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

APPENDIX 22-1

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
PRAIRIE CREEK MINE

UPDATED ACCESS ROAD AVALANCHE HAZARD MAPS
AND ASSESSMENT OF AVALANCHE RISK TO CROSSING
STRUCTURES

V.181224

Report prepared for:  Canadian Zinc Corporation
Vancouver, BC

Report prepared by:  Alpine Solutions Avalanche Services
Squamish, BC

Date:  December 24, 2018

Project #:  1212-003
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<td>Cam Campbell/Brian Gould</td>
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### Checks and Approvals

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<td>December 22, 2018</td>
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<td>Reviewed, for client submission</td>
<td>Brian Gould, P.Eng., Senior Avalanche Specialist</td>
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December 24, 2018
Project No: 1212-003

David Harpley, VP, Environment and Permitting Affairs
Canadian Zinc Corporation
Suite 1710, 650 West Georgia Street
PO Box 11644
Vancouver, British Columbia
V6B 4N9

Dear Mr. Harpley,

Re: **Prairie Creek Mine – Updated Access Road Avalanche Hazard Maps and Assessment of Avalanche Risk to Crossing Structures**

Please find attached our revised report summarizing updated avalanche hazard maps for the Prairie Creek Mine road and assessment of avalanche risk for crossing structures. Thank you for the opportunity to complete this work.

Yours sincerely,

Alpine Solutions Avalanche Services
per:

![Signature](signature.jpg)

Brian Gould, P.Eng.
Executive Summary

This report provides updated avalanche hazard analysis and mapping for the Prairie Creek Mine access road, including the winter route and all-season roads. In addition, this report provides an assessment of avalanche risk to proposed crossing structures, which, according to diagrams provided, are designated to be culverts and associated earthworks. Results of the analysis suggest that avalanches have the potential to temporarily block or damage culvert inlets which could cause associated flood damage to the road.

As indicated in Alpine Solutions (2012), there is avalanche risk to vehicles, and their occupants, travelling the access road at several locations. Revised avalanche hazard maps indicating locations of avalanche hazard are included as an attachment.

Alpine Solutions provides the following recommendations:

1. Canadian Zinc Corporation (CZN) should inform the road design team of the potential for temporary avalanche blockage of culverts, to determine if this may pose a flood risk. If necessary, mitigation measures to reduce the chance of avalanches blocking culverts may be necessary.

2. An avalanche risk management plan should be developed for the access road that includes avalanche hazard forecasting and road closures during high hazard. To reduce hazard, the plan should provide options for avalanche hazard mitigation through artificial (e.g. explosive) avalanche release.

3. In order to decrease the uncertainty associated with the avalanche hazard assessment, avalanche paths should be observed for avalanche occurrences at least once per winter. This typically involves coordination by an avalanche professional, and could be achieved though fixed wing aerial observations coinciding with the end of other major avalanche cycles in the region.
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1 Introduction

1.1 Background and Work Scope

The Prairie Creek Mine is a zinc-silver-lead project located in the South Mackenzie Mountains, approximately 550 km west of Yellowknife, NWT (Figure 1-1). The property has undergone various stages of development since the deposit was first discovered in 1928; however, the site has been on care and maintenance since 1982. Canadian Zinc Corporation (CZN) is planning mining operations, and is proposing a 170 km all-season road (ASR) in order to transport mineral concentrate from the mine site to the Liard Highway, approximately 110 km southwest of Fort Simpson, NWT. Much of the proposed ASR and initial winter roads utilize a historic road used previously by the mine. At least 35 km of this road winds through mountainous terrain that is snow covered in winter.

In 2012, Alpine Solutions Avalanche Services conducted a preliminary snow avalanche risk assessment of the mining road, for planning purposes (Alpine Solutions, 2012). This assessment included a study of available imagery as well as aerial observations from a fixed-wing flight during spring when the landscape was still snow covered. The assessment provided preliminary avalanche hazard maps, and concluded there is potential avalanche risk to vehicles and occupants as well as road infrastructure such as bridges (Alpine Solutions, 2012).
Based on recommendations made in that report, in 2017 CZN requested Alpine Solutions complete additional ground-based field investigations to assess proposed initial winter road and all-season road alignments with associated crossing structures. More recently, an Environmental Assessment (EA) review outlined additional measures and suggestions, including:

1. Review and update the avalanche hazard maps from the 2012 assessment, based on the final road alignment.
2. Incorporate the potential impacts of avalanches on crossing structures near avalanche paths.

This report summarizes an analysis of avalanche risk to crossing structures, and includes updated avalanche hazard assessments and maps for all potential road alignments based on more detailed site observations completed in 2017. Specific methods used to complete the analysis are outlined in Section 3. Section 4 details the updated avalanche hazard assessment according to the avalanche path maps provided in Appendix A. An assessment of avalanche risk to crossing structures and preliminary mitigation concepts are described in Section 5.

2 Uncertainty and Limitations

This report provides an updated avalanche hazard mapping for the proposed access roads and an avalanche risk assessment for exposed crossing structures.

Avalanches are an erratic phenomenon, and characteristics such as return frequency cannot be precisely determined, especially without records of historical avalanche occurrences on the slopes analyzed.

Although other geohazards exist in the region, the scope of this assessment is limited exclusively to snow avalanches. In addition, any significant artificial or natural alteration of the landscape or terrain due forest fire, landslides or other geotechnical event may change the nature (i.e. magnitude, frequency and runout extent) of avalanche hazard, necessitating a re-assessment for the area affected.

3 Methods

The revised avalanche path maps provided in Appendix A, and associated assessment of avalanche hazard is provided in Section 4, are based on the following documents and files provided by CZN:

The location and extent of avalanche paths was determined and mapped according to methods outlined in CAA (2016), and included:

- Analysis of satellite imagery through ArcGIS Pro and Google™ Earth.
- Analysis of topography using 5 m contours for areas with high-resolution DEM.
- Review of previous avalanche hazard assessment for the Prairie Creek Mine Winter Road completed by Alpine Solutions (Alpine Solutions, 2012).
- Aerial reconnaissance and ground-based field surveys at select locations completed by Cam Campbell, August 13-14, 2017.

## 4 Revised Avalanche Hazard Maps

At the time of the assessment, the initial winter road alignment had yet to be finalized between approximately KP24 and KP29. As a result, both the 130226 and the 161125 road alignments were considered in this assessment. In addition, the current winter road plan follows the old winter route between approximately KP23 and KP23.5 as well as KP28 and KP29, so these segments were also included in the assessment.

The proposed ASR and winter road alignments are exposed to 39 separate avalanche paths or areas distributed between KP0.5 and KP36. Maps provided in Appendix A illustrate the location and extent of each avalanche path estimated to affect the road alignments. Table 4-1 summarizes location, estimated length of road affected, and expected frequency for potential magnitudes (Table 4-2) for each avalanche path or area affecting the proposed access road alignments.
### Table 4-1: Name, location, estimated length of road affected, and expected frequency for potential magnitudes (Table 4-2) for each avalanche path or area affecting the proposed access road alignments.

