CANADIAN ZINC CORPORATION

DEVELOPER'S ASSESSMENT REPORT
ALL SEASON ROAD PROJECT
PRAIRIE CREEK MINE

APPENDICES 2 to 14 Volume 3 of 3

SUBMITTED IN SUPPORT OF:

Environmental Assessment of
Prairie Creek Mine EA 1415-01

SUBMITTED TO:

Mackenzie Valley Review Board
Yellowknife, NT X1A 2N7

SUBMITTED BY:

Canadian Zinc Corporation
Vancouver, BC V6B 4N9

April 2015

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APPENDIX 2

TETRA TECH EBA

GEOTECHNICAL EVALUATION AND DEVELOPER'S ASSESSMENT REPORT SECTIONS FOR PROPOSED PRAIRIE CREEK ALL-SEASON ROAD NEAR NAHANNI BUTTE, NORTHWEST TERRITORIES

PRESENTED TO

Canadian Zinc Corporation

MARCH 2015
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EXECUTIVE SUMMARY

The Prairie Creek Mine is located in the southwest corner of the Northwest Territories, surrounded by the Nahanni National Park Reserve of Canada, which is a UNESCO World Heritage site, known for karst terrain of global significance, as well as the South Nahanni River, a Canadian Heritage River. The Mine and access routes have been a part of the landscape and history of the Northwest Territories since 1966, and the mine area is part of the traditional territory claimed by the Nahanni Butte Dene Band. The original winter road before mine construction was 288 km long, accessing the site along the Ram and North Nahanni Rivers from the Mackenzie River to the northeast. In 1980, the construction of Liard Highway No. 7 allowed access from the southeast from Lindberg Landing near Blackstone, and a new winter route, shortened by over 100 km, was used for mine construction. The project owner, Canadian Zinc Corporation (CZN), acquired new mine operating permits in 2013, including new permits for the same winter route, but with some re-alignments.

In 2015, thirty-five years after construction of the existing winter road, climate change, as well as environmental and operational factors, have made a strong case for CZN to consider an all-season road to access the Mine, essentially following the winter road alignment. The all-season road will cross terrain that includes discontinuous permafrost and karst, with the potential occurrence of thermokarst, sinkholes, debris flows and thaw slumps, as well as rock fall, rock slides, and snow avalanches in mountain terrain. Some 85 km of the road passes through the Nahanni National Park Reserve (NNPR).

Tetra Tech EBA was requested by CZN to evaluate the terrain along the proposed all-season route, including analysis of historical stereo aerial photos, review of geology and surficial geology mapping, review of recent high-resolution orthophotography and contour data derived from LiDAR, previous geotechnical and terrain analysis reports for the route and its predecessors, and other terrain and geotechnical reports from the region. Key aspects of the study included the evaluation of likely contributing factors of existing natural and/or anthropogenic slope instabilities in rock and soils as related to the surrounding terrain and/or permafrost, consideration of ground instabilities in karst terrain including sinkholes; and ground-truthing in the form of geotechnical field investigation and laboratory testing for selected portions of the route. Goals of the Tetra Tech EBA's work included providing baseline information on terrain, geology, soils, and permafrost to land managers, stakeholders, and environmental reviewers, including First Nations organizations and communities represented by Dehcho First Nations, Liidlii Kue First Nation, and Naha Dehe Dene Band, as well as providing a basis for the suitable design and construction of an all-season road.

Though most of the route has the potential for permafrost, not all of it is thaw-sensitive. Tetra Tech EBA estimated that about 73 km likely has at least some thaw-sensitive permafrost, and another 24 km may also have thaw-sensitive permafrost, but slope aspect or elevation makes it slightly less likely. Based on a qualitative risk assessment, Tetra Tech EBA estimated that about 7.2 km of the terrain along the proposed all-season route represents a high risk to the road route with respect to slope instabilities or other ground movements (by thawing, sliding, flowing, falling, settling or collapsing), and 54.9 km represents a moderate risk, out of a total of 174.1 km evaluated. The Liard River crossing has a high risk with respect to flooding, and 20.65 km of the route has a moderate risk. Other moderate risks include 4.3 km of the route for overland flow, 29.6 km for seismic activity, and 17.8 km for avalanche activity. Since there is considerable overlap in the moderate risk designations, a total of 76.7 km was estimated to represent a moderate risk to the road, and 7.4 km was estimated to represent a high risk to the road. Where road design and construction mitigations are insufficient to adequately reduce the risk, there are management methods to help further reduce the risk and, in high risk zones, there are also specific contingencies to help manage the risk. Many of the same areas of risk introduced by terrain are also potentially more affected by road development than the lower-risk sections of the road, and so it is anticipated that the proposed mitigations will help protect both the terrain and the road. Road sections KP048.8 to KP050.8, KP053.7 to KP054.6, KP055.8 to KP059.9, and KP115.7 to KP115.9 will need particular attention during detailed design.

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APPENDICES

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Appendix C Station-by-Station Summary of Field Observations
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DEFINITIONS

Active layer	The upper layer of soil that thaws and freezes every year. Does not always extend to the permafrost table in discontinuous permafrost. Active layer thickness depends on average air temperature, type of soil (coarse- or fine-grained), thickness of peat at ground surface, slope aspect, vegetation, etc.
Detachment slide	A type of slope failure that happens when the active layer detaches from the permafrost and slides downslope. Such slides can result from high air temperatures, rainfall events, rapid snowmelt, or surface disturbances.
Discontinuous permafrost	Permafrost that has unfrozen zones around or in it.
Frost-stable	Soils that do not settle or heave when subjected to thawing or freezing. Granular soils like sand or gravel are frost-stable if they have less than 10% silt and clay.
Frost-susceptible	Soils that will settle or heave when subjected to thawing or freezing. Silts are highly frost-susceptible, clays are also frost-susceptible but less so than silts. Sands and gravels can be frost-susceptible if they have more than 10% silt and clay.
Headscarp	The exposed soil face at the upper edge of a slope failure, often near-vertical.
Ice-rich	Permafrost that is more than 100% saturated and/or has visible ice will lose its strength and settle or flow if it thaws. Fine-grained soils are usually more likely to be ice-rich. Ice-rich soils, even if they stay frozen, can creep and deform under very small loads. See also thaw-sensitive.
Karst	Karst topography is landscape formed from the dissolution of soluble rocks, primarily limestone and dolomite in this region. Features include sinkholes, caves, towers, arches, canyons, pavements, corridors, springs and sinking streams.
Patterned ground	Geometric patterns at ground surface, including circles, polygons, and stripes that show the sorting of fine-grained or coarse-grained soils and/or the presence of ice wedges in the soil.
Permafrost	Ground (soil or rock and including ice or organic material) that remains at or below 0°C for at least two consecutive years.
Permafrost table	Top of the permafrost.
Polje	A karst terrain feature with a flat bottom and steep walls, and no obvious outflowing surface stream, sometimes water-filled forming a lake, and sometimes drained. Polje is another name for a major sinkhole. Poljes can have smaller sinkholes on the bottom that are visible when the water is low.
Retrogressive thaw slump/flow	A type of slope instability triggered by permafrost thaw. Compared to slides, slumps and especially flows tend to happen when the moisture contents are higher in the failed soil. If the headscarp keeps failing and advancing upslope, making the failure larger, then it is a retrogressive failure.
Sinkhole (also known as Doline)	Sinkholes are common in karst terrain. They can result from suffosion (see below), collapsed caves (collapse sinkholes), or when the underlying carbonate bedrock dissolves unevenly and creates dish-shaped depressions (solution sinkholes). Sinkholes can be shaped like bowls, funnels, or cylinders; or they can be irregularly-shaped, depending on the cause. Sinkholes can range in size from 1 m to over 1000 m in diameter or length. Sinkholes often occur in lines or groups, and can be water-filled.
Suffosion	The process by which most sinkholes form. In suffosion, water seepage or flow causes underground leaching, piping, and erosion of soils or rocks, where the eroded material is washed into fissures and joints in the limestone or dolomite bedrock into caves below. The resulting material loss material can cause settlement at ground surface and create conical depressions and sinkholes in the landscape. Suffosion sinkholes can be only 1-5 m across, but suffosion can also enlarge other sinkhole types.
Talik	Layer of unfrozen soil, sometimes between the active layer and the permafrost, and sometimes under or beside a water body (river or lake). Taliks can include other unfrozen zones between patches or zones of permafrost in discontinuous permafrost.
Thaw-sensitive	Soil, often fine-grained, permafrost that has an ice content high enough that it will lose its strength and settle significantly or even flow if it thaws. Seasonally-frozen materials can also be thaw-sensitive if they have a high enough moisture content. See also ice-rich.

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. (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. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

1.1 General

Canadian Zinc Corporation (CZN) owns the Prairie Creek Mine which is located northwest of Nahanni Butte and is surrounded by the Nahanni National Park Reserve (NNPR) in the Northwest Territories. Access to the Mine property is currently authorized via a winter road route, which CZN is proposing to upgrade to an all-season access road. CZN is working through the regulatory process for the proposed all-season access road.

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by CZN to investigate, characterize and document the anticipated subsurface conditions along the proposed Prairie Creek all-season route in order to support the regulatory submissions for the all-season access road. The focus of Tetra Tech EBA's work was to address geotechnical engineering-related questions in the final Terms of Reference (TOR) prepared for CZN by the Mackenzie Valley Environmental Impact Review Board (MVEIRB). Questions relating to permafrost were of particular interest, although slope stability and karst terrain were also identified by CZN and/or Allnorth Consultants Ltd. (Allnorth) as items for assessment. Existing environment and baseline conditions, effects of the environment on the route, immediate and cumulative effects of the road on the environment were considered. Climate change was also considered. This assessment of potential impacts is to be incorporated by CZN into its Developer's Assessment Report (DAR) for the proposed all-season road.

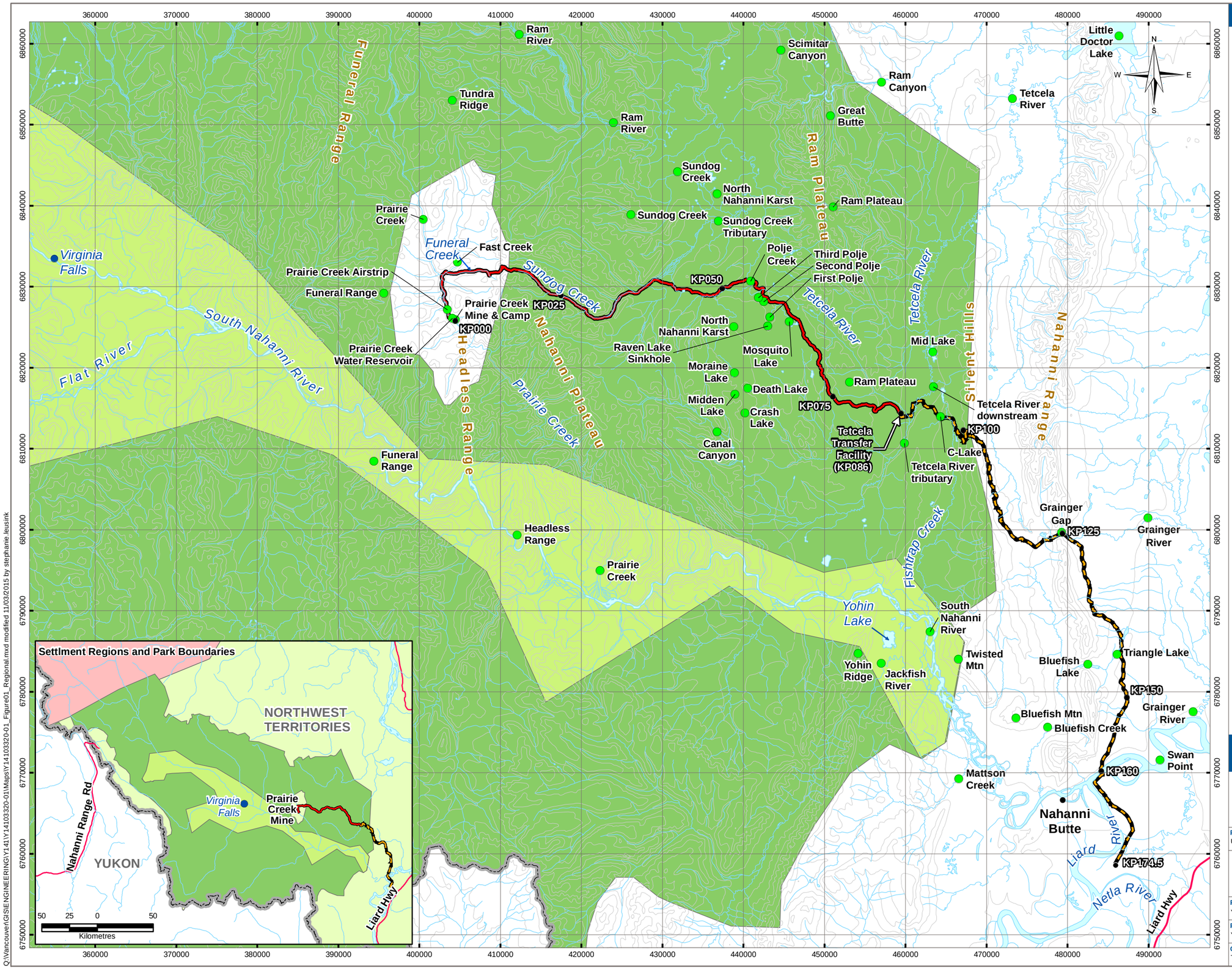
The work was authorized by Mr. Alan Taylor, VP Exploration, Chief Operating Officer, of Canadian Zinc Corporation (CZN), by email on September 15, 2014, with a Change Order transmitted via email on December 1, 2014. The workscope and project requirements were coordinated by Mr. David Harpley, VP Environment & Permitting Affairs, of CZN.

