

To:	David Harpley	Date:	October 24, 2016
c:	Alan Taylor	Memo No.:	3
From:	Rita Kors-Olthof, Jason Pellett	File:	YARC03070-01.001
Subject:	MVEIRB #6 – Road Length Calibration (Related to Undertaking #37) Response to Second Round Information Request EA1415-01 Prairie Creek Mine All-Season Road		

1.0 INTRODUCTION

This technical memo has been prepared for Canadian Zinc Corporation (CZN) by Tetra Tech EBA Inc. (Tetra Tech) to respond to the Second Round Information Request from the Mackenzie Valley Environmental Impact Review Board (MVEIRB) #6: R. This information request is related to Undertaking #37 from the Technical Sessions of June 13 to 16, 2016, previously discussed in Tetra Tech's Memo No. 6, dated July 11, 2016, with reference to Tetra Tech's Memo No. 5, dated May 4, 2016 (Tetra Tech 2016a, 2016b).

2.0 DETAILS OF INFORMATION REQUEST

MVEIRB provided the following commentary and recommendations/requests to CZN for additional information, in turn provided to Tetra Tech on September 26, 2016:

Comment: *CanZinc was asked to confirm whether road length calibration was completed in preparing Table A1 of the landslide risk analysis report. It seems from the response prepared by CanZinc that CanZinc misunderstood what was being asked for with respect to this undertaking. It was not suggested that the route should be sub-divided into 1 km-long increments and the risk analysed for every increment. There is no need to make any changes to the lengths of the segments as presented in Table A1. What is required is for CanZinc to ensure that frequency values presented account for the varying lengths of the segments. It is suggested that all frequency values are calibrated to an equivalent value for a 1 km-long segment length. This approach is considered to be consistent with standard professional practice. If this approach is taken there should be no reason for local 'loss of detail' or local over or under exaggeration of landslide frequency as suggested by CanZinc in the response to the IR. There is no objection to CanZinc calibrating to a larger length (say 3 km) if 1 km is considered to be too short considering the broad natures of slope instabilities in some areas. If the differences in the lengths of the segments can be shown to be negligible, it would be justified to make no further changes.*

Recommendation: *CanZinc to provide a revised response to the Undertaking.*

3.0 SCOPE OF WORK AND METHODOLOGY

Tetra Tech presents in this technical memo a revised response to Undertaking #37. Tetra Tech's Memo Nos. 5 and 6 should be read in conjunction with this memo, in order to provide the context of the information provided here (Tetra Tech 2016a, 2016b).

The frequency values (hazard or likelihood ratings) have now been normalized to equivalent values for 1-km-long segments, as follows:

- In the case of road segments that were shorter than 1 km, the frequencies were normalized assuming that the relationship between uncalibrated frequencies and calibrated frequencies is directly proportional. For example, assuming a 0.5 km long road segment and a 1.0 km segment both affected by a rock fall, the assessed frequency of rock falls along the 0.5 km long segment was doubled to maintain proportionality.
- In the case of assessed road segments that were slightly longer than 1 km, a proportional relationship was also assumed.
- For assessed road segments that were significantly longer than 1 km, and for which a proportional relationship resulted in an unreasonably low rating for that segment, the road segment was considered in 1-km-long sub-segments. It was determined that each 1-km-long sub-segment would be rated the same as the overall road segment.

4.0 RESULTS OF ROAD LENGTH CALIBRATION

4.1 FREQUENCY VALUES – LIKELIHOOD RATINGS

The road length calibration had varying results depending upon the original frequency rating, as well as the segment length, as shown in the attached Table A1. The following observations were made:

- For road segments that were significantly shorter than 1 km, normalizing the frequency values had the effect of increasing the frequency value, thereby indicating a higher hazard or likelihood rating. For instance, a “Low” rating would typically become a “Moderate” rating and a “Moderate” rating would become a “High” rating. In two cases, a “Low” rating became a “High” rating. Ratings that were already “High,” remained “High.”
- “High”-rated road segments did not change upon calibration. In most cases, this was because the road segments were shorter than 1 km, as noted above, thus calibration would tend to emphasize the “High” rating. In two cases, “High”-rated road segments longer than 1 km were subdivided into sub-segments for calibration, thus retaining the “High” rating for each sub-segment.
- For “Moderate”-rated road segments ranging in length from about 0.55 to 2 km, the rating stayed the same. Slightly shorter segments moved up to a “High” rating upon calibration. Slightly longer segments moved down to a “Low” rating upon calibration, unless the “Moderate” rating was deemed more applicable for the sub-segments, as noted above in Section 3.0.
- “Low”-rated road segments longer than 1 km were still rated “Low” upon calibration.

