POST-EA INFORMATION PACKAGE INCLUDING AN UPDATED PROJECT DESCRIPTION
ALL SEASON ROAD TO PRAIRIE CREEK MINE

APPENDIX 10-2

SUBMITTED IN SUPPORT OF:
Water Licences MV/PC2014L8-0006, and
Land Use Permits MV/PC2014F0013

SUBMITTED TO:
Mackenzie Valley Land and Water Board
Yellowknife, NT X1A 2N7

Parks Canada,
Nahanni National Park Reserve
Fort Simpson, NT X0E 0N0

SUBMITTED BY:
Canadian Zinc Corporation
Vancouver, BC, V6B 4N9

February 2019
Permafrost Management Plan
Access Road
Prairie Creek Mine, NT

PRESENTED TO
Canadian Zinc Corporation

DECEMBER 2018
ISSUED FOR USE
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Revision History

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Review and Approval

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<td>Full Name, Job Title</td>
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Distribution List

This Plan and the most recent revisions have been distributed to:

Copy #1 –

Copy #2 –
This Permafrost Management Plan (PMP) describes the methods for managing permafrost during the construction and operation of the Prairie Creek All-Season Road (ASR) leading to the Prairie Creek Mine. The primary goal of this PMP is to prevent and/or mitigate degradation of permafrost along the ASR alignment. It incorporates all commitments and recommendations outlined by applicable regulatory bodies including the Government of the Northwest Territories (GNWT), the Mackenzie Valley Land and Water Board (MVLWB), Natural Resources Canada (NRCan), and Parks Canada (PC). To achieve this, the PMP includes the following sections:

- Permafrost Description;
- Potential Impacts on Permafrost During Project;
- Permafrost Management Plan;
- Permafrost Monitoring Program; and
- Permafrost Adaptive Management.

The ASR alignment is located in a zone of extensive discontinuous permafrost, which means permafrost may be present under 50% to 90% of the terrain. It was previously estimated that approximately 73 km of the ASR is underlain by thaw-sensitive permafrost with potential for another 24 km depending on slope aspects and elevation.

Numerous site reconnaissance, terrain mapping, and geotechnical investigations have been completed to date to better define the presence of permafrost. Currently, confirmed permafrost conditions have been observed in 17 boreholes at various locations along the ASR alignment. Additional geotechnical investigation work is planned as the project moves into detailed design. One of the primary goals will be to delineate and confirm areas of ice-rich permafrost as these have direct implications on the road’s alignment and embankment design.

Development of the ASR involves a number of different construction activities and external factors, all with potential impacts to permafrost. Four impacts were identified to potentially causing permafrost degradation:

- Road Construction and Borrow Pit Development;
- Road Operations;
- Climate Change; and
- Wildfires.

This PMP provides methods and strategies for preventing the above impacts to permafrost. Mitigations pertaining to road construction, route refinement, embankment design, watercourse crossings, borrow pits, snow accumulation, and thermokarst are all discussed. This PMP also outlines a detailed monitoring program with an emphasis on early detection of changes in permafrost. The monitoring program is a vital component of adaptive management and will include visual inspections, ground temperature monitoring, instrumented road sections, and climatic data reviews. The program will be implemented at the start of the road’s construction and will continue through to closure and reclamation.

This management plan was developed to be in line with recommendations from the applicable Northern Land Use Guidelines (GNWT 2015) and the Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions (TAC 2010).
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### ACRONYMS & ABBREVIATIONS

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<tr>
<td>Allnorth</td>
<td>Allnorth Consultants Ltd.</td>
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<td>ASR</td>
<td>All-Season Road</td>
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<tr>
<td>BCMF</td>
<td>British Columbia Ministry of Forest, Lands, and Natural Resource Operations</td>
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<tr>
<td>CZN</td>
<td>Canadian Zinc Corporation</td>
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<tr>
<td>CCR</td>
<td>Capacitively-Coupled Resistivity</td>
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<td>EA</td>
<td>Environmental Assessment</td>
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<td>GNWT</td>
<td>Government of the Northwest Territories</td>
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<td>GPR</td>
<td>Ground Penetrating Radar</td>
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<td>GTC</td>
<td>Ground Temperature Cable</td>
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<tr>
<td>km</td>
<td>Kilometres</td>
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<td>KP</td>
<td>Kilometre Post</td>
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<td>m</td>
<td>Metres</td>
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<tr>
<td>Mine</td>
<td>Prairie Creek Mine</td>
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<tr>
<td>mm</td>
<td>Millimetres</td>
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<td>Mackenzie Valley Land and Water Board</td>
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<td>Natural Resources Canada</td>
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<td>NT</td>
<td>Northwest Territories</td>
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<td>PC</td>
<td>Parks Canada</td>
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<td>Project</td>
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<td>RCP</td>
<td>Road Construction Plan</td>
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<td>ROMP</td>
<td>Road Operations and Maintenance Plan</td>
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<tr>
<td>SBT</td>
<td>Single-Bead Thermistor</td>
</tr>
<tr>
<td>TAC</td>
<td>Transportation Association of Canada</td>
</tr>
<tr>
<td>Tetra Tech</td>
<td>Tetra Tech Canada Inc.</td>
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## Glossary of Terms

<table>
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<th>Definition</th>
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<tr>
<td>Active Layer</td>
<td>The top layer of ground that is subject to annual thawing and freezing in areas underlain by permafrost. The thickness of the active layer varies from year to year, depending on such factors as the ambient air temperature, vegetation, drainage, soil/rock type, water content, snow cover, slope degree, and aspect.</td>
</tr>
<tr>
<td>Continuous Permafrost</td>
<td>An area where at least 90% of the land area is underlain by permafrost.</td>
</tr>
<tr>
<td>Discontinuous Permafrost</td>
<td>An area where 10% to 90% of the land area is underlain by permafrost.</td>
</tr>
<tr>
<td>Drunken Forest</td>
<td>Trees leaning in random directions in a permafrost region.</td>
</tr>
<tr>
<td>Excess Ice</td>
<td>Volume of ice in the ground that exceeds the total pore volume that the ground would have under natural unfrozen conditions.</td>
</tr>
<tr>
<td>Freezing Index</td>
<td>The cumulative number of degree-days below 0°C for a given time period.</td>
</tr>
<tr>
<td>Ground Ice</td>
<td>A general term referring to all types of ice (segregated, intrusive, vein etc.) formed in freezing and frozen ground. Occurs in pores, cavities, voids, cracks, fractures, and other openings in soil or rock.</td>
</tr>
<tr>
<td>Hummock</td>
<td>Small mound of mineral soil, largely silt and clay, formed by differential frost heave that makes the ground irregular.</td>
</tr>
<tr>
<td>Ice Content</td>
<td>The amount of ice contained in frozen or partially frozen soil or rock.</td>
</tr>
<tr>
<td>Ice Lens</td>
<td>A dominantly horizontal, lens-shaped body of ice ranging in thickness from hairline to 0.3 m. Ice layers more than 0.3 m in thickness are better termed massive ice beds.</td>
</tr>
<tr>
<td>Patterned Ground</td>
<td>Geometric patterns at ground surface, including circles, polygons, and stripes that show the sorting of fine-grained or coarse-grained soil and/or the presence of ice wedges in the soil.</td>
</tr>
<tr>
<td>Peatland</td>
<td>Poorly drained organic terrain characterized by a high-water table and the presence of permafrost.</td>
</tr>
<tr>
<td>Permafrost</td>
<td>Ground (soil and/or rock) that remains at or below 0°C for at least two consecutive years. Permafrost is defined exclusively based on temperature. It is not necessarily frozen (i.e. does not necessarily contain ground ice).</td>
</tr>
<tr>
<td>Permafrost, Ice-Poor</td>
<td>Permafrost which, upon thawing, will not experience either significant thaw settlement or loss of strength (i.e. thaw-stable).</td>
</tr>
<tr>
<td>Permafrost, Ice-Rich</td>
<td>Permafrost containing excess ice which, upon thawing, will experience a significant loss of strength below normal thawed values and/or significant settlement due to melting of the excess ice in the ground (i.e. thaw-sensitive).</td>
</tr>
<tr>
<td>Polje</td>
<td>A thermokarst terrain feature with a flat bottom and steep walls with no obvious outflowing surface water. They are major sinkholes that can be water-filled (forming a lake) or drained and can have smaller sinkholes on the bottom.</td>
</tr>
<tr>
<td>Subsidence</td>
<td>The gradual sinking or downward settling of the earth’s surface in response to geologic or man-induced causes.</td>
</tr>
<tr>
<td>Thermokarst</td>
<td>The process by which characteristic landforms result from the thawing of ice-rich permafrost or the melting of massive ice.</td>
</tr>
</tbody>
</table>
LIMITATIONS OF REPORT
This report and its contents are intended for the sole use of Canadian Zinc Corporation (CZN) and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than CZN, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.
1.0 INTRODUCTION

This Permafrost Management Plan (PMP) was prepared for Canadian Zinc Corporation (CZN) by Tetra Tech Canada Inc. (Tetra Tech). It outlines best management practices, a monitoring program, and response actions relating to permafrost for the construction and operation of the Prairie Creek All-Season Road (ASR) leading to the Prairie Creek Mine (Mine) from the Liard Highway, NT.

This PMP is preliminary at this time as the ASR is currently in the preliminary design phase and has not yet been permitted. The details and site-specific information in this PMP will expand prior to final road design. Specifically, further geotechnical and geophysical investigations are to be completed to better define permafrost conditions along the route which will increase the level of detail in this document.

1.1 Company Name, Location, and Mailing Address

Company Name:
Canadian Zinc Corporation

Head Office:
Address: Suite 1710 – 650 West Georgia Street, Vancouver, BC, V6B 4N9
Phone: +1.604.688.2001
Fax: +1.604.688.2043
Email: david@canadianzinc.com

Prairie Creek Mine Site:
Iridium 9555 Satellite Phone 1 (yellow) 011.8816.315.30998
Iridium 9505A Satellite Phone 2 (black) 011.8816.315.30997
Iridium 9505A Satellite Phone 3 (orange) 011.8816.315.30996
Ground-To-Air Radio Handheld FREQ 122.800

1.2 Purpose

The purpose of CZN’s PMP is to establish and implement a plan for managing permafrost during the construction and operation of the Prairie Creek ASR. It incorporates all commitments and recommendations outlined by applicable regulatory bodies including the Government of the Northwest Territories (GNWT), the Mackenzie Valley Land and Water Board (MVLWB), Natural Resources Canada (NRCan), and Parks Canada (PC). To achieve this, the PMP includes the following sections:

- Permafrost Description;
- Potential Impacts on Permafrost During Project;
- Permafrost Management;
- Permafrost Monitoring Program; and
- Permafrost Adaptive Management.

This PMP is a living document that will be updated throughout the life of the ASR to adapt and incorporate any changes that may arise (e.g. site conditions, design modifications). Updates to this plan will also include results...
from ongoing engagement with the potentially-affected Indigenous groups, including Nahanni Butte Dene Band, Liidlii Kué First Nation, and Dehcho First Nations, as well as all applicable regulators and land managers. A final, detailed PMP will be completed after detailed design of the ASR and will be implemented prior to construction. This plan will then be reviewed and updated within 12 months of construction completion.

1.3 Related Documents

This PMP is linked to several other CZN management plans, including:

- Health, Safety, and Emergency Response Plan;
- Engagement Plan;
- Borrow Pit Management and Reclamation Plans;
- Explosives Management Plan;
- Invasive Species Management Plan;
- Rare Plant Management Plan;
- Road Closure and Reclamation Plan;
- Road Construction Plan;
- Road Operations and Maintenance Plan;
- Sediment and Erosion Control Plan;
- Spill Contingency Plan;
- Sundog Creek Diversion Plan;
- Traffic Control Mitigation and Management Plan;
- Waste Management Plan; and

Details of the ASR, including a schedule of road construction and operations, are provided in the Road Construction Plan (RCP). A map book showing the access road is provided in Appendix A.

1.4 Regulatory Guidance

This PMP was prepared with guidance from the following publications:

- Government of Northwest Territories, Department of Lands’ Northern Land Use Guidelines – Access: Roads and Trails (GNWT 2015a);
- Government of Northwest Territories, Department of Lands’ Northern Land Use Guidelines – Pits and Quarries (GNWT 2015b);
- Transportation Association of Canada’s Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions (TAC 2010); and
2.0 PROJECT DESCRIPTION

CZN is planning to operate the Prairie Creek Mine which is located at approximately 61° 33’ north latitude and 124° 48’ west longitude adjacent to Prairie Creek, a tributary of the South Nahanni River, in the southwest corner of the Northwest Territories (Figure 1).

A 170 km all-season road connecting the Mine, at Kilometre Post (KP) 0, to the Liard Highway via the Nahanni Butte access road (Figure 2) will generally follow the alignment of a previously permitted winter road, while reflecting the terrain, site characteristics, and road specifications suitable and preferred for the ASR. Approximately half of the proposed ASR (85 km between KP 17 to KP 102) is located within the Nahanni National Park Reserve (NNPR). The NNPR, a world heritage site, is known for its globally-significant karst terrain, as well as the South Nahanni River, a Canadian Heritage River. Approximately half of the ASR alignment will directly overlap with the alignment of the permitted winter road.

Construction of the ASR will take approximately three years to complete. Initial winter roads will be built to gain access to the Mine, allow further investigation of the ASR alignment to complete detailed design, and to provide access for road construction. CZN’s intent is to build the initial winter roads on the ASR alignment as much as possible to minimize the total extent of disturbance.

The ASR will cross approximately 18 major streams with clear span bridges or large diameter culverts, and 85 minor streams with culvert diameters ranging from 800 mm to 2,000 mm based on the size of the stream. Construction of the ASR will be supported by temporary camps at KP 23 (Sundog), KP 39 (Cat Camp), KP 65, KP 87, KP 121 (Grainger Gap), KP 151 or KP 158, and KP 177.5. The camps at KP 39, KP 87, and KP 121 will likely be retained in a reduced form to support on-going road maintenance.

Borrow pits have been identified all along the ASR route to provide material for the road subgrade and surfacing. Eighty-six borrow sources have been defined for use in road construction, with another thirty as back-up in the event any of the eighty-six are subsequently found to be unsuitable. Currently, approximately 44 of the 86 borrow pits are considered preferred locations and about 9 of these sources may require blasting and/or crushing activities. Blasting may also be required along the ASR alignment at a number of locations such as KP 5, KP 23, KP 25 to KP 29, KP 32, and KP 36 to KP 37. Some of the surfacing borrow pits will be retained to support road maintenance. The remainder will be closed and reclaimed immediately after ASR construction. Most borrow sources are proximal to, or within, the road corridor while others will require short access roads.

Water sources will be utilized in winter for winter road construction and during summer for dust control. Water sources have been defined at KP 0 (the Mine), KP 39 (Cat Camp), KP 60 (Mosquito Lake), KP 70, KP 100, KP 121 (Gap Lake), KP 139, KP 141, and the Liard River. Winter water extraction from lakes will be conducted in conformance with regulatory water withdrawal protocols, limiting extraction to less than 10% of lake volume. Summer water extraction from lakes will similarly be limited to avoid significant water level drawdown and will be monitored using installed staff gauges.
3.0 PERMAFROST DESCRIPTION

3.1 Definition

Permafrost, or perennally frozen ground, is defined as soil or rock having temperatures below 0°C during at least two consecutive winters and the intervening summer (Andersland and Ladanyi 2004). The two-year minimum stipulation excludes the overlying ground surface layer which freezes every winter and thaws every summer, defined as the “active layer”.

The relationship between climate and permafrost is not direct, but instead is mediated by the buffer layer consisting of the snow, vegetation and organic covers and soil. The interactions of the active layer and permafrost with the atmosphere, vegetation, biological, hydrological, and geomorphic process are complex. Simply stated, as the vegetation and organic layer decrease or are removed, the active layer thickens, and degradation of ice-rich permafrost occurs. Increases in vegetation and the organic layer result in less thaw and permafrost aggradation. Changes in snow cover and soil moisture further modify the response of the active layer to thermal changes at the ground surface and in the thawing soil layer. Any modification to the ground surface, including the addition of embankment materials, will modify the ground’s thermal regime and can potentially lead to thaw at the embankment’s toe and ponding water.

Geographically, permafrost is divided into two zones: continuous and discontinuous, as shown below in Figure A. Continuous zones are defined as having 90% or more of the land area underlain by permafrost. In the discontinuous zones, permafrost occurs in scattered areas ranging in size and thickness with 10% to 90% of coverage.

![Figure A: Permafrost Map of Canada (NRCan 2009)](image-url)
Permafrost can be classified into two types: ice-rich (thaw-sensitive) and ice-poor (thaw-stable). Not all permafrost is a concern to the successful construction and operation of an access road. The type of permafrost that is of most concern is ground that is ice-rich and/or thaw-sensitive. For example, fine-grained soils that contain visible ice or are more than 100% saturated are considered thaw-sensitive. Such soils could lose most or all their strength if thawed, which could lead to potential instability and settlement. Ice-rich soils, even if they do not thaw, can also be prone to creep deformation under very small loads. This can potentially lead to the movement of road embankments on even very flat cross-gradients, due only to the weight of the fill as the ice-rich soil beneath creeps and spreads outward away from under the embankment. Bedrock can also be classified as permafrost; however, it is usually not ice-rich, so if it thaws, it would remain stable. Similarly, dense granular soils that do not contain excess ice would not be considered thaw-sensitive.

3.2 Interpreted Permafrost Conditions

The ASR alignment is located in a zone of extensive discontinuous permafrost, which means permafrost may be present under 50% to 90% of the terrain (NRCan 2009). Where present, the active layer (zone of seasonal freezing and thawing) will vary in thickness according to the type of ground cover and soil type. In most areas, the active layer in the coarser-grained soils could be 2 m to 3 m deep, tending to be deeper in areas with little peat at the ground surface. The active layer is likely to be somewhat thinner in silty soils if present on the alluvial fans, possibly less than 2 m. If a significant layer of peat is on top of the mineral soils, the active layer could be less than 1 m.

3.2.1 Permafrost Mapping and Site Reconnaissance

Permafrost mapping and site reconnaissance of the proposed ASR was conducted by Tetra Tech between 2014 to 2016 to identify areas of expected permafrost along the ASR alignment. The mapping identified where permafrost was expected based on landform features such as kettles, patterned ground, solifluction, and thermokarst. The mapping referenced previous work completed by J.D. Mollard and Associates Ltd. (Mollard 1995) as well as Golder Associates Ltd. (Golder 2010). Potential permafrost areas were also identified during field reconnaissance by the presence of specific vegetation on wet slopes (black spruce, tamarack, willow, and birch) and dry slopes (aspen, white spruce, and lodgepole pine). The presence of fine-grained mineral soils (silt and clays) were also used to identify potential permafrost.

A complete set of permafrost terrain maps for the ASR alignment are available in Appendix B.

3.2.2 Geotechnical Investigations

Several investigations have been conducted over the course of preliminary ASR design. In September 2012, SNC-Lavalin Inc. completed a shallow geotechnical investigation program along several sections of the alignment proposed at the time, of which, 16 boreholes are currently relevant (SNC 2012).

In September 2014, during mapping and site reconnaissance work, Tetra Tech drilled 40 boreholes and 4 testpits by hand using shovels, picks, and an Edelman-type hand auger (Tetra Tech EBA 2015). During that same program, Allnorth Consultants Ltd. (Allnorth) excavated numerous shallow testpits along the route and in proposed borrow areas.

In August 2018, further permafrost information was collected by Tetra Tech during a shallow geotechnical investigation program (Tetra Tech 2018). The program utilized a hand-operated window sampler to collect disturbed ground samples from a maximum depth of 5.0 m. Representative samples of undisturbed frozen overburden were not obtained during this program as the frozen core was too thermally damaged.
All borehole and testpit locations noted above are shown on the permafrost terrain maps included in Appendix B.

### 3.2.3 Summary of Interpreted Permafrost Conditions

The proposed ASR has potential for encountering permafrost along most of the route; however, not all of it is thaw-sensitive. It was originally estimated that about 73 km likely has least some thaw-sensitive permafrost, and another 24 km may also have thaw-sensitive permafrost, but slope aspect or elevation makes it slightly less likely (Tetra Tech EBA 2015).

Confirmed permafrost conditions were noted in five boreholes from the 2012 investigation and six boreholes in the 2014 program. The 2018 geotechnical investigation program sampled 39 sites, of which, 6 sites were observed to contain permafrost. To date, confirmed permafrost conditions have been observed in 17 boreholes at various locations along the ASR alignment, which is considerably less than originally estimated.

A detailed table of the interpreted permafrost conditions is included in Appendix C, while known conditions are summarized in the table below:

#### Table 1: Summary of Known Permafrost Conditions

<table>
<thead>
<tr>
<th>Section Landmarks (Range)</th>
<th>Permafrost Locations (Nearest KP)</th>
<th>Depth Below Ground (m)</th>
<th>Borehole (Program)</th>
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<tr>
<td>Sundog Tributary Bridge – Poljie Bridge (KP 39.2 – KP 53.2)</td>
<td>KP 50.5</td>
<td>2.00</td>
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<td>KP 53.2</td>
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<td>BH15 (Tt 2018)</td>
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<td>Poljie Bridge – Tetcela 1 Bridge (KP 53.2 – KP 87.0)</td>
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<td></td>
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<td>2.50</td>
<td>TP07 (Tt-EBA 2014)</td>
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<td></td>
<td>KP 56.7</td>
<td>1.96</td>
<td>BH-M-02 (SNC 2012)</td>
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<td></td>
<td>KP 82.9</td>
<td>1.07</td>
<td>BH-TTF-01 (SNC 2012)</td>
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A comprehensive geotechnical and geophysical investigation program of the ASR is planned to occur during the first winter after permit issue, prior to completion of the final road and crossing designs. One of the primary goals of the additional geotechnical investigation will be to delineate and confirm areas of ice-rich permafrost as these have direct implications on the road’s design.
4.0 POTENTIAL IMPACTS ON PERMAFROST DURING PROJECT

Development of the Prairie Creek ASR, from construction through reclamation, involves a number of different activities and external factors with potential impacts to permafrost. These activities can lead to permafrost degradation and include:

- Road Construction and Borrow Pit Development;
- Road Operations;
- Climate Change; and
- Wildfires.

Each of the above potential impacts are outlined in following sections. Mitigation strategies for each are discussed in Section 5.0 of this management plan.

4.1 Road Construction and Borrow Pit Development

A construction methodology for the proposed ASR is described in detail in CZN’s Road Construction Plan (RCP). The work will include numerous activities with potential permafrost impacts, including:

- Development of winter access roads;
- Road construction in winter, summer, and/or fall;
- Set up and operation of maintenance camps;
- Stripping and stockpiling of organic material from borrow pits;
- Excavation of material from borrow pits;
- Stockpiling, hauling, and placing of borrow materials for the access road;
- Installation of bridges and culverts; and
- Grading and compaction of constructed embankments.

All of these activities require disturbance of potential permafrost terrain. The ground is in its most vulnerable state in between spring and fall when surface temperatures are increasing, and the active layer is thawing. Disturbance of the ground when it is in this vulnerable state can potentially cause deformation or damage to the soil (particularly in areas of soft, fine-grained soils and peatlands). It can also cause groundwater to pipe to the surface and form areas of standing water (collection of surface water in deformations).

In areas of ice-rich permafrost, construction can potentially cause changes or disturbance to the ground surface resulting in increased ground temperatures and causing thaw of ice-rich soils. This can lead to subsequent thaw slumps, slope instability, settlement, erosion, and subsidence in the permafrost. Subsidence or the presence of new low-lying areas or surface channels can also impact surface water drainage, even beyond the road footprint. With thermal and physical erosion comes the likelihood of sedimentation.

Roadway cut slopes in permafrost require the removal of the organic layer and cutting into the native ground, both of which potentially expose permafrost. In ice-rich permafrost areas this can cause subsidence and water ponding.
along the cutslope and embankment toe as well as excessive erosion and sedimentation. This could result in excessive thaw settlement or loss of the road embankment, or even a retrogressive thaw slump or flow.

The same issues apply to the extraction of materials from borrow pits. If borrow sites are located adjacent to the road, these issues are likely to also affect the road. Where borrow pits are not located in permafrost, there may still be the potential for erosion and sedimentation occurring or sloughing of over-steepened pit slopes.

### 4.2 Road Operations

Permafrost can be affected by the physical presence of an access road and there are challenges in operating a roadway through discontinuous permafrost terrain. Permafrost and ice-rich soils are sensitive to changes in ground temperature, and this is particularly true of the warm permafrost found along the route. Changes can cause an increase in the active layer thickness, instability, thaw settlement, and subsidence due to loss of permafrost.

Introducing a new material on the ground surface could change this balance. For example, in warm permafrost, the edges of the embankment tend to cause the permafrost beneath to thaw, typically causing ponding along the embankment toe, while in the middle of the embankment, the permafrost may be preserved or even aggrade. Snow drifting tends to increase this effect. Although the road grade is plowed, the sides of the embankment tend to build up with drifted or plowed snow, which insulates the ground and reduces the amount of heat escaping from it in winter. This means that the permafrost on the edges of the fill does not cool as much in winter as it would without an embankment, while in the middle of the road, it might even be colder than normal because it is plowed all winter. The snow drifting/plowing effect can potentially reach past the toe of the embankment.

The road embankment can also form a barrier to the movement of surface runoff, resulting in water accumulating or ponding along the embankment toe, which in turn can contribute to thaw and potential slope stability issues. Groundwater water flow in the active layer can be affected if the depth of thaw is greater at the edges of the embankment than at the middle.
Increased flow downstream of culvert can cause thaw subsidence and instability due to increased heat loading from the flow water. Culverts can contribute to heave in the winter and thaw settlement in the summer in soils that are frost-susceptible and thaw-sensitive and can result in thermal erosion in ice-rich terrain.

### 4.3 Climate Change

The impacts of climate change will be considered in the design of the ASR. Although numerous other construction and operations factor contribute primarily to permafrost thaw, climate change still needs to be considered as it increases the potential for degradation. Two key factors play a role with respect to climate change and its probable effects on permafrost along the proposed ASR:

- Climate change has been ongoing for many years and is expected to continue during and beyond the service life of the ASR; and
- Already-warm permafrost will continue to get warmer and will either continue slowly thawing or start slowly thawing.

The sensitivity of an area to climate change is governed by the characteristics of the permafrost in that area. The ASR is in an area of extensive, discontinuous permafrost, with average anticipated ground temperatures just below 0°C at lower elevations and likely warmer than -2°C at higher elevations along the route. The subsurface soils are of variable origin along this 170 km route, but permafrost with possible ice-rich lenses or layers has been encountered at various locations along the route. Tetra Tech (2016) previously estimated that about 73 km likely has some thaw-sensitive permafrost, and another 24 km may also have thaw-sensitive permafrost, but slope aspect or elevation makes it slightly less likely.

### 4.4 Wildfires

Permafrost can be adversely affected by wildfires during the summer months, particularly in terrain that is ice-rich. Burning should not be conducted in permafrost terrain or areas with high ground ice content as it can cause ground subsidence. Permafrost terrain that has recently experienced a forest fire is prone to erosion due to ground ice melting and degradation. Areas typically stabilize a few years after the fire, once the ground ice has melted.

### 5.0 PERMAFROST MANAGEMENT

Design and construction of the Prairie Creek ASR will be informed by industry-standard best management practices for anticipating and managing permafrost. It will include considerations for construction through discontinuous permafrost terrain relating to the development of roadways, borrow pits, and associated infrastructure.

Numerous permafrost management and mitigation strategies were referenced from documents provided by the TAC (2010) and the GNWT (2015). Each strategy outlines measures to avoid or reduce adverse effects on permafrost due to roadway and borrow construction. Other resources were referenced from the British Columbia Ministry of Forest, Lands, and Natural Resource Operations (BCMF) including the *Karst Management Handbook* for parts of the road that traverse on or close to karst terrain (BCMF 2003).

This PMP reflects those guidelines in addition to site-specific information currently known about ground conditions along the ASR route.
5.1 Permafrost Identification

Identification of permafrost along the proposed ASR alignment is an essential component prior to detailed design. CZN has committed to conducting detailed geotechnical investigations, including geophysical surveys, to better define the locations and characteristics of permafrost soils. A complete site investigation was recommended by both PC and NRCan to confirm permafrost and subsurface conditions in areas where ground ice is expected.

The future investigation program will focus on perennially frozen overburden and bedrock characterization to collect additional permafrost, particularly volumetric ground ice content and ground temperature data, and will consist of geotechnical drilling (with chilled drilling fluid), auger drilling, permafrost coring, installation of ground temperature measuring instrumentation, and geophysical surveying.

The main objective of the geotechnical investigation program will be to recover quality, undisturbed frozen core samples of the overburden and to conduct in-situ permafrost logging. Laboratory testing of the core samples will be completed to further characterize permafrost conditions along the road alignment and in potential borrow areas. The proposed geotechnical scope of work includes:

- Drilling of geotechnical boreholes along the proposed ASR alignment using self-propelled rotary (with chilled drilling fluid) and/or auger drilling equipment along the proposed road alignment;
- Excavating testpits along the proposed ASR alignment using an excavator;
- Drilling geotechnical boreholes at potential borrow areas using self-propelled rotary or auger drilling equipment;
- Geotechnical logging of permafrost and field testing of frozen soil samples (excess ice content, moisture content, bulk density, and soil salinity);
- Collection of frozen / unfrozen soil samples for offsite geotechnical laboratory testing; and
- Installation of multi-bead instrumentation and associated materials.