<table>
<thead>
<tr>
<th>Name</th>
<th>Alignment Affected</th>
<th>KP From</th>
<th>KP To</th>
<th>Length of Road Affected (m)</th>
<th>Frequency (events:years)</th>
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</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Size 2</td>
</tr>
<tr>
<td>Path 0.5</td>
<td>161125</td>
<td>0.2</td>
<td>0.5</td>
<td>300</td>
<td>1:3</td>
</tr>
<tr>
<td>Path 4.0</td>
<td>161125</td>
<td>3.4</td>
<td>4.2</td>
<td>800</td>
<td>1:1</td>
</tr>
<tr>
<td>Path 7.5</td>
<td>161125</td>
<td>7.7</td>
<td>7.9</td>
<td>200</td>
<td>1:3</td>
</tr>
<tr>
<td>Path 8.0</td>
<td>161125</td>
<td>7.9</td>
<td>8.3</td>
<td>400</td>
<td>~</td>
</tr>
<tr>
<td>Path 8.3</td>
<td>161125</td>
<td>8.3</td>
<td>8.4</td>
<td>100</td>
<td>1:3</td>
</tr>
<tr>
<td>Path 8.7</td>
<td>161125</td>
<td>8.6</td>
<td>8.7</td>
<td>100</td>
<td>~</td>
</tr>
<tr>
<td>Path 9.0</td>
<td>161125</td>
<td>8.9</td>
<td>8.9</td>
<td>50</td>
<td>~</td>
</tr>
<tr>
<td>Path 9.5</td>
<td>161125</td>
<td>9.2</td>
<td>9.7</td>
<td>500</td>
<td>~</td>
</tr>
<tr>
<td>Path 10.0</td>
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<td>10.3</td>
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<td>~</td>
</tr>
<tr>
<td>Path 11.5</td>
<td>161125</td>
<td>11.4</td>
<td>11.5</td>
<td>150</td>
<td>~</td>
</tr>
<tr>
<td>Path 12.5</td>
<td>161125</td>
<td>12.4</td>
<td>12.5</td>
<td>100</td>
<td>1:1</td>
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<tr>
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<td>13.2</td>
<td>13.3</td>
<td>100</td>
<td>~</td>
</tr>
<tr>
<td>Path 15.0</td>
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<td>14.7</td>
<td>15.3</td>
<td>600</td>
<td>1:1</td>
</tr>
<tr>
<td>Path 16.0</td>
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<td>16.3</td>
<td>17</td>
<td>650</td>
<td>~</td>
</tr>
<tr>
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<td>100</td>
<td>~</td>
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<td>1500</td>
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<td>19.3</td>
<td>20.6</td>
<td>1300</td>
<td>1:1</td>
</tr>
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<td>20.4</td>
<td>400</td>
<td>~</td>
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<td>161125</td>
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<td>21.2</td>
<td>650</td>
<td>~</td>
</tr>
<tr>
<td>Path 21.5</td>
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<td>21.1</td>
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<td>~</td>
</tr>
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<td>Path 22.0</td>
<td>161125</td>
<td>21.5</td>
<td>22.7</td>
<td>1200</td>
<td>1:1</td>
</tr>
<tr>
<td>Path 25.0</td>
<td>130226</td>
<td>24.8</td>
<td>25.0</td>
<td>200</td>
<td>~</td>
</tr>
<tr>
<td>Path 25.3</td>
<td>130226</td>
<td>25.1</td>
<td>25.3</td>
<td>200</td>
<td>~</td>
</tr>
<tr>
<td>Path 25.5</td>
<td>161125</td>
<td>25.7</td>
<td>26.0</td>
<td>250</td>
<td>~</td>
</tr>
<tr>
<td>Path 25.7</td>
<td>130226</td>
<td>25.7</td>
<td>25.9</td>
<td>200</td>
<td>~</td>
</tr>
<tr>
<td>Path 26.0</td>
<td>130226</td>
<td>25.9</td>
<td>26.7</td>
<td>800</td>
<td>1:1</td>
</tr>
<tr>
<td>Path 27.0</td>
<td>130226</td>
<td>26.7</td>
<td>27.0</td>
<td>300</td>
<td>1:1</td>
</tr>
<tr>
<td>Path 27.5</td>
<td>130226</td>
<td>27.0</td>
<td>27.7</td>
<td>650</td>
<td>1:1</td>
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<tr>
<td>Name</td>
<td>Alignment Affected</td>
<td>KP From</td>
<td>KP To</td>
<td>Length of Road Affected (m)</td>
<td>Frequency (events:years)</td>
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<td>--------------</td>
<td>-------------------------------------</td>
<td>---------</td>
<td>-------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Path 28.0</td>
<td>130226</td>
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<td>28.0</td>
<td>350</td>
<td>1:1 1:3 ~</td>
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<tr>
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<td>161125, 130226, Winter</td>
<td>28.3</td>
<td>28.7</td>
<td>400</td>
<td>1:1 1:3 ~</td>
</tr>
<tr>
<td>Path 28.7</td>
<td>161125, Winter</td>
<td>28.7</td>
<td>28.9</td>
<td>200</td>
<td>~ 1:10 ~</td>
</tr>
<tr>
<td>Path 29.0</td>
<td>161125, 130226</td>
<td>28.9</td>
<td>29.1</td>
<td>150</td>
<td>~ 1:10 ~</td>
</tr>
<tr>
<td>Path 30.0</td>
<td>161125</td>
<td>29.4</td>
<td>30.0</td>
<td>600</td>
<td>~ 1:10 ~</td>
</tr>
<tr>
<td>Path 30.5</td>
<td>161125</td>
<td>30.0</td>
<td>30.9</td>
<td>900</td>
<td>~ 1:10 ~</td>
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<tr>
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<td>161125</td>
<td>31.2</td>
<td>32.0</td>
<td>750</td>
<td>~ 1:10 ~</td>
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<td>32.3</td>
<td>33.6</td>
<td>1300</td>
<td>1:1 1:10 ~</td>
</tr>
<tr>
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<td>33.6</td>
<td>35.0</td>
<td>1400</td>
<td>1:1 1:10 ~</td>
</tr>
<tr>
<td>Path 35.0</td>
<td>161125</td>
<td>35.0</td>
<td>35.9</td>
<td>900</td>
<td>1:1 1:10 ~</td>
</tr>
</tbody>
</table>
Table 4-2: Canadian classification system for avalanche size (McClung and Schaerer, 2006). For each size class, the table lists: typical impact pressures in kilopascals (kPa); typical mass in tonnes (t); typical path length in metres (m); and a description of the destructive potential, including the approximate forest area in hectares (ha) that could be destroyed.

<table>
<thead>
<tr>
<th>Size</th>
<th>Destructive Potential</th>
<th>Typical Mass (t)</th>
<th>Typical Path Length (m)</th>
<th>Typical Impact Pressures (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Relatively harmless to people.</td>
<td>&lt;10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Could bury, injure or kill a person.</td>
<td>$10^2$</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Could bury a car, destroy a small building, or break a few trees.</td>
<td>$10^3$</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Could destroy a large truck, several buildings, or a forest with an area up to 4 ha.</td>
<td>$10^4$</td>
<td>2000</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>Largest snow avalanches known. Could destroy a village or a 40 ha forest.</td>
<td>$10^5$</td>
<td>3000</td>
<td>1000</td>
</tr>
</tbody>
</table>

5 Potential Avalanche Risk to Crossing Structures

All major and minor crossings, and the associated possible structures, were assessed for potential avalanche risk. At this time, all crossings are determined to be created by fill (earthworks), with culverts buried at least 1 m. Due to their low vulnerability, avalanche risk to culverts is expected to be negligible. However, avalanches may damage or temporarily block exposed inlets, resulting in the potential for associated flood damage.

6 Mitigation

Updated avalanche mapping included in this report indicates areas where avalanches may impact vehicles and their occupants on the access road. As suggested in Alpine Solutions (2012), avalanche risk mitigation for resource roads typically involves operational avalanche hazard forecasting coupled with road closures during periods of high avalanche hazard. Direct avalanche hazard mitigation through frequent artificial (e.g. explosive) avalanche release may also be considered; however, the level of risk reduction depends on the ability to accurately predict the build-up of conditions that could release a large avalanche, and control the slope before these conditions exist. Typically, this requires ongoing snow and weather conditions
assessment by experienced avalanche professionals, and the ability to conduct control with short notice (i.e. less than 24 hours). It is also recognized that the use of explosive release can be disturbing to proximal wildlife.

Mitigation for avalanches impacting crossings that are constructed of fill (with culverts) is expected to involve the determination of the effects of associated flooding (which is beyond the scope of this study), and determination of whether avalanche mitigation is required. Avalanche mitigation would normally involve reducing the chance of the avalanche blockage, which could involve the use of frequent artificial (e.g. explosive) avalanche release to reduce the chance of a large avalanche.

7 Recommendations

Alpine Solutions recommends the following:

1. CZN should inform the road design team of the potential for temporary avalanche blockage of culverts, to determine if this may pose a flood risk. If necessary, mitigation measures to reduce the chance of avalanches blocking culverts may be necessary.

2. An avalanche risk management plan should be developed for the access road that includes avalanche hazard forecasting and road closures during high hazard. To reduce hazard, the plan should provide options for avalanche hazard mitigation through artificial (e.g. explosive) avalanche release.

