CANADIAN ZINC CORPORATION

August 11, 2016

Mr. Chuck Hubert
Senior Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
5102 50th Avenue,
Yellowknife, NT
X1A 2N7

Dear Mr. Hubert

RE: Environmental Assessment EA1415-001, Prairie Creek Mine All Season Road, Undertakings from Technical Session

This letter provides the second batch of responses to Undertakings by Canadian Zinc Corporation (CZN). Attached to this letter are responses to those Undertakings. Responses to Undertakings 19, 23 and 24 are outstanding but will follow shortly in a document from Allnorth.

In addition to the attachments, some further comments are made on some of them here, as well as Undertaking responses by others.

Undertaking 7

A second conference call was held between DFO, Parks Canada and CZN, and a record is attached. Work on this item is continuing, with the agreed goal of completing work to allow DFO to make a determination on fish habitat loss/gain prior to the Hearing phase.

Undertaking 16

CZN's reply to this Undertaking is attached. We refer to the additional information provided by Parks Canada. This Undertaking requests identification of sensitive wildlife and vegetation by road segment. Parks Canada identified four such sections. We have comments on three of these, as follows:

- Karst terrain from Km 53-64 is listed and underground drainage is referred to. This is a water quality issue rather than a wildlife or vegetation issue. The text also implies that a spill would enter underground pathways in rock. Consideration needs to be given to the soil cover, which would likely absorb any spill, which would be small in volume, and prevent downward passage to groundwater. In the unlikely event that part of a spill reaches groundwater, it would be subject to dispersion as the groundwater flows at a relatively slow rate. Therefore, there would be a very low risk to wildlife at the point where the groundwater discharges at surface.

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- Parks Canada refers to an Arctic grayling population between Km 25 and 32. There are pools in this section of the creek, notably between Km 27 and 29. However, these pools are not very deep. The deepest are approximately 1-1.5 m deep in mid-summer, before flows recede later in summer and into the fall. We have seen similar pools further down the creek near Cat Camp with the noted water depths in summer, but with much less water or dry in the fall. There is some groundwater flow in the Km 23 area in winter, as ice accumulation in the tributary crossing has been noted. However, this flow is unlikely to sustain water depths in the pools downstream. Since ice thickness approaches 1 m over winter in these alpine areas, it is probable that all of the pools freeze to the bottom each winter. Therefore, unfortunately, it is unlikely that grayling trapped in the pools as flows recede survive the winter. Grayling will migrate up the creek again in the following spring, but they will also not survive unless they retreat before the fall. The Parks Canada comments imply that a "population" is resident and survives the winter. We do not believe this to be the case.

- Parks Canada refers to a "resident caribou population" downstream of Km 17-40. The available evidence does not support this assertion. The publication "Species at Risk in the NWT, 2016" identifies the road corridor as 'trace occurrence' in terms of northern mountain caribou habitat, with core range to the north. This agrees with our many surveys and observations which have noted caribou accumulations about 7 km north of Km 7, in an area known locally as Caribou Flats, and the occasional siting of between one and three caribou as a group on upland areas either side of the Km 17 and 35 road section. We do not believe this evidence supports a 'resident population' conclusion.

Undertaking 35

The comments here are a follow up to the undertaking reply by ECCC. There is some ambiguity regarding transport and containment suggestions. One response suggests transport trailers should have steel covers and solid sides such as those used at the Red Dog Mine. This would be for bulk concentrate transport in a single containment. However, in another response, ECCC recommends secondary containment for "product". CZN has stated that we would either transport concentrates in bulk using the 'Convey Ore' system, which is similar to the Red Dog Mine approach, or in bags in a truck box with a lid, which would be secondary containment.

Regarding washing, trucks transporting bags would not enter the Concentrate Shed, rather they would be loaded in a side bay. For bulk concentrates, trucks would also be loaded in a bay, with the delivery chute over the trailer at the trailer top level. In addition, since concentrates will have an 8% moisture content, dust generation should not be an issue. Therefore, while we agree with a wheel wash for exiting trucks, truck washing would appear to not be necessary. Further, there are practical issues with washing, such as freezing conditions in winter, and contaminated water collection and disposal. CZN is willing to consider some form of air lancing system for bulk concentrate trucks as additional assurance that they do not leave site with external dust.

CZN will be happy to discuss appropriate monitoring approaches when the draft Concentrate Loading and Management Plan is reviewed prior to operations. However, one aspect of ECCC's recommendation does not make sense to us: “Emphasis should be put on sensitive receptors such as the many creek crossings”. Given the concentrate trucks will have sealed lids, if a dust issue occurs, it can only be from dust that has settled on the exterior of the trucks while on site, and is subsequently lost from the trucks as they depart site. Therefore, if no dust issue is detected proximal to the site, it is very unlikely that one would be detected further from site.

Additional Baseline and Aquatic Habitat Field Studies

Following some concerns noted in Information Requests, and also during the Technical Session, CZN decided to undertake additional vegetation and wildlife baseline studies. Tetra Tech EBA conducted the work, and a summary of their results is attached. A more detailed report will be forthcoming in mid-August.

While the vegetation and wildlife studies were in progress, CZN also took the opportunity to collect additional aquatic habitat data, primarily in the area of the proposed Sundog Creek alignment. This work was led by Hatfield Consultants, and will be reported on as part of Hatfield’s work in defining overall aquatic habitat loss/gain and a determination by DFO.

Timing of Next Steps

As noted above, a report on recent vegetation and wildlife baseline studies is expected in mid-August. At that time, we also plan to provide an update of the draft Wildlife Mitigation and Monitoring Plan. We expect that parties will review these documents prior to a deadline for the submission of 2nd round Information Requests (IR2).

The aquatic habitat work is focussed on a process leading to a determination by DFO on aquatic habitat loss/gain. The goal is to have that determination available before the Hearing phase. Accordingly, we ask that the Board not delay IR2 for the purpose of party review of the on-going aquatic habitat work. We have also commissioned an Archaeological Overview Assessment (AOA) which is in progress. We expect to have a report on the AOA available before the Hearing phase.

If you have any questions, please contact us at 604 688 2001.

Yours truly,
CANADIAN ZINC CORPORATION

David P. Harpley, P. Geo.
VP, Environment and Permitting Affairs

Meeting Report

Meeting date: June 28, 2016

Main Issue:

Undertaking 2: Additional assessment of ecosystems that will be disturbed so as to tailor reclamation approaches (and potentially further examination of potentially permanent impacts, e.g. those associated with permafrost degradation).

Attendees:

Parks Canada – Allison Stoddard, Jonathan Tsetso, Audrey Steedman, Laura James
CZN – Alan Taylor, Dave Harpley
CZN consultants – Amy McLenaghan, Karla Langlois

Summary of discussion:

Ms. Steedman explained the basis for the undertaking by reiterating her comments made at the technical session. The concern is that road construction may cause permafrost thaw, which has the potential to alter the vegetation assemblage (mainly by changing the hydrological regime) during reclamation such that it would not be consistent with adjacent, undisturbed vegetation. Ms Steedman referred to certain locations on the old winter road where black spruce bogs have become sedge wetlands due to increased soil moisture from degraded permafrost. Ms. Steedman referred to the *Principles and Guidelines for Ecological Restoration in Canada's Protected Areas* (Parks Canada and the Canadian Parks Council. 2008) as a guiding document for restoration in National Parks.

Mr. Harpley noted that Cadillac did not pay enough attention to drainage (subsurface flow) and road protection when they built the winter road, citing the example of erosion of the road near the Mine during floods. Also, the road wasn't reclaimed, just left as is. Therefore, winter road performance should not necessarily be comparable to all season road performance.

Ms. Steedman said there is a need to identify areas susceptible to permafrost degradation, determine the vegetation assemblage in these areas prior to disturbance, and devise mitigations to avoid and/or reduce the impact of a different vegetation assemblage establishing after reclamation.

Ms. Langlois suggested an approach consisting of overlaying areas of permafrost potential on the land cover mapping (black spruce bogs) to identify locations where mitigation specific to vegetation may be required.

Ms. Steedman indicated that this would be a valid approach.

Ms. McLenaghan noted that the vegetation type most at risk from changes due to permafrost thaw is Black Spruce bog.

Ms. Steedman added that vegetation recovery in the alpine was also a concern, and that reclamation options should be considered to promote better outcomes. These areas are also identifiable on the land cover mapping.

Developer commitment(s):
CZN agreed to overlay areas of permafrost potential on the established vegetation mapping to identify locations where mitigation specific to vegetation may be needed, and identify any additional data requirements.

Outstanding issue(s) for the party:
The commitment outlined above is considered by Parks Canada to be a first step in identifying the specific ecosystems that will be disturbed so as to tailor reclamation approaches. Following this work, ground truthing and follow-up surveys may be required.

Parks Canada's position is that once a baseline has been confirmed, further discussions are required between Parks Canada and CZN regarding the appropriate reclamation approaches.

Action Items:

Produce this meeting report for review by the parties on the call, and then submit to the Board.

Signature of Parks Canada representative: Allison Steedman

Signature of CZN representative: ____________________

Date: Jan 18 '10

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	David Harpley, VP Environment and Permitting Affairs, Canadian Zinc Corp.	**Date:**	August 2, 2016
c:		**Memo No.:**	002
From:	Karla Langlois and Amy McLenaghan	**File:**	Y14103320-01.008
Subject:	Prairie Creek Mine Proposed All-Season Road, Environmental Assessment June 2016 Technical Session Undertakings #2, 11, 16, and 17		

1.0 INTRODUCTION

The Prairie Creek proposed all-season access road technical session was held June 13 to 16, 2016. Undertakings were identified from the technical session that required additional information and explanation. This memo includes the responses to Undertakings #2, 11, 16, and 17. A response to Undertaking #14 was provided under separate cover (dated July 6, 2016).

2.0 UNDERTAKINGS

2.1 Undertaking #2

Undertaking #2: Parks and CanZinc will discuss need for additional assessment of ecosystems that will be disturbed so as to tailor reclamation approaches (and potentially further examination of potentially permanent impacts, e.g., those associated with permafrost degradation) and report to the Board.

Response: CanZinc, Tetra Tech EBA, and Parks Canada discussed Undertaking #2 during a conference call on June 28, 2016. Since this discussion, Tetra Tech EBA conducted field studies along the proposed all-season access road that included an area along the old winter road (KP 95) that exhibited signs of potentially permanent changes due to permafrost degradation, as discussed in the Cameron report (2015). Results from the field studies will be available in a forthcoming, separate report. Conclusions from the field studies will also be integrated into the reclamation plan. Potentially longer term impacts, particularly those associated with permafrost degradation, may have resulted from the construction and operation of the winter road, however, the engineering practices implemented historically versus the practices employed currently have changed substantially, particularly with respect to construction in permafrost areas. Current construction techniques in permafrost are directed towards protection of the ground thermal regime so that thaw is reduced or avoided, where possible. The documents listed below identify mitigation measures that will be implemented to avoid permafrost degradation:

- Addendum and Progress Report to Address Adequacy Review of Developer's Assessment Report for Environmental Assessment, EA1415-01 – Proposed All-Season Road Access to Prairie Creek Mine, NT (2015);
- Permafrost-Karst Characterization – Developer's Assessment Report for Environmental Assessment, EA1415-01 - Proposed All-Season Road Access to Prairie Creek Mine, NT (2016);
- Memo #2 – IR 13: Responses to Information Requests from Mackenzie Valley Review Board and Oboni Riskope Associates Inc. – Prairie Creek Mine Site Proposed All-Season Access Road, EA1415-01 Technical Review (2016); and

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- Memo #4 – IR 27: Responses to Information Requests from the Government of the Northwest Territories - Prairie Creek Mine Site Proposed All-Season Access Road, EA1415-01 Technical Review (2016).

2.2 Undertaking #11

Undertaking #11: CanZinc will provide a map showing where the road alignment crosses unglaciated areas and describe if and how this information affects prediction of impacts on species at risk and on rare plant assemblages.

Response: Unglaciated areas are unique and rare, and often support habitat for rare plants. Figure 1 shows the distribution of unglaciated areas in the NWT (based on NWT 2012). Figure 2 combines the information from Figure 1 with the most current Earth Observation for Sustainable Development of Forests (EOSD) mapping (Wulder et al. 2004) to show where unglaciated regions and associated land cover classes overlap with respect to the proposed all season road.

Approximately 66 km of the proposed all season road (from KP 0 to approximately KP 66) traverses through the unglaciated region and consists of boreal, subalpine, and alpine ecoregions. Surveys for rare plants and rare/unique plant assemblages were completed along the proposed all season road alignment, including previously unglaciated areas, on several occasions:

- July 2009 (three field survey days)
- August 2010 (five field survey days)
- July 11-17, 2016 (seven field survey days)

These surveys, including the most recent event conducted in 2016, did not detect any SARA-listed species or species ranked by the GNWT. A specific survey for the SARA-listed Raup's willow (*Salix raupii*) was conducted along Sundog Creek between KP 36 and 38 but did not detect any individuals.

As the surveys conducted to date included assessments of previously unglaciated areas, the predictions of impacts to species at risk and rare plant assemblages, as presented in the DAR and supporting documentation (including the latest field survey results from 2016), have not changed.

2.3 Undertaking #16

Undertaking #16: CanZinc will provide information on areas of sensitive wildlife and vegetation by road segment (including alternative segments and distinct borrow locations) in order to allow a risk assessment to account for these in terms of consequences from a spill. Parks Canada will provide any additional existing and known information to support this undertaking.

Response:

Key features, within 1 kilometre (km) from the proposed road, considered most sensitive to a potential spill include:

- Wetlands and open water ponds/lakes within 1 kilometre (km) of the road corridor, especially within the Ecologically Significant Area (i.e., Southern Mackenzie Mountains Key Migratory Bird Habitat) from KP 87-117. Note, wetlands identified from the Earth Observation for Sustainable Development (EOSD) mapping provided in the DAR and waterbodies identified from Google Earth;
- Karst features (located outside of the project footprint). Karst features, particularly the poljes are a unique landform and are thus capable of supporting unique and/or rare vegetation assemblages and/or rare plants; and
- Creek crossings (refer to the DAR Section 9.4 *Risk and Consequence by Road Section*).

Table 1 specifies the nearest road segment and borrow locations where key features are identified.

Table 1: Key Features within a Kilometre of the Proposed All-Season Road

Key Feature	KP Nearest to Key Feature (approx.)	Nearest Proximity to All-Season Road (m) (approx.)	Description/Comment
Wetland 1	38	550	Treed and shrub wetland
Wetland 2	44	4	Shrub wetland with a graminoid wetland within. The proposed all-season road follows the alignment of the permitted winter road.
Wetland 3	51	0	Tall shrub wetland. Proposed all-season road crosses this drainage channel. Does not follow the alignment of the permitted winter road.
Wetland 4	95	0	Treed wetland
Wetland 5	103	850	Treed and shrub wetland
Wetland 6	120	250	Treed and shrub wetland
Wetland 7	121	150	Treed wetland
Wetland 8	121	400	Treed wetland
Wetland 9	125	900	Shrub wetland
Wetland 10	142	120	Treed and shrub wetland
Wetland 11	165	300	Shrub wetland
Wetland 12	166	160	Treed and shrub wetland
Waterbody 1	60	400	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 2	60	980	The proposed all-season road follows the alignment of the permitted winter road.
Mosquito Lake	63	130	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 3	63	900	The proposed all-season road follows the alignment of the permitted winter road.
Waterbodies 4-7	64	130 and 650	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 8	65	90	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 9	65	320	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 10	65	800	The proposed all-season road follows the alignment of the permitted winter road.
Waterbodies 11-14	66	120 and 400	The proposed all-season road follows the alignment of the permitted winter road.
Waterbodies 15-16	67	170 and 180	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 17	71	970	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 18	74	200	The proposed all-season road follows the alignment of the permitted winter road.

Table 1: Key Features within a Kilometre of the Proposed All-Season Road

Key Feature	KP Nearest to Key Feature (approx.)	Nearest Proximity to All-Season Road (m) (approx.)	Description/Comment
Waterbody 19	90 (and Borrow Source)	700	Does not follow the alignment of the permitted winter road.
Waterbody 20	94 and Borrow Source	90	Does not follow the alignment of the permitted winter road.
Waterbodies 21-22	95	20 and 80	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 23	96	80	The proposed all-season road follows the alignment of the permitted winter road.
Waterbodies 24-25	96	650 and 800	Ponds part of the Fishtrap Creek. The proposed all-season road follows the alignment of the permitted winter road.
Waterbodies 26-27	97	600	Ponds part of the Fishtrap Creek.
Waterbodies 28-29	98	450 and 600	Does not follow the alignment of the permitted winter road.
Waterbodies 30-31	103	900	Does not follow the alignment of the permitted winter road.
Waterbodies 32-33	104	500 and 650	Does not follow the alignment of the permitted winter road.
Waterbodies 34-35	105	400 and 700	Does not follow the alignment of the permitted winter road.
Waterbody 36	108	600	Does not follow the alignment of the permitted winter road.
Waterbody 37	119 (and Borrow Source)	0	Does not follow the alignment of the permitted winter road.
Waterbody 38	119	300	Does not follow the alignment of the permitted winter road.
Waterbody 39	120	500	Does not follow the alignment of the permitted winter road.
Waterbody 40	134	200	Does not follow the alignment of the permitted winter road.
Waterbody 41	140	850	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 42	141	50	The proposed all-season road follows the alignment of the permitted winter road.
Waterbody 43	142	250	Does not follow the alignment of the permitted winter road.
Waterbodies 44-45	143	200	Does not follow the alignment of the permitted winter road.
Waterbody 46 (Liard River crossing)	159	0	Liard River crossing
Waterbody 47 (Liard River)	163	200	The proposed all-season road follows the alignment of the permitted winter road.

Table 1: Key Features within a Kilometre of the Proposed All-Season Road

Key Feature	KP Nearest to Key Feature (approx.)	Nearest Proximity to All-Season Road (m) (approx.)	Description/Comment
Waterbody 48 (Liard River)	170	300	Does not follow the alignment of the permitted winter road.
Waterbody 49 (Netla Creek)	175	200	The proposed all-season road follows the alignment of the permitted winter road.
Karst Feature	55	250 and 300	Suspected karst depressions
Karst Feature	56	70	Suspected karst depression with ponded water (approximately 3 m diameter)
Third Polje	57	500	
Second Polje	58	550	
Karst Feature	58	80 and 130	Suspected kettle (non-karst feature) or sinkhole
Karst Feature	59	420	Suspected kettle (non-karst feature) or sinkhole

2.4 Undertaking #17

Undertaking #17: CanZinc will provide their significance conclusions for each individual wildlife species that is a valued component in this EA.

Response:

Tables 3 to 24 present the significance conclusions for each wildlife species considered in the DAR, Appendix 7, specific to Traditional Harvesting, Nahanni National Park Reserve, and Species at Risk and Other Wildlife sections (Appendix 7, Sections 6.0 to 8.0). The predicted species effects are populated directly from the DAR Appendix 7 and collated into significance conclusions using the methods outlined in the DAR and Information Request response (dated April 2016).

Table 2 provides a legend for each predicted effects table.

Table 2: Legend for Each Predicted Effects Table

Abbreviation	Description	Abbreviation	Description
L	Low	N	Neutral or No Significance
M	Moderate	Shading	Positive or Neutral Direction
H	High		

2.4.1 Effects Assessment - Traditional Harvesting

Table 3: Boreal Caribou – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	M
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	M	M	H	H	M	H	M
Dispersal and Local Movements	Adverse	L	M	M	M	M	H	L
Energetics and Body Condition	Adverse	L	M	M	M	M	M	L
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	H	H	M	H	L
Harvesting Areas	Adverse	L	M	M	M	M	H	L
Harvesting Access	Positive	L	M	M	H	M	H	L
Harvesting Pattern	Positive	M	M	M	M	M	M	M
Harvesting Pressure	Adverse	L	M	H	L	M	M	L
Overall Significance								
Adverse Low								

Table 4: Northern Mountain Caribou – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	L	M	M	L
Dispersal and Local Movements	Adverse	L	M	M	L	M	M	L
Energetics and Body Condition	Adverse	L	M	M	L	M	L	L
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	H	N

Table 4: Northern Mountain Caribou – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Predator-Prey Relationships	Adverse	L	M	H	H	M	M	L
Harvesting Areas	Neutral	L	M	M	L	M	M	L
Harvesting Access	Positive	L	M	M	H	M	H	L
Harvesting Pattern	Positive	M	M	M	M	M	M	M
Harvesting Pressure	Adverse	L	M	H	L	M	M	L
Overall Significance								
Adverse Low								

Table 5: Moose – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	H	M	H	L
Dispersal and Local Movements	Adverse	L	M	M	H	M	H	L
Energetics and Body Condition	Adverse	L	M	M	H	M	M	L
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	M	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	H	H	M	M	L
Harvesting Areas	Adverse	M	M	M	M	M	H	M
Harvesting Access	Positive	M	M	M	H	M	H	M
Harvesting Pattern	Positive	M	M	M	M	M	H	M
Harvesting Pressure	Adverse	M	M	H	H	M	H	M
Overall Significance								
Adverse Low								

Table 6: Dall's Sheep – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	H	M	H	L
Dispersal and Local Movements	Adverse	M	M	M	L	M	H	M
Energetics and Body Condition	Adverse	L	M	M	L	M	L	L
Non-Harvest Mortality	Adverse	L	L	M	H	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	H	H	M	M	L
Harvesting Areas	Adverse	L	M	M	M	M	M	L
Harvesting Access	Positive	L	M	M	H	M	H	L
Harvesting Pattern	Positive	M	M	M	M	M	M	M
Harvesting Pressure	Adverse	M	M	H	M	M	M	M
Overall Significance								
Adverse Low								

Table 7: Wolverine – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	L	M	H	L
Dispersal and Local Movements	Adverse	L	M	M	M	M	H	L
Energetics and Body Condition	Adverse	L	M	M	M	M	L	L
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	M	N
Predator-Prey Relationships	Positive	L	M	M	L	M	M	L

Table 7: Wolverine – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Harvesting Areas	Adverse	M	M	M	M	M	H	M
Harvesting Access	Positive	M	M	M	H	M	H	M
Harvesting Pattern	Neutral	L	M	M	M	M	H	L
Harvesting Pressure	Adverse	L	M	H	L	M	M	L
Overall Significance								
Adverse Low								

Table 8: Grey Wolf – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	M	M	H	L
Dispersal and Local Movements	Adverse	L	M	M	M	M	H	L
Energetics and Body Condition	Adverse	L	M	M	M	M	L	L
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Positive	L	M	H	H	M	M	L
Harvesting Areas	Adverse	M	M	M	M	M	H	M
Harvesting Access	Positive	L	M	M	H	M	H	L
Harvesting Pattern	Neutral	L	M	M	M	M	H	L
Harvesting Pressure	Adverse	L	M	H	L	M	M	L
Overall Significance								
Adverse Low								

Table 9: Marten – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	H	L	M	H	L
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	H	M	H	L
Dispersal and Local Movements	Adverse	L	M	M	M	M	H	L
Energetics and Body Condition	Neutral	Not assessed since relatively tolerant to human disturbances and or interactions with the proposed Project are negligible to low.					L	N
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	M	L	H	L	H	L	M
Population Cycles	Adverse	L	H	M	L	L	L	L
Predator-Prey Relationships	Neutral	L	M	M	L	M	M	L
Harvesting Areas	Adverse	M	M	M	M	M	H	M
Harvesting Access	Positive	M	M	M	H	M	H	M
Harvesting Pattern	Neutral	M	M	M	M	M	H	M
Harvesting Pressure	Adverse	L	M	H	L	M	H	L
Overall Significance								
Adverse Low								

Table 10: Beaver – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Neutral	L	L	H	H	L	M	N
Habitat Effectiveness	Adverse	L	M	M	L	M	M	L
Abundance and Occurrence	Adverse	L	M	M	L	M	M	L
Dispersal and Local Movements	Adverse	L	M	M	L	M	M	L
Energetics and Body Condition	Neutral	Not assessed since relatively tolerant to human disturbances and or interactions with the proposed Project are negligible to low.					L	N
Non-Harvest Mortality	Adverse	L	L	M	L	L	H	L
Contaminant Levels	Adverse	L	L	H	L	H	L	M

Table 10: Beaver – Harvested Species

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	M	L	L
Harvesting Areas	Adverse	M	M	M	M	M	H	M
Harvesting Access	Positive	M	M	M	H	M	H	M
Harvesting Pattern	Neutral	M	M	M	M	M	H	N
Harvesting Pressure	Adverse	L	M	H	L	M	H	L
Overall Significance								
Adverse Low								

2.4.2 Effects Assessment – Nahanni National Park Reserve

Table 11: Northern Mountain Caribou – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence	Adverse	L	M	M	L	M	M	L
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	L	M	M	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Adverse	L	M	H	M	M	L	L
Overall Significance								
Adverse Low								

Table 12: Moose – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence	Adverse	M	M	M	M	M	M	M
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	M	M	M	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Adverse	L	M	H	M	M	M	L
Overall Significance								
Adverse Low								

Table 13: Dall's Sheep – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence	Adverse	L	M	M	M	M	M	L
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	M	M	M	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Adverse	L	M	H	M	M	M	L
Overall Significance								
Adverse Low								

Table 14: Mountain Goat – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence	Adverse	L	M	M	L	M	H	L
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	L	M	H	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Adverse	L	M	H	M	M	M	L
Overall Significance								
Adverse Low								

Table 15: Grizzly Bear – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	M	L	H	L	M	H	M
Abundance and Occurrence	Adverse	M	M	M	M	M	M	M
Habitat Fragmentation and Barriers to Movement	Adverse	M	M	M	L	M	M	M
Invasive Wildlife Species	Neutral	L	M	M	L	L	L	N
Ability to Recover	Adverse	M	M	H	M	M	L	M
Overall Significance								
Adverse Moderate								

Table 16: Trumpeter Swan – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence	Adverse	M	M	H	M	M	M	M
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	M	M	M	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Adverse	L	M	M	M	M	M	L
Overall Significance								
Adverse Low								

Table 17: Forest Birds – Nahanni National Park Reserve

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss	Adverse	L	L	H	L	M	H	L
Abundance and Occurrence*	Adverse	L	L	M	L	L	H	L
Habitat Fragmentation and Barriers to Movement	Adverse	L	M	M	M	M	M	L
Invasive Wildlife Species	Adverse	L	M	M	L	H	L	M
Ability to Recover	Adverse	L	M	M	M	M	L	L
Overall Significance								
Adverse Low								

* Forest bird Abundance and Occurrence effects were unspecified in the DAR's summary of predicted effects Table 7-7.

2.4.3 Effects Assessment – Species at Risk and Other Wildlife

Table 18: Collared Pika – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	M	L	M	L	M	H	L
Habitat Effectiveness	Adverse	L	L	M	L	M	H	L
Abundance and Occurrence	Adverse	L	L	M	L	M	M	L
Dispersal and Local Movements	Adverse	L	M	M	L	M	L	L
Project-Related Mortality	Adverse	M	L	M	M	L	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Adverse Low								

Table 19: Wood Bison – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Positive	L	L	M	L	M	M	L
Habitat Effectiveness	Positive	L	L	M	L	M	M	L
Abundance and Occurrence	Positive	L	L	M	H	M	M	L
Dispersal and Local Movements	Positive and Adverse	L	M	M	M	M	H	L
Project-Related Mortality	Adverse	L	L	M	M	M	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Neutral								

Table 20: Barn and Bank Swallows – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Neutral	L	L	L	L	L	M	N
Habitat Effectiveness	Neutral	L	L	M	L	L	M	N
Abundance and Occurrence	Positive	L	L	M	H	M	L	L
Dispersal and Local Movements	Positive	L	M	M	H	M	M	L
Project-Related Mortality	Adverse	L	L	M	M	M	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Neutral								

Table 21: Short-eared Owl – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	L	L	M	L	M	L	L
Habitat Effectiveness	Adverse	L	L	M	L	M	M	L
Abundance and Occurrence	Adverse and Positive	L	L	M	H	M	L	L
Dispersal and Local Movements	Positive	L	M	M	H	M	L	L
Project-Related Mortality	Adverse	L	L	M	M	M	L	L
Population Cycles	Adverse	L	L	L	L	L	M	L
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Adverse Low								

Table 22: Common Nighthawk – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Positive	L	L	M	L	M	M	L
Habitat Effectiveness	Neutral*	L	L	M	L	M	M	N
Abundance and Occurrence	Positive	L	L	M	H	M	H	L
Dispersal and Local Movements	Positive	L	M	M	H	M	H	L
Project-Related Mortality	Adverse	L	L	M	M	M	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Neutral								

* Reclassification to Neutral direction was recommended in the Wildlife and Vegetation Information Request (submitted April 2016).

Table 23: Olive-sided Flycatcher – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Positive	L	L	M	L	M	M	L
Habitat Effectiveness	Positive	L	L	M	L	M	M	L
Abundance and Occurrence	Positive	L	L	M	H	M	H	L
Dispersal and Local Movements	Positive	L	M	M	H	M	H	L
Project-Related Mortality	Adverse	L	L	M	M	M	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Adverse	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Neutral								

Table 24: Forest Raptors – Species at Risk and Other Wildlife

Potential Effect	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty	Significance
Habitat Loss and Fragmentation	Adverse	M	M	M	L	M	M	M
Habitat Effectiveness	Adverse	L	L	M	L	M	M	L
Abundance and Occurrence	Neutral	L	L	M	H	M	H	N
Dispersal and Local Movements	Positive	L	M	M	H	M	H	L
Project-Related Mortality	Adverse	L	L	M	M	M	M	L
Population Cycles	Neutral	L	L	L	M	L	H	N
Predator-Prey Relationships	Positive	L	M	M	L	L	L	L
Invasive Wildlife Species	Neutral	L	M	M	L	H	L	N
Ability to Recover	Neutral	L	L	M	M	M	M	N
Overall Significance								
Adverse Low								

3.0 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. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Zinc Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

4.0 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.

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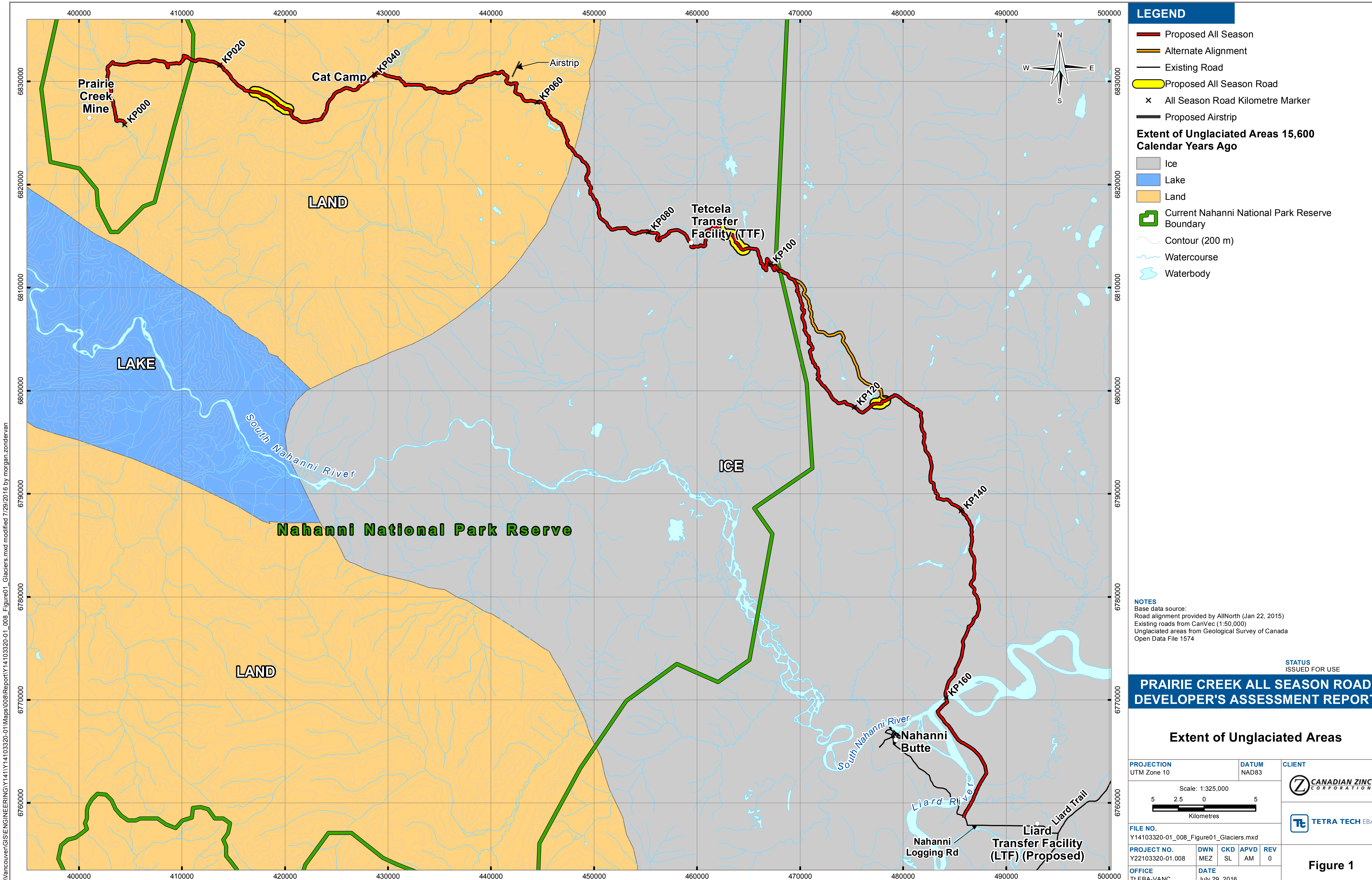
Attachments: Figures (2)
Tetra Tech EBA's General Conditions



LEGEND
Proposed All Season
Alternate Alignment
Existing Road
Proposed All Season Road
All Season Road Kilometre Marker
Proposed Airstrip
Extent of Unglaciated Areas 15,600 Calendar Years Ago
Ice
Lake
Land
Current Nahanni National Park Reserve Boundary
Contour (200 m)
Watercourse
Waterbody
NOTES
Base data source:
Road alignment provided by AllNorth (Jan 22, 2015)
Existing roads from CanVec (1:50,000)
Unglaciated areas from Geological Survey of Canada Open Data File 1574
STATUS
ISSUED FOR USE
PRAIRIE CREEK ALL SEASON ROAD
DEVELOPER'S ASSESSMENT REPORT
Extent of Unglaciated Areas
PROJECTION
UTM Zone 10
DATUM
NAD83
CLIENT
CANADIAN ZINC CORPORATION
Scale: 1:325,000
Kilometres
FILE NO.
Y14103320-01_008_Figure01_Glaciers.mxd
PROJECT NO.
Y22103320-01.008
DWN
MEZ
CKD
SL
APVD
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OFFICE
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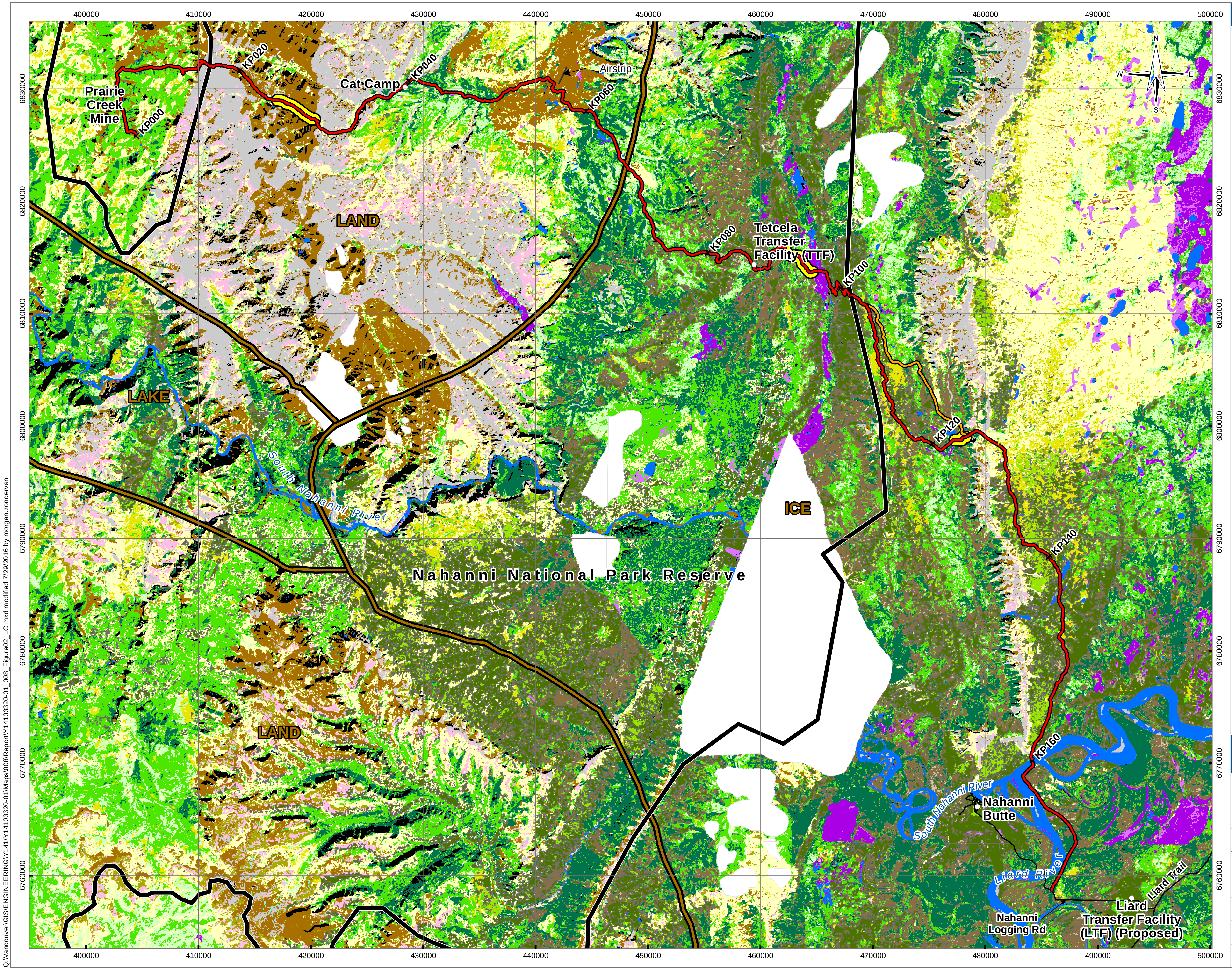
DATE
July 29, 2016
TETRA TECH EBA
Figure 1
Prairie Creek Mine
KP000
KP020
Cat Camp
KP040
Airstrip
KP060
KP080
Tetcela Transfer Facility (TTF)
KP100
KP120
KP140
KP160
LAND
LAKE
ICE
South Nahanni River
Nahanni National Park Rserve
Nahanni Butte
Liard River
Liard Trail
Nahanni Logging Rd
Liard Transfer Facility (LTF) (Proposed)
Q:\Vancouver\GIS\ENGINEERING\Y141\Y14103320-01\Maps\008\Report\Y14103320-01_008_Figure01_Glaciers.mxd modified 7/29/2016 by morgan.zondervan



LEGEND

- Proposed All Season
- Alternate Alignment
- Existing Road
- Proposed All Season Road
- All Season Road Kilometre Marker
- Proposed Airstrip
- Extent of Unglaciated Areas 15,600 Calendar Years Ago
- Current Nahanni National Park Reserve Boundary

Land Cover Class

- Cloud
- Shadow
- Water
- Snow/Ice
- Rock/Rubble
- Exposed Land
- Bryoids
- Shrub Tall
- Shrub Low
- Wetland - Treed
- Wetland - Shrub
- Wetland - Herb
- Herb
- Coniferous Dense
- Coniferous Open
- Coniferous Sparse
- Broadleaf Dense
- Broadleaf Open
- Mixedwood Dense
- Mixedwood Open

NOTES

Base data source:
Road alignment provided by AllNorth (Jan 22, 2015)
Land Cover, circa 2000-Vector (EOSD) (Natural Resources Canada, accessed through geobase.ca)
Existing roads from CanVec (1:50,000)
Unglaciated areas from Geological Survey of Canada Open Data File 1574

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Land Cover Classification

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:325,000
5 2.5 0 5
Kilometres

FILE NO.	Y14103320-01_008_Figure02_LC.mxd			
PROJECT NO.	DWN	CKD	APVD	REV
Y22103320-01.008	MEZ	SL	AM	1
OFFICE	DATE			
Tt EBA-VANC	July 29, 2016			

TETRA TECH EBA

Figure 2

2nd Meeting Report

Meeting date: July 28, 2016

Main Issue:

Undertaking 7: Outstanding information requirements and analysis related to fish and fish habitat loss/gain (including impacts of blasting), to enable DFO to reach a determination and inform the board prior to the hearing phase (before technical reports).

Attendees:

Julie Marentette, Véronique D'Amours-Gauthier, Elizabeth Patreau - DFO
Garry Scrimgeour, Allison Stoddart, Cavan Harpur – Parks Canada
Dave Harpley – CZN
John Wilcockson - Hatfield

Summary of discussion:

DH said that the intent of the meeting was an update on work progress, and to inform parties on recent fieldwork.

JW gave a summary of the fieldwork using photos, as follows:

- The new Km 28.6 Sundog tributary crossing.
- Habitat characteristics of the Sundog channel to be realigned and the old channel to be used, including the inlet area. DH noted that the old channel is well defined, and realignment can be accomplished by removing accumulated sediment at the inlet. DH also noted that fine sediment is common in the area in addition to cobbles, and this sediment is likely mobilized naturally during higher flows.
- The Km 111.3 and 119 crossings on the alternate alignment between Wolverine Pass and Grainger Gap.
- The multiple tributaries of Grainger River draining the east side of the Front Range crossed by the road. DH noted that all were flown downstream where, in each case, a defined channel disappeared or multiple beaver dams were found. Consequently, none of the streams are considered fish habitat at the crossings.