1.2 Background and Regulatory History

The Project consists of the proposed all-season road to the Prairie Creek Mine. The Prairie Creek Mine is located at approximately 61° 33' N and 124° 48' W, adjacent to Prairie Creek, which flows into the South Nahanni River approximately 43 km downstream of the Prairie Creek Mine, and upstream of Nahanni Butte, NT, the nearest community to the Project (Figure 1). The following paragraphs provide some background and regulatory history about the road.

The Mine received Land Use Permits (LUP's) in 1980 and a Water Licence in 1982 for mine and winter road construction and operations. The existing winter access road from the Liard Highway to the Prairie Creek Mine was constructed in 1980 and operated for two winter seasons carrying over 800 loads into the Mine site. The Mine was nearly complete, including an operational winter road to the Liard Highway, when it was placed on 'care and maintenance' due to unfavourable market conditions. Canadian Zinc Corporation (CZN) acquired the Prairie Creek Mine property in 1991 and acquired commercial operating permits in 2013.

Since 1991, CZN has further developed the mineral resource, and completed various studies to support applications to the Mackenzie Valley Land and Water Board (MVLWB) for a Type "A" Water Licence and LUP's to reactivate the Mine and to build two transfer facilities. CZN already held LUP MV2003F0028 to operate the winter access road. MVLWB referred the Mine project, including construction and operation of the winter access road, to the MVEIRB for environmental assessment (EA0809-002). On December 8, 2011, the MVEIRB issued their Report of Environmental Assessment (REA). The MVEIRB concluded that the proposed development, as described in the REA and including CZN's commitments, is not likely to have any significant adverse impacts on the environment or to be a cause for significant public concern.



LEGEND

- Landmark

Proposed All-Season Road

- Phase 1
- Phase 2
- Existing Road
- Contour (200 m)
- Watercourse
- Waterbody
- Previous Nahanni National Park Reserve Boundary
- Current Nahanni National Park Reserve Boundary
- Deh Cho Settlement Region
- Sahtu Settlment Region
- Yukon / NWT Border

NOTES
Base data source:
NTS 1:250,000
Canadian Zinc

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Project Location

PROJECTION UTM Zone 10		**DATUM** NAD83		**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:450,000 (5 2.5 0 5 Kilometres)				TETRA TECH EBA
FILE NO. Y14103320-01_Figure01_Regional.mxd				
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 11, 2015			**Figure 1**

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The file was returned to the Mackenzie Valley Land and Water Board (MVLWB) and mine operations permits were subsequently issued, including Water Licence MV2008L2-0002 issued on September 24, 2013. Since changes were made to the winter access road alignment during the EA, CZN applied for and received new access road Land Use Permits (LUP's) and Water Licences from both the MVLWB (MV2012F0007, MV2012L1-0005) and Parks Canada (Parks2012-L001, Parks2012-W001).

In the previous environmental assessment (EA0809-002), CZN received approval for winter road access to the Mine. CZN is now proposing to upgrade the winter road to an all-season road. The length of the access road from the Mine to the existing Nahanni Butte Access Road, located on the south side of the Liard River, is 174.5 km. Approximately 85 km of the proposed all-season road crosses the Nahanni National Park Reserve (NNPR). The proposed all-season road follows the overall winter road alignment assessed and approved during the EA0809-02 review process. Some realignments are proposed, designed to mitigate geotechnical and logistical issues for all-season use. CZN has proposed to complete the access road upgrade in two phases. A summary of these two phases, as they have been described to date, is presented in Section 2.0 of this report.

1.3 Report Organization

This report has been organized in separate sections reflecting the organization of the DAR. Tetra Tech EBA has provided content herein for specific sections of the DAR to be prepared by CZN as part of their submission requirements to MVEIRB, specifically: terrain, geology, soils, and permafrost, identifying relevant features along the proposed route, based on the review of available aerial photography, oblique photographs taken from the helicopter, and ground-truthing data, for the following DAR sections:

- Existing environment and baseline conditions: Conditions as noted on the aerial coverage and/or from the field and laboratory work (Section 4.1.2 of proposed Table of Contents (TOC), corresponding to Section 5.1.1 of the TOR);
- Effects assessment – accidents and malfunctions (TOC Sections 9.4 and 9.5, TOR Section 7.2.2 Items 7-9): contributions to this section to include commentary on how the environment may contribute to potential accidents, malfunctions and spills with respect to terrain-related aspects; risk assessment including hazards, consequences and risks, and site-specific contingencies for high-risk zones.
- Effects assessment – other (TOC Section 11.1, TOR Section 7.3.1): consideration of the affects that the proposed road might be expected to have on the terrain, geology, soils and permafrost along the route, including karst and slope stability. Possible mitigations that could be implemented; and
- Cumulative assessment (TOC 14.4, TOR Section 7.3.1 - as for effects assessment, in relation to other existing or proposed projects in the vicinity of the proposed all-season road.

The various report sections present the assessment of the potential effects of the Project on the terrain, geology, soils and permafrost and, conversely, of the effects of the terrain, geology, soils and permafrost on the Project.

2.0 PROJECT DESCRIPTION

2.1 Project Roles

CZN is the project owner and provided direction as to the primary areas of interest to be investigated by Tetra Tech EBA. Allnorth is CZN's road consultant for the Project. Based on the findings of the various field programs carried out in 2014, Allnorth developed some further realignments of the proposed route, with the current alignment intended to be within about +/- 50 m of the finished route. As well, Allnorth investigated stream crossings and structures, investigated borrow sources, prepared a general road construction approach and methodology,

prepared general design concepts, and estimated construction earthworks requirements and volumes. Tetra Tech EBA provided geotechnical consulting engineering services to the Project. Tetra Tech EBA accompanied Allnorth in the field to investigate several areas of interest to the Project, and provided further route evaluation and commentary to Allnorth as the route alignment evolved after completion of the field work.

2.2 Summary of Development Phases

The all-season access road project is divided into two development phases (Table 2.2-1). The phased approach to construction includes clearing of the right-of-way (ROW), including some existing sections of winter road that were developed in 1980, as well as some approved, but not yet developed, sections of the winter road route. Based on the findings of the various field programs carried out in 2014, Allnorth has developed some further realignments of the route. It is Tetra Tech EBA's understanding that the current alignment is intended to be within about +/- 50 m of the finished route. We anticipate that some further refining and optimization of the route may be done during detailed design and when the road is actually laid out on the ground. Locations for the observations documented in this report have been recorded corresponding to kilometre post stations, to the approximate nearest 100 m. For example, an observation may be reported at KP122.5, or between KP24.3 and KP28.3. It is noted that because the road alignment is a living document, some of these stations have changed somewhat since the observations were made. For example, one recent change on the Silent Hills switchbacks alignment has resulted in a road length difference of about 300 m from the previous version. However, sufficient description is provided for each observation so that the location can be retrieved using visual landmarks even if the stations are no longer exact.

It is understood from CZN that the route will initially be developed as a winter road to support mine construction and initial operations. The winter road cleared ROW is understood to be up to 20 m wide. The all-season road cleared ROW will be about 30 m wide. Further information about proposed R-O-W clearing and variations in clearing widths are provided in Section 2.4 below. The running surface width of the proposed single-lane road is understood to be generally 5 m wide, with up to three turnouts proposed per kilometre to allow opposing traffic to pass. Actual road embankment footprint width will depend on fill thickness and side-slope gradients. The following proposed Project development phases are proposed by CZN and Allnorth.

Table 2.2-1: Summary of Project Development Phases

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All-Season Access Road Assessment
PHASE 1			
Clearing the road alignment (average 20 m wide ROW) from the Mine to KP086, currently approved under existing Land Use and Water Licences	KP000-KP086	September to January, Year 1 of mine construction	*No. Currently approved.*
Clearing a 4 km long, average 20 m wide ROW along road alignment different from existing winter route	KP024.5-KP028.5	Summer/fall construction, Year 2 or 3 of mine operation	Yes
Construction of an 86 km long all-season road with 5 m wide running surface from the Prairie Creek Mine to the Tetcela Transfer Facility.	KP000-KP086	Summer/fall/winter construction, Year 2 or 3 of mine construction	Yes

Table 2.2-1: Summary of Project Development Phases

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All-Season Access Road Assessment
Clearing and excavation of 31 borrow pits (up to 13.31 ha) and access roads (up to 0.80 ha)	As shown in DAR	Clearing September to January, summer/fall or winter construction, Year 2 or 3, up to Year 5.	Yes
Construction of an expanded Tetcela Transfer Facility (2.0 ha additional compared to approval with winter road)	KP085.8-KP086	Summer/fall or winter construction, Year 2 or 3 of mine construction	Yes
Construction/operation of temporary construction support infrastructure (camps, laydowns, staging, fuel storage; 3.69 ha)	As shown in DAR	Summer/fall or winter construction, Year 2 or 3, up to Year 5 for temporary, life of mine for permanent.	*No. Currently approved.*
Operation and maintenance of the road and facilities	KP000-KP086	~14-year mine life, plus 6-year closure	Yes
PHASE 2			
Clearing the winter road alignment (average 20 m wide ROW) from KP086 to the Nahanni Butte Access Road, currently approved as a winter road under existing Land Use and Water Licenses	KP086-KP174.5	September to January, Year 1 of mine construction	*No. Currently approved.*
Clearing the road alignment (20 m wide ROW) for a 4 km long, 5 m wide running surface different from the existing winter road route.	KP090.5-KP094.5	Winter clearing, tentatively Year 5 of mine operation	Yes
Clearing a 1 km long, 20 m wide ROW along all-season road alignment different from the approved existing winter road route	KP 122.5-KP123.5	Winter clearing, tentatively Year 5 of mine operation	Yes
Construction of an 88.5 km long all-season road with 5 m wide running surface from the Tetcela Transfer Facility to Nahanni Butte Access Road.	KP 86 - KP174.5	Combination of summer/fall and winter construction, tentatively Year 5 of mine operation	Yes
Clearing and excavation of approximately 18 borrow sources (26.15 ha) and access to the borrow sources (3.86 ha)	Locations as identified in the DAR	Clearing September to January. Combination of summer/fall and winter construction, commencing in Year 2 or 3 and tentatively extending to Year 5 of mine operation	Yes
Construction/operation of temporary construction support infrastructure (camps, laydowns, staging, fuel storage; 3.69 ha)	As shown in DAR	Summer/fall or winter construction, Year 2 or 3, up to Year 5 for temporary, life of mine for permanent.	*No. Currently approved.*
Construction of landing areas and operation of a barge crossing of the Liard River	KP160	~14 year mine life, plus 6 year closure	Yes

Table 2.2-1: Summary of Project Development Phases

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All-Season Access Road Assessment
Operation and maintenance of the road and facilities	KP086-KP184.5	~14 year mine life, plus 6 year closure	Yes
Construction and operation of the Liard River winter crossing	KP160	~14 year mine life, plus 6 year closure	*No. Currently approved.*
AIRSTRIP*			
Clearing to accommodate a 1 km long x 50 m wide airstrip	KP055	Winter clearing, ~14 year mine life, plus 6 year closure	Yes
Construction, operation, and maintenance of the airstrip	KP055	~14 year mine life, plus 6 year closure	Yes
COMBINED DEVELOPMENTS			
Closure and reclamation	KP000-174.5 and airstrip	~ 6 years after mine closure (2029-2036)	Yes

Tetra Tech EBA understands that construction will be timed to take place during the most appropriate season(s) for each road section.

2.3 Road Alignment

During EA0809-002, the route was optimized to reduce environmental and logistical risks. Four reroutes were included in the revised route:

- Polje By-Pass, within the expanded Nahanni National Park Reserve (NNPR);
- Silent Hills reroute, within the expanded NNPR;
- Wolverine-Grainger Gap reroute; and,
- Nahanni Front Range reroute.

These rerouted sections were addressed by the positive MVEIRB EA decision in 2012 of the overall route as a winter road, acknowledging that minor changes in the route could be anticipated (MV2012F0007). An updated version of the route for the purpose of an all-season road was presented to MVEIRB in April 2014 (CZN, 2014). Current route designations begin with KP000 at the mine site and about KP160 at the Liard River. From the river, the all-season road follows the old Nahanni Logging Road, meeting the Nahanni Butte Access Road at KP174.5 (Figure 1). Kilometre posts used in the field have been updated to the post-fieldwork stations, as shown on each of the figures and presented on Allnorth's website. We note that there may be minor differences in the stations noted by each party, as each minor change in the route affects the stations further along the route in an iterative design process. However, these stations are generally within 100 m of each other, close enough to reasonably conclusively determine the location under discussion. As mentioned above, kilometre posts are also generally associated with landmarks.