4.2 EFFECTS ON RISK RATINGS

The attached Table A1 also shows the effects of the normalized frequency ratings on the overall risk ratings. The qualitative risk ratings are compared to the normalized risk ratings. The following observations were made:

- Just as in some cases the hazard or likelihood rating increased as a result of normalizing the frequency values, the same effect was noted in the risk ratings. However, in many of these cases, the normalized risk ratings remained as “Low” or lesser ratings (e.g. “Low,” “Very Low,” or “Extremely Low”). Only six short sections, ranging in length from 100 to 300 m, were upgraded from “Low” to “Moderate.”
- No changes occurred in the ratings for road segments with “Moderate” risk ratings.
- No changes occurred in the ratings for road segments with “High” to “Very High” ratings.

Anecdotally, there appeared to be very little correlation between the type of hazard and the change in risk rating. The strongest correlation was in short road segments being normalized to 1-km segments.

5.0 LIMITATIONS OF REPORT

This memo and its contents are intended for the sole use of Canadian Zinc Corporation and their agents. Tetra Tech EBA 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 memo when the memo is used or relied upon by any Party other than Canadian Zinc Corporation and their agents, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this memo is at the sole risk of the user. Use of this memo is subject to the terms and conditions stated in Tetra Tech EBA Inc.'s Services Agreement. Tetra Tech's General Conditions are attached to this memo.

6.0 CLOSURE

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

Respectfully submitted,
Tetra Tech EBA Inc.



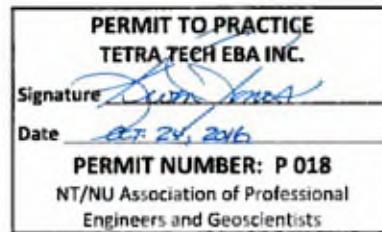
Prepared by:
Rita Kors-Olthof, P.Eng., P.E.
Senior Geotechnical Engineer, Arctic Region
Direct Line: 403.763.9881
Rita.Kors-Olthof@tetrattech.com



Reviewed by:
Shirley McCuaig, Ph.D., P.Geol.
Senior Terrain Geologist, Geotechnical Engineering
Direct Line: 780.451.4130 x381
Shirley.McCuaig@tetrattech.com



Reviewed by:
Jason Pellett, M.Eng., P.Eng./P.Geo.
Senior Geotechnical Engineer
Direct Line: 778.945.5841
Jason.Pellett@tetrattech.com



/kla

Attachment Table A1: Hazard, Consequence and Risk Ratings along the Proposed Prairie Creek Mine All-Season Road, NT General Conditions

REFERENCES

- Tetra Tech EBA Inc. (Tetra Tech), 2016a. Technical Memo No. 6, Discussion for Undertakings #36, 37, 40 and 44, Questions Arising from the Technical Sessions on June 13-16, 2016, EA1415-01 Proposed Prairie Creek Mine All-Season Road, NT. Prepared for Canadian Zinc Corporation. July 2016. Tetra Tech File: Y14103320.01-008.
- Tetra Tech, 2016b. Technical Memo No. 5, Risk Analysis – Landslide Hazards, Proposed Prairie Creek Mine All-Season Road. Prepared for Canadian Zinc Corporation. May 2016. Tetra Tech File: Y14103320.01-006.
- Tetra Tech, 2016c. Technical Memo No. 1, Magnitude/Frequency Analysis – Landslide Hazards, Proposed Prairie Creek All Season Road, NT. Prepared for Canadian Zinc Corporation. April 2016. Tetra Tech File: Y14103320.01-006.
- Wise, M.P., Moore, G.D. and VanDine, D.F. (editors). 2004. Landslide risk case studies in forest development planning and operations, Land Management Handbook 56. British Columbia Ministry of Forests, Forest Science Program, Victoria, B.C.