3. In order to decrease the uncertainty associated with the avalanche hazard assessment, avalanche paths should be observed for avalanche occurrences at least once per winter. This typically involves coordination by an avalanche professional, and could be achieved through fixed wing aerial observations coinciding with the end of other major avalanche cycles in the region.
8 Closure

This document was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Canadian Zinc Corporation. The material in it reflects Alpine Solutions’ best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending Alpine Solutions’ written approval. If this document is issued in an electronic format, an original paper copy is on file at Alpine Solutions and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

ALPINE SOLUTIONS AVALANCHE SERVICES

per:

Reviewed by:

Avalanche Specialist  Senior Avalanche Specialist
9 References


Appendix A – Avalanche Path Maps
1) Datum: NAD83 Projection: Transverse Mercator - UTM Zone 10V
2) This figure is produced at a nominal scale of 1:11" x 17" (B size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: Esri, CDN Zinc Corp.
4) Contour Interval: 100 ft.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads and associated crossing infrastructure are indicated on this map.
1) Datum: NAD83 Projection: Transverse Mercator - UTM Zone: 10V
2) This figure is produced at a nominal scale of 1:13,000 for 11" x 17" ("B" size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data source: ESRI, CDN Zinc Corp.
4) Contour Interval: 10 M.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads are indicated. Additional information can be reviewed in the report.

Title: Access Road Avalanche Paths and Areas
Client: Prairie Creek Mine
Prepared by: Alpine Solutions
1:13,000 Scale
24 Dec 2018
CC, BG
BG

Legend:
- ACCESS ROAD (161129)
- ACCESS ROAD (130228)
- Winter Alignment 2018 (Approx.)
- Major Crossing
- Avalanche Path or Area

Map Notes:
- Map is meant to be read with the accompanying report.
1) Datum: NAD83 Projection: Transverse Mercator UTM Zone: 10V
2) This figure is produced at a nominal scale of 1:11" X 17" (A4) size paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: Esri, CDN Zinc Corp.
4) Contour Interval: 10 M.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine are shown. All proposed mine locations are shown on format.
1) DATUM: NAD83 PROJECTION: TRANSVERSE MERCATOR UTM ZONE: 10V
2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:13,000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTtinGS OR PRINTED PAPER SIZE.
3) IMAGE/DATA SOURCE: ESRI, CDN ZINC CORP.
4) CONTOUR INTERVAL: 10 M.
5) THIS MAP IS MEANT TO BE READ WITH THE ACCOMPANYING REPORT.
6) ONLY AVALANCHE PATHS AND AREAS THAT AFFECT THE PRAIRIE CREEK MINING AREA ARE SHOWN ON THIS MAP.
1) Datum: NAD83 Project: Transverse Mercator. UTM Zone: 10V
2) This figure is produced at a nominal scale of 1:11"x17" ("B" Size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: ESRI, CDN Zinc Corp.
4) Contour Interval: 10 M.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads and associated infrastructure are shown on this map.

Title: Access Road
Avalanche Paths and Areas

Scale: 1:13,000

Date: 24 Dec 2018

Client: CC, BG
Prepared by: Alpine Solutions

Legend:
- ACCESS ROAD 191125
- ACCESS ROAD 130226
- Winter Alignment 2018 (Approx.)
- Major Crossing
- Avalanche Path or Area
1) Datum: NAD83 Projection: Transverse Mercator UTM Zone: 10V
2) This figure is produced at a nominal scale of 1:13,000 (for 11" x 17" (" B" size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: Esri, CDN Zinc Corp.
4) Contour Interval: 10 M.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads and major infrastructure are indicated on this map.
1) DATUM: NAD83 PROJECTION: TRANSVERSE MERCATOR (UTM) 10V
2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:13,000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
3) IMAGE/DATA SOURCE: ESRI, CDN ZINC CORP.
4) CONTOUR INTERVAL: 10 M.
5) THIS MAP IS MEANT TO BE READ WITH THE ACcompanyING REPORT.
6) ONLY AVALANCHE PATHS AND AREAS THAT AFFECT THE PRAIRIE CREEK MINING PROJECT ARE SHOWN ON THIS MAP.
1) DATUM: NAD83 PROJECTION: TRANSVERSE MERCATOR (UTM)
2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:13,000 FOR 11" X 17" (B SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
3) IMAGE/DATA SOURCE: ESRI, CDN ZINC CORP.
4) CONTOUR INTERVAL: 10 M.
5) THIS MAP IS MEANT TO BE READ WITH THE ACCOMPANYING REPORT.
6) ONLY AVALANCHE PATHS AND AREAS THAT AFFECT THE PRAIRIE CREEK MINING AREA ARE SHOWN ON THIS MAP.
POST-EA INFORMATION PACKAGE INCLUDING AN UPDATED PROJECT DESCRIPTION
ALL SEASON ROAD TO PRAIRIE CREEK MINE

APPENDIX 22-2

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
PRAIRIE CREEK MINE

AVAILANCHE SAFETY PLAN
DRAFT

V.181224
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Executive Summary

This draft Avalanche Safety Plan (ASP) outlines the framework to manage avalanche risk to workers travelling on the Prairie Creek Mine access road. The plan assumes that Canadian Zinc Corporation (CZN) will engage a qualified avalanche risk management services company(s) to provide risk management services based on the policies and procedures described in this document.

This document includes:

- Avalanche safety training for workers.
- Check-in procedures.
- Avalanche rescue equipment.
- Operational avalanche hazard forecasting and communication by a qualified Avalanche Technician.
- Road closures during periods of high avalanche hazard.
- Optional direct avalanche hazard mitigation through artificial (explosive) triggering.

This draft ASP also specifies infrastructure requirements including:

- Weather stations.
- Avalanche detection system.
- Communications equipment.
- Avalanche area signs.

The scope of this ASP is expected to be expanded as more specific details of the mine operations become available. Furthermore, this draft ASP is a living document and is required to be reviewed on an ongoing basis to reflect improvements and changes as they are implemented.
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List of Acronyms

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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ASP</td>
<td>Avalanche Safety Plan</td>
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<tr>
<td>CZN</td>
<td>Canadian Zinc Corporation</td>
</tr>
<tr>
<td>CAA</td>
<td>Canadian Avalanche Association</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>HS</td>
<td>Height of the Snowpack</td>
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Glossary of Terms

**Avalanche:** Specifically refers to snow avalanche.

**Snow avalanche:** A volume of snow, usually more than several cubic meters, moved by gravity at perceptible speed. Snow avalanche may contain rock, broken trees, ice or other material.

**Avalanche path:** A fixed locality within which avalanches start, run and stop. Paths consist of a starting zone, a track and a runout zone and sometimes an air blast zone. Also includes road side cutslopes or openings that sluff or slide into the ditch, and/or onto the road.

**Avalanche terrain:** The area and topography within the physical boundary of the potential formation, movement and effect of an avalanche.

**Avalanche forecasting:** The prediction, over a specified scale of terrain, of current and/or future avalanche hazard/risk based on the expected likelihood of triggering, avalanche size and runout extent.

**Avalanche size:** A reporting system for observed avalanches based on the estimated potential destructive effects (McClung and Schaeerer, 2006).

**Avalanche frequency:** The expected (average) number of avalanches per unit of time reaching or exceeding a location. Normally it has units of avalanche(s) per year(s) and is expressed as a ratio (e.g. 1:1, 1:3, 1:10, 1:30 etc.) This is determined from empirical evidence in the field, avalanche occurrence records.

**Avalanche risk:** Avalanche risk is the probability or chance of harm resulting from interactions between avalanche hazard and specific element(s) at risk. Avalanche risk is determined by the exposure of that element, and its vulnerability to the avalanche hazard.

**Avalanche hazard:** A source of potential harm or loss. The potential for an avalanche(s) to cause damage to something of value. It is a function of the likelihood of triggering or frequency, and the avalanche size or magnitude.
**Avalanche hazard assessment:** A process that includes the steps of avalanche hazard identification, analysis and evaluation. It involves the data collection and study of environmental conditions that contribute to the hazard. In **planning**, it includes an estimation of the probabilities and the dimensions of the physical impact of potential avalanches. In **operations**, it involves the systematic observation, monitoring, and investigation of avalanche activity, snowpack and weather conditions. Each process is evaluated to specific criteria to rate the hazard.

**Avalanche season:** The snowpack depth within an avalanche area reaches threshold. The avalanche season for Prairie Creek Mine **begins on October 1st and ends May 31st**. An Avalanche Technician may make the determination of when the avalanche season begins and when the season ends based on the avalanche risk for a particular avalanche area or avalanche path.

**Avalanche threshold:** When the snowpack within avalanche areas becomes deep enough to create an avalanche risk to the highway user.

