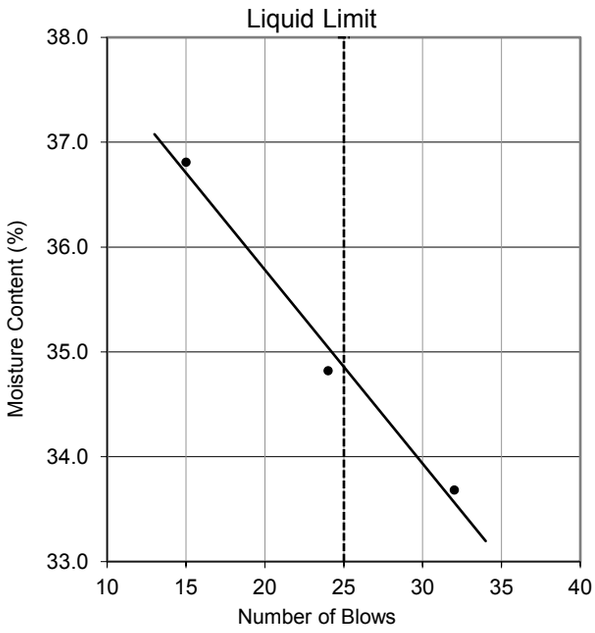
Bore Hole No.: BH-8 **Depth:** 12 feet

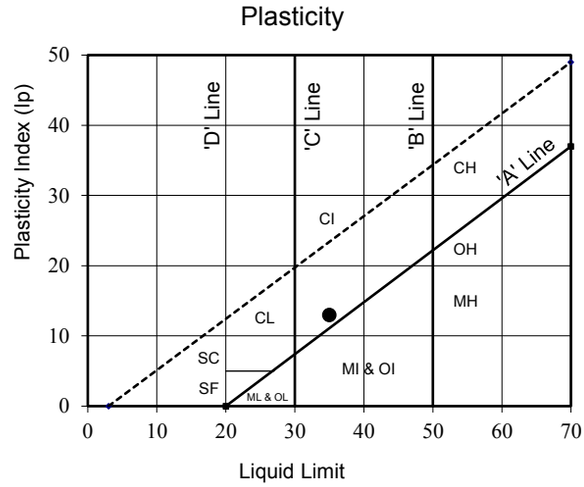
Liquid Limit Test

Trial	A	B	C
No. of Blows	32	24	15
Tare Number	L-26	L-22	LV-15
Wt. of Tare, g	17.56	16.95	15.31
Wt. Wet Soil + Tare, g	27.76	27.21	33.93
Wt. Dry Soil + Tare, g	25.19	24.56	28.92
Wt. of Water, g	2.57	2.65	5.01
Wt. of Dry Soil, g	7.63	7.61	13.61
Moisture Content (%)	33.7	34.8	36.8

Plastic Limit Test

Trial	A	B
Tare Number	# 287	L-31
Wt. of Tare, g	16.92	11.69
Wt. Wet Soil + Tare, g	17.41	12.26
Wt. Dry Soil + Tare, g	17.32	12.16
Wt. of Water, g	0.09	0.10
Wt. of Dry Soil, g	0.40	0.47
Moisture Content (%)	22.5	21.3