In addition to applying for all-season road use from the Mine to the TTF (Phase 1), CZN also applied for all-season road use from the TTF to the Liard Highway (Phase 2), which when combined represents the entire road. This will enable the year-round transport of concentrates and consumables.

The first 40 km of road between the Mine (KP000) to just beyond Cat Camp (KP039) is located at the northwestern end of the road, traversing a series of steep mountain valleys and a high mountain pass (1525 m elevation). Cadillac Explorations Ltd.'s road LUP (1980) provided for all-season use of this section. The road follows mainly the existing winter road alignment between KP000 and KP033.1. A few sections were flagged for further investigation by either Tetra Tech EBA or Allnorth, and a 5 km section was considered for realignment (current realignment from about KP024.3 to KP028.3). Of the remaining 151 km to the Liard Highway, several sections have been rerouted for winter use compared to the 1980 winter route, and will be retained for all-season use. Some of the rerouted sections are intended to avoid challenging terrain, including ice-rich permafrost or intense karst terrain associated with sinkholes and slope stability issues, and one long section at the southeast (Nahanni Butte) end avoids wetland terrain along the Grainger River. Although initial road use for early mine operations would be winter-only, using existing permits, CZN wishes to obtain new permits to allow phased construction, and use of, an all-season road.

Phase 1 includes upgrading of the western portion of the road for all-season use to allow the mineral concentrates to be transported to the TTF year-round. Phase 2 would include upgrading of the eastern portion of the road for all-season use from the TTF to the Liard Transfer Facility.

It is understood that the Nahanni Butte Access Road (KP174.5 to KP184.5) portion may require improvements, including additional gravel, to be carried out by the appropriate organization.

The following sections summarize information provided by CZN and Allnorth regarding proposed road design and construction methods (Allnorth 2015).

2.4 Right-of-Way Clearing

It is understood that CZN intends to complete construction of the Mine using the winter road, and use that road for the first few years of operation. The majority of the winter road ROW (up to 20 m wide) is proposed to be cleared during winter road construction in the first years of mine construction and operations, as shown in Table 2.2-1 above.

For the all-season road, additional clearing would be carried out at a later date. A total typical clearing width of up to about 30 m is proposed depending on vegetation cover, road geometry, side slopes (cut/fill), and environmental restrictions. In relatively flat floodplains, Allnorth anticipates that a smaller clearing width may be needed, but in areas with steep side slopes, a ROW width of up to 40 m may be needed. If viable, mature merchantable timber will be removed and hauled to the nearest market destination(s). However, as this location is remote with very limited market demand, Allnorth references British Columbia Ministry of Forests, Lands and Natural Resource Operations (BCMF 2013) for typical methods to dispose of materials that will not be used in the road embankment. Tetra Tech EBA notes that these methods will need to be chosen or modified according to local conditions along the route.

Allnorth indicates that for embankment fill-only construction (in areas with thaw-sensitive permafrost), a slightly narrower ROW clearing width may be possible, depending on side-slope and fillslope gradients. The organic surface layer, generally peat, would not be disturbed (no stripping), and appropriately-sized ROW timber may be reserved for use in the road prism, as further discussed below in Section 2.5.

Allnorth notes that, when required, burning is to be conducted in accordance with local and NWT regulations. Slash and non-merchantable timber is proposed to be piled within the ROW or other designated disturbed area (such as

a borrow area) during the construction phase. Burn piles will be located in areas not at risk for permafrost degradation. If burning is conducted, it will be done in a manner that mitigates potential fire risk.

2.5 Road Design and Construction

This summary of road embankment design and construction is as provided in Allnorth's report (Allnorth 2015), except as otherwise noted. The proposed width of the all-season road surface is understood to be generally 5 m for a single lane and 8 m wide at turnouts for passing. Allnorth proposes two short sections between about KP025.2 and KP025.6, and KP028.0 and KP028.4 at 4 m width to reduce cost and environmental footprint. Turnouts would be spaced at up to three turnouts per kilometre. Each turnout is proposed to be about 30 m long.

Allnorth has proposed two main construction techniques: conventional road construction in locations where there is little likelihood of the presence of thaw-sensitive permafrost, and embankment fill-only (overlanding) techniques for crossing thaw-sensitive permafrost terrain, with or without existing thermokarst. Allnorth references British Columbia Ministry of Forests, Lands and Natural Resource Operations (BCMF 2013) for typical methods of road construction.

For conventional road sections in areas not located within thaw-sensitive permafrost, Allnorth proposes that soils, organics and woody debris such as limbs and stumps that are not suitable in the road subgrade be stripped and stockpiled outside of the road prism as described above in Section 2.4 for clearing of vegetation (BCMF 2013). Tetra Tech EBA understands that such materials may be reused during reclamation, and that stockpiles will be designed with erosion and sedimentation controls.

In conventional road sections, Allnorth proposes that the subgrade would be constructed using primarily local material, major stream crossing structures would be installed, and ditching and cross drainages installed as required to maintain natural drainage patterns. The placement of suitable granular material [for sub-base and/or base course] would follow. For crossing soft ground, Allnorth indicates that the embankment thickness may need to be increased, and/or a geotextile would be laid first. Some typical cross-sections for conventional construction techniques are provided by Allnorth (BCMF 2013). Tetra Tech EBA notes that these typical cross-sections are generic and the actual cut slope and fill slope gradients will need to be site-specific according to the types of site soils encountered and borrow materials available. Borrow materials and likely corresponding fill slope gradients are further discussed below.

Allnorth proposes embankment fill-only (overland) construction for two construction scenarios: to cross the above-mentioned thaw-sensitive terrain; and, along Sundog Creek (KP033-KP039) where large coarse rock material is to be end-hauled and placed to build up the road grade. Road sections over thaw-sensitive permafrost may be designed with additional subgrade support. Such designs may include geotextiles and/or timber from the ROW placed horizontally in a corduroy style in the road prism. Tetra Tech EBA notes that such methods designed appropriately may help to reduce excessive deformations in the peat and/or creep in the underlying permafrost soils. Corduroy-type designs have received renewed interest in regions with challenging subgrade conditions (de Guzman and Alfaro 2014). For Sundog Creek, primarily between KP033 and KP039, the intent is to build up a platform at the edge of the floodplain and/or channel to form the road subgrade. This platform is to be composed of angular talus. Boulders and blocks would also provide a well-armoured face along the channel where needed for erosion protection.

Allnorth has indicated that there may be a few sections where cuts may be unavoidable in thaw-sensitive permafrost terrain, due to side-slope gradients. If this occurs, the cut slope configuration and mitigations implemented will be tailored to the specific site conditions. Tetra Tech EBA has emphasized that cut slopes in thaw-sensitive permafrost can be expected to result in a long-term requirement for vigilance and higher maintenance to avoid problems, even

when mitigations are implemented, so it is best to avoid cuts if at all possible (personal communication: E.Kragt, R.Kors-Olthof; March 5, 2015).

Tetra Tech EBA understands that the road subgrade is intended to be built with locally-available borrow materials whenever possible to reduce hauling requirements. Allnorth notes that granular material for road construction will be sought from a number of local sources to minimize hauling distances. Investigations will be undertaken to confirm and further define suitable sources. A portable crusher may also be utilized to produce gravel-sized material for use in the road. Allnorth further notes that coarse granular materials are not available in all sections of the road, and it is anticipated that some sections of the road will require the use of suitable local materials (including sand or sand/silt mixtures) to build the subgrade, then topped with imported coarser materials from elsewhere along the road. Tetra Tech EBA notes that some road sections, particularly those in thaw-sensitive permafrost terrain, may also require importing fill from elsewhere on the route even for the subgrade, and this will need to be determined on a site-by-site basis.

In general, Tetra Tech EBA anticipates that embankment side-slopes are likely to be sloped at about two horizontal to one vertical units (2H:1V) for coarse well-graded granular fill. Steeper fills may be possible with suitable material such as coarse angular rock carefully placed to interlock, and crushed rock. Fill slopes in blast rock could be as steep as 1.5H:1V to 1H:1V, depending on the angularity of the rock and whether the rock particles tend to be flat and elongated, or equidimensional. Equidimensional particles interlock better and therefore can stand reliably at steeper angles than flat/elongated particles. These anticipated fill slope angles are based on the assumption that the natural subgrade does not require flatter fill slopes for slope stability reasons, and so should be considered on a site-specific basis. Flatter fill slope gradients may also be required for finer-grained borrow materials such as sands, or sand-silt mixtures. Allnorth proposes a cover layer of coarser-grained material to protect large fills composed of the finer-grained materials against erosion.

Allnorth notes that larger watercourses will be crossed by span-crossing structures (bridges). Some of these have already been proposed for the winter road. Smaller watercourses, and areas where runoff would pond upslope of the road, would be addressed by closed or open-bottom culverts on a case-by-case basis, as required.

2.6 Borrow Sources

Tetra Tech EBA understands that borrow materials for road construction will be obtained from multiple local sources located within or in close proximity to the all-season road right-of way. Approximately 49 preferred borrow sources have been identified by Allnorth for use during the construction phase, and some 25 additional borrow sources have been identified as possible backup sources, targeting granular borrow sources where available. Allnorth has categorized each borrow site by the type of material available and its construction application. The borrow sites will be utilized for three construction applications; Subgrade Borrow Supply, Surfacing Aggregate Supply, and Rock Quarry Supply (includes riprap). Possible sources for winter sand are also noted (Allnorth 2015). Allnorth notes that borrow source development needed for construction of the all-season road will conform with Aboriginal Affairs and Northern Development Canada (AANDC)'s Northern Land Use Guidelines – Pits and Quarries (INAC 2010a).

3.0 SCOPE OF WORK

Tetra Tech EBA has carried out the following tasks:

- Conducted a review of relevant available information to characterize anticipated subsurface conditions along the proposed route;
- Prepared preliminary field maps for areas with insufficient terrain information to be verified by ground-proofing, and to optimize reconnaissance priorities in the field. Allnorth provided base field maps for this task;

- Observed targeted road sections and obtained geo-referenced photos of site features;
- Excavated test holes using hand tools at selected locations to verify shallow soil and permafrost characteristics in mapped terrain areas;
- Installed a temporary ground temperature cable in one test hole;
- Performed laboratory testing of samples collected during the site investigation for purposes of soil classification and determination of relevant engineering properties;
- Verified terrain mapping with field observations and laboratory results;
- Prepared a stand-alone geotechnical evaluation report to be included as an appendix to the DAR to describe the findings of the site investigation as it relates to the road and to permafrost- or stability-related aspects of specific borrow sources, and to address MVEIRB's TOR (currently in the form of this Issued-for-Review report);
- Prepared the applicable sections of the DAR within the standalone report such that they can excerpted and included in the DAR to be submitted by CZN to MVEIRB; and
- Worked with Allnorth's road design team to review and discuss various road sections in an iterative process to optimize proposed route realignments, develop design and construction parameters, and reduce geotechnical engineering-related risks.

4.0 METHODOLOGY

4.1 Review

Prior to mobilizing to the subject site, Tetra Tech EBA conducted a review of available information for the proposed road alignment. Since virtually all previous work was geared towards a winter road alignment, the review included additional review of existing aerial photos, orthoimagery, and Light Detection and Ranging (LiDAR) data, along with the preparation of preliminary field maps (map-books) to guide the onsite evaluation of the all-season road alignment. Allnorth assisted us with the preparation of map-books for use in the field. In addition to checking specific road sections to be rerouted, the primary objective of the review was to identify areas which might require specific focus during the field investigation and to locate suitable locations for potential test holes to be advanced.

Additional information obtained from CZN and Allnorth in advance of the field work included the 1994 aerial photos of the existing winter route, terrain mapping, site reconnaissance reports, previous geotechnical evaluation reports, as well as the proposed road route with route alternatives in some sections. A complete list of information sources is listed in the References at the end of this report.

Further review was carried out after the field work, to correlate the field observations with the anticipated conditions. Tetra Tech EBA contacted Mr. Lynden Penner, P.Eng., of J.D. Mollard & Associates (2010) Ltd. (JDMA) to attempt to locate their mapping and mosaics from 1995. No mosaics or mapping were found, although we had previously noted occasional markings on the aerial photos provided by CZN related to JDMA's 1995 winter route review. Mr. Penner did locate some notations on 1:250,000 scale maps, originally from Dr. Wayne Savigny, of BGC Engineering, and received by Tetra Tech EBA on October 1, 2014. Areas with gaps in aerial coverage along the all-season alignment could not be mapped directly, so, where necessary, Google Earth (2014) or Bing (2014) imagery was used for reference. Existing surficial geology mapping was also referenced where available along the route (Hawes, 1975). A complete list of information sources is listed in the references at the end of this report.

4.2 Site Evaluation

4.2.1 Ground-Truthing

Tetra Tech EBA carried out a ground-truthing program from September 21 through 26, 2014. Tetra Tech EBA's onsite representative was Rita I. Kors-Olthof, P.Eng., P.E. The ground-truthing program was helicopter-assisted.