**Avalanche rescue cache:** A location proximal to an avalanche area where avalanche rescue equipment is stored.

**Facets and depth hoar:** Faceting is a metamorphic process that occurs within the snowpack at the individual snow grain-scale when there is a strong temperature gradient (i.e. > 1 °C over 10 cm) within the snowpack. The faceting process builds angular grains, called **facets**, which bond relatively poorly to one another and other grains creating a snowpack (or layer) that is becomes increasingly weak while the process is ongoing. If the faceting process continues, large, six - sided hollow or filled cup shaped grains called **depth hoar** are formed.
Disclaimer, Uncertainty and Limitations

The intent of this draft Avalanche Safety Plan (ASP) is to outline the framework to manage avalanche risk to workers travelling on the Prairie Creek Mine access road. The plan assumes that Canadian Zinc Corporation (CZN) will engage a qualified avalanche risk management services company(s) to provide avalanche training and risk management services based on the roles described in this document. The scope of this ASP is expected to be expanded as more specific details of the mine operations become available.

Avalanches are a natural phenomenon, and consequently have a varying degree of unpredictability and uncertainty. Although risk cannot be eliminated completely, it can be reduced by measures outlined in this ASP, which follows industry best practices.

Avalanche risk management service companies can only provide advice, and it is the responsibility of CZN and its contractors to implement that advice. Furthermore, if recommendations for risk management (e.g. closure of the road) are made, the authority and final decision to implement any of their recommendations resides with the responsible manager.

This draft ASP is a living document and is required to be reviewed on an ongoing basis to reflect improvements and changes as they are implemented. This ASP is not intended for third parties, which may include recreational visitors, or any other member of the public. Although other geohazards exist in the region, risk reduction measures outlined in this ASP are limited exclusively to snow avalanches. In addition, any artificial or natural alteration of the landscape or terrain due to forest fire, landslides, or other geotechnical event may change the nature of avalanche hazard, potentially necessitating a change in protocols or procedures for the area affected.
1 Introduction

1.1 Background

The Prairie Creek Mine is a zinc-silver-lead mine located in the South Mackenzie Mountains, approximately 550 km west of Yellowknife, Northwest Territories (NWT) (Figure 1-1). In 2012, Alpine Solutions Avalanche Services conducted a preliminary avalanche risk assessment for permitting and operational planning purposes (Alpine Solutions, 2012). The assessment, and subsequent revised mapping (Alpine Solutions, 2018), identified avalanche paths or areas that can potentially pose risk to workers travelling on the Prairie Creek Mine access road (Appendix A). Based on recommendations made in that report, and suggestions outlined in a recent Environmental Assessment (EA) review, Canadian Zinc Corporation (CZN) requested Alpine Solutions complete an avalanche safety plan (ASP).

![Figure 1-1 Prairie Creek Mine location.](image)

This draft ASP focuses on, and is limited to, workers and equipment (i.e. vehicles and heavy machinery) travelling on the access road, as shown in Appendix A.

Risk management measures contained within this draft ASP reflect the priority to complete necessary work, while maintaining risk levels consistent with other hazards that workers are exposed to.
2 Physiography

2.1 Location and Terrain

The Prairie Creek Mine site is located on the east side of Prairie Creek, approximately 43 km upstream from the confluence with the South Nahanni River. The access road will extend approximately 170 km from the Mine to the Nahanni Butte access road, which is 10 km from the Liard Highway. For the purpose of this plan, the access road is separated into two segments:

1. The ‘mountain segment’ which extends from the mine site to Cat Camp at km 40.
2. The ‘non-mountainous segment’ which extends from Cat Camp to the Nahanni Butte access road.

Avalanche hazard affecting the road was only identified along the first segment from the Mine site to Cat Camp. Avalanche terrain was noted on the east side of the Grainger River at Grainger Gap (123 km from the Mine site), but avalanches were not estimated to affect the current road alignment.

The mountain segment of the access road extends north from the mine site (900 m elevation) along the east side of Prairie Creek for approximately 7 km before heading east along the Funeral Creek valley to treeline elevation (1300 m elevation) at approximately 13 km from the Mine site. From here it extends over a pass at 1600 m between Funeral and Sundog Creek tributary valleys. The road then extends 25 km down the Sundog tributary and Sundog Creek drainages to Cat Camp (800 m elevation), approximately 40 km from the Mine site. The remainder of the route mainly heads in a southeasterly direction in primarily non-mountainous terrain before reaching the Liard Highway.

2.2 Snow Climate

The mountain segment of the Prairie Creek winter road is located in the southern region of the Taiga Cordillera, a cold continental climate zone just south of the Arctic. Winter conditions are expected to be generally cold and dry, and are interspersed with short periods of moderate temperatures and snowfall.

The area typically experiences monthly average temperatures below 0°C from October through April, with monthly averages near -20°C to -25°C during December through February. Precipitation data suggests that the area receives the majority of its annual snowfall during October and March. Wind is predominantly from the west. Normally the area experiences three to five precipitation events in the fall (October through early November), followed by a long stable period from November through February. Precipitation returns in March and April with typically another eight to ten precipitation events. Rain-on-snow events are expected in April when temperatures begin to reach daytime highs above freezing.

The effect of wind and topography in the area is estimated to influence snowpack height and distribution significantly. As a result, windward (typically westerly) slopes are likely to be heavily
scoured, possibly to ground in some areas, while leeward (typically easterly) slopes will be loaded and is likely to form thick wind slab. Experience with this type of landscape and climate regime suggests leeward avalanche starting zones may have three to ten times the valley bottom snowpack height, depending on slope shape and proximity to ridge crests. Average snowpack height is estimated to be greatest near the pass separating Funeral Creek and Sundog tributary.

Considering the long periods of cold dry weather, the snowpack is expected to be shallow and weak, characterized by layers of depth hoar and facets throughout the entire snowpack. As a result, avalanches which affect the road will likely be usually full-depth releases, which normally would not occur more than once per year. Although large size avalanches (which run full path) would usually only be expected in late winter or spring, smaller early season avalanches, which occur in October and November, could still present hazard to personnel and vehicles transiting the road.

### 2.3 Avalanche Season

Avalanche season is the period of time when avalanches may potentially affect exposed elements at risk. This time period is not constant as it depends primarily on snowpack depth in avalanche starting zones which varies on an annual basis. Although avalanche season typically begins in the late fall and ends in late spring, for the purposes of this ASP it is assumed that **avalanche season begins on October 1st and ends May 31st**. However, an Avalanche Technician can be consulted to determine whether it is currently avalanche season.

### 3 Operational Priorities and Assumptions

The priority of this draft ASP is to ensure avalanche risk is low to workers travelling on and associated with the access road while minimizing disruption to mine operations. Avalanche risk management is accomplished through a combination of procedures which potentially include:

- a) avalanche safety training,
- b) safe travel practices,
- c) avalanche hazard forecasting and area closures, if necessary, and
- d) direct control of avalanche hazard through the use of artificial (e.g. explosives) triggering.

Currently, workers are assumed to be only persons travelling on the access road in vehicles or equipment. Avalanche Technicians referred to in this document are qualified professional avalanche personnel that have Canadian Avalanche Association (CAA) Level 2 certification as a minimum. A Qualified Person must have CAA Level 3 certification (or similar professional designation) as a minimum.
3.1 Roles and Responsibilities

The success of this draft ASP is contingent on mutual efforts by CZN’s or contractor’s health and safety supervisors and workers, as well as the avalanche risk management service company’s personnel. The following outlines the roles and responsibilities of the parties involved:

3.1.1 Health and Safety Supervisors

Health and safety supervisors are responsible for:

- Ensuring all workers follow the policies and procedures contained in this draft ASP.
- Providing workers with the resources needed to follow the policies and procedures contained in this ASP (i.e. avalanche safety training, rescue equipment and advanced rescue response resources).

3.1.2 Workers

Workers are responsible for:

- Following the operational procedures outlined in this draft ASP.
- Ensuring they are familiar with daily avalanche related work restrictions.
- Avoiding working alone during avalanche season unless an Avalanche Technician deems it to be safe.
- Stop all work immediately if they ever feel unsafe and report the unsafe conditions to their supervisor.

3.1.3 Avalanche Risk Management Service Company

Qualified avalanche personnel provided by an avalanche risk management services company will be necessary to provide ongoing services to manage avalanche risk including:

- Determine the beginning and end of avalanche season, and whether a threshold for avalanches (minimum snowpack depth) has been reached.
- Provide avalanche bulletins with forecast of avalanche hazard during avalanche season and providing recommendations for closure, if necessary, or other avalanche risk mitigation measures.
- Provide training on avalanche awareness and rescue procedures to all workers who will be working in avalanche terrain.
- Provide on-site mitigation, including avalanche explosive control, if requested.
- Provide a CAA Professional Member (Qualified Person) to approve the risk management plan for the contractors they are managing risk for.
- Provide Avalanche Technicians as necessary with a minimum of CAA ‘Level 2’ certification, as well as valid advanced first aid certification.