USCS Symbol	CI
Liquid Limit (%)	35
Plastic Limit (%)	22
Plasticity Index (%)	13

Soil Description: Medium Plastic Clay

Per: Stephen Bonnier

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Sieve Analysis

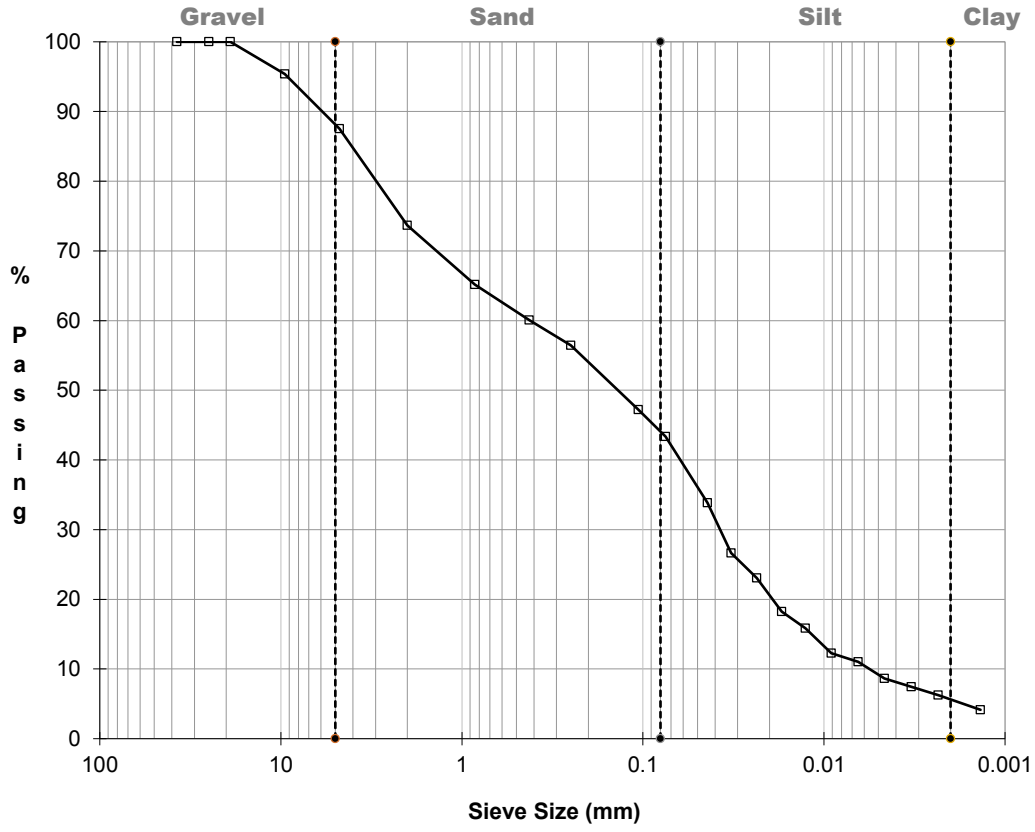
Report Date: December 04, 2018
Project Number: 181-13597-12
Report Number: 18-050

To: Parks Canada

Project: Banff Campground Geotechnical

Borehole No.:	BH-01
Sample Depth:	3 m
Source:	Minnewaka
Sampled By:	AB
Tested By:	KB

October 18- 21, 2018	November 26- 27, 2016	October 18- 21, 2018



Sieve Size (mm)	Percent Passing
37.500	100.0
25.000	100.0
19.000	100.0
9.500	95.4
4.750	87.5
2.000	73.7
0.850	65.2
0.425	60.0
0.250	56.4
0.106	47.2
0.075	43.4
0.044	33.9
0.033	26.7
0.024	23.1
0.017	18.3
0.013	15.9
0.009	12.3
0.006	11.0
0.005	8.6
0.003	7.4
0.002	6.2
0.001	4.1

Gravel =	12.5 %
Sand =	44.2 %
Silt =	37.1 %
Clay =	6.2 %

Remarks:

Per: Stephen Bonnier

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Sieve Analysis

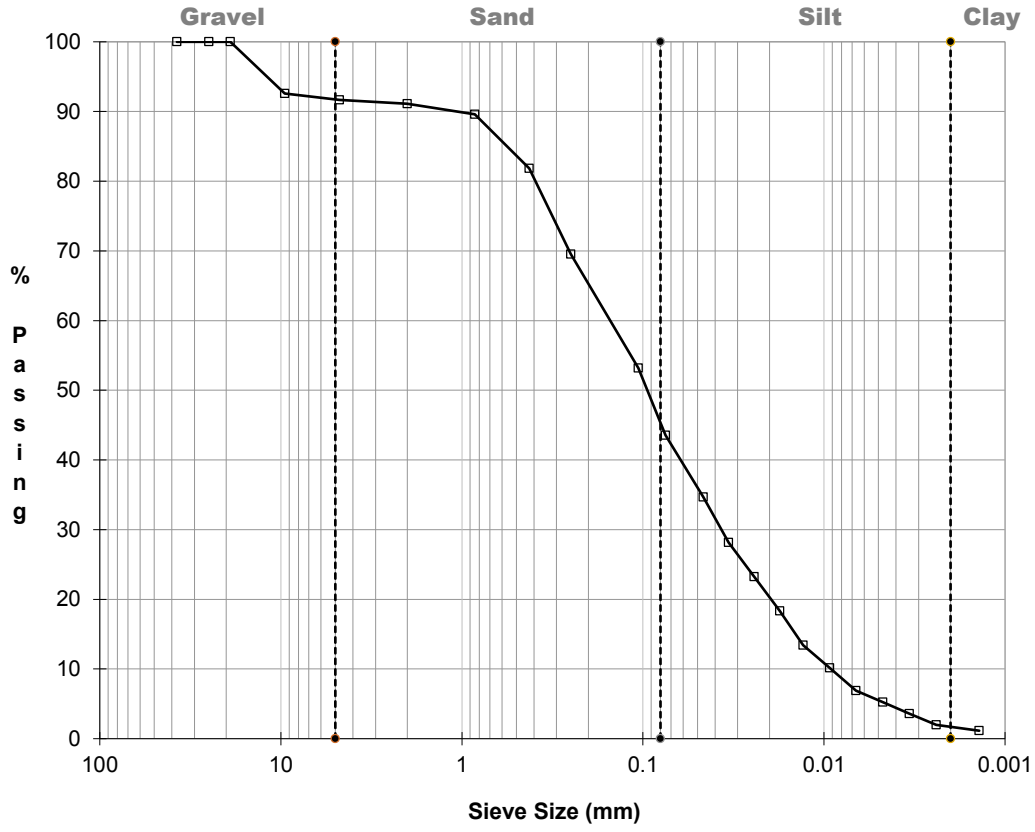
Report Date: December 04, 2018
Project Number: 181-13597-12
Report Number: 18-050

To: Parks Canada

Project: Banff Campground Geotechnical

Borehole No.:	BH-04
Sample Depth:	1.5 m
Source:	Jobsite
Sampled By:	AB
Tested By:	KB

October 18- 21, 2018	November 26- 27, 2016	October 18- 21, 2018



Sieve Size (mm)	Percent Passing
37.500	100.0
25.000	100.0
19.000	100.0
9.500	92.6
4.750	91.7
2.000	91.1
0.850	89.6
0.425	81.8
0.250	69.5
0.106	53.2
0.075	43.5
0.047	34.7
0.034	28.1
0.024	23.2
0.018	18.3
0.013	13.4
0.009	10.1
0.007	6.9
0.005	5.2
0.003	3.6
0.002	2.0
0.001	1.1

Gravel =	8.3 %
Sand =	48.2 %
Silt =	41.5 %
Clay =	2.0 %

Remarks:

Per: _____

Sieve Analysis

WSP Canada Inc.

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Tel. No. (403) 247-1813, FAX No. (403) 247 - 1814