For the geophysical component of the proposed investigation, the objective will be to obtain supporting data for the geotechnical investigation along the route, at watercourse crossings, in borrow areas, and in areas with identified geohazards. The geophysical data, in combination with geotechnical borehole data, will help determine the distribution of frozen soil areas along the road alignment as well as give an indication of whether soils are ice-poor and hence thaw stable, or ice-rich and therefore prone to excessive thaw settlement. The proposed geophysical investigation will include the following:

- Ground profiling along the ASR alignment consisting of both Ground Penetrating Radar (GPR) and Capacitively-Coupled Resistivity (CCR);
- Investigations at each proposed borrow location, using both GPR and CCR techniques, to help determine material characteristics (material type, ice content, thickness of overburden);
- Two geophysical lines (GPR and CCR) per watercourse crossing in possible permafrost terrain, which will help characterize the subsurface conditions near proposed bridge abutments and major culverts; and
- Specialized investigations for areas where thermokarst or other potential permafrost hazards have been identified.
5.2 Road Alignment

The first strategy for road alignments in permafrost areas is to avoid thaw-sensitive terrain, where possible. The proposed ASR route has been located on drier, warmer south to southwest slopes and ridges that offer the least probability of permafrost.

Future geotechnical and geophysical investigations may lead to minor refinements of the ASR alignment. Where thaw-sensitive permafrost terrain cannot be avoided, embankments will be designed and constructed to manage the underlying soil conditions.

5.3 Construction Considerations

Construction mitigation measures that can be employed to minimize permafrost disturbance along the alignment include:

- **Leave Organics in Place.** Ground organics will be left in place and excavations will be avoided, where possible. For wet or ice-rich permafrost sections, typical overland construction will include no disturbance of the natural ground layer.

- **Construction Season.** Construction during summer/fall months will only take place in thaw-stable terrain that is likely to be seasonally dry. Subgrade construction in thaw-sensitive permafrost terrain will be avoided during the summer/fall months. Sections with significant permafrost and/or determined as ice-rich will be constructed during winter/spring when the soils still maintain a frozen state. Under these conditions the ground will support heavy equipment with minimal site disturbance. Winter construction is proposed to take place when the ground is frozen and construction access will be by winter road.

- **Forward Hauling.** Where possible, fill materials will be forward-hauled and placed prior to equipment advancing. This prevents equipment from coming into direct contact with the organic layer and, thus, preserves the underlying permafrost ground.

- **Snow Grubbing.** Initial snow cover will be carefully removed prior to construction of embankments to reduce settlement of the fill during the thaw period.

- **Subgrade Support.** Road subgrades should be constructed with adequate support either by placing downed timber horizontally in a corduroy style or by using geotextiles, where required, to help support the subgrade and prevent thaw settlement.

5.4 Embankment Design

The ASR embankment design will reflect minimal disturbance to the surface, minimal cuts, and shallow slopes to minimize large exposed slopes. Design embankments will follow the recommendations outlined in the *Northern Land Use Guidelines – Access: Roads and Trails* (GNWT 2015a) and the *Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions* (TAC 2010). The intent will be to prevent or slow the rate of thaw settlement by using thicker embankments constructed of denser soils or corduroy logs.

A typical embankment cross-section for ice-rich permafrost terrain is shown in Figure C below.
Embankment design should consider the following mitigations:

- Employ fill-only techniques for thaw-sensitive permafrost areas, meaning no cuts will take place and the road grade for that section will be composed of fill soils;

- Design and construct with thicknesses and widths based on terrain type, or use "corduroy" style embankment-supporting structures, or geotextile to protect underlying soils (especially important where sections of the road have permafrost underlying wetlands); and

- Flatten sideslopes in areas of potential thaw so that embankment toes are further from the road surface.

If cutslopes in thaw-sensitive terrain are unavoidable, mitigative solutions are limited. It may be possible to protect some cutslopes with a drainage blanket, or design near-vertical cutslopes to allow the organic layer to be draped over the cutslope to shade and protect it. These cutslopes will require greater vigilance for monitoring and maintenance.

### 5.5 Watercourse Crossings

One of the most common causes of permafrost degradation along roads is icing and drainage blockage at watercourse crossings. Blockages and changes in flow path tend to have a rapid impact on permafrost which can lead to subsequent impacts to the environment and road operations. Crossing selections and design will follow the drainage and erosion control recommendations outlined in the *Northern Land Use Guidelines – Access: Roads and Trails* (GNWT 2015a) and the *Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions* (TAC 2010). Further erosion control guidelines are outlined in CZN’s *Sediment and Erosion Control Plan*. 

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Figure C: Typical Embankment Section over Permafrost (Allnorth 2015)
The ASR design will incorporate adequate watercourse crossings to reflect natural drainage, flow paths, and patterns. Alterations to natural flows can increase the potential for erosion and ponding of water, both of which can potentially accelerate thawing of permafrost. To minimize crossing impacts to permafrost, the following design considerations will be implemented:

- **Crossing Selection.** Careful placement of crossings even where there are no obvious stream channels will help reduce the likelihood of ponding water alongside the road embankment. Water flows will be diverted away from road embankments until the appropriate cross-drainage location is reached.

- **Crossing Type.** The type of crossing (bridge, culvert, permeable embankment) will be chosen to reduce concentrated water flows or ponding that tends to cause thermal erosion (e.g. a small bridge could be used instead of a culvert).

- **Thaw-Stable Foundations.** Bridge and culvert foundations will be over-excavated where thaw-sensitive soils exist so that they are replaced with thaw-stable granular aggregate to reduce the potential for frost heave.

### 5.5.1 Minor Watercourse Crossing (Culverts)

The following considerations will be incorporated when designing culverts in permafrost ground:

- Culverts will be generously sized to compensate for design uncertainties, ice/snow/sediment blockage, and possible settlement (thaw or subgrade-related);

- Culverts will be designed to have a slight camber, such that the middle of the culvert has some vertical distance that compressible or thaw-sensitive soils can settle before a dip in the culvert can occur;

- Clay cut-offs or equivalent will be installed at each end of culverts to limit groundwater flow beneath;

- Elevated secondary culverts will be installed, where necessary, as overflow protection during spring in the event of ice blockage in the primary culvert; and

- Culverts that help to counteract loss of lateral restraint, due to thawing soils, will be used.

### 5.5.2 Major Watercourse Crossings (Bridges)

Bridge foundations and structures will be designed to be resilient to climate change and will account for potential changes in permafrost regime. For major stream crossings where permafrost is potentially present, foundations will be prepared with strictly frost-stable materials. Major watercourse foundations may consist of:

- Shallow foundations placed on a load-bearing, thaw-stable aggregate;

- Piles driven or drilled into a suitable thaw-stable layer;

- Deep foundations excavated to bedrock; or

- Other engineered approaches to prevent foundation permafrost degradation, if required.

### 5.6 Borrow Pits

The development, use, and restoration of borrow pits must be carefully planned and carried out to reduce or avoid negative impacts to permafrost. Pit development will follow the recommendations outlined in the *Northern Land Use Guidelines – Pits and Quarries* (GNWT 2015b) and the *Guidelines for Development and Management of Transportation Infrastructure in Permafrost Regions* (TAC 2010).
Geotechnical and permafrost characterization will be conducted within each proposed borrow pit to determine the presence of permafrost for all proposed borrow pits. The investigations will extend beyond the extents of each borrow pit as buffer zones will be incorporated between all pits within permafrost terrain. This information will be utilized to select borrow pits with little or no permafrost, particularly avoiding ice-rich soils. It will also guide the design of each pit to ensure that proper thermal insulating layers are maintained between the area of excavation and any surrounding permafrost soils.

Where permafrost is encountered in borrow pits, either the borrow will not be used or it will be used subject to mitigation to avoid significant permafrost degradation. General mitigations for borrow pits in ice-rich areas include:

- **Minimize Surface Area.** Surface areas of the open cuts will be minimized such that only small sections of the pit are opened at one time;
- **Grade Pit Slopes/Stockpiles.** Borrow pit slopes and stockpiles will be graded to reduce slumping; and
- **Pit Restoration.** Borrow pits will be restored when construction is completed by grading slopes to match the natural ground and drainage of the surrounding area. Overburden soils and vegetation cover will be replaced as soon as possible after pit excavation is completed. If massive ice is encountered, the borrow pit will be quickly reclaimed to protect the permafrost.

If permafrost is present in a borrow pit and cannot be avoided, mitigation must be in place for dealing with any thawing soils as well as controlling any melt water. Excavated borrow materials containing excess ice will require thawing and drainage, at which point CZN's *Sediment and Erosion Control Plan* should be referenced. Prior to placement, the following treatments will also be considered:

- Permafrost soils that need to thaw and drain should be stockpiled in suitable areas designated for the treatment and disposal of runoff;
- Additional preparation including air-drying or blending with drier materials should be done, if necessary;
- Grade stockpiles and working areas to maintain positive drainage during and after extraction of borrow materials;
- Perimeter berms should be constructed around stockpiles to reduce the likelihood of surface water inflows and to control the outflow of thaw water;
- Settling basins can be used to treat silty thaw water before draining offsite; and
- Pumping and provisions for erosion protection and dispersing the drainage water at the pump outlet may be required.

Borrow pits identified to date are highly variable in material type. Borrow soils consisting of silts and clays are frost-susceptible and, if frozen with a high moisture content, are likely to be thaw-sensitive. Coarse-grained soils such as sands and gravels should be frost-stable, if they contain less than 10% fines. Similarly, bedrock is likely to be frost-stable and not thaw-sensitive, unless it is weathered bedrock containing ice.

CZN will be preparing *Borrow Pit Management and Reclamation Plans* for each pit and will incorporate site-specific recommendations relating to permafrost.
5.7 Snow Accumulation

Collection of snow along the sides of the road is identified as potentially resulting in warmer ground temperatures, which could lead to thawing permafrost and ponding of water along the toe of the road embankment. This effect applies to areas where snow drifting or plowed snow accumulation is a potential concern. This effect has been identified on several highways in the Northwest Territories and Yukon Territory (e.g. Dempster Highway, Alaska Highway).

In areas where snow accumulation and/or drifting are an issue, design mitigations can be used to minimize the potential impacts to permafrost, such as flattening embankment sideslopes. Flatter slope gradients can reduce the likelihood of snow accumulating against the road embankment resulting in permafrost thaw. This also allows for snow clearing to take place beyond the crest (edge of the travelling surface) and onto the sideslopes.

5.8 Thermokarsts

The proposed ASR passes through some potential thermokarst-prone terrain (thaw-sensitive, ice-rich permafrost); however, thermokarst features noted along the alignment are small (Tetra Tech EBA 2016a). The probability of other thermokarsts being present with no surface evidence is low. The potential for sinkhole development, lack of thermokarst detection, and rapid instability is very small.

If potential thermokarst features are detected, they are likely to be small and relatively minor adjustments to the ASR alignment could be made (likely in the order of a few tens of metres). Should thermokarsts be unavoidable during construction, the same mitigations outlined in Section 5.3 would apply.

6.0 PERMAFROST MONITORING PROGRAM

A monitoring program is a key component for understanding the effects of the Prairie Creek ASR on permafrost. The program outlined in this section is conceptual until the detailed geotechnical and geophysical investigations have been completed.

Once a final design of the ASR is completed, a detailed permafrost monitoring program can be developed. Currently, it is anticipated that a permafrost monitoring program for the ASR will include the following:

- Performance Monitoring;
- Ground Temperature Monitoring;
- Fully-Instrumented Road Sections; and
- Climatic Data Reviews.

CZN has committed to establishing a detailed permafrost monitoring program prior to the start of construction which will expand on this conceptual program with an emphasis on early detection to any changes in permafrost. The program will be implemented at the start of the road's construction and will continue through to its closure and reclamation. This permafrost monitoring program should be updated at least two years prior to closure of ASR to address any changes for long-term monitoring.
6.1 Performance Monitoring

Performance monitoring of the ASR should be carried out on a regular basis to identify problem areas and promote early detection. Visual inspections at the below intervals will identify deficiencies that need additional mitigation or response action. Areas of potential permafrost should be periodically inspected during operations as well as after reclamation for local settlements that could suggest thawing.

6.1.1 Monthly (Operational)

Operational inspections of the ASR will be performed by a designated Road Maintenance Superintendent once a month. Inspections will be documented with field notes and photographs of all road features and borrow pits. Records from each inspection will be maintained onsite at all times and readily available to reference.

The entire ASR should be visually inspected once a month for any obvious signs of permafrost degradation or thaw settlement. Indicators of this could include erosion, seepage, sinkholes, slumping, and tension cracks. Performance monitoring will be of particular importance at the following ASR features:

- **Cut Embankments.** Cut embankments will be monitored regularly, especially during the winter months, to identify sections that need additional mitigations for snow accumulation and thaw settlement.
- **Borrow Pits.** Borrow pits will be inspected during operations for sign of thaw settlement, erosion, thaw settlement, and any new seepage.
- **Watercourse Crossings.** Culverts and bridges will be checked for signs of erosion during summer and ice blockage during the winter.

In addition to the above performance monitoring, special inspections will be carried out immediately following any wildfires occurring within 100 m of the ASR alignment and permafrost terrain.

6.1.2 Annually (Geotechnical)

Annual inspections will be performed by a qualified Geotechnical Engineer with experience in permafrost engineering. Inspections will take place during the summer months to identify any adverse impacts on permafrost areas from the construction and operation of the ASR. The road alignment, borrow pits, and watercourse structures will be visually examined for signs of permafrost distress, including:

- Cracking (longitudinal, transverse, localized);
- Deflections or sinkholes in road surface;
- Erosion at watercourse crossings;
- Settlement or seepage in cut embankments and borrow pits;
- Slumping along road embankments;
- Previously-burned wildfire areas near road alignment; and
- Any other signs of permafrost degradation.

All deficiencies will be photographed and documented. Ground temperature instrumentation will be read as part of this inspection to assess permafrost performance. Records of all road maintenance performed during the previous year, as required by the Road Operations and Maintenance Plan, will also be reviewed as part of this inspection.
Geotechnical inspections will also be conducted following any unforeseen extreme events, such as:

- Wildfires;
- Earthquakes;
- Flooding; and
- Any large permafrost deficiency (cracking, sinkholes etc.).

The frequency of the annual geotechnical inspections could be lessened after a few years if the ASR is performing adequately and no permafrost deficiencies have been noted.

### 6.2 Ground Temperature Monitoring

A key component for monitoring permafrost is having adequate instrumentation installed to monitor ground temperatures. Ground Temperature Cables (GTCs) will be utilized along the ASR to measure ground temperatures prior to construction and to monitor it after reclamation. The objectives of the ground temperature monitoring will be to:

1. Establish baseline ground temperatures for permafrost areas under road embankments and within borrow pits.
2. Monitor ground temperatures for evaluating the thermal evolution of road embankments and borrow pits.

The below ground temperature monitoring is intended, as a minimum, to actively monitor permafrost features along the ASR in permafrost terrain:

- **Permafrost Zones.** GTCs will be installed through the centerline of the road embankment to assess active layer development and embankment thermal regime at each road section identified to be built over permafrost soils. Additional GTCs will also be installed, prior to construction, in native, undisturbed permafrost adjacent to the ASR for acquiring baseline ground temperature data.

- **Permafrost Hazards.** GTCs will be installed, prior to construction, in all areas where thermokarsts, hummocks, or other permafrost hazards have been identified within the ASR footprint.

- **Major Watercourse Crossings.** GTCs will be installed on both sides of all major watercourse crossings through the approach embankments and into the below subgrade to monitor any potential changes from erosion or seepage.

- **Borrow Pits.** GTCs will be installed in each borrow pit, identified to contain permafrost soils, to monitor natural permafrost conditions, and assess the thermal evolution of each pit.

Some of the above GTCs can likely be installed as part of the geotechnical investigation program to be completed prior to the ASR’s final design. All ground temperature cables should be measured on a monthly basis until the road’s performance has stabilized, at which point, monitoring on a quarterly basis is possible.

### 6.3 Fully-Instrumented Road Sections

In addition to the above ground temperature monitoring, CZN will install two fully-instrumented sections along the ASR to monitor overall road performance. The instrumentation sections will be utilized to measure ground temperatures, stability, settlement, and groundwater levels at high-risk permafrost areas along the ASR prior to the road’s construction until it is reclaimed. The instrumentation sections would include:
- **Vertical GTCs.** Four vertical GTCs installed through the road embankment and 2 m into the underlying subgrade;

- **Horizontal GTCs.** Two horizontal GTCs extended laterally beneath the road embankment, extending well beyond the road footprint to avoid damage from road operations;

- **Settlement Survey Monuments.** Three settlement survey monuments with one along the road running surface and one on either sideslopes of the road embankments; and

- **Standpipe Piezometer.** One standpipe piezometer to monitor groundwater levels below the road embankment.

Locations for the instrumentation sections would be selected based on permafrost conditions, terrain type, and accessibility. Each instrumentation section would be read with the same frequency as the GTCs in Section 6.2.

### 6.4 Climatic Data Reviews

Climatic data, including mean daily air temperatures and the calculated freezing indices, will be compiled and reviewed on an annual basis. The information can assist with interpreting observed ground temperatures measured along the ASR and will help to illustrate fluctuations in air and ground temperatures. Climatic data review will focus on highly sensitive areas of the ASR to better assess how permafrost conditions may be altered due to climate change.

Air temperatures will be sourced from weather stations at the Mine and any Environment Canada stations nearby. Although air temperatures do not solely influence ground temperatures, they offer help in understanding observed temperature trends. Freezing indices (the number of degree-days below 0°C) will be calculated, using this data, to show changes in seasonal temperatures from year to year.

Climatic data reviews will be performed annually in conjunction with the annual geotechnical inspection.

### 7.0 PERMAFROST ADAPTIVE MANAGEMENT

Adaptive management of permafrost along the Prairie Creek ASR will be a systematic approach that links ground temperature monitoring and site observations with response actions to prevent degradation. Possible changes in the permafrost regime, due to construction and climate, require thaw triggers and planned responses to mitigate permafrost degradation.

The following permafrost response action plan was developed in accordance with CZN’s commitments made during the EA process. The plan outlines how adaptive management will be used to respond to conditions leading to degradation of permafrost (outlined in Section 4.0) and includes the following:

- Triggers to identify signs of potential permafrost degradation; and

- Response Actions to correct or mitigate the occurrence of permafrost degradation.

### 7.1 Pre-Construction Scouting

Pre-construction scouting is a mitigative measure that will continue to be used to identify unexpected permafrost terrain. Scouting will be completed using a similar methodology to the 2018 Geotechnical Investigation Program completed by Tetra Tech and Allnorth, which included considerable reconnaissance. An suitable member of the construction management team will monitor ahead of the road construction front to visually identify any unforeseen
areas of potential permafrost. Sections displaying characteristics of permafrost ground can be further investigated by hand using shovels, picks, or hand-held window sampling drills.

Identification of unexpected permafrost will be more difficult during construction in winter; however, scouting can still be completed in conjunction with advanced snow clearing and foundation preparation. During summer construction, pre-construction scouting will be performed to identify signs of potential permafrost, including:

- Drunken Forest;
- Hummocks;
- Patterned Ground;
- Peatlands or Sedge Wetlands;
- Poljes;
- Thermokarsts;
- Areas of with wet, fine-grained soils (silts and clays);
- Areas on wetter, thick organic, slopes typically covered in black spruce, tamarack, willow, and birch; and
- Areas on drier slopes covered with aspen, white spruce, and lodgepole pine.

This proactive approach to identifying unexpected permafrost along the alignment may trigger further investigation and, if required, may result in the ASR design team making minor modifications to either the road alignment or embankment design.

7.2 Improved Water Management

If ponding is observed near watercourse structures during operation of the ASR, improved water management measures will be implemented. Ponding water creates surface thaw which is a primary contributor to permafrost degradation. Possible scenarios of deficient water management include:

- Culvert blockages (icing, organic debris);
- Ponding water along road embankments; and
- Ponding water in borrow pits.

CZN’s possible response actions for improving water management along the ASR will be:

- **Boarding Up Culverts.** Boarding up culvert ends in winter will prevent snow from blowing in, thus making the ground much colder in winter and counteracting summer thaw;

- **Mobile Pumping.** Have a dewatering team and mobile pumps available during spring to deal with ponding areas quickly and effectively at various locations along the ASR.

- **Stacked Culverts.** In locations where culverts experience ice blockage, consider installing an additional culvert above the existing one to create a flow path over the ice, although this is primarily an issue to be addressed at the design stage.
7.3 Snow Accumulation

Snow accumulation will be proactively managed, if necessary, with adequate embankment design along the ASR. Proper road maintenance during the winter months is essential to preserving permafrost beneath the road surface and the surrounding ditch areas.

Snow removal, if required, will be focused on the lee side of higher sections of the road embankment and any cutslopes where snow tends to drift. Where such drifts cross the road surface, these will be readily dealt with by plowing. In cases where excessive snow remains on the cutslope itself, equipment should be mobilized to remove the excess snow and dispose of it appropriately. Guidelines for snow removal are outlined in the *Road Operations and Maintenance Plan* (ROMP).

In areas where snow drifting becomes a reoccurring issue, the below strategies may be implemented to reduce drifting and accumulation:

- **Snow Fence.** Snow fencing can be installed upwind of road embankments to keep snow drifts off the road surface and away from drainage ditches.

- **Regrade Embankment Sideslopes.** Additional embankment material can be added along sideslopes to decrease the slope gradient. This can also help keep early thaw along the embankment toes at a distance from the road surface.

If zones of excessive snow accumulation occur in permafrost areas, additional engineered solutions may be considered.
REFERENCES


FIGURES

Figure 1  Prairie Creek Mine Overview
Figure 2  Proposed Access Road Alignment
Figure 1

Prairie Creek Mine Overview

**LEGEND**

- **Proposed Prairie Creek Access Road**

**NOTES**

Base data source: Imagery from ESRI; DigitalGlobe (2016).

**SCALE: 1:15,000**

**DATUM: NAD83**

**PROJECTION: NWT Lambert**

**ISSUED FOR REVIEW**

**DATE: November 21, 2018**

**CLIENT: TETRA TECH**

**PROJECT NO.: ENG.EARC03145-01**

**FILE NO.: EARC03145-01_Figure1.mxd**
Figure 2

**PRAIRIE CREEK ACCESS ROAD**

Legend:
- Access Road Kilometre Marker
- Proposed Prairie Creek Access Road
- Proposed Winter Road Alignment
- Existing Road
- Nahanni National Park Reserve Boundary
- Watercourse
- Waterbody

**NOTES**
- Base data source:
  - Road alignment provided by AllNorth (July 2018)
  - Existing roads from CanVec (1:50,000)
  - Watercourses from CanVec (1:250,000)

**SCALE**
- 1:350,000

**STATUS**
- BASED FOR REVIEW

**PROJ NAM**
- ENG.EARC03145-01

**DATE**
- December 3, 2018

**FILE NAM**
- EARC03145-01_Figure2.mxd
APPENDIX A

ACCESS ROAD MAP BOOK
APPENDIX B

PERMAFROST TERRAIN MAP BOOK
**LEGEND**

- Access Road Kilometre Marker
- Camp/Laydown
- Watercourse Crossing
- Prairie Creek Access Road (November 2018)
- Potential Permafrost Section
- Proposed Geophysical Line
- Proposed Winter Road Alignment
- Nahanni National Park Reserve Boundary
- Potential Borrow Source
- Contour (40 m)
- Watercourse

**Geology**

- Clay
- Weak Clay
- Medium-Strong Clay
- Strong Clay
- Fault

**Landslide**

- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1994)
- Landslide Failure Scar Large (2012)
- Landslide Head Scarp Large (1949)
- River Position (1949)

---

**NOTES**

Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

400 Metres

Scale: 1:20,000

---

**PRARIE CREEK ACCESS ROAD**

Permafrost Terrain Map Book
Route avoids drainages into poljes

Bedrock bluffs

Meltwater channel (major)

Karst Depression

Possible Sinkhole or Kettle

Thermokarst Terrain

Landslide Failure scar (1949)

Landslide Failure scar (1994)

Landslide Head Scarp (1949)

Landslide Head Scarp (1994)

Landslide Head Scarp (2012)

River Position (1949)

River Position (1994)

River Position (Post-1994)

Permafrost Terrain Map Book

NOTES

Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981
LEGEND

Access Road Kilometre Marker

2014 Test Pit (Tetra Tech EBA, 2014)

Prairie Creek Access Road (November 2018)

Potential Permafrost Section

Proposed Geophysical Line

Proposed Winter Road Alignment

Nahanni National Park Reserve Boundary

Potential Borrow Source

Contour (40 m)

Watercourse

Landslide Failure Scar Large (1949)

Landslide Failure Scar Large (1994)

Landslide Head Scarp Large (1949)

Contour (40 m)

Scale: 1:20,000

NOTES

Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

# ACCESS ROAD KILOMETRE MARKER

# 2014 Test Pit (Tetra Tech EBA, 2014)

# Prairie Creek Access Road (November 2018)

# Potential Permafrost Section

# Proposed Geophysical Line

# Proposed Winter Road Alignment

# Nahanni National Park Reserve Boundary

# Potential Borrow Source

# Contour (40 m)

# Watercourse

# Landslide Failure Scar Large (1949)

# Landslide Failure Scar Large (1994)

# Landslide Head Scarp Large (1949)

# Contour (40 m)

Scale: 1:20,000
Escarpments along Tetcela River
Upland terrain with ridges, knolls and hummocks
Thermokarst ponds in peatland terrain

LEGEND
- Access Road Kilometre Marker
- 2018 Borehole (Tetra Tech, 2018)
- 2014 Borehole (Tetra Tech EBA, 2014)
- 2012 Borehole (SNC-Lavalin, 2012)
- Camp/Laydown
- Observation Point
- Sinkhole
- Watercourse Crossing
- Prairie Creek Access Road (November 2018)
- Potential Permafrost Section
- Proposed Geophysical Line
- Proposed Permafrost Monitoring
- Proposed Winter Road Alignment
- Nahanni National Park Reserve Boundary
- Potential Borrow Source
- Proposed Geophysical Special Investigation
- Contour (40 m)
- Watercourse
- Waterbody
- Geology
- Gully
- Thermokarst Terrain
- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1962)
- Landslide Failure Scar Large (1994)
- Landslide Failure Scar Large (2012)
- Landslide Head Scarp Large (1949)
- Landslide Head Scarp Large (1962)
- Landslide Head Scarp Large (1994)
- Slide Block (1949)

Scale: 1:20,000

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

PRAIRIE CREEK ACCESS ROAD
Permafrost Terrain Map Book

PROJECTION
UTM Zone 10

STATUS
TETRA TECH CORPORATION

PERM NO.
EARC03145-01_FigureB.mxd

FILE NO.
EARC03145-01

November 30, 2018

ENG.8402/2014-01
LEGEND

Access Road Kilometre Marker
2014 Testpit (Tetra Tech EBA, 2014)
Camp/Laydown
Observation Point
Watershed Crossing
Prairie Creek Access Road (November 2018)
Potential Permafrost Section
Proposed Winter Road Alignment
Potential Borrow Source
Contour (40 m)
Watercourse
Waterbody
Gully

Geology

Meltwater channel (major)
Meltwater channel (minor)
Landslide Failure Scar Large (1949)
Landslide Failure Scar Large (1962)
Landslide Failure Scar Large (1984)
Landslide Failure Scar Large (2012)
Landslide Head Scarp Large (1949)
Landslide Head Scarp Large (1962)
River Position (1949)
River Position (1962)
River Position (1984)

NOTES

Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

Permafrost Terrain Map Book

PRARIE CREEK ACCESS ROAD

MELT WATER CHANNEL

GEOMORPHIC LANDFORMS

LSM 1949
LSM 1962
LSM 1994
LSM 2012
Landslide Head Scarp Large
Landslide Failure Scar Large
River Position

WATERBODY

WATERCOURSE

CONTOUR (40m)

BEDROCK OUTCROP

BEAVER DAM

POSSIBLE THERMO KarST

PRIOR ACCESS ROAD (November 2018)

PRAIRIE CREEK ACCESS ROAD

MAP PROJECTION

NAD83

UTM Zone 10

Tt-VANC

ENG.EARC03145-01

November 30, 2018

Permafrost Terrain Map Book
Permafrost Terrain Map Book

Access Road Kilometre Marker

2018 Borehole (Tetra Tech, 2018)

Observation Point

Prairie Creek Access Road (November 2018)

Potential Permafrost Section

Proposed Geophysical Line

Proposed Winter Road Alignment

Potential Borrow Source

Contour (40 m)

Watercourse

Waterbody

Geology

Gully

Meltwater channel (major)

Thermokarst Terrain

NOTES

Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

Status: Draft

PRAIRIE CREEK ACCESS ROAD

© 2018 Borehole (Tetra Tech, 2018)
Permafrost Terrain Map Book

Legend:
- Access Road Kilometre Marker
- 2018 Borehole (Tetra Tech, 2018)
- Observation Point
- Prairie Creek Access Road (November 2018)
- Potential Permafrost Section
- Proposed Geophysical Line
- Proposed Winter Road Alignment
- Potential Borrow Source
- Contour (40 m)
- Watercourse
- Waterbody

Geology:
- Gully
- Meltwater channel (major)
- Meltwater channel (minor)
- Landslide Failure Scar Large (1949)

Notes:
- Base data source: CanVec; GeoBase.
- Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

Status: TB

Permafrost Terrain Map Book

PRAIRIE CREEK ACCESS ROAD
Permafrost Terrain Map Book

LEGEND

- Access Road Kilometre Marker
- 2018 Borehole (Tetra Tech, 2018)
- 2014 Testpit (Tetra Tech EBA, 2014)
- Camp Laydown
- Observation Point
- Watercourse Crossing

- Prairie Creek Access Road (November 2018)
- Potential Permafrost Section
- Proposed Geophysical Line
- Proposed Winter Road Alignment
- Contour (40 m)
- Watercourse
- Waterbody
- Geology
  - Gully
  - Landslide Failure Scars Large (1949)
  - Landslide Head Scarp Large (1949)
  - Tension Crack (1949)

NOTES

- Base data source: CanVec; GeoBase.
- Surficial Geology based on Hawes, 1980 and 1981

PROJECTION

- NAD83 UTM Zone 10

SCALE

- 1:20,000

STATUS

- B22

PROJECT NO.