Table A1: Hazard, Consequence and Risk Ratings along the Proposed Prairie Creek Mine All-Season Road, NT

Proposed Route Location			Geohazards (Geomorphic Processes) ¹	Magnitude Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3} (normalized to 1-km road segment) ⁸	Magnitude Proxy Rating ^{4,5}	Velocity Proxy Rating ⁵	Vulnerability Estimate (Magnitude & Velocity Proxies) ^{4,5}	Deposition vs. Scouring Proxy ⁵	Consequence Rating (Vulnerability Proxies) ^{4,5}	Risk Rating ^{3,4,5,6,7}	Normalized Risk Rating ^{3,4,5,6,7,8}	Comments
From KP (km)	To KP (km)	Distance (km)												
0.0	0.4	0.4	Rockfall Gully Erosion	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Several older rockfalls, three small 2012 rockfalls Gullying of steep slope at KP0-0.3
0.4	1.0	0.6	Rockfall Debris Slide	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Several older rockfalls 1994 debris slide in older colluvium immediately above colluvial fan
1.0	1.4	0.4	Rockfall Gully Erosion	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	
1.9	2.1	0.2	Debris Flow	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	Debris flow on fan fed by rockslide and rockfall, some from 2012, with 1994 activity on the fan
2.2	2.3	0.1	Rockslide Rockfall	Medium	Moderate	High	Low	High	Moderate	Low	Low	Low	Moderate	No evidence of recent activity
2.7	3.4	0.7	Debris Flow Rockfall Gully Erosion	Small	Moderate	Moderate	Very Low	High	Low	Low	Very Low	Very Low	Very Low	No evidence of recent activity on fan despite recent rockfall at high elevations
3.4	4.2	0.8	Rockfall Debris Flow	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	The most active rockfall is immediately adjacent to road Debris flow fan is immediately adjacent to road, but no evidence of recent activity
4.2	4.8	0.6	Rockslide	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	Recent activity on lower part of slope, but most material from these slides will be caught behind colluvial terrace and is unlikely to affect road
5.8	6.1	0.3	Rockfall	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	Two 2012 scars
6.6	7.1	0.5	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	
7.5	8.7	1.2	Rockfall Gully Erosion	Small	Moderate	Moderate	Very Low	High	Low	Low	Very Low	Very Low	Very Low	Two 1994 scars at high elevation; do not reach road, 1949 ones reach or cross road
8.7	9.7	1.0	Rockfall Gully Erosion	Small	Moderate	Moderate	Very Low	High	Low	Low	Very Low	Very Low	Very Low	Rockfalls from 1949 photos present, a few almost reach the road alignment.
10.7	11.2	0.5	Rockfall Gully Erosion	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Rockfall in tributary valley could contribute to debris flow at this location but it does not appear to have ever done so in the past.
11.7	12.6	0.9	Rockslide Rockfall Gully Erosion	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	2012 rockslide at higher elevation, may have just reached the road, difficult to be certain
13.3	13.4	0.1	Debris Flow	Small	Low	High	Very Low	High	Low	Low	Very Low	Extremely Low	Low	Rockfalls and rockslides in tributary valleys above road could contribute to debris flows at this location but do not appear to have ever done so in the past
13.8	14.7	0.9	Rockfall	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	3 rockfalls cross road; a number of rockfalls from 1994
14.7	15.6	0.9	Rockfall Rockslide Gully Erosion	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	3 rockfalls from 2012, 3 from 1994, 1 from 1982; 3 from 1949 that cross road 3 rockslides from 1949, 1 of these crosses road
16.3	17.0	0.7	Rockslide Rockfall	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	4 from 1949 and 1 from 1994, all of which cross the road; apparently little obvious effect on road as only occasional boulders seen in recent time (D. Harpley, pers. comm. Apr. 8, 2016) Evidence of rockfall activity in 1994 and 2012
17.0	19.0	2.0	Rockslide Rockfall Solifluction	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Most almost reach road, a few older ones and one from 1994 cross it; small to moderate-sized slides more frequent than large ones
19.0	20.5	1.5	Rockslide Rockfall Gully Erosion	Medium	Low	Low	Low	High	Moderate	Low	Low	Very Low	Very Low	Recent activity above road, but no slides meet road. Some slides from 1949 still active (or reactivated) in 1994. Road crosses older, gentler colluvial fans with no visible activity.
20.5	21.6	1.1	Rockslide Rockfall	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	1 rockslide from 1949 crosses road; more recent rockslides are located at higher elevations, although no historical evidence of upper elevation rockslides reaching the road
21.6	22.5	0.9	Rockslide Rockfall Gully Erosion	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Rockslides adjacent to the road alignment; 5 rockslides intersect the road, with most recent of these visible on 1994 photos and the other 4 on 1949 photos Rockfall adjacent to road, from 1949
22.9	23.4	0.5	Debris Slide	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Debris slides on the downslope side of the original alignment; new alignment has no visible hazards
24.0	24.3	0.3	Debris Slide	Medium	Moderate	High	Low	High	Moderate	Low	Low	Low	Moderate	Recent and 1949 activity does not reach road, therefore given moderate rather than high frequency rating