Tetra Tech EBA was accompanied on site by a representative of Allnorth, Mr. Ernest Kragt or Mr. Brian Mitchell. Onsite coordination with Allnorth enabled the project team to identify potential problem areas while still on site, as well as to improve the efficiency of data acquisition and recording. Tetra Tech EBA geo-referenced points of interest using GPS coordinates. It is noted that GPS accuracy can be limited by vegetation and terrain obstructions. Where possible, Tetra Tech EBA also tied in points of interest to local landmarks or features.

Priority for site evaluation was given to road segments with one or more of the following conditions:

- Anticipated permafrost areas, particularly those considered likely to be ice-rich;
- Slopes in suspected ice-rich permafrost areas;
- Slopes that currently exhibit signs of instability or that are affected by debris flow activity;
- Areas requiring large cuts or fills; and
- Realignment areas lacking ground-truthing data.

Tetra Tech EBA's focus was to identify and target potential trouble spots, and otherwise to obtain a general overview of geotechnical conditions along the proposed road alignment. While the above-mentioned review identified in advance most of the areas that should be visited, Tetra Tech EBA was also able to identify and evaluate some additional challenging terrain features or issues along the proposed road route(s) during the course of the field work. When potential trouble spots were identified, the project team worked on route changes to avoid those areas whenever possible and, where such areas were unavoidable, to find design and construction solutions that would mitigate the possible issues.

In the targeted areas of interest that were visited, Tetra Tech EBA noted relevant terrain features, the presence of patterned ground, surface water drainage features, vegetation, as well as exposed soils, tension cracks and other signs of slope instability. Where no local topographic information was available, Tetra Tech EBA also measured sideslope gradients.

Tetra Tech EBA obtained near-surface soil samples with hand tools in order to verify the available terrain mapping as well as other terrain features that were identified in the field. Tools used include a pick and shovel, as well as an Edelman-type hand auger. In addition to excavating test pits and drilling boreholes, exposed soil at natural slopes and slope instabilities were sampled where encountered, and where they could be safely accessed. Slope failure headscarps of up to 2.25 m in height were sampled, with an additional 0.25 to 0.30 m obtained by drilling until refusal on frozen soils. In ground undisturbed by either slope instability or human influences, sampling to depths of up to 1.25 m could be achieved using the hand auger, sometimes meeting refusal before that depth on frozen soils or granular material. During the course of the site work in September 2014, Tetra Tech EBA logged 40 test pits, test holes and/or slope failure headscarps along the route, and we understand that Allnorth has also excavated numerous shallow test holes along the route and in proposed borrow areas. The 40 test holes logged by Tetra Tech EBA, and four test holes sampled by Allnorth on behalf of Tetra Tech EBA, are located as shown in the figures presented in Section 5 for each ground-truthing location. Borehole and test hole logs are presented in Appendix B,

organized by road sections. Relevant borehole logs from SNC-Lavalin Inc. (SLI 2012a) are also included for specific road sections.

Tetra Tech EBA installed one temporary ground temperature cable at TP-14, recovering the cable after completion of measurements.

4.2.2 Road Sections Visited

Tetra Tech EBA visited representative locations along the following proposed road sections in order to characterize the terrain along and adjacent to the proposed road route, as follows:

- **KP024.3 to KP028.3:** The all-season route is proposed to run along the south side of the valley, whereas the winter route is on the north side. Tetra Tech logged five test holes in this section.
- **KP048.8 to KP058.6:** The road is to be re-routed to the north of the winter route. Four shallow boreholes were advanced by SLI at a set of switchbacks between about KP057 and KP057.5 (old KP 57 and 58) in 2012, then designated as the “M switchbacks” (SLI 2012a). EBA logged 10 test holes in the western two-thirds of this section, including two that incorporated observations on exposed soils at the headscarps within the thaw slump/flow at KP054.
- **KP080.3 to KP086:** The north Tetcela re-route leaves the existing winter route at about KP080.3, staying north of the winter route and on higher ground. The Tetcela Transfer Facility is located between KP085.8 and KP086. SLI logged two test holes in this section for the proposed Tetcela Transfer Facility on the winter road (SLI 2012a). Tetra Tech EBA logged three test holes along the proposed reroute.
- **KP086 to KP095:** The south Tetcela re-route, south of existing winter route. The route rejoins the winter road at about KP086.6. Subsequent to the September 2014 field work, this section was subsequently divided into two sections by Allnorth: KP 86.2 to 90.6 (staying on the winter route from Tetcela River up to KP 90.6) and about KP 90.6 to 95 (reroute south to toe of uplands area, skirting around west and south sides of C-Lake and then east to the existing winter alignment). Tetra Tech EBA logged six test holes in this section, including one on the currently proposed route. Allnorth obtained an additional sample after Tetra Tech EBA’s departure from site.
- **KP095.7 to KP101.7:** The road is to be re-routed on the west flank of the Silent Hills, west of Wolverine Pass, for the most part located north of the existing winter route. In 2012, SLI advanced 10 shallow boreholes in this section, designated “Silent Hills Switchbacks” (SLI 2012a). Tetra Tech EBA logged two confirmatory test holes in this section.
- **KP101.7 to KP118.0:** The all-season road is to be located west of the existing winter road and along the east flank of the Silent Hills. Tetra Tech EBA was able to traverse this part of the route in the helicopter. Allnorth obtained three soil samples in this section on behalf of Tetra Tech EBA after our departure from site.
- **KP124.7 to KP159.8:** The road is to be realigned to the west of the existing winter road, and along the toe of the Front Range. Tetra Tech EBA logged 14 test holes along this section.

The remainder of the route between the Liard River crossing and Liard Highway 7 follows the approximate alignment of the Nahanni Logging Road and the Nahanni Butte Access Road. The Nahanni Logging Road portion is from KP160 to KP174.15 and the Nahanni Butte Access Road portion is from KP174.15 to KP184.17. The boreholes advanced by SLI as noted above are the only recent test holes known to Tetra Tech EBA, other than six test holes at Polje Crossing, also by SLI (SLI 2012a). Golder did not advance any testholes along the route during their terrain assessment in September of 2009, and J.D. Mollard and Associates Limited (Mollard)’s work in 1995 was strictly a

desktop study of the winter route. It is not known whether there may be borehole information available from earlier in the history of the road. Tetra Tech EBA's test holes were intended to confirm and augment the information available along the route from previous studies.

4.3 Laboratory Testing

Laboratory testing was carried out in Tetra Tech EBA's Yellowknife and Edmonton geotechnical laboratories to characterize the soils along the route, including soil moisture content, grain size analysis (sieves and hydrometers), and Atterberg limits. Laboratory test results are presented in Appendix B on and following the test hole logs.

4.4 Effects Assessment

The assessment methodology employed to assess potential impacts on the valued components – that is, impacts on existing ground conditions including permafrost, slopes, and karst terrain conform to the impact assessment steps summarized in Section 4.1 of the MVEIRB TOR for the Prairie Creek All-Season road. Consistent with the MVEIRB TOR, the assessment methodology employed includes:

- identify valued components used and how they were determined;
- identify the natural range of background conditions (where historic data are available), and current baseline conditions, and analyze for discernible trends over time in each valued component, where appropriate, in light of the natural or existing variability for each;
- identify potential direct and indirect impacts (consequences) on the valued components that may occur as a result of the proposed development, identifying analytical assumptions;
- identify and evaluate proposed mitigation measures as to their technical and economic feasibility to reduce the predicted impacts and discuss constraints, uncertainties and implementation challenges to the effective use of the proposed measures and clearly identify mitigation commitments;
- predict the likelihood of each impact occurring after the committed-to mitigation measures are implemented, providing a rationale for the confidence held in the prediction. The developer will also present the predictions in a manner that facilitates the formulation of testable questions for future follow-up programs, as well as textually and schematically indicate the pathways of predicted impacts;
- compare the predicted impacts to pre-development conditions or to conditions without the Project as appropriate. Include a description of any plans, strategies or commitments to avoid, reduce or otherwise manage and mitigate the identified potential adverse impacts, with consideration of best management practices in relation to the valued component or development component in question;
- describe techniques such as models utilized in impact prediction including techniques used where uncertainty in impact prediction was identified;
- identify, and provide an opinion on the significance of any residual adverse impacts predicted to remain after any mitigation measures and indicate the methodologies for reaching such conclusions; and
- identify any monitoring, evaluation, and adaptive management plans required to:
    i. detect potential unexpected changes;
    ii. confirm that predictions are accurate; and

iii. proactively manage against developing adverse impacts when they (or unexpected changes) are encountered.

The developer will describe how the predicted impacts are expected to arise from the proposed development, as well as its views on impact significance. This will include describing the mechanisms for cause and effect and providing supporting references (including where Traditional Knowledge was used). Where professional judgment has been used in determining impacts, this must be made clear. The developer will also provide a discussion on the uncertainty involved with each prediction. For each predicted impact, the developer will describe:

- the nature or type of the impact;
- the geographical range of the impact;
- the timing of the impact (including duration, frequency and extent);
- the magnitude of the impact (what degree of change is expected);
- the reversibility of the impact; and
- the likelihood and certainty of the impact.

The criteria described above will be used by the developer as a basis for its opinions on the significance of impacts on the biophysical and human environment.

This assessment of potential effects related to the all-season road addresses the terrain, surficial geology, permafrost and karst issues discussed in this supporting report to the DAR for the Prairie Creek all-season road. The assessment of effects considers magnitude, geographic extent, estimated duration, qualitative frequency of occurrence, reversibility and likelihood of predicted effects.

The following criteria have been used for the significance determination with respect to terrain conditions, as summarized in Table 4.4-1:

- Direction and Magnitude – The degree, extensiveness, or scale to which an activity may affect a valued component. Effects can be negative (adverse) or positive (beneficial) while magnitude may be defined as low, moderate or high, depending on how the particular valued component or group of components are affected;
- Geographic Extent – The geographic location or area where the effect is predicted to occur. The geographic extent may be identified as local (confined to the area of the access road), regional (with respect to Dehcho), or territorial in scale;
- Duration – The length of time that an effect is expected to occur as a result of an activity. Short-term duration is defined as the construction phase (in this case one year for each phase), medium-term duration (up to the end of service life of the road, estimated at 20 years), or long-term duration (extending beyond end of road life);
- Frequency – The predicted rate of occurrence over which an effect may take place. Frequency is defined as low if it occurs once, medium if it occurs intermittently or periodically, or high if it occurs often or continuously;
- Reversibility – Whether the predicted effect(s) can be reversed, or the capacity of the valued component to be restored to pre-development conditions with mine and road closure and reclamation; and
- Likelihood - the likelihood and certainty of an effect.

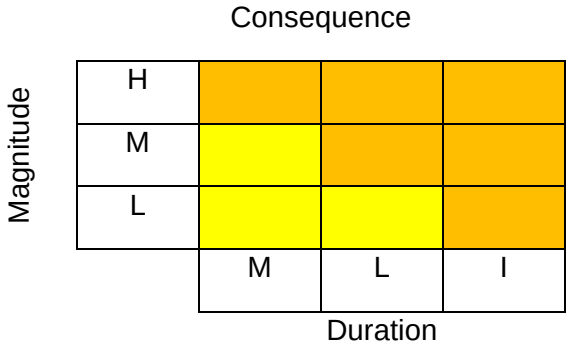
Table 4.4-1: Effects Assessment and Consequence Criteria Associated with the Project

Criterion (of effect)	Low	Moderate	High
Magnitude	Change is slightly above baseline conditions but within likely range of natural variability	Change is measurably above baseline conditions within likely range of natural variability	Change exceeds baseline conditions and causes changes beyond the range of natural variability
Geographic extent	Area of effect does not extend past the footprint of the project	Area of effect extends beyond the project footprint but is not of regional or territorial consequence	Area of effect is likely to extend into the region or be of territorial consequence
Duration	Effect is only evident during the construction or startup phase	Effect occurs or lasts for the service life / operational phase of the road	Effect extends beyond the operational life of the road
Frequency	Factors causing the effect occur infrequently (i.e. may or may not occur during the Project life)	Factors causing the effect occur at irregular intervals and infrequently (i.e. could occur two or more times during the Project life)	Factors causing the effects may occur regularly and/or frequently (i.e. could occur annually or as a result of high precipitation)
Reversibility	Effect can be reversed during the Project life	Effect can be reversed within 100 years	Effect is not reversible even after road closure, reclamation and regrowth
Likelihood	Unlikely, but could occur	Could reasonably be expected to occur	Will occur, or is likely to occur
Consequence	Slight decline in condition of the VC* during Project life, likely not noticeable thereafter	Changes in the condition of the VC over baseline that exceed guidelines and/or persist past Project life	Significant long-term or irreversible changes to the condition of the VC

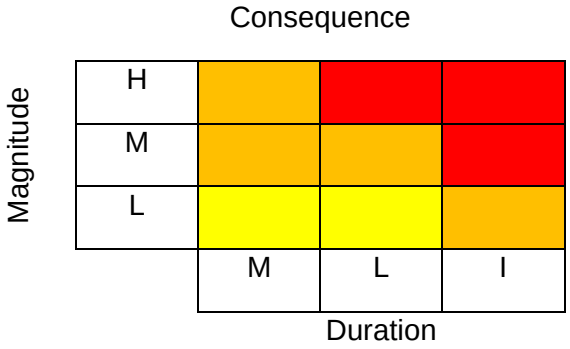
To determine the level of consequence from a residual effect as it is defined in Table 4.4-1 above, the primary factors considered are the magnitude, duration, and location of the effect. In the local area or footprint, the highest consequence rating is moderate, whereas in the regional area, the highest consequence rating is high.