DH said that CZN was working on completing the last undertakings from the Technical Session, including engineering memos that will relate to the Project footprint. Then a detailed summary of habitat loss would be provided in writing, including figures showing habitat types and photos. This will specifically include photographic examples showing how the different types of floodplain are defined. After some discussion on timing, it was agreed that the summary would be provided by August 19. The next call will occur shortly after that once parties had reviewed the material. The suggested time frame was August 29-31.

Developer commitment(s):

CZN to provide a habitat loss summary by August 19.

Outstanding issue(s) for the party:

DFO to review habitat loss summary, engineering memos for footprints and associated photographs of habitat types including floodplains after August 19.

Action Items:

Schedule the next call after the habitat summary has been circulated.

Signature of DFO representative: ______________________

Signature of Parks Canada representative: ______________________

Signature of CZN representative: ______________________

Date: August 2, 2016

UNDERTAKING 9

CanZinc will provide additional information on the removal of water from standing water, including identifying the water bodies, and how a maximum withdrawal of 10% of volume will be determined and over what time period.

CZN previously quantified the surface area, bathymetry and volume of lakes proposed for water withdrawal to support winter extraction according to DFO's *Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut.* This information was provided in a memo from Hatfield Consultants dated November 19, 2012. A link to this document was provided in the DAR Addendum, section 4.11.

CZN has proposed to use some of these same lakes for summer water withdrawal, principally for dust control. We understand that some parties may be concerned that excessive withdrawal may lead to significant water level change, and how withdrawal will be quantified and controlled, hence the desire for this undertaking.

Before providing the answers specific to the undertaking, it is appropriate to review the existing information that frames this issue. In the DAR Addendum, section 4.11, we estimated a summer water demand for dust control of 10,080 m^3. This was based on 70 km requiring watering 3 times/week over 12 weeks, at a rate of 4,000 L/km. Lakes we may use for water withdrawal are listed in the table below. Smaller lakes, or lakes off of the alignment, were excluded from consideration. Lake data is derived from the Hatfield memo. We have added some columns. Each lake is now considered further.

Lake Name	Surface Area (m^2)	Total Lake Volume (m^3)	10% Withdrawal Volume	1% Withdrawal Volume	Water level change at 1% (mm)
Mosquito Lake	450,500	1,092,000	109,200	10,920	2.4
Km 70	217,700	1,248,000	124,800	12,480	5.7
Km 115	95,720	190,400	19,040	1,904	2.0
Km 121	252,400	291,600	29,160	2,916	1.2
Km 139	393,900	371,200	37,120	3,712	0.9
Km 141	186,200	486,000	48,600	4,860	2.6

Mosquito Lake

This lake has a stream inflow and outflow. In summer, inflows are assumed to keep the lake level static. The distance from Cat Camp (Km 40), where we identified a water source, and the Tetcela River main stem is about 50 km. For argument's sake, we can assume that dust control is required for this total section, without the use of any other water source (Polje Creek is at about Km 53, but was found to be dry in September 2015). Using the above noted watering schedule, we generate a volume of 7,200 m^3. This amount is less than 1% of lake volume (10,920 m^3, see table). Withdrawal of 1% is equivalent to a 2.4 mm level change (dividing the withdrawal volume by the lake surface area). In reality, no such level change is likely to occur since lake inflow will replace the water withdrawn. However, even if the calculated level change occurred, no significant effects are expected as the change is so small. Therefore, we propose to limit summer season withdrawal from this lake to 1% of lake volume.

Km 70

Using the same logic as for Mosquito Lake, we also propose to limit summer season withdrawal from this lake to 1% of lake volume. We may in fact not use this lake since it is somewhat off the alignment.

Km 115

This lake has a significant upstream catchment that would compensate for any withdrawal. For a summer season withdrawal of 5% of lake volume, the maximum level change would only be 1 cm. Therefore, we propose this limit. We may also not use this lake as it is off the alignment.

Km 121

This lake west of Grainger Gap has a substantial upstream catchment to compensate for any withdrawal, being part of the upper Grainger River system. A 5% water withdrawal would mean a maximum level change of 6 mm. Therefore, we propose this limit.

Km 139 and 141

These lakes are in close proximity to one another. The Km 139 lake has a larger area, but smaller volume, and the upstream catchment is limited. Lake Km 141 has a significant upstream catchment. Limiting summer season extraction to 2% of lake volume means a maximum level change of 1.8 and 5.2 mm respectively, although the latter in particular is highly unlikely to occur.

Other Remarks

The water withdrawal rates noted above are based on each summer season (entire open water period). It is assumed that spring runoff will replenish all lakes to full capacity prior to the summer period. The rate of extraction for any given lake within the summer period will be limited by the fact that watering for dust control is not needed on successive days. Further, CZN applied for Class B Water Licences. This limits daily extraction to less than 300 m^3/day in total. It should also be noted that the summer haul season is projected to start around June 15. Potentially dry road conditions are considered to be possible over the period July-September. This would be the likely period of dust control.

Water withdrawal volumes will be tracked either by using an in-line flow meter, or by recording the number of fills of tanks of known capacity. Records will be kept and can be provided at regular intervals along with other road monitoring data.

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	David Harpley VP Environment and Permitting Affairs Canadian Zinc Corp.	**Date:**	July 6, 2016
c:		**Memo No.:**	001
From:	Karla Langlois	**File:**	Y14103320-01.008
Subject:	Prairie Creek Mine Proposed All-Season Road, Environmental Assessment June 2016 Technical Session Undertaking #14		

1.0 INTRODUCTION

The Prairie Creek proposed all-season access road technical session was held June 13 to 16, 2016. Undertakings were identified from the technical session that require additional confirmation and explanation. This memo is response to Undertaking #14. Responses to additional Undertakings will be provided under separate cover.

2.0 UNDERTAKING #14

Undertaking #14: CanZinc will confirm whether the original effects assessment for the winter road considered loss of habitat and habitat fragmentation for migratory birds and avian species at risk.

Response: Tetra Tech EBA reviewed the original effects assessment for the winter road and verified that effects from habitat loss and fragmentation were not originally considered for migratory birds and avian species at risk. The reason is that the proposed winter road generally follows the original 1980's winter road with some re-alignments, and minimizes habitat loss along the new re-alignment sections (i.e., beyond the original road corridor) and for two transfer facilities.

Since the winter road is permitted, it is appropriate for this environmental assessment to only consider potential effects from those sections of the proposed all-season road alignment that diverge significantly from the winter road alignment. Potential habitat loss and fragmentation effects were assessed for the following avian species/species groups for the proposed all-season road:

- Forest birds;
- Trumpeter Swan;
- Forest raptors;
- Common Nighthawk;
- Olive-sided Flycatcher;
- Barn and Bank Swallows;
- Short-eared Owl; and
- Harlequin Duck[1].

[1] All assessed within the Developers Assessment Report with exception to Harlequin Duck. Harlequin Duck assessed within the Environment and Climate Change Canada Information Request #34 response (dated April 28, 2016).

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Tel 867.920.2287 Fax 867.873.3324

Direct loss and fragmentation of habitat for additional open water/wetland species, such as Yellow Rail, Rusty Blackbird, and Horned Grebe, are restricted primarily to a few creek crossings (i.e., Fishtrap Creek, Tetcela River, and unnamed creek west of Grainger Gap).

3.0 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. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Zinc Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

4.0 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.

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Attachment: Tetra Tech EBA's General Conditions

Allnorth

Proposed Prairie Creek Mine Access Road

Response to Technical Review Undertakings

Response to the undertakings outlined from

June 13 to 16, 2016 Technical Review

August 10, 2016

Prepared For: Canadian Zinc Corporation

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1	June 30, 2016	DH		Draft
2	Aug 10, 2016	EK	DH	Final

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APPENDICES

1 BACKGROUND

Canadian Zinc Corporation (CZN) has applied to build an "all season" access road connecting the Prairie Creek Mine to Highway 7. As part of the environmental assessment (EA) process, Allnorth completed an evaluation and submitted a report titled "Proposed Prairie Creek Mine Access Road" on February 27, 2015. Following comments from the Mackenzie Valley Environmental Impact Review Board (MVEIRB) on April 23, 2015, Allnorth submitted a supplementary report in September, 2015.

A Technical Session was completed in Yellowknife, Northwest Territories from June 13 to 16, 2016 involving various government agencies supported by their designated consultants and Canadian Zinc supported by their consultants. The session produced a number of "undertakings" to be followed up by Canadian Zinc.

This document provides Allnorth's responses to some of those undertakings on behalf of Canadian Zinc.

2 UNDERTAKING RESPONSE

2.1 Undertaking #20

CanZinc will describe the basis for the engineer's conclusions that the road can be constructed without the use of run-away lanes and/or railings, with reference to sections of the road that have steeper grades, tighter curves, and narrower running surfaces. CanZinc will also provide examples of other resource roads that face similar circumstances and where similar design decisions have been made.

2.1.1 Response:

With our document "Response to Information Requests" dated May 3, 2016, Section 4.1, Response item #2, we reviewed 4 different reference manuals and guidebook publications including:

- B.C.FLRO Engineering Manual
- Health, Safety, and Reclamation Code for Mines in British Columbia
- Geometric Design Guide for Canadian Roads (TAC) (used by MOT)
- Northern Land use Guidelines

All four publications did not provide specific standards related to when and where runaway lanes and/or safety railings are to be applied and utilized. The *"Geometric Design Guide for Canadian Roads (TAC) (used by MOT)"* only provides standards for public highway roads designed >50km/hr.

The "Health, Safety, and Reclamation Code for Mines in British Columbia" (standards typically used within active mine sites for 100 Ton Ore trucks (Cat 777 for example)) did state roads should utilize runaway lanes and/or retardation barriers with road grades in excess 5%, where conditions and/or risks warrant, as directed by (mine) manager.

Assessing the risk associated with safe road operations is a combination of design speed, road gradient (sustained and short, interrupted grades), road widths, road horizontal and vertical alignment, terrain, traffic volumes, and environmental conditions. The assessment also considers if the grades are favorable or adverse relative to the direction of loaded concentrate truck traffic. In the case of the Prairie Creek Mine, the majority of heavy truck traffic is hauling from the mine site to Fort Nelson. Any road grades downhill would be considered "favorable". Any road grades uphill would be considered "adverse". Favorable grades can produce increased undesirable speeds; adverse grades reduce speeds and are more manageable. The road design is and must be designed to reflect heavy transportation both ways, however the majority of traffic going to the mine site will be empty concentrate trucks (apart from relatively light supplies e.g. 5,000 L of diesel) and some heavy transport trucks.

An additional assessment to support the non-application of runaway lanes and/or barriers has been completed. The majority of the road traverses rolling terrain which minimizes the likelihood of sustained grades >8%. Three sections of the proposed alignment have been identified which may contain sustained road grades <8% (8 to 10% for greater than > 500 m) through mountainous terrain or significant elevation differences. These sections have been analyzed in greater detail regarding road grades, horizontal and vertical curve design. Table 1 below summarizes the findings for these sections.

Table 1: Road Sections containing longer, steeper, sustained road grades.

Section	Terrain and Road Design Considerations.	Management Approach
KP 10 to 17	Loaded concentrate trucks will be hauling in an "adverse" condition (uphill). A preliminary design was completed for the most critical 700 m section from KP 13 to 13.7, which includes a relatively tight 27m radius switchback. A ground profile (of existing original road) was reviewed for the remaining section. The preliminary design and ground profile identified is: • KP 10 to 12. Road grades ranging from 4 to 7% sustained. Good horizontal and vertical alignment. • KP 12 to 13.8. Road grades 8 to 10% sustained. Switchback corner at 13.3 (27 m radius @ 1.4%) and approach corner at 13.6 (radius 45 m). • KP 13.8 to 17.0. Road grades 6 to 8 % sustained. Two switchbacks at KP 16 improved to +/- 40 m radius curves. Additional curves at KP 15.3 and 15.35 contain +/- 40 m radius curves.	• KP 13.0 to 13.8 proper signage identifying 20 km/hr speed zone. • KP 15.2 to 16.2 proper signage identifying 20 km/hr speed zone • Delineator's at all tighter corners including KP 13.3, 13.8, 15.3, 15.35, 15.8, 16.1. • To be considered during detailed design: retardation barriers at corners KP 13.3, 13.8, 16.1 • Re-evaluate the benefit and application of runaway lanes during detailed design
KP 22 to 24	Loaded concentrate trucks will be hauling in a "favorable" condition (downhill). A preliminary design of a 700 m section was completed for the most critical section to ensure the road design criteria are compatible to the terrain and the proposed major crossing at KP 23.4. The preliminary design identified is: • Road grades ranging from 9 to 12% with maximum 500 m sustained grades, within the design parameters for 40 km/hr. • Horizontal curves at 65 m or greater, within the design	• Place proper signage identifying 20 km/hr speed zone • Delineators at corners. • Detailed design should improve vertical curve alignment (2 locations) from present 20 km/hr, closer to 40 km/hr.

<table>
<tr><th>Section</th><th>Terrain and Road Design Considerations.</th><th>Management Approach</th></tr>
<tr><td></td><td>parameters for 40 km/hr.
• Some vertical curve values (K 3.8, 5.0) within a design speed between 20 to 30 km/hr.

A ground profile of the remaining section indicates grades below 8% and interrupted.</td><td></td></tr>
<tr><td>KP 96 to 102</td><td>Loaded concentrate trucks will be hauling in an “adverse” condition. The road gains roughly 320 m in elevation over 4.5 km. which calculates to an average 7% grade. The proposed alignment was reviewed in the field and office to determine the best alignment which will remain stable through terrain which has geohazards.

A preliminary design was completed for the most critical 1000 m section from KP 98.5 to 99.5, which includes a 30 m radius switchback. This section provides a good basis to determine alignment and road grades. A ground profile (of existing original road) was reviewed for the remaining section.

The preliminary design and ground profile identified:
• Road grades ranging from 2 to 9% and variable, short, interrupted grades up to 11%.
• The terrain through this section is variable. The preliminary design has, and the detailed design will, take advantage of this terrain. The final design will provide grade breaks, avoiding sustained grades.
• Generally, good horizontal and vertical alignment.
• Two switchbacks are proposed, KP 99.0 and 100.5. KP 99.0 curve radius is 30 m (approx. 25 km/hr design speed), KP 100.5 offers a 75 m curve radius.
• KP 101.3 contains a potential curve radius of 35 m.</td><td>• At detailed design stage, attempt to improve corners 99.0 and 101.3
• KP 98.8 to 99.1 and 101.1 to 101.5 proper signage identifying 20 km/hr speed zone.
• Delineator’s at all tighter corners, specifically KP 99 and 101.3
• To be considered during detailed design: retardation barriers at corners KP 99.0 and 101.3.</td></tr>
</table>

Examples of resource roads operating with similar road design specifications, and located in similar terrain, can be commonly found throughout the mountainous areas of coastal and interior British Columbia. Many logging roads located in Hope, Boston Bar, Lytton, Lillooet, and Terrace, for example, gain significant elevation climbing from lower valley bottoms to high mountain slopes. It is not uncommon to see grades of 15 to 20%, 4 to 5 m running surfaces with numerous switchbacks, and significant fill drop-offs. Occasionally, berms may be used, although runaway lanes have never been observed. Table 2 below identifies a few such roads.

Table 2: Examples of similar resource roads operating in B.C.

Road	Location
Yalakom FSR	Lillooet, Carpenter Lake
Marshal Creek Rd.	Lillooet, Carpenter Lake
Camoo Creek Rd.	Lillooet, Carpenter Lake

Road	Location
Spuzzum Creek FSR	Yale, Hope
Kleanza Creek FSR	Terrace
Williams Creek FSR	Terrace
Falling Creek Connector	Chetwynd

The winter alignment (comparable to the all season alignment within mountainous sections), completed by SNC Lavalin, did not identify runaway lanes or barriers; suggesting they did not consider them to be a necessity. Based on our review of the above documents, field investigations, completed road designs and road profiles, at this stage of the design; it is our professional opinion that runaway lanes are not required. The use, installation of runaway lanes and retardation barriers may be considered at limited locations during the detailed design stage.

2.2 Undertaking #22

CanZinc will describe its approach to end of winter season demobilization and shutdown of road construction including: when shutdown/demobilization will occur, the conditions that will trigger demobilization, who to consult on making this decision, drainage and surface water management considerations, and the removal of temporary infrastructure and equipment.

2.2.1 Response:

Required shutdown and demobilization procedures are critical to ensure an "uneventful" and stable transition from winter construction activity into spring thaw. The Road Construction Manager (RCM), Environmental Monitor (EM), and designated construction supervisors will closely monitor weather forecasts and localized environmental conditions to minimize impacts from the seasonal shutdown. It is typical for warming to occur as the normal end of the winter season on March 31 approaches, and for ground conditions to deteriorate. As such, there would be advanced warning of a need to plan for demobilization. Warm spells can also occur during the winter season which, depending on the length and temperatures, could lead to a temporary suspension of activities. Activities implemented during the late winter period could include:

- Conduct heavy hauling during colder daily temperatures.
- Limit site clearing during warmer periods of the day.
- Pullback all snowfills and re-establish natural drainage paths.
- Use of water bars, berms, etc. to manage surface water flows over disturbed areas.
- Proactive approach toward erosion and sediment control which includes installing additional silt fences, as required.
- Limit site clearing on a day to day basis, avoiding excessive, unnecessary exposure of mineral soils.
- Restrict travel on sections of road vulnerable to breakdown of subgrade as soils warm and frost exits.
- Focus construction activities to sections with well drained (gravel) soils, and avoid sections with poor soils (silt, clay, saturated, organics).
- Designate areas for equipment storage.

- Ensure extra erosion control supplies (such as silt fences) are strategically located through the construction zone which could be utilized, if necessary, after construction activities cease, and during the spring thaw when additional mitigation measures and protection may be needed.
- Continue to conduct monitoring into spring.

"Allnorth's Supplement to Original Submission (DAR)" dated September 8, 2015, Appendix C, Operational Management Plans, the "Sedimentation and Erosion Control Plan", Section 4.6.1 describes the procedures to be followed for seasonal and unavoidable shutdowns. Below is a clip of that section.

Seasonal / Adverse Weather Shutdowns

As the construction is scheduled over a period of several years, the operations will experience seasonal shut downs or unavoidable adverse weather shutdowns. It is important to apply additional protection procedures and measures during these periods when generally the disturbed areas are at greatest risk of exposure and the majority, if not all, of the road construction personnel are not on site and therefore cannot respond to a problem or situation. The following will be implemented:

- Plan seasonal shutdowns accordingly. Only clear sufficient right of way, including stripping and grubbing, to fulfill the scheduled subgrade construction.
- Plan and schedule known challenging construction sections, particularly wet, sensitive sites, and significant stream crossings during suitable weather conditions.
- Ensure completion is attainable within the available operating window.
- Plan all erosion and sedimentation measures that require placement/installation when crews/equipment are available prior to a shut down and implement accordingly.
- Ensure all natural drainages and streams are fully functioning.
- Anticipate problem areas and ensure sufficient supplies of material and resources within proximity to respond. (Example silt fencing, erosion mats, etc.)
- Restrict access of road structures vulnerable to vehicle damage during these periods.
- Ensure equipment is properly stored at acceptable locations, as to not adversely damage road structure or create avoidable disturbance as operations return.
- When unavoidable adverse weather impacts the project, EM and construction crews to make necessary corrective action to stabilize the site and to avoid additional sedimentation or erosion impacts prior to the evacuation of the site.
- Ongoing EM and Contractor inspections during periods of inactivity to take corrective planning and action if required.

To clarify, the designated EM, under the authority of the RCM, will be responsible to ensure the above procedures are followed. During seasonal shutdowns, equipment will be parked at designated locations unless an environmental situation does not permit. The relevant agency Inspector will be kept informed of all activities, and consulted regarding plans for demobilization.

2.3 Undertaking #25

CanZinc will provide information on design flow (return period) requirements for major temporary crossing related to the length of time the crossings are expected to be in place.

2.3.1 Response:

Major stream crossings greatly influence the construction schedule in order to avoid the utilization of temporary crossing structures over an extended period. However, if temporary structures are utilized over an extended period (> 3 months), the design flow will be based on a 10 year return period.

2.4 Undertaking #26

CanZinc will provide additional information on the proposed Sundog realignment to understand how the channel will be constructed to maintain the natural hydrologic and sediment regime, and monitoring and maintenance plans, provide a document (signed by a qualified professional) that includes:

1. Additional commentary on landslide influences on historic channel position in the reach to be provided.
2. The diversion concept has already been provided at a conceptual level, with initial hydraulic analysis to confirm feasibility and annotated images to show alignment. Tetra Tech EBA will assist CZN in providing a preliminary design including details of the proposed diversion berm at the upstream end. We will also provide commentary on our expectations regarding hydraulic performance and sediment movement. The preliminary design will be based on the alignment and LiDAR elevation data as of 2012. We would want to obtain additional channel bed profile and substrate information prior to developing the final design. Our recommendation is for CZN to commit that the final design will be developed to provide hydraulic/sediment capacity equivalent to the existing channel and will mimic the habitat characteristics of the existing channel. The final design will also consider the risks of new channel avulsion, and any measures required to minimize those risks.

Tetra Tech EBA has addressed the above items under separate cover. The original undertaking requested information on alternatives considered to the creek realignment. Comments are provided below. Following this, some supplementary information related to the realignment is provided.

2.4.1 Alternative Alignments

Our submission *"Additional Supplement to Original Submission"* dated September 8, 2015, reviewed an alternative alignment from KP 32 to 43 which entailed a southern routing up a steep slope to exit the canyon and thus avoid this section along Sundog Creek. This alignment was dismissed because of excessive grade through extreme terrain. Therefore, the only option was to retain the road through the confining Sundog valley. An alternative to the proposed alignment was reviewed internally which included crossing Sundog near KP 34.6, following along the northwest side on the valley, and then crossing again near KP 36.5. Additional details of this alternative, including preliminary bridge designs with supporting road designs, have been included in Appendix A**.**

The alternative would generally utilize the previous winter road alignment. Typically, it is preferable to avoid back and forth stream crossings, especially over a wide floodplain such as Sundog Creek. The preliminary designs in Appendix D indicate that the bridge structures and approaches could be vulnerable to high stream flows. The northwest side of the Sundog floodplain does offer improved constructability vs. the proposed alignment, but the road prism will also occupy some portions of active braided or secondary channel. Therefore, we do not recommend this alternative because of the risks posed to the bridge crossings.

2.4.2 Sundog Re-alignment

(A) Re-alignment Construction

A preliminary design of the Sundog Creek realignment has been completed under the direction of Tetra Tech EBA. Refer to their report for design details.

Construction of the Sundog re-alignment will occur in summer or fall/early winter when the creek has no surface water. All construction would be conducted continuously and completed within one season.

Construction would follow a three stage process. This includes:

(1) Construction of the main body from 0+250 to 1+475.
(2) Construction of the lower portion connecting to an existing channel.
(3) Construction of the upper portion and connection to the current channel.

Pre-determined safe offsets of approximately 250 m from the both entry and exit ends would be retained in their natural state until the completion of the re-alignment section from 0+250 to 1+475. Construction would start at the lower portion of the re-alignment and progress upstream. All proposed stream design characteristics would be constructed continuously to avoid repeated disturbance. If surface water is encountered, the sealed off bottom exit or end would restrict surface water from discharging to other channels. The water would filter through the natural gravels. The reconstructed channel within the natural streambed material would be washed with pressurized water to allow fine sediments to settle into the reconstructed porous rock stream bed, or collect in a sump at the downstream end of the excavation for subsequent removal. This will minimize suspended solids release when the diversion becomes active. Water required for the washing process will be extracted from an adjacent, stable floodplain area.

The construction of the lower portion of the re-alignment connecting back to an existing channel would follow. A small berm with filter cloth would be maintained until the re-constructed channel is washed. The small filter berm would remain in place until the upper portion is complete and existing channel is ready to be diverted.

The construction of the top portion would be the final step in the re-alignment. A berm would remain until the channel is washed. With the completion and of all required channel construction, and small berms removed, the realigned channel will be ready to receive surface water in the subsequent spring.

(B) Monitoring

The re-alignment will be inspected by a qualified professional during the first freshet. In addition, it will be the responsibility of the Road Operations Manager (ROM) to complete formal inspections during spring runoff and after intense summer rainfalls. It is expected that less formal, casual inspections will be done on a regular basis to ensure continued stability of the re-alignment.

2.5 Undertaking #27

CanZinc will provide a prioritized list of road crossings, in terms of likelihood of disruption. Hazards could include avulsion, rockfall, avalanche, etc.

2.5.1 Response:

Table 3 below provides a list of the proposed major crossings, ranked from the greatest to the least risk related to avulsion, rockfall, avalanche, etc. (rank categories explained at the end).

Table 3: List of Major Stream Crossings Ranked by Risk

Major Crossing Location	Structure Type	Associated Risk	Description/Mitigation:
KP 6.2 (existing structures to be upgraded)	bridge	Avulsion	• Crossing over an active floodplain. • Thoroughly armor foundations • Train existing main channel to manage and contain flows • Installation of overflow culverts as required. • Design final road elevation to avoid large damming/back-up of head water • Monitoring annually and following unseasonal heavy rainfall periods
KP 39.8	bridge	Avulsion	• Crossing over an active floodplain. • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Installation of overflow culverts as required. • Design final road elevation to avoid large damming/back-up of head water • Monitoring annually and following unseasonal heavy rainfall periods
KP 124.8	bridge	Avulsion	• Crossing over an active floodplain. Large, single span bridge over single, defined channel • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Installation of overflow culverts as required. • Design final road elevation to avoid large damming/back-up of head water • Monitoring annually and following unseasonal heavy rainfall periods
KP 89.8	bridge	Avulsion Woody Log Debris	• Large, single span bridge over single, defined channel. May experience high water levels during spring runoff, flooding larger footprint. • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Installation of overflow culverts as required. • Design final road elevation to avoid large damming/back-up of head water • Monitoring annually and following unseasonal heavy rainfall periods
KP 118.1*	large	Avulsion	• Braided, multiple channels on 70 m floodplain only active during heavy runoff periods.

Major Crossing Location	Structure Type	Associated Risk	Description/Mitigation:
	multiple culverts	Ice Jams	• Armor existing braided channel and direct waterflows into selected, defined channels • Thoroughly armor/rip rap inlet/outlets • Design final road elevation to avoid large damming/back-up of head water • Monitoring annually and following unseasonal heavy rainfall periods • Periodic maintenance of road structure
KP 53.7	bridge	Avulsion	• Structure to span active, defined channel. High water levels possible during heavy runoff, flooding larger footprint • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Installation of overflow culverts as required. • Monitoring annually and following unseasonal heavy rainfall periods
KP 20.3*	Large multiple culverts	Avulsion	• Stable channel. • Thoroughly armor/rip rap inlet/outlets • Armor existing main channel to manage and contain flows • Monitoring annually and following unseasonal heavy rainfall periods
KP 43.4*	Large multiple culverts	Avulsion	• Stable channel. • Thoroughly armor/rip rap inlet/outlets • Armor existing main channel to manage and contain flows • Monitoring annually and following unseasonal heavy rainfall periods
KP 87.4	bridge	Avulsion	• Structure to span active, defined channel. High water levels outside active channel possible but low probability • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Installation of overflow culverts as required. • Monitoring annually and following unseasonal heavy rainfall periods
KP 151.3	large culvert	Avulsion	• Single, defined and contained channel which experiences significant water flow during spring thaw and unseasonal heavy rainfall periods. • Thoroughly armor inlet/outlets • Armor existing main channel • Monitoring annually and following unseasonal heavy rainfall periods
KP 123.3	bridge	Avulsion	• Shallow gradient, slow moving, stable channel. • Thoroughly armor foundations • Armor existing main channel to manage and contain flows • Monitoring annually and following unseasonal heavy rainfall periods
KP 122.3	bridge		• Shallow gradient, slow moving, stable channel. • Thoroughly armor inlet/outlets • Monitoring annually and following unseasonal heavy rainfall

Major Crossing Location	Structure Type	Associated Risk	Description/Mitigation:
			periods
KP 95.0*	large multiple culverts		• Shallow gradient, slow moving, stable channel. • Thoroughly armor inlet/outlets • Monitoring annually and following unseasonal heavy rainfall periods
KP 111.7*	large multiple culverts		• Shallow gradient, slow moving, stable channel. • Thoroughly armor inlet/outlets • Monitoring annually and following unseasonal heavy rainfall periods
KP 23.5*	bridge		• Structure and foundation located above/outside deep canyon stream channel on suspected bedrock. • Monitoring annually and following unseasonal heavy rainfall periods
KP 25.3*	bridge		• Structure and foundation located above/outside deep canyon stream channel on suspected bedrock. • Monitoring annually and following unseasonal heavy rainfall periods
Moderate		Moderate probability of risk related to environmental factors such as avulsion occurring on road structure which will require additional road or structural maintenance to ensure safe and reliable operations. An increased frequency of monitoring will be implemented.	
Low to Moderate		Low to moderate probability of risk related to environmental factors such as avulsion occurring on road structure. May require additional road or structural maintenance to ensure safe and reliable operations.	
Low		Low probability of risk related to environmental factors such as avulsion occurring on road structure. Expect standard road or structural maintenance to ensure safe and reliable operations.	

* Not fish-bearing

2.6 Undertaking #29

CanZinc will provide information on measures to minimize riparian disturbance during culvert and crossing installation and measures to restore riparian zones and areas around crossings.

2.6.1 Response:

Measures to minimize riparian disturbance during culvert and crossing installation have been described in documents already submitted. "Allnorth's Supplement to Original Submission (DAR)" dated September 8, 2015, Appendix C Operational Management Plans, Sedimentation and Erosion Control Plan, Section 4.1,4.3, 4.5, 6.1, and 6.2 describe specific procedures to be followed to ensure minimal riparian disturbance during construction activities. Sections 7.1 and 7.2 provide the ongoing monitoring to be completed during and after construction to ensure long term stability. These procedures are again emphasized in "Road Construction and Maintenance Plan", Section 5. These plans will be subject to regulatory review prior to construction, and CZN will incorporate relevant and appropriate additional approaches.

The "Road Operations Plan" describes the ongoing monitoring during the operation of the road. The "Road Closure and Reclamation Plan" Section 4.2 outlines the approach to de-activate road structures (bridges, culverts) following mine closure. Reclamation plans can be further developed during the operating life of the road reflecting on real time experience.

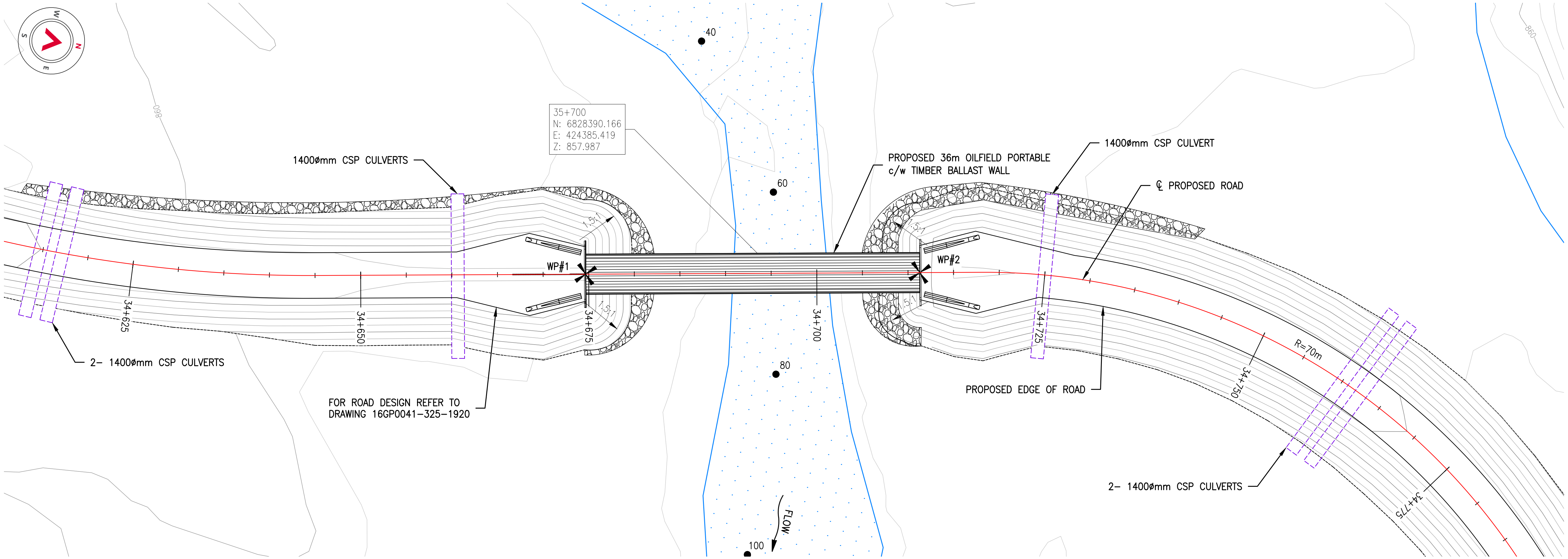
We trust this report satisfies your requirements at this time and thank you for the opportunity to work with you on the project. If you have questions or concerns do not hesitate to contact our office.

Yours truly,

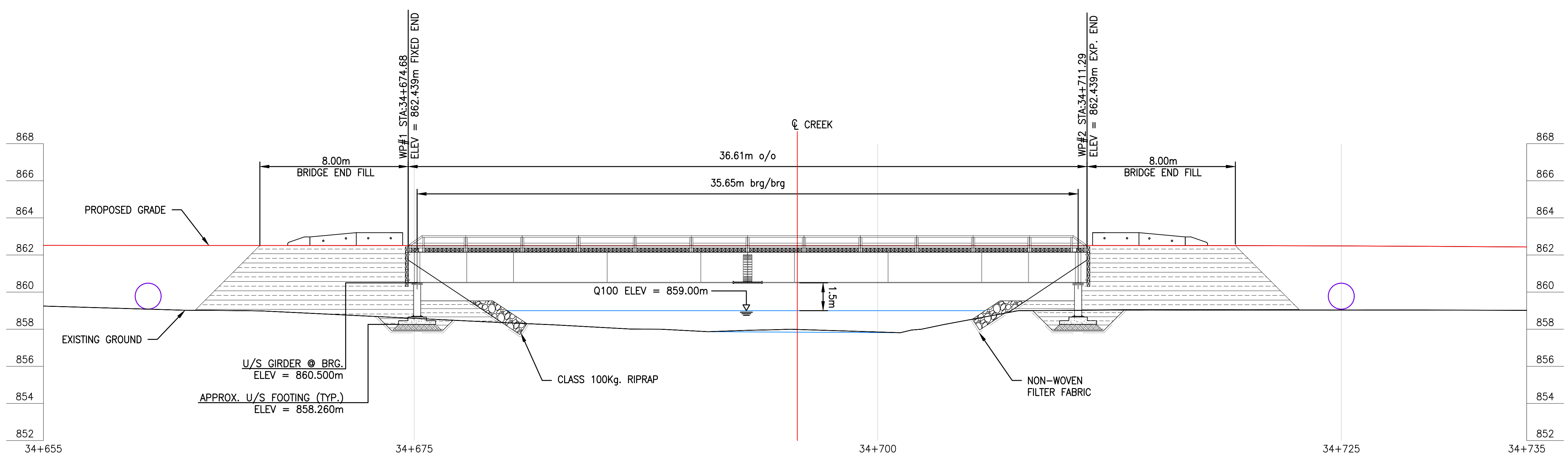
ALLNORTH CONSULTANTS LIMITED

Prepared By:	Reviewed By:
Ernest Kragt	Bradley Major, P.Eng.
Project Coordinator	Division Manager

Appendix A Alternative Alignment & Bridge Designs



GENERAL ARRANGEMENT PLAN
SCALE: 1:500



BRIDGE PROFILE
SCALE: 1:250

REFERENCE DRAWINGS

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REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/06/30	ISSUED FOR REVIEW	TJB	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TJB	DATE: 106/06/28
PROJECT NO:	14-GP-0128	DSGN: EK	DATE: 16/06/28
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	AS NOTED	APVD: WBM	DATE: -

PROJECT:

STREAM CROSSING
PRAIRIE CREEK MINE
AT km 34+700

TITLE:

GENERAL ARRANGEMENT PLAN AND BRIDGE PROFILE

DWG NO: **16GP0041-034-1960-001** REV: **0**

Date: 2016/07/08 | User: Tammy Beer | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\Site Plans\16GP0041-040-1920-34.8km-38.9km_site plan | Layout: 16GP0041-034-1960-001 | Paper Size: 558.8mm x 431.8mm

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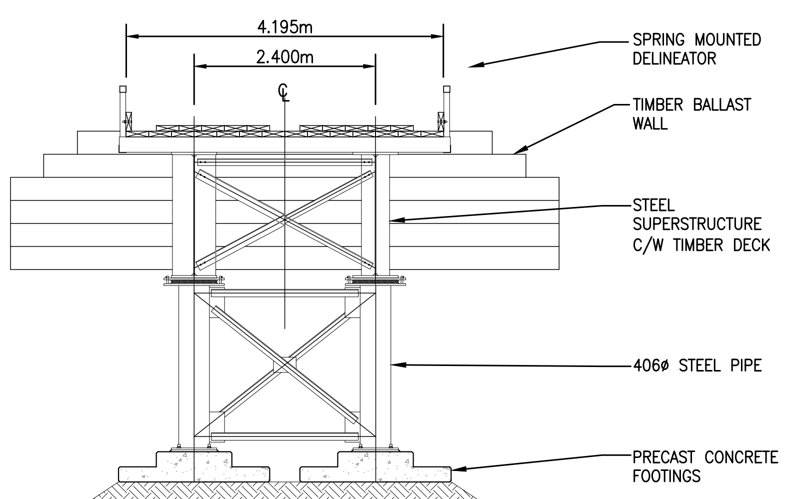


ABUTMENT ELEVATION
SCALE: 1:100

NOTES:

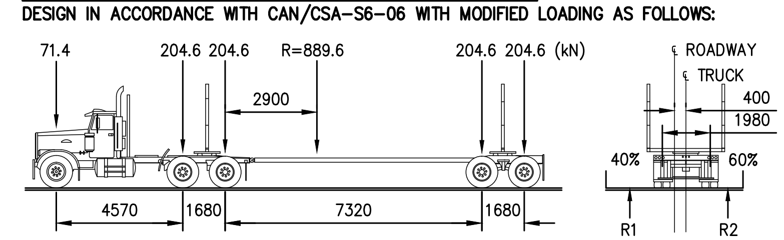
1. THESE DRAWINGS ARE INTENDED FOR CONCEPTUAL PURPOSES ONLY.
2. BRIDGE STRUCTURE SHOWN ON GENERAL ARRANGEMENT PLAN AS MANUFACTURED BY RAPID–SPAN STRUCTURES LTD.
3. RIPRAP SHALL EXTEND AROUND ABUTMENTS AS SHOWN ON THE PLAN. THE RIPRAP SHALL BE CLASS 100kg. AND SHALL HAVE A MINIMUM DEPTH OF 700mm.

CLASS OF RIPRAP (kg.)	NOMINAL THICKNESS OF RIPRAP (mm)	ROCK GRADATION PERCENTAGE SMALLER THAN GIVEN ROCK MASS (kg)			APPROXIMATE AVERAGE DIMENSION (mm)		
		15%	50%	85%	15%	50%	85%
10	350	1	10	30	90	195	280
25	450	2.5	25	75	120	260	380
50	550	5	50	150	155	330	475
100	700	10	100	300	195	415	600
250	1000	25	250	750	260	565	815
500	1200	50	500	1500	330	715	1030

4. NO SITE SPECIFIC GEOTECHNICAL INVESTIGATION HAS BEEN COMPLETED AT THE SITE TO DATE. THEREFORE, THIS CONCEPTUAL DESIGN HAS BEEN PREPARED WITHOUT THE BENEFIT OF GEOTECHNICAL ADVICE. GROUND CONDITIONS MAY VARY AND THE FOUNDATION CONCEPT MAY NEED TO BE MODIFIED TO ACCOMMODATE ACTUAL SITE CONDITIONS.
5. BACK FILL OF APPROACHES SHALL GENERALLY CONFORM TO THE LINES SHOWN ON THE DRAWINGS AND SHALL BE PLACED IN LIFTS NOT EXCEEDING 305mm THICK, COMPACTED TO 95% STANDARD PROCTOR DENSITY. MATERIAL SHALL BE NON–FROZEN, CLEAN, FREE DRAINING, WELL GRADED GRANULAR FILL OF 75mm MAXIMUM SIZE. USE LIGHT MECHANICAL TAMPERS ONLY.
6. CONSTRUCTION SHALL BE CARRIED OUT IN SUCH A MANNER AS TO ENSURE WATER QUALITY IS MAINTAINED BY KEEPING SOIL EROSION AND RUN–OFF TO A MINIMUM DURING INCLEMENT WEATHER AND BY TAKING MEASURES TO PREVENT SEDIMENTATION, LEACHATE, AND CONSTRUCTION MATERIALS FROM ENTERING THE STREAM.
7. OPERATE MACHINERY IN A MANNER THAT MINIMIZES DISTURBANCE TO THE BANKS OF THE WATERCOURSE. MACHINERY IS TO ARRIVE ON SITE IN CLEAN CONDITION AND IS TO BE MAINTAINED FREE OF FLUID LEAKS. REFUEL AND SERVICE MACHINERY AT MINIMUM 100m AWAY FROM THE WATERCOURSE. ENSURE EMERGENCY SPILL KIT IS ON SITE IN CASE OF FLUID LEAKS OR SPILLS FROM MACHINERY.
8. ALL EXPOSED MINERAL SOILS MUST BE SEEDED USING AN APPROVED RECLAMATION GRASS SEED MIXTURE AND COVERED WITH AN APPROVED EROSION CONTROL BLANKET.
9. MAINTAIN EFFECTIVE SEDIMENT AND EROSION CONTROL MEASURES UNTIL COMPLETE RE–VEGETATION OF DISTURBED AREA IS ACHIEVED.
10. ENVIRONMENTAL MANAGEMENT PLAN TO BE PREPARED FOR PROJECT BY OTHERS. COMPLETION OF WORKS TO COMPLY WITH MITIGATION RECOMMENDATIONS OUTLINED IN ENVIRONMENTAL MANAGEMENT PLAN.
11. ALL PERMITS AND REGULATORY APPROVALS TO BE IN PLACE PRIOR TO COMMENCING WORK. INSTALLATION OF WORKS TO COMPLY WITH BEST MANAGEMENT PRACTICES.
12. DESIGN SPEED OF APPROACH ROAD SHOWN IS 30 km/hr. LOCAL CHAINAGE SHOWN RELATIVE TO APPROXIMATE CENTRE OF STREAM.
13. STRUCTURE DESIGN SHALL BE COMPLETED IN ACCORDANCE WITH CAN/CSA–S6–06 CANADIAN HIGHWAY BRIDGE DESIGN CODE, WITH VARIATIONS IN THE DESIGN LOADING VEHICLE TO MEET ANTICIPATED VEHICLE LOADING.