- 6400012186-01

NO. 5/28/2019

Permafrost Terrain Map Book

PRAIRIE CREEK ACCESS ROAD

November 30, 2018
LEGEND
- Access Road Kilometre Marker
- 2018 Borehole (Tetra Tech, 2018)
- 2014 Testpit (Tetra Tech EBA, 2014)
- Camp Layout
- Observation Point
- Watercourse Crossing
- Prairie Creek Access Road (November 2018)
- Potential Permafrost Section
- Proposed Geophysical Line
- Proposed Winter Road Alignment
- Contour (40 m)
- Watercourse
- Waterbody
- Geology
  - Gully
  - Landslide Failure Scar Large (1949)
  - Landslide Failure Scar Large (2012)
  - Landslide Head Scarp Large (1949)
  - River Position (1949)
  - River Position (Post-1994)
  - Tension Crack (1949)

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981
LEGEND

- Access Road Kilometre Marker
- 2018 Borehole (Tetra Tech, 2018)
- Prairie Creek Access Road (November 2018)
- Proposed Geophysical Line
- Proposed Winter Road Alignment
- Contour (40 m)
- Watercourse
- Waterbody
- River Position (1949)

NOTES

Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

Permafrost Terrain Map Book

PRAIRIE CREEK ACCESS ROAD

Permafrost Terrain Map Book

STATUS

Permafrost Terrain Map Book

FILE NO.

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OFFICE

PROJECT NO.

DATE

FILE NO.

PROJECTION

DWN

DATUM

CKD

REV

APVD

CLIENT

B27

December 30, 2018

ENG:\\EARC03145-01
APPENDIX C

INTERPRETED PERMAFROST CONDITIONS ALONG ACCESS ROAD
### Interpreted Permafrost Conditions along Access Road

<table>
<thead>
<tr>
<th>Road Section</th>
<th>Distance (km)</th>
<th>Interpreted Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start KP (km)</td>
<td>End KP (km)</td>
<td></td>
</tr>
</tbody>
</table>
| 0            | 6.4          | • Permafrost may be present but is not a dominant process in the local terrain.  
               | 6.4          | • Soil stripes are present about 150 m or more upslope of road.                  |
| 6.4          | 6.9          | • Permafrost may be present but is not a dominant process in the local terrain.  
               | 6.9          | • Soil stripes are present about 300 m upslope.                                  |
| 13.3         | 13.4         | • Permafrost may be present but is not a dominant process in the local terrain.  
               | 13.4         | • Gradual thaw could add water to unstable slopes or stream crossing below.       |
| 14.2         | 14.6         | • Soil stripes and indistinct circles are present about 200 m upslope of road.  |
| 14.6         | 16.1         | • Permafrost may be present but is not a dominant process in the local terrain.  |
| 16.1         | 17.0         | • Permafrost present above road and below road from about 16.2 to 16.7; solifluction evidence in both areas.  
               | 17.0         | • Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to unstable slopes.  
               | 17.6         | • Permafrost present above road forming solifluction lobes. Flat area above road at 19.1 displays soil circles about 280 m from road. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to unstable slopes. Separated from road by stable ground from 18.9 to 19.3.  
               | 19.3         | • Permafrost present but is not a dominant process in the local terrain.        |
| 39.2         | 43.1         | • Permafrost present above road, and from 40.2 to 41.3 also below road in old landslide area. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to unstable slopes.  
               | 43.1         | • Permafrost above road could contribute water to slope upon thawing. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to unstable slopes in old landslide area.  
               | 44.4         | • Road traverses on or near various permafrost areas. Gradual thaw with climate change could add water to potentially already-wet organic terrain.  
               | 44.4         | • Road traverses downslope of permafrost areas.                                |
| 45.7         | 46.2         | • Road crosses permafrost area. Gradual thaw with climate change could increase surface water drainage. |
| 46.7         | 47.6         | • Road crosses permafrost area. Gradual thaw with climate change or site disturbance could increase rate of creep and lateral spread.  
               | 47.6         | • Permafrost may be present but is not a dominant process in the local terrain. |
| 47.8         | 48.4         | • Permafrost present above road. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to unstable slopes.  
               | 48.4         | • Road crosses permafrost area and permafrost observed at KP 50.5 in BH11.1 (2018).  
               | 49.5         | • Road crosses permafrost area. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to seeping unstable slopes. Road crosses above creek near 48.8 and 49.2.  
               | 50.4         | • Permafrost may be present but is not a dominant process in the local terrain.  
               | 50.8         | • Road crosses permafrost area and permafrost observed at KP 50.5 in BH11.1 (2018).  
               | 50.8         | • Gradual thaw with climate change could add water to already-wet organic terrain.  
               | 51.2         | • Permafrost may be present but is not a dominant process in the local terrain.  
               | 51.5         | • Road crosses permafrost area. Gradual thaw with climate change or exposure of thaw-sensitive soils could have potential to add water to seeping unstable slopes.  
               | 51.7         | • Permafrost may be present but is not a dominant process in the local terrain.  |
### Interpreted Permafrost Conditions along Access Road

<table>
<thead>
<tr>
<th>Road Section</th>
<th>Distance (km)</th>
<th>Interpreted Permafrost Conditions</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td><strong>End KP (km)</strong></td>
</tr>
<tr>
<td></td>
<td>51.7</td>
<td>52.8</td>
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<tr>
<td></td>
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<td>54.5</td>
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<td></td>
<td>89.3</td>
<td>91.1</td>
</tr>
<tr>
<td></td>
<td>91.1</td>
<td>94.2</td>
</tr>
</tbody>
</table>

- **Road crosses permafrost area. Gradual thaw with climate change could add water to already-wet and/or seeping organic terrain.**
- **Permafrost observed at KP 53.2 in BH15 (Ti 2018) and KP 53.4 in BH05 (Ti-EBA 2014).**
- **Road crosses lower slope in unstable permafrost terrain. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to seeping unstable slopes.**
- **Permafrost observed at KP 54.2 in TP07 (Ti-EBA 2014).**
- **Road crosses potentially unstable permafrost terrain.**
- **Permafrost may be present but is not a dominant process in the local terrain.**
- **Permafrost may be present but is not a dominant process in the local terrain.**
- **Permafrost terrain near or at road. Suspected kettle at 58.8 unlikely to affect road.**
- **Permafrost may be present but is not a dominant process in the local terrain.**
- **Permafrost terrain near areas of permafrost terrain on both sides of route.**
- **Permafrost may be present but is not a dominant process in the terrain at the road.**
- **Road skirts along the crests of slope failures in unstable permafrost terrain on both sides of route.**
- **Permafrost is present in the terrain at the road.**
- **Road skirts above mostly the crests of slope failures in unstable permafrost terrain on both sides of route.**
- **Permafrost terrain above and below road and observed in BH-TTF-01 (SNC 2012). Permafrost may be present but is not a dominant process in the terrain at the road.**
- **Permafrost terrain at road and observed above road in BH-TTF-02 (SNC 2012).**
- **Permafrost terrain at road and observed above road in BH08 (Ti-EBA 2014).**
- **Permafrost terrain below road is unstable.**
- **Unstable permafrost terrain mostly above road in old slump area and between KP 88.0 to KP 88.3.**
- **Permafrost may be present but is not a dominant process in the local terrain.**
- **Potentially unstable permafrost terrain at road, except between 92.3 and 92.8. Thermokarst below road in two locations. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to unstable slopes.**
## Interpreted Permafrost Conditions along Access Road

<table>
<thead>
<tr>
<th>Road Section</th>
<th>Distance (km)</th>
<th>Interpreted Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start KP</td>
<td>End KP</td>
<td></td>
</tr>
<tr>
<td>(km)</td>
<td>(km)</td>
<td></td>
</tr>
<tr>
<td>94.2</td>
<td>95.7</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost observed at KP 94.6 in BH33 (Tt 2018).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain at and near road in floodplain, including nearby thermokarst.</td>
</tr>
<tr>
<td>95.7</td>
<td>96.9</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost observed at KP 96.5 in TP14 (Tt-EBA 2014), KP 96.6 in BH96.6 (Tt 2018), and KP 96.7 in BH-SWI-04 (SNC 2012).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road skirts just above valley bottom and permafrost/thermokarst terrain, and along toe of unstable slope.</td>
</tr>
<tr>
<td>96.9</td>
<td>101.9</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost observed at KP 99.8 in BH-SWI-02 (SNC 2012).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost may be present but is not a dominant process in the local terrain.</td>
</tr>
<tr>
<td>101.9</td>
<td>103.3</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road located on or just downslope of permafrost terrain. Seepage on slope 103.1 to 103.3. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>103.3</td>
<td>106.7</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road located on or just downslope of permafrost terrain. Seepage on slope. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>106.7</td>
<td>109.9</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road located on or just downslope of permafrost terrain. Seeage on slope above road. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>109.9</td>
<td>116.5</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain along, upslope and/or downslope of road. Seeage on slope above road. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>116.5</td>
<td>123.0</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Scattered areas of permafrost terrain upslope and/or downslope of road. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>123.0</td>
<td>123.8</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost may be present but is not a dominant process in the local terrain.</td>
</tr>
<tr>
<td>103.3</td>
<td>107.0</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain along, upslope and/or downslope of road. Seeage on slope above road. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>107.0</td>
<td>109.4</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain along, upslope and/or downslope of road. Seeage on slope. Gradual thaw with climate change or exposure of thaw-sensitive soils could add water to potentially unstable slopes.</td>
</tr>
<tr>
<td>109.4</td>
<td>114.0</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain at and near road in floodplain and fans below steeper slopes.</td>
</tr>
<tr>
<td>114.0</td>
<td>123.8</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost observed at KP 122.7 in BH49.1 (Tt 2018).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost terrain areas mostly below road in floodplain and fans below steeper slopes. Permafrost areas become sporadic southbound. Possible thermokarst south of road at 122.1.</td>
</tr>
<tr>
<td>123.8</td>
<td>125.6</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost in valley west of northeast end of Grainger Gap. Meltwater, if any, would run towards Grainger River.</td>
</tr>
<tr>
<td>125.6</td>
<td>126.6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost area above road, thermokarst near road in vicinity of 126.5. Thaw may increase surface water runoff or seeage downslope. Rock glacier well upslope of road.</td>
</tr>
<tr>
<td>126.6</td>
<td>133.2</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost observed at KP 128.6 in BH50 (Tt 2018).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost is present but appears not to have resulted in instabilities in the immediate vicinity of the road. Permafrost more likely further upslope. Local rockslide or slump areas upslope appear to contain permafrost.</td>
</tr>
<tr>
<td>133.2</td>
<td>135</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Areas of permafrost above and below road. Road has only one short crossing of potentially unstable permafrost from 134.5 to 134.6.</td>
</tr>
<tr>
<td>135</td>
<td>154.3</td>
<td>19.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Although permafrost is present, no obvious permafrost-related instabilities were noted. The road crosses a stream that may contain permafrost within its floodplain at about 149.3. Larger fans below 151.0 and 154.3 have no permafrost, though a fan downslope of 152.2 does.</td>
</tr>
</tbody>
</table>
## Interpreted Permafrost Conditions along Access Road

<table>
<thead>
<tr>
<th>Road Section</th>
<th>Distance (km)</th>
<th>Interpreted Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start KP (km)</td>
<td>End KP (km)</td>
<td></td>
</tr>
<tr>
<td>154.3</td>
<td>159.3</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Large earthflows are mapped below the road which have permafrost, though it is not known if this a significant contributing factor to the slope failures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Section ends at north side of Liard River.</td>
</tr>
<tr>
<td>160.0</td>
<td>171.0</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Section starts at south side of Liard River.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost may be present but is not a dominant process in the local terrain.</td>
</tr>
<tr>
<td>171.0</td>
<td>171.7</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost in organic terrain north of Bay Creek. Road realignment is proposed here to avoid eroding bank of Liard River, but inland side of realignment has permafrost.</td>
</tr>
<tr>
<td>171.7</td>
<td>181.2</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Areas of permafrost beside and/or under road route, including built road.</td>
</tr>
<tr>
<td>181.2</td>
<td>184.2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Permafrost may be present but is not a dominant process in the local terrain.</td>
</tr>
</tbody>
</table>
APPENDIX D

TETRA TECH’S LIMITATIONS ON USE OF THIS DOCUMENT
LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

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1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

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While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.
1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.14 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.15 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.16 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.17 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client’s expense upon written request, otherwise samples will be discarded.
POST-EA INFORMATION PACKAGE INCLUDING AN UPDATED PROJECT DESCRIPTION
ALL SEASON ROAD TO PRAIRIE CREEK MINE

APPENDIX 10-1

SUBMITTED IN SUPPORT OF:
Water Licences MV/PC2014L8-0006, and
Land Use Permits MV/PC2014F0013

SUBMITTED TO:
Mackenzie Valley Land and Water Board
Yellowknife, NT X1A 2N7

Parks Canada,
Nahanni National Park Reserve
Fort Simpson, NT X0E 0N0

SUBMITTED BY:
Canadian Zinc Corporation
Vancouver, BC, V6B 4N9

February 2019
2018 Geotechnical Investigation Data Report
Proposed All-Season Road
Prairie Creek Mine, NT

PRESENTED TO
Canadian Zinc Corporation

DECEMBER 21, 2018
ISSUED FOR USE
FILE: 704-ENG.EARC03130-01
EXECUTIVE SUMMARY

Tetra Tech Canada Inc. (Tetra Tech) was retained by Canadian Zinc Corporation (CZN) to conduct a geotechnical site investigation along the proposed Prairie Creek All-Season Road (ASR) leading to the Prairie Creek Mine (Mine), NT. The Mine is located in the southwest corner of the Northwest Territories, approximately 500 km west of Yellowknife. The proposed ASR will traverse 170 km through varying mountainous terrain, with some 85 km of the route passing through the Nahanni National Park Reserve.

The primary focus of the investigation was to acquire geotechnical and permafrost data, including determination of frozen and unfrozen overburden conditions. Each window sampler hole was logged and sampled according to appropriate geotechnical and permafrost standards. Tetra Tech installed three temporary single-bead thermistor strings (SBTS) to verify ground thermal conditions.

The geotechnical site investigation program was carried out between August 10 to 30, 2018 and consisted of window sampling and testing of frozen and unfrozen overburden. A total of 43 sample holes with depths ranging from 0.6 m to 5.0 m were window sampled and logged at 39 sites along the proposed ASR. This report presents the geotechnical and permafrost data collected during the investigation, including soil logs, geotechnical laboratory test results, and ground temperature readings collected from temporarily installed single bead thermistor strings. Terrain and subsurface conditions along the proposed all-season road are summarized from the new data. In general, less permafrost was intercepted than expected.

Data obtained from this investigation program was used to reduce the required number of boreholes planned for the main drilling program in the future. The upcoming investigation program was refined based on the confirmed presence or absence of permafrost and general terrain and ground descriptions observed at each window sampler site. Data obtained from the 2018 program allowed Tetra Tech to reduce the initial number of boreholes required for the future investigation program by 24 boreholes (a reduction of 36%). Two new boreholes were added to the future program to further investigate bedrock conditions at two proposed watercourse crossings near KP 23.5 and KP 39. Installation of ground temperature monitoring instrumentation will be revised to match the requirements of the remaining boreholes. Proposed geophysical survey lines along the ASR alignment have also been revised, with a total reduction of 12%.
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# ACRONYMS & ABBREVIATIONS

<table>
<thead>
<tr>
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<th>Definition</th>
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<tbody>
<tr>
<td>Allnorth</td>
<td>Allnorth Consultants Ltd.</td>
</tr>
<tr>
<td>ASR</td>
<td>All-Season Road</td>
</tr>
<tr>
<td>BGL</td>
<td>Below Ground Level</td>
</tr>
<tr>
<td>CZN</td>
<td>Canadian Zinc Corporation</td>
</tr>
<tr>
<td>CCR</td>
<td>Capacitively-Coupled Resistivity</td>
</tr>
<tr>
<td>GTC</td>
<td>Ground Temperature Cable</td>
</tr>
<tr>
<td>GPR</td>
<td>Ground Penetrating Radar</td>
</tr>
<tr>
<td>N&lt;sub&gt;be&lt;/sub&gt;</td>
<td>Well bonded perennially frozen soil with excess ice</td>
</tr>
<tr>
<td>N&lt;sub&gt;bn&lt;/sub&gt;</td>
<td>Well bonded perennially frozen soil, no excess ice</td>
</tr>
<tr>
<td>N&lt;sub&gt;f&lt;/sub&gt;</td>
<td>Poorly bonded or friable frozen soil, no excess ice</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>KP</td>
<td>Kilometre Post</td>
</tr>
<tr>
<td>Mine</td>
<td>Prairie Creek Mine</td>
</tr>
<tr>
<td>MVLWB</td>
<td>Mackenzie Valley Land and Water Board</td>
</tr>
<tr>
<td>Project</td>
<td>Prairie Creek All-Season Road</td>
</tr>
<tr>
<td>SBTS</td>
<td>Single Bead Thermistor String</td>
</tr>
<tr>
<td>Tetra Tech</td>
<td>Tetra Tech Canada Inc.</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>V&lt;sub&gt;c&lt;/sub&gt;</td>
<td>Perennially frozen soil with excess ice visible as ice coating on particles</td>
</tr>
<tr>
<td>V&lt;sub&gt;r&lt;/sub&gt;</td>
<td>Perennially frozen soil with excess ice visible as random or irregularly oriented ice formations</td>
</tr>
<tr>
<td>V&lt;sub&gt;s&lt;/sub&gt;</td>
<td>Perennially frozen soil with excess ice visible as stratified or distinctly oriented ice formations</td>
</tr>
<tr>
<td>V&lt;sub&gt;u&lt;/sub&gt;</td>
<td>Perennially frozen soil with excess ice visible as uniformly distributed ice formations</td>
</tr>
<tr>
<td>V&lt;sub&gt;x&lt;/sub&gt;</td>
<td>Perennially frozen soil with excess ice visible as individual ice inclusions</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS

ACTIVE LAYER – the top layer of ground that is subject to annual thawing and freezing in areas underlain by permafrost. The thickness of the active layer varies from year to year, depending on such factors as the ambient air temperature, vegetation, drainage, soil and rock type, water content, snow cover, slope degree, and aspect.

CRYOSTRUCTURE – the structural characteristics of frozen earth materials determined by the amount and distribution of pore ice and lenses of segregated ice. Can be described as massive, layered, reticulate etc.

DEPTH ALONG AXIS (m) – depth measured along the borehole axis from its collar.

DEPTH OF ZERO ANNUAL AMPLITUDE (depth of zero seasonal temperature variations) – the distance from the ground surface downward to the level beneath which there is practically no annual fluctuation in ground temperature.

EXCESS ICE – the volume of ice in the ground that exceeds the total pore volume that the ground would have under natural unfrozen conditions.

GROUND ICE – a general term referring to all types of ice (segregated, intrusive, vein etc.) formed in freezing and frozen ground. Occurs in pores, cavities, voids, cracks, fractures, and other openings in soil or rock.

ICE AND SOIL TYPE (ICE and SILT etc.) – discrete visible ice formations in frozen soils that are greater than 50% by volume. Frozen core interval that contains more ice (>50% by volume of visible ice) than soil particles.

ICE COATINGS – discernible layers of ice found on or below the larger soil particles in a frozen soil mass.

ICE CONTENT – the amount of ice contained in frozen or partially frozen soil or rock. Ice content is normally expressed in one of two ways:
  - On a dry-weight basis (gravimetric), as the ratio of the mass of the ice in a sample to the mass of the dry sample, expressed as a percentage; or
  - On a volume basis (volumetric), as the ratio of the volume of ice in a sample to the volume of the whole sample, expressed as a percentage.

ICE LENS – a dominantly horizontal, lens-shaped body of ice ranging in thickness from hairline to 0.3 m. Ice layers more than 0.3 m in thickness are better termed massive ice beds.

ICE WEDGE – a massive, generally wedge-shaped body of foliated or vertically banded, commonly white, ground ice with its apex pointing downward.

PERMAFROST – ground (soil and/or rock) that remains at or below 0°C for at least two consecutive years. Permafrost is defined exclusively based on temperature. It is not necessarily frozen, i.e. it does not necessarily contain ground ice.

PERMAFROST, ICE-RICH – permafrost containing excess ice.

PERMAFROST TABLE – the upper boundary of permafrost.

SUPRAPERMAFROST WATER – water occurring in the active layer above the permafrost table.

SUBPERMAFROST WATER – water occurring in the unfrozen ground below the permafrost base.

TALIK – a layer or body of unfrozen ground in a permafrost area. Several types of taliks can be distinguished based on their relationship to the permafrost: closed, open, lateral, isolated etc.

TRUE DEPTH (m) – depth measured from the borehole collar perpendicular (normal) to the ground surface.
LIMITATIONS OF REPORT
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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Canadian Zinc Corporation (CZN) to conduct a geotechnical investigation along the proposed Prairie Creek All-Season Road (Project) alignment. The proposed all-season road (ASR) runs from the hamlet of Nahanni Butte to the Prairie Creek Mine (Mine) located in the Nahanni National Park Reserve, NT as shown in Figure 1.

The geotechnical investigation consisted of sampling overburden material along the ASR alignment with a hand-operated Window Sampler (the sampler), logging recovered soil, and testing the soil samples. The primary focus of the investigation was to acquire geotechnical data, including some information on permafrost, to optimize the scope of the proposed geotechnical drilling program and support the design of the ASR.

This report presents the geotechnical and permafrost data collected during the site investigation, including soil sampling logs, geotechnical laboratory test results, and ground temperature measurements. Results from the 2018 investigation were used to revise the proposed winter geotechnical drilling program as discussed in Section 4.0.

2.0 2018 GEOTECHNICAL INVESTIGATION

2.1 General

The geotechnical investigation was completed from August 10 to 30, 2018. It was managed by Dr. Vladislav E. Roujanski, senior geologist/geocryologist, based in Tetra Tech’s Edmonton office. Field soil sampling, logging, and on-site testing was conducted by Mr. Ryan Okkema, E.I.T. while technical support for the field program was provided by Mr. Kevin Jones, P.Eng.

Mr. Ernest Kragt of Allnorth Consultants Ltd. (Allnorth) was on site coordinating the 2018 program on behalf of CZN. The investigation was performed in conjunction with Allnorth personnel who conducted surveys of the proposed stream crossing sites along the ASR.

The Project is located within Zone 10 of the Universal Transverse Mercator (UTM) Grid. The horizontal datum for used for the Project is the North American Datum 1983 (NAD83).

2.2 Site Access

Personnel and equipment were transported to soil sampling locations using a Bell 407 helicopter operated by Great Slave helicopters. Existing helipads from previous investigations were used to access sampling locations, where possible. Additional helipads were cleared as required to access new sampling locations.

Sampling equipment was slung to each location by net, requiring the helicopter to transport the equipment and the crew separately. Once landed at the helipads, many sampling sites required carrying the window sampler and accompanying equipment various distances to avoid dense vegetation and uneven terrain. A minimum of seven trips were required to transport all the necessary equipment, with the heaviest items weighing upwards of 50 lbs.

Helicopter access was often limited due to heavy fog and wind. Multiple weather-days occurred during the extent of the project, delaying completion of the field program by approximately one week. In addition, the helicopter support was shared between two to four field crews at one time, causing delays while other crews were being relocated.
2.3 Soil Sampling Locations

Fifty-eight soil sampling locations were initially selected to characterize the subsurface conditions along the ASR and in some of the potential borrow areas. Selection of the sampling locations was based on anticipated occurrences of permafrost and fine-grained material.

Some sampling site locations were adjusted, while others were removed as weather delays continued to set the investigation progress behind schedule. Planning was adjusted to place multiple sampling sites within close proximity of each other while keeping them within different terrain units to collect as much data as possible without the need for continual helicopter support.

In total, 39 sampling sites were investigated during the 2018 geotechnical program. Forty-four sampling holes were advanced, five of which were confirmation holes. The completed 2018 sampling hole locations are shown on the terrain maps (Figures 2 to 28).

Survey control for the geotechnical investigation was provided by Tetra Tech field personnel using a handheld GPS unit (Garmin GPSMAP 62) to locate and verify the sampling sites. Table 1 summarizes the coordinates and completion depth for each of the sampling site holes. Soil logs for each sampling hole are included in Appendix B.

Table 1: Sampling Site Information Summary

<table>
<thead>
<tr>
<th>Alignment Section</th>
<th>Sample Site</th>
<th>Coordinates (UTM ZONE 10)</th>
<th>Elevation (m)</th>
<th>Completion Depth (m)</th>
<th>Sample Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nahanni Access Road to Junction Highway 7 (KP 169.5 – 179.5)</td>
<td>BH65</td>
<td>Easting: 486.585, Northing: 6,757,825</td>
<td>195</td>
<td>5.0</td>
<td>10-Aug</td>
</tr>
<tr>
<td></td>
<td>BH67</td>
<td>Easting: 495.001, Northing: 6,757,048</td>
<td>182</td>
<td>4.0</td>
<td>11-Aug</td>
</tr>
<tr>
<td></td>
<td>BH66</td>
<td>Easting: 492.025, Northing: 6,757,722</td>
<td>199</td>
<td>5.0</td>
<td>11-Aug</td>
</tr>
<tr>
<td>Liard South Landing to Nahanni Butte Access Road (KP 156.4 – 169.5)</td>
<td>BH64</td>
<td>Easting: 487.245, Northing: 6,761,295</td>
<td>205</td>
<td>5.0</td>
<td>11-Aug</td>
</tr>
<tr>
<td></td>
<td>BH63</td>
<td>Easting: 484.770, Northing: 6,766,959</td>
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<td>5.0</td>
<td>11-Aug</td>
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<tr>
<td></td>
<td>BH62</td>
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<tr>
<td>Grainger Bridge to Liard North Landing (KP 121.2 – 155.8)</td>
<td>BH61</td>
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<tr>
<td></td>
<td>BH57</td>
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<tr>
<td></td>
<td>BP154</td>
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<tr>
<td></td>
<td>BP146</td>
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<td>2.1</td>
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<tr>
<td></td>
<td>BH54</td>
<td>Easting: 486.269, Northing: 6,787,498</td>
<td>522</td>
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<tr>
<td></td>
<td>BH137.1</td>
<td>Easting: 486.283, Northing: 6,787,574</td>
<td>518</td>
<td>3.0</td>
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<tr>
<td></td>
<td>BH51.1</td>
<td>Easting: 482.426, Northing: 6,793,845</td>
<td>643</td>
<td>0.72</td>
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<td></td>
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<td></td>
<td>BH49.1</td>
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<td>3.6</td>
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<tr>
<td></td>
<td>BH49.2</td>
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<td>482</td>
<td>3.5</td>
<td>17-Aug</td>
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</tbody>
</table>
### Table 1: Sampling Site Information Summary

<table>
<thead>
<tr>
<th>Alignment Section</th>
<th>Sample Site</th>
<th>Coordinates (UTM ZONE 10)</th>
<th>Elevation (m)</th>
<th>Completion Depth (m)</th>
<th>Sample Date</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Easting (m)</td>
<td>Northing (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetcela 1 Bridge to Grainger Bridge (KP 87.0 – 121.2)</td>
<td>BH43.1</td>
<td>473,287</td>
<td>6,805,463</td>
<td>497</td>
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<tr>
<td></td>
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<td>473,242</td>
<td>6,805,478</td>
<td>489</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>BH43.2 Conf.</td>
<td>473,242</td>
<td>6,805,478</td>
<td>489</td>
<td>0.72</td>
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<td>6,810,694</td>
<td>507</td>
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<tr>
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<td>BP103.1</td>
<td>469,361</td>
<td>6,810,717</td>
<td>519</td>
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<td>6,811,632</td>
<td>554</td>
<td>2.65</td>
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<td>6,811,644</td>
<td>567</td>
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<td>6,812,280</td>
<td>268</td>
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<tr>
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<td>6,812,280</td>
<td>268</td>
<td>2.92</td>
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<tr>
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<td>6,812,501</td>
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<tr>
<td></td>
<td>BH33</td>
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<td>6,813,836</td>
<td>246</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>BH96.6 Conf.</td>
<td>466,214</td>
<td>6,812,501</td>
<td>259</td>
<td>2.15</td>
</tr>
<tr>
<td>Poljie Bridge to Tetcela 1 Bridge (KP 53.2 – 87.0)</td>
<td>BH18</td>
<td>443,580</td>
<td>6,828,387</td>
<td>887</td>
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<tr>
<td></td>
<td>BH15</td>
<td>441,175</td>
<td>6,830,896</td>
<td>735</td>
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</tr>
<tr>
<td></td>
<td>BH17</td>
<td>442,271</td>
<td>6,828,925</td>
<td>823</td>
<td>1.6</td>
</tr>
<tr>
<td>Sundog Tributary Bridge to Poljie Bridge (KP 39.2 – 53.2)</td>
<td>BP50B</td>
<td>437,590</td>
<td>6,829,985</td>
<td>804</td>
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</tr>
<tr>
<td></td>
<td>BP50.1B</td>
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<td>6,829,936</td>
<td>802</td>
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<td>BH11</td>
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<td>6,829,975</td>
<td>789</td>
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<tr>
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<td>BH11.1</td>
<td>437,988</td>
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<td>BH 12</td>
<td>439,900</td>
<td>6,830,627</td>
<td>717</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>BP53</td>
<td>440,249</td>
<td>6,830,824</td>
<td>713</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>BH7</td>
<td>431,863</td>
<td>6,829,686</td>
<td>845</td>
<td>2.8</td>
</tr>
</tbody>
</table>

### 2.4 Investigation Methodology

A hand-operated Atlas Copco-made Cobra Pro Impact Percussion Hammer (window sampler) was used to collect overburden soil samples along the ASR alignment. This method uses a hydraulic impact hammer to drive a core barrel with a cutting knife edge into the soil (Photo 1). Core barrels with either a 25 mm (1 inch) or 50 mm (2 inch) diameter bore were used to collect samples. The window sampler cores up to 1.0 m depth at a time, with additional 1.0 m threaded rods added to sample at greater depths.