The following schematics summarize the concept of consequence, where magnitude is low (L), moderate (M), or high (H), and durations are short- to medium-term (M), long-term (L), and irreversible (I). Colour-coding is as follows: red indicates “high” consequence, orange is “moderate” and yellow is “low” consequence.

Local Level of Consequence



Regional Level of Consequence



An explanation of the significance of environmental effects based on the criteria outlined in Table 4.4-1 is provided in Table 4.4-2.

Table 4.4-2: Significance Criteria for Environmental Effects Assessment

Overall Significance	**Low**	The effect is expected to be of low significance and further assessment and/or specific management are likely not required.
	Moderate	The effect is expected to be of moderate significance and specific management measures or plans are necessary.
	High	The effect is expected to be of high significance and further study or monitoring is necessary to supplement the baseline data, and to be used for refining a management strategy and plan.

Further discussion specific to the determination of hazards, consequences and risks directly applicable to slope stability and permafrost vulnerability is presented in Section 6 of this report.

4.5 Assessment of Permafrost Impact

The assessment of permafrost is an important part of this study. As noted in the definitions at the beginning of this report, permafrost is defined as ground (soil or rock, and including ice or organic material) that remains at or below 0°C for at least two consecutive years. The differences in permafrost in coarse-grained soils compared to fine-grained soils typically include the thickness of the active layer, soil moisture contents (frozen and unfrozen), sensitivity to thaw, and the likelihood or rate of soil creep.

Not all permafrost is a concern to the successful construction and operation of an all-season road. The type of permafrost that is of most concern is permafrost that is thaw-sensitive and/or ice-rich. For example, fine-grained soils that contain visible ice or are more than 100% saturated are considered thaw-sensitive. Such soils could lose most or all of their strength if thawed, and this could lead to potential instability and/or intolerable settlement. Ice-rich soils, even if they do not thaw, can also be prone to creep deformation under very small loads. This can potentially lead to the movement of road embankments on even very flat cross-slopes, due only to the weight of the fill as the ice-rich soil beneath creeps and spreads outward away from under the embankment.

As noted, bedrock can also be classified as permafrost. Usually, bedrock is not ice-rich, so if it thaws, it would remain stable, and so would not be cause for concern. Similarly, dense granular soils that do not contain excess ice would not be considered thaw-sensitive.

4.6 Reporting

Tetra Tech EBA's geotechnical evaluation report summarizes the findings of the information review, the field work, and the laboratory testing, and addresses the applicable sections of the MVEIRB TOR. The report includes sections on climate, permafrost, and climate change considerations as they relate to permafrost at the site, and each road section has a short discussion about the permafrost characteristics in that section of the road. This current version of the report is issued for review, pending receipt of commentary from CZN. The "Issued-for-Use" report will be included as an appendix to the DAR, and specific sections of the report will be incorporated in the main text of the DAR. Tetra Tech EBA requests the opportunity to review the portions of the DAR incorporating any part of our work product.

5.0 EXISTING ENVIRONMENT AND BASELINE CONDITIONS

5.1 Terrain, Geology, Soils and Permafrost

5.1.1 General

Terrain, geology, soils and permafrost are diverse over the length of the proposed all-season road, with numerous and varied terrain units encountered along the route. These features are summarized in the following report sections on the basis of existing information, supplemented with the ground-truthing work carried out in 2014. The description of features encountered is organized by road section evaluated. Figures are included to show where the 2014 field work was done, as well as related previous field work done by others in road sections where permafrost and/or slope stability is important.

Items relating to permafrost or borrow that are consistent to all of the road sections are described in separate subsections, after the station-by-station discussions. Borrow is discussed further in Section 5.2. Permafrost is discussed further in Section 5.4. Test hole logs are presented by road section in Appendix B, along with the related laboratory test results. A summary of site-specific features along the proposed all-season route is also included in the station-by-station summary of mapping and field observations in Appendix C.

Further discussion of hazards, consequences and risks related to the various features encountered along the road section is presented in Section 7.0.

5.1.2 KP000 to KP024.3

5.1.2.1 General

This section at the western end of the road leads from the Mine along the valley bottoms or low on the steep slopes of the Prairie Creek, Fast Creek, and Funeral Creek drainages, and the upper end of the Sundog Creek drainage. Much of the existing road bed in this section appears to be located on relatively coarse-grained materials. Allnorth reports that, within the road section that could be reached by ATV from the Mine (KP000 to about KP025), about 80% of the road bed was about 3 to 3.5 m wide, with occasional sections up to about 4 m wide or less than about 3 m wide. A few locations were affected by sloughing and will need repairs to restore access.

5.1.2.2 Geology

The route crosses several bedrock units in this section of the route, including cherty shales near the Mine, then heading north along Prairie Creek, dolostones and dolomites of the Cadillac and Arnica Formations, up to Casket Creek at about KP006.2. These formations appear to be dipping out of the slope, creating some increased likelihood of debris on the road should rock slides or falls occur. North of this point, and then heading east along Fast Creek and Funeral Creek to about KP009, there are thinly-bedded argillaceous limestones of the Funeral formation, which appear to be subject to periodic ravelling and failure as indicated by two large scalloped headscarps in sloughing talus above the route between about KP008 and KP008.7. Further east, bedrock mapping on the south slope above the road alternates between exposures of Arnica dolomites (about KP009 to KP011.3, KP012.5 to KP012.8), Funeral limestones (KP009 to KP012.5), Cadillac dolostones (KP012.8 to KP015.3), and Root River dolomites (KP015.3 to KP017.8). The Funeral formation, which is the most prevalent rock type north of Funeral Creek seems also to have an effect on the slope south of the creek, with possible run-up noted between KP010.2 and KP010.6. This possibility is not entirely clear, however, from the available air photos and imagery. Talus between KP011 and KP012 also seems more recent than adjacent areas, suggesting that the Funeral formation is more active in the generation of talus. Beyond KP017.8, limestones and dolostones of the Sunblood formation are mapped. Along the route are also dolomites from the Camsell formation (about KP016.5 to KP024).

5.1.2.3 Surficial Materials and Soils

The primary surficial materials on the slopes in this road section are talus and scree, essentially broken rock from progressive and ongoing failures in the bedrock exposed further upslope. The age of the talus mounds varies in accordance with the frequency of failure, which seems to be correlated with the types of rock as noted above. For instance, sections of the route through the Funeral formation seem to have more recent deposits.

Surficial materials anticipated at the valley bottoms in this section of the route are likely to consist of alluvial deposits, typically cobbly, along the streams, with materials between gravel and boulder size possible along the floodplains which could include glaciofluvial terraces in the areas influenced by the last glaciation. According to Duk-Rodkin et al (2007), the Prairie Creek drainage was not glaciated during the last glaciation. A Cordilleran ice cap was present at the height of land between the Funeral Creek and Sundog Creek drainages, mapped between roughly KP014 and KP020, a glaciation that began about the time that the Laurentide continental ice sheet reached its maximum, about 30,000 years ago. Glaciation is relevant to this section of route in the types of materials that will be encountered beneath the road, terraces available that allow for easy placement of the route, and in opportunities for borrow. Glaciofluvial deposits encountered downstream of about KP014 in the Funeral Creek drainage, or downstream of about KP020 in the Sundog Creek drainage may relate to this glaciation.

In some of the wider valley bottom areas, particularly in the Sundog drainage which has more of this type of terrain, there may be additional development of soils in the terraces and lower-lying areas, and even the development of organic soils in some places, similar to that seen in the field on the glaciofluvial terraces near KP025.4. Similar gradations of soils are anticipated anywhere there are terraces in this section, including gravel and sand with cobbles and boulders, and varying proportions of silt.

Generally, the route seems to be optimized with respect to location, although there are some terrain sections to be crossed that are quite steep with sidehill cuts, e.g. KP013.85 climbing to a hairpin corner at KP016.1 and then east. Due to the amount of elevation to be gained in the Funeral Creek section, it cannot all be done at valley bottom, since the valley is generally narrow and tight, and not conducive to route refinements. In the route section mapped within the Funeral formation type rocks, it is probably also an advantage to be up on the slope somewhat, since at least one section of the route appears as though slope failure events on the north side of the creek could potentially affect the south side, as mentioned above.

5.1.3 KP024.3 to KP028.3

5.1.3.1 General

The all-season route is proposed to run along the south side of the valley, whereas the winter route is on the north side (Figures 2 and 3). The all-season route is intended to take advantage of level to moderately-sloped terrain along what appears to be a series of treed bedrock-controlled ledges covered with rubble and/or debris deposits from upslope in this section. Tetra Tech logged five test holes in this section: TP-08, TP-08a, TP-09, TP-10, and TP-11.

5.1.3.2 Geology

Bedrock was not encountered in any of the shallow test holes, but is visible along the KP025.4 tributary and along Sundog Creek (the main stream along this road section).

Bedrock has therefore not been ground-truthed in this area but is anticipated to be similar to the bedrock units mapped in the surrounding area: primarily dolomites of the Arnica and Sombre formations are expected, with silty argillaceous dolomite of the Camsell formation also mapped near the west end of this section.

LEGEND

- Sinkhole
- Testpit

Proposed All-Season Road

- Phase 1

NOTES
Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Sundog Creek Crossing at KP025.4 and Realignment

PROJECTION UTM Zone 10		**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:3,000 50 25 0 50 Metres					TETRA TECH EBA
FILE NO. Y14103320-01_Figure02.mxd					
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0	**Figure 2**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015				

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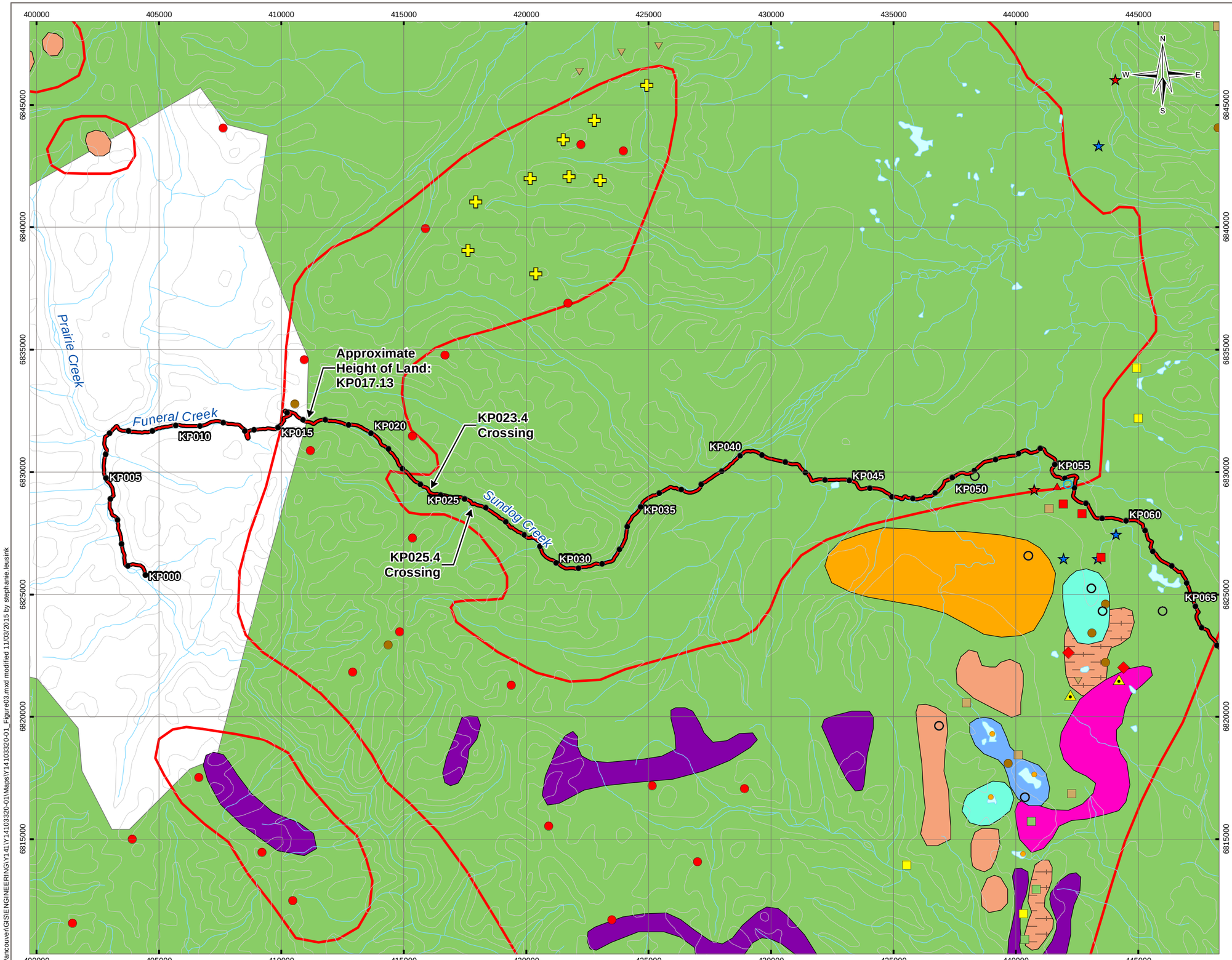