LOADING DIAGRAM L-100 OFF HIGHWAY G.V.W. = 90 680kg:

DESIGN IN ACCORDANCE WITH CAN/CSA–S6–06 WITH MODIFIED LOADING AS FOLLOWS:



REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/06/30	ISSUED FOR REVIEW	TJB	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN:	TJB	DATE:	106/06/28
PROJECT NO:	14-GP-0128	DSGN:	EK	DATE:	16/06/28
DRAWING SIZE:	ANSI "B"	CHKD:	EK	DATE:	-
SCALE:	AS NOTED	APVD:	WBM	DATE:	-

PROJECT:

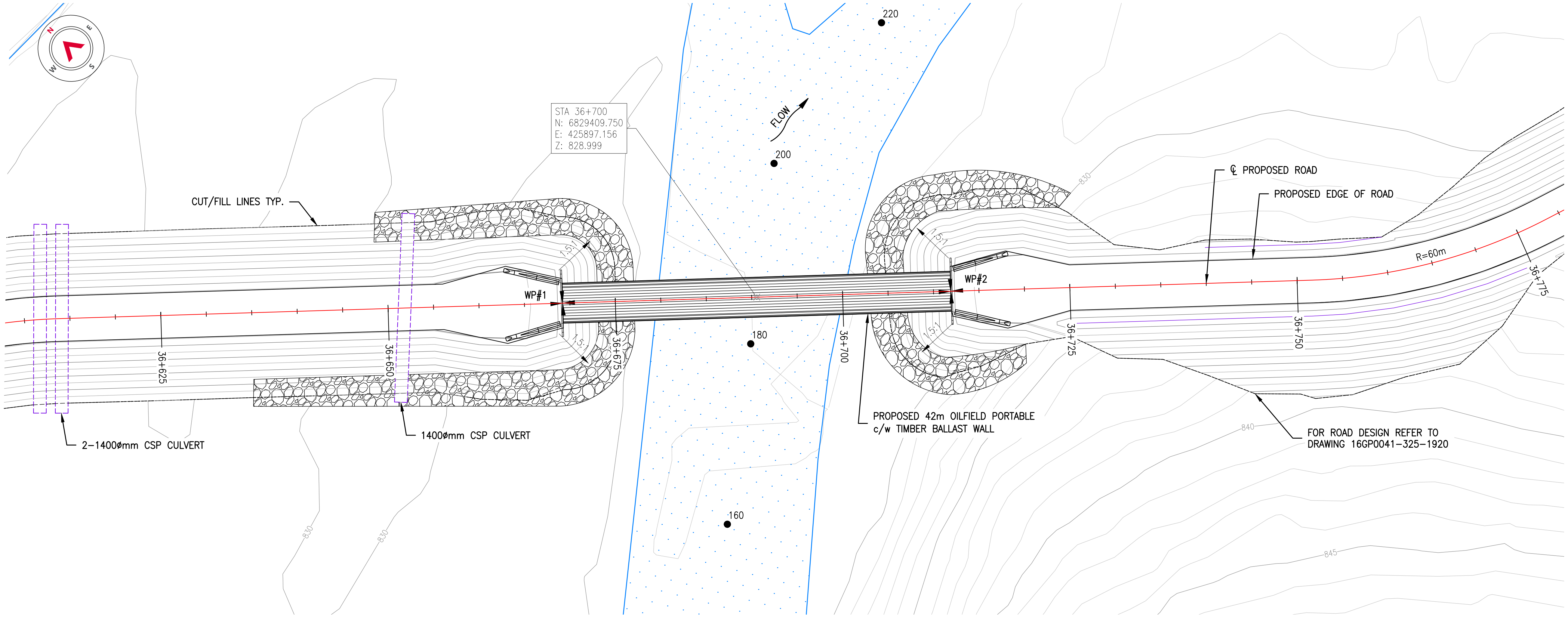
STREAM CROSSING
PRAIRIE CREEK MINE
AT km 34+700

TITLE:

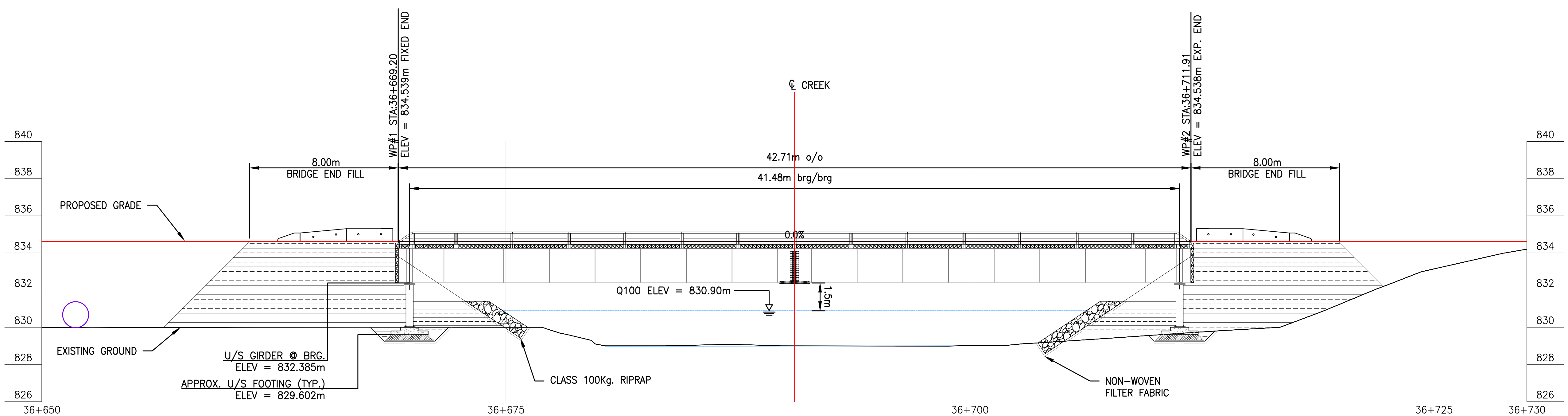
ABUTMENT ELEVATION
AND
GENERAL NOTES

DWG NO: **16GP0041-034-1960-002** REV: **0**

Date: 2016/07/08 | User: Tammy Beer | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\Site Plans\16GP0041-040-1920-34.8km-38.9km_site plan | Layout: 16GP0041-035-1960-002 | Paper Size: 558.8mm x 431.8mm



GENERAL ARRANGEMENT PLAN
SCALE: 1:500



BRIDGE PROFILE
SCALE: 1:250

REFERENCE DRAWINGS

DRAWING NO	DRAWING DESCRIPTION/TITLE	REF
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		3
		4
		5
		6
		7
		8

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/06/30	ISSUED FOR REVIEW	TJB	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TJB	DATE: 106/06/28
PROJECT NO:	14-GP-0128	DSGN: EK	DATE: 16/06/28
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	AS NOTED	APVD: WBM	DATE: -

PROJECT:

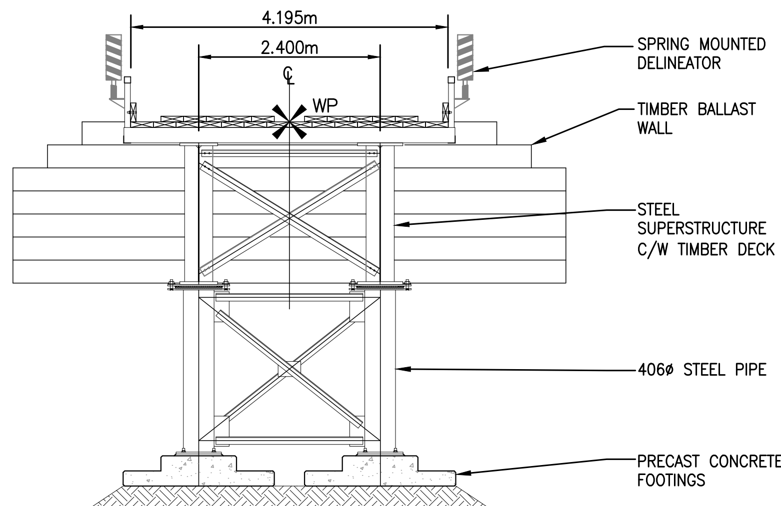
STREAM CROSSING
PRAIRIE CREEK MINE
AT km 36+700

TITLE:

GENERAL ARRANGEMENT PLAN AND BRIDGE PROFILE

DWG NO: **16GP0041-036-1960-001** REV: **0**

Date: 2016/07/08 | User: Tammy Beer | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\Site Plans\16GP0041-040-1920-34.8km-38.9km_site plan | Layout: 16GP0041-036-1960-001 | Paper Size: 558.8mm x 431.8mm



ABUTMENT ELEVATION
SCALE: 1:100

NOTES:

1. THESE DRAWINGS ARE INTENDED FOR CONCEPTUAL PURPOSES ONLY.
2. BRIDGE STRUCTURE SHOWN ON GENERAL ARRANGEMENT PLAN AS MANUFACTURED BY RAPID–SPAN STRUCTURES LTD.
3. RIPRAP SHALL EXTEND AROUND ABUTMENTS AS SHOWN ON THE PLAN. THE RIPRAP SHALL BE CLASS 100kg. AND SHALL HAVE A MINIMUM DEPTH OF 700mm.

CLASS OF RIPRAP (kg.)	NOMINAL THICKNESS OF RIPRAP (mm)	ROCK GRADATION PERCENTAGE SMALLER THAN GIVEN ROCK MASS (kg)			APPROXIMATE AVERAGE DIMENSION (mm)		
		15%	50%	85%	15%	50%	85%
10	350	1	10	30	90	195	280
25	450	2.5	25	75	120	260	380
50	550	5	50	150	155	330	475
100	700	10	100	300	195	415	600
250	1000	25	250	750	260	565	815
500	1200	50	500	1500	330	715	1030

4. NO SITE SPECIFIC GEOTECHNICAL INVESTIGATION HAS BEEN COMPLETED AT THE SITE TO DATE. THEREFORE, THIS CONCEPTUAL DESIGN HAS BEEN PREPARED WITHOUT THE BENEFIT OF GEOTECHNICAL ADVICE. GROUND CONDITIONS MAY VARY AND THE FOUNDATION CONCEPT MAY NEED TO BE MODIFIED TO ACCOMMODATE ACTUAL SITE CONDITIONS.
5. BACK FILL OF APPROACHES SHALL GENERALLY CONFORM TO THE LINES SHOWN ON THE DRAWINGS AND SHALL BE PLACED IN LIFTS NOT EXCEEDING 305mm THICK, COMPACTED TO 95% STANDARD PROCTOR DENSITY. MATERIAL SHALL BE NON–FROZEN, CLEAN, FREE DRAINING, WELL GRADED GRANULAR FILL OF 75mm MAXIMUM SIZE. USE LIGHT MECHANICAL TAMPERS ONLY.
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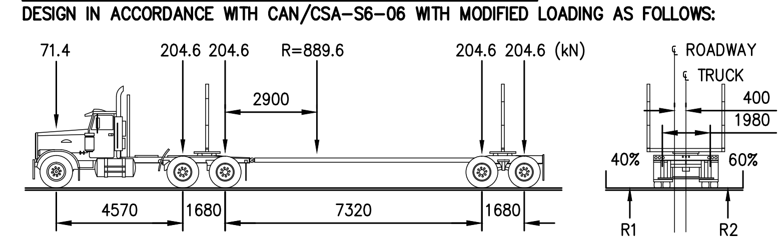
LOADING DIAGRAM L-100 OFF HIGHWAY G.V.W. = 90 680kg:

DESIGN IN ACCORDANCE WITH CAN/CSA–S6–06 WITH MODIFIED LOADING AS FOLLOWS:



REFERENCE DRAWINGS		
DRAWING NO	DRAWING DESCRIPTION/TITLE	REF
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		2
		3
		4
		5
		6
		7
		8

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/06/30	ISSUED FOR REVIEW	TJB	WBM

CLIENT:
CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TJB	DATE: 106/06/28
PROJECT NO: 14-GP-0128		DSGN: EK	DATE: 16/06/28
DRAWING SIZE: ANSI "B"		CHKD: EK	DATE: -
SCALE: AS NOTED		APVD: WBM	DATE: -

PROJECT:
STREAM CROSSING
PRAIRIE CREEK MINE
AT km 36+700

TITLE:
ABUTMENT ELEVATION
AND
GENERAL NOTES

DWG NO: **16GP0041-036-1960-002** REV: **0**

Date: 2016/07/08 | User: Tammy Beer | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\Site Plans\16GP0041-040-1920-34.8km-38.9km_site plan | Layout: 16GP0041-036-1960-002 | Paper Size: 558.8mm x 431.8mm

CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 34+480 to km 35+000

DRAWING LIST

DRAWING NO	DRAWING TITLE	REVISION
16GP0041-325-1920-009	PLAN AND PROFILE DRAWINGS km 34+480 to km 35+000	
16GP0041-325-1920-010	CROSS SECTION DRAWING PAGE 1 of 1	

Allnorth

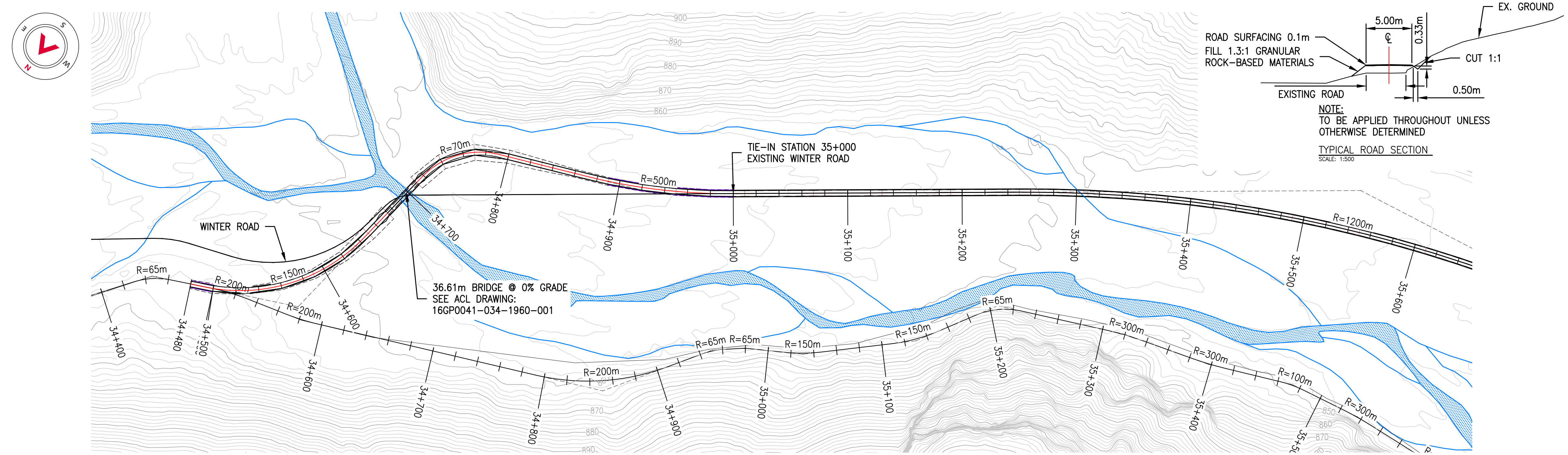
DESCRIPTION: **ISSUED FOR REVIEW**
ISSUE DATE: **16/07/08**

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT NO:	-	DRWN:	TMM	DATE:	16/07/08
PROJECT NO:	16GP0041	DSGN:	TMM	DATE:	16/07/08
DRAWING SIZE:	ANSI B	CHKD:	EK	DATE:	-
SCALE:	AS NOTED	APVD:	WBM	DATE:	-

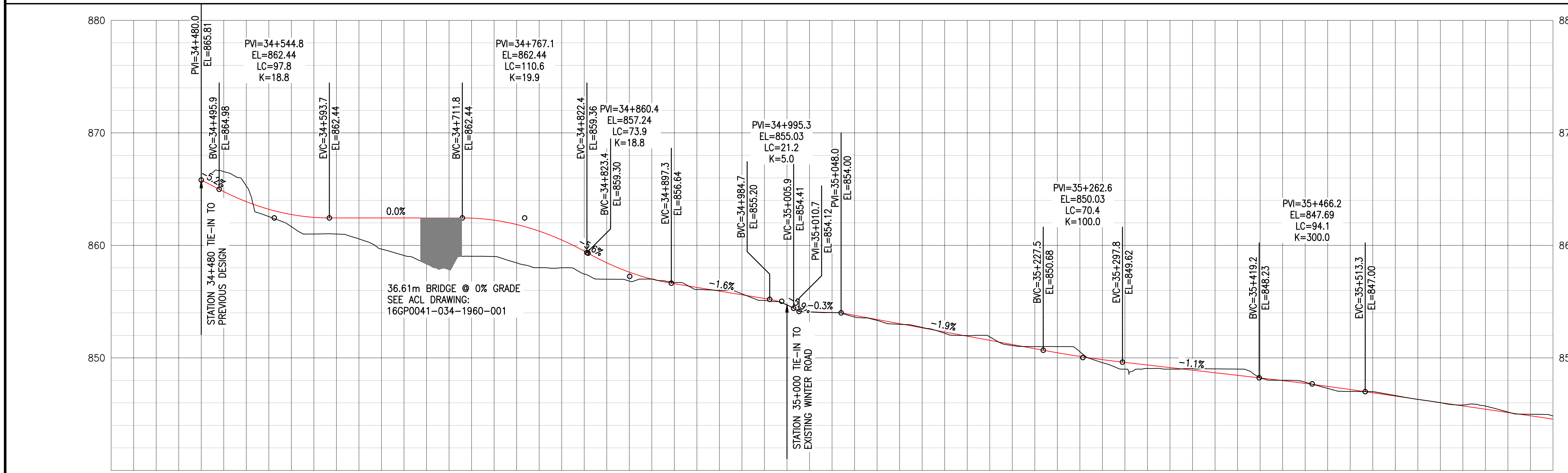
DWG NO: **16GP0041-325-1920** REV: **0**

Date: 2016/07/08 | User: Teena Major | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\16GP0041-040-1920-34.8km-38.9km_1_2000 | Layout: Cover Page km34-35 | Paper Size: 863.6mm x 558.8mm



SOILS:

FIELD STATIONS:



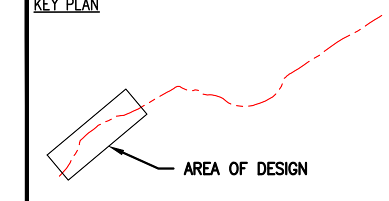
CHAINAGE: 34+400 | 34+500 | 34+600 | 34+700 | 34+800 | 34+900 | 35+000 | 35+100 | 35+200 | 35+300 | 35+400 | 35+500 | 35+600 | 35+680

MASS MOVEMENT:

EARTHWORKS:

ROAD WIDTH: 2.5m / 2.5m — 2.5m / 2.5m

KEY PLAN



LEGEND
- PROPOSED DESIGN CL
- PROPOSED ROAD EDGES
- PROPOSED CUT/FILL LINES
- EX. ROAD EDGES
- WATERCOURSES

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/08
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/07/08
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE: H = 1:4000, V = 1:4000		APVD: WBM	DATE: -

PROJECT:

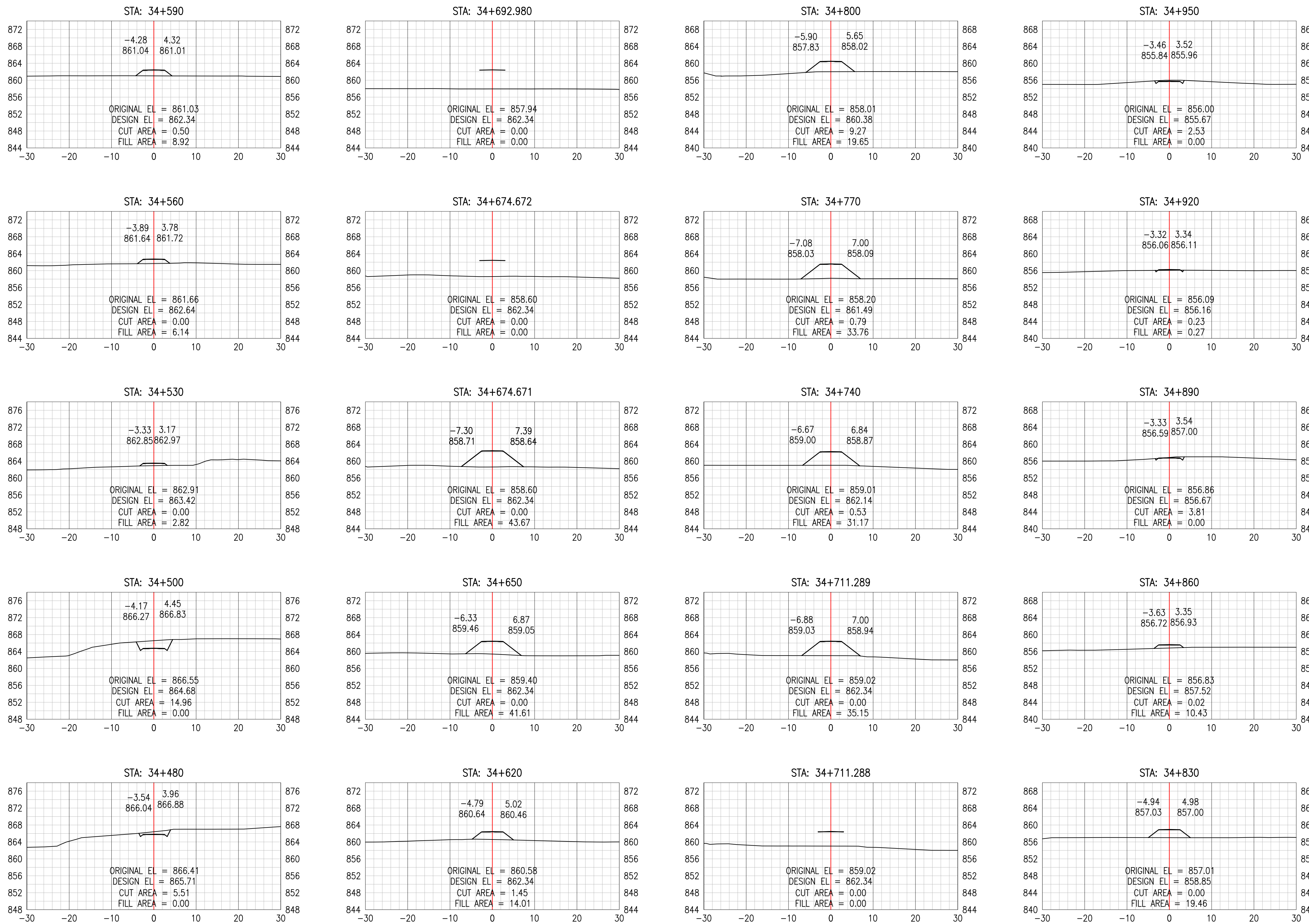
PRAIRIE CREEK MINE GEOMETRIC DESIGN km 34+480 to km 35+000

TITLE:

PLAN AND PROFILE DRAWING km 34+480 to km 35+000

DWG NO: 16GP0041-325-1920-009 REV: 0

Date: 2016/07/08 | User: Teena Major | File: P:\GP\2016\0001\6GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\16GP0041-040-1920-34.8km-38.9km_1_2000 | Layout: 16GP0041-325-1920-009 | Paper Size: 558.8mm x 431.8mm



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REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/08
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/07/08
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	1:1000	APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE GEOMETRIC DESIGN km 34+480 to km 35+000

TITLE:

CROSS SECTION DRAWINGS PAGE 1 of 1

DWG NO: 16GP0041-325-1920-0010 REV: 0

CANADIAN ZINC CORPORATION

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 36+300 to km 36+856

DRAWING LIST		
DRAWING NO	**DRAWING TITLE**	**REVISION**
16GP0041-325-1920-011	PLAN AND PROFILE DRAWINGS km 36+300 to km 36+856	
16GP0041-325-1920-012	CROSS SECTION DRAWING PAGE 1 of 2	
16GP0041-325-1920-0013	CROSS SECTION DRAWING PAGE 2 of 2	

Allnorth

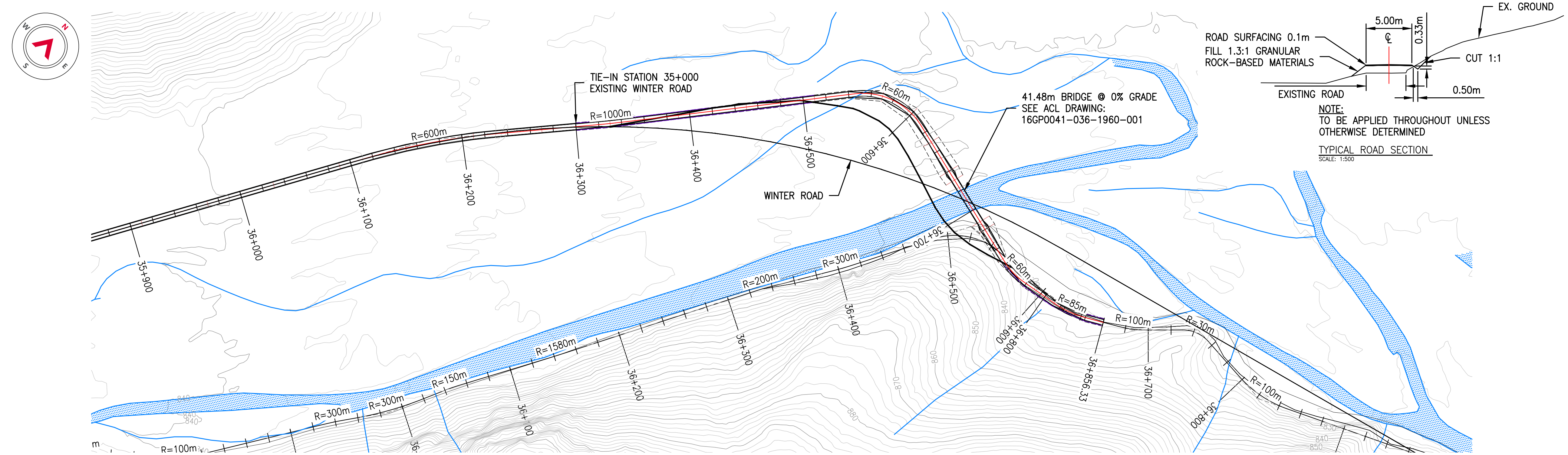
DESCRIPTION: ISSUED FOR REVIEW
ISSUE DATE: 16/07/08

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

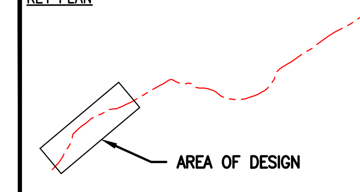
CLIENT NO:	-	DRWN:	TMM	DATE:	16/07/08
PROJECT NO:	16GP0041	DSGN:	TMM	DATE:	16/07/08
DRAWING SIZE:	ANSI B	CHKD:	EK	DATE:	-
SCALE:	AS NOTED	APVD:	WBM	DATE:	-

DWG NO: **16GP0041-325-1920** REV: **0**

Date: 2016/07/08 | User: Teena Major | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\16GP0041-040-1920-34.8km-38.9km_1_2000 | Layout: Cover Page km36 | Paper Size: 863.6mm x 558.8mm



KEY PLAN

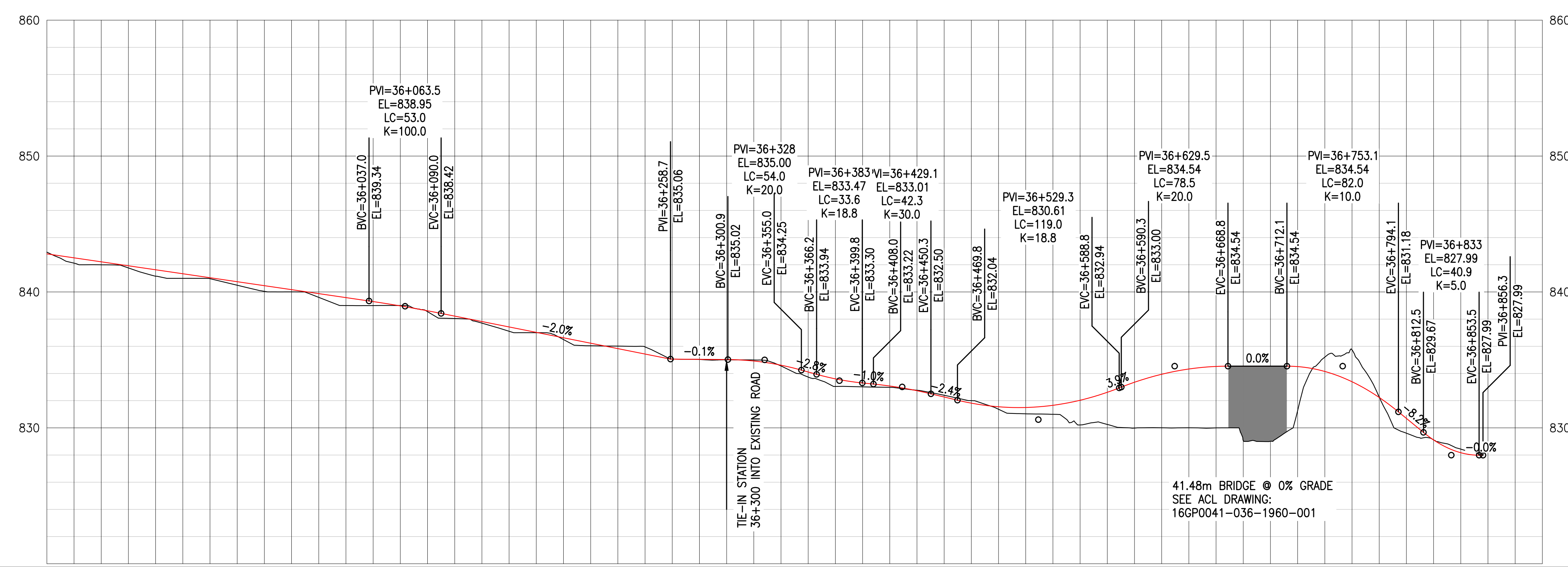


LEGEND

- PROPOSED DESIGN CL
- PROPOSED ROAD EDGES
- PROPOSED CUT/FILL LINES
- EX. ROAD EDGES
- WATERCOURSES

SOILS:

FIELD STATIONS:



CHAINAGE: 35+800 | 35+900 | 36+000 | 36+100 | 36+200 | 36+300 | 36+400 | 36+500 | 36+600 | 36+700 | 36+800 | 36+900

MASS MOVEMENT:

EARTHWORKS:

2.5m
2.5m

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:	DRWN: TMM	DATE: 16/07/08
PROJECT NO: 16-GP-0041	DSGN: TMM	DATE: 16/07/08
DRAWING SIZE: ANSI "B"	CHKD: EK	DATE: -
SCALE: H = 1:4000, V = 1:4000	APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE GEOMETRIC DESIGN km 36+300 to km 36+856

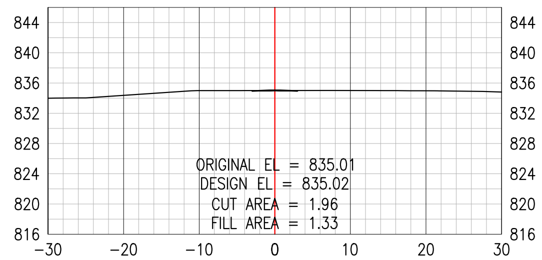
TITLE:

PLAN AND PROFILE DRAWING km 36+300 to km 36+856

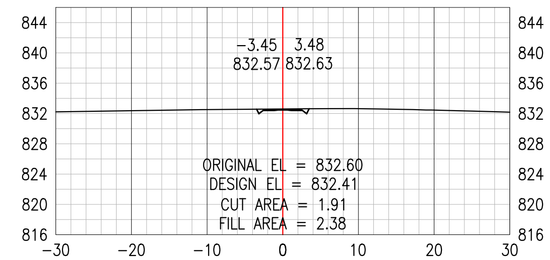
DWG NO: 16GP0041-325-1920-011 REV: 0

Date: 2016/07/08 | User: Teena Major | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\16GP0041-040-1920-34.8km-38.9km_1_2000 | Layout: 16GP0041-325-1920-011 | Paper Size: 558.8mm x 431.8mm

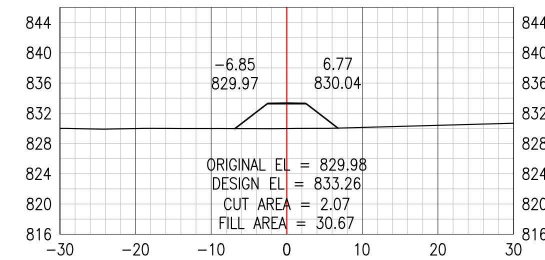
STA: 36+300



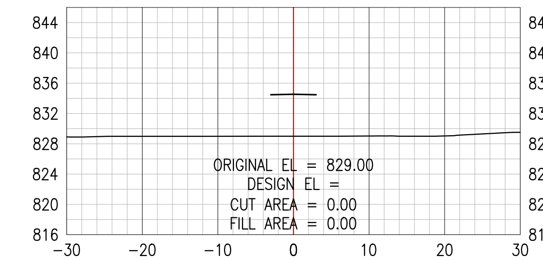
STA: 36+450



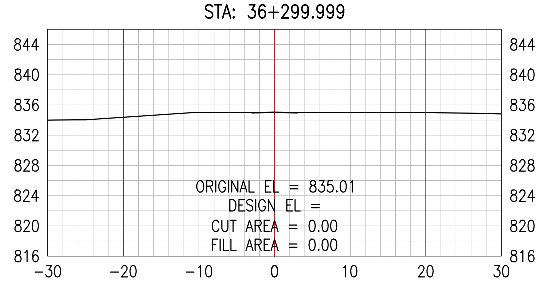
STA: 36+600



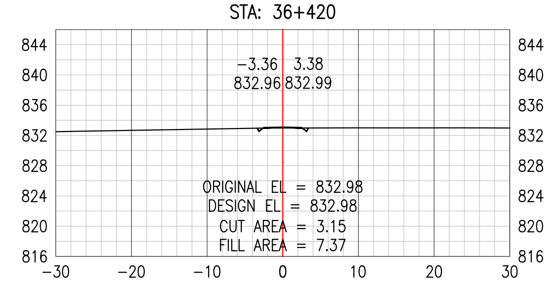
STA: 36+690



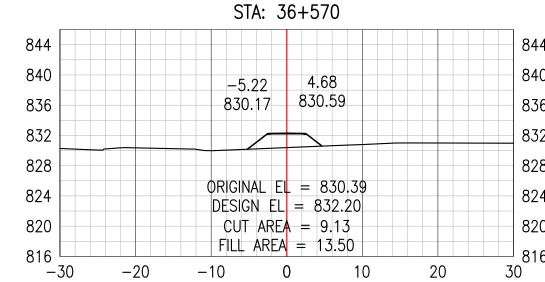
STA: 36+299.999



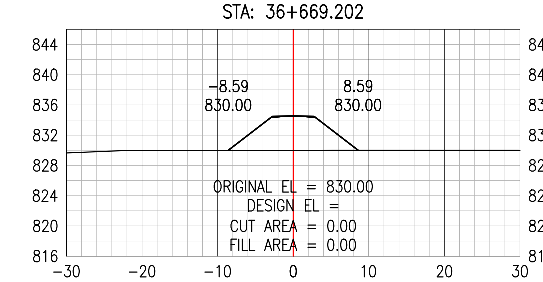
STA: 36+420



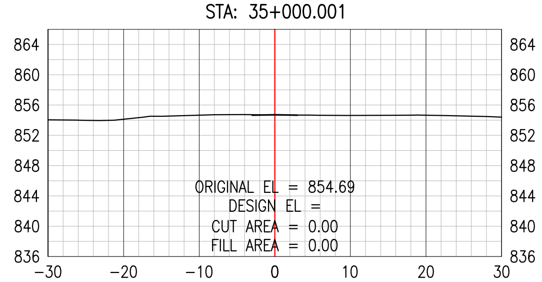
STA: 36+570



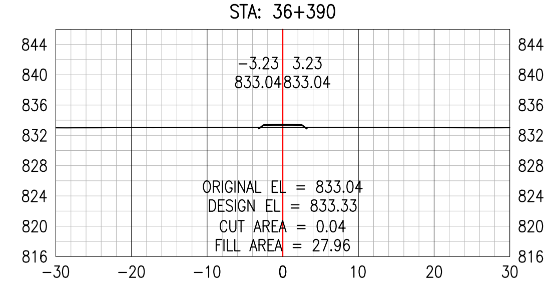
STA: 36+669.202



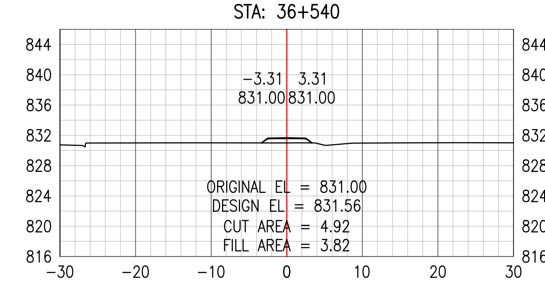
STA: 35+000.001



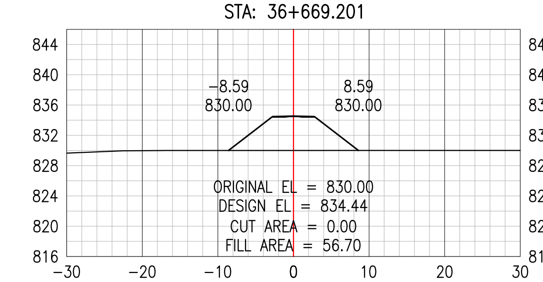
STA: 36+390



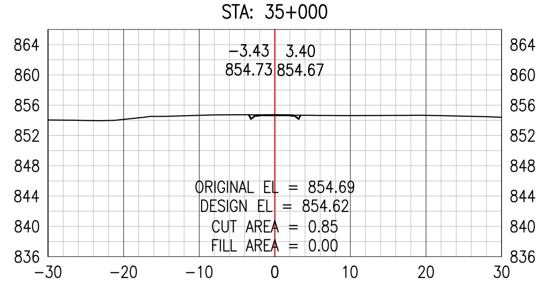
STA: 36+540



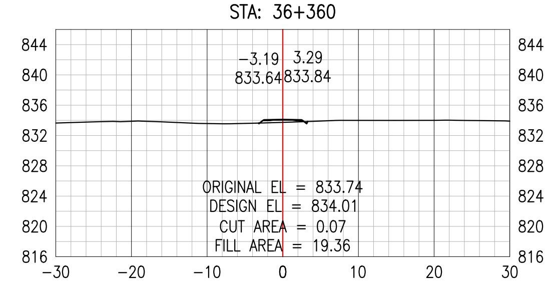
STA: 36+669.201



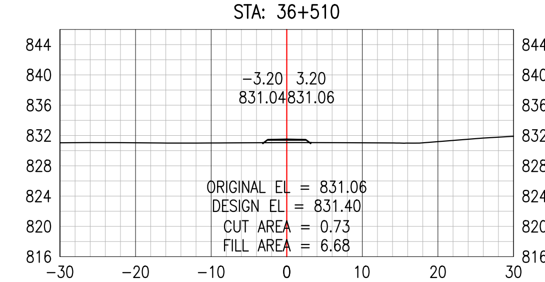
STA: 35+000



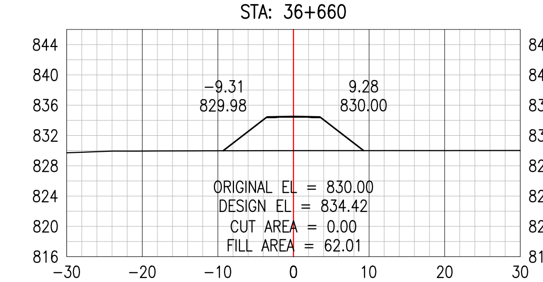
STA: 36+360



STA: 36+510



STA: 36+660



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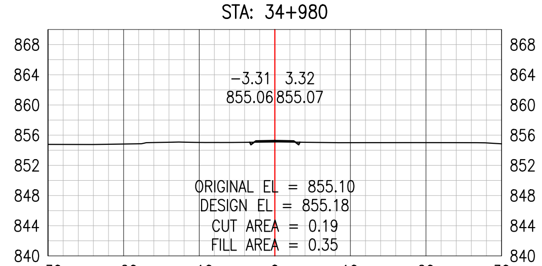