The core barrel extraction system is comprised of a steel extruder table, leverage operated extruder, bore grip, and lever arms. The extruder uses mechanical advantage to leverage the rod string up using a rolling ball clamp that grips onto the rod when jacking the core barrel up.
As a minimum, two personnel were required to operate the window sampler. A third person was also often required while extracting the sampler to prevent the rod string from falling down hole after breaking the rods.

The maximum depth of window sampling for this investigation was 5.0 m. Overburden samples were taken from the open window slits of the core barrel, double-bagged for moisture retention, and shipped off-site for geotechnical testing.

For logging purposes, the window sampler recovers partially undisturbed cores that provide an accurate representation of the overburden strata. However, when removing a partially undisturbed, unfrozen soil sample from the open window core barrel, the soil core begins crumbling and the extruded sample comes out disturbed. Frozen overburden material can be sampled with only minor superficial thermal disturbance. Small sections of the frozen undisturbed core can be slid out of the core barrel or removed through the barrel window. The window sampler performed best in fine-grained soils, or soil containing some gravel with a maximum diameter of up to 20 mm. The 50 mm (2 inch) core barrel allows for coring into coarser grained material with gravel up to 50 mm and provides a larger sample. The 25 mm (1 inch) core barrel performs slightly better than the 50 mm core barrel in stiff to hard fine-grained material or permafrost, where greater penetration force is required for the core barrel to pass through the material. However, the 25 mm core barrel does not collect a suitably sized sample for geotechnical laboratory testing purposes. Therefore, the 50 mm core barrel was used for most of the program.

Refusal of the sampler occurred when the core barrel would hit competent bedrock, coarse gravelly or cobbly material, stiff clay or hard soil at a greater depth, and coarse-grained perennially frozen material. The greatest penetration depth (1.5 m) in permafrost with the sampler was achieved in frozen silt, with some sand and trace clay (BH33). Once the advancement rate of the window sampler became too slow or stopped, sampling would be discontinued to prevent damage to the equipment. When sampling became too difficult to advance with the 50 mm core barrel, it would be exchanged for the 25 mm core barrel with better penetration to sample further. This technique is only usable if the material being cored is believed to be fine-grained frozen/unfrozen mineral or organic soil.

Three instances of metal fatigue and shearing occurred during the program. While advancing BH137.1, a nipple sheared on the fourth run, leaving the core barrel and two rods 0.5 m down hole without any means of recovery. Similarly, a second nipple sheared during the first run at sample hole BH 96.6, leaving the top of the core barrel exposed above ground. The core barrel was recovered later into the project. Finally, at the last sampling site, the main adapter sheared at the base of the 32 mm hexagonal shaft that fits into the receiver of the hammer. This equipment failure ultimately ended the program as it was required to operate the hammer.

2.5 Geotechnical Sampling and Logging

Frozen and unfrozen overburden sample examination and logging was conducted immediately following core recovery at each sampling site. This ensured minimal thermal disturbance to any frozen samples, and allowed accurate identification, logging, and sampling of frozen and unfrozen soils.

The soil phase, whether thawed, unfrozen, or frozen, was described independently of the frozen state. The soil core logging involved three steps:

1. Description of soil composition (lithology) according to the Modified Unified Soil Classification System guidelines (Appendix C);
2. Description of the frozen state of the soil (visible or non-visible ice); and
3. Description of characteristic ice features, including cryogenic structures (cryostructures) found within frozen soil. Steps 2 and 3 were carried out according to ASTM (2007) procedure.

All soil cores were photographed immediately upon recovery, prior to sample removal from the window sampler. The window slit in the core barrel often required cleaning before a photo could be taken, as foreign material from shallower depths would collect in the window during extraction and cover the actual core within the barrel. Close-up photographs were taken of ground ice formations and cryostructures wherever present.
Photographs of the selected core samples are included in the Photographs section of this report.

Soil samples were selected from the core to be representative of each major soil type. One to three samples were collected per sample hole.

Representative samples of undisturbed frozen overburden core were not obtained during this program as the frozen core was too thermally damaged in field storage throughout the day, despite efforts to keep the samples in coolers with ice packs. Of the 39 sites sampled, only 6 sites were observed to contain permafrost material. Representative disturbed soil samples were placed in plastic bags, double-bagged for moisture preservation, and transported to Tetra Tech’s geotechnical laboratory in Edmonton for off-site laboratory testing.

### 2.6 Geotechnical Laboratory Testing

#### 2.6.1 General

One sample was tested on-site for excess ice content. The remainder of the soil samples were shipped to Edmonton for testing and storage at Tetra Tech’s geotechnical laboratory. The off-site testing included natural moisture and salinity contents, and particle size analyses.

The testing results are summarized below in Tables 2, 3, and 4. Full test results are presented in Appendix C, and are detailed on the borehole logs in Appendix B.

#### 2.6.2 Classification Laboratory Testing

**On-site Excess Ice Content Analysis**

On-site excess ice content testing was completed on one sample from sample hole BH33 that displayed visible ice. The test results are summarized in Table 2.

<table>
<thead>
<tr>
<th>Sample Hole No.</th>
<th>Sample No.</th>
<th>From (m)</th>
<th>To (m)</th>
<th>Excess Ice Content (% by volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH33</td>
<td>S1</td>
<td>0.50</td>
<td>1.00</td>
<td>27</td>
</tr>
</tbody>
</table>

**Off-site Moisture Content, Hydrometers, Particle Size Analysis, and Atterberg Limits**

Off-site laboratory testing was completed on 30 single or combined samples. Combined samples were of similar material from the same sampling site. Samples were selected for testing to confirm and accurately classify soil types within specific sections of the ASR. Atterberg Limits were determined for seven fine-grained samples. Hydrometer, particle size distribution analysis, and moisture content determination results are summarized in Table 3. Atterberg Limits results are summarized in Table 4.
### Table 3: Summary of Off-site Hydrometer and Particle Size Laboratory Test Results

<table>
<thead>
<tr>
<th>Sample Hole No.</th>
<th>Sample No.</th>
<th>Depth From (m)</th>
<th>Depth To (m)</th>
<th>Moisture Content (%)</th>
<th>Clay (%)</th>
<th>Silt (%)</th>
<th>Sand (%)</th>
<th>Gravel (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH7</td>
<td>S1, S2</td>
<td>0.50</td>
<td>2.00</td>
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<td>4.8</td>
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<td>87.6</td>
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<td>S1</td>
<td>1.40</td>
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<td>12.5</td>
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<td>75.8</td>
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<td>14.5</td>
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<td>78.3</td>
<td>22.0</td>
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<tr>
<td>BP53</td>
<td>S1, S2</td>
<td>0.30</td>
<td>3.00</td>
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<td>7.8</td>
<td>9.2</td>
<td>89.2</td>
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<td>2.00</td>
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<td>8.5</td>
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<td>79.1</td>
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<td>S1</td>
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<td>S2</td>
<td>1.40</td>
<td>1.90</td>
<td>11.4</td>
<td>17.0</td>
<td>46.0</td>
<td>21.0</td>
<td>16.0</td>
</tr>
<tr>
<td>BH38</td>
<td>S1</td>
<td>0.30</td>
<td>1.00</td>
<td>8.2</td>
<td>44.1</td>
<td>21.9</td>
<td>34.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BP102</td>
<td>S1</td>
<td>0.58</td>
<td>1.00</td>
<td>23.8</td>
<td>67.9</td>
<td>20.1</td>
<td>12.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BP103.2</td>
<td>S1</td>
<td>1.60</td>
<td>2.00</td>
<td>17.6</td>
<td>36.0</td>
<td>42.0</td>
<td>19.0</td>
<td>3.0</td>
</tr>
<tr>
<td>BH42</td>
<td>S2, S3</td>
<td>0.67</td>
<td>2.0</td>
<td>15.3</td>
<td>60.8</td>
<td>30.2</td>
<td>9.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH43.1</td>
<td>S2, S3</td>
<td>0.57</td>
<td>1.55</td>
<td>4.8</td>
<td>11.9</td>
<td>57.1</td>
<td>31.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH49.1</td>
<td>S1, S2</td>
<td>0.50</td>
<td>2.00</td>
<td>16.0</td>
<td>31.6</td>
<td>43.4</td>
<td>25.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH50</td>
<td>S1</td>
<td>0.54</td>
<td>0.72</td>
<td>46.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BH50</td>
<td>S2</td>
<td>1.30</td>
<td>2.00</td>
<td>11.8</td>
<td>20.8</td>
<td>46.2</td>
<td>33.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH50</td>
<td>S3</td>
<td>2.50</td>
<td>2.90</td>
<td>10.6</td>
<td>9.0</td>
<td>29.0</td>
<td>30.0</td>
<td>32.0</td>
</tr>
<tr>
<td>BH137.1</td>
<td>S2</td>
<td>1.60</td>
<td>2.00</td>
<td>14.4</td>
<td>17.0</td>
<td>36.0</td>
<td>33.0</td>
<td>14.0</td>
</tr>
<tr>
<td>BH54</td>
<td>S1, S2</td>
<td>0.30</td>
<td>2.85</td>
<td>8.2</td>
<td>33.9</td>
<td>50.1</td>
<td>16.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BP146</td>
<td>S1</td>
<td>0.30</td>
<td>1.00</td>
<td>14.9</td>
<td>18.0</td>
<td>43.0</td>
<td>31.0</td>
<td>8.0</td>
</tr>
<tr>
<td>BP154</td>
<td>S1</td>
<td>0.13</td>
<td>0.81</td>
<td>12.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BH57</td>
<td>S1, S2</td>
<td>0.50</td>
<td>1.45</td>
<td>3.9</td>
<td>39.5</td>
<td>36.5</td>
<td>24.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH61</td>
<td>S1</td>
<td>0.60</td>
<td>1.00</td>
<td>24.9</td>
<td>11.0</td>
<td>78.0</td>
<td>11.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH62</td>
<td>S2</td>
<td>1.40</td>
<td>2.00</td>
<td>8.0</td>
<td>41.1</td>
<td>58.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH63</td>
<td>S1</td>
<td>1.10</td>
<td>2.00</td>
<td>28.7</td>
<td>9.0</td>
<td>86.0</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>BH67</td>
<td>S1, S2</td>
<td>1.35</td>
<td>3.00</td>
<td>23.5</td>
<td>21.0</td>
<td>73.0</td>
<td>6.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Table 4: Summary of Atterberg Limit Test Results

<table>
<thead>
<tr>
<th>Sample Hole No.</th>
<th>Sample No.</th>
<th>Depth From (m)</th>
<th>Depth To (m)</th>
<th>Atterberg Limit USCS Symbol</th>
<th>Soil Plasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH96.6 Conf.</td>
<td>S2</td>
<td>2.00</td>
<td>2.15</td>
<td>CL // CI</td>
<td>Low to Medium</td>
</tr>
<tr>
<td>BH36</td>
<td>S2</td>
<td>1.40</td>
<td>1.90</td>
<td>CI</td>
<td>Medium</td>
</tr>
<tr>
<td>BP103.2</td>
<td>S1</td>
<td>1.60</td>
<td>2.00</td>
<td>CI</td>
<td>Medium</td>
</tr>
<tr>
<td>BH50</td>
<td>S3</td>
<td>2.50</td>
<td>2.90</td>
<td>CL</td>
<td>Low</td>
</tr>
<tr>
<td>BP146</td>
<td>S1</td>
<td>0.30</td>
<td>1.00</td>
<td>CL</td>
<td>Low</td>
</tr>
<tr>
<td>BH61</td>
<td>S1</td>
<td>0.60</td>
<td>1.00</td>
<td>CL</td>
<td>Low</td>
</tr>
<tr>
<td>BH63</td>
<td>S1</td>
<td>1.10</td>
<td>2.00</td>
<td>CL // CI</td>
<td>Low to Medium</td>
</tr>
</tbody>
</table>

Salinity testing was performed on selected samples from sites where permafrost conditions were expected but were not observed. Table 5 summarizes the salinity test results.

Table 5: Summary of Salinity Test Results

<table>
<thead>
<tr>
<th>Sample Hole No.</th>
<th>Sample No.</th>
<th>Depth From (m)</th>
<th>Depth To (m)</th>
<th>Soil Type</th>
<th>Salinity (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH12</td>
<td>S1</td>
<td>1.30</td>
<td>2.00</td>
<td>SAND – gravelly, trace silt, clay, brown</td>
<td>0.2</td>
</tr>
<tr>
<td>BH17</td>
<td>S1</td>
<td>1.20</td>
<td>1.60</td>
<td>GRAVEL – sandy, trace silt, clay, grey</td>
<td>1.7</td>
</tr>
<tr>
<td>BH42</td>
<td>S2</td>
<td>0.67</td>
<td>1.00</td>
<td>CLAY – sandy, trace gravel, silt, brown</td>
<td>9.3</td>
</tr>
<tr>
<td>BH43.1</td>
<td>S2</td>
<td>0.57</td>
<td>0.94</td>
<td>SAND – gravelly, trace clay, silt, brown</td>
<td>9.7</td>
</tr>
</tbody>
</table>

2.7 Ground Temperature Measurements

Single bead thermistor strings (SBTS) were installed in some sampling holes to confirm permafrost conditions. SBTS installation details and readings are summarized in Table 6.

Table 6: Single Bead Thermistor String Installation Details and Readings

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Single Bead No.</th>
<th>Installation Depth (m)</th>
<th>Installation Date</th>
<th>Reading Date</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH50</td>
<td>7</td>
<td>0.6</td>
<td>August 16, 2018</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BH49.1</td>
<td>6</td>
<td>1.0</td>
<td>August 17, 2018</td>
<td>August 17, 2018</td>
<td>0.02</td>
</tr>
<tr>
<td>BH96.6</td>
<td>3</td>
<td>1.3</td>
<td>August 21, 2018</td>
<td>August 26, 2018</td>
<td>0.14</td>
</tr>
<tr>
<td>BH11.1</td>
<td>3</td>
<td>1.5</td>
<td>August 27, 2018</td>
<td>August 28, 2018</td>
<td>0.30</td>
</tr>
</tbody>
</table>

SBTS #7 installed in sampling hole BH50 to a depth of 0.6 m, was not revisited to collect ground temperature data because of the tight schedule and helicopter unavailability.

Ground temperatures collected with SBTSs installed in BH49.1, BH96.6, and BH11.1 (Table 6), one to five days after installation, were slightly above the freezing point, although frozen conditions were observed in these three holes. This can be explained by sampling-induced thermal disturbance of the ground.
3.0 TERRAIN AND SUBSURFACE CONDITIONS

3.1 General

Ground and terrain conditions observed at each of the 39 sampling sites along the ASR alignment are discussed in the following sections. The discussions are based on the data collected during the sampling, logging, field, and laboratory testing phases of the investigation. Subsurface conditions are not uniform; it is expected that conditions between and surrounding the sampling sites may vary from the subsurface conditions identified within the holes. However, the window sampling data does give a general indication of the range of subsurface properties to be expected along the alignment. Some sampling sites have a confirmation hole that was advanced nearby to confirm the findings from the original 2018 sampling hole.

Permafrost conditions were observed at six sampling sites along the ASR alignment (Appendix B).

Sampling sites are summarized within seven sections of the ASR alignment that have been selected by Allnorth as per the major stream crossings. Table 7 summarizes these sections and their ranges are marked by kilometre posts (KP).

Table 7: Sections of All-Season Road

<table>
<thead>
<tr>
<th>Section Landmark Name</th>
<th>Section Range (KP)</th>
<th>Number of Sampling Sites Within Section</th>
<th>Permafrost Observed within Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine Site to Sundog Tributary Bridge</td>
<td>0.0 – 39.2</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Sundog Tributary Bridge to Polje Bridge</td>
<td>39.2 – 53.2</td>
<td>7</td>
<td>Yes</td>
</tr>
<tr>
<td>Poljie Bridge to Tetcela 1 Bridge</td>
<td>53.2 – 87.0</td>
<td>3</td>
<td>Yes</td>
</tr>
<tr>
<td>Tetcela 1 Bridge to Grainger Bridge</td>
<td>87.0 – 121.2</td>
<td>16</td>
<td>Yes</td>
</tr>
<tr>
<td>Grainger Bridge to Liard North Landing</td>
<td>121.2 – 155.8</td>
<td>11</td>
<td>Yes</td>
</tr>
<tr>
<td>Laird South Landing to Nahanni Butte Access Road</td>
<td>156.4 – 169.4</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>Nahanni Butte Access Road to Junction Highway 7</td>
<td>169.5 – 179.5</td>
<td>3</td>
<td>No</td>
</tr>
</tbody>
</table>

3.2 Sundog Tributary Bridge to Polje Bridge (KP 39.2 – KP 53.2)

3.2.1 General

Seven sites were investigated along this section of the ASR alignment, between the Sundog Tributary Bridge and the Polje Bridge. The terrain within this section of the ASR comprises colluvial and glaciofluvial deposits, with a seasonally flooded, peatland area located west of the Polje Bridge. Sampling depths were relatively deep along this section ranging from 2.4 m to 5.0 m due to the high sand content and lack of gravel.

Permafrost conditions were observed at one site: sampling site BH11.1. Well-bonded permafrost (Nbn) was cored between 2.0 m and 2.4 m BGL.

General terrain and subsurface conditions are discussed below and are summarized in Table 8.
Table 8: Sampling Summary for KP 39.2 – KP 53.2

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH7</td>
<td>2.8.</td>
<td>0.0</td>
<td>SAND - trace silt, clay and gravel; SAND - some gravel, trace silt and clay</td>
<td>None</td>
</tr>
<tr>
<td>BP50B</td>
<td>5.0</td>
<td>0.15</td>
<td>SAND - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BP50.1B</td>
<td>5.0</td>
<td>0.12</td>
<td>SAND - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH11</td>
<td>4.0</td>
<td>0.1</td>
<td>SAND - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH11.1</td>
<td>2.4</td>
<td>0.15</td>
<td>SAND - trace silt and gravel; SAND - gravelly, trace silt and clay</td>
<td>Nbn</td>
</tr>
<tr>
<td>BH12</td>
<td>2.7</td>
<td>0.41</td>
<td>SAND - gravelly, trace silt and clay; SAND - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BP53</td>
<td>4.0</td>
<td>0.06</td>
<td>SAND; SAND - trace silt, gravel, and clay</td>
<td>None</td>
</tr>
</tbody>
</table>

3.2.2 Terrain and Overburden

Sampling site BH7 is located within the winter road cut section with sand and gravel exposed nearby. The surrounding vegetation consists of dense spruce with grass ground cover. The soil is primarily sand with traces of silt, clay, and gravel. The gravel is sub rounded to angular, up to 20 mm in diameter. The soil appears to be moderately uniformly graded sand, with gravel content increasing with depth. Sampling was terminated at a depth of 2.8 m due to equipment failure.

Sampling sites BP50B, BP50.1B, and BH11 are located within 50 m of one another, in a proposed geophysical special investigation zone. Areas of colluvial, fluvial, and glaciofluvial material are present in this region. A forest fire recently passed through the area. Young spruce and aspen are returning with grassy ground cover. All three sites are underlain by sand with trace silt. The sampling holes in this soil type were advanced to depths ranging from 4.0 m to 5.0 m.

Sampling hole BH11.1 is located 400 m east of the BH11, on the side slope of a small stream valley. A forest fire recently passed through the area, with mainly grass, moss, and shrubs covering presently ground. Peat and organic material cover is approximately 0.4 m thick. Sand with traces of silt and gravel make up the soil constituents up to 1.3 m, with gravel content increasing with depth. The gravel is rounded to angular, up to 40 mm in diameter. Well-bonded perennially frozen sand with trace silt was observed between 2.0 m and 2.4 m depth (Photo 2). Sampling with the window sampler could not continue past 2.4 m because of the refusal on permafrost. A SBTS was installed to a depth of 1.5 m BGL and was read one day later, reading 0.3°C. The SBTS was not installed to the depth of the observed permafrost (2.0 m) as the string could not be lowered down hole past 1.5 m.

Sampling site BH12 is located 700 m west of the Polje Bridge, along the ASR alignment. The region is comprised of seasonally inundated peatland. Sparse black spruce is present in the area. Amorphous peat and black topsoil makes up the top 0.63 m of the overburden, underlain by saturated grey gravelly sand with traces of silt and clay. Silt and gravel contents vary with depth, but sand is the predominant material. Sampling continued to a depth of 2.7 m BGL where the sampler could not be advanced further.

Sampling site BH53 is located 300 m west of the Polje Bridge, along the ASR alignment. A forest fire has recently passed through the area, with young spruce returning and thin grass covering presently sandy soil. Sand with traces of silt and gravel was observed in the sampling hole down to a depth of 4.0 m BGL. The gravel is rounded and up to 20 mm in diameter.
3.3 Polje Bridge to Tetcela 1 Bridge (KP 53.2 – KP 87.0)

3.3.1 General

Three sampling sites were investigated along this section of the ASR alignment between the Polje Bridge and Tetcela 1 Bridge. Terrain along this section includes glaciofluvial deposits and colluvial mass wastage. Polje karst formations are situated just south of the ASR. Sampling sites BH17 and BH18 are situated within proposed geophysical special investigation areas. Sampling depth ranged from 1.6 m to 4.0 m.

Permafrost conditions were observed in sampling hole BH15. Well-bonded (Nbn) permafrost was present at 3.5 m to 3.7 m BGL. Sampling with the window sampler could not continue past 3.7 m due to refusal on permafrost.

General terrain and subsurface conditions are discussed in the following section and are summarized in Table 9.

### Table 9: Sampling Summary for KP 53.2 – KP 87.0

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH15</td>
<td>3.7</td>
<td>0.08</td>
<td>GRAVEL &amp; SILT - trace sand; SAND - trace silt and clay</td>
<td>Nbn</td>
</tr>
<tr>
<td>BH17</td>
<td>1.6</td>
<td>0.8</td>
<td>SILT - clayey; GRAVEL - sandy, trace silt and clay</td>
<td>None</td>
</tr>
<tr>
<td>BH18</td>
<td>4.0</td>
<td>0.05</td>
<td>SAND — gravelly, trace clay and silt; SAND - trace silt</td>
<td>None</td>
</tr>
</tbody>
</table>

3.3.2 Terrain and Overburden

Sampling site BH15 is located on the ASR alignment just east of the Tetcela Bridge Crossing. The area has been recently burned with vegetation and is slowly recovering. A thin blanket of fibrous peat is underlain by silt and gravel with trace sand. The gravel is angular and up to 50 mm in diameter. The underlying soil is uniform sand with traces of silt and clay. Well-bonded (Nbn) frozen core approx. 0.1 m long was recovered at the base of the sampling hole, at a depth of 3.6 m to 3.7 m (see Photo 3). Sampling could not advance past this point due to refusal on permafrost.

Sampling site BH17 is in a geophysical special investigation area where mass wasting, and exposed bedrock was observed. It is a west-facing ten-degree slope covered with sparse black spruce and grassy shrubs. The top 1.0 m of soil includes fibrous brown peat and black organic topsoil. Approximately 1.0 m BGL, the soil transitions to soft clayey silt, grey with medium plasticity. The clayey silt is underlain by sandy gravel with traces of silt and clay. The gravel is flakey shale. The sampler could not advance past the shale gravel layer, with refusal at 1.6 m BGL.

Sampling site BH18 is in another geophysical special investigation area. This site is a possible kettle or sinkhole next to the road alignment near KP 59. The area was recently burned, with vegetation reappearing. Vegetation includes moss and grass with sparse shrubs. Moss and fibrous peat make up the top 0.15 m of the overburden, covering sand and gravel of varying quantities, with traces of silt and clay. The gravel is angular with particle size increasing with depth. Particles are up to 40 mm in diameter at 3.5 m BGL. The sampler hit refusal at 4.0 m.

3.4 Tetcela 1 Bridge to Grainger Bridge (KP 87.0 – KP 121.2)

3.4.1 General

This section of the ASR alignment passes through a broad range of terrain and soil types, from glaciofluvial deposits and colluvial mass wastage zones to low lying wetlands, organic deposits, and muskeg which contain patches of
permafrost. This section of the ASR alignment is underlain mainly by sandy and gravelly soil. Therefore, sampling depths along this section of the ASR alignment were relatively shallow due to higher gravel content. Sampling hole depths ranged from 0.72 m to 2.92 m.

Permafrost conditions were observed at two sampling sites, BH33 and BH96.6, with a confirmation hole sampled at BH96.6 Conf. Ice-rich, stratified permafrost (Vs) with excess ice content of 27% (% by volume of visible ice) and well-bonded (Nbn and Nbe) permafrost were observed at sampling site BH33. The visible ice was present at 0.39 m depth and down to 1.0 m, with non-visible ice (Nbe) below to a depth of 1.45 m. Sampling holes BH96.6 and BH96.6 Conf. both contained visible ice inclusions, up to 3% excess ice content (% by volume of visible ice) at 2.0 m depth.

General terrain and subsurface conditions are discussed in the following section and are summarized in Table 10.

Table 10: Sampling Summary for KP 87.0 – KP 121.2

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH33</td>
<td>1.45</td>
<td>0.13</td>
<td>SILT - some sand, trace clay</td>
<td>Vs 27%; Nbe and Nbn</td>
</tr>
<tr>
<td>BH96.6</td>
<td>2.3</td>
<td>1.0</td>
<td>CLAY - gravelly, some sand, trace silt; CLAY - some sand and gravel, trace silt</td>
<td>Vx 1%-3%</td>
</tr>
<tr>
<td>BH96.6 Conf.</td>
<td>2.15</td>
<td>0.72</td>
<td>CLAY - sandy, some gravel, trace silt CLAY - silty, sandy, some gravel</td>
<td>Vx 1%-3%</td>
</tr>
<tr>
<td>BH36</td>
<td>1.9</td>
<td>0.1</td>
<td>GRAVEL &amp; CLAY - some sand, trace silt; CLAY - silty, sandy, some gravel</td>
<td>None</td>
</tr>
<tr>
<td>BH97</td>
<td>0.62</td>
<td>0.06</td>
<td>SILT; CLAY - some gravel and silt, trace sand</td>
<td>None</td>
</tr>
<tr>
<td>BH97 Conf.</td>
<td>2.92</td>
<td>0.04</td>
<td>CLAY - sandy, some gravel, trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH37</td>
<td>0.70</td>
<td>0.08</td>
<td>SILT; GRAVEL &amp; CLAY - some silt and sand</td>
<td>None</td>
</tr>
<tr>
<td>BH38</td>
<td>1.26</td>
<td>0.15</td>
<td>SILT - trace clay; GRAVEL &amp; CLAY - Sandy, trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BP102</td>
<td>2.65</td>
<td>0.45</td>
<td>CLAY - sandy, some gravel, silt; CLAY - trace silt and gravel</td>
<td>None</td>
</tr>
<tr>
<td>BP103.1</td>
<td>2.8</td>
<td>0.17</td>
<td>CLAY - silty, some sand, trace gravel; CLAY - some gravel, trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BP103.2</td>
<td>2.45</td>
<td>0.4</td>
<td>SILT - trace clay and sand; CLAY – silty, some sand</td>
<td>None</td>
</tr>
<tr>
<td>BP109</td>
<td>2.7</td>
<td>0.08</td>
<td>SILT - trace clay;</td>
<td>None</td>
</tr>
<tr>
<td>BH42</td>
<td>2.9</td>
<td>0.08</td>
<td>SILT - trace clay; CLAY - sandy, trace silt and gravel</td>
<td>None</td>
</tr>
<tr>
<td>BH43.1</td>
<td>1.55</td>
<td>0.25</td>
<td>SILT – some clay; SAND - gravelly, some clay, trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH43.2</td>
<td>0.72</td>
<td>0.09</td>
<td>SILT - some gravel, trace sand; SAND - gravelly, trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH43.2 Conf.</td>
<td>0.71</td>
<td>0.15</td>
<td>SILT - trace sand and gravel and clay; SAND – gravelly, clay, trace silt</td>
<td>None</td>
</tr>
</tbody>
</table>
3.4.2 Terrain and Overburden

The sampling site BH33 is located within flat low-lying thermokarst-affected terrain which consists of fluvial deposits locally covered by thick organic material. A stream crossing is located approximately 20 m away. Sampling hole BH33 was completed in dense stunted black spruce forest with ground covered with thick moss. The moss blanket is underlain by perennially frozen (Nbn) silty black topsoil layer approximately 0.4 m thick. The frozen topsoil overlies grey silt with some sand and trace clay which displays clear, visible ice stratification (Photo 4). An excess ice content (beaker) test conducted in the field on a sample collected from the silty soil layer between 0.4 m and 1.0 m depth BGL indicated excess ice content of 27% (% by volume of visible ice). Well-bonded (Nbe) permafrost was observed from a depth of 1.0 m to 1.45 m BGL. The frozen silt material became too hard to sample below 1.45 m and the sampling was terminated at this depth.