LEGEND

- Sinkhole (EBA)

Karst Features (Parks Canada)

- Arch
- Canyon
- Caves
- Corridor Karst
- Karst Lake
- Karst Pavement
- Karst Tower
- Polje (Karst Corrosion Plain)
- Remnant Karst Plateau
- Sinkhole, Cenote, Collapse Sinkhole
- Spring

Karst Features (ENR)

- Karst Cave penetrable >= 10 m
- Large Tor on Karst Rocks
- Sinkhole Exceptional
- Spring
- Closed depression draining underground
- Closed depression sinking stream
- Suffosion sinkholes
- Sinkholes clustered
- Sinkholes scattered
- Intersecting solutional corridors
- Solutional pavement

Significance Ranking of Karst Terrains (ENR)

- Established global - very significant

Proposed All-Season Road

- Phase 1
- Contour (200 m)
- Watercourse
- Waterbody
- Current Nahanni National Park Reserve Boundary

NOTES

Parks Canada data is approximated from Parks Canada (2006).
ENR data is approximated from Ford (2009), PAS-ENR (2012).
Base data source: NTS 1:250,000; Canadian Zinc.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Karst Topography KP015 to KP065

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:150,000
2 1 0 2
Kilometres

TETRA TECH EBA

FILE NO. Y14103320-01_Figure03.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01	SL	MEZ	RKO	0

OFFICE Tt EBA-VANC

DATE March 11, 2015

Figure 3

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Exposed bedrock in the vicinity of the KP025.4 tributary stream crossing thus appears to be dolomite. West and north of this road section, the road passes through an area mapped as established karst terrain, and karst terrain is also mapped within 1 km south of this road section, with remnant karst plateaus and sinkholes also mapped in the area, so it is reasonable to anticipate that some similar features might also be encountered along the route (Figures 3a and 3b; Ford 2009, 2012; Parks 2006). This section of the route is therefore considered to potentially host karst features, and it is anticipated that similar features may be encountered elsewhere in this mountainous section, whether or not they are currently obvious at ground surface.

Figure 3 presents some excerpts from the mapping by Ford (2009) and Parks Canada (2006) which show the proximity of important features in the general area of the road. Some suspected suffosion-related micro-landforms were observed in the field in this section at and near TP-11, at about KP025.6 along the route. On the 2012 aerial coverage, two larger suspected sinkhole features (5 m estimated diameter) were identified between the route and the creek, at about KP026 and about 60 m or more downslope of the route (Figure 2). These features could be related either to water carrying sediments through dissolved passages in the underlying carbonate bedrock, or fines being washed through coarse-grained debris ranging from coarse gravel to talus blocks. The limited depth achievable with hand-held investigation equipment means that the reason(s) for the piping could not be determined conclusively; however, the nearby bedrock mapping and the apparent presence of limestone in the vicinity is suggestive of potential suffosion in rock. It is anticipated that these micro-landforms can be avoided or managed with detailed design and layout. The available information suggests that the hazards presented by these features are likely to be of a lower level than the upslope hazards along the existing route on the north side of Sundog Creek. Therefore, the reroute on the south side of Sundog Creek is preferred.

5.1.3.3 Surficial Materials and Soils

Terrain and soil types vary in this road section, with relatively coarse-grained soils encountered on the open slopes near the KP025.4 tributary stream crossing (TP-08, TP-08a, TP-09), and finer-grained silt/sand mixtures found on the bedrock-controlled ledge to the south. The exact thickness of landforms could not be determined with the equipment on hand, but a range of thicknesses may be roughly estimated based on contour information, landform type and visual observations. Development of the landforms in this area have resulted in densely-vegetated elongated depressions along the bedrock-controlled ledges, interspersed with older talus (light areas with trees) and more recent alluvial mounds, between which the proposed all-season road is routed. The deposits near the road appear older than the more-active talus further upslope, which is also further from the reroute than active talus on the existing route. There is likely to be some creep on steeper sections of the mounds and talus deposits. Terraces were also noted west and east of the KP025.4 tributary crossing. The upper terraces are probably glaciofluvial, while lower terraces may be fluvial. This terrain unit becomes glaciofluvial veneer and colluvial veneer where bedrock is near-surface. Where the glaciofluvial terraces are present, talus forming aprons, cones, blankets and veneers can be expected on top of the terraces. Soil thicknesses could range from less than 1 to 2 m, to more than 10 m, depending on proximity to the bedrock-controlled ledges and/or the eroded stream gully below as well as the lower reaches of tributary gullies, where bedrock is exposed.

Where talus is close to the road, the possibility exists that periodic or ongoing ravelling could impact the road. As well, rock slides or rock falls from bluffs or cliffs upslope are also potential hazards along this road section. Such hazards appear to be somewhat mitigated along route sections located along well-vegetated bench areas, whose dense vegetation suggests longer periods between impacts are likely.

Two important soil types were encountered along this road section, gravel and silt. These are described below, according to results of index testing, and classified in accordance with anticipated engineering behaviour.

On the northwest and southeast sides of the KP025.4 tributary crossing, the soils appear stable enough to have developed a significant organic layer, ranging from 50 mm thick in TP-08a, to 150 mm thick in TP-08, to 250 mm thick in TP-09. This organic layer is generally coarse-grained with most of the constituents also found in the soils beneath. Generally, the underlying mineral soil consists of GRAVEL, trace to some sand, trace to some cobbles, trace of boulders, trace of silt and clay, trace of organics. As would be expected in a glaciofluvial deposit, there are some large variations in gradation, with some areas closer to SAND and GRAVEL, or GRAVEL and COBBLES. Some boulders were also encountered, both at ground surface and below. Appendix B presents test hole logs and laboratory test results for this area.

Further east, there appears to be a gradual transition from glaciofluvial terraces to bedrock-controlled ledges with glaciofluvial and/or colluvial veneers where the soil is thinner. According to Duk-Rodkin et al (2007), the western extent of the Laurentide ice sheet is mapped at roughly KP026. At about KP025.6 and nearby to the east, the surficial soils are finer-grained than the soils near the tributary crossing, consisting of SILT, with a trace of sand or SAND and SILT, with a trace of clay, moist, light brown, with organic pockets, and increasing sand and gravel with depth. Because the material is fine-grained, ice-rich permafrost may be more likely here. However, no frozen soil was encountered in the test holes, and no obvious indicators were noted at ground surface (TP-10 and TP-11). If present, the thickness of frozen soils may be limited by relatively shallow bedrock.

5.1.3.4 Permafrost

Permafrost in this area is mapped as extensive discontinuous, which means it may be present under 50 to 90% of the terrain. Elevations are high enough in this area (in the range of about 1100 m amsl) that it may well be present. Where present, the active layer (zone of seasonal freezing and thawing) will vary in thickness according to the type of ground cover and soil type. In this area, the active layer in the coarser-grained soils could be 2 to 3 m deep, tending to be deeper in areas with little peat at ground surface. The active layer is likely to be somewhat thinner in the silty soils, possibly less than 2 m. If there is a significant layer of peat on top of the mineral soils, conceivably the active layer could be less than 1 m. Permafrost, where present, is considered likely to be “warm” permafrost, probably warmer than -2°C, and potentially just below freezing. Continued climate warming is likely to result in eventual thaw of permafrost soils. As there are no obvious indicators of ice-rich zones along this section, the effects of thaw are anticipated to be relatively minor.

Most of the streams on open slopes in this section are likely to be ephemeral and/or freeze to the bottom every winter. It is possible that the main stream could have water year-round in pools, particularly in bedrock substrates. In this road section, no obvious permafrost-related issues were noted along streams. It is noted, however, that there are numerous debris flow channels along the route, including a series of channels from about KP027.2 to KP027.7. As debris flow deposits can be very wet, it is possible that they could freeze while still wet if they occur late in the season. If the deposits thaw again in spring, it is possible that they could remobilize, or if the deeper portions do not thaw in spring, they could be subject to creep. Since the local climate is assumed still to be subject to warming, however, the aggradation of permafrost is considered to be unlikely in this area.

At the proposed borrow site, ice content for the total thickness of the deposit is not known, but no ice was encountered in the shallow test holes. While permafrost may be present here, it is unlikely that there will be significant ice-rich zones if the bulk of the deposit is as coarse as the material encountered.

While fires are possible along this road section, none are recorded here, and no obvious evidence of past fires was observed in the field. It is anticipated that fires in this road section are likely to be self-limiting due to the large proportion of ground that is un-treed. Fires potentially could affect ground temperature regimes and permafrost, but such effects are anticipated to be relatively minor in this road section.

5.1.3.5 Borrow

Because a full-bench cut is proposed on the southeast approach to the crossing, Allnorth has proposed a borrow site here. Fines content for this material varied from 4.6 to 6.5 to 11.8% from the various test holes. Results with fines content of less than 10% indicate a generally frost-stable material, whereas fines content of more than 10% indicates a frost-susceptible material. Materials proposed for borrow should be further tested to confirm their suitability for a specified use, for example, use in subgrade as compared to use as base course or structural fill.

5.1.4 KP028.3 to KP040.1

5.1.4.1 General

This road section is the remainder of the route following the Sundog Creek drainage, which is a wide braided stream in this section. The route generally stays on the south and southeast side of the stream, except for a short distance at the west end between KP028.3 and KP028.8 where it crosses to the north and again back to the south side.

5.1.4.2 Geology

The route is located within dolomite of the Arnica formation, then transitions at the Sundog fault between about KP032 and KP036.5 to a northeast-running section of limestones of Nahanni formation, calcareous shales and argillaceous limestones of the Headless formation, and dolomites of the Sombre and Camsell formations. These layers seem to be relatively level both in the mapping and in the formations consisting of large bedrock bluffs observed in the slope above the route in this area (Appendix C), which likely improves the stability of the slopes along this section compared to those with out-dipping bedrock layers noted elsewhere on the route. The route then stays within the Nahanni formation for the remainder of the route to Cat Camp.

5.1.4.3 Surficial Materials and Soils

As for the sections further west, most of this section is located in a valley in which the road skirts along the toes of talus/scree and around the outer edges of alluvial debris fans. Talus/scree predominates until about KP033.6, after which the talus/scree slopes are interspersed with prominent bedrock bluffs. The debris fans can be expected to continue to accumulate, and some events may be large enough to cross the road or plug culverts, particularly in sections that cross over the fan, such as KP031.3. Some road sections are also subject to rock fall from above, although the bedding layers being relatively horizontal means that rock slides along bedding planes are probably uncommon in this part of the road. Areas of wider floodplains are present, but in most of this section, there is not a consistent terrace for the road to follow, due to the meandering and braiding of the stream within it. The primary purpose of the all-season road in this section as compared to the winter road is to avoid crossing and recrossing Sundog Creek, except at the west end where it is easier to avoid the climb over a large rock knoll on the south side.

5.1.4.4 Permafrost

Permafrost in this area is mapped as extensive discontinuous, which means it may be present under 50 to 90% of the terrain. Elevations are high enough in this area (in the range of about 1100 m amsl at the west end down to about 800 m amsl at the northeast end) that it may well be present. Where present, the active layer (zone of seasonal freezing and thawing) will vary in thickness according to the type of ground cover and soil type. In this area, the active layer in the coarser-grained soils could be 2 to 3 m deep, tending to be deeper in areas with little peat at ground surface. The active layer is likely to be somewhat thinner in silty soils if present on the alluvial fans, possibly less than 2 m. If there is a significant layer of peat on top of the mineral soils, conceivably the active layer could be less than 1 m. Permafrost, where present, is considered likely to be “warm” permafrost, probably warmer than -2°C, and potentially just below freezing. Continued climate warming is likely to result in eventual thaw of

permafrost soils. As there are no obvious indicators of ice-rich zones along this section from the imagery, the effects of thaw are anticipated to be relatively minor.

Most of the streams on open slopes in this section are likely to be ephemeral and/or freeze to the bottom every winter. It is possible that the main stream could have water year-round in pools, as described in the previous section.

5.1.5 KP040.1 to KP048.8

5.1.5.1 General

This section of the proposed route follows the existing winter road. It climbs out of the Sundog Creek drainage, and from KP041.5 to KP045.5 is located on a series of granular terraces. Further east, the route continues along the north side of a stream (Polje tributary) until it reaches the Polje reroute point at about KP048.8.

5.1.5.2 Geology

Bedrock is not evident along the proposed all-season road section between KP040.1 to KP048.8. However, this section of the road appears to be underlain by the Horn River formation, which includes black pyritic shale that is fissile and brittle, and may be associated with slope failures especially in locations where bedrock is shallow.

5.1.5.3 Surficial Materials and Soils

No estimate of bedrock depth or surficial material unit thickness is possible in this section. However, some estimates may be made of the possible thicknesses of the granular terraces at the west end of this section, based on the heights of slopes ascended or descended to get on and off the terraces. The flat terrace located from KP041.5 to KP043.3 and the duned terraces from KP043.5 to KP045.5 could be up to 15 m or so thick. The duned terraces appear to be somewhat thinner and also more irregular, however. These terraces are reported by Allnorth to consist of fine sand, which may be glaciofluvial in origin, and have been modified into dunes at the east end.