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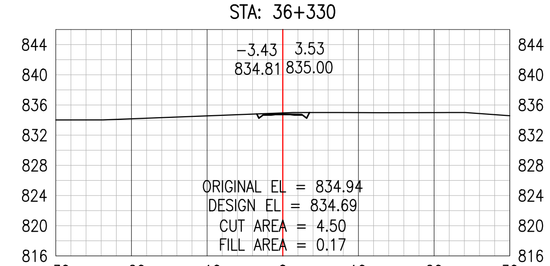

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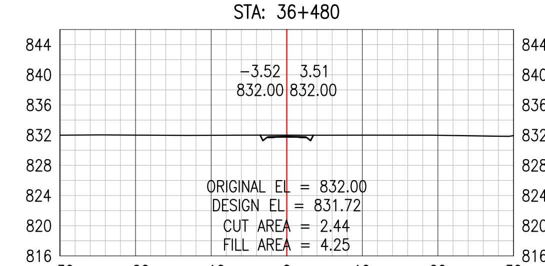

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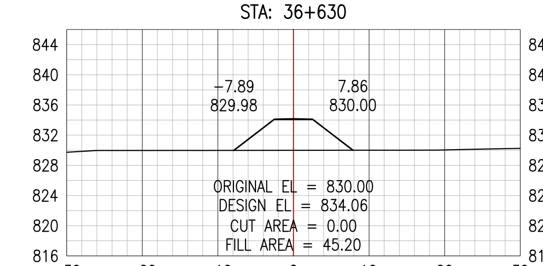

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0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/08
PROJECT NO: 16GP0041		DSGN: TMM	DATE: 16/07/08
DRAWING SIZE: ANSI "B"		CHKD: EK	DATE: -
SCALE: 1:1000		APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE GEOMETRIC DESIGN km 36+600 to km 36+856

TITLE:

CROSS SECTION DRAWINGS PAGE 1 of 2

DWG NO: **16GP0041-325-1920-012** REV: **0**

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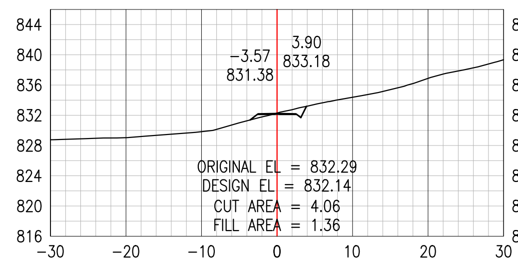

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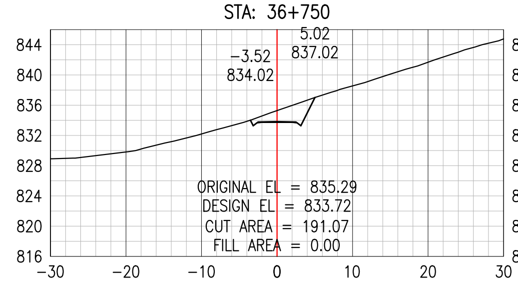

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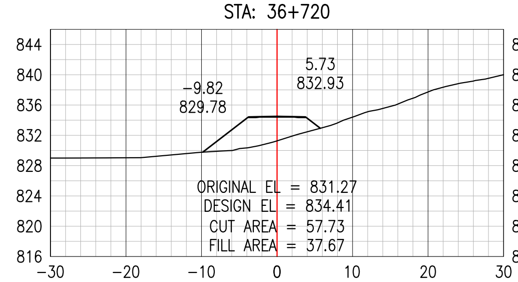

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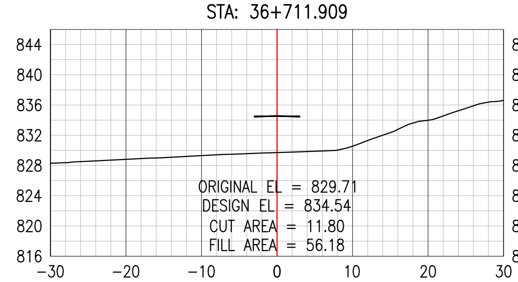

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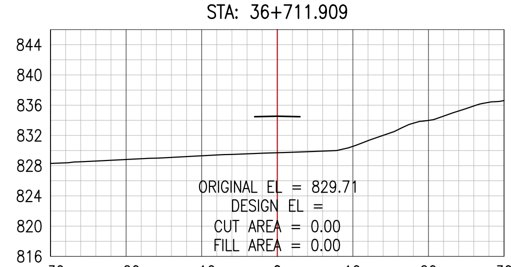

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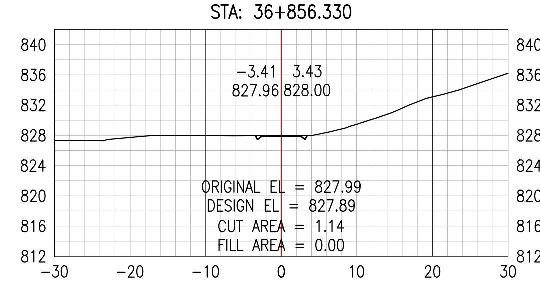

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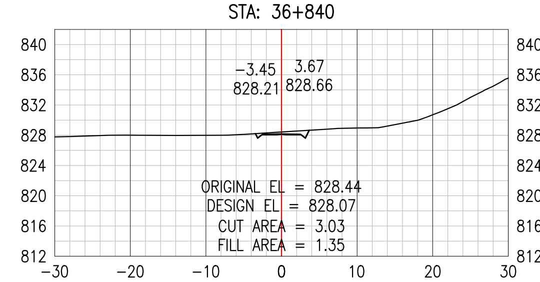

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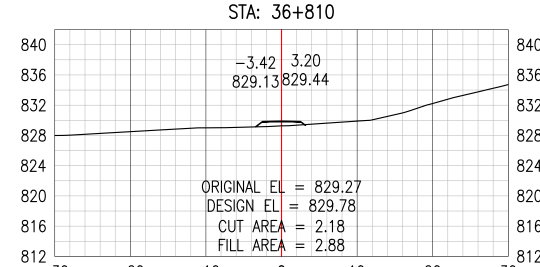

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2016/07/08	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/08
PROJECT NO:	16GP0041	DSGN: TMM	DATE: 16/07/08
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	1:1000	APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 36+600 to km 36+856

TITLE:

CROSS SECTION DRAWINGS
PAGE 2 of 2

DWG NO: **16GP0041-325-1920-013** REV: **0**

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TETRA TECH EBA

July 5, 2016

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FILE: Y14103320-01
Via Email: david@canadianzinc.com

Canadian Zinc Corporation
Suite 1710, 650 West Georgia Street
Vancouver, BC V6B 4N9

Attention: David Harpley
VP Environmental & Permitting Affairs

Subject: Undertaking 26, Sundog Creek Realignment Reach, KP 35-38, Supplemental Assessment
Proposed Prairie Creek All Season Road, NT

1.0 INTRODUCTION

As part of its review of Canadian Zinc's (CZN) Developer's Assessment Report (DAR) for the Prairie Creek All-Season Road Project, the Mackenzie Valley Review Board (MVRB) has requested additional information regarding channel stability and sediment transport for a segment of Sundog Creek where re-alignment is proposed in the vicinity of Kilometre Post (KP) markers 35 to 38. The additional information was requested in the form of Undertaking 26 that resulted from Technical Sessions held in Yellowknife in June 2016.

This report has been prepared to supplement our March 15, 2016 letter report: Sundog Creek Realignment Reach, KP 35-38, Hydrotechnical Assessment; Proposed Prairie Creek All Season Road, NT. It provides further description of our understanding of the stream geomorphology and processes in the reach of interest, but does not change or alter the findings or recommendations presented in the original document.

2.0 REACH CHARACTERISTICS

In the original assessment, re-alignment was proposed for a reach of Sundog Creek that was determined to be "quasi-stable" with flood flows that are generally contained within a single channel presently located on the south side of the historic floodplain.

Figures 1 through 3 show year 2012 orthophoto and LiDAR-derived terrain surface images, together with year 1949 edge of vegetation as determined from historical aerial imagery. The extents of Figures 1 through 3 are identical. Edge-of-vegetation information from historical imagery for year 1994 is presented in our March 15 report and is very similar to the edge of vegetation as of 2012.

Since 1949, there have been two "active" flow paths through the reach, both visible in Figure 1: the main channel, approximately 20 m wide, now located along the south bank; and a second flow path, also about 20 m wide, located in the middle of the historic floodplain. Figure 2 includes a cross section showing the 1949 edge of vegetation in the middle of the historic floodplain and the 2012 active incised channel along the southern edge. Significant channel movement since 1949 has been limited to the south part of the historic floodplain. Much of the northern flow path, as of 2012, continues to correspond to the edge of vegetation that existed in 1949.

Hydraulic modelling of this reach predicts that the incised channel along the south bank has sufficient hydraulic capacity to convey the 100-year flow within the main (20 m wide) channel section without overtopping into the broader floodplain. The finding that the flow should normally be contained within a relatively-narrow channel is consistent with the quasi-stable nature of this reach. An explanation is required, and is provided below, for the areas of exposed alluvium within portions of the adjacent floodplain area and also the existence of the second flow path through the central part of the historic floodplain.

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Our assessment is that the north flow path developed in response to landslides at the south bank which deflected the flow into the central part of the historic floodplain. Terrain analysis identified two areas of historic landslides which correspond to the areas where flow has been deflected into the central historic floodplain and north flow path. The landslide area locations are marked on the figures, and areas of past slope failures are visually apparent on the terrain surface images.

The first of the landslide areas is located at about KP 35.5 and corresponds to the upstream point of divergence between the north and south channels. The second is located just downstream from KP 36.0, where the 1949 edge of vegetation extends into the south floodplain with a fan shape consistent with a major pre-1949 landslide blockage of the channel.

The available information strongly indicates that the past landslides at the areas indicted are the cause of episodic natural re-routing of flow into the central floodplain area.

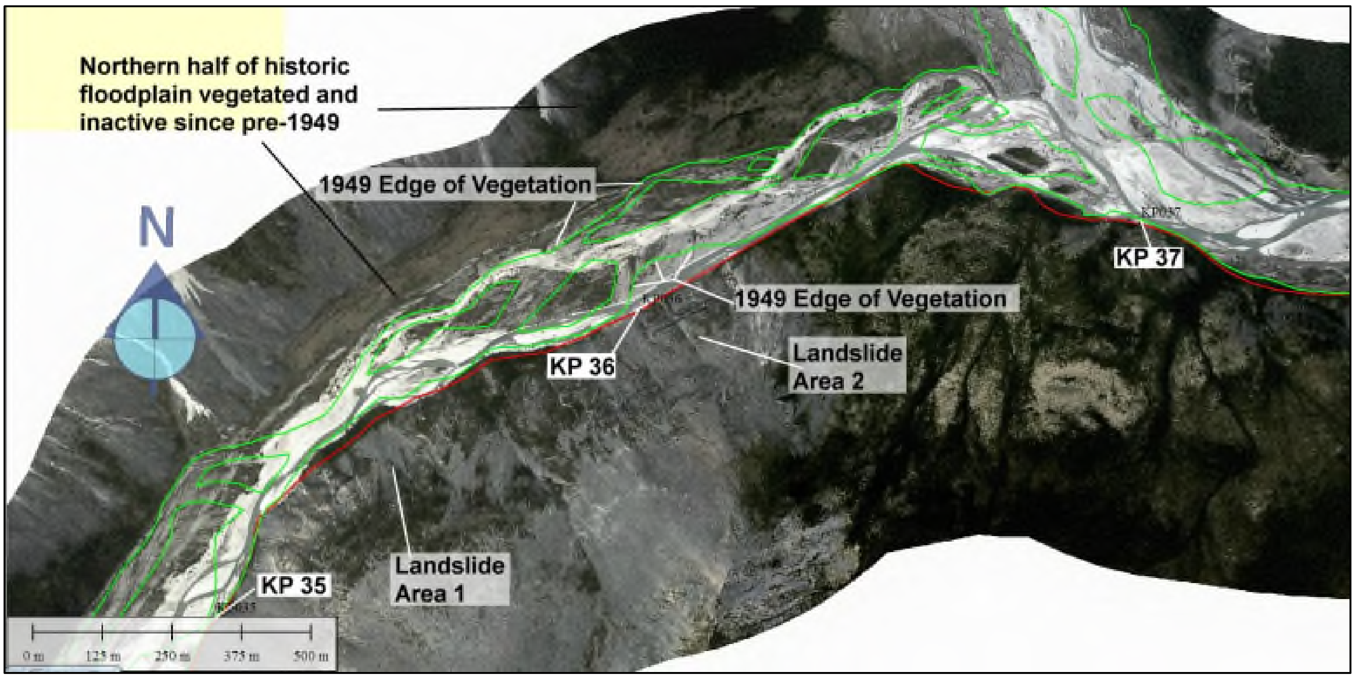

Figure 1: Sundog Creek 1949 channel position shown on 2012 orthophoto image.

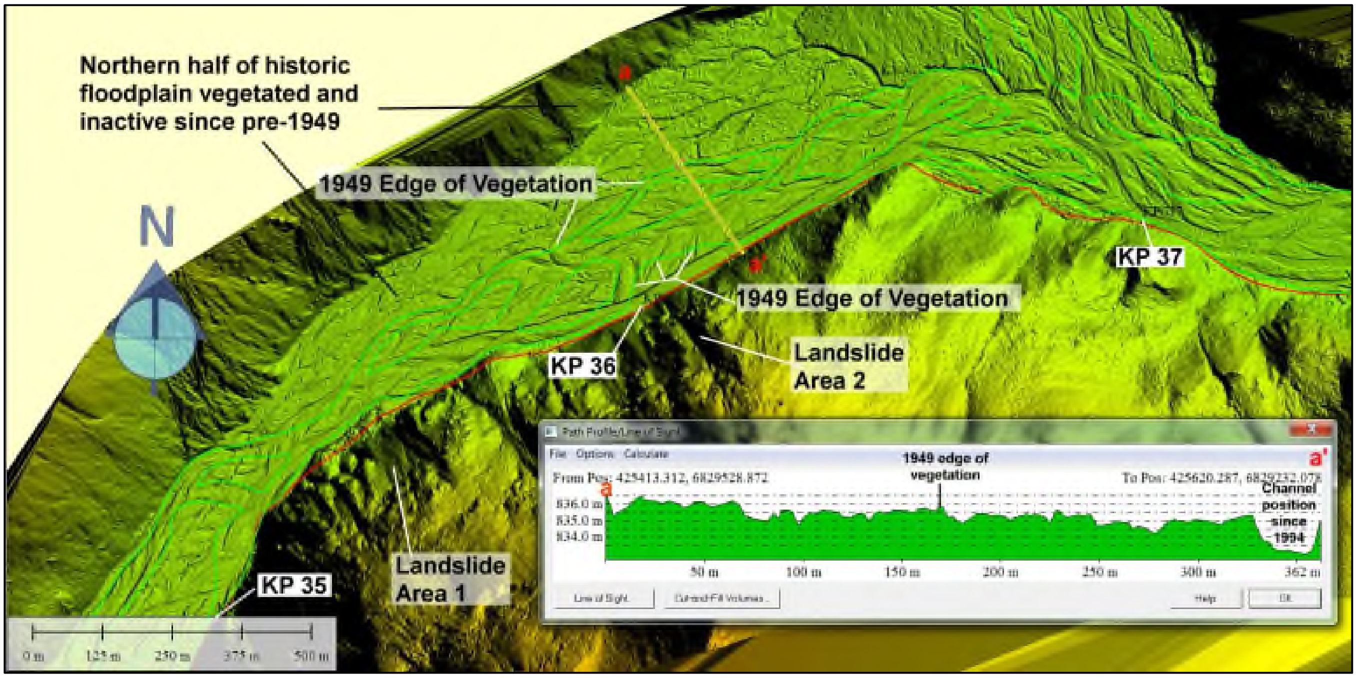

Figure 2: Sundog Creek 1949 channel position shown on 2012 terrain surface with cross section across full width of historic floodplain.

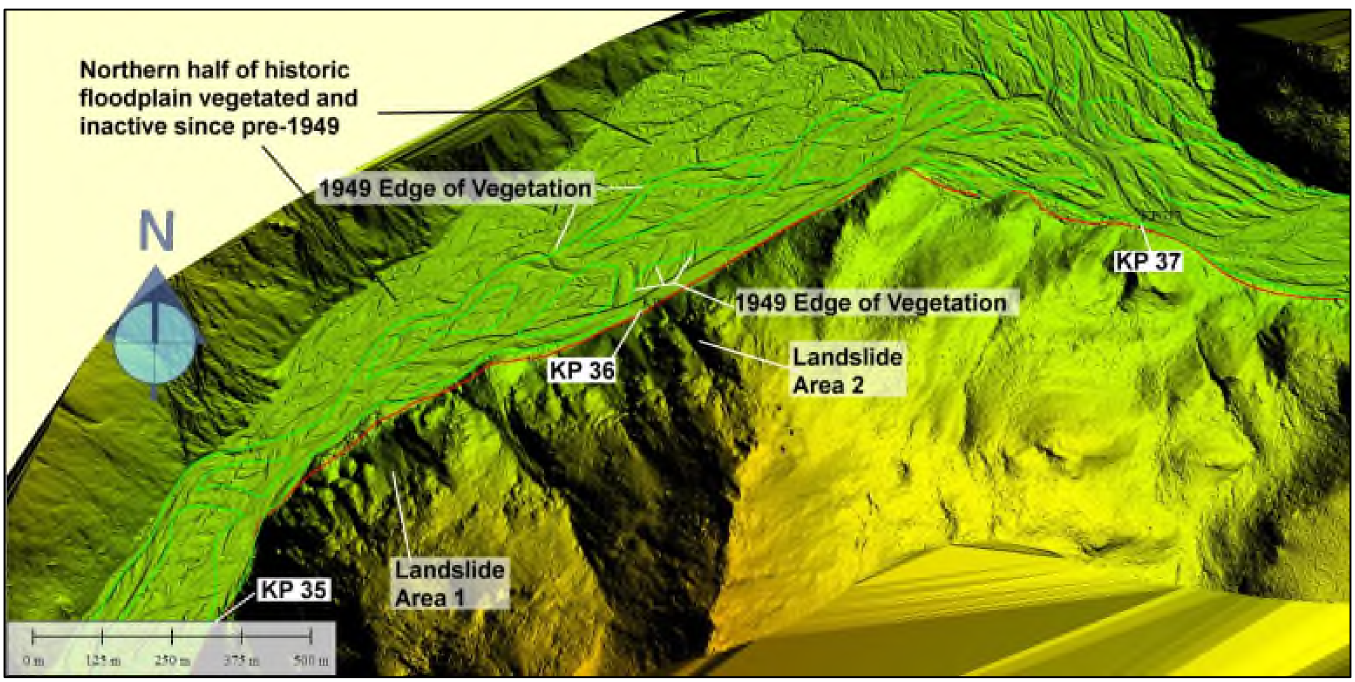

Figure 3: Sundog Creek 1949 channel position shown on 2012 terrain surface without cross section.

3.0 SEDIMENT TRANSPORT

As indicated above, Sundog Creek downstream of about KP 35.5 has a main channel along the south bank which is capable of passing a 100-year flow without overtopping into adjacent floodplain areas. This channel is well defined and has incised to a depth of more than two metres below the adjacent floodplain areas. In contrast, the remnant channels that exist across the broad historic floodplain have maximum depths of 0.5 m below the adjacent ground, with less hydraulic and sediment transport capacity. The remnant channels are normally dry.

The existing main channel in this reach is in balance with its hydrologic and sediment inputs. The channel bottom may locally rise and fall as bedforms such as gravel bars pass through the reach, with most bed material movement occurring during high flow events. There is no evidence of aggradation or infilling, other than episodic landslide blockages. The approach for a realigned channel is to provide equivalent hydraulic capacity to the existing channel, defined by its dimensions and slope and substrate material. The realigned channel may be more durable than the existing because of its position in the central floodplain with minimal susceptibility to landslide blockages.

Our recommendation is for CZN to commit that the final design will be developed to provide hydraulic/sediment capacity equivalent to the geometry of the existing channel, defined by its geometry, and to mimic the substrate characteristics of the existing channel. Once constructed and commissioned, the realigned channel is expected to be in balance with its hydrologic and sediment inputs, and to convey sediment through the reach in a sustained manner similar to the existing channel, without need for recurring dredging or other planned maintenance.

4.0 MONITORING AND MAINTENANCE

The realigned channel is expected to be generally stable, and not require dredging or other recurring maintenance. There is, however, a risk of future avulsions at the upstream and downstream extents of the realigned reach at its connections to the existing channel(s), and of lateral shifting along the main segment. These are addressed below. In this discussion, an avulsion refers to a sudden abandonment of one channel and the formation of a new channel. Lateral shifting refers to a more gradual channel movement, such as by erosion on the outside of a bend, and deposition on the opposite side.

The risk of an avulsion at the upper end of the re-aligned reach can be mitigated by construction of a barrier berm on the existing channel to an elevation that is higher than the level of adjacent stable (vegetated) floodplain areas. In addition, an overflow pilot channel could be constructed so that, in the event of a sediment blockage at the bypass inlet, clear-water overflows above the blockage would be directed back to the desired alignment.

The central segment of realigned channel will be expected to exhibit natural channel behaviours, which include lateral shifting. We do not anticipate that lateral shifting would threaten the road within the project life, but monitoring is recommended on an annual basis so that preventative measures could be taken if warranted. Shifting is expected to occur on an incremental progressive basis, such that any remedial measures, such as additional realignment activity, could be scheduled to be performed under late summer no-flow conditions.

There is a high likelihood of localized avulsions or channel shifting downstream where the realigned channel will connect to the major tributary that enters from the north which has an apparent high sediment load and braided channel behaviour. However, the location of such channel movement would not be in proximity to the road and is not expected to threaten the road or to trigger a need for maintenance activity.

5.0 LIMITATIONS

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6.0 CLOSURE

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

Respectfully submitted,
Tetra Tech EBA Inc.

REGISTERED PROFESSIONAL ENGINEER
W. A. ROZEBOOM
LICENSEE
NT/NU

July 5, 2016

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/cee

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Signature ____________
Date July 5, 2016.
PERMIT NUMBER: P 018
NT/NU Association of Professional Engineers and Geoscientists

August 10, 2016

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Via Email: david@canadianzinc.com

Canadian Zinc Corporation
Suite 1710, 650 West Georgia Street
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Attention: David Harpley
Vice President Environmental & Permitting Affairs

Subject: Sundog Creek Realignment Reach, KP 35-38, Preliminary Design
Proposed Prairie Creek All Season Road, NT

1.0 INTRODUCTION

As part of its review of Canadian Zinc's (CZN) Developer's Assessment Report (DAR) for the Prairie Creek All-Season Road Project, the Mackenzie Valley Review Board (MVRB) has requested further design details for the proposed re-alignment of Sundog Creek in the vicinity of Kilometre Post (KP) markers 35 to 38, including a diversion berm to be constructed at the upstream end of the realigned reach. The additional information was requested in the form of undertakings that resulted from Technical Sessions held in Yellowknife in June 2016.

This report has been prepared to supplement our July 5, 2016 letter report, Undertaking 26, Sundog Creek Realignment Reach, KP 35-38, Supplemental Assessment, which addressed channel stability issues. It also supplements our prior March 17, 2016 report, Sundog Creek Realignment Reach, KP 35-38, Hydrotechnical Assessment; Proposed Prairie Creek All Season Road, which presented a conceptual design for the channel realignment.

A preliminary design is presented in this letter report for the proposed realignment and diversion berm, and refines and updates the conceptual level information presented in our March 17 letter report.

Drawings showing the preliminary design for the realigned channel and diversion berm were prepared as a collaborative effort between Tetra Tech EBA and Allnorth Consultants, and are included in Appendix A. Tetra Tech EBA provided direction to Allnorth with respect to the location and geometry of the realignment features shown on the preliminary design drawings.

2.0 REFINEMENTS SINCE CONCEPTUAL DESIGN

The realignment reach conceptual design consisted of a simple trapezoidal channel with uniform bed slope and geometry. A berm to divert flow to the realigned channel was initially placed at a narrow section located downstream from the point of diversion.

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In the preliminary design, the channel width and bottom slope are varied along the realignment reach to provide complexity that is more representative of a natural channel. Also, the width of the excavated channel is narrowed from the originally-suggested 20 m width to avoid unnecessary excavation beyond what is necessary to convey the 100-year design flow, while not adversely altering water velocities which influence fish passage. During recent July 2016 fish habitat inspections by Hatfield Consultants, it was noted that the old channel to be reactivated is well developed. A simulation of 100 year flows with the existing channel blocked (Figure 8) indicates that flows will largely remain in the channel without avulsion, at least in the upstream portion. As a result, while excavation is still required to reduce the risks of overland flow and avulsion, the extent of excavation can be reduced from that assumed previously.

Hatfield noted in the field that the existing active channel to be realigned has large cobble substrate in the steeper segments with higher velocities, and gravel substrate in flatter segments with lower velocities. Similar variability is desirable for the realigned channel from a habitat perspective. During construction, the channel slope and geometry can varied slightly as directed by the field engineer to take advantage of existing substrate features (boulders, etc.) when encountered.

The limit of channel excavation for the realignment reach is extended upstream somewhat from that shown in the conceptual design in order to deepen the channel through an area of deposition and connect to a relatively large (and deeper) historic channel at this location.

The location of the diversion berm has been moved upstream slightly from the position shown in the conceptual design. This will reduce the required height of the berm.

A dry pilot inlet to the realigned channel has been added near its upstream end. In the event of a blockage of the main inlet, the pilot inlet will provide an alternate flow path for water to reach the realigned channel and reduce the risk of water overtopping the diversion berm.

3.0 CHANNEL STABILITY AT UPPER END OF REALIGNMENT

Aerial and ground field inspections along the realignment reach were performed in July 2016 by Canadian Zinc and Hatfield Consultants. Photographs from these inspections were provided to Tera Tech EBA for use in assessing the recent stability of the existing channel in the vicinity of the inlet to the realigned channel and companion diversion berm.

Figures 1 through 4 show conditions in the vicinity of the proposed diversion berm and upstream end of the proposed realignment, as observed in 2008, 2012, and 2016. The images are annotated with a line drawn though persistent identifiable features, primarily vegetation. The labelled reference features are as follows:

- Label “a” is just downstream of a clump of vegetation in an historic north channel
- Label “b” bisects two upstream clumps of central island vegetation
- Label “c” is at the downstream tip of south island vegetation
- Label “d” is on the right (south) edge of bank corresponding to a line drawn through the above points
- Labels “e” and “f” are at north bank deposition areas where vegetation is starting to establish

Our interpretation of the figures is that the positions of the braided channels in this location, over the eight years from 2008 to 2016, have been reasonably stable. The amount of flow in the north braid adjacent to Labels “e” and “f” appears to have decreased over this period, balanced by an increase of flow in the adjacent south braid. However, there is very little change in the positions of the braids in the areas where the diversion berm and inlet to the realigned channel are proposed.

With confirmation of reasonably stable conditions, we conclude that the LiDAR data obtained in 2012 are representative of current conditions and are suitable for the development of the preliminary designs for the diversion berm and realigned channel.

4.0 BERM PRELIMINARY DETAILS

The diversion berm will vary in height between 0.6 m to 1.8 m depending on ground elevations. It will have a 3 m crest width and 2H:1V slopes. The front face will be armoured with rip rap. Aggregate gradation and compaction for the core of the berm will be specified.

The preliminary berm design has assumed a constant top elevation of 846.0 m. Hydraulic modeling of the proposed berm and channel geometry determined that the 100-year water level would be essentially at the top of berm at its south end. Therefore, for the final design, the top of berm will be raised by 1.0 m to elevation 847.0 to provide freeboard. This will also ensure that, in the event of a local blockage of the realigned channel main inlet, water would flow into the pilot channel inlet and not overtop the berm.

5.0 INUNDATION EXTENTS AND FLOW VELOCITIES

Our March 17 letter report presented inundation extents and water velocities for existing conditions and for the conceptual realigned channel based on 2-dimensional hydraulic modelling for 2-year and 100-year flows. For ease of reference, results for existing conditions are repeated here in Figures 5 and 6. In subsequent runs not previously reported, it was determined that a 10-year flood is the approximate threshold at which water first begins to overtop into the existing-conditions historic north channel where the realignment is proposed.

Figure 7 shows the 2-year inundation extents for the conceptual design. This version was developed for the June 2016 technical session in response to a Board request for a figure that showed the proposed realignment features together with the proposed road alignment and road Kilometre Post (KP) markers.

Figure 8 shows the 100-year inundation limits and water velocities that were modelled for a scenario in which the main channel is blocked, but without any excavation to improve the capacity of the north historic channel alignment. Conditions similar to this are believed to have occurred naturally as a result of landslides. Without improvements, there is overland flow at this design flood level, with a possibility of avulsions. Also, a major braid would re-establish in the existing channel downstream of about KP 36.5 where the road will partially occupy the existing channel.

A preliminary design for the realigned channel and associated features is presented in Appendix A.

The expected performance of the preliminary design was modelled using HEC-RAS 2-D software. Inundation limits and water velocities for 2-year and 100-year flow conditions are presented in Figures 9 and 10 respectively. The final design will be developed in an iterative process to provide desired capacity without excessive excavation. Minor additional tweaks to the presented preliminary channel geometry will be made to increase channel capacity at the points where the 100-year simulation for the preliminary design shows some limited overtopping back into the original channel. This can be accomplished with minor localized deepening or widening.

6.0 LIMITATIONS

This report and its contents are intended for the sole use of Canadian Zinc Corporation and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Zinc Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement.

7.0 CLOSURE

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

Respectfully submitted,
Tetra Tech EBA Inc.

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Aug 10, 2016

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FIGURES

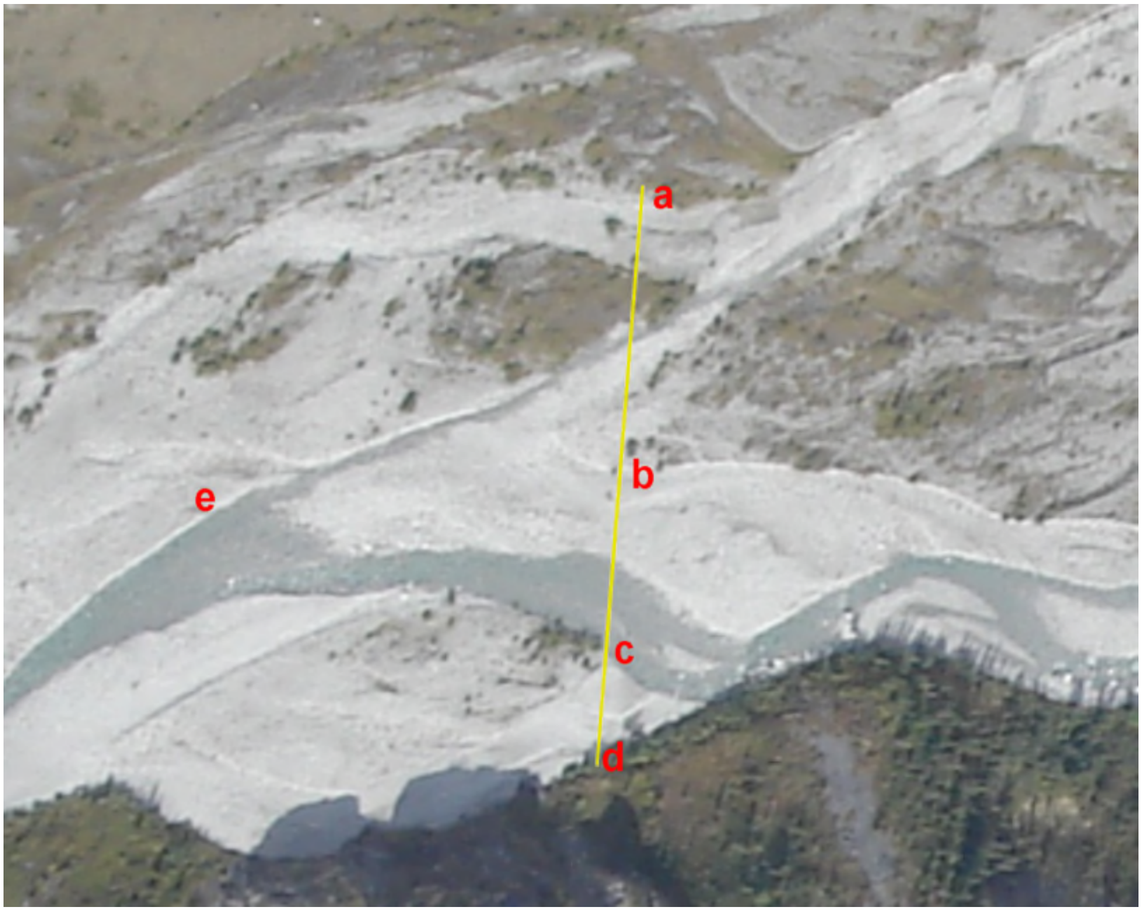


Figure 1: Sundog Creek on Aug 27, 2008. Oblique photo; flow left to right.

Figure 2: Sundog Creek as of 2012. Orthophoto; flow left to right.

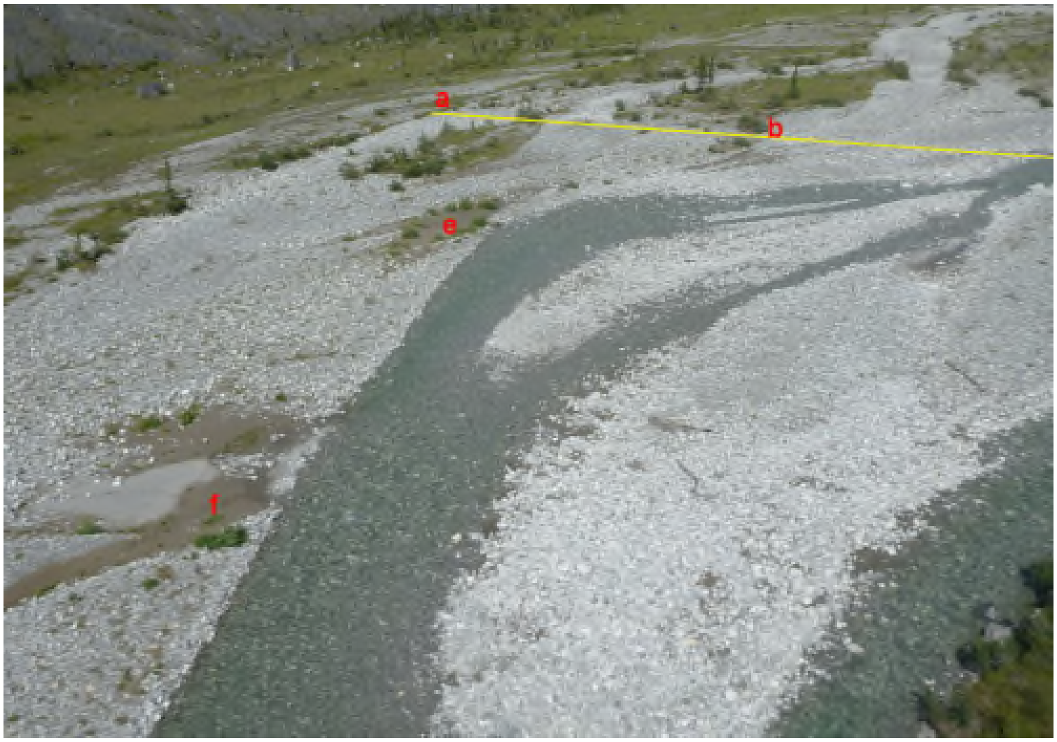


Figure 3: Sundog Creek on July 14, 2016. Oblique photo viewing downstream.

Figure 4: Sundog Creek on July 14, 2016. Oblique photo; flow left to right.

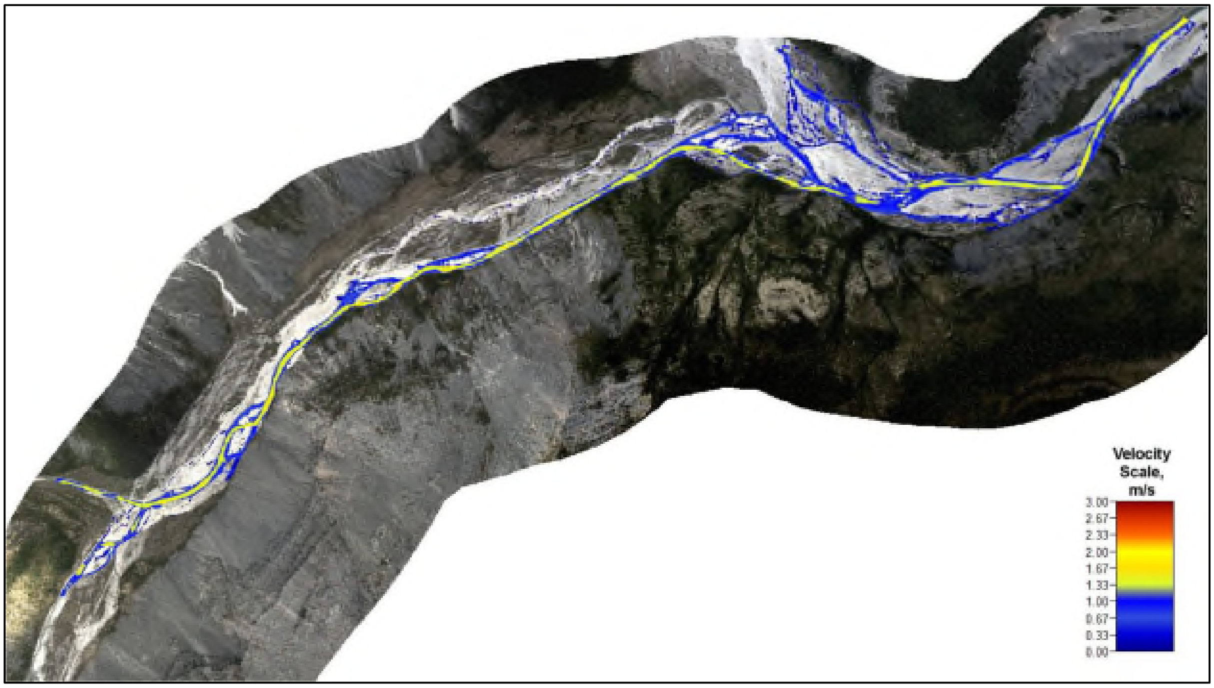


Figure 5: Sundog Creek Existing Geometry 2-year Inundation Limits and Flow Velocities.

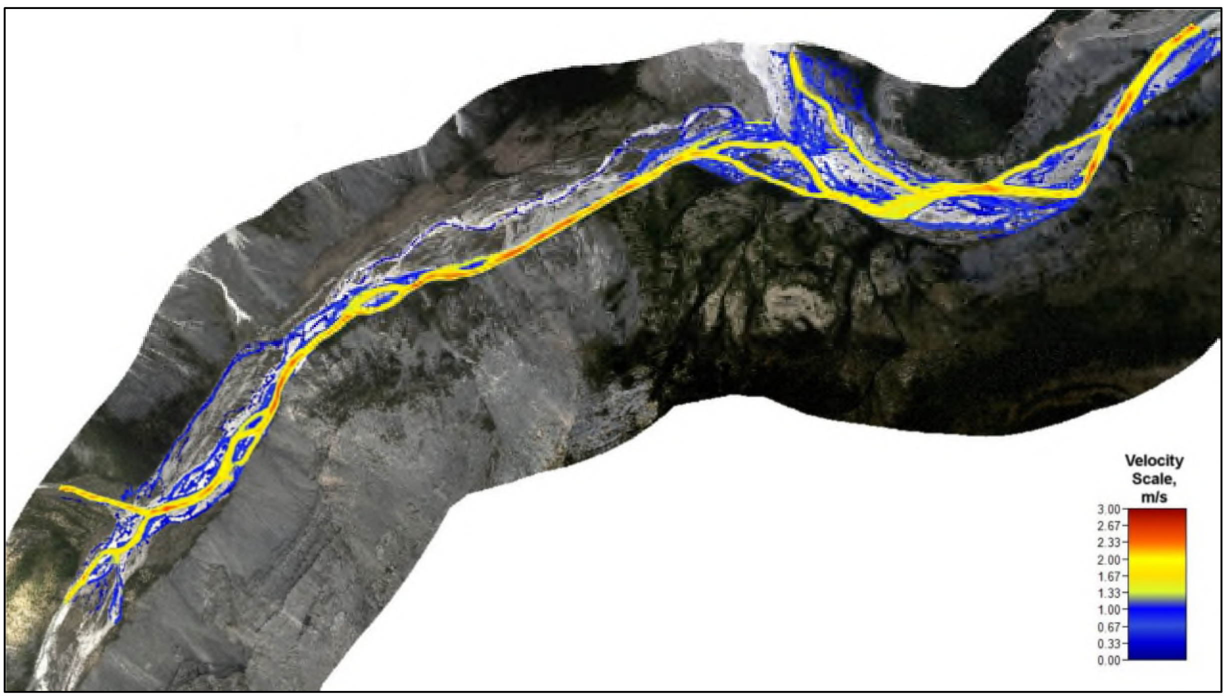


Figure 6: Sundog Creek Existing Geometry 100-year Inundation Limits and Flow Velocities.