3.2 Training

Unless approved by the avalanche risk management services company, or accompanied by an Avalanche Technician, any worker who will be travelling on the access road during
avalanche season is required to attend an avalanche awareness training course that includes the following topics:

- Formation and nature of avalanches;
- Avalanche terrain;
- Avalanche risk management policy and procedure;
- Contact information for Avalanche Technician guidance;
- Safe travel procedures through avalanche areas; and
- Avalanche rescue practice using avalanche rescue equipment.

Normally this course would take 4 hours. If it has been at least one year since attending a course, an avalanche rescue refresher must be completed.

Training is not required for workers accompanied by an Avalanche Technician in an avalanche area.

4 Operational Risk Management Procedures

4.1 Avalanche Hazard Bulletins

Daily avalanche hazard bulletins will be produced by an Avalanche Technician from an analysis of weather, snowpack, and avalanche information. This information will be primarily gathered from in-situ observations by an Avalanche Technician or designate at the site.

Daily avalanche hazard will be communicated to project managers, and any other recipients requested, in the form of an Avalanche Hazard bulletin (Appendix E). The bulletin should be posted and relayed to any workers travelling the road in the morning, normally during any safety briefing that is occurring. The avalanche hazard bulletin includes the forecasted avalanche hazard level, based on the three-level avalanche hazard scale (Appendix E), and an associated weather forecast. The bulletin also lists any road closures, travel restrictions and planned avalanche control for the current day. The bulletin should be posted, and relayed to the daily work crew in the morning safety briefing. In addition, avalanche hazard signboards should be updated as soon as possible after the bulletin has been received.

4.2 Avalanche Blocking Road

Avalanche deposits can block a road, making it impassable for vehicles. In addition, avalanches directly impacting vehicles have the potential to push the vehicle off the opposite side of the road. Specific safety procedures for travelling through avalanche paths in vehicles include:

- If you are following another vehicle, make sure there is at least 100 m between you and the vehicle in front of you.
- Do not stop in an avalanche area, as indicated by signs along the road (Figure 5-1). If you need to stop in the avalanche area (e.g. due to road conditions or blockage),
remain in your vehicle, or carefully exit the vehicle on the downslope side of the vehicle, if possible, and exit the avalanche path by foot until the avalanche hazard can be assessed by an Avalanche Technician.

If you are buried in a vehicle, follow the procedures outlined in the Avalanche Rescue Card (Appendix C).

If an avalanche occurs and blocks a road at any time, it is important to immediately notify a Mine site safety representative, and/or avalanche personnel. If avalanche personnel are not available, assume other avalanche paths could also be triggered and block the road. All traffic should exit the avalanche area immediately or stop away from the avalanche debris, and wait for further instructions.

If Avalanche Personnel are available, they must be contacted immediately. Contact information should be provided on the daily Hazard Form.

If workers are trapped in between avalanche paths, they may have to remain there until avalanche personnel are contacted. If conditions are suitable for a helicopter, it may be possible to have workers transported away from the zone via helicopter. At no point should any workers exit their vehicles or walk over avalanche debris without authorization from avalanche personnel.

4.3 Check-in Procedures

Working in remote terrain can present added risk to personnel if an accident occurs. Not only are remote worksites further from emergency services, but also emergency services may not be notified if no individual is able to call them when an accident occurs. Typical mitigation for this type of risk normally involves the use of interval check-in procedures.

All personnel working in or travelling through avalanche paths should follow Prairie Creek Mine check-in procedures as a minimum, unless otherwise specified by an Avalanche Technician. We understand that CZN intends to use GPS-tracking devices on Mine vehicles using the road. This may obviate the need for some check-ins.

4.4 Noting Avalanche Activity

Avalanche observations help avalanche technicians to improve avalanche forecasting accuracy. For this reason, workers should note all avalanches that they observe during their regular work. Established avalanche observation guidelines are available from the CAA (2016), and should be used when possible. Specific items to be noted include:

- Date/time of observation.
- Location or path name.
- Date of the avalanche (estimated if unknown).
- Destructive size (Table 4-3).
- Dimensions of the avalanche (estimated if unknown).
If possible, large scale (wide angle) photographs of the avalanche should be taken and kept in a file of avalanche records.

### Table 4-3 - Canadian classification system for avalanche size (McClung & Schaerer, 2006).

<table>
<thead>
<tr>
<th>Size</th>
<th>Destructive Potential</th>
<th>Typical Mass (tonnes)</th>
<th>Typical Path Length (m)</th>
<th>Typical Impact Pressures (kPa)</th>
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<tr>
<td>1</td>
<td>Relatively harmless to people.</td>
<td>&lt; 10</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Could bury, injure or kill a person.</td>
<td>$10^2$</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Could bury a car, destroy a small building, or break a few trees.</td>
<td>$10^3$</td>
<td>1000</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares.</td>
<td>$10^4$</td>
<td>2000</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>Largest snow avalanches known. Could destroy a village or a 40 ha forest.</td>
<td>$10^5$</td>
<td>3000</td>
<td>1000</td>
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#### 4.5 Established Worksite in an Avalanche Path

If a situation arises in which an established worksite must be developed, either in or adjacent to an avalanche path, a more detailed set of operational procedures, equipment, and rescue plan would need to be created as an addendum to this plan. This normally would be developed under the guidance of a Qualified Person. Specific details in the addendum may include:

- Revised decision-making procedures.
- Avalanche control procedures.
- Designated avalanche personnel required on site.
- Rescue resources not already indicated in this plan.

#### 4.6 Avalanche Explosive Control

Typically avalanche risk control incorporates road closures during periods of high avalanche hazard. An avalanche explosive control plan may be required to reduce closure times and maintain schedule. This plan would normally be included as an appendix to the ASP, and include documentation regarding the storage, transportation and type of explosives, as well as detailed procedures for avalanche explosive control. Typically, the blasting plan includes the following sections:

- Blasting personnel.
- Transportation of explosives.
- Handling of explosives.
- Management of the danger area, and associated elements at risk (e.g. people, equipment, wildlife, etc.).
• Record keeping.
• Misfire disposal procedures.
• Incident reporting.
• Operational procedures.
• Emergency response plan.
• Letter of approval by agency with blasting jurisdiction.

A list of the regulations, protocols, acts, and standards is provided in Appendix F.

5 Equipment and Infrastructure Requirements

5.1 Snow and Weather

Snowpack and weather monitoring stations used for assessing avalanche conditions should be established at select locations within the project area. The existing weather station located at valley bottom near the mine site provides temperature, wind, and humidity information. Additional instrumentation that is expected to be added includes telemetry, a precipitation gauge that can measure snow water equivalent, and a snow depth sensor if possible. Alternatively, a manual weather station should be established at the Mine site with the following equipment:

• Thermometers with ability to log maximum and minimum values. Snow boards for measuring accumulated snowfall amounts at specified time intervals.
• Snowpack height (HS) stake.

In addition, an automated ridgetop weather station with an anemometer, thermometer, as well as telemetry should be established.

5.2 Communications

Very High Frequency (VHF) radio systems are important for communicating updates on avalanche hazard and for emergency response. Satellite phones may also be incorporated, depending on the communication requirements.

5.3 Avalanche Detection System

An avalanche detection system enables remote monitoring of avalanche activity in order to assist with avalanche hazard forecasting. It can alert Avalanche Technicians of avalanche occurrences in specific avalanche paths as well as trigger automatic gates or traffic lights that close the road if an avalanche is detected. In the case of the Prairie Creek road, it could alert drivers by satellite link to not enter any avalanche areas until the area has been assessed by an avalanche technician.

The Wyssen Avalanche Control GINA® system is a cost-effective geophone-based detection system that can be equipped with a battery and solar or fuel cell power supply and narrow-
band radio communications. Supplier information for the GINA system is provided in Appendix G.

5.4 Avalanche Area Indicator Signs

Avalanche area indicator signs should be located at all access points to an avalanche hazard area. For access road hazard areas, they normally indicate not to stop, as shown in Figure 5-1. Corresponding “End of Avalanche Area” signs can also be used.

![Avalanche Area Indicator Signs](image)

**Figure 5-1: Example of a roadside signs indicating the start and end of an avalanche area.**

### Avalanche Path Number Signs

Signs indicating the avalanche path number are in place at the beginning of each avalanche path defined in the avalanche atlas (Figure 5-2). These signs are typically mounted to trees and on the uphill side of the road.