Sampling sites BH96.6 and BH96.6 Conf. are located within moderately dense black spruce growth with ground covered by thick moss layer. This is a low-lying area with a drainage path nearby that feeds into the wetlands west of the ASR alignment. Organics and topsoil are present up to 1.0 m BGL, transitioning into saturated clay and gravel layer down to a depth of 1.8 m. The clayey soil includes various quantities of silt, sand, and gravel up to 20 mm in diameter. Ground ice inclusions (Vx 1% to 3%) were observed within this clayey layer (Photo 5). Confirmation hole BH96.6 Conf. completed 3.0 m away to further verify permafrost conditions revealed similar subsurface conditions. A SBTS was installed in BH96.6 to a depth of 1.3 m BGL and was read five days later: 0.14°C.

Sampling sites BH36, BH97, and BH97 Conf. are located within 40 m of one another, 200 m south of BH96.6. These sampling sites are in mixed spruce and aspen forest with ground covered with moss. Multiple attempts were required to sample in this area due to high gravel content in the soil. Sampling site BH36 reached a depth of 1.9 m BGL. The encountered soil was brown gravelly clay with some sand and trace silt. The clay is medium plastic, classified as CI (Atterberg Limits test conducted). Sample hole BH97 reached only a depth of 0.62 m BGL in firm clay, sand, and gravel. Hence a confirmation hole was sampled 4 m west, resulting in 0.92 m final depth. Angular gravel up to 50 mm in diameter is present 0.2 m BGL.

Sampling sites BH37 and BH38 are both located on the double switchback west of Wolverine Pass. This section of the ASR passes over a large colluvial slope with exposed bedrock outcrops and steep terrain. Vegetation in the area consists of mixed aspen, spruce, and pine with grass and dead vegetation. Sampling depth was limited, with BH37 reaching 0.7 m BGL and BH38 reaching 1.26 m BGL. Soil consists mainly of brown clay and gravel, with sand and silt. The gravel was angular and up to 20 mm in diameter.

Sampling site BP102 is located immediately east of Wolverine Pass approximately 20 m down the ASR alignment. Moderately dense aspen and spruce mixed forest with ground covered with grass and leaf litter. The top 0.27 m consists of fibrous peat and organics. It overlies very firm clay with trace silt layer that extends down to 0.44 m depth. At this depth, organic soil inclusions start to alternate with the grey clay every 0.1 m to a depth of 1.6 m BGL. Sand and some gravel with trace silt is also present in the alternating clayey layers. Grey clay with varying quantities of sand, silt, and gravel continue to a depth of 2.65 m where the clay becomes too firm to advance. Gravel is sub angular, up to 20 mm in diameter.

Sampling site BP103.1 is located in the sparse spruce forest with moss and grass ground cover on a gentle slope. Sampling hole BP103.2 is located nearby in similar terrain. Topsoil accounts for the top 0.4 m of overburden, underlain by clay with varying quantities of silt, sand, and gravel. Final penetration depths were 2.8 m at BP103.1 and 2.0 m at BP103.2.

BP109 is in a potential borrow area set along the southeast side of a large shale outcrop. Dense aspen, scattered spruce, and grass cover a gentle slope dipping away from the outcrop. Below a 0.08 m dry moss and peat layer, brown silt, and trace clay continue to a depth of 2.7 m BGL, where the soil became too firm to advance. Gravel is sub angular, up to 20 mm in diameter.

Sampling site BH42 is located east of the shale outcrop, near the proposed BH41 location. Material here is mainly colluvium with fluvial deposits along drainage paths away from the outcrop. Terrain includes sparse, stunted black spruce and mossy, uneven ground. A 0.18 m moss and peat layer is underlain by 0.45 m of silt with trace clay, and transitions into firm, medium plastic, sandy clay with trace silt and gravel. The gravel is angular and up to 50 mm in diameter. The clay soil became too firm to advance past 2.9 m BGL.
The remaining sampling sites BH43.1, BH43.2, and BH43.2 Conf. are located in a region of glaciofluvial deposits that have formed small, steep ridges and low-lying areas covered by organics and occupied by wetland. Sampling hole BH43.1 is located at the base of a ridge, amongst black spruce and mossy ground cover. A 0.25 m layer of moss organics and fibrous peat is underlain by sand with varying quantities of gravel, clay, and trace silt. The soil is dark brown with sub-rounded gravel up to 40 mm diameter. BH43.2 and BH43.2 Conf. are located on the crest of a steep ridge 25 m west of BH43.1. The ridge is covered with dense spruce and sparse aspen with moss ground cover. Overlying soil constituents are primarily silt with varying amounts of sand and sub angular gravel up to 50 mm diameter. At 0.4 m depth, the soil is gravelly sand with some clay and trace silt, brownish grey in colour. At 0.70 m, the gravel is observed to be oxidized and highly fractured rock. Sampling could not advance past 0.72 m BGL with refusal on coarse material. Sampling hole BH42.2 Conf. was advanced nearby to confirm the findings.

### 3.5 Grainger Bridge to Liard North Landing (KP 121.2 – KP 155.8)

#### 3.5.1 General

This section of the ASR alignment, which spans between the Grainger Gap and the Liard River, runs along the eastern face of the Nahanni Mountain Range. General terrain conditions for this section of the ASR includes east-facing slopes with multiple drainage channels and peatlands within flat poorly-drained terrain with sparse to moderately dense stunted black spruce indicative of permafrost conditions. The soil consists mainly of glacial morainal or fluvial deposits along run-off channels.

Soil sampling with the sampler was difficult in the coarser glacial soil, frequently encountering cobble-size material or bedrock. Sample depths ranged from 0.72 m to 5.0 m.

Permafrost was encountered at two sampling sites along this section of the ASR: a 40 mm thick ice lens was observed at a depth of 0.5 m BGL in sampling hole BH49.1 located near the entrance to Grainger Gap. Visible ice inclusions (Vx 1 to 3% of ice) were also observed at a depth of 0.54 m to 0.72 m in sampling hole BH50.

General terrain and subsurface conditions are discussed in the following section and are summarized in Table 11.
Table 11: Sampling Summary for KP 121.2 – KP 155.8

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH49.1</td>
<td>3.6</td>
<td>0.06</td>
<td>SAND - some silt, trace clay; SAND - gravelly, some clay and silt</td>
<td>ICE lens, 40 mm, fused ice crystals</td>
</tr>
<tr>
<td>BH49.2</td>
<td>3.5</td>
<td>0.2</td>
<td>SAND - some silt, trace clay; SILT - trace clay; SAND &amp; GRAVEL - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH50</td>
<td>2.9</td>
<td>1.0</td>
<td>SILT &amp; SAND - some gravel, trace clay SAND - gravelly, some clay, some silt GRAVEL borderline SAND- clayey, some silt</td>
<td>Vx 1%-3%</td>
</tr>
<tr>
<td>BH51.1</td>
<td>0.72</td>
<td>0.29</td>
<td>SILT - some sand and gravel, trace clay</td>
<td>None</td>
</tr>
<tr>
<td>BH51.2</td>
<td>2.38</td>
<td>0.4</td>
<td>SILT - trace sand and gravel and clay SAND - trace silt and gravel clay</td>
<td>None</td>
</tr>
<tr>
<td>BH137.1</td>
<td>3.0</td>
<td>0.2</td>
<td>SAND &amp; SILT - trace gravel; CLAY - sandy, some silt and gravel; SAND - some silt and gravel</td>
<td>None</td>
</tr>
<tr>
<td>BH54</td>
<td>2.85</td>
<td>0.05</td>
<td>SAND - clayey, trace silt and gravel</td>
<td>None</td>
</tr>
<tr>
<td>BP146</td>
<td>2.1</td>
<td>0.15</td>
<td>CLAY - silty, some sand, trace gravel</td>
<td>None</td>
</tr>
<tr>
<td>BH57</td>
<td>1.45</td>
<td>0.12</td>
<td>CLAY &amp; SAND - some gravel</td>
<td>None</td>
</tr>
<tr>
<td>BP154</td>
<td>0.81</td>
<td>0.13</td>
<td>CLAY - silty, sandy, some gravel</td>
<td>None</td>
</tr>
<tr>
<td>BH61</td>
<td>5.0</td>
<td>0.1</td>
<td>CLAY - silty, some sand; SILT - some clay, trace sand</td>
<td>None</td>
</tr>
</tbody>
</table>

3.5.2 Terrain and Overburden

Sampling holes BH49.1 and BH49.2 are located approximately 1 km southeast of the Grainger Gap on the ASR alignment. A braided channel with cobble-covered bed runs nearby. The terrain is flat with grass, sparse shrubs, and patches of stunted trees. Thermokarst terrain was previously identified in the surrounding area. Both sampling sites are characterized by similar soil types consisting mainly of sand with varying contents of silt and clay, and a layer of rounded to sub-rounded gravel observed at a depth of 2.0 m BGL. Both sampling holes had refusal on coarse dense soil at 3.60 m depth. A 40 mm thick ice lens was observed at a depth of 0.5 m BGL (Photo 6). A SBTS was installed in this sampling hole to a depth of 1.0 m to confirm permafrost conditions. However, the SBTS was only read once directly after installation, reading 0.02°C.

Sampling hole BH50 is located within peatland with sparse, stunted black spruce. The peat layer is underlain by organic black soil. The soil transitions from saturated silt and sand with gravel to gravel and sand with firm, medium plastic clay below 2.0 m depth. Well-bonded permafrost with ice inclusions (Vx 1% to 3%) was observed between 0.54 m to 0.72 m (Photo 7). A SBTS was installed to a depth of 0.6 m with the thermistor bead positioned within the frozen layer.

Sampling hole BH51.1 and a confirmation hole BH51.2 are located just inside moderately dense spruce forest, with shrubs and moss ground cover. Organic layer includes dark brown fibrous peat underlain by sandy organic topsoil down to 0.3 m. The underlying layer consists of brown silt with varying quantities of sand, sub rounded gravel with trace clay. Sampling hole BH51.1 was terminated on presumably gravel at a depth of 0.72 m, hence sampling hole BH51.2 was drilled as a confirmation hole 3.0 m away from BH51.1. Sampling hole BH51.2 advanced to 2.4 m depth, revealed a higher clay component starting at 0.91 m BGL, with angular to sub rounded gravel up to 30 mm in diameter.
Sampling hole BH137.1 is located at KP 137.1, within a dense black spruce forest, near a small stream. Ground is level with thick moss cover. Organic material and black topsoil account for the top 0.35 m. The organic layer is underlain by saturated sand and silt with trace sub rounded gravel. By a depth of 1.55 m BGL, soil texture displays stratification and consists of layers of firm, grey clay and brown sand, with varying quantities of silt and large gravel. Sampling at BH137.1 was terminated due to equipment failure, as a threaded nipple failed during hammering and the core barrel was lost down hole.

Sampling hole BH54 is located on a ridge roughly 40 m south of BH137.1. Vegetation includes a mix of aspen and spruce with leafy ground cover and dense shrubs. Soil comprises of light brown clayey sand with varying amounts of gravel, up to 20 mm in diameter. Bright red silt inclusions, approximately 5 mm in diameter, were observed within the uppermost overburden layer approximately 1 m thick. Sampling was terminated at a depth of 2.85 m due to difficulty advancing.

Sampling hole BP146 is located in Borrow Pit 143. Vegetation consists of dense aspen growth with shrubs and ground covered with leaf litter and grass. Soil consists of stiff, silty clay with sand and trace gravel up to 50 mm in diameter. Roots were observed to a depth of 1.0 m. Sampling continued to a depth of 2.1 m BGL with no changes in the overburden material components; however, the soil consistency became too dense to continue advancing the sampler. Laboratory testing of the clayey material sample recovered in this hole indicated a CL clay with low plasticity.

Sampling sites BH57 and BP154 are situated close together within potential borrow area 154. Vegetation consists of dense aspen forest with clearings covered by shrubs and grass. Soil composition is similar between the two sample sites, with a thin organic peat layer underlain by sandy, brown clay with silt and some gravel. Due to shallow refusal at both sites at 1.0 m to 1.5 m depths, confirmation holes were advanced at both sites and sampled to confirm the presence of shallow bedrock or dense gravel. Sampling site BH57 could not be advanced past 1.45 m depth and sampling site BP154 could not be advanced past 1.0 m depth. Gravel up to 50 mm in diameter was encountered at approximately 1.0 m depth at both sites.

Sampling hole BH61 is located on the north bank of the Liard River, within moderately dense aspen and spruce forest with grass ground cover. The north bank of the river is composed of fluvial deposits that at BH61 site consist of low plasticity clay and silt with some sand underlain at approximately 1 m BGL by silt with some clay and trace sand. The underlying soil turns into primarily silt, grey, saturated with trace sand from 2.2 m to 5.0 m BGL.

### 3.6 Liard South Landing to Nahanni Butte Road (KP 156.4 – KP 169.5)

#### 3.6.1 General

South of the Liard River crossing, the terrain along the ASR alignment consists of the densely forested floodplain of the Liard River, generally flat land with patches of peatlands, and shallow drainage channels. Sampling holes were easily advanced to a depth of 5 m BGL along this section of the alignment because of the favorable soil conditions, i.e. fine-grained soils. The ASR alignment runs close to the winter road cutline, which follows the east bank of the Liard River.

No permafrost was encountered at the sampling sites along this section of the ASR alignment.

General terrain and subsurface conditions are discussed in the following section and are summarized in Table 12.
Table 12: Sampling Summary for KP 156.4 – KP 169.5

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH62</td>
<td>5.0</td>
<td>0.2</td>
<td>SILT - trace clay; SAND - clayey, some silt</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CLAY borderline SILT - trace sand;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SILT - some sand; SAND - trace clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CLAY; SILT - trace clay; SAND - trace silt</td>
<td>None</td>
</tr>
</tbody>
</table>

3.6.2 Terrain and Overburden

Sampling hole BH62 is located approximately two hundred meters south of the Laird South Landing within tall, moderately dense pine and aspen mixed forest. Terrain is flat with ground covered with moss. Sampling up to five meters resulted in a mix of brown clayey sand and silt in varying quantities.

Sample hole BH63 is located on the winter road cutline, where the ASR alignment meets with the cutline at KP 159. Vegetation at the sampling site consists of dense aspen and birch mixed forest with dense shrubs along the cutline. Terrain is flat. The uppermost layer of silty clay is underlain by silt and sand with trace to some clay.

Sampling hole BH64 is located at the edge of the winter road cutline, where the ASR alignment leaves the current cutline. The sampling site is situated along the boundary between the mixed coniferous and deciduous growth and stunted black spruce forest indicative of the presence of permafrost. Ground is covered with grass and sparse shrubs. BH64 encountered a thin layer of greyish brown clay underlain by silt with trace clay, and fine-grained sand for the remainder of the sampling hole.

3.7 Nahanni Butte Road to Highway 7 Junction (KP 169.5 – KP 179.5)

3.7.1 General

The final ten kilometers of the ASR alignment follow the existing all-season Nahanni Butte access road to the Highway 7 junction. Sampling holes were easily advanced to a depth up to 5.0 m BGL.

General terrain and subsurface conditions are discussed in the following section and are summarized in Table 13.
Table 13: Sampling Summary for KP 169.5 – KP 179.5

<table>
<thead>
<tr>
<th>Sampling Hole No.</th>
<th>Total Depth (m)</th>
<th>Organic Layer Thickness (m)</th>
<th>Major Soil Types</th>
<th>Permafrost Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH65</td>
<td>5.0</td>
<td>0.32</td>
<td>CLAY; CLAY - trace sand and silt; SAND - some silt</td>
<td>None</td>
</tr>
<tr>
<td>BH66</td>
<td>5.0</td>
<td>0.56</td>
<td>CLAY - trace silt; SAND - trace silt</td>
<td>None</td>
</tr>
<tr>
<td>BH67</td>
<td>4.0</td>
<td>0.6</td>
<td>CLAY - some silt and sand; CLAY - silty, trace sand</td>
<td>None</td>
</tr>
</tbody>
</table>

3.7.2 Terrain and Overburden

Terrain along this section of the ASR consists of flat floodplain composed of saturated fine-grained soil as it is seasonally underwater. The water table was observed close to the ground surface in the completed sampling holes. Sampling holes BH65 and BH66 revealed similar soil composition. Moss and wet organic soil cover stiff, medium plastic, grey silty clay which is underlain by clean, uniformly graded sand.

Sampling hole BH67 is situated near the Highway 7 Junction turn off to the Nahanni Butte Access Road. Vegetation in the area consists of dense shrubs with ground covered by grass. Ground conditions are dry and level. Soil from BH67 is comprised of lacustrine deposits, namely brown clay with some silt and trace sand.

No permafrost was encountered along this section of the ASR alignment within the upper 5.0 m depth interval.

4.0 REFINEMENT OF GEOTECHNICAL INVESTIGATION PROGRAM

4.1 Initial Winter Geotechnical Investigation Program

Prior to the completion of the summer 2018 window sampling program, the scope of the proposed winter geotechnical investigation program included drilling 67 geotechnical boreholes and excavating 36 testpits along the proposed ASR alignment. Thirteen geotechnical boreholes would be drilled in support of the borrow source investigation being undertaken by Allnorth, which includes 146 testpits. The focus of the proposed winter geotechnical investigation program is on perennially frozen overburden and bedrock characterization to collect additional permafrost, particularly volumetric ground ice content and ground temperature data, and will consist of geotechnical diamond drilling (with chilled drilling fluid), auger drilling, permafrost coring, installation of ground temperature measuring instrumentation, and geophysical surveying. Logging of permafrost and field testing of frozen samples, and collection of frozen and unfrozen soil samples for off-site laboratory testing would be performed in conjunction with the drilling operations.

Boreholes and testpits initially proposed for the winter program are summarized in Tables A, B, and C provided in the appendix section. The winter geotechnical investigation scope of work includes:

- The use of self-propelled rotary (with chilled drilling fluid) and auger drilling equipment (a track-mounted MARL Technologies A/R 80 drill) to complete 67 geotechnical boreholes along the proposed road alignment as summarized in Table A. To optimize the drilling program, it was proposed that two drill rigs be used – one starting at the Liard River crossing and progressing north along the ASR alignment using the winter road, and another rig moving from the Mine eastward;

- The use of an excavator to excavate 36 testpits along the proposed road alignment as summarized in Table B.
The use of self-propelled rotary (with chilled drilling fluid) or, possibly, auger drilling equipment to complete 13 geotechnical boreholes in potential borrow areas, as summarized in Table C in support of the borrow material investigation being undertaken by Allnorth (146 testpits);

Geotechnical logging of permafrost and field testing of frozen soil samples (excess ice content, moisture content, bulk density, and soil salinity);

Collection of frozen / unfrozen soil samples for offsite geotechnical laboratory testing; and

Installation of thirteen 20 m long multi-bead GTCs and thirty-two 10 m long single-bead thermistor strings and associated materials (casing, protective housing etc.).

4.2 2018 Window Sampling Learnings

In September 2018, Tetra Tech and Allnorth personnel reviewed field notes, photos, window sampler hole and terrain logs, and previously compiled terrain maps along the proposed ASR alignment for each window sampling site and the proposed 67 borehole locations (proposed winter program). The data obtained during the window sampling program confirmed the presence or absence of permafrost in some areas where its occurrence was assumed.

Specific sites along the ASR alignment where permafrost was anticipated but not observed in soil samples, recovered with the window sampler, will require further investigation during the proposed winter program. Likewise, sites where permafrost was confirmed during the summer 2018 window sampling were removed from the scope of proposed winter geotechnical investigation program. Due to the mechanical limitations of the window sampler tool, ground thermal conditions at some sampling sites were not confirmed, and bedrock characterization and installation of GTCs could not be performed. Therefore, these proposed boreholes remain in the scope of proposed winter geotechnical investigation program.

4.3 Refined Winter Geotechnical Investigation Program

The refined winter geotechnical investigation program is based on the confirmed presence or absence of permafrost and general terrain and ground observations made at each window sampler site. Data obtained from the 2018 investigation program allowed Tetra Tech to reduce the initial number of boreholes required for the future investigation program by 24 boreholes (a reduction of 36%). Two new boreholes were added to the future program to further investigate bedrock conditions at two proposed watercourse crossings near KP 23.5 and KP 39. Proposed geophysical survey lines along the ASR alignment have also been revised by a total reduction of 12%.

Revisions to the proposed future investigation program are detailed on the updated terrain maps, included on Figures 2 to 28. The originally proposed testpits along the ASR alignment have not been optimized and remain unchanged at this time. Borrow pit evaluations, including boreholes and testpits, led by Allnorth are also unchanged.

A summary of the proposed geotechnical investigation works includes:

- Drilling of 45 geotechnical boreholes along ASR alignment (see Table D);
- Excavating 36 testpits along the ASR alignment (see Table B);
- Drilling of 13 boreholes at potential borrow pits (see Table C); and
- Excavating 146 testpits at potential borrow pits, to be undertaken by Allnorth.

Tables outlining each of the above work fronts are included in the appendix of this report. Installation of ground temperature monitoring instrumentation will be reduced to match the requirements of the remaining boreholes along the ASR alignment.
5.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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PERMIT TO PRACTICE
TETRA TECH CANADA INC.

Signature:

Date: December 21, 2018

PERMIT NUMBER: P 018
NT/NU Association of Professional Engineers and Geoscientists
REFERENCES


# TABLES

<table>
<thead>
<tr>
<th>Table A</th>
<th>Proposed Boreholes for Original 2018 Investigation Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table B</td>
<td>Proposed Testpits along ASR Alignment</td>
</tr>
<tr>
<td>Table C</td>
<td>Proposed Allnorth Testpits at Borrow Pit Locations</td>
</tr>
<tr>
<td>Table D</td>
<td>Proposed Boreholes for Refined 2019 Investigation Program</td>
</tr>
</tbody>
</table>
Table A: Proposed Boreholes for Original 2018 Investigation Program (Tetra Tech, 2018)

<table>
<thead>
<tr>
<th>Borehole No.</th>
<th>Nearest ASR Kilometre Post (KP)</th>
<th>Drilling Method</th>
<th>Approximate Depth (m)</th>
<th>Ground Temperature Instrumentation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH01</td>
<td>25.5</td>
<td>Diamond¹</td>
<td>6</td>
<td>SBTS</td>
<td></td>
</tr>
<tr>
<td>BH02</td>
<td>25.5</td>
<td>Diamond¹</td>
<td>10 - 15</td>
<td>GTC</td>
<td>Special Geophysical Investigation</td>
</tr>
<tr>
<td>BH03</td>
<td>26.5</td>
<td>Diamond¹</td>
<td>6</td>
<td>SBTS</td>
<td></td>
</tr>
<tr>
<td>BH04</td>
<td>41</td>
<td>Diamond²</td>
<td>6</td>
<td>SBTS</td>
<td></td>
</tr>
<tr>
<td>BH05</td>
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\(^*\) Borehole completed during 2018 Window Sampling Program.

\(^\wedge\) Borehole relocated based on proximity to 2012 Geotechnical Investigation Program (SNC, 2012).

\(^1\) Diamond drilling using a helicopter-portable drill rig (core sampling).

\(^2\) Diamond drilling using a MARL Technologies A/R 80 dual auger/rotary combo drill with a 98 mm hole diameter (core sampling).

\(^3\) Auger drilling using a MARL Technologies A/R 80 dual auger/rotary combo drill with a 152 mm hole diameter (CRREL core sampling).
### Table B: Proposed Testpits along ASR Alignment (Tetra Tech, 2018)

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### Table C: Proposed Allnorth Testpits at Borrow Pit Locations (Tetra Tech, 2018)

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<td>Expect silts/clay. Material to construct subgrade material.</td>
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<td>Aggregate and sands.</td>
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<td>Aggregate. Exposed bedrock on surface, possible borehole.</td>
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<td>BP47B</td>
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<td>Aggregate. Expect excellent source to be shallow and easy to obtain. A dry stream fan. Only accessible in winter with ice bridge</td>
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<tr>
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<td>ROCK QUARRY, CORING REQUIRED, ONLY CONSIDER IF BP 47A NOT PROBABLE. Only accessible in winter with ice bridge</td>
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### Table D: Proposed Boreholes for Refined 2019 Investigation Program (Tetra Tech, 2019)

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Table D: Proposed Boreholes for Refined 2019 Investigation Program (Tetra Tech, 2019)

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</tbody>
</table>

* Borehole added at watercourse crossing location.

<sup>1</sup> Diamond drilling using a helicopter-portable drill rig (core sampling).

<sup>2</sup> Diamond drilling using a MARL Technologies A/R 80 dual auger/rotary combo drill with a 98 mm hole diameter (core sampling).