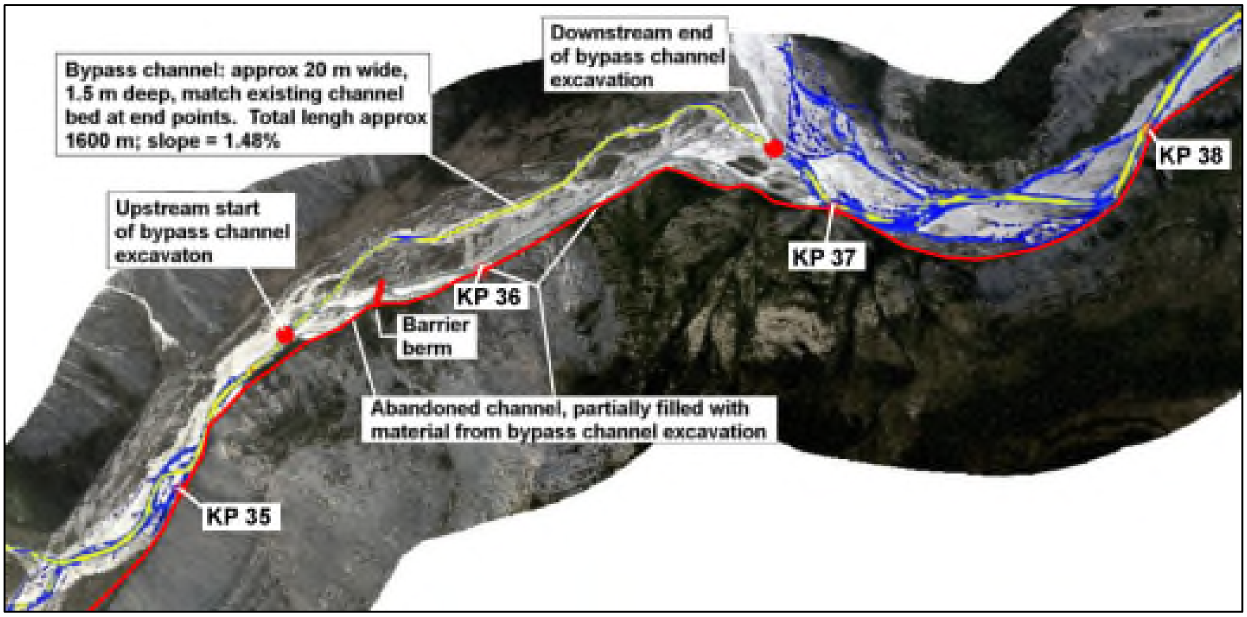


Figure 7: Sundog Creek Conceptual Design Channel Realignment 2-year flow with Road KP Markers.

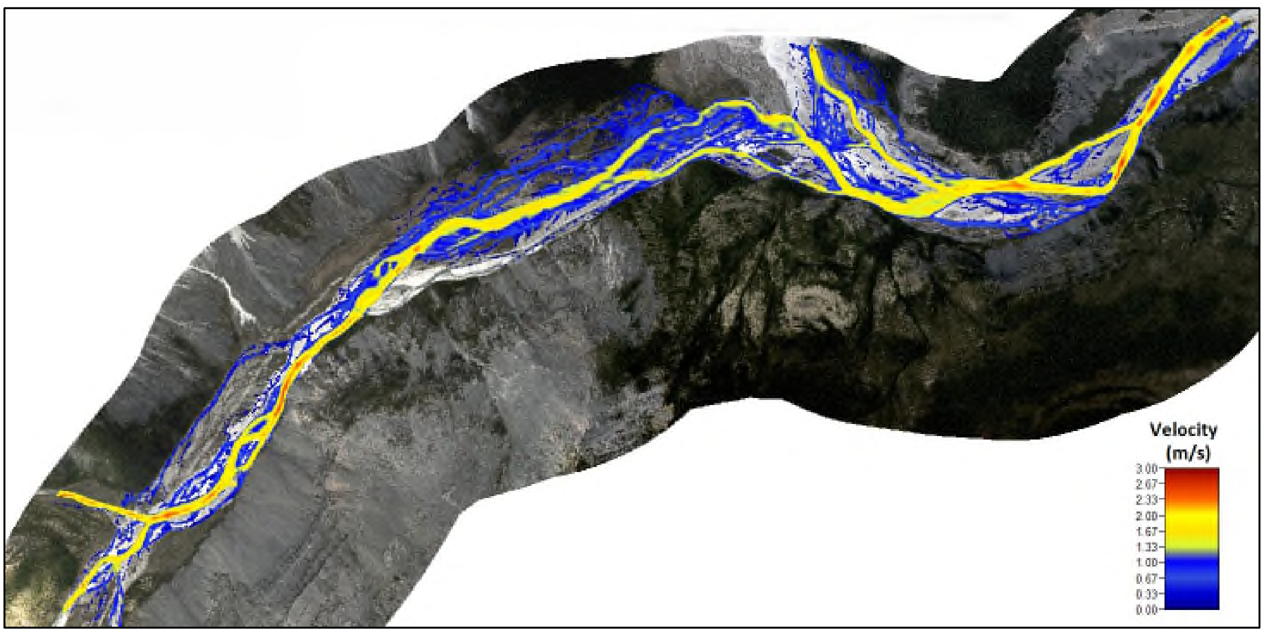


Figure 8: Sundog Creek Main Channel Blockage 100-year Inundation Limits and Flow Velocities.

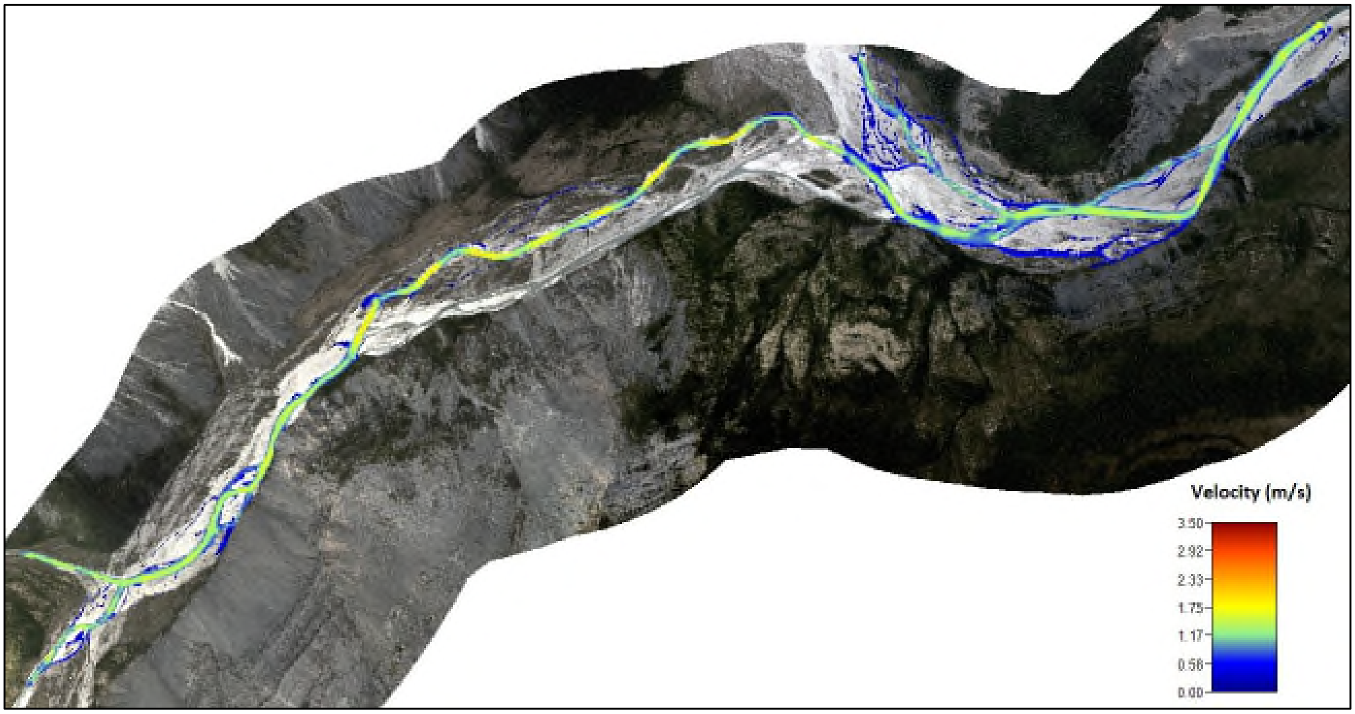


Figure 9: Sundog Creek Preliminary Design 2-year Inundation Limits and Flow Velocities.

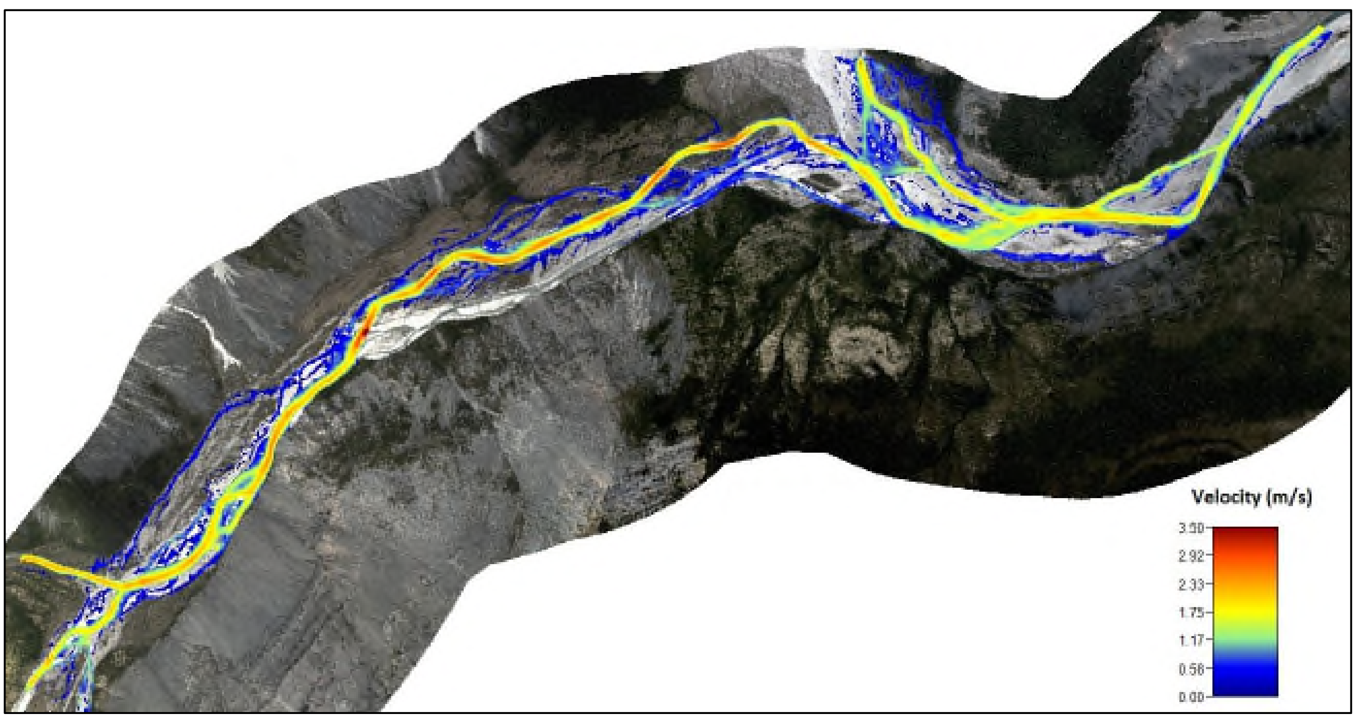
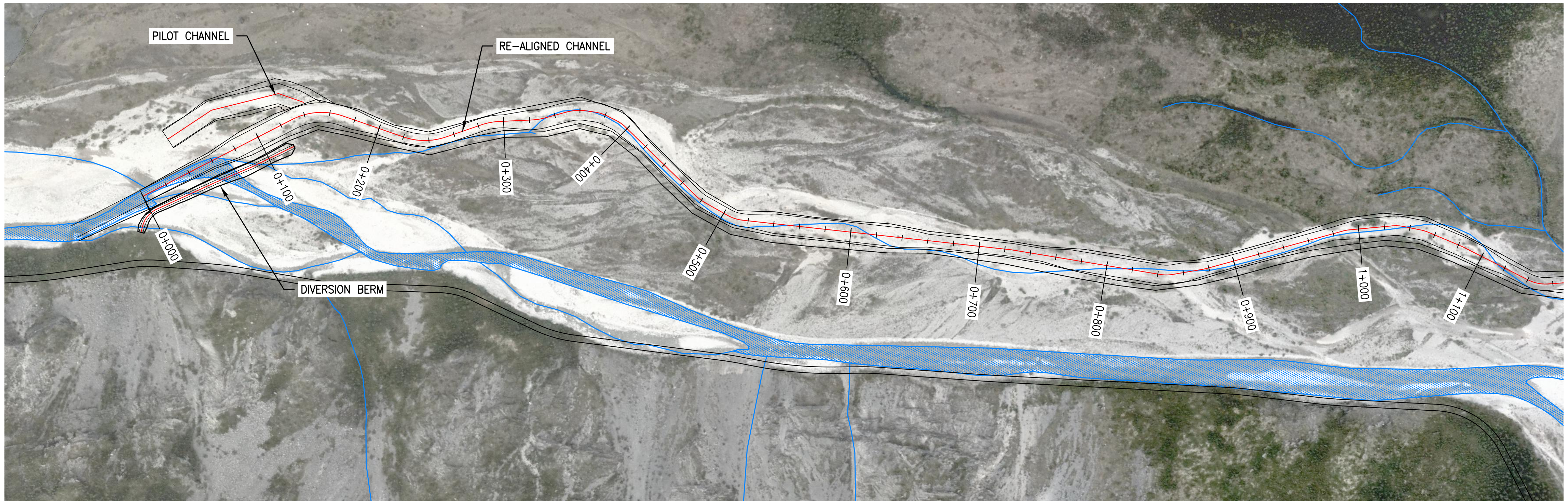


Figure 10: Sundog Creek Preliminary Design 100-year Inundation Limits and Flow Velocities.

APPENDIX A

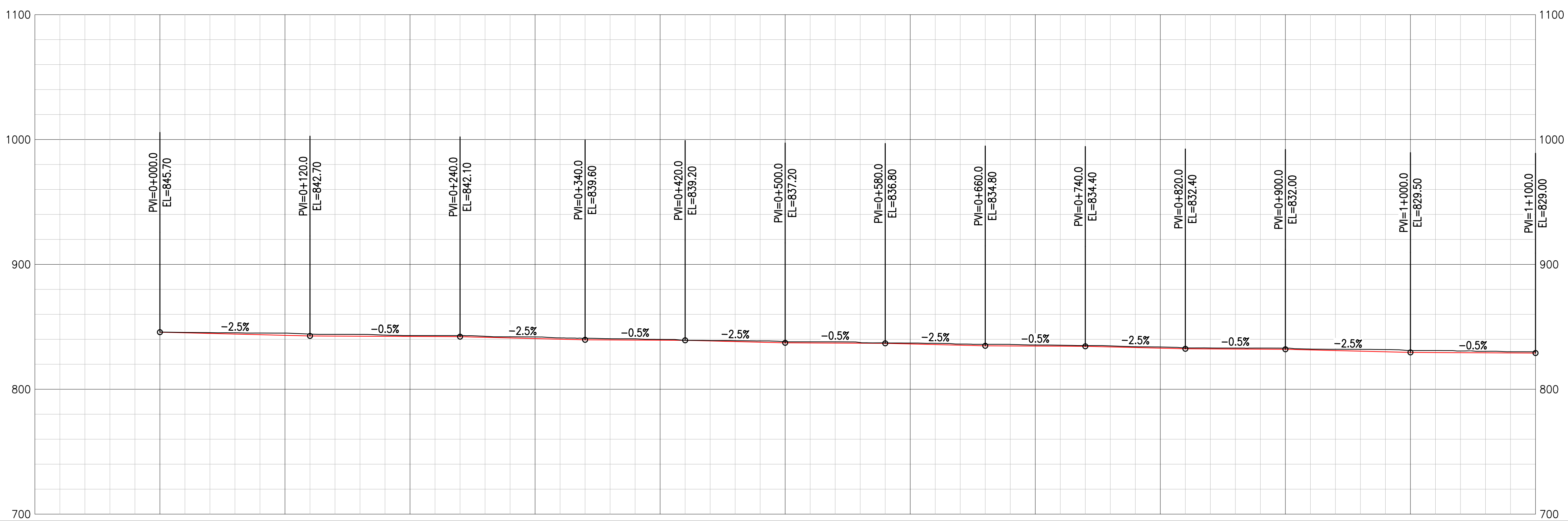
PRELIMINARY DESIGN DRAWINGS FOR REALIGNED CHANNEL, DIVERSION BERM, AND PILOT CHANNEL

ALLNORTH DRAWINGS REVISED AUGUST 9, 2016



SOILS:

FIELD STATIONS:

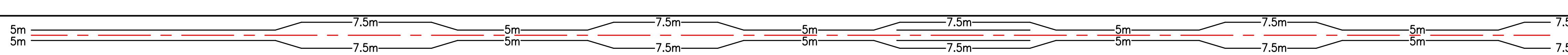


CHAINAGE: −0+100 0+000 0+100 0+200 0+300 0+400 0+500 0+600 0+700 0+800 0+900 1+000 1+100

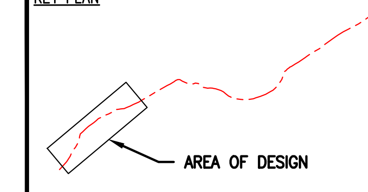
MASS MOVEMENT:

EARTHWORKS:

CHANNEL WIDTH:



KEY PLAN



LEGEND

- PROPOSED DESIGN CL
- PROPOSED CUT/FILL LINES
- WATERCOURSES

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
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2	2016/08/05	REVISED PROFILE	TMM	WBM
1	2016/08/04	REVISED ALIGNMENT	TMM	WBM
0	2016/07/05	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/06/24
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/06/24
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE: H = 1:4000, V = 1:4000		APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 0+000 to km 1+565

TITLE:

PLAN AND PROFILE
PROPOSED SUNDOG CREEK
CHANNEL REALIGNMENT
km 0+000 to km 1+000

DWG NO: **16GP0041-040-1920-001** REV: **3**

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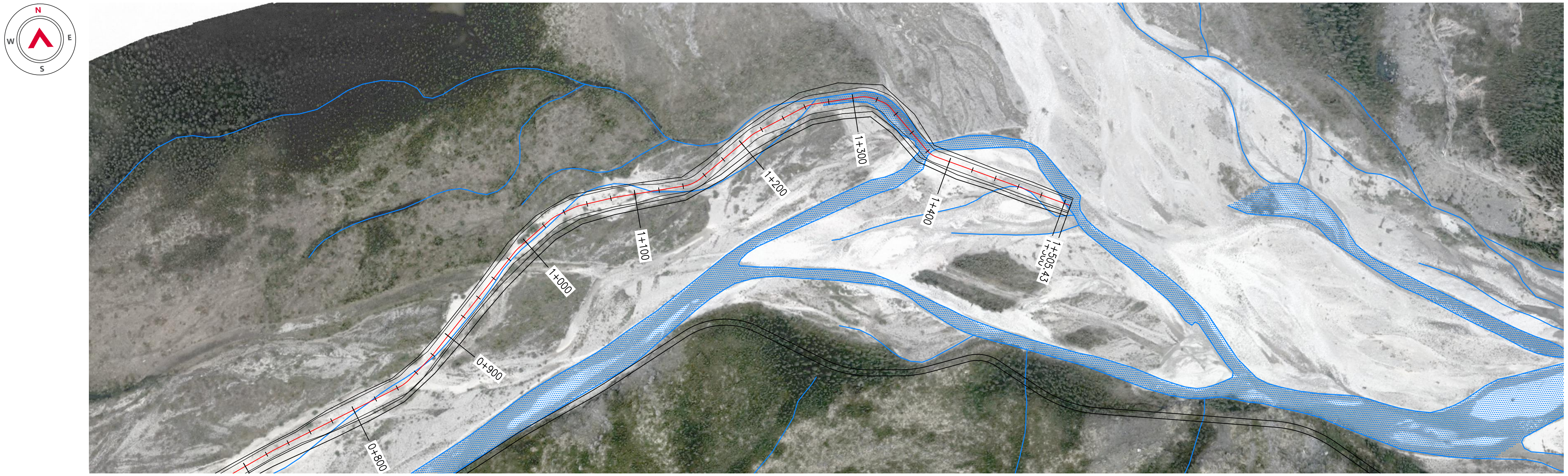
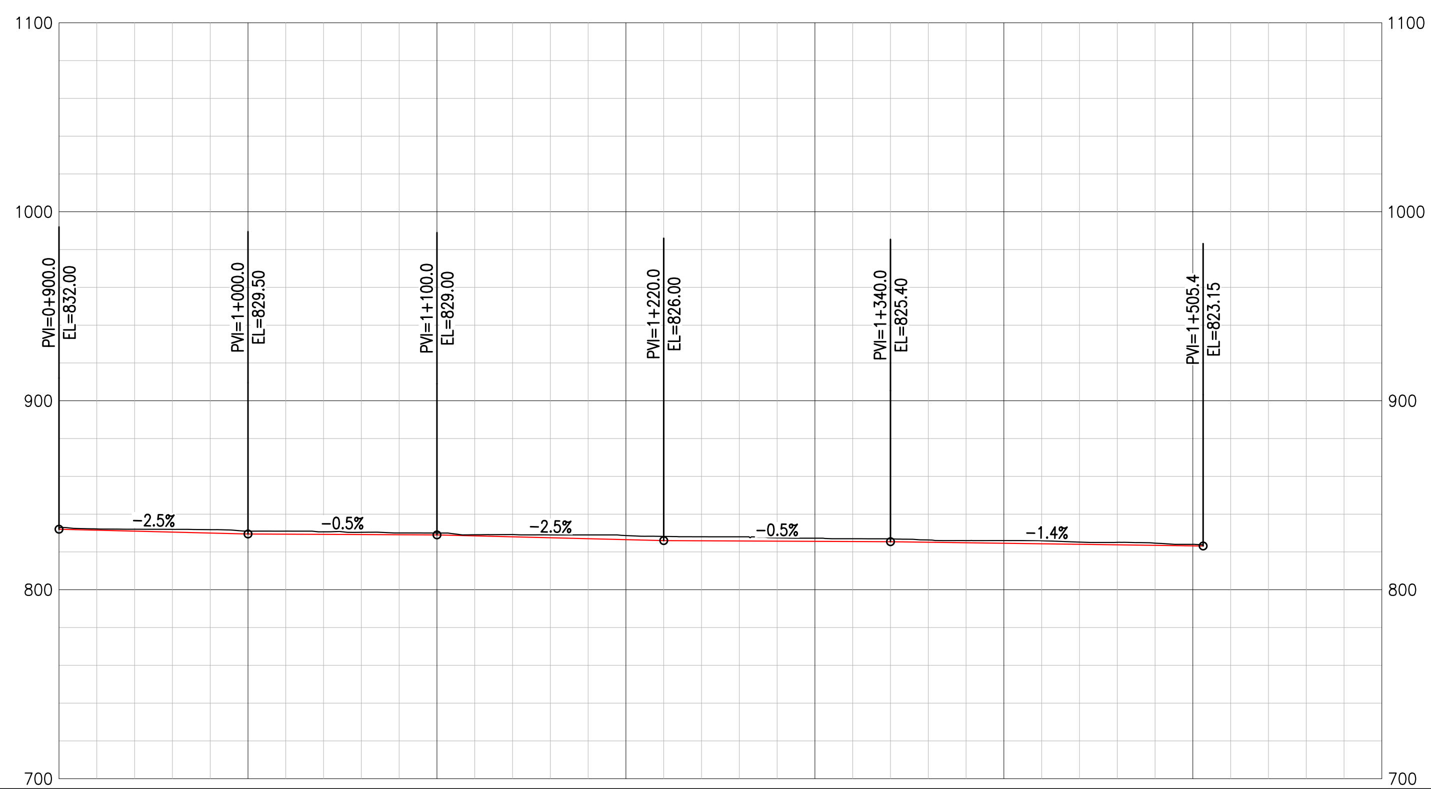
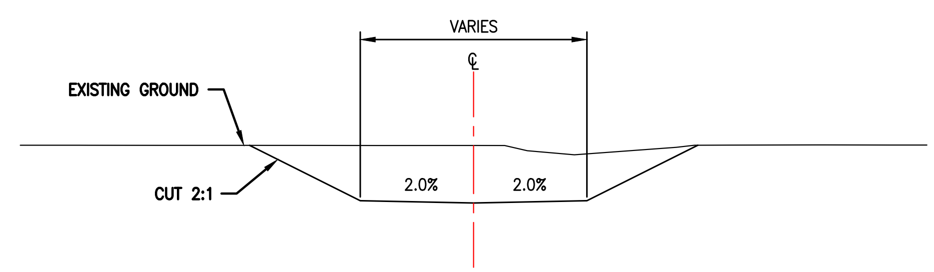


SOILS:

FIELD STATIONS:





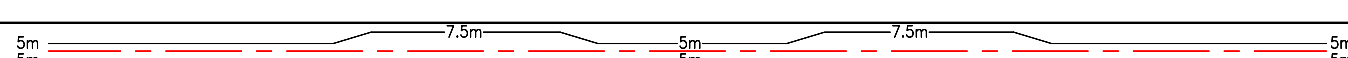
TYPICAL CREEK CHANNEL
SCALE: 1:500

CHAINAGE: 0+900 | 1+000 | 1+100 | 1+200 | 1+300 | 1+400 | 1+500 | 1+600

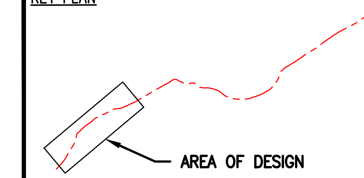
MASS MOVEMENT:

EARTHWORKS:

CHANNEL WIDTH:



KEY PLAN



LEGEND

- PROPOSED DESIGN CL
- PROPOSED CUT/FILL LINES
- WATERCOURSES

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
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1	2016/08/04	REVISED ALIGNMENT	TMM	WBM
0	2016/07/05	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/05
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/06/24
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE: H = 1:4000, V = 1:4000		APVD: WBM	DATE: -

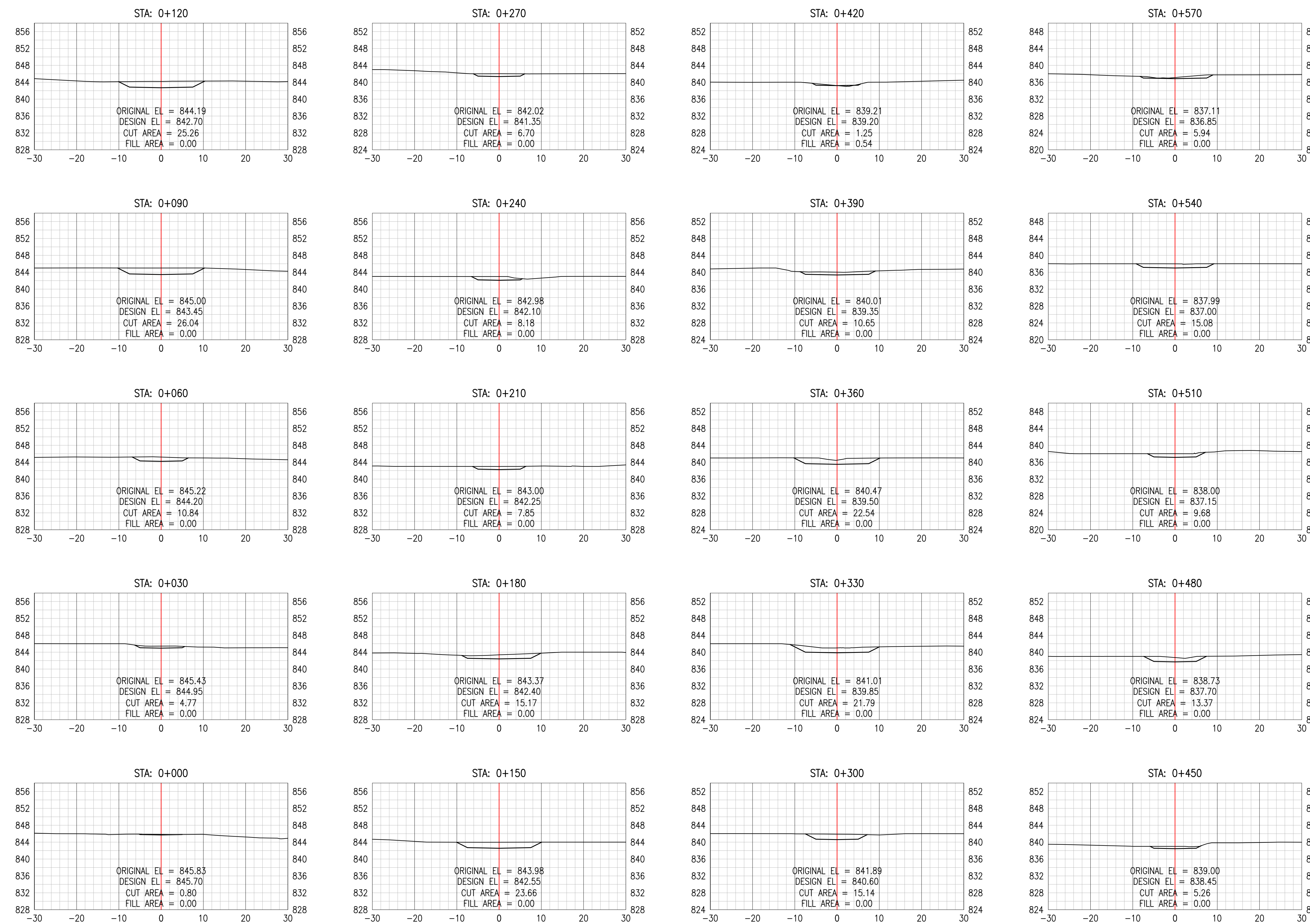
PROJECT:

PRAIRIE CREEK MINE GEOMETRIC DESIGN km 0+000 to km 1+551

TITLE:

PLAN AND PROFILE PROPOSED SUNDOG CREEK CHANNEL REALIGNMENT km 1+000 to km 1+551

DWG NO: **16GP0041-040-1920-002** REV: **2**



REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
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2	2016/08/05	REVISED PROFILE	TMM	WBM
1	2016/08/04	REVISED ALIGNMENT	TMM	WBM
0	2016/07/05	ISSUED FOR REVIEW	TMM	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/05
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/06/24
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	1:1000	APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 0+000 to km 1+551

TITLE:

CROSS SECTIONS
PROPOSED SUNDOG CREEK
CHANNEL REALIGNMENT
PAGE 1 of 3

DWG NO: **16GP0041-040-1920-003** REV: **3**

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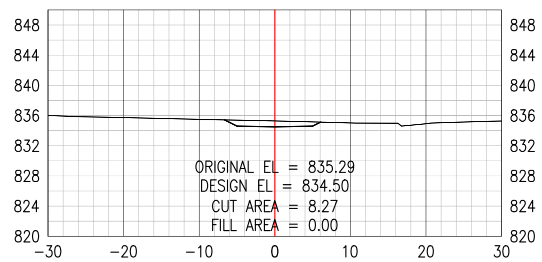

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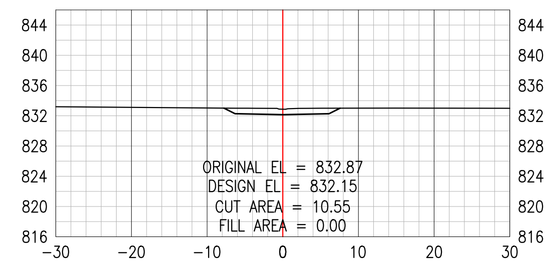

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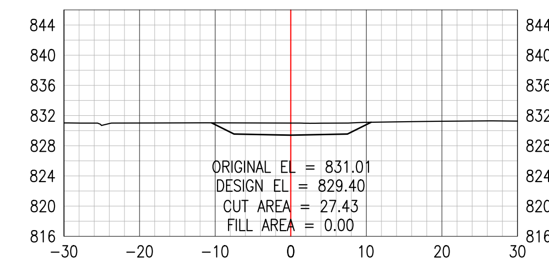

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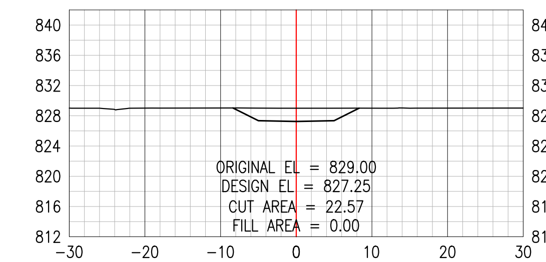

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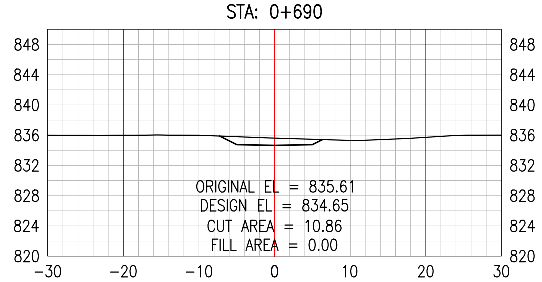

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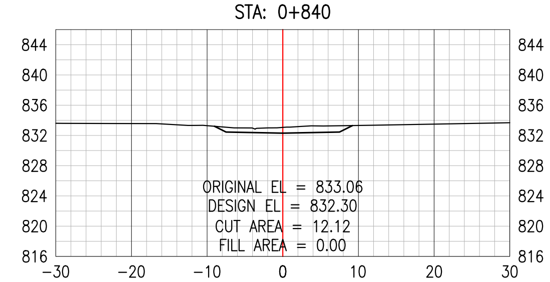

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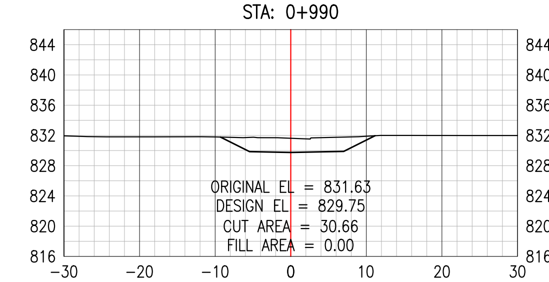

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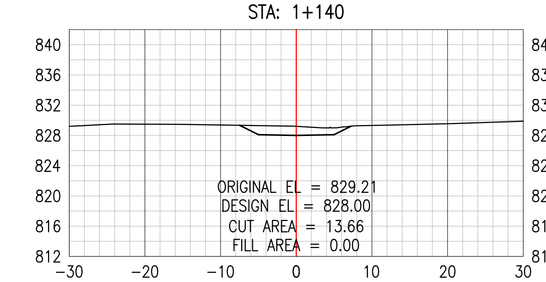

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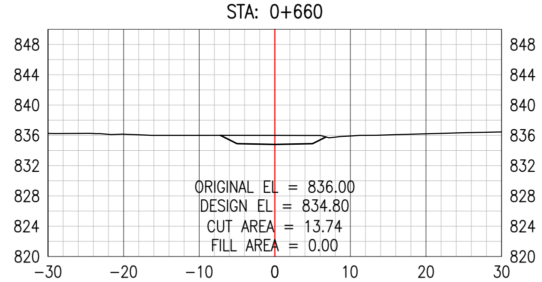

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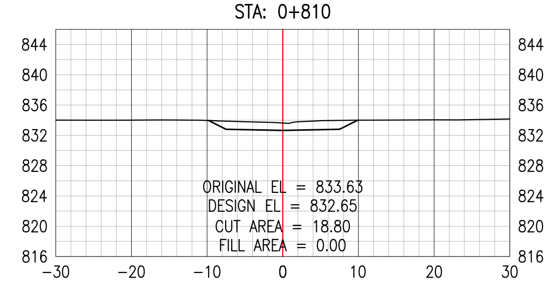

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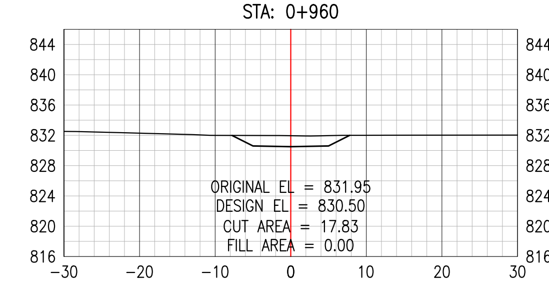

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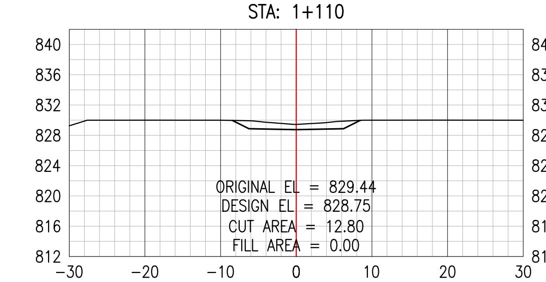

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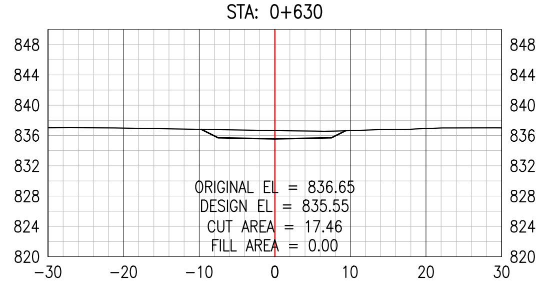

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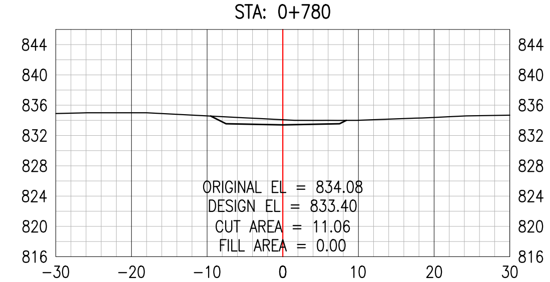

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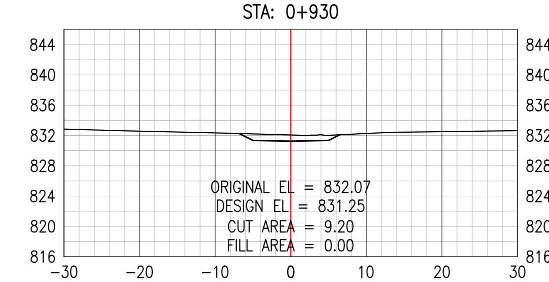

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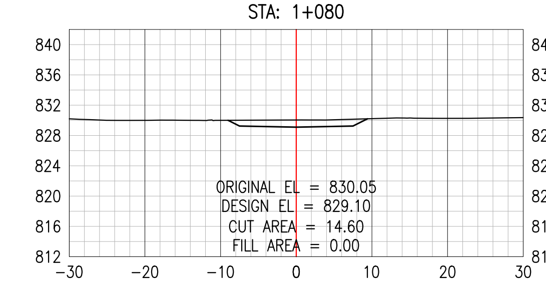

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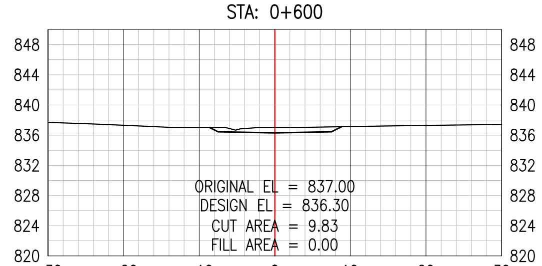

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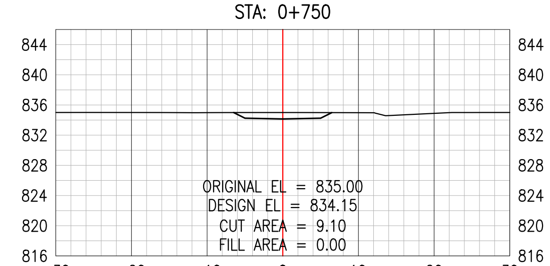

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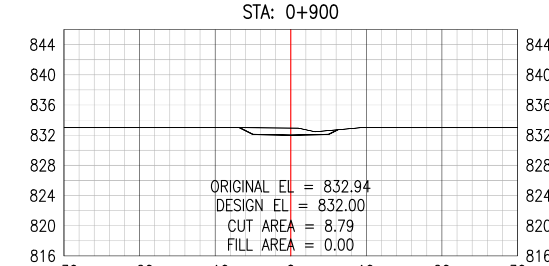

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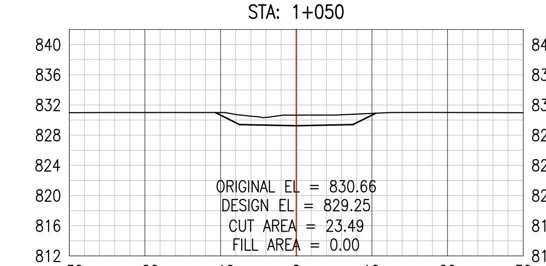

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2	2016/08/05	REVISED PROFILE	TMM	WBM
1	2016/08/04	REVISED ALIGNMENT	TMM	WBM
0	2016/07/05	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN:	TMM	DATE:	16/07/05
PROJECT NO:	16-GP-0041	DSGN:	TMM	DATE:	16/06/24
DRAWING SIZE:	ANSI "B"	CHKD:	EK	DATE:	-
SCALE:	1:1000	APVD:	WBM	DATE:	-

PROJECT:

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 0+000 to km 1+551

TITLE:

CROSS SECTIONS
PROPOSED SUNDOG CREEK
CHANNEL REALIGNMENT
PAGE 2 of 3

DWG NO: **16GP0041-040-1920-004**

REV: **3**

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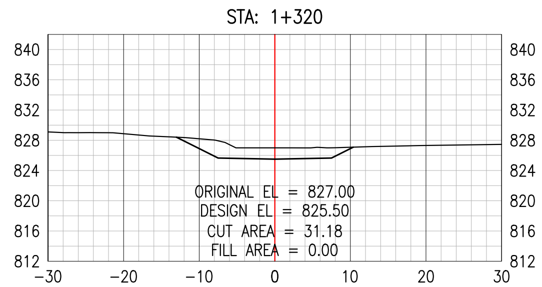

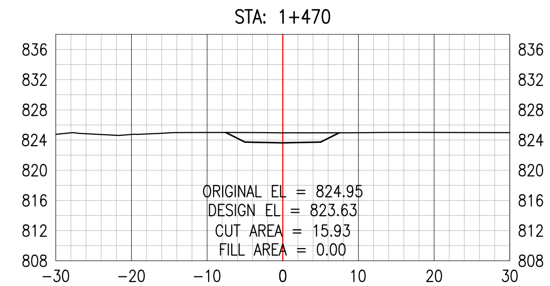

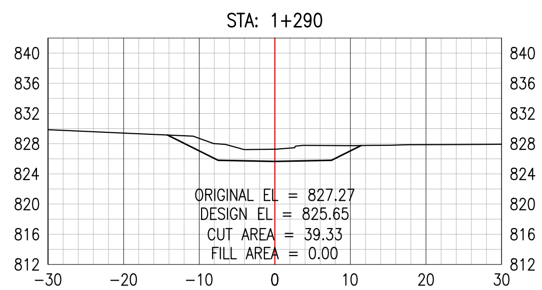

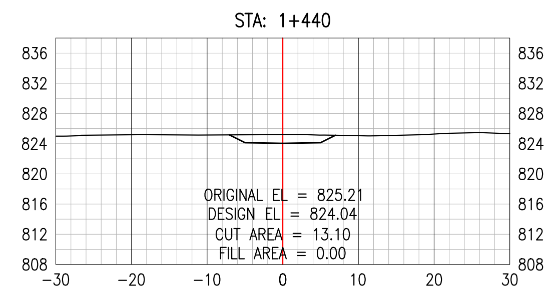

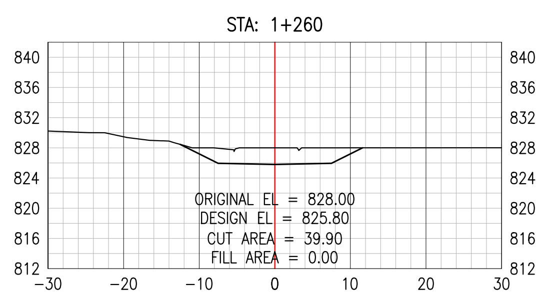

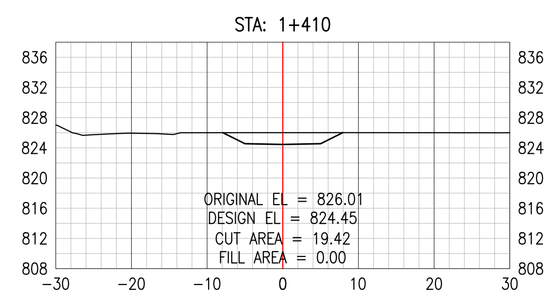

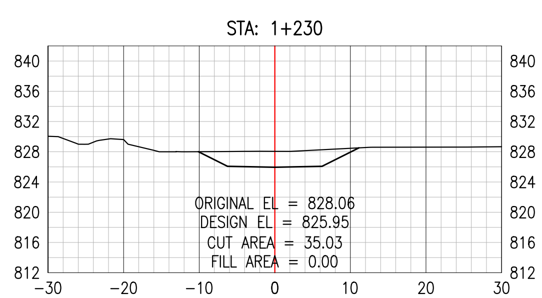

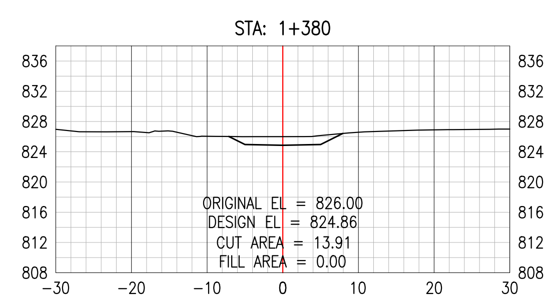

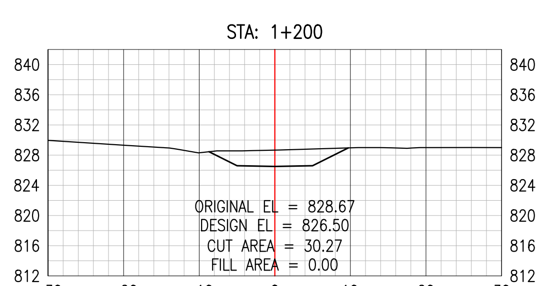

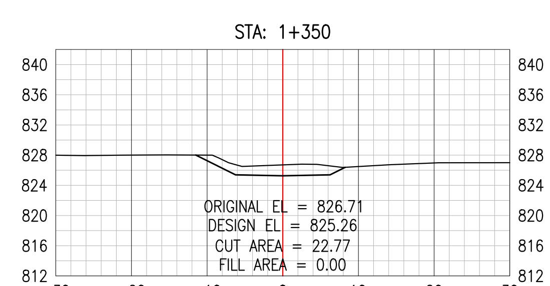

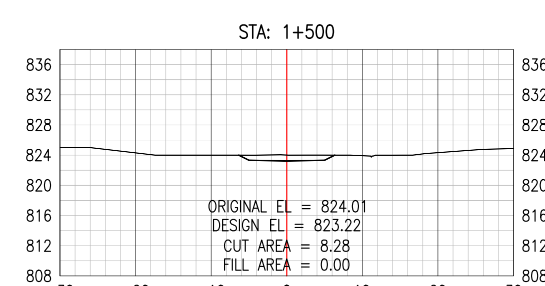

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2	2016/08/05	REVISED PROFILE	TMM	WBM
1	2016/08/04	REVISED ALIGNMENT	TMM	WBM
0	2016/07/05	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/07/05
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/06/24
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	1:1000	APVD: WBM	DATE: -

PROJECT:

PRAIRIE CREEK MINE
GEOMETRIC DESIGN
km 0+000 to km 1+551

TITLE:

CROSS SECTIONS
PROPOSED SUNDOG CREEK
CHANNEL REALIGNMENT
PAGE 3 of 3

DWG NO: **16GP0041-040-1920-005** REV: **3**

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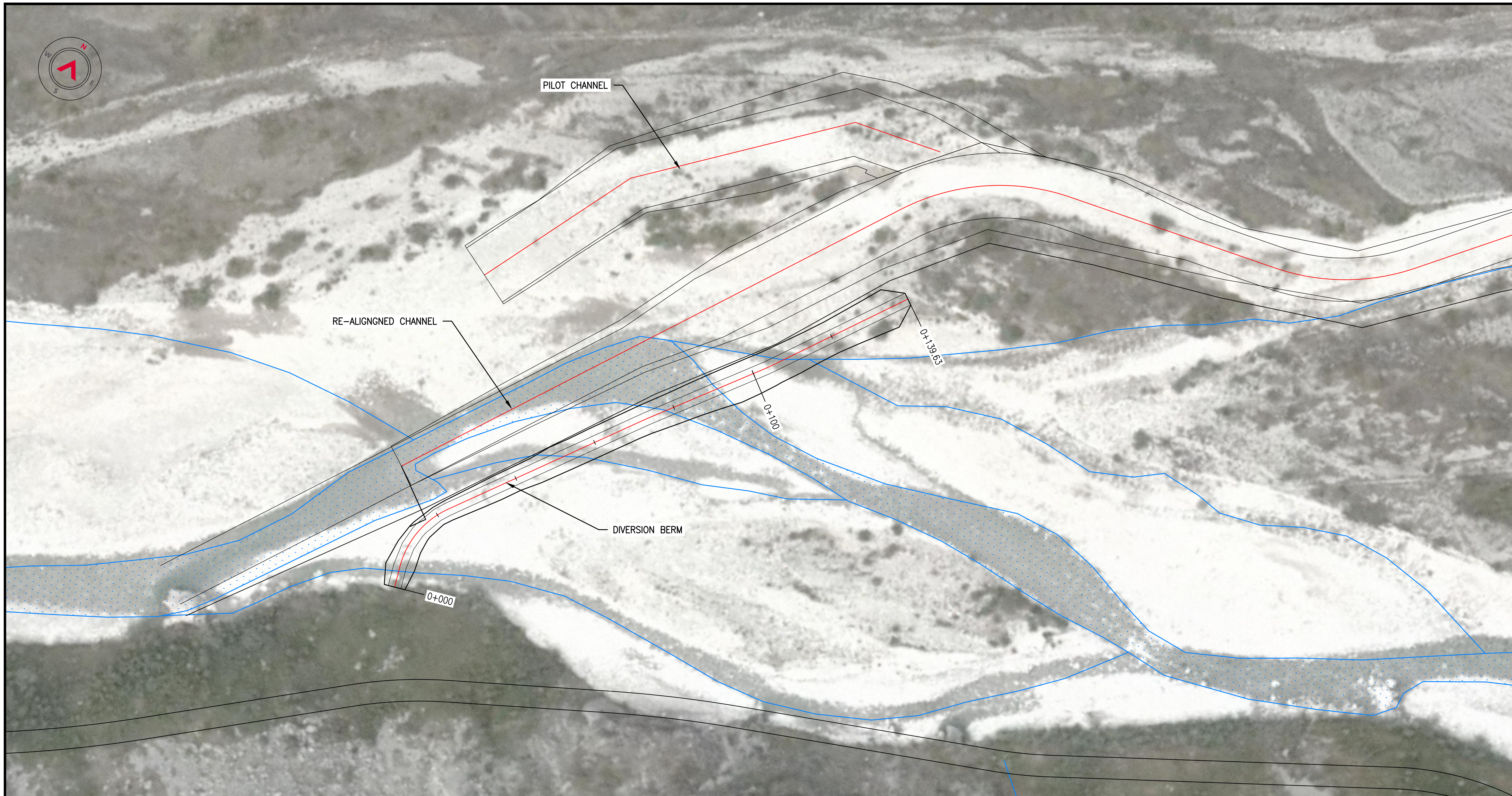
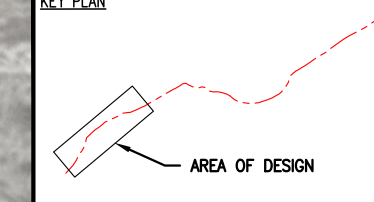
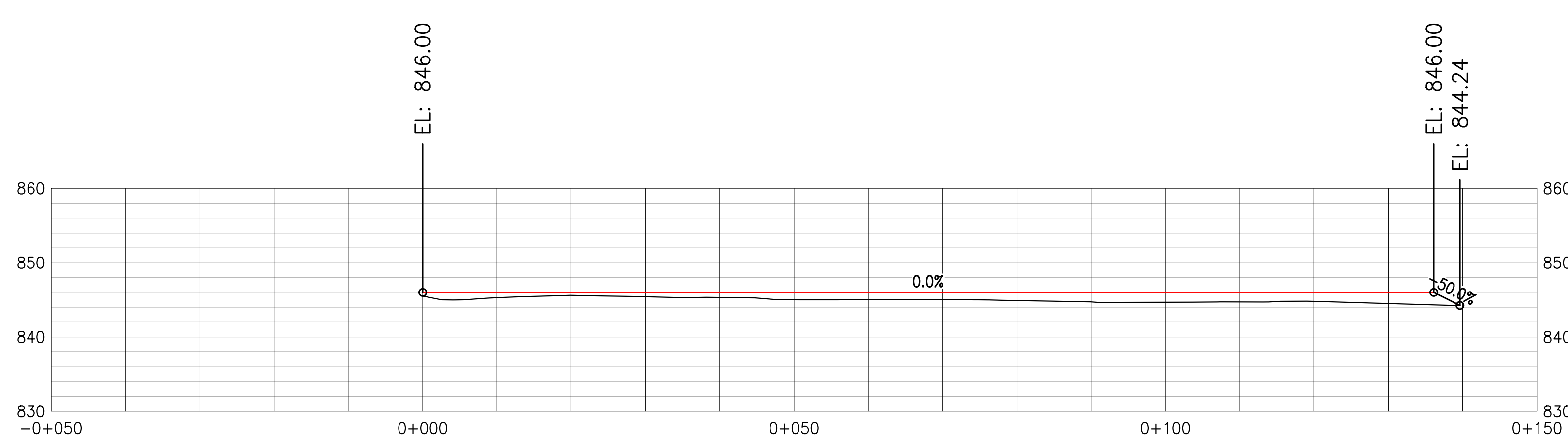


KEY PLAN



LEGEND

- PROPOSED DESIGN CL
- PROPOSED CUT/FILL LINES
- WATERCOURSES



REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
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0	2016/08/04	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:	DRWN: TMM	DATE: 16/08/04
PROJECT NO: 16-GP-0041	DSGN: TMM	DATE: 16/08/04
DRAWING SIZE: ANSI "B"	CHKD: EK	DATE: -
SCALE: 1:1000	APVD: WBM	DATE: -

PROJECT:

SUNDOG CREEK REALIGNMENT BERM DESIGN km 0+000 to km 0+130

TITLE:

PLAN VIEW BERM DESIGN km 0+000 to km 0+130

DWG NO: **16GP0041-040-1920-006**

REV: **1**

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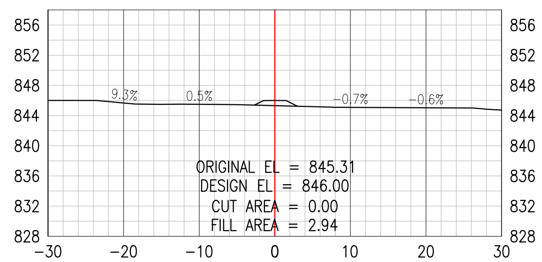

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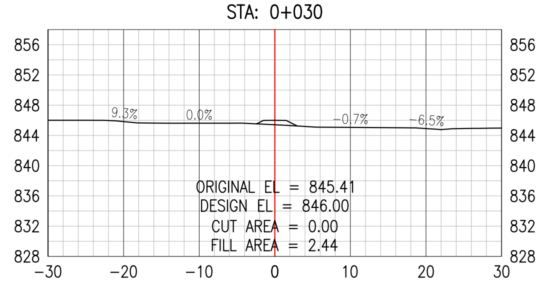

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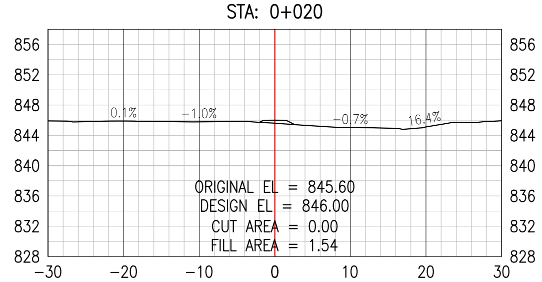

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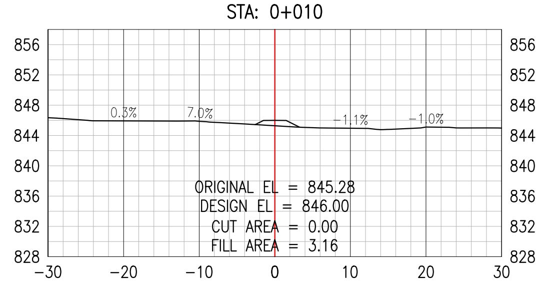

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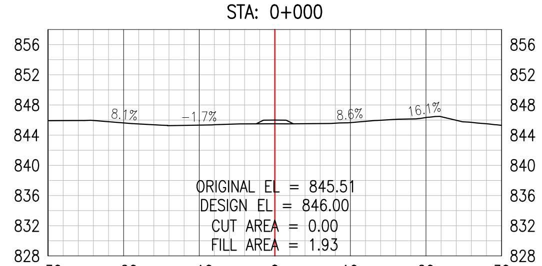

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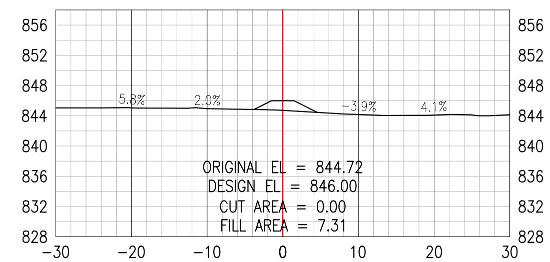

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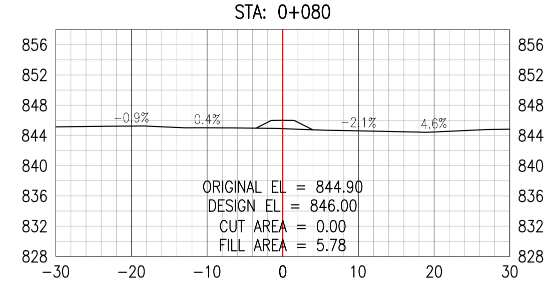

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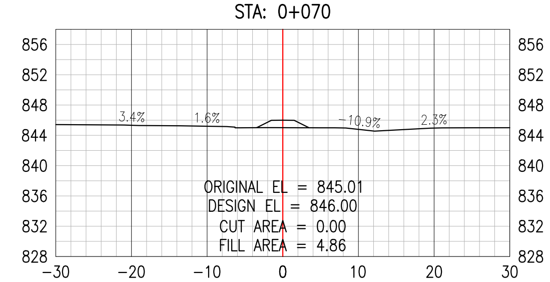

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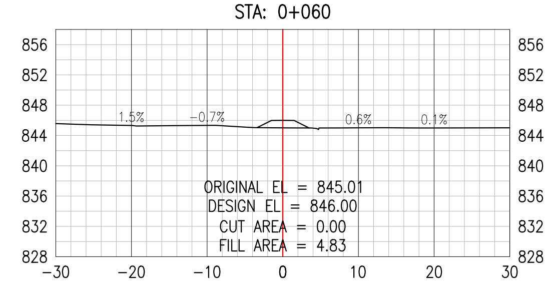

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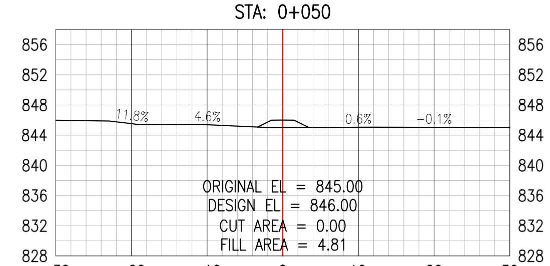

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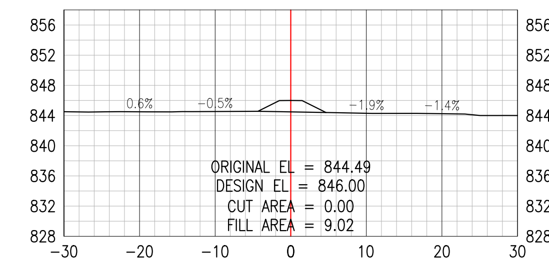

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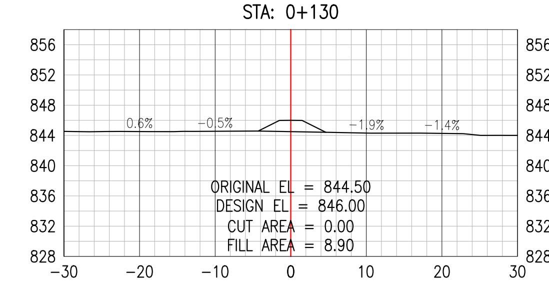

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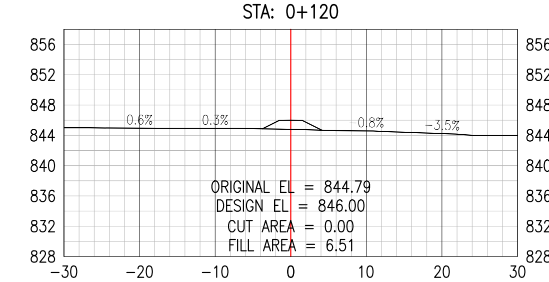

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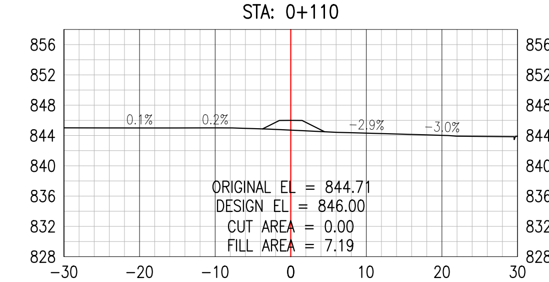

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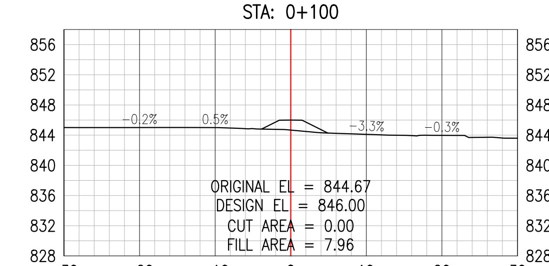

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0	2016/08/04	ISSUED FOR REVIEW	TMM	WBM

CLIENT: CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: TMM	DATE: 16/08/04
PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/08/04
DRAWING SIZE:	ANSI "B"	CHKD: EK	DATE: -
SCALE:	1:1000	APVD: WBM	DATE: -

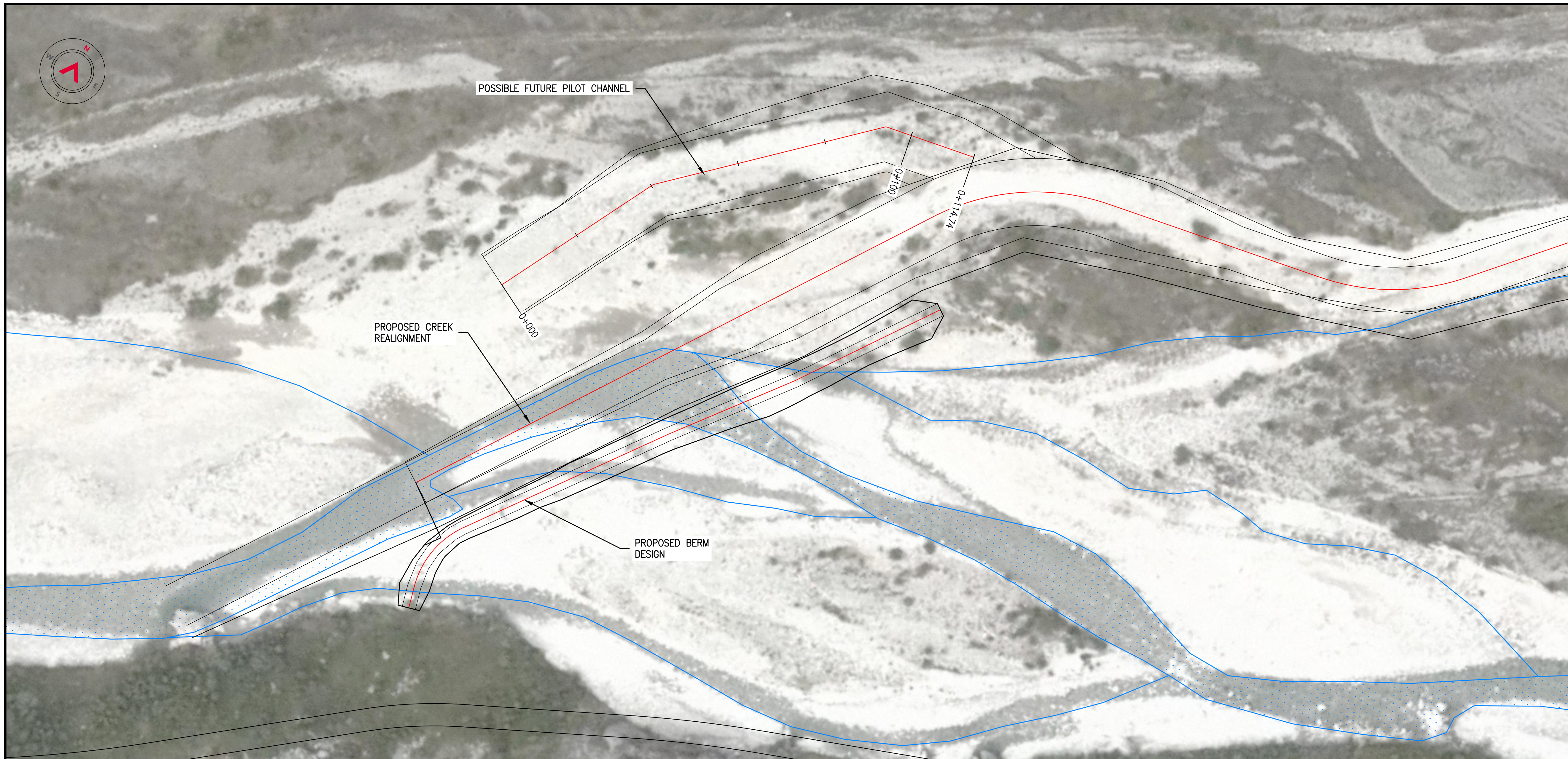
PROJECT:

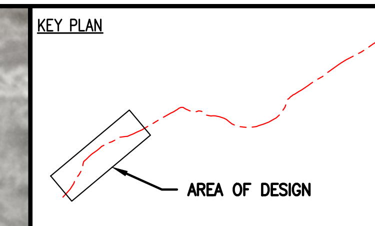
SUNDOG CREEK REALIGNMENT BERM DESIGN km 34+800 to km 39+000

TITLE:

CROSS SECTION DRAWINGS PAGE 1 of 1

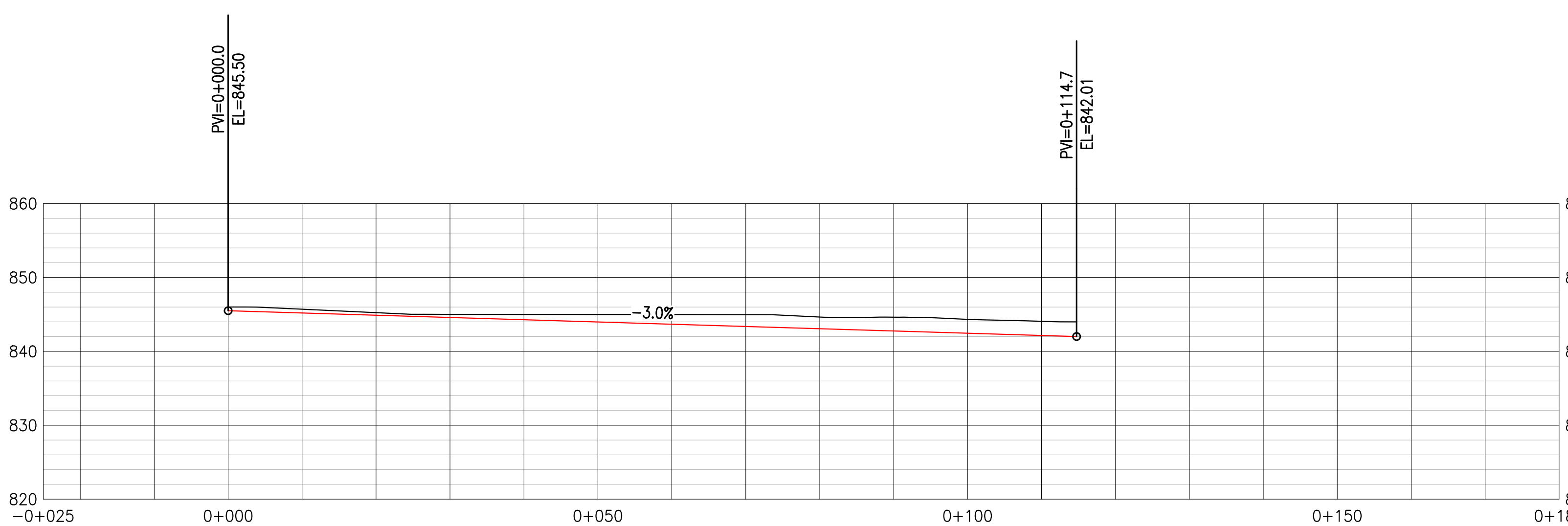
DWG NO: **16GP0041-325-1920-007** REV: **1**





LEGEND

- PROPOSED DESIGN CL
- PROPOSED CUT/FILL LINES
- WATERCOURSES



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0	2016/08/04	ISSUED FOR REVIEW	TMM	WBM

CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN:	TMM	DATE:	16/08/04
PROJECT NO:	16-GP-0041	DSGN:	TMM	DATE:	16/08/04
DRAWING SIZE:	ANSI "B"	CHKD:	EK	DATE:	-
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PROJECT:

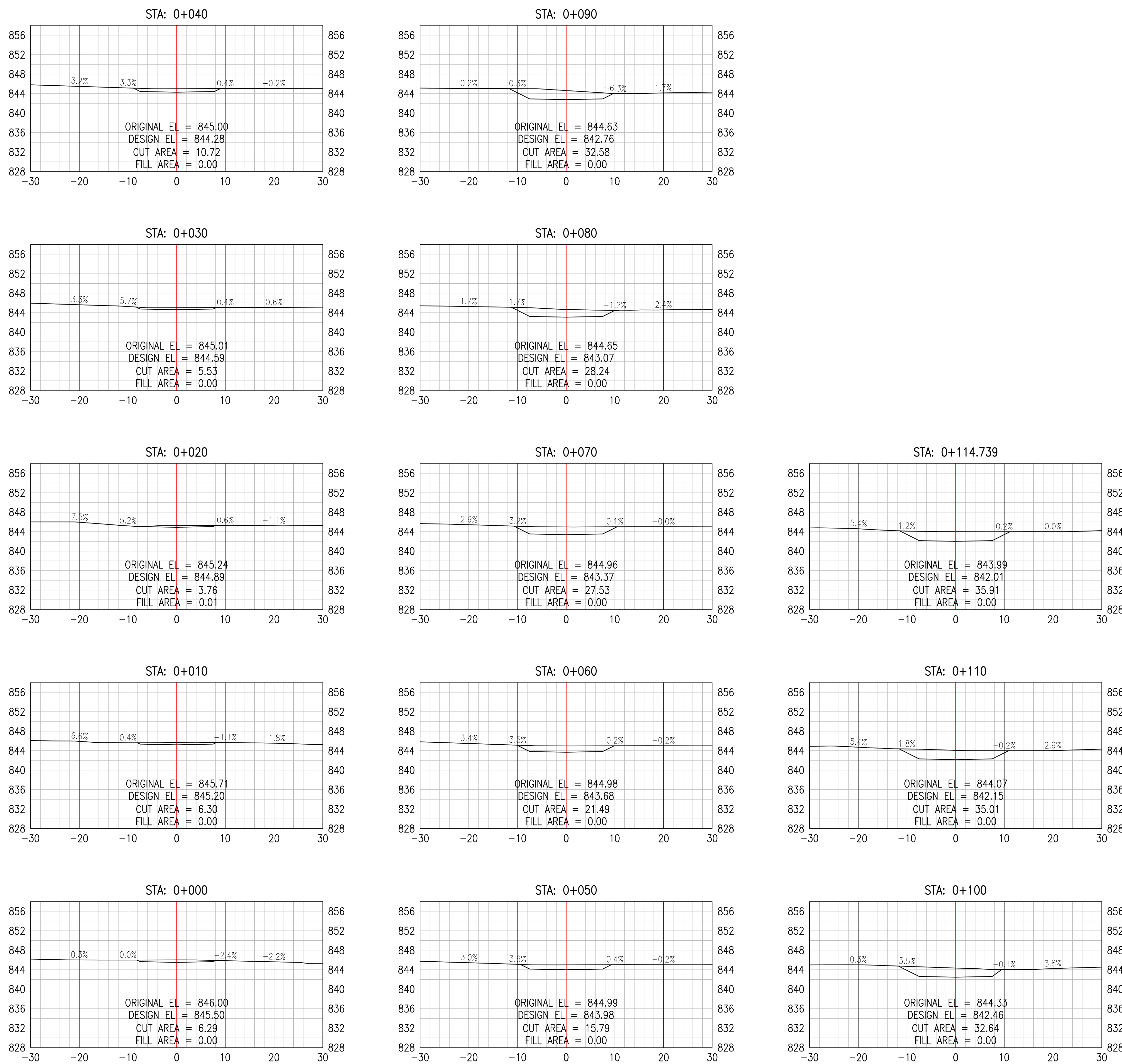
SUNDOG CREEK REALIGNMENT PILOT CHANNEL km 0+000 to km 0+156

TITLE:

PLAN AND PROFILE DRAWING PILOT CHANNELDESIGN km 0+000 to km 0+156

DWG NO: **16GP0041-040-1920-006** REV: **0**

Date: 2016/08/09 | User: Tammy Beer | File: P:\GP\2016\000\16GP0041 Canadian Zinc-LowerSundogRealignment\1000-Drawings\1011-Civil\01-Production\16GP0041-040-1920-34.8km-38.9km_1:2000 CREEK-R1 | Layout: 008 | Paper Size: 558.8mm x 431.8mm



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CLIENT:

CANADIAN ZINC CORPORATION

Allnorth

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PROJECT NO:	16-GP-0041	DSGN: TMM	DATE: 16/08/04
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SCALE:	1:1000	APVD: WBM	DATE: -

PROJECT:

SUNDOG CREEK REALIGNMENT PILOT CHANNEL DESIGN km 0+000 to km0+114

TITLE:

CROSS SECTION DRAWINGS PAGE 1 of 1

DWG NO: **16GP0041-325-1920-009** REV: **0**

UNDERTAKING 28

CanZinc will provide information on how the design and construction of the realignment can minimize sediment impacts during construction and operation phases.

As previously noted, the Sundog Creek realignment will be constructed by deepening the former channel so that it attains a similar profile and hydraulic capacity as the existing channel. This will be accomplished by excavation. Refer to our reply to Undertaking 26 for the design approach. The excavation is expected to expose alluvial material of a similar composition to those currently at surface. We note that alluvial material is constantly being deposited and resuspended in this active system.

The newly exposed alluvial material is expected to contain a limited quantity of finer material which may become suspended during initial flows in the spring. The quantity is expected to be limited because the alluvial material is generally very coarse, from sand size to large cobbles. Any fines that become suspended are expected to settle a short distance downstream, and the period of 'adjustment' to spring flows is expected to be short (several days). In terms of effects, no spawning or over-wintering habitat has been identified immediately downstream of the realignment channel. The habitat downstream is run and riffle until about 3 km away where deep pools exist adjacent to rock bluffs which may be over-wintering locations.

The above details were provided prior to the recent Technical Session. Some concern remains related to the potential for sediment impacts from construction. In light of these concerns, and to mitigate the potential for sediment impacts, CZN will implement sediment flushing/removal during channel construction.

Channel construction will occur in the late summer or fall when the reach is dry and the potential for flows prior to winter is low. Starting at the upstream end, after excavation of a portion of the channel, perhaps every 100 m, we propose to dig a sump in the adjacent stabilized floodplain to access water. We will pump from this sump and hose down the newly exposed material in the excavation. We anticipate that one of two things will happen: either the alluvial material is sufficiently permeable that washed fines will be carried down to be deposited between deeper, coarser material; or, the suspended fines will flow down the new channel and settle in a small pool formed by the damming effect of the unexcavated channel downstream. Once the pool has drained, any sediment accumulation can be removed. The process is then repeated for the next downstream channel section, and the pool location for the previous section would be included in the hose down operation. At the downstream end of the realignment, a sump may need to be dug to collect fines as there would be no dam to form a pond. The sump would be filled with coarse material after completion of the hose down. Sumps used for water supply would also be filled. This hose down process should effectively limit the mobilization of fines during early spring flows. It would not prevent fines mobilization during higher flows when the coarse bedload material is also mobilized, but this is a process that occurs at present naturally.

In our reply to Undertaking 26, it is stated that "the realigned channel is expected to be in balance with its hydrologic and sediment inputs, and to convey sediment through the reach in a sustained manner similar to the existing channel, without need for recurring dredging or other planned maintenance”. In the technical session, CZN said that periodic dredging would be required. This was an error. We did not consult with our consultant before making this comment. However, in the unlikely event there is a localized sediment accumulation that could negatively affect the performance of the realignment, limited removal might be contemplated during a period of no flow. If this occurs, the above described hose-down and fines management can be implemented.

ISSUED FOR USE

To:	David Harpley	**Date:**	July 11, 2016
c:	Alan Taylor	**Memo No.:**	6
From:	Rita Kors-Olthof, Vladislav Roujanski, Jason Pellett, Kevin Jones	**File:**	Y14103320-01.008
Subject:	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		

1.0 INTRODUCTION

This technical memo provides comments from Tetra Tech EBA Inc. (Tetra Tech EBA) on several undertakings for Canadian Zinc Corporation (CZN) contained in the document "EA1415-01 Technical Sessions Undertakings Final" prepared by the Mackenzie Valley Review Board (MVRB), dated June 28, 2016. This memo specifically addresses those undertakings that pertain to geotechnical, permafrost and risk-related considerations and questions. The undertakings are shown in each section in italics, followed by Tetra Tech EBA's responses in regular text.

2.0 RESPONSES TO UNDERTAKINGS

2.1 Undertaking #36

CanZinc will provide detail on assumptions on how effects to people (e.g. traffic and stationary crews) were considered related to geohazards (Table 7.2.2-1 in DAR Appendix 2).

Section 7.1 of Tetra Tech EBA's geotechnical evaluation report (Tetra Tech EBA, 2015a) noted that "The MVEIRB TOR Section 7.2.2, Item 7, requires consideration of how the environment may contribute to potential accidents, malfunctions, and spills. Tetra Tech EBA has considered the ways in which flooding, overland flow, landslides and ground movement, seismic activity, and avalanche activity can affect the integrity and/or operation of the road, which in turn can have an effect on potential accidents, malfunctions and spills. These potential environmental contributors are discussed below, and the risk matrix and specific road design and construction mitigations to be used to manage these events are discussed in the following sections. Although not directly assessed as a separate environmental cause, it is recognized that climate change can contribute to all of the listed types of events except for seismic activity."

Section 7.2.2 reiterated the primary purpose of the risk assessment was to be its contribution to the assessment of spill risk: "Note that Table 7.2.2-1 is not a direct assessment of spill risk, but we anticipate that it will assist CZN in assessing the spill risk due to environmental factors along the route."

Although people working and visiting the route were recognized in the definitions of the qualitative risk assessment parameters as being an element of value (valued component), or element at risk, people were not specifically considered in the qualitative risk analyses carried out for presentation in the geotechnical evaluation report (Tetra Tech EBA 2015a). Effects only on the road itself were considered in the analysis, for the sole purpose of CZN's spill risk assessment.

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The same purpose for the risk assessment was assumed in the updated assessment for slope-related hazards (Tetra Tech EBA 2016g), with consideration for personnel noted as follows in Section 2.1 Definitions and Criteria for temporal probability: "[Temporal probability] would be numerically equal to 1 in a quantitative analysis, and thus does not affect risk analysis results related specifically to effects on the road itself. The temporal probability would account for the presence of people, understood to be during daytime only and very intermittently, therefore tending to significantly reduce risk. Vulnerability would likely be higher for people, however, which would conversely tend to increase risk. Risks to personnel are not shown in the tables or further discussed here."

However, personnel were considered in the provisions for additional contingencies in Section 7.3 Mitigation and Residual Effects in the geotechnical evaluation report (Tetra Tech EBA 2015a), as follows: "The following sections describe the anticipated physical mitigations and the site-specific contingencies for road sections along which additional provisions are required. Physical mitigation strategies need to be incorporated into an integrated design and construction approach that includes consideration of traffic volume and vehicle type, vertical and horizontal roadway geometry, applicable codes and standards for road use (according to the applicable road section), control features during operation, maintenance requirements, safety, cost, and other considerations. Additional contingencies are intended to enhance the safety of personnel on the road, and improve the conditions under which the loads of concentrate and supplies are being transported, for situations in which road design and construction considerations may not be sufficient to achieve those goals."

Those additional contingencies were listed as follows in Section 7.3.3 of the geotechnical evaluation report (Tetra Tech EBA 2015a), and are largely based on administrative controls and inspection protocols:

"Although the proposed physical mitigations described above are expected to help enormously in reducing problems related to the described types of risks, it is not possible to completely eliminate the hazards, and so the residual risks must be dealt with in other ways, for example, using administrative mitigations (administrative controls). Such controls could include signage, personnel procedures and training, inspection and maintenance schedules, and notification and reporting protocols. Site-specific contingencies for high-risk areas are as follows:

- Carry out at least monthly visual inspections for areas designated high-risk due to potential slope stability or ground stability issues until seasonal baselines for behavior of the area are established;
- When the baselines are established, carry out regular visual inspections for areas designated high-risk due to potential slope stability or ground stability issues. A suggested schedule for inspection of those areas would include at least one inspection prior to spring freshet to confirm that culverts are free-draining, then monthly during the thaw season, and at least once during the winter for areas with hazards that exist also in winter (for example, for rock fall that is freeze/thaw-related); and
- Carry out inspections for high-risk areas within 24 hours of major rainfall events, abnormally high spring thaw events or significant seismic events, and/or prior to mine traffic travelling the road.

"Where problems are detected, they would be repaired or corrected in a timely manner, and prioritized in accordance with the urgency of the problem.