![Avalanche Path Number Sign](image)

**Figure 5-2: Avalanche path sign**

5.5 Avalanche Transceivers

Avalanche transceivers should be used for any small vehicles (1 ton or smaller), and should be worn and turned on (in send mode) before travelling through an avalanche area. They should be worn around the upper torso as suggested by the manufacturer and under any outer
layers of clothing. Transceivers need to be tested for proper functioning (send and receive) before each use. Avalanche transceivers are not required to be worn by drivers of larger vehicles, including transport trucks, and large mine vehicles. However, there should be one transceiver per vehicle, switched on.

Normally a transceiver used on a daily basis will need replacement batteries two to three times per season. Transceiver batteries need to be replaced as per manufacturer’s recommendations. Alkaline batteries are required (rechargeable batteries must not be used), and date of battery replacement should be recorded on a label attached to the unit. In order to increase battery life, transceivers should be turned off when not in use.

5.6 Avalanche Rescue Cache

Equipment contained in an avalanche rescue cache includes items listed in Appendix B, and is normally located at sites designated by the Avalanche Technician, or technician team. All equipment should be stored in portable packs (with the exception of those items which will not fit in packs, e.g., long-handled shovels and one-piece probes). Equipment should be located in a clean, dry environment either at the site office, or in unlocked weatherproof boxes at specified locations along the access road. Boxes should be on an adjustable height pedestal to ensure they do not get buried with snow (Figure 5-2).

Tags listing the pack contents are normally attached to the outside of each pack. The equipment may be sealed with an easily removable seal. The seal must not restrict use during a rescue operation but it will allow for easy checking for cache tampering and equipment replenishment.

Signs indicating the locations of avalanche rescue caches should be in plain view.
6 Emergency Response
In the event of avalanche involvement, a rescue will need to be initiated immediately. **TIME IS OF THE ESSENCE.** If people are buried in a vehicle, they may have several hours of oxygen available to survive provided they are not injured. If they are buried on foot, then they may only have 10-15 minutes, or less.

Rescuer safety is of paramount importance in an avalanche rescue. Under no circumstance should a rescue party enter an avalanche area unless it is deemed low risk. If in doubt, wait for guidance from a qualified avalanche professional or Search and Rescue group with avalanche personnel.

There are 3 separate documents that make up the overall avalanche rescue plan

1. **Immediate Action Plan** – for those involved in, or witnessing an avalanche
2. **Incident Commander Plan** – for the site rescue leader
3. **Base Rescue Leader Plan** – for base/office personnel
The **Immediate Action Plan** is a one-page (two sided) card format that should be in every vehicle, and at worksites available for crews working in avalanche areas. It should be given to all workers entering the area.

The **Incident Commander Plan** should be available to safety personnel (in vehicle and office), and in first party rescue packs.

The **Base Rescue Leader Plan** should be at the base office and used by personnel with access to outside phone lines.

Each of these plans is presented separately in Appendix C so they can be copied or printed out, and made easily available.

### 7 Quality Assurance

Information included in this document should be reviewed annually prior to the commencement of avalanche season.
8 Closure

This document was prepared by Alpine Solutions Avalanche Services for the sole use and benefit of Canadian Zinc Corporation and its contractors for the Prairie Creek Mine. The material in it reflects Alpine Solutions best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this risk management plan, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this risk management plan.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending Alpine Solutions written approval. If this document is issued in an electronic format, an original paper copy is on file at Alpine Solutions and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

Cam Campbell, M.Sc., Eng.L.
Senior Avalanche Specialist
References


Appendix A – Avalanche Path Maps
1) DATUM: NAD83 PROJECTION: TRANSVERSE MERCATOR UTM Zone: 10V
2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:11" X 17" ( "B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
3) IMAGE/DATA SOURCE: ESRI, CDN ZINC CORP.
4) CONTOUR INTERVAL: 100 FT.
5) THIS MAP IS MEANT TO BE READ WITH THE ACCOMPANYING REPORT.
6) ONLY AVALANCHE PATHS AND AREAS THAT AFFECT THE PRAIRIE CREEK MINE ACCESS AND ASSOCIATED CROSSING INFRASTRUCTURE ARE INDICATED ON THIS MAP.
1) Datum: NAD83 Projection: Transverse Mercator - UTM Zone 10V. 
2) This figure is produced at a nominal scale of 1:13,000 for 11" x 17" (B) size paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: ESRI, CDN Zinc Corp.
4) Contour Interval: 10 m.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads and associated structures have been indicated on this map.
1) Datum: NAD83 Projection: Transverse Mercator - UTM Zone 10V (UTM Grid North, Central Meridian at 100W, False Easting 0)

2) This figure is produced at a nominal scale of 1:13,000, printed on 11"x17" paper. Actual scale may differ according to changes in printer settings or printed paper size.

3) Image/Data Source: Esri, CDN Zinc Corp.

4) Contour Interval: 10 m.

5) This map is meant to be read with the accompanying report.

6) Only avalanche paths and areas that affect the Prairie Creek Mine are shown. Additional information can be found in the accompanying report.
1) Datum: NAD83 Projected: Universal Transverse Mercator. UTM Zone: 10V
2) This figure is produced at a nominal scale of 1:13,000 for 11" x 17" (A size) paper. Actual scale may differ according to printer settings or printed paper size.
3) Image/Data Source: ESRI, CDN Zinc Corp.
4) Contour Interval: 10 M.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine access roads and/or structures are indicated on this map.
LEGEND

ACCESS ROAD 161126
ACCESS ROAD 130226
WINTER_ALIGNMENT2018 (APPROX.)
MAJOR CROSSING
AVALANCHE PATH OR AREA

MAP NOTES:
1) DATUM: NAD83 PROJECTION - WERNER MERCATOR (UTM) - UTM PROJECTED COORDINATES OF A HOVERING GPS COORDINATE SIGNED TO DATUM WGS84

2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:13,000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

3) IMAGE/DATA SOURCE: ESRI, CDN ZINC CORP.

4) CONTOUR INTERVAL: 10 M.

5) THIS MAP IS MEANT TO BE READ WITH THE ACCOMPANYING REPORT.

6) ONLY AVALANCHE PATHS AND AREAS THAT AFFECT THE PRAIRIE CREEK MINING AREA AND ADJACENT INFRASTRUCTURE ARE OBSERVED ON THIS MAP.

TITLES:

ACCESS ROAD AVALANCHE PATHS AND AREAS

PRAIRIE CREEK MINE
1) Datum: NAD83 Projection: Transverse Mercator
2) This figure is produced at a nominal scale of 1:13,000 for 11" x 17" ("B" size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
3) Image/Data Source: Esri, CDN Zinc Corp.
4) Contour Interval: 10 M
5) This map is meant to be read with the accompanying report.
6) Access road, avalanche paths, and areas that affect the Prairie Creek Mine are shown in this map. A detailed description of these areas is provided in the report.
1) Datum: NAD83 Projection: Transverse Mercator UTM Zone: 10V
This figure is produced at a nominal scale of 1:13,000 for 11"x17" ("B" size) paper. Actual scale may differ according to changes in printer settings or printed paper size.
2) Image/-data source: ESRI, CDN Zinc Corp.
3) Contour interval: 10 m.
4) This map is meant to be read with the accompanying report.
5) Only avalanche paths and areas that affect the Prairie Creek Mine Access Roads and associated infrastructure are indicated on this map.
1) Datum: NAD83 Projection UTM Zone 10V
2) This figure is produced at a nominal scale of 1:13,000 for 11" x 17" Size. Actual scale may differ according to changes in printer settings or printed paper size.
3) Imagination/Source: Esri, CDN Zinc Corp.
4) Contour Interval: 10m.
5) This map is meant to be read with the accompanying report.
6) Only avalanche paths and areas that affect the Prairie Creek Mine Access Roads and associated crossings. Remaining areas are not illustrated on map.
Appendix B – Avalanche Rescue Equipment Cache

The following is a sample list of equipment for avalanche rescue caches.