At the west end of this portion of the route, the existing winter road climbs from the Sundog Creek drainage at KP040.1 up to the edge of the granular terrace at KP041.5, crossing a series of swales and gullies along the climb east. Mollard (1995) suggested the possibility of an area of old mass-wasted till here. There is no obvious distress, but patchy trees on this irregular north-facing slope suggest possibly wet seeping areas in mid-slope and slopewash colluvium.

At KP045.5, the terrain returns to slopewash colluvium, possibly over old till, with the route mostly in the valley bottom. From KP046.3, the terrain eastbound becomes steeper, with the road winding its way around steep toes of knolls, especially between about KP047 and KP048, where there are some areas of exposed soils on the air photos at each cut location on knolls, and on a steep slope section above an outside bend of the creek between about KP047.4 and KP047.6. From KP047.6 to KP047.65, a very tight outside bend of the creek has resulted in erosion at the slope toe and a slope failure below the road. The sloughing has not retrogressed to the road yet, even in the 2012 imagery, but some consideration should be made to protecting this slope from further erosion. A similar situation is present near KP048.45, at HP49b, where another outside bend of the creek comes very close to the road. There is little vertical difference between road and creek here though, so it may be easier to protect.

5.1.5.4 Permafrost

Because the area is mapped as extensive discontinuous permafrost (Heginbottom et al 1995), 50 to 90% of the terrain may have permafrost. There is only a net change of about 20 m elevation along this route section, so the prevalence of permafrost is probably about the same throughout. The main differences along the route will be in the depth to permafrost, that is, in the thickness of the active layer. On the granular terraces at the west end of this

section, the active layer could be 2 m or more deep, especially in areas that have little overlying organics. In the slopewash colluvium/till terrain in the far west end and eastern sections of this part of the route, active layer thickness is probably a little thinner due to the likely finer-grained nature of the till/colluvial soils, especially where a thick layer of organics is present. In shady gullies that are well-treed, it is possible that permafrost could be shallower than 1 m. But in areas where the soils have been exposed by slope disturbances, or along the winter road itself, the active layer may be 1.5 to 2 m thick, or more if those soils have been exposed for some time. Where present, permafrost will be "warm" as discussed for the previous road sections.

No recent forest fires appear to have occurred in this section, as the area appears fully vegetated on the imagery, so related effects from fires in permafrost terrain would not be expected in this area.

There are no obvious indicators of thaw-sensitive permafrost in this area. However, because the soils are generally finer-grained than the soils along the westernmost 40 km of the route, it is anticipated that the soils will be more thaw-sensitive and frost-susceptible in this section if the soil moisture contents are high enough.

5.1.6 KP048.8 to KP058.6

5.1.6.1 General

The current winter road route has been re-routed to the north of the previous winter road in order to avoid intense karst terrain upslope to the south (Figures 4, 5 and 6), where small- to moderate-sized soil slope failures were noted by Golder Associates (Golder 2010). For the all-season road, some additional modifications are proposed. Four shallow boreholes were advanced by SNC-Lavalin Inc. (SLI) at a set of switchbacks between about KP057 and KP057.5 (old KP 57 and 58) in 2012, designated "M switchbacks" (SLI 2012a). This switchback has been widened and kept further north and upslope out of a drainage area. KP054 was of particular importance due to a large retrogressive thaw slump/flow located immediately south of the proposed route. EBA logged 10 test holes in this road section, including two that incorporated observations of exposed soils at the headscarps within the thaw slump/flow (BH-01 through BH-05, TP-01 through TP-03, TP-06, and TP-07).

5.1.6.2 Geology

Bedrock is not evident along the proposed all-season road section between KP048.8 and about KP054; however, limestone, dolomites, and shale may be present, as encountered elsewhere on the route. Bedrock outcrops are noted between KP054 and KP058.6, where both carbonates (KP054.6) and shale rock (KP055.3 and KP055.9) types are noted and proposed as potential borrow sources (Allnorth 2014). The Horn River formation is suggested by Golder (2010) along the south side of the valley, on the steeper slopes near the existing winter route. This formation consists of shale, and on the Ram Plateau it is underlain by limestone and dolomite of the Nahanni formation, which in turn overlie the shale and argillaceous limestone of the Headless and/or Funeral formations. This mapping appears to be consistent with the observations made of the relative elevations of rock types seen along the route in this section. The Poljes are evidence of the karst terrain in the region, which is to be protected by the reroute as it is presently proposed for the revised winter road and all-season road. The locations of the Poljes and other karst-related features are noted on Figure 3. The proposed route skirts between these valued features and canyons, avoiding them so as to reduce the possibility of impacting them directly or indirectly.

No obvious evidence of karst-related activity was noted along the traverse or helicopter flights along or immediately adjacent to the proposed reroute. A sinkhole was mapped near KP051 (Parks 2006), but not seen in the field. A suspected sinkhole feature is visible on the imagery about 170 m south of the route, however (Figure 3). A sinkhole was observed near KP056, about 80 m south-southeast below of the route. The surrounding terrain appears to be subsiding as well in that location; thus, avoiding this terrain is prudent for the integrity of the road (Figures 3 and 6).

Bedrock was not encountered in any of the test holes in this section; however, it is anticipated to be relatively shallow, on the basis of the numerous bedrock outcrops that were noted. Locally, bedrock can be deeper, but it is anticipated that soil between about KP054.6 and KP058.6 is typically present as a discontinuous residual or colluvial veneer and/or reworked tills, thus often less than 1 to 2 m thick. Bedrock is more likely to be exposed along ridges, and surficial materials are likely to form infills between those ridges. Between KP048.8 and KP054, bedrock is likely to be deeper, given that outcrops were not noted directly adjacent to the route, and test holes at KP054 did not encounter bedrock within 2.5 m of the original ground surface.

5.1.6.3 Surficial Materials and Soils

Since bedrock was not noted between KP048.8 and KP054.6, nor encountered in the test holes between KP049.7 and KP054, no estimate of bedrock depth or surficial material unit thickness is possible in this section. However, there are some large exposed soil slopes that were encountered during the field work, many of which are related to loss of toe support due to erosion and undermining at outside creek bends. The soil debris slide downslope of KP050.5, for instance, is located on a slope of about 35 m in height (Figure 4, Appendix C). This slide is unlikely to affect the road with the present stream configuration. The treed area above the exposed sand slope is actually a ridge, behind which runs the road. The road would be at a point estimated at a slope of 4H:1V above the present toe of slope (drawing an imaginary line through the ridge). The treed slope just west of the exposed sand slope is an older failure currently growing in, since the stream has moved away from the slope toe. Further to the west in this route section, the route was moved away from the crest of the steeper slope during the field work, so as to reduce the hazard at the location of the road. Although only sandy soils were evident here and in the shallow test holes advanced along the route as far west as about KP049.7, the surficial geology mapping further to the east suggests that bedrock is probably relatively shallow in this area and therefore may also be present beneath the soils on this slope (Hawes, 1975). Mapping of glacial limits in NNPR indicates that this area was once covered by the Laurentide continental ice sheet, thus some glacial deposits should be anticipated here (Duk-Rodkin et al 2007).

Two main soil regimes were encountered along the route in the section shown on Figure 4. At the upper crossing of the KP049.7 stream, which was removed from consideration during the field work, 0.5 m of SILT, with some fine-grained sand and some clay was encountered at ground surface on the southwestern side slope of the stream, where slope instability was observed. Beneath the silt, a medium-plastic silty CLAY was encountered, at the surface of which was free water (Figure 4 and BH-01). Upstream and downstream, more instability was noted. While the slope failure appears to be fairly shallow, this location was deemed not optimal for development of a road and therefore the noted change in crossing location was made as a result of the field work.

Elsewhere along this section of the route, from KP049.7 at the lower crossing to KP50.5 near the large slope failure along the creek, surficial materials appear to consist of 80 to 150 mm of PEAT overlying fine to medium grained SAND, with trace to some silt. The soil was somewhat siltier towards the west end of this section, with silt content varying from some silt to silty. Minor gravel or cobbles was also noted in this section (TP-03). The presence of jack pine along the route reinforced the observations that the sandy soils are usually relatively dry and well-drained.

Just east of the Polje Creek crossing, a retrogressive thaw slump/flow was investigated. Here, the soils return to silt and clay with some variations noted (Figure 5, BH-05, TP-06 and TP-07). Underlying a PEAT layer of about 300 mm thickness, it appears there is a layer of colluvium, or perhaps reworked till, which shows evidence of having been modified by water, consisting of a layer of SILT, which varies from clayey to trace clay, with some sand to sandy, and trace gravel. This material is layered and sometimes varved (TP-07) with coarser particles interspersed between finer-grained layers. Also in TP-07, which was located at the headscarp of the thaw slump/flow, a layer of medium to coarse-grained sand and trace gravel, over a discontinuous layer of shale boulders was encountered. These layers were not seen downslope in TP-06, about 30 m above the toe of the thaw slump/flow. Beneath the silts, sands and/or boulders, silty clay was encountered, interpreted at TP-07 as CLAY TILL (or till-like, in any case). This material contained 61% clay, 38 to 39% silt, and up to 1% sand, and was high plastic.

436600 436800 437000 437200 437400 437600 437800 438000 438200 438400

6830200 6830000 6829800 6829600 6829400 6829200 6829000

N W E S

BH01
TP03
BH02
TP02
TP01
KP050
BH03
BH04
KP051
KP049
Swale
Revegetated
Old Channel
Ridge
Series of narrow ridges and gullies
Upper Polje Creek

LEGEND

- Observation Point
- Borehole
- Testpit
- Slide
- Swale
- Old Channel

Proposed All-Season Road

- Phase 1

NOTES
Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Polje Karst North Reroute KP048.8 to KP051

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CANADIAN ZINC CORPORATION	
Scale: 1:6,000 — 100 50 0 100 Metres			
FILE NO. Y14103320-01_Figure04.mxd		TETRA TECH EBA	
PROJECT NO. Y14103320-01	**DWN** SL / **CKD** MEZ / **APVD** RKO / **REV** 0		**Figure 4**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015		

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LEGEND

- Observation Point
- Borehole
- Testpit
- Slide

Proposed All-Season Road

- Phase 1

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Polje Creek Retrogressive Thaw Slump/Flow KP054

PROJECTION UTM Zone 10		**DATUM** NAD83		**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:4,000 — 50 25 0 50 — Metres				TETRA TECH EBA
FILE NO. Y14103320-01_Figure05.mxd				
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 11, 2015			**Figure 5**

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Soil moistures in the clay were 29 to 32% which, although high, and above the plastic limit (29), they are but well below the liquid limit (62) for this material. It is possible that this slope failure is related to thaw of permafrost following the 1996 forest fire (see further discussion under the heading Permafrost, below).

SLI (2012a) noted an historical landslide between about KP056.8 and KP057.4 (current stations), in the vicinity of their boreholes BH-M-01 through BH-M-04 (Figure 6). However, they did not mark the slide location on their figure, and no air photo coverage is currently available for the area, so the exact boundaries of the slide they observed are unknown. It seems that at least some of the boreholes were within the identified slide area, since SLI mentioned that the soils encountered were compact, suggesting to them that some consolidation had occurred after the landslide. SLI identified topsoil at ground surface in three of the four boreholes, varying in thickness from 0.2 to 0.3 m in BH-M-04 and BH-M-02, and up to 1.3 m thick in BH-M-03. In all cases, SLI described the topsoil with other constituents such as gravelly organic clay, clay, gravel, organic silt, and shale. In BH-M-01, SILT was encountered at ground surface, extending to 0.2 m below grade, beneath which was silty organic CLAY with trace shale. Silt was also found below the topsoil in BH-M-04, between 0.2 and 0.9 m below grade.

Beneath these finer-grained surficial layers, coarse SAND was found in all the holes except BH-M-03, with other constituents including gravel and silt in BH-M-01 and BH-M-04 (some gravel to gravelly, trace to some silt to silty). Trace to some shale was also noted. In BH-M-03, GRAVEL was encountered beneath the topsoil, with some coarse sand and trace silt noted. The material was generally moist, with soil colour in the boreholes varying from brown to black to dark grey. In BH-M-02, the soil was frozen at 1.96 m below grade, with free water encountered at the end of hole at 3.8 m depth, suggesting the presence of a thin layer of permafrost. Likely the thaw depth would have been at the approximate seasonal maximum at the time of drilling (September 24, 2012). Oddly, no frozen soils were observed in the borehole with the greatest organic cover (BH-M-03). It is possible that the soils were only marginally frozen, with drilling resulting in the thaw of the soils before it could be noted. This might be especially true of the soils in BH-M-03, which could have been the most difficult to drill due to significant coarse content.