"It is possible that road sections not originally designated as "high risk" may become high risk as a result of an environmental event. Regular users of the road, such as truck drivers, become a valuable part of the road monitoring system when they are encouraged to report events or observations that seem at all out of the ordinary, no matter where it is along the road, or at what time of day. Early corrective action can help prevent a small problem such as a plugged culvert from turning into a big problem like a slope failure."

2.2 Undertaking #37

Confirm whether road length calibration was completed in preparing Table A1 (PR#187), and if so provide the relevant details (re velocity proxies in landslide magnitude and effects table).

Tetra Tech EBA assigned hazard ratings for each road section per Table 2.2 (modified from Wise et al. 2004) in the magnitude-frequency analysis memo (Tetra Tech EBA 2016c), based on the "[p]robability that at least one landslide event will occur [in that road section] within the assumed 20-year design life of the road." This rating system is consistent with the usage in the risk analysis memo (Tetra Tech EBA 2016g). It is noted that the length of any particular road segment is considered along with numerous other factors in the risk analysis in determining the consequence of an event.

Tetra Tech EBA has reviewed the methodology suggested by Knight Piésold, comparing it to that used by Tetra Tech EBA for the risk analysis of landslide hazards (Tetra Tech EBA 2016g). Based on the methodology suggested in Table 2 of Wise et al. (2004), "road length calibration" would consist of normalizing the probabilities of occurrence (frequencies) of slope instabilities to 1 km long road segments. Tetra Tech EBA did not apply this procedure to the risk analysis, for the following reasons:

- The procedure has the effect of averaging or generalizing landslide risk to 1 km sections along the road or, rather, making it seem as though that risk is either more widely distributed or concentrated, as the case may be;
- The net effect of the procedure is to obscure the details that the risk analysis was meant to reveal, even if the probabilities of occurrence are reported as per-km equivalences for a specified road section; and
- Since the point of the risk analysis was to determine which road sections are actually more at risk, the specificity retained by not using the procedure is considered more valuable, particularly for the purposes of effective detailed design and construction.

In the example provided by Knight Piésold (email communications: J.Haley, K.Jones; June 30, 2016), "assuming you have a 0.5 km long road segment and a 1.0 km segment both affected by a rock fall, you would need to double the assessed frequency of rock falls along the 0.5 km long segment in order to normalize them." So, for instance, if there were 10 events along the 0.5 km (500 m) section over a given time period, one would say that this is equivalent to 20 events in a 1 km section.

This method does allow reporting of events on a per-kilometre basis, thus normalizing or standardizing the reporting, and allowing an "apples-to-apples" comparison to the other road sections. However, it tends to obscure what is really happening in any particular section, and does not lead to additional information that would facilitate the effective management of the identified events in that section. That is, with normalized results, you can say that a particular road section is more problematic than another, but the detail has been lost for that section.

The loss of detail occurs because the road section being evaluated is not in fact a 1 km section, nor are there actually 20 events in that section. This result suggests that the road section is worse than it really is. In such a case, therefore, perhaps it would be more realistic to include the actual adjacent terrain to make up 1 km, for instance, the 250 m on either side of that 500 m section. Now suppose that those adjacent sections have no events, resulting in a normalized probability of occurrence of 10 events over 1 km. While that would in fact be true, this result suggests a probability of 5 events over the 500 m in question, which is not the case at all. As another example, earthflows such as those just north of the Liard River are large features, on the order of 0.8 km wide (KP154.5 to KP155.3) to 3.4 km wide (KP155.9 to KP159.3). The former could be considered as one event per km, but the scale of the feature would not be reflected in that observation. The latter would be even more difficult to define in this way, due to the lack of scale.

Therefore, in order to directly apply the analysis results to determine an appropriate design and construction solution, Tetra Tech EBA recommends using the magnitude-frequency results as is.

2.3 Undertaking #40

CanZinc will provide general information regarding the range of instability conditions (e.g. landslide, rockfall, tension cracks, etc.) that may be encountered along the road and the appropriate mitigations to address them.

Tetra Tech EBA understands this undertaking to consist of information summaries for each type of instability anticipated and the associated mitigations that have been recommended. This information has been previously provided in other formats, some of which are in summary form, for example, in Sections 7.3 and 8 of the geotechnical evaluation report (Tetra Tech EBA 2015a), and some of which are in station-by-station form, for example, in the risk analysis memo for landslide hazards (Tetra Tech EBA 2016g).

The primary mitigation for each of the instability conditions is avoidance. That is, if a hazard can be avoided by realigning the proposed road route, that is the preferred solution, and has been carried out for numerous locations along the proposed all-season road. Sometimes, of course, realigning the road route is not possible, due to a narrow corridor in the mountains, for example; or because a greater hazard would present itself by avoiding the first hazard, for instance, avoiding a thermokarst area, but resulting in a higher risk from a debris flow or rockfall due to moving the road too close to this new source of hazard. In that case, the route location needs to be optimized to reduce the risk from each hazard, or the more serious hazard could be avoided in favour of the less serious hazard.

When a hazard cannot entirely be avoided and some residual risk remains, then other mitigations need to be considered. These can consist of engineering controls and/or administrative controls. Sometimes the most appropriate controls will only become obvious after further analysis or identification of a problem that arises after construction or as a result of an unexpected environmental event (e.g. unusually large rainstorm). Table 1 below summarizes typical instabilities that may be encountered along the road and some appropriate mitigations for each. It is noted that site-specific recommendations would be formulated, along with appropriate design parameters on a site-specific basis, at the time of detailed design.

Table 2: Instability Types and Typical Mitigations

Instability Type	Typical Mitigations (after avoidance; not an exhaustive list)	Tetra Tech EBA Reference
Rockfall	Engineering controls (physical mitigations, e.g. scaling, retention of natural terrain barriers that protect the road from rockfall, improved cross-drainage where newer activity is present below the road to reduce likelihood of concentrated water flows, implement additional mitigations if/as needed based on monitoring results); administrative controls (e.g. signage, awareness training, inspections and monitoring, maintenance protocols, “ownership” protocols where each observer, even if only a driver, has the duty to report)	2015a, 2015b, 2015c, 2016g
Rockslide	As for rockfall. Install additional water drainage measures if/as needed.	2015a, 2015b, 2015c, 2016g

Table 2: Instability Types and Typical Mitigations

Instability Type	Typical Mitigations (after avoidance; not an exhaustive list)	Tetra Tech EBA Reference
Debris Slide	Engineering controls (e.g. buttressing cut or fill slopes and/or failed slope areas, modified cut and fill designs, controlling surface water drainage into/out of area, erosion protection and sedimentation control measures, extra surface water drainage measures, reduce/avoid concentrated water flow in areas not naturally receiving water (e.g. avoid directing water off the ends of switchbacks)), implementing additional mitigations if considered warranted on the basis of monitoring results; administrative controls (e.g. signage, inspections, movement tracking, maintenance schedules/protocols, notification/reporting protocols)	2015a, 2015c, 2016g
Debris Flow	Avoiding multiple crossings of a debris flow feature. In design, accounting for the likelihood that debris flow channels may change over time. Crossing at apex or near toe of fan to limit exposure. Engineering controls (e.g. consider alternative crossing types (bridge, ford), install upslope catchment basin, controlling surface water drainage into/out of area, erosion and sedimentation control measures, extra surface water drainage measures, additional and/or staggered placement of culverts where debris flows have potential to reach or overrun road, larger culverts, channel armouring, barriers, nets and or catch-basins; consider sacrificial road section in areas with regular debris flows, but note potential implications for continuous access; consider additional mitigations if/as needed based on monitoring results; consider the possibility that debris flows may run elsewhere on the fan), administrative controls (e.g. signage, inspections, movement tracking, monitoring and maintenance protocols, consideration of allowable adjacent developments)	2015a, 2015b, 2016g
Thaw Flow (active-layer detachments (skin flows) and retrogressive thaw flows)	As for debris flows and debris slides; ground temperature and active layer tracking. Recognition that terrain similar to terrain in which thaw flows have occurred may also be subject to thaw flows, and be affected in similar ways by possible forest fires, and therefore need similar treatment in design/construction. Avoid exposing ice-rich permafrost. Reduce likelihood of slumps or instabilities occurring that could be caused or influenced by the road near or at stream crossings, with appropriate design of approaches and crossings. Monitor performance to track slope movements that may need future mitigation.	2015a, 2015b, 2016g
Slump (bedrock)	As for rockslide, but direct engineering controls may not be applicable except for control of surface water drainage, especially at switchback locations (to prevent concentrated water flows in areas unaccustomed to them). In some cases, possible mitigations could also include modified cut and fill designs, and/or buttressing of cut or fill slopes. Monitor slope to track movements that might require additional mitigation.	2015c, 2016g
Slump (surficial/bedrock)	As for bedrock slump, control of surface water drainage may be even more important, especially for highly disturbed or very prominent slip surfaces within soil or at soil/bedrock interface. Mitigations may need to consider the underlying bedrock. Monitor slope to track movements that might require additional mitigation.	2015c, 2016g

Table 2: Instability Types and Typical Mitigations

Instability Type	Typical Mitigations (after avoidance; not an exhaustive list)	Tetra Tech EBA Reference
Slump (surficial)	As for surficial bedrock slump, control of surface water drainage may be even more important. Noting the potential for renewed activity within old slump areas that should be accounted for in design. Not using ice-rich slump areas for borrow, even if material appears to be granular. Fill-only embankment construction if ice-rich material must be crossed. Reduce the likelihood of creating new slump areas by designing cut/fill slopes at appropriate angles for the material. Maintain good control of surface water drainage. Monitor slope to track movements that might require additional mitigation.	2015a, 2016g
Lateral spread	As for other slope movements. Can be associated with permafrost creep or weight of soil in weak deposits, or additional water in soil; can even happen in rockfall colluvial deposits; movement tracking and site measurements should attempt to determine cause if not yet known.	2015c
Gully Erosion	Track gully erosion progression; reduce water flow in areas not naturally receiving water (e.g. for water off the ends of switchbacks); stay out of gullies in design/construction, with particular attention to those that lead to valued elements; careful surface water drainage control at gully crossings and heads of gullies; recognize existing and potential for new slope instabilities on gully sidewalls at crossing locations; recognize relationship of some gullies with debris flow activity and design accordingly. Standard culvert options for gullies without debris slide or debris flow activity.	2015a, 2015c, 2016g
Earth Slump / Earthflow	As for debris flows and thaw flows; monitor periodically for new or retrogressive activity	2015c, 2016g
Soil Creep (permafrost)	Implement design and construction procedures as for high-ice-content permafrost soils, e.g. wide embankment so that trouble spots (usually toes) are further from travel surface, use method of construction that spreads the load over wider area (e.g. corduroy, geotextile), reduce concentrated water flows or ponding that tend to cause thermokarst and thermal erosion. Design to recognize/ accommodate ice-rich soil creep/deformation under very small loads (e.g. much less than that from road embankment, even self-weight) and at very low slope angles. Determine contributing factors to creep to design appropriate mitigations if/as needed.	2015a, 2015b, 2015c
Tension Cracks	As for rockfall/slides, debris slides, thaw flows, slumps; confirm suspect areas at time of detailed design. Tracking: check for widening/lengthening of tension cracks, more tension cracks progressing further upslope or to the sides indicating enlargement of distressed area. Some areas may be amenable to repair if dealt with promptly, e.g. cutslopes that can be buttressed, fillslopes that can be reconstructed into horizontally-layered fill (if they were originally built as sidecast fills). Optimize cross-drainage provisions for tension cracks likely to be affected by water crossing road. Monitor slope to track movements that might require additional mitigation.	2015a, 2015c, 2016g
Thermokarst / Thaw Settlement	In thermokarst-prone terrain, i.e. thaw-sensitive high-ice-content permafrost: avoid cuts, use fill-only embankment sections, “corduroy” log or other support to mitigate loading on subgrade, avoid uncontrolled surface water drainage or water ponding along the toe of the road embankment, avoid traffic on ground surface during the thaw season in thaw-sensitive areas. Some areas may be possible to remediate with granular replacement soils if poor ground conditions become apparent after construction, e.g. in vicinity of problematic culverts where ground is thawing beneath. Or if conditions are known, then design can accommodate/mitigate possibility of thaw. During winter operations, the snow cover should be carefully	2015a, 2015b, 2015c, 2016b, 2016d, 2016e, 2016f

Table 2: Instability Types and Typical Mitigations

Instability Type	Typical Mitigations (after avoidance; not an exhaustive list)	Tetra Tech EBA Reference
Thermokarst / Thaw Settlement cont'd	removed before construction of the embankment to reduce settlement of the fill during the thaw period. Snow accumulation should be reduced on the lee side of higher sections of the road embankment to maintain thermal regime of the frozen subgrade, using techniques that could include snow fencing upwind of the road, flatter fill slope gradients (6H:1V). Performance monitoring will help identify areas that need additional mitigations against snow accumulation. In permafrost areas, design bridge foundations / stream crossing structures that are resilient to climate change and potential changes in permafrost regime.	
Slope toe erosion/undermining	e.g. Erosion of fill slope along creek, or natural slope failure that is continually being eroded and undermined by stream or river – if feature has the potential to affect the performance of the road, then apply erosion protection sized in accordance with the ability of the stream to move material (i.e. riprap). Proactive inspection, monitoring, and maintenance can be important if the erosion potentially could undermine slope support for road, causing a soil debris slide (see above). Note areas that would also benefit from improved control of surface water drainage from upslope. Erosion protection is even more important where physical erosion can lead to thermal erosion, or if erosion rates are high and there is little or no opportunity to realign the road at that location. Riprap placement may be part of a Sediment and Erosion Control Plan. See also TAC (2005) for SECP guidelines.	2015a, 2015b, 2015c, 2016b, 2016g
Rock glacier	Avoid cutting into ice-rich material (e.g. proposed borrow sources), mitigate effects of potential meltwater on slopes/road downslope with additional cross-road drainage and consider sizing of cross-drainage to accommodate potentially increased water flows.	2015a, 2015b, 2015c, 2016g

2.4 Undertaking #44

As requested by CanZinc during the Technical Session, this detailed wording has been prepared by Board staff and consultants to clearly outline the information being requested on this topic. Following feedback from CanZinc and discussion with CanZinc and their consultants on June 23 and 24, the undertaking has been revised as follows:

The historic air photo interpretation identified slope displacements in areas of natural terrain along the road alignment. These areas are generally denoted on the terrain stability maps as 'slide blocks.' The areas are also defined by the mapped presence of tension cracks. These areas have been mapped between the following chainages:

- *Km 40.5 to 41.5*;
- *Km 69.25 to 70.25;*
- *Km 83.75 to 85;*
- *Km 97.75 to 99.25;*
- *Km 104 to 106 (preferred alternate alignment);*
- *Km 108 to 109.5 (preferred alternate alignment)*

The interpretation of these areas to date is based on a review of several years of historic air photos. Different mechanisms of instability are inferred for the various areas. In some areas, the instability is inferred to be within glaciofluvial deposits, whereas in others, it is inferred that the displacements occurred within the bedrock. The presence of permafrost and the degradation of permafrost may be significant factors in explaining the ground displacements in these areas. The historic air photo interpretation identified recent displacements on the 1994 air photos at Km 69.5 to 70.25, as well as at Km 104 to 106 and Km 108 to 109 of the preferred alternate alignment.

It is possible the road could be affected by future displacements of the natural terrain in these areas. It is also possible that the formation of cuts or fills for the proposed all season road could adversely affect terrain stability in the areas of adjacent natural terrain. The potential impacts in this respect are expected to be related to the nature and depth of the instability at each area, which are uncertain at his stage. In addition, the appropriate mitigation solution in these areas could vary, depending on the nature of the instability. It is assumed that these uncertainties and considerations will be fully addressed in the terrain stability assessment process that is to be carried out for areas of 'potentially unstable' and 'unstable' terrain along the alignment as part of the detailed design.

In light of these considerations, the following undertaking is requested in respect of the Environmental Assessment process:

- *Ensure all these areas are highlighted as 'potentially unstable' or 'unstable' terrain on the terrain stability maps so they are 'flagged' for future terrain stability assessment.*
- *Review whether the area from Km 69.25 to Km 70.25 can be avoided by re-locating the alignment towards the west and, if not, provide the reasons why not.*
- *Review whether the preferred alternate alignment can be altered between Km 104 and Km 106 to reduce the length that is within the area where recent slide block development was identified on the 1994 air photos and if not, provide the reasons why not.*
- *Review whether the area from Km 108 to Km 109.5 along the preferred alternate alignment can be avoided by re-locating the alignment towards the northeast and, if not, provide the reasons why not.*
- *Provide a range of mitigation options for these areas to account for:*
  - The uncertainties regarding the mechanisms of terrain instability
  - The possibility of the road being affected by future displacements of the adjacent natural terrain slopes and the possibility of the formation of cuts or fills for the proposed road causing instability in the adjacent areas of natural terrain.

Tetra Tech EBA notes that the areas identified to date as "potentially unstable" and "unstable" terrain have been highlighted as such on the terrain stability maps, and these are "flagged" for future terrain stability assessment. Where work carried out in future phases of the project may identify additional such terrain, that terrain will also be flagged accordingly.

Tetra Tech EBA further notes that all but one of the road sections listed above in this undertaking have undergone detailed consideration of up to three to five different routes, in which the route determined to be the least risky (i.e. best satisfying the concerns raised by geotechnical and terrain assessment reviewers), while still providing the necessary road grades, was chosen. In cases where some concerns might still remain after route optimization, for example, in a case where there might be more than one hazard type to consider, the optimized route would generally be located where the risk is most easily managed. Several aspects of all of these route sections have been previously discussed in detail in a minimum of four to six of the documents prepared for this project to date, depending upon the topic (Tetra Tech EBA 2015a, 2015b, 2015c, 2016c, 2016e, 2016g). The remaining route sections for which MVRB would like additional information are discussed as follows:

- *Review whether the area from Km 69.25 to Km 70.25 can be avoided by re-locating the alignment towards the west and, if not, provide the reasons why not.*

  Rerouting of this road section was not previously considered, as it appeared that the road was already essentially in the optimal location when considering both road grades and slope stability. Map Sheet A11 from Tetra Tech EBA's April 18, 2016 Issued for Review memo (attached) shows this area (Tetra Tech EBA 2016e). It is noted that the road stations shown on this map sheet reflect the February 2015 route, whose stations are offset about 300 m from the most recent 2016 routing. Thus, KP069 on the map sheet is equivalent to about KP068.7 on the 2016 routing, as shown in the attached excerpt from Allnorth's website. The following discussion will refer to both sets of stations for clarity.

  The updated risk analysis presented in Tetra Tech EBA's memo of May 4, 2016 (2016g) notes that "The route between KP67 and KP76 was analyzed using [the] 1994 hard copy air photos [2016e]. As the slides are very similar to adjacent slides visible in the 1949 air photos, it is assumed that these features are also older than 1949. These slides appear to be slumps in surficial sediment, but Rutter and Boydell (1981) show the area to consist of bedrock. It is therefore possible that these are slumps in bedrock rather than in surficial sediments." Also noted in the associated Table A1 of that memo was that between KP067.9 and 72.0, "the route passes between older slump features in surficial sediments or possibly slumps in soft bedrock." Surficial materials are mapped as residual or colluvial veneer in this section, suggesting that they should be a relatively thin layer over bedrock. Based on the helicopter photos from Allnorth and the 1994 air photos, the area has near-surface bedrock and possibly some bedrock outcrops on the steeper knolls and ridges (Tetra Tech EBA 2015a). The 2012 LiDAR imagery seems to corroborate those observations.

  Tetra Tech EBA and Allnorth discussed the implications and challenges inherent in moving the alignment towards the west in the KP069.25 to 70.25 section (personal communications: E.Kragt, R.Kors-Olthof; June 29, June 30 and July 5, 2016).

  It is possible to move the route west to follow the ridgetop between about KP69.2 and KP69.5 as shown by the 2015 stations marked in white on the website excerpt (about KP68.9 to KP69.2 for the 2016 stations marked in red). The move would result in a greater distance between the route and the steeper slope below to the east. However, the route change becomes highly problematic at the end of this section, where a steep descent off the nose of the ridge is needed to get to the area of the saddle below. That steep descent (at about a 25% grade) would necessitate considerable fill (and/or some kind of engineered structure to try to limit the fill volume and footprint), a solution which in turn could be problematic due to the potential for loading the heads of the swales/gullies both to the west and the east, and the potential for blocking natural seepage exiting the adjacent slopes south and north. The road route would need to return to its existing location by the point of the saddle in any case, in order to avoid the above-mentioned drainages. The advantages of being on the ridgetop in this location would be negated by the challenges of getting off the ridgetop at the south end. At the time of detailed design, further consideration could possibly be given to a smaller move west in this section, perhaps on the order of 10 m. It should be recognized, however, that this section also has a steep side-hill, and that such a move may not be feasible either

  Once at the south side of the saddle at about KP69.7 (about KP69.4 in the 2016 stations marked in red), the existing road route passes along the west side of a small knoll. Here again, conceivably the road could be routed a little to the west onto flatter terrain and away from the steeper slope below to the east, but once again, it would need to return to the original route at about KP70 (marked in white on the website excerpt), or even a little further east, so as to avoid the swale and disturbed-looking terrain to the west. Also to be considered is whether the advantages of a realignment in this section would outweigh the implications of an increase in disturbed area due to an additional footprint along those few hundred metres. This area could be checked further during detailed design to confirm the optimum alignment but, based on the aerial observations, moving the road east over the next 200 m would mean possibly coming in closer proximity to a potentially hazardous feature (possible sinkhole?) near about KP70.1 at about 100 m east of the existing route, as well as descending off the north side of the saddle only to have to climb up again, returning to the route at about KP70.3 (about KP070 for the 2016 station marked in red) so as to avoid the steep nose of the next ridge. Thus road geometry and the possibility of moving closer to a new source of hazard would need to be considered for that section. Again, very minor route realignments could be considered at the time of detailed design, but it is anticipated that larger moves would not be warranted or desirable.

Continuing south another 500 m or so, it is apparent that this section of the existing route must have been carefully chosen to avoid the steepest grades, while also avoiding potentially hazardous features such as gullies and rock bluffs, skirting around these wherever possible. While a field review might reveal further information useful in a detailed design decision, on the basis of the currently available information, Tetra Tech EBA and Allnorth see no significant benefit in altering the route and, conversely, do see the possibility of introducing new problems with a realignment in this section.

That said, this road section does entail some important design and construction considerations, as follows:

- This road section has some apparent near-surface bedrock, with several knolls and bluffs having steeper slope gradients and lighter-coloured areas that appear to be exposed sediments or possibly bedrock outcroppings. Some of the road cuts appear as though they may have exposed some bedrock. There are a few areas that appear to have fillslope disturbance below the road, for which the source is unknown but could be either natural sloughing or as a result of sidecast fill materials either not having revegetated or having moved since being placed. The possibility of sidecast fill being present in some areas seems quite likely given the typical construction techniques for resource roads in that time period (early 1980's). Also of potential concern is that part of this road section is located within an old burn area, which could affect the protective peat layer and the stability of surficial soils.
- Due to sometimes steep sideslopes, the cut and fill configuration of a widened road grade needs to be carefully considered during detailed design. Sidecast fill is strongly discouraged. Sidecast fill is fill material that is simply pushed out and over the edge of the road cut, usually with a bulldozer, to create a wider road base. The resulting sloping soil layers, typically subparallel to the underlying natural slope, tend to be highly prone to sloughing, especially with the addition of surface water infiltration from rain and/or rapid snowmelt events. Therefore, if fill is to be placed, it is recommended that the fill be built up in horizontal layers, compacted during placement. It may be necessary to "toe-in" the fill, so that the lower edge of the fill is anchored in mineral soils, not the peaty or organic surficial soils. Fill slope gradients will need to be considered as well. Such design details will depend on such characteristics as soil types (granular vs. fine-grained), depth to permafrost table (if present within the apparently thin overburden soils), whether a significant proportion of ground ice is present in the soil (considered less likely in this area of the route), or whether the road section can be treated in a conventional manner. Cutslope design needs to be similarly considered on a site-specific basis, with slope gradients designed for the long-term stability of the cut.
- As noted by MVRB, it is possible that the natural terrain in this road section may experience movements in future, potentially affecting the integrity of the road, or that the road cuts or fills may trigger a slope failure in the natural terrain. While it is not possible to prevent natural events, it is possible to mitigate the results of those events to some extent, if not by realigning the route to avoid possible hazardous areas, then by providing additional features such as additional drainage (to accommodate the inadvertent blockage of a

culvert that might in turn cause water ponding and further instability, for instance), or buttressing or other treatments on questionable slopes above or below the road, and so on. The above-mentioned control of design and construction parameters will go a long way towards reducing the impact of problems caused by either the road or natural conditions. This includes close control of surface water drainage.

- *Review whether the preferred alternate alignment can be altered between Km 104 and Km 106 to reduce the length that is within the area where recent slide block development was identified on the 1994 air photos and if not, provide the reasons why not.*

  This is a section of the alternative alignment that has been previously reviewed in detail, and that was further discussed by Tetra Tetra EBA and Allnorth regarding this undertaking (personal communications, E.Kragt, R.Kors-Olthof; June 29, 2016). It is located as shown in Map Sheet A15b at the back of this memo. Several routes were considered, including routes further to the northeast (Tetra Tech EBA 2015b, 2015c; Tetra Tech EBA 2016e). Those routes were avoided due to wet organic terrain in the valley bottom enroute to the east side of the valley, as well as additional slope instability hazards on the east valley wall that were avoided with the present routing. Route sub-sections both closer to the toe of the rock bluff upslope to the west and downslope further onto the creeping permafrost area were considered. The upslope route, west of the bedrock knoll, was also considered, but that resulted in road grade issues further south near Km 110, where the upper route would eventually have to descend to the elevation of the lower route to make the valley crossing. Using the upper route in its entirety would also have entailed either a very rugged rocky crossing east of Km 116 on the upper route, or a very wet valley crossing east of Km 118 on the upper route to get to Grainger Gap. The upper route also has more gullied terrain, which is avoided on the lower route. The optimum location for this road section proved to be close to the toe of the rock bluff so as to reduce the amount of permafrost creep and wet seeping ground potentially experienced at the road location, but far enough from the rock bluff so as to reduce the rockfall/slide hazard. The rock bluff was considered to be the greater hazard in this case, so the road could not be tucked in closer to the rock to avoid the creeping ground.

  Therefore, the route location has already been optimized to reduce the risk from both hazard types, and Tetra Tech EBA and Allnorth see no benefit in further attempts to realign this particular road section, based on the information currently available. Rock fall/slide risk can be further reduced with administrative controls and periodic inspections, along with scaling if/as needed. Risk from permafrost creep can be mitigated with road embankment designs appropriate to high-ice-content permafrost areas, with fill-only sections, and embankment designs that reduce the impact of potential permafrost creep on the travel surface, such as wider embankments, and good management of surface water to reduce the likelihood of thermal erosion and thermokarst near or under the road embankment. Several Tetra Tech EBA documents discuss suitable mitigations for this terrain type, whether or not it appears to be creeping (2010, 2015a, 2015b, 2015c, 2016d, 2016f) and/or describe locations where creep has been noted (2016c, 2016e, 2016g).

- *Review whether the area from Km 108 to Km 109.5 along the preferred alternate alignment can be avoided by re-locating the alignment towards the northeast and, if not, provide the reasons why not.*

  As for the previous section, this road section has been previously reviewed in detail, located as shown on Map Sheets A15b and A16 at the back of this memo. This section was further discussed by Tetra Tetra EBA and Allnorth regarding this undertaking (personal communications, E.Kragt, R.Kors-Olthof; June 29, 2016). Again, route sub-sections both closer to the toe of the rock bluff upslope to the west and downslope further onto the creeping permafrost area were considered. The limitations for road grades noted in the previous section apply to this section also, as do the proposed mitigations. Again, the present route location is considered to have been optimized, based on the available information.

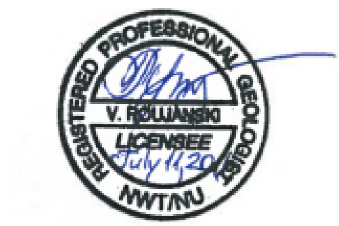
3.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Canadian Zinc Corporation and their agents. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Zinc Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

4.0 CLOSURE

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

Tetra Tech EBA Inc.



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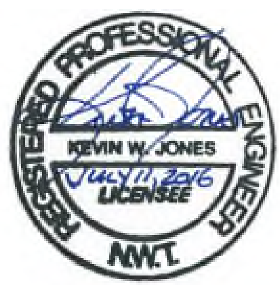

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Attachments: Mapsheet A11
Excerpt from Allnorth Website
Mapsheets A15b and A16
General Conditions

PERMIT TO PRACTICE
TETRA TECH EBA INC.
Signature
Date JULY 11, 2016
PERMIT NUMBER: P 018
NT/NU Association of Professional Engineers and Geoscientists

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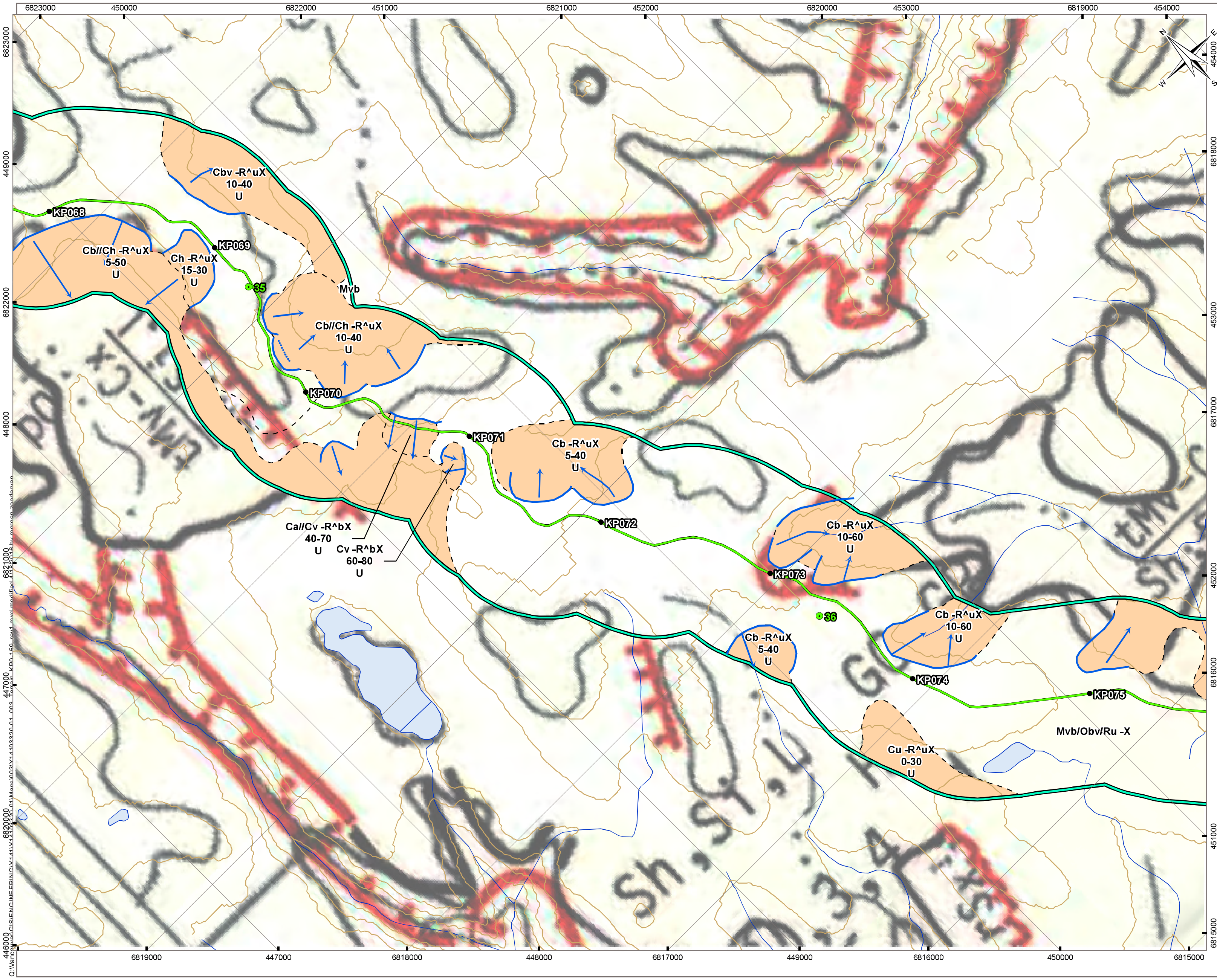
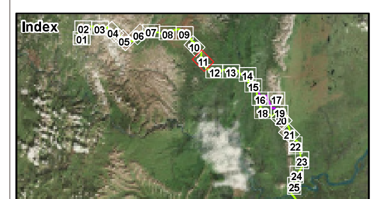


LEGEND

- 1 km Buffer
- **Field Site**
  - Ground-based Observation
  - Airborne Observation
  - TFSA
- Terrain Boundary
- **Slope Stability Class**
  - P Potentially Unstable Terrain
  - U Unstable Terrain
- Prairie Creek Access Road (Apr 5, 2016)
- Prairie Creek Access Road (Feb 24, 2015)
- Alternative Alignment (Apr 5, 2016)
- Alternative Alignment (July 30, 2015)
- Landslide Failure Scar Large (1994)
- Landslide Head Scarp Large (1994)
- Slide Block (1994)
- Contour (40 m)
- Watercourse
- Waterbody



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

STATUS
ISSUED FOR REVIEW

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:20,000
400 200 0 400
Metres

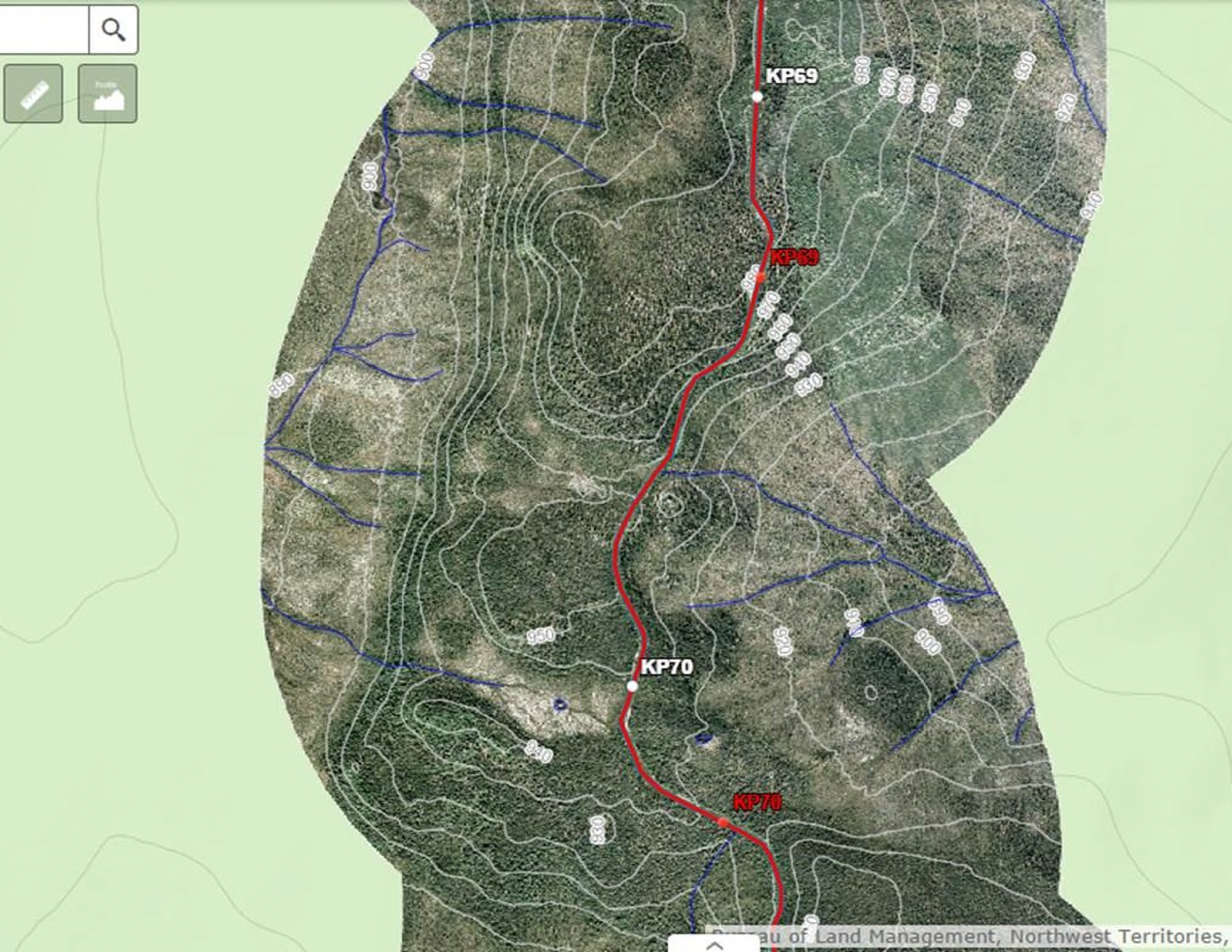
FILE NO.
Y14103320-01_003_Terrain_KP0-159_rev1.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01.003	MEZ	SL	SMC	1

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

TETRA TECH EBA

Figure A11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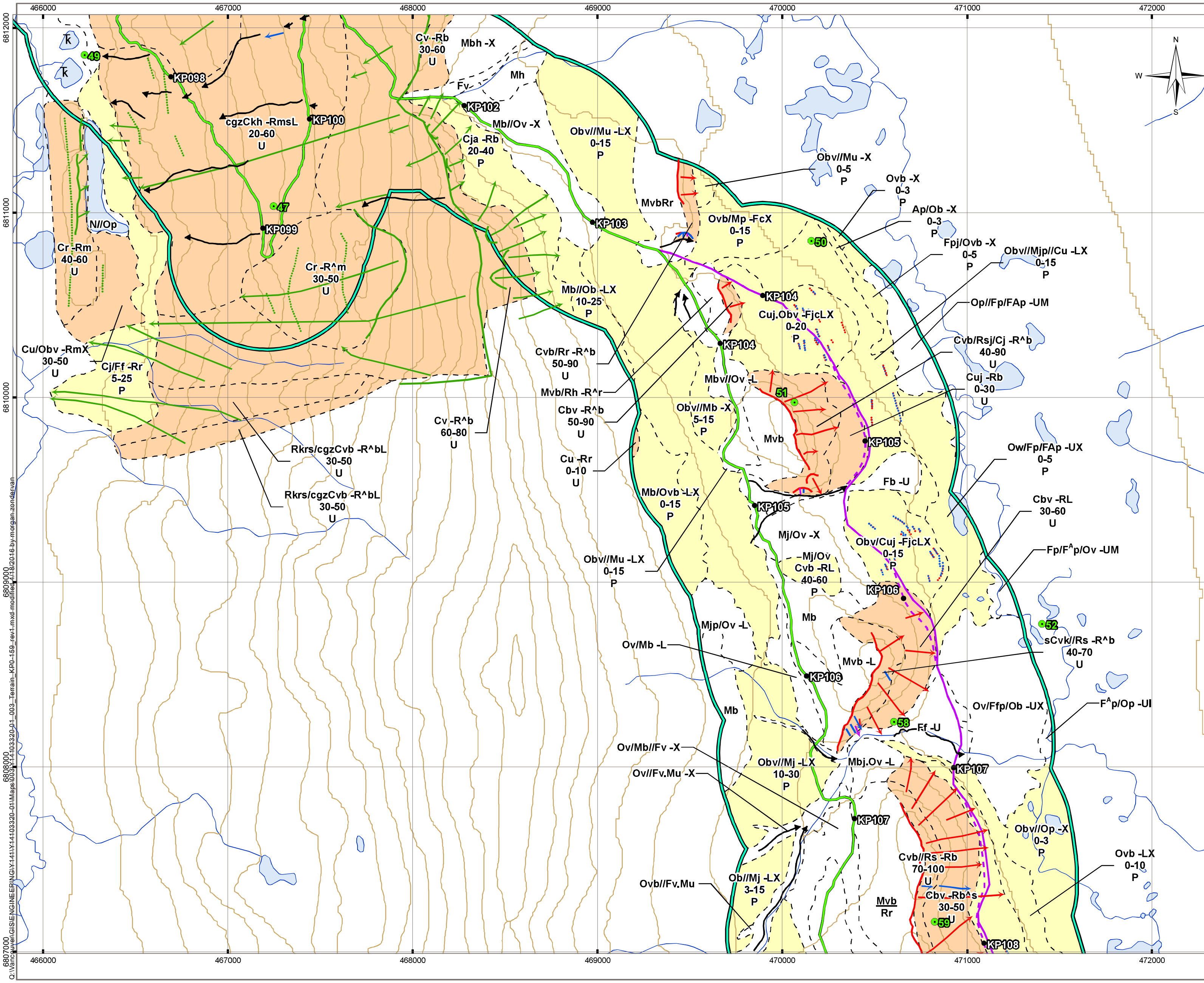


LEGEND

1 km Buffer

Field Site

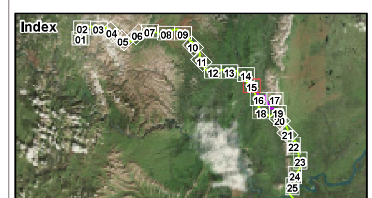
- Ground-based Observation
- Airborne Observation
- TFSA
- Terrain Boundary

Slope Stability Class

- P Potentially Unstable Terrain
- U Unstable Terrain
- Prairie Creek Access Road (Apr 5, 2016)
- Prairie Creek Access Road (Feb 24, 2015)
- Alternative Alignment (Apr 5, 2016)
- Alternative Alignment (July 30, 2015)