<sup>3</sup> Auger drilling using a MARL Technologies A/R 80 dual auger/rotary combo drill with a 152 mm hole diameter (CRREL core sampling).
FIGURES

Figure 1  Project Location
Figures 2-28  Modified Terrain Stability Maps showing 2018 Window Sampler Hole Locations and Refined Proposed Investigation Program
Figure 3
As-Built Window Sampler Hole (August 2018)
BH1 Proposed Borehole (Winter 2019 Program)
TP1 Proposed Testpit (Winter 2019 Program)
Proposed Geophysical Line (Winter 2019 Program)
Proposed Geophysical Special Investigation
Potential Borrow Pit (AllNorth, May 2018)
Potential Borrow Pit Access Road (AllNorth, May 2018)
Terrain Boundary
Potential Unstable Terrain
Unstable Terrain
Landslide Failure Scarp Large (1949)
Landslide Failure Scarp Large (1994)
Landslide Head Scarp Large (2012)
Landslide Head Scarp Large (1949)
Landslide Head Scarp Large (1982)
River Position (Post-1994)
Contour (40 m)
Watercourse
Waterbody
Slope Stability Class
Ground-based Observation
Airborne Observation
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NOTES

Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Figure 4

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and
As-Built 2018 Window Sampler Hole Locations
and Revised Proposed Winter Program

PROJECCT

STATUS

ENG.EARC03130-01

December 2018

SCALE

SMC

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Figure 8

NOTES.Title block based on data from Natural Resources Canada 2018, 1:20,000

Base data source: CanVec, GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

Notes:
- Potential Borrow Pit (AllNorth, May 2018)
- Potential Borrow Pit Access Road (AllNorth, May 2018)
- Prairie Creek Access Road (July 2018)
- Winter Road Alignment (Feb 2013)
- Terrain Boundary
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Permafrost Monitoring
- Proposed Geophysical Special Investigation
- Potential Borehole (AllNorth, May 2018)
- Potential Borehole Footings (AllNorth, May 2018)

Legend:
- Potential Borehole (August 2018)
- BH1 Proposed Borehole (Winter 2019 Program)
- TP1 Proposed Testpit (Winter 2019 Program)
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Geophysical Special Investigation
- Terrain Boundary
- Field Site
- Proposed Geophysical Special Investigation
- Potential Borehole Footings (AllNorth, May 2018)
- Potential Borehole (AllNorth, May 2018)
- Prairie Creek Access Road (July 2018)
- Winter Road Alignment (Feb 2013)
- Terrain Mapping Boundary (Former 1 km Buffer)

Terrain Stability Class:
- Potentially Unstable Terrain
- Unstable Terrain

Geology:
- Gully
- Possible Sinkhole or Kettle
- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1994)
- Landslide Head Scarp Large (1949)
- Slide Block (1949)
- River Position (1949)
- Contour (40 m)
- Watercourse
- Waterbody
- Field Site
- Ground-based Observation
- Airborne Observation

TFSA

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

Project Title: EARC03130-01_Terrain_KP0-182_20181108.mxd
Modified by Megan Verburg 12/21/2018

Figure 8
Figure 11

NOTES

Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

MODIFIED VIEW OF SLOPE MAP - 1994

- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1994)
- Landslide Failure Scar Large (2012)
- Landslide Head Scarp Large (1994)
- Slide Block (1994)
- Contour (40 m)
- Waterbody
- Waterline

LEGEND

As-Built Window Sampler Hole (August 2018)
BH1 Proposed Borehole (Winter 2019 Program)
TP1 Proposed Testpit (Winter 2019 Program)
Proposed Geophysical Line (Winter 2019 Program)
Proposed Permafrost Monitoring
Proposed Geophysical Special Investigation
Prairie Creek Access Road (July 2018)
Winter Road Alignment (Fall 2013)
Terrain Mapping Boundary (Former 1 km Buffer)

SITE

Ground-based Observation
Airborne Observation
TFSA
Potential Borrow Pit (AllNorth, May 2018)
Potential Borrow Pit Access Road (AllNorth, May 2018)
Terrain Boundary

SLOPE STABILITY CLASS

Potentially Unstable Terrain
Unstable Terrain

GEOLOGY

Gully
Possible Sinkhole or Kettle

PROPOSED ACTIVITIES

Potential Borrow Pit (AllNorth, May 2018)
Potential Borrow Pit Access Road (AllNorth, May 2018)

INDEX MAP

PROJECTION

NAD83
UTM Zone 10

SCALE

1:20,000

NOTES

Surficial Geology based on Hawes, 1980 and 1981
CONTENT FOR USE

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and
As-Built 2018 Window Sampler Hole Locations
and Revised Proposed Winter Program

Figure 11
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program
Figure 13

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

PRAIRIE CREEK ALL-SEASON ROAD

LEGEND

- As-Built Window Sampler Hole (August 2018)
- BH1 Proposed Borehole (Winter 2019 Program)
- TP1 Proposed Testpit (Winter 2019 Program)
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Permafrost Monitoring
- Proposed Geophysical Special Investigation
- Prairie Creek Access Road (July 2018)
- Winter Road Allignment (Feb 2013)
- Terrain Mapping Boundary (Former 1 km Buffer)

Site
- Ground-based Observation
- Airborne Observation
- TFSA

- Potential Borrow Pit (AllNorth, May 2018)
- Potential Borrow Pit Access Road (AllNorth, May 2018)
- Terrain Boundary

Slope Stability Class
- Potentially Unstable Terrain
- Unstable Terrain
- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1994)
- Landslide Head Scarp Large (1949)
- Landslide Head Scarp Large (1994)
- Contour (40 m)
- Watercourse
- Waterbody

Data Source
- Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

References
- Survey by Graham, Brewing, Stoffler, UTSAG (surveyed) 1980 and 1981
- ESRI World Shaded Relief

Scale: 1:20,000

NOTES
- Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

References
- Survey by Graham, Brewing, Stoffler, UTSAG (surveyed) 1980 and 1981
- ESRI World Shaded Relief

Scale: 1:20,000

NOTES
- Base data source: CanVec; GeoBase.
Figure 14

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

LEGEND

As-Built Window Sampler Hole (August 2018)
BH1 Proposed Borehole (Winter 2019 Program)
TP1 Proposed Testpit (Winter 2019 Program)
Proposed Geophysical Line (Winter 2019 Program)
Proposed Permafrost Monitoring
Proposed Geophysical Special Investigation
Prairie Creek Access Road (July 2018)
Winter Road Alignment (Feb 2013)
Terrain Mapping Boundary (Former 1 km Buffer)

Site
Ground-based Observation
Airborne Observation
TFSA

Potential Borehole (AllNorth, May 2018)
Potential Borehole Access Road (AllNorth, May 2018)

Terrain Boundary

Slope Stability Class
Potentially Unstable Terrain
Unstable Terrain

Geology
Thermokarst Terrain
Landslide Failure Scar Large (1949)
Landslide Failure Scar Large (1994)
Landslide Head Scarp Large (1949)
Landslide Head Scarp Large (1994)
Side Block (1949)
River Position (1949)
River Position (1994)
River Position (Post-1994)
Tension Crack (1949)
Contour (40 m)

Waterbody

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

PRAIRIE CREEK ALL-SEASON ROAD

December 2018
Figure 16

There is a legend on the map that provides a key to the symbols used in the map. The legend includes various annotations and symbols such as:

- As-Built Window Sampler Hole (August 2018)
- BH1 Proposed Borehole (Winter 2019 Program)
- TP1 Proposed Testpit (Winter 2019 Program)
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Permafrost Monitoring
- Proposed Geophysical Special Investigation
- Prairie Creek Access Road (July 2018)
- Winter Road Alignment (Feb 2013)
- Terrain Mapping Boundary (Former 1 km Buffer)
- Field Site
- Ground-based Observation
- Airborne Observation
- TFSA
- Potential Borrow Pit (AllNorth, May 2018)
- Potential Borrow Pit Access Road (AllNorth, May 2018)
- Terrain Boundary

The map also includes annotations for different features such as:

- Thermokarst Terrain
- Landslide Failure Scar Large (1949)
- Landslide Failure Scar Large (1962)
- Landslide Failure Scar Large (1994)
- Landslide Failure Scar Large (2012)
- Landslide Head Scarp Large (1949)
- Landslide Head Scarp Large (1962)
- Landslide Head Scarp Large (1994)
- Slide Block (1949)
- Slide Block (1962)
- Slide Block (1994)
- Contour (40 m)
- Watercourse
- Waterbody

The map is labeled with various points and lines, indicating the boundaries and features of the area. The map also includes a scale of 1:20,000.
Figure 17

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

LEGEND

- As-Built Window Sampler Hole (August 2018)
- BH1 Proposed Borehole (Winter 2019 Program)
- TPI Proposed Testpit (Winter 2019 Program)
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Geophysical Special Investigation
- Prairie Creek Access Road (July 2018)
- Winter Road Alignment (Fall 2013)
- Terrain Mapping Boundary (Former 1 km Buffer)

Site
- Ground-based Observation
- Airborne Observation
- TFSA

Potential Borrow Pit (AllNorth, May 2018)
- Potential Borrow Pit Access Road (AllNorth, May 2018)

Terrain Boundary
- Pavement Unstable Terrain
- Unstable Terrain

Geology
- Gully
- Meltwater channel (major)
- Meltwater channel (minor)
- Landslide Failure Scar Large (1962)
- Landslide Failure Scar Large (1994)
- Landslide Head Scarp Large (1962)
- Slide Block (1962)
- Slide Block (1994)
- Contour (40 m)
- Watercourse
- Waterbody

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

UFOCS 2018-01
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

PRAIRIE CREEK ALL-SEASON ROAD

December 2018

ENG.09.0213.03.01
Figure 20

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981
Meltwater channel (major)
Thermokarst Terrain
Contour (40 m)
Watercourse
Waterbody

LEGEND
As-Built Window Sampler Hole (August 2018)
BH1 Proposed Borehole (Winter 2019 Program)
TP1 Proposed Testpit (Winter 2019 Program)
Proposed Geophysical Line (Winter 2019 Program)
Proposed Permafrost Monitoring
Proposed Geophysical Special Investigation
Prairie Creek Access Road (July 2018)
Winter Road Alignment (Feb 2013)
Terrain Mapping Boundary (Former 1 km Buffer)

SITE
- Ground-based Observation
- Airborne Observation
- TFSA
- Potential Borehole (AllNorth, May 2018)
- Potential Borehole Access Road (AllNorth, May 2018)
- Terrain Boundary

Slope Stability Class
- Potentially Unstable Terrain
- Unstable Terrain

Geology
- Gully
- Meltwater channel (major)
- Thermokarst Terrain
- Contour (40 m)
- Watercourse

PRAIRIE CREEK ALL-SEASON ROAD
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

STATUS
SMC
EARC03130-01_Terrain_KP0-182_20181108.mxd
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

PROJECT
ENG.EARC03130-01
December 2018

SCALE
1:20,000

MEASUREMENTS

PROJ. NO.
ENG.EARC03130-01
ISSUED FOR USE

FILE NO.
EARC03130-01_Terrain_KP0-182_20181108.mxd

CLIENT
TETRA TECH
Figure 23

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

PROJECTION
NAD83
UTM Zone 10

SCALE
1:20,000

STATUS
SMC
EARC03130-01_Terrain_KP0-182_20181108.mxd
Modified Terrain Stability Mapping and
As-Built 2018 Window Sampler Hole Locations
and Revised Proposed Winter Program

Scale: 1:20,000

Figure 23
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

NOTES


LEGEND

As-Built Window Sampler Hole (August 2018)
BH1 Proposed Borehole (Winter 2019 Program)
TP1 Proposed Testpit (Winter 2019 Program)
Proposed Geophysical Line (Winter 2019 Program)
Proposed Geophysical Special Investigation
Prairie Creek Access Road (July 2018)
Winter Road Alignment (Feb 2013)
Terrain Mapping Boundary (Former 1 km Buffer)

Site
Ground-based Observation
Airborne Observation
TFSA

Potential Borrow Pit (AllNorth, May 2018)
Potential Borrow Pit Access Road (AllNorth, May 2018)
Terrain Boundary

Slope Stability Class
Potentially Unstable Terrain
Unstable Terrain

Geography
Gully
Landslide Failure Scar Large (1949)
Landslide Failure Scar Large (2012)
Landslide Head Scarp Large (1949)
River Position (1949)
River Position (Post-1994)
Tension Crack (1949)
Contour (40 m)
Watercourse
Waterbody
Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

NOTES
Base data source: CanVec; GeoBase.
Surficial Geology based on Hawes, 1980 and 1981

PROJECT
URM Zone 10

Scale: 1:20,000

PRAIRIE CREEK ALL-SEASON ROAD

TERMINOLOGY

LEGEND
- As-Built Window Sampler Hole (August 2018)
- BH1 Proposed Borehole (Winter 2019 Program)
- TP1 Proposed Testpit (Winter 2019 Program)
- Proposed Geophysical Line (Winter 2019 Program)
- Proposed Permafrost Monitoring
- Proposed Geophysical Special Investigation
- Prairie Creek Access Road (July 2018)
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- Proposed Geophysical Line (Winter 2019 Program)
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- Potential Borrow Pit (AllNorth, May 2018)
- Potential Borrow Pit Access Road (AllNorth, May 2018)
- Terrain Boundary
- Slope Stability Class
- Potentially Unstable Terrain
- Unstable Terrain
- Geology
- Escarpment
- River Position (1949)
- River Position (Post-1994)
- Contour (40 m)
- Watercourse
- Waterbody

FIELD SITE
- Ground-based Observation
- Airborne Observation
- TFSA

PRODUCTION
Tetra Tech

Project NO.
ENG AREC 1310 01

DATE
December 2018

FILE NO.
45642039-01_Terrain_KP0-182_20181108.pdf

Page 25
Figure 26

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

SCALE: 1:20,000

Client: CANADIAN ZINC CORPORATION

DATE MODIFIED: December 2018

NOTES
Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

400 Metres

Legend

As-Built Window Sampler Hole (August 2018)

BH1 Proposed Borehole (Winter 2019 Program)

TP1 Proposed Testpit (Winter 2019 Program)

Proposed Geophysical Line (Winter 2019 Program)

Proposed Permafrost Monitoring

Proposed Geophysical Special Investigation

Prairie Creek Access Road (July 2018)

Winter Road Alignment (Feb 2013)

Terrain Mapping Boundary (Former 1 km Buffer)

Site

Ground-based Observation

Airborne Observation

Potential Borehole Pit (AllNorth, May 2018)

Potential Borehole Access Road (AllNorth, May 2018)

Terrain Boundary

Slope Stability Class

Potentially Unstable Terrain

Unstable Terrain

Geology

Escarpment

River Position (1949)

River Position (Post-1994)

Contour (40 m)

Watercourse

Waterbody

NOTES

Watercourse: Calculated groundwater.

Surface Geology based on Hawes, 1980 and 1981

POINT FOR USE
Figure 27

NOTES
Base data source: CanVec; GeoBase.

Surficial Geology based on Hawes, 1980 and 1981

Scale: 1:20,000

STATUS
SMC
EARC03130-01_Terrain_KP0-182_20181108.mxd

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

PRAIRIE CREEK ALL-SEASON ROAD
Figure 28

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

PROJECT TITLE: Modified Terrain Stability Mapping and As-Built 2018 Window Sampler Hole Locations and Revised Proposed Winter Program

CLIENT: PRARIE CREEK ALL-SEASON ROAD

DATE: December 2018

SCALE: 1:20,000

NOTES:
- Base data source: CanVec; GeoBase.
- Surficial Geology based on Hawes, 1980 and 1981

Slope Stability Class
- Potentially Unstable Terrain
- Unstable Terrain
- Contour (40 m)
- Watercourse
- River Position (1946)
- Waterbody

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<td>Photo 6</td>
<td>Sample Hole BH49.1</td>
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<td>Photo 7</td>
<td>Sample Hole BH50</td>
</tr>
</tbody>
</table>
Hand Portable Impact Percussion Hammer Window Sampler

Sample Hole BH11.1; Nbn at Depth: 2.00 m – 2.40 m
Sample Hole BH15; Nbn at Depth: 3.54 m – 3.70 m

Sample Hole BH33; Vs 27% at Depth: 0.39 m – 1.00 m
Photo 5: Sample Hole BH96.6; Vx 1%-3% at Depth: 2.00 m – 2.30 m

Photo 6: Sample Hole BH49.1; Ice Lens at Depth: 0.96 – 1.00 m
Sample Hole BH50; Vx 1%-3% at Depth: 0.54 – 0.72 m
APPENDIX A

TETRA TECH’S LIMITATIONS ON USE OF THIS DOCUMENT
LIMITATIONS ON USE OF THIS DOCUMENT

GEOTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the “Professional Document”).

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Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.
1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant that the conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

1.9 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.10 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.11 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.12 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.13 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.
APPENDIX B

WINDOW SAMPLING LOGS
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>Elevation (m)</th>
</tr>
</thead>
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<td>789</td>
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<tr>
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<td>785</td>
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</tbody>
</table>

**Lithological Description**

- **MOSS** - fibrous peat, brown, (100 mm thick)
- **SILT** - rootlets, light grey, (50 mm thick)
- **SAND** - uniformly graded, orange
  - trace silt, brown

**END OF BOREHOLE** (4.00 metres)

Note: Young spruce and willow, light moss and shrub cover, 6° slope facing east
Borehole No: BH11.1

**Project:** Summer 2018 Geotechnical Investigation  
**Location:** Prairie Creek, Northwest Territories  
**Ground Elev:** 757 m  
**UTM:** 437988 E; 6829921 N; Z 10

---

**Lithological Description**

- No recovery
- **PEAT - fibrous moss,** (150 mm thick)
- **SAND - trace silt,** roots disseminated throughout, brown, (110 mm thick)
- **ORGANICS - roots,** black, (50 mm thick)
- **SAND - trace silt,** brown
  - trace gravel, angular and flat gravel to 10 mm diameter
  - gravelly, trace clay, angular and rounded gravel to 40 mm diameter

**Ground Ice Description**

- **Nbn, solid frozen core**

**Window Sampler**

- **No recovery**
- **R1**
- **R2**
- **S1**
- **S2**

**END OF BOREHOLE** (2.40 metres)

- **SBTS #3** installed to 1.5 metres, as far as possible.
- **Reading Aug. 28, -30° C**
- **Note:** Stopped due to refusal
- Young vegetation recent fire, side of drainage area, gentle slope north, mossy and grass ground cover

---

**Method**

- **Type:** Handheld Cobra Pro Window Sampler

**Logged By:** RO  
**Reviewed By:** VR

---

**Depth (m)**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
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<tbody>
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<td></td>
<td>Plastic Limit</td>
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</tr>
</tbody>
</table>

**Elevation (m)**

- 757
- 756
- 755
- 754
- 753
- 752
- 751
- 750

**Sample Number**

- R1
- R2
- S1
- S2

---

**Contractor:** Tetra Tech Canada  
**Completion Depth:** 2.4 m

**Drilling Rig Type:** Handheld Cobra Pro Window Sampler  
**Start Date:** 2018 August 27

**Logged By:** RO  
**Completion Date:** 2018 August 27

**Reviewed By:** VR  
**Page 1 of 1**
Lithological Description

No recovery

PEAT - moss, rootlets, fibrous, dark brown
  - organics, amorphous, black

SAND - gravelly, trace silt, trace clay, very wet, brown, subangular gravel to 30 mm diameter
  - trace silt, rounded gravel to 40 mm diameter
  - angular flat gravel to 30 mm diameter

END OF BOREHOLE (2.70 metres)
Note: Stopped due to refusal
Sparse black spruce, level, thick muskeg ground cover, highwater table

Contractor: Tetra Tech Canada
Completion Depth: 2.7 m
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Start Date: 2018 August 28
Logged By: RO
Completion Date: 2018 August 28
Reviewed By: VR
Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories

Borehole No: BH137.1

Lithological Description

Method

Window Sampler

Depth (m) 1 2 3 4 5 6 7

No recovery

ORGANICS - moss, rootlets, trace organic matter, soft, almost black, (200 mm thick)

SAND AND SILT - trace gravel, excess water, brown, subrounded gravel to 10 mm diameter

- 140 mm thick organic layer - crumbly, black
- trace clay

CLAY - sandy, some silt, some gravel, firm, medium plastic, grey

SAND - some silt and gravel, light brown, subangular gravel to 40 mm diameter

CLAY - trace silt and sand, very firm, medium plastic, grey

SAND - some silt, trace gravel, light brown
- subrounded cobble

END OF BOREHOLE (3.00 metres)
Note: Rod bolt sheared, core barrel lost down hole.
Medium dense black spruce and brush, near stream, muskeg, moss cover, level

Sample Type

Sample Number

Plastic Limit

Moisture Content

Liquid Limit

Recovery (%)

Sample Moisture Content

Plastic Limit

Liquid Limit

Elevation (m) 511 512 513 514 515 516 517 518

Contractor: Tetra Tech Canada
Completion Depth: 3 m
Start Date: 2018 August 16
Logged By: RO
Completion Date: 2018 August 16
Reviewed By: VR
Borehole No: BH15

Project: Summer 2018 Geotechnical Investigation
Project No: ENG.EARC03130-01
Location: Prairie Creek, Northwest Territories
Ground Elev: 735 m
UTM: 441175 E; 6830896 N; Z 10

Method
- Window Sampler

Lithological Description
- No recovery
- PEAT - rootlets, fibrous, brown, (80 mm thick)
- SILT - light brown to brown, (200 mm thick)
- GRAVEL AND SILT - trace sand, possible cobble region, coarse angular grave to 50 mm diameter
- SAND - trace silt, trace clay, brown

Ground Ice Description
- END OF BOREHOLE (3.70 metres)
- Note: Stopped due to refusal
- Gentle slope, recent fire, scattered black spruce light moss cover

Contractor: Tetra Tech Canada
Completion Depth: 3.7 m
Start Date: 2018 August 28
Logged By: RO
Completion Date: 2018 August 28
Reviewed By: VR
Lithological Description

No recovery

PEAT - fibrous, brown, (200 mm thick)

ORGANICS - silty, trace clay and gravel, rootlets throughout, soft, black, angular gravel to 20 mm diameter

SILT - clayey, very soft, medium plastic, grey

GRAVEL - sandy, trace silt, trace clay, flakey gravel shale material, grey, weathered bedrock?

END OF BOREHOLE (1.60 metres)

Note: Stopped due to auger refusal

West facing slope, 8°, grassy ground cover, sparse black spruce

Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR
Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Project No: ENG.EARC03130-01
Ground Elev: 823 m
UTM: 442271 E; 6828925 N; Z 10
Completion Depth: 1.6 m
Start Date: 2018 August 30
Completion Date: 2018 August 30
Lithological Description

Sample Type | Sample Number | Moisture Content (%) | Plastic Limit | Moisture Content | Liquid Limit | Recovery (%)
--- | --- | --- | --- | --- | --- | ---
MOSS - fibrous peat, brown, (50 mm thick) | R1 S1 | 6.9 | 20 | 40 | 60 | 80 | 100
SILT - rootlets throughout, light brown (80 mm thick) | | | | | | |
SAND - gravelly, trace clay, trace silt, fades from brown to dark brown, angular gravel up to 20 mm diameter | | | | | | |
- dark brown to grey | | | | | | |
SAND - some clay, trace silt | R2 S2 | 6.9 | 20 | 40 | 60 | 80 | 100
GRAVEL AND SAND - trace silt, trace clay, very firm, angular and flat gravel to 30 mm diameter | R3 S3 | 6.9 | 20 | 40 | 60 | 80 | 100
END OF BOREHOLE (4.00 metres) | | | | | | |
Note: Stopped due to refusal
Recent fire within the decade through area, young vegetation, young spruce, mossy cover, level terrain near sinkhole area or possible kettle

Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Ground Elev: 887 m
UTM: 443580 E; 6828387 N; Z 10

Project No: ENG.EARC03130-01
Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR
Completion Depth: 4 m
Start Date: 2018 August 27
Completion Date: 2018 August 27
Window Sampler

Lithological Description

Moss - organics, (130 mm thick)
Topsoil - silty, organics, black, (260 mm thick)
Silt - some sand, trace clay, grey

END OF BOREHOLE (1.45 metres)
Note: Could not continue, too solid

Dense black spruce, thick moss cover, flat ground

Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR

Project No: ENG.EARC03130-01
Ground Elev: 246 m
UTM: 465138 E; 6813836 N; Z 10

Borehole No: BH33
Completion Depth: 1.45 m
Start Date: 2018 August 21
Completion Date: 2018 August 21

Recovery (%)
40 60 80 100

Sample Number
20 40 60 80

Moisture Content (%)
Moisture Content
Plastic Limit
Liquid Limit
Sample Type
R R1 S1 R1

Ground Ice Description
Clear ice, Vs 27%

Sample Type

Plastic Moisture Limit Content Limit

Recovery (%)
No recovery

PEAT - rootlets, fibrous, (100 mm thick)

GRAVEL AND CLAY - some sand, trace silt, brown, angular to subangular gravel to 40 mm diameter
- trace clay, firm, low plastic

CLAY - silty, sandy, some gravel, firm, medium plastic, grey

END OF BOREHOLE (1.90 metres)
Note: Stopped due to gravel
- 12° slope, grass, mossy cover, mix of aspen, pine and spruce
Lithological Description

Depth (m) | Sample Type | Sample Number | Recovery (%) | Elevation (m) |
---|---|---|---|---|
0 | R1S1 | | | 567 |

**PEAT** - leafy ground matter, fibrous, brown, (80 mm thick)

**SILT** - rootlets disseminated throughout, light brown, (70 mm thick)

**GRAVEL AND CLAY** - some sand, some silt, trace rootlets, poorly graded, light brown, angular gravel to 20 mm diameter

**END OF BOREHOLE** (0.70 metres)
Note: Barrel stuck on gravel, could not advance
Medium density aspen, leafy ground cover on top of small ridge just west of wolverine pass
Borehole No: BH38

Lithological Description

Method

Window Sampler

Depth (m)

0

PEAT - fibrous, dark brown, (150 mm thick)

SILT - trace clay, rootlets disseminated throughout, light brown

GRAVEL AND CLAY - sandy, trace silt, brownish grey, angular gravel to 50 mm diameter

END OF BOREHOLE (1.26 metres)

Note: Stopped due to gravel
Dense aspen, dispersed pine, leafy ground, on top of small ridge, close to wolverine pass

Contractor: Tetra Tech Canada
Completion Depth: 1.26 m

Drilling Rig Type: Handheld Cobra Pro Window Sampler
Start Date: 2018 August 20

Logged By: RO
Completion Date: 2018 August 20

Reviewed By: VR
Page 1 of 1

ROCK CORE ENG.EARC03130-01.GPJ EBA.GDT 18/11/9
Lithological Description

- MOSS - fibrous peat, brown, (80 mm thick)
- SILT - trace clay, soft, dark grey
- CLAY - sandy, trace gravel, trace silt, firm, medium plastic, grey, angular gravel to 50 mm diameter
  - some silt, very firm, low plastic, grey brown, subangular grave to 50 mm diameter
  - some sand

END OF BOREHOLE (2.90 metres)
Note: Too firm to continue
Gentle slope, moss and grass ground cover, thin, small black spruce, uneven clumpy terrain
Borehole No: BH43.1

Lithological Description

1. ORGANICS - moss, silty, dark brown, (200 mm thick)
2. PEAT - fibrous, fairly dry, (50 mm thick)
3. SILT - some clay, firm, light brown
4. SAND - gravelly, some clay, trace silt, compact, dark brown, angular gravel to 40 mm diameter
   - clean, uniformly graded
   - gravelly, some clay, trace silt, brown, subrounded gravel to 20 mm diameter

Note: Stopped due to gravel

END OF BOREHOLE (1.55 metres)

Black spruce, gentle slope, moss ground cover, 15 m off cutline
MOSS - organics, (100 mm thick)
PEAT - silty, rootlets, fibrous, dry, light brown, (50 mm thick)
SILT - some gravel, trace sand, rootlets disseminated throughout
   - some gravel, fairly dry, light brown, subrounded gravel to 40 mm diameter
SAND - gravelly, trace silt, fairly dry, dark brown, angular planar gravel to 40 mm long

END OF BOREHOLE (0.71 metres)
Note: Stuck possible gravel zone, try confirmation hole 3 m north
   On level ridge top, 30° ridge slope, dense spruce, moss ground cover, scattered aspen
Borehole No: BH43.2 Conf.

Project: Summer 2018 Geotechnical Investigation
Project No: ENG.EARC03130-01
Location: Prairie Creek, Northwest Territories
Contractor: Tetra Tech Canada
Ground Elev: 489 m
UTM: 473242 E; 6805478 N; Z 10

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Lithological Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>MOSS - fibrous ground cover, (90 mm thick)</td>
</tr>
<tr>
<td></td>
<td>SILT - trace sand and gravel, trace clay, light brown, subangular gravel to 10 mm diameter</td>
</tr>
<tr>
<td></td>
<td>SAND - gravel, some clay, trace silt, brown to grey oxidized rock inclusions, appears to be highly weathered bedrock, angular to subangular gravel to 50 mm diameter</td>
</tr>
<tr>
<td></td>
<td>END OF BOREHOLE (0.72 metres)</td>
</tr>
<tr>
<td></td>
<td>Note: Stopped due to gravel</td>
</tr>
</tbody>
</table>

Sample Type | Sample Number | Recovery (%) | Elevation (m) |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>S1</td>
<td>40</td>
<td>489</td>
</tr>
</tbody>
</table>

Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR
Completion Date: 2018 August 18
Page 1 of 1
**Borehole No: BH49.1**

**Project:** Summer 2018 Geotechnical Investigation  
**Location:** Prairie Creek, Northwest Territories

**Contractor:** Tetra Tech Canada  
**Drilling Rig Type:** Handheld Cobra Pro Window Sampler  
**Logged By:** RO  
**Reviewed By:** VR  
**Completion Date:** 2018 August 17

---

### Lithological Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>No recovery</td>
</tr>
<tr>
<td>0.5</td>
<td>Window Sampler</td>
<td>ORGANICS - silty, rotten wet grass and moss, (60 mm thick)</td>
</tr>
<tr>
<td>0.6</td>
<td>Window Sampler</td>
<td>SAND - some silt, trace clay, organics, grass and roots disseminated throughout, very wet, brownish grey</td>
</tr>
<tr>
<td>0.7</td>
<td>Window Sampler</td>
<td>- trace rootlets</td>
</tr>
<tr>
<td>2.6</td>
<td>Window Sampler</td>
<td>gravelly, some clay, subrounded gravel to 50 mm diameter</td>
</tr>
<tr>
<td>3.0</td>
<td>Window Sampler</td>
<td>- 60 mm thick moss inclusions, organic, fibrous peat</td>
</tr>
<tr>
<td>3.1</td>
<td>Window Sampler</td>
<td>- trace silt</td>
</tr>
<tr>
<td>3.2</td>
<td>Window Sampler</td>
<td>- 90 mm thick peat layer - organics, amorphous, black to brown</td>
</tr>
<tr>
<td>3.4</td>
<td>Window Sampler</td>
<td>- trace gravel, rounded gravel to 40 mm diameter</td>
</tr>
<tr>
<td>3.5</td>
<td>Window Sampler</td>
<td>- gravel &lt; 10 mm</td>
</tr>
<tr>
<td>7.0</td>
<td>Window Sampler</td>
<td>some gravel</td>
</tr>
<tr>
<td>7.5</td>
<td>Window Sampler</td>
<td>END OF BOREHOLE (3.60 metres) SBTS #6 installed to 1.00 metre. Initial reading: 0.03° C</td>
</tr>
</tbody>
</table>

Note: Flat, grassy bog land, no trees, wet near cobble bedded stream coming through pass, grass and moss.