Table A1: Hazard, Consequence and Risk Ratings along the Proposed Prairie Creek Mine All-Season Road, NT

Proposed Route Location			Geohazards (Geomorphic Processes) ¹	Magnitude Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3} (normalized to 1-km road segment) ⁸	Magnitude Proxy Rating ^{4,5}	Velocity Proxy Rating ⁵	Vulnerability Estimate (Magnitude & Velocity Proxies) ^{4,5}	Deposition vs. Scouring Proxy ⁵	Consequence Rating (Vulnerability Proxies) ^{4,5}	Risk Rating ^{3,4,5,6,7}	Normalized Risk Rating ^{3,4,5,6,7,8}	Comments
From KP (km)	To KP (km)	Distance (km)												
24.8	24.9	0.1	Debris Slide Gully Erosion	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Road has been moved away from slope north of 24.9, but slides are small and unlikely to create significant hazards
25.5	26.6	1.1	Debris Slide Gully Erosion	Small	Moderate	Moderate	Very Low	High	Low	High	Moderate	Moderate	Moderate	2 at KP25.8 unlikely to affect road; 1 at KP25.6 could possibly affect road, although latter may be a gully - hard to tell on photos
26.2	26.3	0.1	Debris Flow	Medium	Moderate	Moderate	Low	High	Moderate	High	High	High	High	Debris flow of moderate likelihood and high consequence. A sinuous ridge of debris above road is of unknown origin. It appears to have directed water flow across the road in the past, scouring out the area below the road and a forming a small depositional fan adjacent to the river. Uncertain if debris flows have formed above road or not. Mapped as debris flow to be conservative. Difficult to tell size of individual events as this is a fairly old feature.
27.2	27.4	0.2	Debris Slide or Flow	Medium	High	High	Low	High	Moderate	High	High	Very High	Very High	Medium-sized debris slide or debris flow crossed alignment at gully in 1994; to be spanned with bridge
			Rockslide	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Recent activity, but does not reach road
			Rockfall Gully Erosion											
27.5	28.0	0.5	Rockslide Gully Erosion	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Small slides from 1949 immediately below road
28.1	28.4	0.3	Rockfall	Small	High	High	Very Low	High	Low	High	Moderate	High	High	Re-route to south side of river: Minor activity in limited areas in 1994 and 2012; shaded in 1949 so unable to determine activity level at that time
29.0	29.2	0.2	Debris Flow Rockslide	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Recent debris flow activity on colluvial fan, reaches road at KP29.1; fan crosses road from 29.05 to 29.15
30.1	30.2	0.1	Debris Flow	Medium	Moderate	High	Low	High	Moderate	Low	Low	Low	Moderate	Old rockslides appear to have developed into debris flows at lower elevations
30.6	30.8	0.2	Debris Flow	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Evidence of recent activity on colluvial fan, does not reach road; 1949 debris flow crosses road and road is on fan
30.8	31.2	0.4	Rockslide Rockfall	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Recent rockslide at KP31 reaches road, older slide crosses it Rockfalls from 1949
31.2	31.8	0.6	Debris Flow Rockslide	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	2 colluvial cones with recent activity reaching or crossing road, potential for major scour at ~KP031.2, rest of section is deposition. Recent debris flow activity crosses 50 m of road. Pre-1949 activity crosses about 80 m of road.
32.2	32.5	0.3	Debris Flow	Medium	Low	High	Low	High	Moderate	Low	Low	Very Low	Moderate	Debris flows from 1949 and 1994, do not reach road, but fan crosses road
32.5	36.2	3.7	Rockfall Rockslide	Medium	High	High	Low	High	Moderate	Low	Low	Moderate	Moderate	Majority are from 1949 photos, but plenty of evidence of recent activity
36.7	37.2	0.5	Gully Erosion Rockfall	Medium	Moderate	High	Low	Moderate	Low	Low	Very Low	Very Low	Low	Gullies at edge of polygon with soil creep at higher elevation, does not affect road
37.2	37.8	0.6	Rockfall	Small	High	High	Very Low	High	Low	Low	Very Low	Low	Low	Several rockfalls on 1994 photos
37.8	38.7	0.9	Rockfall	Large	Low	Low	Moderate	High	High	Low	Moderate	Low	Low	Rockfall from 1949 covered in vegetation at the toe
40.2	41.4	1.2	Lateral Spread in Surficial Material Gully Erosion	Very Large	Low	Low	High	Moderate	High	Low	Moderate	Low	Low	Road crosses lateral spread with no evidence of movement since 1949
41.9	42.0	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	
42.9	43.3	0.4	Lateral Spread in Surficial Material Gully Erosion	Large	Low	Low	Moderate	Moderate	Moderate	High	High	Moderate	Moderate	Road is at crest of slide (lateral spread in glaciofluvial sediments)
45.8	46.2	0.4	Soil Creep in Permafrost Terrain Gully Erosion	Large	Low	Moderate	Moderate	Low	Low	Low	Very Low	Extremely Low	Very Low	Road crosses wet permafrost area that may experience slow soil creep
46.8	48.4	1.6	Slump in Surficial Material Gully Erosion	Very Large	Moderate	Moderate	High	Moderate	High	Low	Moderate	Moderate	Moderate	Two large slumps in glaciofluvial material, likely very old, road skirts bottom of slides. Possible undermining along creek below road in a few short sections.
49.7	50.0	0.3	Debris Slide Gully Erosion	Large	Moderate	Moderate	Moderate	High	High	High	Very High	Very High	Very High	Re-route shifts road back from slides; road is already well back from slide areas that are being eroded by creek (the latter areas would have a high frequency)