Geology

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



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

STATUS
ISSUED FOR REVIEW

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION / TETRA TECH EBA

Scale: 1:20,000
400 200 0 400
Metres

FILE NO.
Y14103320-01_003_Terrain_KP0-159_rev1.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01.003	MEZ	SL	SMC	1

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure A15b

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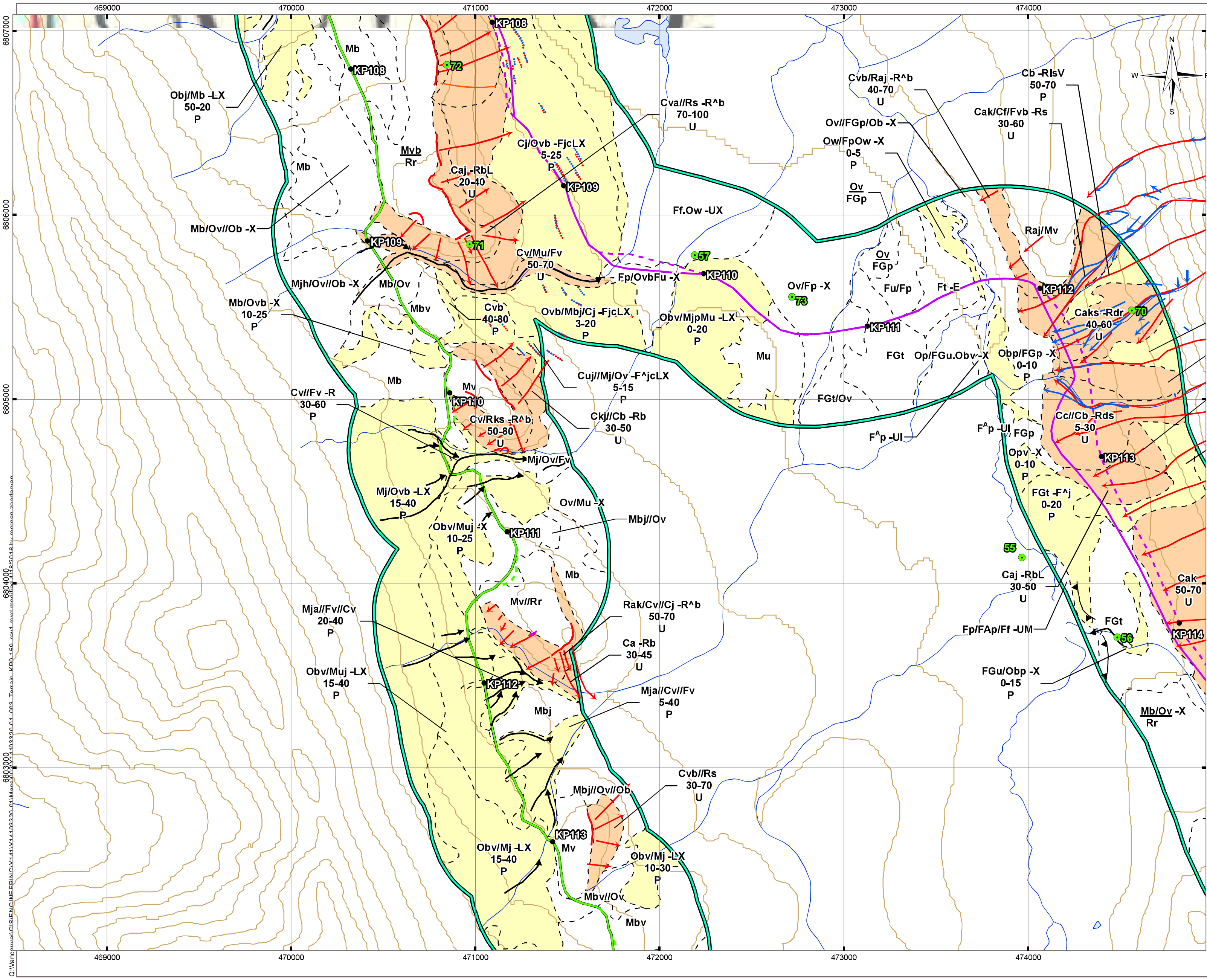

LEGEND

- 1 km Buffer

Field Site
- Ground-based Observation
- Airborne Observation
- TFSA
- Terrain Boundary

Slope Stability Class
- P Potentially Unstable Terrain
- U Unstable Terrain
- Prairie Creek Access Road (Apr 5, 2016)
- Prairie Creek Access Road (Feb 24, 2015)
- Alternative Alignment (Apr 5, 2016)
- Alternative Alignment (July 30, 2015)

Geology
- Gully
- Meltwater channel (major)
- Landslide Failure Scar Large (1962)
- Landslide Failure Scar Large (1994)
- Landslide Failure Scar Large (2012)
- Landslide Head Scarp Large (1962)
- Slide Block (1962)
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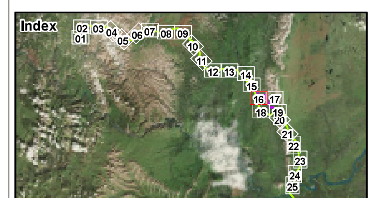
- River Position (1962)
- Contour (40 m)
- Watercourse
- Waterbody



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

STATUS
ISSUED FOR REVIEW

PRAIRIE CREEK ALL-SEASON ROAD

Modified Terrain Stability Mapping

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:20,000 — 400 200 0 400 Metres

TETRA TECH EBA

FILE NO. Y14103320-01_003_Terrain_KP0-159_rev1.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01.003	MEZ	SL	SMC	1

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure A16

Undertaking #43: ***CanZinc to provide return periods for earthquakes of similar magnitude as the 1985 and 1987 events or higher.***

A list of earthquakes of magnitude 6.0 or higher occurring on record in the region is indicated in the table below:

Date	Time(UT)	Lat	Long	Depth	Magnitude	Region and Comment
1988/03/25	19:36:46	62.119	-124.209	10.0g	6.0MS	129 km N from Nahanni Butte
1985/12/23	05:16:03	62.187	-124.243	10.0g	6.9MS	125 km S from Wrigley
1985/10/05	15:24:02	62.208	-124.217	6.0g	6.6MS	122 km S from Wrigley

"g" - depth fixed by seismologist

A total of 3 events of 6.0 magnitude or higher were found on record (since 1985) within a 200 kilometre radius of the Prairie Creek Mine site at 61°.33 latitude, 124°.48 longitude. This data is generated from the Natural Resources Earthquake Database (http://www.earthquakescanada.nrcan.gc.ca/). All 3 events occurred in the North Nahanni/Ram Plateau region.

Return Period (RP) is calculated as follows: RP)=(n+1)/m where n= # of years on record and m=# of recorded occurrences of event. Therefore, for earthquakes of magnitude 6.0 or higher occurring on record in the region, RP= (31+1)/3=10.6 years.

Undertaking 45

CanZinc will provide a list of camp locations/intermediate rescue locations along the road, and a listing of substances and associated quantities that could be stored at these locations during and after construction.

Camp locations for the construction period were listed in the DAR, Appendix 1, Table 9, as follows:

KP 23.2 Drum Camp
KP 40 Cat Camp*
KP 65 Camp
KP 87 Tetcela Camp*
KP 102 Wolverine Camp
KP 124 Grainger Gap Camp*
KP 142.8 Camp
KP 151 Camp
KP 159 Liard Camp

Those marked with an asterisk will be retained at a smaller size to support road maintenance during the operating period. There will be no other locations for refuge/rescue, except for the cabs of trucks.

As noted in our reply to PCA IR8, camp facilities will include a diesel-fed generator with a storage tank up to a capacity of 4,500 litres, a double-chamber garbage incinerator plus an ash bin, and a sewage tank or sump. In addition, fuel for the construction fleet will be stored in tanks. For example, Rowe's Construction uses 2 double-walled enviro-tanks for diesel with 90,000 L capacity each, as well as a smaller 20,000 L enviro-tank split between diesel and gas. In addition, there will be small containers (up to 20 L) of motor oil to top up engines.

During the operating period, maintenance vehicles would be fuelled from enviro tanks on half-tonne service/monitoring vehicles. A trailer and small genset may be retained at the noted camps, with a storage tank no greater than 500 L.

Undertaking 46

To understand spill management for areas of very high and high risk levels (as noted in Table 7-3 of the DAR Addendum) and areas of significant karst terrain (approximately 53.6 to 64.5), CanZinc will provide more specific details regarding spill response, mitigations, and clean up including: the reasonable and worst cases for fuel, concentrate, and acid, during winter and summer conditions. For the reasonable and worst-case scenario, please describe:
a. the volume of spill;
b. the assumptions about environmental conditions (e.g., day versus night, weather conditions, interactions with surface water, terrain conditions, etc.);
c. the assumptions regarding spill response deployment and equipment;
d. the estimated timeline for initial containment to mitigate mobility of the spilled materials.

The road sections identified as of very high and high spill risk, as noted in Table 7-3 of the DAR Addendum, and those with significant karst terrain (Km 53.6 to 64.5), are shown below in an abbreviated version of the table.

Km from Mine		Likelihood	Consequence	Risk	
From	**To**				
Funeral Creek					
7.4	12.0	Moderate	High	High	
12.0	17.2	High		Very High	
Sundog Creek					
23.5	28.1	Moderate	High	High	
28.1	40.2				
Sundog Creek tributaries					
53.6	59.9	Moderate	Moderate	Moderate	
59.9	64.5	Low		Low	
Tetcela & Fishtrap					
95.8	102.0	High	Moderate	High	

Spill Volume

If concentrates are hauled in bags, they will be 3 tonne bags tied-down inside a truck box which will have a lockable solid lid. In the event of an accident and truck overturn, the bags are likely to remain attached within the trailers. However, one may become detached and split, and in a worst case, several could split. Reasonable and worst case spilled quantities are assumed to be 2 and 8 tonnes, respectively. If concentrates are hauled in bulk, they will be in containerized trailers, two per vehicle, also with lockable lids. Each truck load would be approximately 40 tonnes. In the event of a spill, reasonable and worst case spilled quantities are assumed to be 5 and 20 tonnes, respectively.

Diesel fuel will be back-hauled by the concentrate trucks in dedicated tanks, attached either to the truck or one of the trailers. In the DAR, we listed tank capacity at 10,000 L. After further review of requirements, this has been reduced to 5,170 L. The tanks will be double-walled, with the capacity of the space between the walls being 110% of the inner tank, or approximately 5,700 L. The tanks will be puncture-resistant. The experience of a transport engineer provided to us (Don Watt, Allnorth, pers. comm.) is that when fuel tankers have infrequently been involved in accidents, the resulting spills are relatively small, and do not include tank rupture. Fuel tanks are designed to be sturdy and resistant to rupture. Therefore, reasonable and worst case spilled quantities are assumed to be 100 L and 500 L.

Sulphuric acid would be transported in 1,400 L rigid HDPE totes. These vessels are robust and difficult to puncture. Totes would be transported one at a time as each one would sustain operations for 2-2.5 weeks. Reasonable and worst case spilled quantities are assumed to be 50 and 200 L.

Response Time

For the estimation of response time, it is necessary to consider where resources will be. In the first instance, a response is likely to be mounted by the driver of the truck that caused the spill using a kit on-board, or failing that, a response would be mounted by drivers of trucks in the same convoy or arriving on the scene a short time afterwards. While the response these truck drivers would mount may be effective, they may be limited in their ability to respond with the spill equipment readily available. Therefore, we can assume that small spills would have a response time of within an hour, but larger spills may have a longer response time.

Response times were discussed in Section 9.5.1 of the DAR. There will be designated spill control points at key locations along the road, and response materials will be stored at these locations. There will also be trailers stocked with response equipment parked at other locations so that responding crews can hook them up and move them to the spill location. However, for any response beyond the abilities of truck drivers, a spill response team will need to mobilize to the spill location. A response team with heavy equipment will be stationed at the Mine. Maintenance crews and barge/transfer facility operators will also be trained in spill response. Therefore, we can assume that a spill response team will never be more than 90 km from the site of a large spill. We can further assume that responders would travel at approximately 40 km/hour, and therefore they would arrive at the spill site within approximately 2h15m. It is likely that maintenance crews will be working on the road and will be closer, and could respond to a spill faster than the other crews, thus lowering the response time.

Spill Control Points

If a spill occurs, there is a potential for spilled material to enter a water body and flow either above or below any ice cover. Flow can also occur in a dry watercourse. Contaminants can be carried away from the spill site. A number of areas exist where a spill could enter a watercourse. These include along Prairie and Funeral Creeks, Sundog Creek, and the Polje, Tetcela and Grainger stream crossings. “Control Points” will be established at pre-determined locations from which spill containment and recovery operations can be mounted to limit the migration of a spilled substance from an upstream location in the event of a spill.

Establishing a Control Point along Prairie Creek would be potentially difficult because the creeks may have significant flows of water. However, a silt or other form of curtain will be stored approximately mid-point between the Mine and Funeral Creek ready for deployment to reduce flow in part of Prairie Creek adjacent to a spill. The curtain is not intended to contain a spill, but rather would assist spill response by providing a more quiescent environment. The Funeral Creek stream width is quite narrow. Absorbents will be available for placement along the bank between the stream and the road, and/or across the stream itself temporarily, as necessary. A Control Point will be established near the mouth of Funeral Creek.

The upper section of Funeral Creek includes two tributaries crossed by the road which are not fish-bearing. However, the creek downstream of Km 12.7 is sensitive because of the possible presence of over-wintering fish, and the fact that spawning was noted in August. This section of the road (Km 12.7-17.2) is considered the most challenging in terms of mounting a response in the event of a spill because of the steeper terrain and grade separation between the road and creek. Consequently, Control Points will be established on these tributaries at their confluence with the main stem. The intent is to prevent migration downstream of the Control Point of any substance that might be spilled in the upstream catchment. Similar Control Points will also be established on Sundog Creek in two locations (one just above the main waterfall (Km 25) and one just before the creek flows onto the fluvial outwash plain (Km 29)), and downstream of the Polje Creek, Tetcela River and Grainger River crossings. An additional control point will be established at the toe of the Silent Hills on the west side.

Spill Equipment

Spill kits will be carried on vehicles with materials appropriate for the loads (i.e. type of sorbent). All concentrate trucks will carry sorbent specific to hydrocarbons.

For the operating period, comprehensive spill kits will be maintained at the Mine site, Cat Camp, the Tetcela Transfer Facility (TTF) or Tetcela Maintenance Camp (TMC), Grainger Gap, and the Liard Transfer Facility. In addition, custom built and stocked road trailers dedicated to spill response will be on hand, containing equipment, materials and tools. This will include absorbents and soda ash. The trailers would be stationed at Cat Camp, the TTF/TMC and Grainger Gap to be approximately evenly spaced along the road. One or more of the trailers could be readily hooked up and towed to a spill site. There is no need to locate the trailers in high risk locations because responders will still need to travel to the spill location, collecting the nearest trailer on the way. The trailers would be used for preventative maintenance, training and spill response activities.

Non-dedicated equipment such as backhoes, dozers, crane trucks, dump trucks, vacuum trucks etc. would be called to spill sites on a priority basis in the event of need. The Mine, maintenance camps and Liard Transfer Facility will have heavy equipment present during the operating period. This would be made available immediately in the event of need.

Equipment at the Control Points will include booms and absorbents in addition to material to create temporary dams, such as board weirs, sand bags and other inert materials that would be stored at the location. Shovels will also be left on site for use in making a dam also. A supply of soda ash will also be kept at Control Points to neutralize any acid spill.

CZN considers it appropriate to be prepared for a hydrocarbon spill at high risk locations. In summer, temporary dams may only be effective for a short period before they are inundated, or liquid would start to seep. It would take time for a vacuum truck and equipment to arrive at a spill location, and this could hamper response to a large spill. Therefore, we propose to acquire two bladders with a capacity of at least 5,000 L. This would provide the means to commence the recovery and temporary storage of spilled liquid quite soon after the spill. One would be stationed with a pump at one of the Control Points on an upstream tributary to Funeral Creek. This bladder would also be available to the Control Point on the other tributary because they would be in close proximity. A bladder at this location is considered important because the location is some distance from the road, and it would not be accessible to a vacuum truck. The other bladder would be stored with a pump on the trailer stationed at Cat Camp. From this location, the trailer could be taken upstream (west) on Sundog Creek, or east to respond to any spills near the tributaries of Sundog Creek. These locations would address the road sections considered to have a highest risk and potential consequence of spills.

The Silent Hills is also a high risk location, but there is no significant watercourse. A bladder is not proposed here because it is not likely to be useful, and control strategies such as temporary dams are likely to be sufficiently effective.

Response to Specific Spills

Concentrates

To address the potential for concentrate spills, spill exercises addressing these potential occurrences will be undertaken. Spilled material will be recovered, potentially involving a back hoe, although the expected small quantity may only require shovels. Any contaminated soil would also be recovered. Standard procedure would be to recover soil from the impacted area after excavation for testing to confirm presence/absence of contamination. If bags were to roll down a steep grade after an accident and split in an area where no heavy machinery access is possible, then shovels and manpower will be required to recover the material.

Bulk Fuel

Control Point locations have been designed to stop the wider migration of spills of diesel fuel. Response equipment and material would be appropriate for the possible quantity of a spill. Spill kits will be stocked with the necessary response material for the spill. A vacuum truck will be on stand-by at the Mine with a capacity of at least 10,000 litres. In addition, we have proposed the use of bladders to facilitate the rapid commencement of spilled liquid recovery.

Acid

Response equipment and material would be appropriate for the quantity and nature of an acid spill, and dedicated spill response kits would be appropriately stocked. A vacuum truck will be on stand-by at the Mine. Bags of soda ash to neutralize any spilled acid will also be stored in the trailers and at Control Points in animal-proof containers (salt is an attractant to ungulates), and exchanged seasonally (to avoid caking in wet conditions).

Spill Response and Mitigation by Road Section

Km 7.4-12

Between Km 7.4 and Km 12, the road parallels Funeral Creek. The road is adjacent to the creek in places, and in others there is a vegetated area separating the two. Conditions are similar to the Prairie Creek section except there is some grade. The consequence is also higher because of the presence of spawning Bull trout in the fall. Driving along this section may occur in early morning and evening, and hence may occur in low light conditions in winter, although the adjacent snow cover would provide some illumination. Fog is possible in the fall shoulder period, but usually not dense enough to limit driving visibility. In any event, hauling would be discontinued if visibility or weather conditions are sufficiently poor.

A spill along this section would be problematic because of the potentially close proximity to flowing water. However, the grade difference between the road and stream is not great, and therefore an accident is unlikely to result in a worst case spill. A concentrate spill in summer would likely cause relatively low and short term water quality impairment. Recovery of spilled material should be close to 100%, but a small amount may enter water and be carried downstream and remain in bed sediments. In winter, impacts would be much less, unless there is ice break-through, and recovery should be total. However, the risk of a concentrate spill is very low due to the fact that truck speeds will be low as they ascend grade out-bound.

An acid spill should be small in volume. In summer, flowing alkaline water should dilute any acid spill, resulting in low and short term effects. Effects will likely have dissipated before a spill response is mounted. In winter, impacts would be less, unless there is ice break-through and a spill into underlying water. A spill response in that situation might involve soda ash addition to neutralize pH, both at the spill site and immediately downstream. A fuel spill would have a greater potential for effects. In summer, spilled fuel reaching the creek will float, but a portion may dissolve. Rapid response is required to limit migration on land and in water, and to minimize dissolution in water. Some fuel may sorb onto soil and stream bank, and require a more prolonged response and recovery effort. In winter, impacts should be much less, unless there is ice break-through. Absorption of fuel by snow should be effective. However, there may be open water beads in the creek, and fuel may percolate through ice, therefore downstream interception may still be required in winter.

Travel time from the Mine to the furthest part of this road section would be about 20 minutes. Any spill not contained by the truck driver would likely take the Mine-based response team 30-60 minutes to contain.

Km 12-17.2

The road is not proximal to the creek from approximately Km 12.3 onwards where the grade steepens. Also, the creek is impassable to migrating fish where the main stem splits into three forks (upstream of Km 12.7).

The section considered to pose the highest risk of a spill is from Km 13 to Km 17. A spill over this section could be a worst case scenario from a response perspective because of the grade separation between the road and the creek below. In the event of a spill, it may be difficult to access the area below the road and the speed of spill response may be affected. However, the distance from the creek, and the fact that fish cannot migrate upstream of Km 12.7, compensates for this difficulty and should allow a timely interception to be mounted at Km 12.7 (a Control Point).

Like the previous road section, driving along this section may occur in early morning and evening, hence may occur in low light conditions in winter. Due to the grade difference between the road and stream, an accident could result in a worst case spill. A concentrate spill in summer would likely cause relatively low and short term water quality impairment. Recovery of spilled material should be close to 100%, but a small amount may be carried downstream to the Control Point. In winter, impacts would be much less and recovery should be total. Truck speeds will be low as they ascend grade out-bound.

An acid spill of any volume in summer is unlikely to have a significant effect due to either flowing alkaline water diluting any spill, or interception if the spill reaches the Control Point. Soda ash would be available to neutralize pH. In winter, impacts would be less due to snow absorption. A large fuel spill in summer would be retarded by absorption onto soil and rock, but migration with water in a creek tributary is possible. A rapid response at the Control Point would be required, where a pump and bladder will be available to recover liquid. In winter, impacts should be much less due to absorption of fuel by snow.

Travel time from the Mine to the furthest part of this road section would be about 25 minutes. However, for a significant spill, the first priority would be arrival at the Km 12.7 Control Point. That would take about 20 minutes by road, and 10 minutes on foot. Deployment of booms and pads would be immediate, but commencement of pumping, if necessary, would take a little longer.

Km 23.5-28.1

Over this section, the road parallels Sundog Creek but is upslope and setback from the creek by an average of 150-200 m. There is well vegetated terrain between the road and creek, and the slopes below the road are not steep, for the most part. There are no fish upstream of Km 25.3 due to a large waterfall preventing migration. Downstream, Arctic grayling are present in summer, but shallow pool depths and ice thicknesses likely prevent their presence in winter. Driving along this section may occur in morning and late afternoon, and hence may occur in low light conditions in winter.

There is a grade difference between the road and stream, but the usually shallow slopes mean that an accident is unlikely to result in a worst case spill. A concentrate spill in summer would likely cause relatively low and short term water quality impairment. Recovery of spilled material should be close to 100%. In winter, impacts would be less, and recovery should be total.

An acid spill should be small in volume and unlikely to reach the creek. In any event, in summer, flowing alkaline water would dilute any acid reaching the creek. Effects will likely have dissipated before a spill response is mounted. In winter, impacts would be less. Soda ash to neutralize pH would be available at Control Points. A fuel spill will also be absorbed significantly. In summer, any spilled fuel able to reach the creek will float, but a portion may dissolve. Rapid response is required to limit effects, hence the Control Points planned for Km's 25 and 29. In winter, impacts should be much less as absorption by snow should be effective. The risk of an acid or fuel spill is reduced since trucks will be ascending grade.

Travel time from the Mine to the furthest part of this road section would be about 45 minutes. However, a road maintenance crew may be closer. Any spill not contained by the truck driver would likely take a response team 30-60 minutes to contain from the time they received notice of the spill, depending on their location at the time.

Km 28.1-40.2

This section traverses the fluvial floodplain of Sundog Creek, and is essentially flat. Therefore, the risk of an accident is very low, but should there be a spill, the porous nature of the alluvium would allow subsurface migration. There are vegetated portions of the floodplain that the road alignment would preferentially cross. There are also unvegetated portions where the road is separated from the creek. However, there are a few small portions were the creek is adjacent to the road. Arctic grayling can be present in summer, but they are restricted to the occasional shallow pool and side channel. Long stretches of the creek can be dry in summer, and the entire section will be dry in winter. Grayling presence in winter is unlikely. Driving along this section may occur in morning and late afternoon, and hence may occur in low light conditions in winter.

The flat terrain means that an accident is unlikely to result in a worst case spill. A concentrate spill in summer would likely cause relatively low and short term water quality impairment. Recovery of spilled material should be close to 100%. In winter, impacts would be less, and recovery should be total.

An acid spill should be small in volume and unlikely to reach the creek. The slow speed of groundwater flow and alkaline water would dissipate any acid spill before it reaches the creek. However, a trench could be dug between the spill site and the creek for interception, and to confirm this. A fuel spill would be more persistent. The approach would be the same (interception trench), but the response and spill recovery operation will need to be over a longer period.

Because the ground is flat, and groundwater flow is slow relative to surface water, there would be a little more time for spill response in most cases before spilled liquid could migrate to surface water, if any were present. Travel time from the Mine to the furthest part of this road section would be about 60 minutes. However, a road maintenance crew is likely to be closer. If spill containment with a cut-off trench is required, this would likely occur within 2 hours.

Km 53.6-59.9

This section climbs onto the Ram Plateau from Polje Creek in the west, and from Km 55.5 is adjacent to slopes leading down to the Poljes. The terrain has a few rocky outcrops ascending the plateau, but generally has soil cover and sparse vegetation. Soil cover and vegetation is more developed on the plateau top. Polje Creek hosts Arctic grayling in summer, but over-wintering habitat is limited. The Poljes do not host fish as they are periodically dry and do not have a surface outlet. Driving along this section may occur in morning and late afternoon, and hence may occur in low light conditions in winter.

The terrain has gentle cross slopes from Polje Creek east, and is nearly flat on the plateau top. An accident is unlikely to result in a worst case spill. A concentrate spill in summer or winter would have little impact. Recovery of spilled material should be close to 100%.

An acid spill should be small in volume and unlikely to reach a watercourse. Effects will be low due to the alkaline bedrock. A fuel spill would be more persistent. The spill would be absorbed by soil in summer, and snow in winter. Soil remediation (removal) would be required. Percolation to underlying groundwater prior to spill response is considered unlikely.

Travel time from the Mine to the furthest part of this road section would be about 90 minutes. However, a road maintenance crew will almost certainly be closer. Spill containment would likely occur within an hour, followed by immediate spill and impacted soil recovery.

Km 59.9-64.5

This section is on the plateau and is essentially flat, with soil cover and vegetation. Mosquito Lake is to the south, but the lake drains to the closed polje system. Driving along this section may occur in morning and late afternoon, and hence may occur in low light conditions in winter.

An accident is very unlikely, and would not result in a worst case spill. All spill considerations are the same as for the previous road section.

Travel time from the Mine to the furthest part of this road section would be about 100 minutes. However, a road maintenance crew will almost certainly be closer. Spill containment would likely occur within an hour, followed by immediate spill and impacted soil recovery.

Km 95.8-102

This section covers the ascent of the western slope of the Silent Hills to Wolverine Pass. The slope is densely wooded, and has several small streams flowing from east to west. Adjacent to the toe of the slope is the upper Fishtrap Creek wetland system, consisting of ponds, muskeg and also beaver dams downstream. The slope itself is quite steep overall, however considerable engineering investigation has defined a route that traverses the slope at a steady, relatively low grade, with two changes in direction in flatter locations that provide for a suitable turn radius. A spill over this section would not be a worst case scenario because tree cover would prevent a roll-over downslope. Also, the dense vegetation would absorb a spill, and there would be opportunities for spill interception downslope. Further, Fishtrap Creek is not considered to be fish habitat proximal to this area. A Control Point has been defined for the toe of the slope, although this is considered to be more of a spill response equipment storage location, allowing deployment upslope if a spill occurs.

Driving along this section may occur in the morning and afternoon, hence should occur in at least moderate light conditions even in winter. A concentrate spill in summer would cause little in the way of effects. Recovery of spilled material should be close to 100%. In winter, impacts would be much less and recovery should be total. Truck speeds will be low as they ascend grade out-bound.

An acid spill of any volume in summer is unlikely to have a significant effect due to absorption by soil. In winter, impacts would be less due to snow absorption. A fuel spill in summer would also be retarded by soil absorption. However, soil remediation would be required. In winter, impacts should be much less due to absorption of fuel by snow.

A road maintenance crew will almost certainly be no more than an hour away from this location. Spill containment would be expected to occur within an hour, followed by immediate spill and impacted soil recovery. Any spill is unlikely to migrate a significant distance from the spill location.

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	David Harpley, VP Environment and Permitting Affairs	**Date:**	July 25, 2016
c:		**Memo No.:**	01
From:	Karla Langlois and Amy McLenaghan	**File:**	Y14103320
Subject:	Baseline Vegetation and Wildlife Studies, Prairie Creek All-Season Road July 11-17 Field Summary Revision 01		

1.0 INTRODUCTION

Canadian Zinc Corporation retained Tetra Tech EBA to conduct baseline vegetation and wildlife studies along the proposed Prairie Creek mine all-season access road from July 11 to 17, 2016. The field team included Amy McLenaghan and Karla Langlois of Tetra Tech EBA, and Steve Moore, a recently retired biologist formerly of Tetra Tech EBA.

Baseline assessments for vegetation community typing (ecotyping), rare plant habitat, and wildlife were completed by aerial and ground-based surveys, and focussed primarily on the proposed all-season road development footprint. Ground-based surveys were constrained by limited helicopter access primarily in the boreal zone.

The following is a summary of the field program activities. The field data are currently being analyzed and results, including a review of the potential environmental effects and mitigation presented in the Developers Assessment Report (DAR), will be provided in a summary report under separate cover.

2.0 BASELINE VEGETATION COMMUNITY AND RARE PLANT SURVEYS

The most current mapping available for the Project area for preparation of the DAR in 2014 was Earth Observation for Sustainable Development of Forests (EOSD) mapping (Wulder et al. 2004) which was used to verify Beak's (1981) earlier baseline vegetation work and ecotyping. The spatial data associated with Parks Canada (2015) ecotyping were unavailable at the time the DAR was being prepared.

Baseline ecotyping and rare plant surveys were generally conducted in areas of proposed new disturbance, such as borrow pits and road realignment areas. The EOSD ecotype mapping was field verified in several proposed disturbance areas and the Parks Canada ecotyping was used as an aid. The rare plant component of the work was conducted on an opportunistic basis while ground-truthing ecotypes. Rare plant surveys followed the Alberta Native Plant Council's *Guidelines for Rare Vascular Plant Surveys in Alberta – 2012 Update*. As a guide, plot data collected for ecotype verification followed the field data collection approach identified in the *BC MOE/MOF 2010 Field manual for describing terrestrial ecosystems – 2nd ed*. Plots measured 400 m^2 and data collected included percent cover by species as well as site characteristics (e.g., slope, aspect, elevation, geographic location in UTM). Ecotypes with the greatest amount of anticipated disturbance were targeted.

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Tel 867.920.2287 Fax 867.873.3324

2.1 Ecotyping Results

Thirty-three plots were completed across various ecotypes and are summarized in Table 1 and 2 below for each ecotype mapping system (Parks Canada and EOSD, respectively).

Table 1: Ecotyping Results Based on Parks Canada Mapping

Ecotype	Area Affected (ha)	Number of Plots	Plot Type
Alpine Herb Tundra and Meadow	23.32	2	GIF*
Terrain or Cloud Shadow/Water	75.67	0	
Subalpine Tall Shrub	1.52	2	GIF
Spruce-Lichen-Moss Woodland	271.28	2	GIF
Low Sparse Shrub	132.34	3	GIF
Rock Lichen	205.09	0	
Rock	52.26	0	
Mixed Predominantly Coniferous Forest	362.22	8	6 GIFs, 2 Visuals
Medium-Low Shrub**	165.24	3	GIF
Coniferous Forest	398.94	4	GIF
Subalpine Shrub – Sparse Trees	16.43	2	GIF
Spruce-Lichen Woodland	27.79	1	GIF
Wetland	22.63	1	GIF
Alluvial non-vegetated	4.55	1	GIF
Water/Terrain Shadow	0.39	0	
Deciduous Forest/Tall Shrub	96.42	0	
Mixed Predominantly Deciduous Forest/Tall Shrub	131.61	2	GIF
Recently Burnt	41.32	3	GIF
Ice/Snow	14.82	0	
Permanent Water	12.18	0	
Intermittent Water	42.76	0	

* Ground Inspection Form
** One plot was located outside the Park boundary and was mapped as "Shrub-Tall" according to the EOSD mapping.

Table 2: Ecotyping Results Based on the EOSD Mapping

Ecotype	Area Affected (ha)	# of Plots	Plot Type
Shadow	29.42	0	
Water	17.57	0	
Rock/Rubble	160.76	0	
Exposed/Barren Land	434.12	1	GIF
Bryoids	9.50	1	GIF
Shrub – Tall	25.69	3	GIF
Shrub – Low	221.74	9	GIF
Wetland – Treed	32.04	0	
Wetland – Shrub	3.73	1	GIF

Table 2: Ecotyping Results Based on the EOSD Mapping

Ecotype	Area Affected (ha)	# of Plots	Plot Type
Wetland – Herb	0	0	
Herbs	1.52	2	GIF
Coniferous – Dense	273.47	1	GIF
Coniferous – Open	415.66	5	GIF
Coniferous – Sparse	82.52	0	
Broadleaf – Dense	164.17	0	
Broadleaf – Open	24.60	0	
Mixedwood – Dense	191.00	3	2 GIF; 1 visual
Mixedwood – Open	13.59	7	6 GIF; 1 visual

Both classification systems have their merits and shortcomings. Any ecotype mapping can be outdated the moment it is published, particularly in light of changes resulting from fire and human disturbance. Since the Beak mapping was produced in 1981, there have been very few anthropogenic changes to the landscape; however, fire has influenced areas of the Project, and no one set of ecotype mapping accurately captures this information.

The level of detail of the EOSD mapping for wetlands is useful. Most of the sensitive wildlife species that may be in the Project Area prefer wetland habitats. The EOSD mapping provides better wetland habitat correlation in this respect. However, the Parks ecotype mapping is better at depicting variation between boreal and alpine/subalpine vegetation assemblages. Both mapping datasets can be used to complement the other. Further evaluation of the mapping datasets will be completed and reported under separate cover.

2.2 Rare Plants

No *Species at Risk Act* species such as Raup's willow (*Salix raupii*) were detected. A specific survey for this willow was conducted along Sundog Creek between kilometre Point (KP) 36 and 38. The Government of the Northwest Territories (GNWT) ranks 217 vascular plants as either "At Risk", "May Be At Risk", or "Sensitive"; Tetra Tech EBA also searched for these species. No species ranked by the GNWT were detected.

2.3 Vegetation Comments and Recommendations

Vegetation comments and recommendations are as follows:

- Ground-truthing of the EOSD and Parks Canada mapping was undertaken. Data collection was restricted in the Silent Hills area (KP 96-102) by access limitations (landing locations for the helicopter), however the ecotypes defined for this area by the EOSD mapping are predominantly mixedwood, deciduous, and shrub ecotypes, and these were partially confirmed by aerial survey.

- A recent forest fire (1-2 years) has burnt a portion of the route from approximately KP 60 to 72.5. All existing ecotyping is no longer valid. An older burn (12-15 years ago) is also not accurately depicted on Parks Canada ecotype mapping (KP 48.5 to 60). No mapping dataset accurately depicts current burned conditions; however, each dataset can be updated to reflect these changes based on the information gathered in the field. Pre-fire, common ecotypes were coniferous, mixedwood and wetland; post-fire, each ecotype has been reset to a shrub community.

- Should Parks Canada wish to confirm their mapping, the following ecotypes would benefit from further evaluation:
  - Terrain or Cloud Shadow/Water – This ecotype occurs where imagery is poor and the land cover could not be properly classified. Due to the size of this ecotype (75.67 ha) further ground-truthing would be required to determine which ecotypes are actually present.
  - Rock/Lichen – No plot data was collected in this ecotype.
  - Wetland – This ecotype is likely more prevalent than depicted by the Parks Canada mapping, although it is somewhat more accurately depicted by the EOSD mapping due to a larger number of wetland categories. More wetland ecotype data would need to be collected.
  - Deciduous Forest/Tall Shrub – This ecotype is more prevalent in the Silent Hills area.
- Both the Parks Canada and EOSD ecotyping could be smoothed out somewhat to create polygon features for each ecotype. The mapping is somewhat pixilated in areas, reducing its usability.
- The timing of the rare plant survey was too late for the flowering periods of plant families such as Ranunculaceae (buttercups) and Rosaceae (rose). An early rare plant survey is recommended prior to construction.

While further evaluation of the field data is required, our preliminary conclusion is that this new information does not alter the effects assessment in the DAR, but enhances the baseline database. As stated in the DAR, the potential effects of land clearing on terrestrial ecosystems are considered low, since:

- The amount of land clearing has been minimized by incorporating the approved winter road and its facilities with the all season route, for the most part, and utilizing borrow material within the proposed road right-of-way, as much as possible;
- The proposed re-alignments of the access road will result in a shorter road; and
- The proposed re-alignments east and west of the Tetcela River reduce the effects on wetlands.

Vegetation data were also collected in the areas identified by Cameron (2015) where vegetation assemblages were thought to be altered due to permafrost thaw caused by the old winter road. Additional data evaluation is required (forthcoming under a separate report); recommendations from the analysis will be put forth for the reclamation plan.

3.0 BASELINE WILDLIFE SURVEYS

Wildlife and wildlife habitat were recorded along the proposed all-season road and within select borrow sources during aerial and ground-based surveys. The surveys included:

1. **Black bear habitat potential:** Survey transects were completed in conjunction with the ecotype ground-truthing program. Twenty-seven detailed 100 metre (m) transects and three 20 m radius visual plots were surveyed within 13 habitat types in the boreal and montane regions. No bears (black or grizzly bears) were observed; however, bear presence was detected from scat, tracks/trails, and feeding sign mainly in the boreal zone and along the existing access road from KP 1 to 12. Field results will be assessed to determine black bear habitat potentials along the access road, particularly at the camp locations to determine the adequacy of proposed mitigation.

2. **Harlequin duck presence/absence:** an aerial survey was conducted along Sundog Creek (from KP 17.5 to 38.5), Funeral/Fast Creek (KP 7.5 to 11.5), and Prairie Creek (KP 0 to 7.5). The aerial surveys were flown 30 m above ground level and at approximately 60 km/hr. These watercourses were regularly flown throughout the field program, outside the specified Harlequin Duck survey, and Funeral/Fast Creek was also slowly driven with an ATV. No Harlequin Ducks were observed during the designated surveys or incidentally. The pilot had reported an observation of an unknown duck species diving into Sundog Creek near KP 28.5 several days prior to the aerial survey. Harlequin Ducks were assessed in the Information Response (dated April 28, 2016), which assumed the presence of Harlequin Ducks along this watercourse.

3. **Cliff-nesting raptor nest presence/absence:** An aerial survey was conducted along suitable south-facing cliffs available along Sundog Creek (from KP 34 to 37.8), and all raptors were recorded incidentally throughout the field program. During the aerial cliff-nest survey, one large inactive stick nest, likely once occupied by a Golden Eagle, was detected near KP 37.4. A single Peregrine Falcon was also observed along Sundog Creek near KP 37.5. Although, no scrape was detected, the presence of the Peregrine Falcon may indicate an active nest site in the area.

4. **Collared Pika presence/absence:** Ground-based Collared Pika observation stations and talus transects were completed to detect the presence of Collared Pikas. Surveys were completed in borrow sources in the Sundog Creek re-alignment (all talus borrows or those immediately adjacent to talus from KP 32 to KP 38.5) and Borrow Sources 14 and 16. Evidence of both active and possibly inactive pika sites was observed. Active sites were found at Borrow Sources 33 and 34, as indicated by calling individuals and/or fresh haypiles and pellets. Possible inactive sites, as determined from the presence of old haypiles (and lack of calling individuals and or fresh haypiles) were found at Borrow Sources 35 and 38, and adjacent to Borrow Source 16 (approximately 50 m away from borrow).

5. **Waterfowl and Trumpeter Swan presence/absence:** Aerial surveys within the wetland complexes east of the Silent Hills and Fishtrap Creek were conducted. Observations of Trumpeter Swan and duck species were recorded within 1 km of the access road. Trumpeter Swans were also recorded incidentally throughout the field program while in transit. Ducks were not identified to species. The designated waterfowl/swan aerial survey covered approximately 100% (preliminary estimate) of the wetlands in the Fishtrap Creek and approximately 40% (preliminary estimate) of the wetlands east of the Silent Hills with focus on those nearest to the proposed road. Trumpeter Swans and ducks were detected including adults with broods (data still to be assessed).

6. **Beaver presence/absence:** All active/inactive beaver dams and lodges along and near the proposed all-season access road were recorded during an aerial reconnaissance survey of the road, as well as during the aerial waterfowl/Trumpeter Swan survey. Based on these surveys, beavers occur near the proposed road in the lower elevation boreal forest zone in the Fishtrap Creek and east of Silent Hills areas.

7. **Incidental wildlife:** additional wildlife was also recorded incidentally, including but not limited to Moose, Dall's Sheep, caribou, and forest raptors. A single caribou was observed on July 16 that appeared to have a collar (observation location: Latitude 61.585580°; Longitude -124.548350°).

Overall the field program confirmed the presence of target species and species habitat. Additional baseline wildlife surveys for forest and wetland birds are planned for the May to June window, at which time additional waterfowl and cliff-nesting raptor surveys may be conducted concurrently, and the black bear habitat potential maps may be updated with any new relevant information.

Cliff-nesting raptor surveys should also continue to identify the presence of active raptor nest sites, particularly along Sundog Creek where the proposed access road traverses within the valley, for development and implementation of the monitoring plan. Collared Pika surveys should also continue at Borrow Sources 35, 38, and 16 if these borrows are intended to be developed. Alternative borrows to sources 33 and 34 should be selected to avoid active Collared Pika sites.

4.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Canadian Zinc Corporation and their agents. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Canadian Zinc Corporation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

5.0 CLOSURE

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

Respectfully submitted,
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Attachments: Tetra Tech EBA's General Conditions