---

### Ground Ice Description

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
<th>Plastic Limit</th>
<th>Moisture Content</th>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>S1</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>S2</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Contractor:** Tetra Tech Canada  
**Completion Depth:** 3.6 m  
**Start Date:** 2018 August 17  
**Logged By:** RO  
**Reviewed By:** VR  
**Page 1 of 1**
Lithological Description

No recovery

ORGANICS - silty, sandy, roots, organics, rootlets throughout, (200 mm thick)

SAND - some silt, trace clay, rootlets disseminated throughout, grey

SILT - trace clay, soft, low plastic, grey

SAND - some silt, grey

- trace silt and gravel, rounded gravel to 10 mm diameter

SAND AND GRAVEL - trace silt, light brown grey, subrounded gravel to 40 mm diameter

END OF BOREHOLE (3.50 metres)

Note: Stopped due to refusal

Flat, grassy terrain, dry, short brush and small stunted spruce
**Lithological Description**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Method</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Window Sampler</td>
<td>R1 S1</td>
<td>46.7</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>R2 S2</td>
<td>11.8</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>R3 S3</td>
<td>10.6</td>
</tr>
</tbody>
</table>

**Ground Ice Description**

- No recovery
- MUSKEG - organics, (50 mm thick)
- PEAT - fine fibrous, black
- ORGANICS - silty, some gravel, trace sand, wet, dark black - trace clay, plastic
- SILT AND SAND - some gravel, trace clay, grey, subrounded gravel to 30 mm diameter
- SAND - gravelly, some clay, some silt, very wet, light brown, angular gravel
- SILT - clayey, some sand, trace gravel, dark brown
- GRAVEL borderline SAND - clayey, some silt, firm, low plastic, grey, rounded gravel to 30 mm diameter

**End of Borehole** (3.00 metres)

Note: Clay got too firm, would not advance
Thin trees, small black spruce, moss and muskeg, boggy, gentle slope
SBTS #7 installed at 0.6 metres below ground level, reading was not recovered
Lithological Description

**PEAT** - rootlets, fibrous, dark brown, (130 mm thick)

**TOPSOIL** - organics, sandy, rootlets, black, (160 mm thick)

**SILT** - some sand and gravel, trace clay, damp, light brown, subrounded gravel

**END OF BOREHOLE** (0.75 metres)

Note: Sampler bottomed out on gravel, cobble stuck in knife, confirmation hole 3 m away.
Just inside spruce growth, medium density, mix of moss and leaf cover from brush, gentle slope.

**Method**

- *Window Sampler*

**Project**

- Summer 2018 Geotechnical Investigation

**Location**

- Prairie Creek, Northwest Territories

**Ground Elev**

- 643 m

**UTM**

- 482426 E; 6793845 N; Z 10

**Project No**

- ENG.EARC03130-01

**Completion Depth**

- 0.75 m

**Start Date**

- 2018 August 16

**Completion Date**

- 2018 August 16

**Contractor**

- Tetra Tech Canada

**Drilling Rig Type**

- Handheld Cobra Pro Window Sampler

**Logged By**

- RO

**Reviewed By**

- VR

**Page**

- 1 of 1
Borehole No: BH51.2

Lithological Description

Depth (m) | Method | Sample Type | Sample Number | Recovery (%) | Elevation (m)
---|---|---|---|---|---
0 | No recovery - rock stuck in knife but still hammered down without recovery | | | |
1 | | | |
2 | PEAT - rootlets, fibrous, dark brown | | |
3 | - silty, damp, light grey | | |
4 | SILT - trace sand and gravel, damp, loose, light brown | | |
5 | - some clay, low plastic, brown, small cobble in knife, angular to subrounded gravel | | |
6 | SAND - trace silt, trace gravel, trace clay, subrounded gravel to 30 mm diameter | | |
7 | END OF BOREHOLE (2.38 metres) | | |
Note: Stopped due to refusal
Just inside spruce growth, medium density, mix of moss and leaf cover from brush, gentle slope

Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR
Completion Date: 2018 August 16

Image: ROCK CORE ENG.EARC03130-01.GPJ EBA.GDT 18/11/9
**Borehole No: BH54**

**Project: Summer 2018 Geotechnical Investigation**
**Project No: ENG.EARC03130-01**

**Location:**
**Ground Elev: 522 m**
**Prairie Creek, Northwest Territories**
**UTM: 486269 E; 6787498 N; Z 10**

---

**Lithological Description**

**Method**

**Depth (m)**

**Sample Type**

**Sample Number**

**Moisture Content (%)**

**Plastic Limit**

**Liquid Limit**

**Recovery (%)**

- **PEAT** - rootlets, plant matter, amorphous, (50 mm thick)
- **SAND** - clayey, trace silt, trace gravel, light brown, bright red silt inclusions to 5 mm diameter, gravel to 7 mm diameter
- some gravel, subangular to subrounded gravel to 20 mm diameter
- very wet

**END OF BOREHOLE (2.85 metres)**

Note: Stopped due to hard soil
Moderate trees, spruce and aspen, leafy ground cover, gentle slope, dense brush

**Window Sampler**

**Contractor:** Tetra Tech Canada
**Completion Depth:** 2.85 m

**Drilling Rig Type:** Handheld Cobra Pro Window Sampler
**Start Date:** 2018 August 15

**Logged By:** RO
**Completion Date:** 2018 August 15

**Reviewed By:** VR
**Page 1 of 1**
**Lithological Description**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Depth (m)</th>
<th>Elevation (m)</th>
<th>Plastic Limit</th>
<th>Moisture Content</th>
<th>Liquid Limit</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Sampler</td>
<td>R1</td>
<td>1</td>
<td>276</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>PEAT - rootlets, dead vegetation, fibrous</td>
<td>3.9</td>
<td>2</td>
<td>275</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>CLAY AND SAND - some gravel, firm, light brown to grey brown</td>
<td>3.9</td>
<td>3</td>
<td>274</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>- roots disseminated throughout for 230 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- some gravel, firm, grey, angular gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END OF BOREHOLE (1.45 metres)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note: Stopped due to refusal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6° slope, on alignment, forested aspen and thick brush, grass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Borehole No: BH61
Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Ground Elev: 181 m

Lithological Description

Sample Type | Sample Number | Moisture Content (%) | Plastic Limit | Moisture Content | Liquid Limit | Recovery (%)
--- | --- | --- | --- | --- | --- | ---
PEAT - topsoil, rootlets, dead grass, fibrous, (100 mm thick) | R1 | 24.9 | 60 | 80 | 100 | 40
- silty
CLAY - silty, some sand, low plastic | S1 | |
SILT - some clay, trace sand, roots disseminated throughout | R2 | |
- wet, grey
SAND - silty
SAND AND SILT - brown
SILT - wet, grey | R3 | |
- trace sand
END OF BOREHOLE (5.00 metres)
Note: Fairly young growth, aspen and spruce medium density, grassy cover, level, north side of Liard Crossing

Contractor: Tetra Tech Canada
Completion Depth: 5 m
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Start Date: 2018 August 12
Logged By: RO
Completion Date: 2018 August 12
Reviewed By: VR
Page 1 of 1
Borehole No: BH62

Lithological Description

Method

Depth (m)

Sample Type

Sample Number

Plastic Limit

Moisture Content

Liquid Limit

Recovery (%)

- 20
- 40
- 60
- 80
- 100

Elevation (m)

0
1
2
3
4
5
6
7
8
9
10

MOSS - grounded, (40 mm thick)
PEAT - medium rootlets, fibrous, (160 mm thick)
SILT - trace clay, grey
SAND - clayey, some silt, fine sand
- uniformly graded, light brown
SILT - clayey, trace sand, grey
SAND - some silt, some clay
SILT - sandy, clayey
SILT AND SAND
SAND - some silt

END OF BOREHOLE (5.00 metres)
Note: Pine and aspen, moderate density, tall, moss ground cover, near Liard crossing, level
Lithological Description

- No recovery
- ORGANICS - rootlets, dark brown
- CLAY borderline SILT - trace sand, low plastic, brown
- No recovery
- SILT - some sand, fine sand
- SAND
  - 100 mm thick silt layer - clay lump inclusions

END OF BOREHOLE (5.00 metres)
Note: Forested, aspen and birch, dense, on cutline, heavy grass, level
**Lithological Description**

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Recovery (%)</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>205</td>
</tr>
</tbody>
</table>

- **CLAY** - greyish brown
- **SILT** - trace clay, brown
- **SAND** - trace silt, brown
- **SAND** - trace silt, brown, very fine sand

**END OF BOREHOLE** (5.00 metres)

Note: Heavily forested, edge of cutline, mixed aspen and black spruce, grassy ground cover, level
Borehole No: BH65

Lithological Description

ORGANICS - moss, woody rootlets, compacted

CLAY - stiff, medium plastic, dark grey
- trace silt, oxidized silt inclusions
- trace sand, oxidized
- highly weathered, trace gravel and sand inclusions
SILT - trace clay and sand, grey
No recovery

SAND - some silt, grey
- uniformly graded water coming up hole during extruding
- trace silt, water rising from hole

END OF BOREHOLE (5.00 metres)
Note: Cleared area on other side of ditch along road, level, wet moss

Contractor: Tetra Tech Canada
Completion Depth: 5 m
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Start Date: 2018 August 10
Logged By: RO
Completion Date: 2018 August 10
Reviewed By: VR
Borehole No: BH66

Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories

Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR

Recovery (%)

Sample Number

Sample Type

Lithological Description

Depth (m)  Method

0  ORGANICS - moss, spongy, wet

1  TOPSOIL (ORGANIC) - small rootlets, dark brown

2  CLAY - trace silt, grey

3  SAND - trace silt, soft, grey

4  No recovery

5  SAND - trace silt, dark grey

6  No recovery

7  SAND - trace silt, dark grey

7.5  END OF BOREHOLE (5.00 metres)

Note: Just outside road allowance, thick moss mat, wet, level

Completion Depth: 5 m

Start Date: 2018 August 11
Completion Date: 2018 August 11
**Borehole No: BH67**

**Lithological Description**

- **ORGANICS** - grass, small rootlets, dark brown
- **CLAY** - silty, light brown
  - some silt
  - some sand, fine sand
  - clay lumps disseminated throughout
  - silty, trace sand, firm, brown

END OF BOREHOLE (4.00 metres)

*Note: Outside road allowance, heavy grass and vegetation, level, no trees, dry ground*
Borehole No: BH7

Lithological Description

- No recovery
- SAND - trace silt, trace clay, trace gravel, brown, subrounded to angular gravel to 20 mm diameter
- some gravel, moderately well graded, darker than above, angular gravel

END OF BOREHOLE (2.80 metres)
Note: Stopped due to broken adapter
Along road alignment, cut section, dense spruce, exposed cut bank of sand and gravel nearby
**Lithological Description**

- **Method**: Window Sampler

- **Sample Type**: Recovery (%)

- **Sample Number**: R1, R2, R3

- **Elevation (m)**
  - 259
  - 258
  - 257
  - 256
  - 255
  - 254
  - 253
  - 252
  - 251

- **Depth (m)**
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7

- **Sample Description**
  - **No recovery**
  - MOSS - fibrous peat, wet, (200 mm thick)
  - ORGANICS - black, (200 mm thick)
  - CLAY - gravelly, some sand, trace silt, wet, brown to black
    - some gravel, rounded gravel to 20 mm diameter
  - END OF BOREHOLE (2.30 metres)

- **Note**: Black spruce, medium density, thick moss cover, gentle slope

**Project Information**

- **Project**: Summer 2018 Geotechnical Investigation
- **Location**: Prairie Creek, Northwest Territories
- **Ground Elev**: 259 m
- **Contractor**: Tetra Tech Canada
- **Drilling Rig Type**: Handheld Cobra Pro Window Sampler
- **Logged By**: RO
- **Reviewed By**: VR
- **Completion Date**: 2018 August 21

**Details**

- **Start Date**: 2018 August 21
- **Completion Depth**: 2.3 m

**Recovery**

- **40**
- **60**
- **80**
- **100**
**Lithological Description**

- **No recovery**
- MOSS - amorphous peat, some rootlets, (110 mm thick)
- ORGANICS - trace rootlets, black
- CLAY - silty, some gravel, trace sand, angular gravel to 50 mm diameter
- No recovery
- ORGANICS - gravel dispersed throughout, black
- CLAY - sandy, some gravel, trace silt, firm, low to medium plastic, subrounded gravel to 40 mm diameter
  - silty, brown, gravel to 20 mm diameter
- END OF BOREHOLE (2.15 metres)
  - Note: Sampled to confirm permafrost conditions in area

**Ground Ice Description**

- Small cloudy ice crystals, Vx 1-3%

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Moisture Content (%)</th>
<th>Plastic Limit</th>
<th>Moisture Content</th>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S1</td>
<td>18.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>15.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Method**

- Window Sampler

**Project: Summer 2018 Geotechnical Investigation**

**Location:** Prairie Creek, Northwest Territories

**Contractor:** Tetra Tech Canada

**Drilling Rig Type:** Handheld Cobra Pro Window Sampler

**Logged By:** RO

**Reviewed By:** VR

**Completion Date:** 2018 August 26

**Completion Depth:** 2.15 m
**Lithological Description**

No recovery

PEAT - organics, dead leaf vegetation, fibrous, brown

CLAY - trace silt, very firm, low plastic, grey

ORGANICS - rootlets disseminated throughout, black, rotten wood chunks

CLAY - sandy, some gravel, some silt, grey, angular gravel to 20 mm diameter

Alternating 100 mm thick layers of ORGANICS - black, rotten wood and CLAY - trace sand and silt, trace gravel, grey, brown inclusions, subangular gravel to 30 mm diameter

CLAY - some silt, firm, low plastic, grey

- trace silt and gravel, medium plastic
- some light brown silt inclusions, subangular gravel up to 20 mm diameter

END OF BOREHOLE (2.65 metres)

Note: Too firm to advance

Medium dense mix of aspen, spruce, gentle slope in wolverine pass, leafy grass ground cover
Borehole No: BP103.1

Lithological Description

- No recovery
- TOPSOIL - organic, rootlets, black
- CLAY - silty, some sand, cobbles and gravel disseminated throughout, firm, high plastic, grey
  - some sand and gravel, medium plastic, grey brown, angular gravel to 40 mm diameter
  - trace gravel, angular gravel to 20 mm diameter
  - some gravel, trace silt, very firm, high plastic, grey
- END OF BOREHOLE (2.80 metres)
  - Note: Too firm to advance
  - Sparse spruce, gentle slope, moss and brush cover

Contractor: Tetra Tech Canada
Drilling Rig Type: Handheld Cobra Pro Window Sampler
Logged By: RO
Reviewed By: VR
Completion Date: 2018 August 18

Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Ground Elev: 519 m
Project No: ENG.EARC03130-01
UTM: 469361 E; 6810717 N; Z 10
### Lithological Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
<th>Plastic Limit</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>MOSS - roots, (80 mm thick)</td>
<td>17.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>TOPSOIL - rootlets disseminated throughout, black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>SILT - trace clay and sand, firm, low plastic, grey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.45</td>
<td>CLAY silty, somme sand, very firm, medium plastic, grey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- very hard clay</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Too firm to advance
- Thin trees, spruce, gentle grade, moss and grass cover, brush, near cutline and helipad

**End of Borehole** (2.45 metres)
Borehole No: BP109

Lithological Description

- MOSS - fibrous peat, dry, (80 mm thick)
- SILT - trace clay, rootlets throughout, lumpy, light brown
  - crumbly, firm, non plastic

END OF BOREHOLE (2.70 metres)
Note: Too firm to continue
Dense aspen and scattered spruce, grassy leafy ground cover, southeast of large shale outcrop, 6° slope
Lithological Description

PEAT - organic ground cover, fibrous, (150 mm thick)
CLAY - silty, some sand, trace gravel, roots disseminated throughout, low plastic, light brown, semiangular to rounded gravel to 50 mm diameter
- no visible roots

END OF BOREHOLE (2.10 metres)
Note: Material too dense to drill through
Heavy aspen density, mid height, leafy ground cover and grass/brush, level, near drainage area (50 m)
# Lithological Description

**Window Sampler**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Method</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Moisture Content (%)</th>
<th>Plastic Limit</th>
<th>Moisture Content</th>
<th>Liquid Limit</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>PEAT</td>
<td>R1</td>
<td></td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLAY</td>
<td>S1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.81</td>
<td></td>
<td>END OF BOREHOLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Stopped due to refusal
Aspen, medium density, tall, little vegetation dover, gentle slope, leafy dead vegetation cover

---

**Lithological Description**

- **PEAT** - dead organics, bark, fibrous, (130 mm thick)
- **CLAY** - silty, sandy, some gravel, damp, light brown, angular gravel to 50 mm diameter

**Recovery (%)**

- 40
- 60
- 80
- 100

**Sample Number**

<table>
<thead>
<tr>
<th>Moisture Content (%)</th>
<th>Plastic Limit</th>
<th>Moisture Content</th>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>
Lithological Description

**Window Sampler**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Lithological Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>PEAT - rootlets, dead organics, fibrous, (80 mm thick) CLAY - some sand, some gravel, trace silt, damp, light brown</td>
</tr>
<tr>
<td></td>
<td>- large 50 mm diameter gravel piece</td>
</tr>
<tr>
<td>1</td>
<td>END OF BOREHOLE (1.00 metre)</td>
</tr>
<tr>
<td></td>
<td>Note: Stopped due to refusal Redrill, 4 m north of original</td>
</tr>
</tbody>
</table>

**Method**

- Project: Summer 2018 Geotechnical Investigation
- Location: Prairie Creek, Northwest Territories
- Contractor: Tetra Tech Canada
- Drilling Rig Type: Handheld Cobra Pro Window Sampler
- Logged By: RO
- Reviewed By: VR

**Sample Recovery**

<table>
<thead>
<tr>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 60 80 100</td>
</tr>
</tbody>
</table>

**Borehole No:** BP154 Conf.

**Project No:** ENG.EARC03130-01

**Ground Elev:** 319 m

**UTM:** 485724 E; 6775181 N; Z 10

**Completion Depth:** 1 m

**Start Date:** 2018 August 13

**Completion Date:** 2018 August 13

**Page:** 1 of 1
Borehole No: BP50.1B
Project: Summer 2018 Geotechnical Investigation
Location: Prairie Creek, Northwest Territories
Ground Elev: 802 m
UTM: 437628 E; 6829936 N; Z 10

Lithological Description

- PEAT - moss, fibrous, (120 mm thick)
- SILT - light grey, (60 mm thick)
- SAND - trace silt, orange to brown

Note: Young vegetation, recent fire, some moss and brush cover, on top of small ridge
Lithological Description

- PEAT - moss, fibrous, brown, (150 mm thick)
- SAND - trace silt, light grey, fine sand
  - uniformly graded, brown and orange
  - brown

END OF BOREHOLE (5.00 metres)

Note: Young vegetation, recent fire, some moss and brush cover, on top of small ridge
Project: Summer 2018 Geotechnical Investigation  
Location: Prairie Creek, Northwest Territories
Ground Elev: 713 m
UTM: 440249 E; 6830824 N; Z 10

**Borehole No: BP53**

**Method**
- Window Sampler

**Lithological Description**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Plastic Limit (%)</th>
<th>Moisture Content (%)</th>
<th>Liquid Limit (%)</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>PEAT AND SAND - organics, fibrous, grey and brown, (60 mm thick)</td>
<td>R1</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAND - rootlets throughout, white</td>
<td>S1</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- uniformly graded, brown</td>
<td>R2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- trace silt, trace clay</td>
<td>R3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- trace gravel, rounded gravel to 20 mm diameter</td>
<td>S2</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>END OF BOREHOLE (4.00 metres)</td>
<td>R4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Flat, recent fire, young spruce, minimal ground cover

**Contractor:** Tetra Tech Canada  
**Drilling Rig Type:** Handheld Cobra Pro Window Sampler  
**Logged By:** RO  
**Reviewed By:** VR  
**Completion Date:** 2018 August 28
Lithological Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>MOSS - fibrous peat, rootlets, dark brown, (60 mm thick)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation (m)</td>
<td>END OF BOREHOLE (0.62 metres)</td>
</tr>
<tr>
<td></td>
<td>Note: Stopped due to refusal on rock</td>
</tr>
<tr>
<td></td>
<td>Medium dense pine, scattered aspen, gentle grade, moss ground cover, multiple attempts</td>
</tr>
</tbody>
</table>
**Lithological Description**

- **PEAT** - fibrous, brown, (40 mm thick)
- **SILT** - rootlets disseminated throughout, light brown to brown red
- **CLAY AND GRAVEL** - some silt, trace sand, very firm, low plastic, angular grave to 50 mm diameter
- crumbly, less firm

**END OF BOREHOLE** (2.92 metres)

Note: Stopped due to refusal on rock
4 m west of original
APPENDIX C

OFF-SITE GEOTECHNICAL LABORATORY SOIL TEST RESULTS
**SIEVE ANALYSIS REPORT**

**Washed Sieve: ASTM C136 and C117**

<table>
<thead>
<tr>
<th>Project No.: ENG.EARC03130-01</th>
<th>Sample No.: BH 7-S1/S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project: Prairie Creek 2018 Geotechnical Investigation</td>
<td>Date Sampled: August 30, 2018</td>
</tr>
<tr>
<td>Client: Canadian Zinc Corp.</td>
<td>Sampled by: RO</td>
</tr>
<tr>
<td>Attention: David Harpley</td>
<td>Date Tested: October 14, 2018</td>
</tr>
<tr>
<td>Email: <a href="mailto:David.Harpley@norzinc.com">David.Harpley@norzinc.com</a></td>
<td>Tested by: OO</td>
</tr>
</tbody>
</table>

**Soil Proportions (%):**

| Silt & Clay: 5 | Gravel: 13 | Sand: 82 | Cobble: 0 |

**Source:** BH 7-S1/S2 Combined

**Supplier:**

**Sample Location:** N 6829686, E 431863 (0.5-2.0 m depth)

**Specification:**

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>19</td>
<td>95</td>
</tr>
<tr>
<td>12.5</td>
<td>93</td>
</tr>
<tr>
<td>9.5</td>
<td>92</td>
</tr>
<tr>
<td>4.75</td>
<td>87</td>
</tr>
<tr>
<td>2.0</td>
<td>80</td>
</tr>
<tr>
<td>0.85</td>
<td>56</td>
</tr>
<tr>
<td>0.425</td>
<td>16</td>
</tr>
<tr>
<td>0.250</td>
<td>9</td>
</tr>
<tr>
<td>0.150</td>
<td>7</td>
</tr>
<tr>
<td>0.075</td>
<td>5.4</td>
</tr>
</tbody>
</table>

**Remarks:**

**Reviewed By:** [Signature] P.Eng.

---

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**SIEVE ANALYSIS REPORT**

Washed Sieve: ASTM C136 and C117

<table>
<thead>
<tr>
<th>Project No.: ENG.EARC03130-01</th>
<th>Sample No.: BH 11.1-S1</th>
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</thead>
<tbody>
<tr>
<td>Project: Prairie Creek 2018 Geotechnical Investigation</td>
<td>Date Sampled: August 27, 2018</td>
</tr>
<tr>
<td>Client: Canadian Zinc Corp.</td>
<td>Sampled by: RO</td>
</tr>
<tr>
<td>Attention: David Harpley</td>
<td>Date Tested: October 11, 2018</td>
</tr>
<tr>
<td>Email: <a href="mailto:David.Harpley@norzinc.com">David.Harpley@norzinc.com</a></td>
<td>Tested by: OO Office: Edmonton</td>
</tr>
</tbody>
</table>

Moisture Content (as received): 12.5%

By Particle Mass: Two (2) or Three (3)

<table>
<thead>
<tr>
<th>Soil Proportions (%)</th>
<th>Silt &amp; Clay</th>
<th>14</th>
<th>Gravel</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
<td>58</td>
<td>Cobbles</td>
<td>0</td>
</tr>
<tr>
<td>Source: BH 11.1-S1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Location: N 6829921, E 437988 (1.4-2.0 m depth)</td>
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<tr>
<td>Specification:</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>100</td>
</tr>
<tr>
<td>25</td>
<td>93</td>
</tr>
<tr>
<td>19</td>
<td>92</td>
</tr>
<tr>
<td>12.5</td>
<td>84</td>
</tr>
<tr>
<td>9.5</td>
<td>81</td>
</tr>
<tr>
<td>4.75</td>
<td>72</td>
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<tr>
<td>2.0</td>
<td>62</td>
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<tr>
<td>0.85</td>
<td>59</td>
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<tr>
<td>0.425</td>
<td>56</td>
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<td>0.250</td>
<td>45</td>
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<td>0.150</td>
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<tr>
<td>0.075</td>
<td>14.2</td>
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</table>

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Reviewed By: [Signature] P.Eng.
SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Attention: David Harpley
Email: David.Harpley@norzinc.com
Sample No.: BH 12-S1
Date Sampled: August 28, 2018
Sampled by: RO
Date Tested: October 11, 2018
Tested by: OO Office: Edmonton

Moisture Content (as received): 14.5%
No. Crushed Faces: Two (2) or Three (3)
By Particle Mass: 

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Sieve Size (mm)

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
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</thead>
<tbody>
<tr>
<td>37.5</td>
<td>100</td>
</tr>
<tr>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>19</td>
<td>85</td>
</tr>
<tr>
<td>12.5</td>
<td>82</td>
</tr>
<tr>
<td>9.5</td>
<td>81</td>
</tr>
<tr>
<td>4.75</td>
<td>78</td>
</tr>
<tr>
<td>2.0</td>
<td>72</td>
</tr>
<tr>
<td>0.85</td>
<td>64</td>
</tr>
<tr>
<td>0.425</td>
<td>47</td>
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<tr>
<td>0.250</td>
<td>22</td>
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<tr>
<td>0.150</td>
<td>9</td>
</tr>
<tr>
<td>0.075</td>
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</tr>
</tbody>
</table>

Sieve Size (mm)
SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 15-S1

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 28, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 11, 2018

Email: David.Harpley@norzinc.com
Tested by: OO

Sample Location: N 6830896, E 441175 (1.5-2.0 m depth)
Office: Edmonton

Specification:

Soil Proportions (%): Silt & Clay 8 Gravel 0
Sand 92 Cobble 0

Source: BH 15-S1

Supplier: 

No. Crushed Faces: Two (2) or Three (3)

Moisture Content (as received): 6.3%

By Particle Mass: 

Sieve Size | Percent Passing
--- | ---
0.075 | 8.5
0.150 | 19
0.250 | 56
0.425 | 95
0.85 | 100
2.0 | 100

Sieve Size (mm)

Remarks: 

Reviewed By: P. Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 17-S1

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 30, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 11, 2018

Email: David.Harpley@norzinc.com
Tested by: OO Office: Edmonton

Soil Proportions (%): Silt & Clay 10 Gravel 61 Sand 29 Cobbles 0

Source: BH 17-S1

Supplier: 

Sample Location: N 6828925, E 442271 (1.2-2.6 m depth)

Specification: 

Moisture Content (as received): 6.0%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: 

Sieve Size (mm) | Percent Passing
--- | ---
25 | 100
19 | 99
12.5 | 84
9.5 | 67
4.75 | 39
2.0 | 24
0.85 | 17
0.425 | 14
0.250 | 13
0.150 | 12
0.075 | 10.3

Remarks: 

Reviewed By: P. Eng. 