Table A1: Hazard, Consequence and Risk Ratings along the Proposed Prairie Creek Mine All-Season Road, NT

Proposed Route Location			Geohazards (Geomorphic Processes) ¹	Magnitude Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3} (normalized to 1-km road segment) ⁸	Magnitude Proxy Rating ^{4,5}	Velocity Proxy Rating ⁵	Vulnerability Estimate (Magnitude & Velocity Proxies) ^{4,5}	Deposition vs. Scouring Proxy ⁵	Consequence Rating (Vulnerability Proxies) ^{4,5}	Risk Rating ^{3,4,5,6,7}	Normalized Risk Rating ^{3,4,5,6,7,8}	Comments
From KP (km)	To KP (km)	Distance (km)												
53.7	54.2	0.5	Thaw Flow Slide	Medium	High	High	Low	Moderate	Low	High	Moderate	High	High	Thaw flow slide from 2012 nearby, but offset 100 m from road at closest point; 125 m from road if retrogression is uphill only
54.5	57.6	3.1	Slump in Surficial Material	Very Large	Moderate	Moderate	High	Moderate	High	Low	Moderate	Moderate	Moderate	Alternate routes avoid most of these areas
			Debris Slide Rockfall											
59.7	60.4	0.7	Debris Slide	Medium	Moderate	Moderate	Low	High	Moderate	High	High	High	High	Route crosses a few older slides visible in 1949 photos
61.4	61.5	0.1	Gully Erosion	Medium	Moderate	Moderate	Low	Moderate	Low	High	Moderate	Moderate	Moderate	Road traverses upper edge of this sizable gully
67.9	72.0	4.1	Slump in Surficial Material or Bedrock	Large	Moderate	Moderate	Moderate	Low	Low	Low	Very Low	Very Low	Very Low	Route passes between older slump features in surficial sediments (or possibly slumps in soft bedrock)
			Rockfall											Route crosses an older rockfall area and passes above others that are not likely to affect road
72.9	75.2	2.3	Slump in Surficial Material or Bedrock	Large	Moderate	Moderate	Moderate	Low	Low	Low	Very Low	Very Low	Very Low	Route passes between older slump features in surficial sediments (or possibly slumps in soft bedrock)
76.0	81.4	5.4	Slump in Surficial Material or Bedrock	Large	Moderate	Moderate	Moderate	Low	Low	Low	Very Low	Very Low	Very Low	Route passes between older slump features in surficial sediments (or possibly slumps in soft bedrock)
83.5	85.5	2.0	Debris Slide	Medium	Moderate	Moderate	Low	High	Moderate	High	High	High	High	Road is well back from older and younger debris slides and tension cracks
85.5	87.3	1.8	Lateral Spread in Surficial Material	Very Large	Low	Low	High	Moderate	High	Low	Moderate	Low	Low	Road avoids most of lateral spread
			Debris Slide	Large	Moderate	Moderate	Moderate	High	High	Low	Moderate	Moderate	Moderate	Road crosses toe of older debris slide
88.0	89.5	1.5	Lateral Spread in Surficial Material	Very Large	Low	Low	High	Moderate	High	Low	Moderate	Low	Low	Road skirts bottom of lateral spread that is likely quite old; it crosses a small portion at the edge with much less obvious evidence of activity (between KP88 and KP88.4)
			Gully Erosion											
91.0	94.2	3.2	Soil Creep in Permafrost Terrain	Medium	Moderate	Moderate	Low	Low	Very Low	Low	Extremely Low	Extremely Low	Extremely Low	Creep due to permafrost in wetland areas only; these make up about 30% of this section of route
			Gully Erosion											