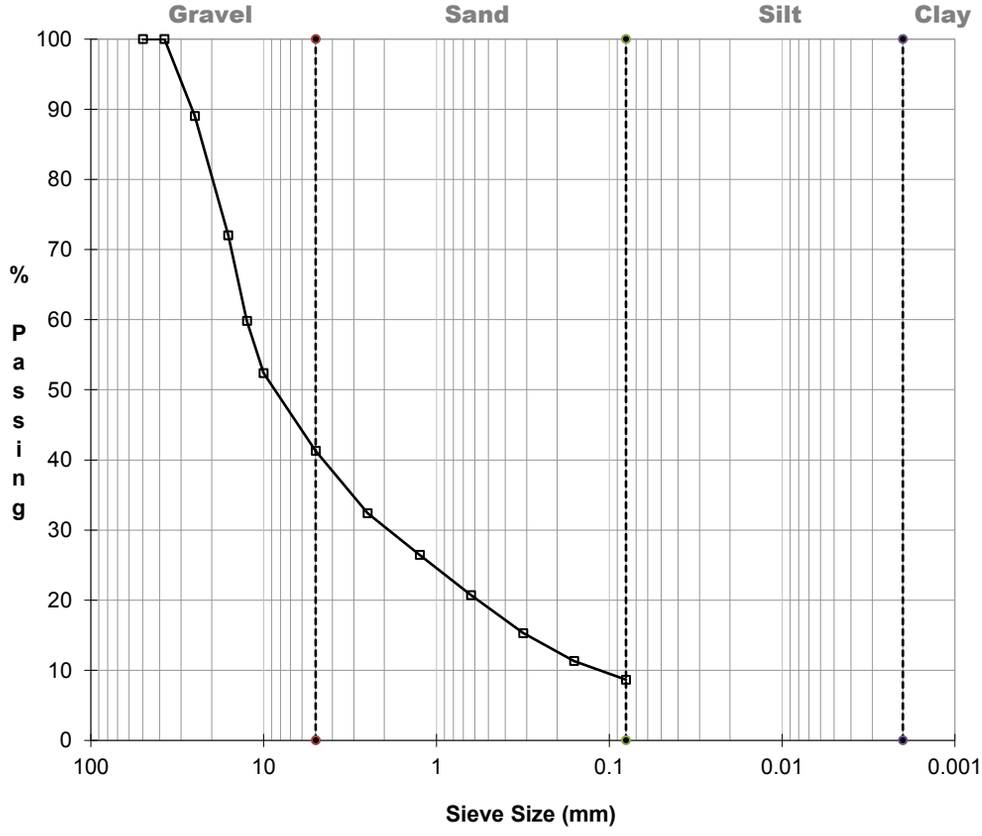
Report Date: **Dec. 05, 2018**
Project Number: **181-13597-12**
Report Number: **18-050**

To: Parks Canada

Borehole No.: BH-8
Sample Depth: 5 feet
Source: Jobsite
Sampled By: AB
Tested By: KB

Project: Banff Campground Geotechnical
Castle Mountain

Sampled Date: October 18, 2018 Test Date: Dec 05, 2018



Sieve Size (mm)	Percent Passing
50.000	100.0
37.500	100.0
25.000	89.0
16.000	72.0
12.500	59.8
10.000	52.4
5.000	41.3
2.500	32.4
1.250	26.4
0.630	20.7
0.315	15.3
0.160	11.3
0.080	8.7

Gravel	=	58.7
Sand	=	32.6
Silt/Clay	=	8.7

Remarks:

Per: Stephen Bernier

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of test results is provided only on written request.

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SULPHATE TEST

(ASTM C1580)

TRN: 18-050

Client:	Parks Canada	Sampled By:	AB
Project:	Banff Campground Geotechnical	Tested By:	DH
Job No.:	181-13597-12	Sample Date:	October 2018
Report Date:	December 3, 2018	Test Date:	November 24, 2018

BH No. (Minnewanka)	**BH18-01**	**BH18-04**	**BH18-01**
Depth in meter	3.00	1.50	1.00
Tare No.	# 27	# 16.0	# 19.0
Actual Reading	38.0	21.0	22.0
Correction Factor	1	1	1
Corrected Reading	38	21	22
SO4 Content (%)	**0.076**	**0.042**	**0.044**
BH No. (Castle Mtn.)	**BH18-08**		
Depth in meter	5.00		
Tare No.	# 15		
Actual Reading	50.0		
Correction Factor	1.0		
Corrected Reading	50		
SO4 Content (%)	**0.100**		
BH No.			
Depth in meter			
Tare No.			
Actual Reading			
Correction Factor			
Corrected Reading			
SO4 Content (%)			
BH No.			
Depth in meter			
Tare No.			
Actual Reading			
Correction Factor			
Corrected Reading			
SO4 Content (%)			

Per: Stephen Bernier