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 18-S1/S2/S3

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 27, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 11, 2018
Email: David.Harpley@norzinc.com

Tested by: OO Office: Edmonton

Moisture Content (as received): 6.9%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: 

Soil Proportions (%): Silt & Clay 12 Gravel 29
Sand 59 Cobbles 0

Source: BH 18-S1/S2/S3 Combined

Supplier:

Sample Location: N 6828387, E 443580 (0.3-4.0 m depth)

Specification:

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
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<td>71</td>
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<td>2.0</td>
<td>60</td>
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<tr>
<td>0.85</td>
<td>52</td>
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<tr>
<td>0.425</td>
<td>42</td>
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<tr>
<td>0.250</td>
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<tr>
<td>0.150</td>
<td>21</td>
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<tr>
<td>0.075</td>
<td>12.2</td>
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</tbody>
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Remarks:

Reviewed By: [Signature] P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 36-S1
Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 20, 2018
Client: Canadian Zinc Corp.
Date Tested: October 10, 2018
Attention: David Harpley
Sampled by: RO
Email: David.Harpley@norzinc.com
Tested by: OO Office: Edmonton

Moisture Content (as received): 10.9%
No. Crushed Faces: Two (2) or Three (3)
By Particle Mass: 

Soil Proportions (%): Silt & Clay 45 Gravel 40 
Sand 15 Cobbles 0
Source: BH 36-S1
Supplier: 
Sample Location: N 6812314, E 466332 (0.55-1.0 m depth)
Specification: 

### Sieve Size | Percent Passing
--- | ---
37.5 | 100
25 | 90
19 | 84
12.5 | 70
9.5 | 67
4.75 | 60
2.0 | 55
0.85 | 52
0.425 | 50
0.250 | 49
0.150 | 47
0.075 | 44.9

Remarks: 

Reviewed By: [Signature] P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 38-S1
Date Sampled: August 20, 2018

Project: Prairie Creek 2018 Geotechnical Investigation
Sampled by: RO
Date Tested: October 10, 2018

Client: Canadian Zinc Corp.
Tested by: 

Attention: David Harpley
Email: David.Harpley@norzinc.com

Date: August 20, 2018
Office: Edmonton

Sample Location: N 6810876, E 467189 (0.3-1.0 m depth)
Specified: 

Source: BH 38-S1
Supplier: 

Soil Proportions (%): Silt & Clay 44, Gravel 34, Sand 22, Cobbles 0

No. Crushed Faces: Two (2) or Three (3)

Moisture Content (as received): 8.2%

By Particle Mass: 

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>100</td>
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<tr>
<td>19</td>
<td>90</td>
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<td>12.5</td>
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<td>60</td>
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<td>0.85</td>
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<tr>
<td>0.425</td>
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<td>50</td>
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Remarks: 

Reviewed By: P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 42-S2/S3

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 19, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 11, 2018

Email: David.Harpley@norzinc.com
Tested by: Office: Edmonton

Soil Proportions (%): Silt & Clay 61 Gravel 9
Sand 30 Cobble 0
Source: BH 42-S2/S3 Combined
No. Crushed Faces: Two (2) or Three (3)

Supplier: 
By Particle Mass: 

Sample Location: N 6806071, E 471367 (0.67-2.0 m depth)

Sieve Size Percent Passing

19 100
12.5 97
9.5 94
4.75 91
2.0 85
0.85 79
0.425 73
0.250 69
0.150 65
0.075 60.8

Remarks: 

Reviewed By: _______ P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 43.1-S2/S3
Sampled by: RO
Sampled by: RO
Sample Location: N 6805463, E 473287 (0.57-1.55 m depth)

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 18, 2018
Date Tested: October 11, 2018

Client: Canadian Zinc Corp.
Date Tested: October 11, 2018

Attention: David Harpley
Email: David.Harpley@norzinc.com

Specified by: David.Harpley@norzinc.com

Soil Proportions (%):
- Silt & Clay: 12
- Gravel: 31
- Sand: 57
- Cobbles: 0

Source: BH 43.1-S2/S3 Combined

Supplier:

Datum: 12/31

Moisture Content (as received): 4.8%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass:

### Sieve Size vs. Percent Passing

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
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<tbody>
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### Remarks:

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Reviewed By: [Signature] P.Eng.
SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 49.1-S1/S2

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 17, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 11, 2018

Email: David.Harpley@norzinc.com
Tested by: OO Office: Edmonton

Moisture Content (as received): 16.0%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: _______ _______

Soil Proportions (%): Silt & Clay 32 Gravel 25 Sand 43 Cobble 0

Source: BH 49.1-S1/S2 Combined

Supplier: _______

Sample Location: N 6798799, E 480425 (0.5-2.0 m depth)

Spec: _______

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<th>Percent Passing</th>
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<td>0.425</td>
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<td>4.75</td>
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<td>25</td>
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<td>37.5</td>
<td>93</td>
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<td>50</td>
<td>100</td>
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Remarks: _______________________________________________________

Reviewed By: ________________________ P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Attention: David Harpley
Sample No.: BH 50-S2
Date Sampled: August 16, 2018
Sampled by: RO
Date Tested: October 11, 2018
Tested by: OO Office: Edmonton

Moisture Content (as received): 11.8%
No. Crushed Faces: Two (2) or Three (3)
By Particle Mass: ___ ___

Soil Proportions (%): Silt & Clay 21 Gravel 33 Sand 47 Cobbles 0

Source: BH 50-S2
Supplier: 
Sample Location: N 6793872, E 482392 (1.3-2.0 m depth)
Specification: 

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
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<tr>
<td>0.85</td>
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<tr>
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<td>9.0</td>
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<tr>
<td>25</td>
<td>92</td>
</tr>
<tr>
<td>37.5</td>
<td>100</td>
</tr>
</tbody>
</table>

Sieve Size (mm)

0.075 0.150 0.250 0.425 0.85 2.0 4.75 9.5 12.5 19 25 37.5 50 80

0 10 20 30 40 50 60 70 80 90 100

Remarks: 

Reviewed By: P.Eng.

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SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01  Sample No.: BP 53-S1/S2
Project: Prairie Creek 2018 Geotechnical Investigation  Date Sampled: August 28, 2018
Client: Canadian Zinc Corp.  Sampled by: RO
Attention: David Harpley  Date Tested: October 11, 2018
Email: David.Harpley@norzinc.com  Tested by: OO  Office: Edmonton

Moisture Content (as received): 6.1%
No. Crushed Faces: Two (2) or Three (3)

Soil Proportions (%): Silt & Clay 8  Gravel 3
Sand 89  Cobble 0
Source: BH 53-S1/S2 Combined
Supplier:
Sample Location: N 6830824, E 440249 (0.3-3.0 m depth)
Specification:

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>100</td>
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<tr>
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<td>93</td>
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<td>0.425</td>
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<tr>
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</tr>
</tbody>
</table>

By Particle Mass:_______

Remarks: ____________________________________________________________

Reviewed By: [Signature]  P.Eng.

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SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01

Project: Prairie Creek 2018 Geotechnical Investigation

Client: Canadian Zinc Corp.

Attention: David Harpley

Email: David.Harpley@norzinc.com

Sample No.: BH 54-S1/S2

Date Sampled: August 15, 2018

Sampled by: RO

Date Tested: October 11, 2018

Tested by: OO Office: Edmonton

Moisture Content (as received): 8.2%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: 34 Silt & Clay 16 Gravel (0.075 - 37.5 mm)

Source: BH 54-S1/S2 Combined

Supplier: BH 54-S1/S2 Combined

Sample Location: N 6787498, E 486269 (0.3-2.85 m depth)

Specimen: 34 Silt & Clay 16 Gravel (0.075 - 37.5 mm)

Sieve Size | Percent Passing
--- | ---
37.5 | 100
25 | 98
19 | 97
12.5 | 93
9.5 | 91
4.75 | 84
2.0 | 76
0.85 | 68
0.425 | 59
0.250 | 50
0.150 | 42
0.075 | 33.9

Sieve Size (mm)

Remarks: 

Reviewed By: P.Eng.
SIEVE ANALYSIS REPORT
Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Attention: David Harpley
Email: David.Harpley@norzinc.com
Sample No.: BH 57-S1/S2
Date Sampled: August 13, 2018
Sampled by: RO
Date Tested: October 14, 2018
Tested by: OO Office: Edmonton

Moisture Content (as received): 3.9%
No. Crushed Faces: Two (2) or Three (3)

Soil Proportions (%): Silt & Clay 40 Gravel 24 Sand 36 Cobbles 0
Source: BH 57-S1/S2 Combined
Supplier: 
Sample Location: N 6775213, E 485825 (0.5-1.45 m depth)
Specification: 

<table>
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<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
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</thead>
<tbody>
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Remarks: 

Reviewed By: P. Eng.

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Project No.: ENG.EARC03130-01
Sample No.: BH 62-S2

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 12, 2018

Client: Canadian Zinc Corp.
Date Tested: October 11, 2018

Attention: David Harpley
Client: Canadian Zinc Corp.
Email: David.Harpley@norzinc.com

Sample Location: N 6769778, E 484310 (1.4-2.0 m depth)

Specification:

Moisture Content (as received): 8.0%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: 

Sieve Size (mm)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
<th>Sieve Size (mm)</th>
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SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BH 96.6conf.-S1

Project: Prairie Creek 2018 Geotechnical Investigation
Date Sampled: August 26, 2018

Client: Canadian Zinc Corp.
Sampled by: RO

Attention: David Harpley
Date Tested: October 10, 2018

Email: David.Harpley@norzinc.com
Tested by: OO Office: Edmonton

Soil Proportions (%): Silts & Clays 52 Gravel 19
Sand 29 Cobble 0

Source: BH 96.6conf.-S1

Supplier:

Sample Location: N 6812501, E 466214 (1.56-2.0 m depth)

Specification:

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>19</td>
<td>97</td>
</tr>
<tr>
<td>12.5</td>
<td>92</td>
</tr>
<tr>
<td>9.5</td>
<td>89</td>
</tr>
<tr>
<td>4.75</td>
<td>81</td>
</tr>
<tr>
<td>2.0</td>
<td>74</td>
</tr>
<tr>
<td>0.85</td>
<td>66</td>
</tr>
<tr>
<td>0.425</td>
<td>61</td>
</tr>
<tr>
<td>0.250</td>
<td>58</td>
</tr>
<tr>
<td>0.150</td>
<td>55</td>
</tr>
<tr>
<td>0.075</td>
<td>52.1</td>
</tr>
</tbody>
</table>

Moisture Content (as received): 18.2%

No. Crushed Faces: Two (2) or Three (3)

By Particle Mass: _______ _______

Remarks: ________________________________

Reviewed By: [Signature] P.Eng.

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### SIEVE ANALYSIS REPORT

**Washed Sieve: ASTM C136 and C117**

<table>
<thead>
<tr>
<th>Project No.:</th>
<th>ENG.EARC03130-01</th>
<th>Sample No.:</th>
<th>BP 102-S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project:</td>
<td>Prairie Creek 2018 Geotechnical Investigation</td>
<td>Date Sampled:</td>
<td>August 19, 2018</td>
</tr>
<tr>
<td>Client:</td>
<td>Canadian Zinc Corp.</td>
<td>Sampled by:</td>
<td>RO</td>
</tr>
<tr>
<td>Attention:</td>
<td>David Harpley</td>
<td>Date Tested:</td>
<td>October 11, 2018</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:David.Harpley@norzinc.com">David.Harpley@norzinc.com</a></td>
<td>Tested by:</td>
<td>OO</td>
</tr>
<tr>
<td>Source:</td>
<td>BH 102-S1</td>
<td>Office:</td>
<td>Edmonton</td>
</tr>
<tr>
<td>Supplier:</td>
<td></td>
<td>Moisture Content (as received):</td>
<td>23.8%</td>
</tr>
<tr>
<td>Sample Location:</td>
<td>N 6811632, E 468000 (0.58-1.0 m depth)</td>
<td>No. Crushed Faces:</td>
<td>Two (2) or Three (3)</td>
</tr>
<tr>
<td>Specification:</td>
<td></td>
<td>By Particle Mass:</td>
<td></td>
</tr>
</tbody>
</table>

**Soil Proportions (%):**
- Silt & Clay: 68
- Gravel: 12
- Sand: 20
- Cobbles: 0

**Moisture Content:** 23.8%

**By Particle Mass:**

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.075</td>
<td>67.9</td>
</tr>
<tr>
<td>0.150</td>
<td>72</td>
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<tr>
<td>0.250</td>
<td>75</td>
</tr>
<tr>
<td>0.425</td>
<td>78</td>
</tr>
<tr>
<td>0.85</td>
<td>82</td>
</tr>
<tr>
<td>2.0</td>
<td>85</td>
</tr>
<tr>
<td>4.75</td>
<td>88</td>
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<td>9.5</td>
<td>93</td>
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<td>12.5</td>
<td>95</td>
</tr>
<tr>
<td>19</td>
<td>100</td>
</tr>
</tbody>
</table>

**Remarks:**

Reviewed By: P.Eng.

---

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SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.: ENG.EARC03130-01
Sample No.: BP 154-S1
Date Sampled: August 13, 2018
Sampled by: RO

Project: Prairie Creek 2018 Geotechnical Investigation
Date Tested: October 11, 2018
Client: Canadian Zinc Corp.
Tested by: OO

Attention: David Harpley
Office: Edmonton
Email: David.Harpley@norzinc.com

Sample Location: N 6775176, E 485724 (0.13-0.81 m depth)

Soil Proportions (%): Silt & Clay 58 Gravel 12
Sand 30 Cobbles 0

Source: BH 154-S1
Supplier: 

No. Crushed Faces: Two (2) or Three (3)
By Particle Mass: 

Remarks: 

Moisture Content (as received): 12.2%

### Sieve Analysis Table

<table>
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<tr>
<th>Sieve Size (mm)</th>
<th>Percent Passing</th>
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<tbody>
<tr>
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<td>100</td>
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<tr>
<td>19</td>
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<tr>
<td>12.5</td>
<td>92</td>
</tr>
<tr>
<td>9.5</td>
<td>91</td>
</tr>
<tr>
<td>4.75</td>
<td>88</td>
</tr>
<tr>
<td>2.0</td>
<td>85</td>
</tr>
<tr>
<td>0.85</td>
<td>81</td>
</tr>
<tr>
<td>0.425</td>
<td>76</td>
</tr>
<tr>
<td>0.250</td>
<td>71</td>
</tr>
<tr>
<td>0.150</td>
<td>66</td>
</tr>
<tr>
<td>0.075</td>
<td>58.6</td>
</tr>
</tbody>
</table>

Sieve Size (mm)

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Reviewed By: [Signature] P.Eng.
Sample Description: CLAY, silty, sandy, some gravel, grey

Liquid Limit ($W_l$): 33  Natural Moisture (%): 11.4
Plastic Limit: 17  Soil Plasticity: Medium
Plasticity Index (Ip): 16  Mod.USCS Symbol: CI

Remarks:

Reviewed By: P.Eng.
Project: Prairie Creek 2018 Geotechnical Investigation
Sample Number: BH 50-S3
Sampled By: RO
Tested By: OO
Date Sampled: August 16, 2018
Sampled By: RO
Tested By: OO
Date Sampled: August 16, 2018
Sample Description: GRAVEL, clayey, sandy, greyish brown

Liquid Limit ($W_1$): 23
Plastic Limit: 12
Plasticity Index ($I_p$): 11

Natural Moisture (%): 10.6
Soil Plasticity: Low
Mod.USCS Symbol: CL

Remarks:

Reviewed By: P.Eng.
Project: Prairie Creek 2018 Geotechnical Investigation
Sample Number: BH 61-S1

Project No: ENG.EARC03130-01
Sampled By: RO

Client: Canadian Zinc Corp.
Tested By: OO

Attention: David Harpley
Date Sampled: August 12, 2018

Email: David.Harpley@norzinc.com
Date Tested: October 17, 2018

Sample Description: CLAY, silty, some sand, greyish brown

### Plasticity Chart

<table>
<thead>
<tr>
<th>Plasticity Chart</th>
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<tbody>
<tr>
<td>0</td>
</tr>
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<td>0</td>
</tr>
<tr>
<td>10</td>
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</tr>
<tr>
<td>CL</td>
</tr>
<tr>
<td>ML</td>
</tr>
<tr>
<td>ML or OL</td>
</tr>
</tbody>
</table>

Liquid Limit ($W_L$) : 27  
Natural Moisture (%) : 24.9

Plastic Limit : 19  
Soil Plasticity: Low

Plasticity Index (Ip) : 8  
Mod.USCS Symbol: CL

Remarks:

Reviewed By: P.Eng.
Project: Prairie Creek 2018 Geotechnical Investigation
Sample Number: BH 63-S1
Sampled By: RO
Tested By: OO
Sampled By: RO
Tested By: OO

Client: Canadian Zinc Corp.
Borehole Number: BH 63
Date Sampled: August 11, 2018
Date Tested: October 17, 2018

Attention: David Harpley
Date: 1.1-2.0 m
Email: David.Harpley@norzinc.com

Sample Description: CLAY, silty, trace sand, greyish brown

Liquid Limit (W₁): 29
Natural Moisture (%): 28.7
Plastic Limit: 22
Soil Plasticity: Low to Medium
Plasticity Index (Ip): 7
Mod.USCS Symbol: CL-ML

Remarks:

Reviewed By: P.Eng.

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Sample Description: CLAY, silty, sandy, some gravel, brown

Liquid Limit (W_l) : 30
Plastic Limit : 16
Plasticity Index (Ip) : 14
Natural Moisture (%) : 15.8
Soil Plasticity: Low to Medium
Mod.USCS Symbol: CL-CI

Remarks:

Reviewed By: P.Eng.
Sample Description: CLAY, silty, some sand, trace gravel, greyish brown

Liquid Limit ($W_L$): 43
Natural Moisture (%): 17.6
Plastic Limit: 19
Soil Plasticity: Medium
Plasticity Index (Ip): 24
Mod. USCS Symbol: CI

Remarks:

Reviewed By: P. Eng.
Sample Description: CLAY, silty, sandy, trace gravel, brown

Plasticity Chart

Liquid Limit ($W_l$): 27  Natural Moisture (%): 14.9
Plastic Limit: 13  Soil Plasticity: Low
Plasticity Index ($I_p$): 14  Mod. USCS Symbol: CL

Remarks:

Reviewed By: [Signature] P.Eng.

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# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

**ASTM D7928**

<table>
<thead>
<tr>
<th>Project:</th>
<th>Prairie Creek 2018 Geotechnical Investigation</th>
<th>Sample No.:</th>
<th>BH 33-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client:</td>
<td>Canadian Zinc Corp.</td>
<td>Borehole/ TP:</td>
<td>N 6813836, E 465138</td>
</tr>
<tr>
<td>Project No.:</td>
<td>ENG.EARC03130-01</td>
<td>Depth:</td>
<td>1.0-1.45 m</td>
</tr>
<tr>
<td>Location:</td>
<td>Prairie Creek Mine, NWT</td>
<td>Date Tested:</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td>Description:</td>
<td>SILT, some sand, trace clay, greyish brown</td>
<td>Tested By:</td>
<td>LL</td>
</tr>
</tbody>
</table>

## Particle Size Percent Passing

<table>
<thead>
<tr>
<th>Particle Size (µm)</th>
<th>Percent Passing (P)</th>
</tr>
</thead>
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<td></td>
</tr>
<tr>
<td>75</td>
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<tr>
<td>50</td>
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<tr>
<td>37.5</td>
<td></td>
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<tr>
<td>25</td>
<td></td>
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<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>4.75</td>
<td></td>
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<tr>
<td>2</td>
<td>100</td>
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<tr>
<td>850 µm</td>
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<tr>
<td>425 µm</td>
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<td>250 µm</td>
<td>100</td>
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<td>150 µm</td>
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<td>75 µm</td>
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<tr>
<td>32 µm</td>
<td>31</td>
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<td>21 µm</td>
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<td>9 µm</td>
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<td>6 µm</td>
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<tr>
<td>3 µm</td>
<td>6</td>
</tr>
<tr>
<td>1 µm</td>
<td>4</td>
</tr>
</tbody>
</table>

**Remarks:**
* Unless expressly stated, this test was performed by the Air Dry Method
** The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual

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PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D7928 †

Project: Prairie Creek 2018 Geotechnical Investigation
Sample No.: BH 36-S2
Client: Canadian Zinc Corp.
Borehole/ TP: N 6812314, E 466332
Project No.: ENG.EARC03130-01
Depth: 1.4-1.9 m
Location: Prairie Creek Mine, NWT
Date Tested: October 15, 2018
Description **: CLAY, silty, sandy, some gravel, grey
Tested By: LL

<table>
<thead>
<tr>
<th>Particle Size (µm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>17</td>
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<tr>
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<td>28</td>
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</tbody>
</table>

Remarks: * Unless expressly stated, this test was performed by the Air Dry Method
** The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
† The description is behaviour based & subject to Tetra Tech description protocols.

Reviewed By: [Signature] P.Eng.

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**PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT**

**ASTM D7928 †**

<table>
<thead>
<tr>
<th>Project:</th>
<th>Prairie Creek 2018 Geotechnical Investigation</th>
<th>Sample No.:</th>
<th>BH 50-S3</th>
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<tbody>
<tr>
<td>Client:</td>
<td>Canadian Zinc Corp.</td>
<td>Borehole/ TP:</td>
<td>N 6793872, E 482392</td>
</tr>
<tr>
<td>Project No.:</td>
<td>ENG.EARC03130-01</td>
<td>Depth:</td>
<td>2.5-2.9 m</td>
</tr>
<tr>
<td>Location:</td>
<td>Prairie Creek Mine, NWT</td>
<td>Date Tested</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td>Description **:</td>
<td>GRAVEL, clayey, sandy, greyish brown</td>
<td>Tested By:</td>
<td>LL</td>
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</table>

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
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<td>6 µm</td>
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</tr>
<tr>
<td>3 µm</td>
<td>5</td>
</tr>
<tr>
<td>1 µm</td>
<td>2</td>
</tr>
</tbody>
</table>

**Remarks:**

* Unless expressly stated, this test was performed by the Air Dry Method

** The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual

† The description is behaviour based & subject to Tetra Tech description protocols.

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**PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT**

**ASTM D7928 †**

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Percent Passing</th>
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</thead>
<tbody>
<tr>
<td>100 mm</td>
<td>100</td>
</tr>
<tr>
<td>75 mm</td>
<td>89</td>
</tr>
<tr>
<td>50 mm</td>
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<td>1.18 mm</td>
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<td>0.125 mm</td>
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<tr>
<td>0.063 mm</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

**Remarks:**
* Unless expressly stated, this test was performed by the Air Dry Method
  ** The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
  † The description is behaviour based & subject to Tetra Tech description protocols.

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PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D7928 †

Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Sample No.: BH 63-S1
Borehole/ TP: N 6766959, E 484770
Project No.: ENG.EARC03130-01
Location: Prairie Creek Mine, NWT
Depth: 1.1-2.0 m
Date Tested: October 15, 2018

Description **: CLAY, silty, trace sand, greyish brown
Tested By: LL

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>75</td>
<td>85</td>
</tr>
<tr>
<td>50</td>
<td>42</td>
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<tr>
<td>37.5</td>
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<td>25</td>
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<td>2.0</td>
<td>0.5</td>
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<tr>
<td>1.1</td>
<td>0.1</td>
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<table>
<thead>
<tr>
<th>Particle Size (µm)</th>
<th>Percent Passing</th>
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</thead>
<tbody>
<tr>
<td>850</td>
<td>100</td>
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<tr>
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<td>3</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

Clay size | Silt Size | Sand | Gravel |
---|---|---|---|
Fine | Medium | Coarse |
Fine | Coarse |

Remarks: * Unless expressly stated, this test was performed by the Air Dry Method
** The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual
† The description is behaviour based & subject to Tetra Tech description protocols.

Reviewed By: P.Eng.

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**PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT**

**ASTM D7928**

| Project: Prairie Creek 2018 Geotechnical Investigation | Sample No.: BH 67-S1/S2 |
| Client: Canadian Zinc Corp. | Borehole/ TP: N 6757048, E 495001 |
| Project No.: ENG.EARC03130-01 | Depth: 1.35-3.0 m |
| Location: Prairie Creek Mine, NWT | Date Tested: October 15, 2018 |
| Description **: CLAY, silty, trace sand, brown | Tested By: LL |

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Percent Passing</th>
<th>Clay size</th>
<th>Silt Size</th>
<th>Sand</th>
<th>Gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>75 mm</td>
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<td></td>
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<tr>
<td>50 mm</td>
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<td></td>
</tr>
<tr>
<td>37.5 mm</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>25 mm</td>
<td></td>
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<tr>
<td>19 mm</td>
<td></td>
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<tr>
<td>12.5 mm</td>
<td></td>
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<tr>
<td>9.5 mm</td>
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<tr>
<td>4.75 mm</td>
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<tr>
<td>850 µm</td>
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<tr>
<td>425 µm</td>
<td>100</td>
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<tr>
<td>250 µm</td>
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<tr>
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<td>19 µm</td>
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<tr>
<td>11 µm</td>
<td>41</td>
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<tr>
<td>8 µm</td>
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<tr>
<td>1 µm</td>
<td>19</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

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** The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

Reviewed By: [Signature] P.Eng.
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D7928 †

Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Sample No.: BH 96.6conf.-S2
Borehole/ TP: ENG.EARC03130-01
Depth: 2.0-2.15 m
Location: Prairie Creek Mine, NWT
Date Tested: October 15, 2018

Description **: CLAY, silty, sandy, some gravel, brown
Tested By: LL

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>95</td>
</tr>
<tr>
<td>37.5</td>
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<td>25</td>
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<tr>
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<td>0.4</td>
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<tr>
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<td>0.05</td>
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### Particle Size Percent Passing

<table>
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<tr>
<th>Material Description</th>
<th>Proportion (%)</th>
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<tbody>
<tr>
<td>Clay Size **</td>
<td>14</td>
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<tr>
<td>Silt Size</td>
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<tr>
<td>Sand</td>
<td>34</td>
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<tr>
<td>Gravel</td>
<td>18</td>
</tr>
<tr>
<td>Cobbles</td>
<td>0</td>
</tr>
</tbody>
</table>

Remarks:  
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** The upper clay size of 2 um, per the Canadian Foundation Engineering Manual  
† The description is behaviour based & subject to Tetra Tech description protocols.

Reviewed By: ________ P.Eng.
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D7928 †

Project: Prairie Creek 2018 Geotechnical Investigation
Client: Canadian Zinc Corp.
Sample No.: BH 103-S1
Project No.: ENG.EARC03130-01
Location: Prairie Creek Mine, NWT
Date Tested: October 15, 2018
Borehole/ TP: N 6810694, E 467502
Depth: 1.6-2.0 m
Description **: CLAY, silty, some sand, trace gravel, greyish brown
Tested By: LL

Remarks: * Unless expressly stated, this test was performed by the Air Dry Method
** The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual
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<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
<td></td>
</tr>
<tr>
<td>75 mm</td>
<td></td>
</tr>
<tr>
<td>50 mm</td>
<td></td>
</tr>
<tr>
<td>37.5 mm</td>
<td></td>
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<tr>
<td>25 mm</td>
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<tr>
<td>19 mm</td>
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<td>12.5 mm</td>
<td>98</td>
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<tr>
<td>9.5 mm</td>
<td>98</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>97</td>
</tr>
<tr>
<td>2.0 mm</td>
<td>94</td>
</tr>
<tr>
<td>850 µm</td>
<td>91</td>
</tr>
<tr>
<td>425 µm</td>
<td>87</td>
</tr>
<tr>
<td>250 µm</td>
<td>84</td>
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<tr>
<td>150 µm</td>
<td>81</td>
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<tr>
<td>75 µm</td>
<td>78</td>
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<td>27 µm</td>
<td>70</td>
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<tr>
<td>18 µm</td>
<td>64</td>
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<tr>
<td>10 µm</td>
<td>58</td>
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<tr>
<td>8 µm</td>
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<td>6 µm</td>
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<tr>
<td>3 µm</td>
<td>41</td>
</tr>
<tr>
<td>1 µm</td>
<td>32</td>
</tr>
</tbody>
</table>

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### PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

**ASTM D7928**

<table>
<thead>
<tr>
<th>Project:</th>
<th>Prairie Creek 2018 Geotechnical Investigation</th>
<th>Sample No.:</th>
<th>BH 137.1-S2</th>
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<tbody>
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<td>Client:</td>
<td>Canadian Zinc Corp.</td>
<td>Borehole/ TP:</td>
<td>N 6787574, E 486283</td>
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<tr>
<td>Project No.:</td>
<td>ENG.EARC03130-01</td>
<td>Depth:</td>
<td>1.6-2.0 m</td>
</tr>
<tr>
<td>Location:</td>
<td>Prairie Creek Mine, NWT</td>
<td>Date Tested</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td>Description **:</td>
<td>CLAY, sandy, some gravel, brown</td>
<td>Tested By:</td>
<td>LL</td>
</tr>
</tbody>
</table>

#### Particle Size Percent Passing

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>75</td>
<td>92</td>
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<tr>
<td>50</td>
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<td>12.5</td>
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<td>4.75</td>
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<td>2</td>
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<td>850 µm</td>
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<td>11 µm</td>
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</tr>
<tr>
<td>3 µm</td>
<td>25</td>
</tr>
<tr>
<td>1 µm</td>
<td>19</td>
</tr>
</tbody>
</table>

#### Remarks:

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** The upper clay size of 2 µm, per the Canadian Foundation Engineering Manual

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Reviewed By: [Signature] P.Eng.
PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D7928 †

<table>
<thead>
<tr>
<th>Project:</th>
<th>Prairie Creek 2018 Geotechnical Investigation</th>
<th>Sample No.:</th>
<th>BH 146-S1</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>Project No.:</td>
<td>ENG.EARC03130-01</td>
<td>Depth:</td>
<td>0.3-1.0 m</td>
</tr>
<tr>
<td>Location:</td>
<td>Prairie Creek Mine, NWT</td>
<td>Date Tested</td>
<td>October 15, 2018</td>
</tr>
<tr>
<td>Description **:</td>
<td>CLAY, silty, sandy, trace gravel, brown</td>
<td>Tested By:</td>
<td>LL</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
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<tr>
<td>75</td>
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</tbody>
</table>

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### Determination of the Soluble Salt Content of Soils by Refractometer

**ASTM D4542**

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Location</th>
<th>Depth (m)</th>
<th>Soil Type</th>
<th>Salinity (ppt)</th>
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</thead>
<tbody>
<tr>
<td>BH 12-S1</td>
<td>N 6830627, E 439900</td>
<td>1.3-2.0</td>
<td>SAND, some gravel, trace silt, clay, brown</td>
<td>0.2</td>
</tr>
<tr>
<td>BH 17-S1</td>
<td>N 6828925, E 442271</td>
<td>1.2-1.6</td>
<td>GRAVEL, some sand, trace silt, clay, grey</td>
<td>1.7</td>
</tr>
<tr>
<td>BH 42-S2</td>
<td>N 6806071, E 471367</td>
<td>0.67-1.0</td>
<td>CLAY, some sand, trace gravel, silt, brown</td>
<td>9.3</td>
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<td>BH 43-S2</td>
<td>N 6805463, E 473287</td>
<td>0.57-0.94</td>
<td>SAND, some gravel, clay, trace silt, brown</td>
<td>9.7</td>
</tr>
</tbody>
</table>

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Reviewed By: [Signature] P.Eng.