95.5	101.7	6.2	Slump in Bedrock	Very Large	Low	Low	High	Moderate	High	High	Very High	High	High	Large rotational to translational slide that likely occurred quite some time ago
			Debris Slides											A few recent but small debris slides at upper elevations
			Gully Erosion											Abundant gullies
101.7	102.0	0.3	Rockfall	Medium	Moderate	High	Low	High	Moderate	Low	Low	Moderate	Rockfall on 1949 air photos	
Alternative Route														
103.5	108.5	5.0	Rockfall	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Alternate route passes along base of rockfall area to avoid wet areas of recent soil creep in permafrost below; best location for both geohazards
			Soil creep in Permafrost Terrain											
108.5	109.4	0.9	Soil Creep in Permafrost Terrain	Medium	High	High	Low	Low	Very Low	Low	Extremely Low	Very Low	Very Low	Road crosses area with small amount of recent soil creep in permafrost, although soil creep polygon is very large, likely only the portion along the road would affect the road
111.8	113.1	1.3	Debris Flow	Large	Moderate	Moderate	Moderate	High	High	Low	Moderate	Moderate	Moderate	Road crosses debris flow area, but has been adjusted to lowest location on fans to avoid flows/slides that do not extend to edge of fan
			Debris Slide											
113.1	116.2	3.1	Rockslide	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Older rockslides reach or cross road in KP114 to 115.5 area, but road has been shifted to lowest possible elevation through slide area to avoid as many slides as possible
			Rockfall											Recent rockfall, but small and well above road
119.9	120.3	0.4	Rockfall	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Alternate route passes along base of rockfall area to avoid river floodplain
Original Route														
109.0	109.2	0.2	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	High	Low	Low	Moderate	2 gullies intersect the road
109.9	110.2	0.3	Rockfall	Medium	Moderate	Moderate	Low	High	Moderate	Low	Low	Low	Low	Re-route has shifted road back from rockfall area
110.2	115.1	4.9	Gully Erosion	Medium	Moderate	Moderate	Low	Moderate	Low	High	Moderate	Moderate	Moderate	Several gullies intersect road alignment
115.5	115.7	0.2	Rockfall	Medium	Moderate	High	Low	High	Moderate	Low	Low	Low	Moderate	Road crosses toe of older rockfall/rock slide area; scars visible on 1962 photos
116.5	116.9	0.4	Gully Erosion	Small	Low	Moderate	Very Low	Moderate	Very Low	Low	Extremely Low	Negligible	Extremely Low	In coarse-grained material; activity is older in 1949 photo; water flow in gullies likely rare
120.7	120.8	0.1	Debris Slide	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Very small slide, short slope; likely to have little effect on road
129.0	129.1	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	Gully erosion peters out at road, but still quite wet in 1949 photos
135.9	136.0	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	Inactive in 1971 photos, snow covered in 1949 and activity level uncertain due to poor quality 1949 photo

Table A1: Hazard, Consequence and Risk Ratings along the Proposed Prairie Creek Mine All-Season Road, NT