- 6 X 3.2 m collapsible probes
- 2 Short - handled Rescue shovels - "D" handle preferred
- Basic first aid kit in weatherproof case
- 6 Headlamps - new batteries each winter - remove each spring
- Tarp
- Blanket
- 4 Chemical heat packs
- 25 marker wands
- 1 roll of flagging tape
- 6 spare Avalanche Transceivers
- Fox 40 whistle or Air horn.
- Solid section probes – 3.2 m X ½” rigid conduit
- 4 Steel spade shovels
Appendix C - Avalanche Rescue Plan

TIME IS OF THE ESSENCE IN AVALANCHE RESCUE
VICTIMS RECOVERED WITHIN 10 MINUTES HAVE A 90% CHANCE OF SURVIVAL

There are three main components for an avalanche rescue each with its own corresponding plan. In small minor avalanche incidents, one person may assume all three roles. However, in larger avalanche incidents, the rescue may scale up to have many people involved with each component:

a) **Rescue Leader** – on-site and immediate rescue response. Direct communication with Incident Commander.

b) **Incident commander (IC)** – coordinate communication and resources from Rescue Leader to Base Rescue Leader. On-site if possible.

c) **Base Rescue Leader** – coordinates and initiates outside resources if required. Direct communication with Incident Commander.

The following rescue plan documents and checklists will assist personnel who are involved in, or witness an avalanche incident:

a) **Avalanche Rescue Card**

This is a quick reference card (2-sided) for use if you are involved in, or witness an avalanche incident. Print, laminate and keep a copy in all vehicles and field packs.

b) **Incident Commander Plan**

Actions to be taken by the Incident Commander (IC) to initiate the rescue response at the accident site.

c) **Base Rescue Leader Plan**

Actions to be taken by a Base Rescue Leader in coordination with the Incident Commander.
There are three possible scenarios where personnel could be required to respond to an avalanche incident:

1) An avalanche incident occurs within a work crew, where a worker is buried and must be rescued by the other members of the same work crew.

2) An avalanche incident occurs within one work crew, and another work crew situated nearby must respond and undertake the rescue.

3) An avalanche incident occurs to a third-party, and a work crew either happens upon it, or responds from a nearby worksite.

Keep this rescue plan in your vehicle or at the base of operations for reference during an emergency response. It is recommended that you print and laminate the avalanche rescue card for quick reference in the field.
AVALANCHE RESCUE CARD

STAY CALM - CALL FOR HELP
INITIATE RESCUE – DO NOT GO FOR OUTSIDE HELP

1) CALL FOR HELP: use phone or radio if possible

2) Choose/assign a RESCUE LEADER

3) ASSESS SAFETY and use appropriate measures:
   - Risk of further avalanche
   - Route safety
   - Avalanche guard/signal

4) Head count: HOW MANY MISSING?

5) Identify/mark LAST SEEN POINT

6) Turn all TRANSCEIVERS TO RECEIVE

7) Determine the SEARCH AREA:
   - Below last seen point
   - Areas where snow has accumulated

8) Prioritize search area if necessary:
   - Fall line below last seen point
   - In line with clues
   - Areas where snow has accumulated

9) SIGNAL SEARCH:
   - 40 m search strip width
   - Look/listen to transceiver
   - Investigate visual clues
   - Take probe, shovel, first aid gear

10) Transceiver signal: start coarse search, MOVE FAST

11) Fine search: MOVE SLOW and bracket

12) PROBING:
   - Systematic probing pattern
   - Leave probe in snow after probe strike

13) SHOVEL: AS FAST AS POSSIBLE
   - Dig from below and towards tip of probe
   - Change shovellers often
   - Be careful near the end of probe

14) PATIENT CARE: treat for hypothermia/shock/injuries, and GROUP SAFETY. Watch for hypothermia/fatigue.

IF YOU ARE BURIED IN A VEHICLE, do the following:
1. Shut off the engine and lights
2. DO NOT smoke
3. NOTIFY others on the radio
4. If you are wearing an avalanche transceiver, check to make sure it is on
5. Turn your four way flashers on
6. Honk briefly 2-3 times/minute
7. If you are completely buried, try pushing a probe out of the snow
8. Stay calm and wait to be rescued

DO NOT GET OUT OF VEHICLE TO DIG YOURSELF OUT, AS ANOTHER AVALANCHE COULD COME DOWN. WAIT FOR INSTRUCTIONS FROM SAFETY OFFICER OR AVALANCHE PERSONNEL

Images courtesy of BACKCOUNTRY ACCESS
### INCIDENT COMMANDER PLAN

#### IMMEDIATE ACTION

**AS INCIDENT COMMANDER YOU LEAD THE OVERALL RESCUE RESPONSE**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Retain and interview witnesses. Confirm Accident particulars.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reported by/Witness: ________________________________ Time: __________</td>
</tr>
<tr>
<td>Step 2</td>
<td>Call 911; Notify base (or emergency contact); Initiate Rescue Plan.</td>
</tr>
<tr>
<td>Base Rescue Leader: ________________________________</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
<td>Choose a safe muster point and assemble the first rescue party. Ensure no further danger exists at accident site and dispatch first party with rescue packs.</td>
</tr>
<tr>
<td>Rescue Leader: ________________________________</td>
<td></td>
</tr>
<tr>
<td>Step 4</td>
<td>Contact base to request additional outside resources (PEP, RCMP, Medical)</td>
</tr>
<tr>
<td>Step 5</td>
<td>Maintain communications: log “in/out” personnel and equipment. Record details in <em>Rescue Resource / Personnel Log Sheet</em>.</td>
</tr>
</tbody>
</table>
# Initial Incident Report Form for Avalanche (Incident Commander)

1. **Date:**

2. **Time Accident Reported:**

3. ** Reported by:**

4. **Location of Accident:**
   (Avalanche Path / Zone Number)

5. **Time Accident Occurred:**

6. **# of Vehicles Caught:**

7. **# of People Caught:**

<table>
<thead>
<tr>
<th>Name of Victim(s)</th>
<th>Wearing a transceiver?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. _____________________________</td>
<td>Yes / No</td>
</tr>
<tr>
<td>2. _____________________________</td>
<td>Yes / No</td>
</tr>
<tr>
<td>3. _____________________________</td>
<td>Yes / No</td>
</tr>
<tr>
<td>4. _____________________________</td>
<td>Yes / No</td>
</tr>
<tr>
<td>5. _____________________________</td>
<td>Yes / No</td>
</tr>
<tr>
<td>6. _____________________________</td>
<td>Yes / No</td>
</tr>
</tbody>
</table>
# INCIDENT COMMANDER CHECKLIST

<table>
<thead>
<tr>
<th>Task</th>
<th>Time Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ First Party arrival time on scene</td>
<td>___________</td>
</tr>
<tr>
<td>□ Move all personnel to safe location</td>
<td>___________</td>
</tr>
<tr>
<td>□ Hold and question witness</td>
<td>___________</td>
</tr>
<tr>
<td>□ Re-evaluate avalanche hazard (consult avalanche technician)</td>
<td>___________</td>
</tr>
<tr>
<td>□ Establish a watchman with a warning signal (whistle)</td>
<td>___________</td>
</tr>
<tr>
<td>□ Establish an escape route</td>
<td>___________</td>
</tr>
<tr>
<td>□ Establish and mark the <strong>Last Seen Point</strong> (use witness)</td>
<td>___________</td>
</tr>
<tr>
<td>□ Once transceiver search finished, switch to “Send” mode</td>
<td>___________</td>
</tr>
<tr>
<td>□ Probe the entire avalanche (re-check likely areas)</td>
<td>___________</td>
</tr>
<tr>
<td>□ Organize systematic probe line</td>
<td>___________</td>
</tr>
<tr>
<td>□ Mark all probed areas with flagged wands</td>
<td>___________</td>
</tr>
<tr>
<td>□ Draw a sketch of the avalanche. Note all probed areas</td>
<td>___________</td>
</tr>
</tbody>
</table>

**KEEP SITE UNCONTAMINATED FOR RESCUE DOGS**
## ON-SCENE PERSONNEL LOG SHEET

<table>
<thead>
<tr>
<th>Name / Affiliation</th>
<th>Arrival Time</th>
<th>Departure Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
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<tr>
<td>4.</td>
<td></td>
<td></td>
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<tr>
<td>5.</td>
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<tr>
<td>6.</td>
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<td></td>
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<tr>
<td>7.</td>
<td></td>
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<tr>
<td>8.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
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<tr>
<td>10.</td>
<td></td>
<td></td>
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<tr>
<td>11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
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</tbody>
</table>
Map Sketch

Use this sheet to sketch the incident site. Indicate the avalanche boundaries including the starting zone and run out zone. Mark the last seen point and the location where the victim came to rest or was buried. If possible, **TAKE PHOTOS.**
**BASE RESCUE LEADER PLAN**

The **Base Rescue Leader** should have access to reliable phones, ideally in an office setting. The **Base Rescue Leader** must communicate with the **Incident Commander** on the scene and ensure they have the resources required.