Proposed Route Location			Geohazards (Geomorphic Processes) ¹	Magnitude Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3}	Hazard (Likelihood) Rating ^{2,3} (normalized to 1-km road segment) ⁸	Magnitude Proxy Rating ^{4,5}	Velocity Proxy Rating ⁵	Vulnerability Estimate (Magnitude & Velocity Proxies) ^{4,5}	Deposition vs. Scouring Proxy ⁵	Consequence Rating (Vulnerability Proxies) ^{4,5}	Risk Rating ^{3,4,5,6,7}	Normalized Risk Rating ^{3,4,5,6,7,8}	Comments
From KP (km)	To KP (km)	Distance (km)												
136.4	137.3	0.9	Debris Slide	Large	Low	Low	Moderate	High	High	High	Very High	High	High	Large debris slides in this section. One feature at KP136.4 may be a debris flow, but feature is rather indistinct - may have a low frequency and/or may be intermixed with fluvial sediment. Features assigned a "low" frequency, but potentially could have a "moderate" frequency, due to the difficulty in distinguishing features on both sets of photos.
139.0	139.1	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	Inactive but wet in 1949 and 1982
139.7	139.8	0.1	Debris Slide	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Very small slide, short slope; unlikely to affect road
140.6	140.9	0.3	Debris Slide	Small	Moderate	High	Very Low	High	Low	Low	Very Low	Very Low	Low	Very small slides, short slopes; not large enough or close enough to affect road
143.9	144.0	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	Stream in drains lake, expect ongoing but minimal erosion
146.3	146.4	0.1	Gully Erosion	Small	Moderate	Moderate	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Extremely Low	Road crosses drainage path in flattest part; gullying unlikely to affect road
148.0	148.1	0.1	Gully Erosion	Small	Moderate	High	Very Low	Moderate	Very Low	Low	Extremely Low	Extremely Low	Very Low	Very small and inactive but wet in 1949
151.2	154.5	3.3	Gully Erosion	Small	Moderate	Moderate	Very Low	Moderate	Very Low	High	Low	Low	Low	Smaller gullies inactive in 1949, a few cross road; larger gullies active in 1949, with streams feeding fluvial fans, road crosses these at best possible locations
154.5	155.3	0.8	Earth Slump - Earth Flow	Very Large	Low	Low	High	Moderate	High	High	Very High	High	High	Assumed to be old as inactive in 1949, but could have moderate likelihood; road has been moved upslope to avoid this area
155.9	159.3	3.4	Earth Slump - Earth Flow	Very Large	Low	Low	High	Moderate	High	High	Very High	High	High	Assumed to be old as inactive in 1949, road has been moved upslope but is still immediately adjacent to upper portion of slide near KP 158 and tension cracks near KP157
			Debris Flow	Medium	High	High	Low	High	Moderate	High	High	Very High	Very High	Debris flows visible on 2012 imagery cross route at 158.4 to 158.5; road must cross eastern portion of slump-flow in order to reach river crossing
			Gully Erosion											

¹Geohazards are described as per Howes and Kenk (1997); however, it is assumed that fluvial fans also contain some components of debris floods and water floods.

²Ratings apply to the dominant / most probable hazard (indicated in **bold italics**) along the proposed road alignment.

³Definitions of magnitude and hazard likelihood (encounter probability) classes are provided in Tables 2.1 and 2.2 of the memo.

⁴Applied as partial proxy for consequence (vulnerability), as shown in Tables 2.2, 2.3, and 2.4 of the memo.

⁵Discussion and definitions of consequence and vulnerability classes are provided in Tables 2.3 and 2.4 of the memo. Resulting risk classes are shown in Table 2.5.

⁶Risk is the product of hazard likelihood and consequence. Definitions of hazard (likelihood) and consequence (vulnerability) classes are provided in Tables 2.1 and 2.4 of the memo. Resulting risk classes are shown in Table 2.5.

⁷Risk tolerance is not addressed in the risk matrix, but should be recognized as a necessary component in making land management decisions.

⁸Normalized hazard ratings as noted in Wise et al. (2004), and resulting normalized risk ratings.

Notes/Limitations:

- Magnitude/Frequency assessment applies only to road segments where geohazards are present.
- A thickness of 1 m is assumed for landslide magnitude calculations; this should be considered a minimum estimate.
- If several slides are present within a described route section, the average magnitude or range of magnitudes is given.
- The groupings of some portions of the route may contain localized areas of benign or potentially unstable terrain within the defined kilometre range, regardless of its magnitude and frequency ratings, due to the scale of mapping.
- Kilometre ranges are as per route alignment dated February 2015.