<table>
<thead>
<tr>
<th>1. RECORD THIS INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Date:</strong></td>
</tr>
<tr>
<td><strong>2. Time Accident Reported:</strong></td>
</tr>
<tr>
<td><strong>3. Reported by:</strong></td>
</tr>
<tr>
<td><strong>4. Location of Accident:</strong></td>
</tr>
<tr>
<td>(ROW km, GPS location)</td>
</tr>
<tr>
<td><strong>5. Time Accident Occurred:</strong></td>
</tr>
<tr>
<td><strong>6. # of Vehicles Caught:</strong></td>
</tr>
<tr>
<td><strong>7. # of People Caught:</strong></td>
</tr>
<tr>
<td><strong>8. Weather conditions:</strong></td>
</tr>
<tr>
<td>Snowing?</td>
</tr>
<tr>
<td>Windy?</td>
</tr>
<tr>
<td>Visibility?</td>
</tr>
</tbody>
</table>
2. CALL FOR OUTSIDE RESOURCES IMMEDIATELY

Call **9-1-1** to activate POLICE, AMBULANCE, SEARCH and RESCUE (PEP), and AVALANCHE RESCUE DOG TEAMS.

Be clear “There has been an avalanche. We need local Search and Rescue and an avalanche rescue dog.”

For areas where 9-1-1 is not in effect, for non-emergencies, or for additional assistance call the resources listed in the emergency contact list on page 10.

<table>
<thead>
<tr>
<th>Avalanche Technicians (TO BE UPDATED BEFORE IMPLEMENTATION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Cam Campbell</td>
</tr>
<tr>
<td>Brian Gould</td>
</tr>
</tbody>
</table>
Appendix D - Emergency Contacts

Prairie Creek Mine– AVALANCHE Emergency Contact Information
(TO BE UPDATED BEFORE IMPLEMENTATION)

<table>
<thead>
<tr>
<th>Organization</th>
<th>Name</th>
<th>Location</th>
<th>Phone</th>
<th>Alternate Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avalanche Technician #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avalanche Technician #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZC Contact #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICZC Contact #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Response Organizations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMP</td>
<td></td>
<td>Provincial</td>
<td>911</td>
<td>867-669-1111</td>
</tr>
<tr>
<td>Parks Canada</td>
<td></td>
<td>National</td>
<td>1-877-852-3100</td>
<td></td>
</tr>
<tr>
<td>Avalanche Response Assistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helicopter Companies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Organizations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canadian Avalanche Centre</td>
<td></td>
<td>Incident reporting</td>
<td>Revelstoke</td>
<td>250-837-2141</td>
</tr>
</tbody>
</table>

Page 36
ALPINE SOLUTIONS AVALANCHE SERVICES
Appendix E – Avalanche Hazard Bulletin Example
# Prairie Creek Mine

## EXAMPLE Avalanche Hazard Bulletin

<table>
<thead>
<tr>
<th>Date/Time Issued</th>
<th>Avalanche Technician</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018/12/25 5:00 PM</td>
<td>Brian Gould</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Avalanche Hazard</th>
<th>Weather Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday, March 25</td>
<td>2 - MODERATE</td>
<td>Monday: Light precipitation with moderate SW winds at ridgetop. Freezing levels reaching 1000 m.</td>
</tr>
<tr>
<td>Tuesday, February 26</td>
<td>2 - MODERATE</td>
<td>Tuesday/Wednesday: Mainly sunny skies with few clouds. Freezing levels will hover around 900 m in the afternoon. Ridgetop winds will be light from the NW on Tuesday, then blowing light from the SW on Wednesday.</td>
</tr>
<tr>
<td>Wednesday, February 27</td>
<td>2 - MODERATE</td>
<td></td>
</tr>
</tbody>
</table>

| Road Status and Travel Advice | Do not stop in avalanche hazard areas. Notify avalanche technicians if any avalanches are observed. |

<table>
<thead>
<tr>
<th>Hazard Rating</th>
<th>Descriptions and Work Restrictions</th>
<th>Technician Contacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>Avalanches are unlikely to affect access road or worksites Standard work practices</td>
<td>Cam Campbell 778-868-5131 <a href="mailto:ccampbell@avalancheservices.ca">ccampbell@avalancheservices.ca</a></td>
</tr>
<tr>
<td>MODERATE</td>
<td>Small avalanches possible to affect the access road or worksites Large avalanches unlikely to affect the access road or worksites Check the hazard bulletin for specific restrictions in effect.</td>
<td>Brian Gould 604-815-8196 <a href="mailto:bgould@avalancheservices.ca">bgould@avalancheservices.ca</a></td>
</tr>
<tr>
<td>HIGH</td>
<td>Large avalanches likely to affect the access road or worksites Area closures in effect, unless approved/accompanied by an Avalanche Forecaster.</td>
<td>Julie McBride 604-202-0325 <a href="mailto:jmcbride@avalancheservices.ca">jmcbride@avalancheservices.ca</a></td>
</tr>
</tbody>
</table>
### Appendix F – Avalanche Explosive Regulatory Agencies

<table>
<thead>
<tr>
<th>Application</th>
<th>Agency/Regulation</th>
<th>Source</th>
</tr>
</thead>
</table>
Appendix G – Supplier information for GINA system
GINA ® Geophones in Avalanches

GINA ® enables the monitoring of avalanche activities in specific avalanche paths. Fully integrated into Wyssen Avalanche Control Center WAC.3, GINA ® is a cost-efficient solution to control individual areas.

Advantages

- Very reliable
- Direct detection avalanches
- Real time detection
- Independent of weather conditions, detection possible even in whiteout conditions

The geophone system consists of a central unit and one or more geophone sensing units. The central unit is responsible for communication with warning-systems while the sensing units continuously record and evaluate the ground vibrations.

Geophone central unit

The central unit communicates with attached warning-systems or traffic lights and connects to the servers through the mobile network. Normally powered by grid power, the central can also be equipped with battery and solar or fuel cell if no grid power is available.

Geophone sensing unit

The geophone sensing unit is designed to be a contained stand-alone unit which records and evaluates the ground vibrations continuously. Each geophone sensing unit contains the following components:

- Sensing element
- Optimized power electronics for continuous measurement
- Radio modem for communication to the base station
- Battery

The sensing element needs to be coupled with the ground. To achieve this, the unit is put into the ground and connected to a small box which contains the rest of the geophone sensing unit. The sensing unit samples the sensing element 80 times per second. The measurement is performed with a resolution of 24 bits and can detect very small vibrations. A simple but effective STA/LTA trigger is used to detect any event. The sensing unit doesn’t distinguish between avalanches or rockfall this filtering is done later in the base station.
Facts / Technical data

<table>
<thead>
<tr>
<th></th>
<th>fully integrated in our Wyssen Avalanche Control Center WAC.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>up to 50 m (165 ft)</td>
</tr>
<tr>
<td>Opening angle</td>
<td>360°</td>
</tr>
<tr>
<td>Communication</td>
<td>Mobile phone network or radio connection</td>
</tr>
<tr>
<td>Power supply</td>
<td>Grid power, solar or fuel cell</td>
</tr>
</tbody>
</table>

Local Algorithm

The basic STA/LTA trigger is defined as a threshold of the ratio between short term average (STA) and long term average (LTA). This results in a trigger which will catch all events of a certain magnitude while being unsusceptible to slow changes in ground vibration amplitude.

As soon as the trigger is activated the system wakes from its very low power state to a fully operational state and records all the data and sends as much as possible to the central unit. The central unit then has to decide whether there was an avalanche or whether it was some other sort of signal which activated the trigger.

Power

Even without any signal triggering, each geophone sensing unit will send a signal to the central unit every few hours to give a sign of live while not wasting too much power. Measurements show that the whole geophone sensing unit including communication and continuous measurement does consume a small power supply, less than 2 milliamperes. Therefore the most feasible power source is primary batteries which need to be replaced once per year. Primary batteries as a power supply are superior to most other forms of power supply in terms of withstanding low temperature and having low self-discharge.

Communication

The communication from the geophone sensing units to the central unit is done by a narrow band radio system. A narrow band radio can have a very high range (up to 20km / 12.5 miles in our case) in ideal conditions. The radios operate in a license free frequency band at 868MHz. This band is called an ISM band because it is open for industrial, scientific and medical communications.

2. Version

A further version of GINA is stand-alone sensing units without a central unit. Each sensing unit is independent and sends the recorded data direct via mobile phone network. This version is only possible, when the solar cells receive enough solar radiation. Therefore, this version cannot be connected to warning-systems and traffic lights.