Tetra Tech EBA identified three possible scarps just upslope of the route in this section, as well as a linear feature downslope (marked with a dashed line on Figure 6) that may be related. All of the scarps appear relatively well-vegetated on the 2012 imagery. No 1994 air photos are available in this road section to compare to. As a result of Allnorth's 2014 work, the route along the climb up from Polje Creek has been moved further upslope than it was previously in order to improve road grades, avoid downslope slope issues, and stay out of the gully that drains to the Third Polje below, but the section from KP056.5 to KP057.5 remains essentially on the 2012 route investigated by SLI (2012a). Therefore, the slope instability hazards have not been eliminated, but they have been reduced with the 2014 realignment of this section. There is an apparent slope failure downslope of the route between about KP057.4 and KP057.7, above the east end of the Third Polje. This may be the same mud slide observed by Dillon in September 2009 and presumed to have occurred on or about September 9, 2009, coinciding with a peak in water level in the WSC gauge at Blackstone River (Dillon 2009). Since the local slope gradients at this location vary from about 3% in most of the distressed area to 8% at the downslope extent of the debris lobes, it is possible that this recent failure is related to thaw of permafrost following the 1996 forest fire (Figure 6). This area appears to be located within a larger, older failure area, marked with dashed lines on the figure. Further discussion about the potential effects of fire is presented under the heading Permafrost, below.

Golder (2010) identified two large slope failures in glacial soils over shale/siltstone near the east end of the Polje reroute. Superimposing the features identified by Golder along the road route, Tetra Tech EBA identified a headscarp located within about 50 m southwest of and below the current road route (about KP057.8 to KP058.2), and where the route rejoins the winter road, there is a headscarp within about 25 to 50 m south below the route (about KP058.7 to KP059.2). Two suspected scarps were also noted above the road near KP058.2. The probable headscarp locations below the road are clearer than the suspected scarps above the road (Figure 6). This is because the terrain above the road is much flatter, and the suspected scarp locations above the road may only

indicate a difference in the vegetation. About 150 m to the north of KP059, Golder also mapped a sinkhole (Allnorth's helipad HP60). The road route is located on nearly level terrain above the crest of slope which allows ample room, if needed, for fine-tuning the route during detailed design and layout. Behaviour of the slopes can be confirmed and appropriate setback distances from these features determined at that time. The next such feature, south of KP059.2 to KP059.9, is about 75 to 300 m south of the road, decreasing heading east. No air photo coverage was available to Tetra Tech EBA in this section, but the 2012 imagery shows the crests of slope in this area. Generally, the road is well-positioned to avoid this apparent slope instability.

5.1.6.4 Permafrost

Some slopes are in shady valleys and/or have essentially north-facing aspects such as at BH-01 upslope of KP049.7, or have a relatively thick peat cover and evidence of suspected thaw-related failures, such as at KP054. These areas are suspected to have permafrost that needs to be protected against anthropogenic disturbance, or that should be avoided to prevent thaw-related issues from affecting the road. The road has been re-routed away from a few obviously unstable slope sections between about KP049.5 and KP055, some of which appear to have permafrost thaw-related failures, and some of which are more likely only erosion-related slope failures. The suspected slope instabilities along the road route between KP056.5 and KP057.5 may also be at least partly thaw-related. The hazard has been reduced somewhat as a result of the 2014 realignment removing the switchback lower on the slope.

Frozen soil was not encountered at BH-01, but due to the slope disturbance, the active layer is probably deeper now than it would have been prior to disturbance. Frozen soil, probably permafrost, was encountered in the thaw slump at KP054, in TP-07. Although no intact soil sample could be retrieved due to refusal of the auger, the overlying samples were very cold. In this case, the frozen soil was at about 2.5 m below original grade. Of this depth, 2.25 m was logged on the headscarp of the slide, and 0.25 m was logged in a borehole below grade. Because some time had elapsed between the slope failure and logging, the original depth to permafrost was probably less than 2.5 m, and might have been less than 2 m. While the 300 mm thick peat might suggest a thinner active layer on slope aspects that are either northerly, neutral or shaded (where the active layer might be as shallow as 1 m), on this broad open west-southwest facing slope, a 2 m or so active layer thickness may be more reasonable. It is also noted that there is considerable seepage through this slope section and a stream is mapped here, so the presence of water probably increases the active layer thickness somewhat. Climate warming may slowly increase the active layer thickness over time. Eventually, a talik or unfrozen zone is likely to develop between the seasonally-frozen soil and the remaining permafrost beneath, if/where present.

It is further noted that this entire road section runs through an area that burned in a forest fire in 1996. It is likely that the thickness and integrity of the peat has been affected in at least in at least part of this area, likely increasing the active layer thickness since the fire. Field observations suggest that where the fire appears to have been very hot, the surface of the peat holds less moisture and is less resilient or spongy than it probably was prior to the fire. This is an effect that seems to have persisted in the 18 years since the fire occurred. It also seems likely that peat thickness may have been reduced in some locations, based on prior observations of forests subjected to prescribed burns. Trees on sandy slopes that would likely have been drier at the time of the fire seem to have been most affected. In many locations, only the trees in the valley bottom or in cool wet gullies seem to have been preserved.

Because the area is mapped as extensive discontinuous permafrost (Heginbottom et al 1995), 50 to 90% of the terrain may have permafrost. This road section is at a somewhat lower elevation than the previous section, so there may be fewer areas where permafrost is present but there is also more organic terrain where permafrost may be present, protected under thick layers of peat. Where present, permafrost will be "warm" as discussed previously. On south or west-facing aspects, permafrost may be only marginally frozen, particularly in areas that have been subjected to forest fires and in which the peat has been damaged. The soils between KP049.7 and KP051.7 are likely to be warmer than the soils in shaded areas, or which are protected with a thicker layer of peat.

LEGEND

- Allnorth Soil Sample
- Sinkhole
- Observation Point
- SLI Borehole
- Slide
- Suspected Area of Movement

Proposed All-Season Road

- Phase 1

NOTES
Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Google; Landsat (2013).

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Slope Instabilities above Poljes KP055 to KP059

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CANADIAN ZINC CORPORATION	
Scale: 1:10,000 — 200 100 0 200 Metres			
FILE NO. Y14103320-01_Figure06.mxd		TETRA TECH EBA	
PROJECT NO. Y14103320-01	**DWN** SL / **CKD** MEZ / **APVD** RKO / **REV** 0		**Figure 6**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015		

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5.1.6.5 Borrow

Allnorth has proposed borrow sites at about KP050.3 (BP 50B), KP050.9 (BP 50), KP051.7 (BP 51), KP053.3 (BP 53). Tetra Tech EBA has not visited the latter three proposed borrow sites, but did traverse the route adjacent to BP 50B. It is understood from Allnorth's data that similar sand materials are anticipated at each of the borrow sites, with some variation in silt content. Coarser-grained granular borrow materials are anticipated at KP055.3 (BP 55) and KP056.7 (BP 56B). As frozen soil was not encountered in sandy soils during the field work, and only shallow holes could be advanced, the presence or absence of permafrost, the probable ice content, and permafrost characteristics could not be determined. Until such time as these characteristics can be confirmed, it is recommended that a buffer zone be maintained between the road and borrow areas. If the borrow area proves to have higher than anticipated ice content and subsequently thaws, the road should be protected by the buffer zone. It is noted, however, that this section of the route is largely south or southeast-facing, with some southwest-facing sections, and is therefore generally anticipated to be a relatively warm slope, and may or may not have permafrost in it. Irrespective of permafrost, however, caution is advised at BP 56B, due to the proximity of the existing slope problems noted above.

Borrow areas are also proposed in bedrock outcrop areas, such as at about KP054.7 (BP 54) in carbonate rock and KP055.9 (BP 56) in shale. Few or no issues associated with thawing permafrost are anticipated at these locations. Borrow areas should be further tested to determine the uses for which they are most suited and frost-susceptible soils avoided where possible.

5.1.7 KP058.6 to KP080.3

5.1.7.1 General

This section of the route is located along the existing winter road, which climbs away from the Polje terrain and follows a series of ridges to stay on high ground enroute to the Tetcela River drainage.

5.1.7.2 Geology

Shale was noted by Allnorth on the granular terrace at the northwest end of this section, and this area is mapped within the Horn River shale formation. Heading southeast the route crosses into the Fort Simpson formation which includes shale and siltstone and overlies the Horn River formation. These rock types are in turn underlain by limestone and dolomite of the Nahanni formation which shows its presence with the appearance of sinkholes located along the route, for example, between KP065 and KP066.3. Ponds near the road are generally noted to be located within deep, wide bowls. Several of the ridges along the route either appear to be comprised of bedrock or bedrock is probably near-surface.

5.1.7.3 Surficial Materials and Soils

Surficial materials in this section are mapped as residual or colluvial veneer up to about KP079, indicating that they should be a relatively thin layer over bedrock. East of KP079, this section is mapped as a colluvium or till veneer.

Soils with a till-like texture can be anticipated, either silty soils as encountered on the slope down to the Tetcela River east of this road section, or possibly some slightly coarser, less-weathered soils along the route. For example, Allnorth encountered fine sand at about KP070.9 and KP072.9, and sandy till-like soils at about KP077 and KP078.4. Glaciofluvial gravel may also be encountered in a few areas closer to the west end of this section, with Allnorth reporting fine glaciofluvial gravels at about KP064.9 and KP065.1.

Few areas of distress were noted along this part of the route, but there were a few short road sections crossing the heads of gullies that will need closer attention during detailed design and construction in order to properly route

nearby streams and reduce the likelihood of sloughing into the gullies or onto steep slopes below. Examples of such gullies or slopes include the road from KP060.6 to KP061.6, KP068.5 to KP69.3, and KP070.2 to KP071.

A peaty wetland was noted at about KP072.8.

5.1.7.4 Permafrost

Permafrost is likely to be present in this relatively high elevation section of the route, with about 855 m elevation at the northwest end, climbing to 990 m and descending again to about 708 m at the southeast end of this section. However, because the surficial soils are generally expected to be relatively thin over shallow bedrock in much of this part of the route, the potential effects of thaw-sensitive permafrost, if present, are likely to be small. Sections of coarser grained soils, such as the granular terrace between KP058.6 to KP059.9 are also less likely to contain thaw-sensitive soils.

It is understood that there was a fire in the area from KP064 to KP110 sometime between 1940 and 1950. A more recent fire (date unknown) seems to be evident on the imagery between about KP066.5 and KP069.5, where portions of the route and parts east appear similar to burned areas along the Polje reroute. It is possible that a fire may have affected the organic layer and increased thaw of permafrost in this section; however, because the soils are probably thin here, the effects would likely be less than in the Polje area.

5.1.8 KP080.3 to KP086

5.1.8.1 General

The all-season reroute departs from the winter road at about KP080.3, staying north of the winter route and on higher ground (Figure 7). Where the route approximately parallels the top of bank above a major tributary of the upper Tetcela River, it is on mostly gently-sloping terrain (about KP083.5 to KP086). The re-route is proposed to run about 50 m south of a small stream traversed during the field work. SLI logged two test holes in this section for the proposed Tetcela Transfer Facility, near the winter road (SLI 2012a). Tetra Tech EBA logged three test holes in this section of the proposed reroute (TP-12, TP-12a, and TP-13). Numerous slope instabilities were noted below the road, on the slope down to the Tetcela River tributary (Figure 8, KP084-KP085).

5.1.8.2 Geology

The depth to bedrock is not known in this section, as it was not encountered in Tetra Tech EBA's hand-dug test holes near the all-season route (TP-12a, TP-12/BH-06, and TP-13/BH-07, up to 1.1 m depth), nor in SLI's boreholes near the winter road (3.1 to 4.6 m depth) (SLI 2012a). Surficial geology mapping suggests the presence of colluvial soils or till veneer over shale, siltstone or limestone bedrock (Hawes, 1975), however, so that suggests bedrock could be as shallow as 1 or 2 m.

Geology mapping indicates shale and siltstone of the Fort Simpson formation overlies shale of the Horn River formation, which in turn overlies limestone and dolomite of the Nahanni formation, and then the argillaceaous limestones and shales of the Headless and Funeral formations (Douglas and Norris, 1976a). Of particular interest are the formations that potentially affect slope stability along the Tetcela River above and below the route, which include the Fort Simpson, Horn River and Nahanni formations. A normal fault (the Tetcela Fault) is mapped just west of KP084, which is not apparent from the air in the vicinity of the road. There is, however, a prominent bluff on the north side of the Tetcela River tributary opposite KP084 which may be related to the fault (Figures 7 and 8).

LEGEND

- Borehole
- Testpit
- SLI Borehole

Proposed All-Season Road

- Phase 1
- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS

ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Tetcela North Reroute
KP080 to KP087

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:15,000

200 100 0 200

Metres

TETRA TECH EBA

FILE NO. Y14103320-01_Figure07.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01	SL	MEZ	RKO	0

OFFICE	DATE
Tt EBA-VANC	March 11, 2015

Figure 7

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5.1.8.3 Surficial Materials and Soils

At about KP080.3, the winter road begins its descent into, then across a gully, descending the east sidewall of the gully, then bending east to follow just above the valley bottom. This gully appears to consist of a shallow earth slide, with smaller old slope instabilities within the gully and just east of the gully. Suspected headscarps are more obvious on 1994 air photos than on 2012 imagery. A few short bare patches were noted by Mollard (1995) that seem to be related to cutslope disturbances, or possibly sloughing, seepage and/or sedimentation along this section of the route. These areas are clearly visible on the 1994 air photos, but not on the 2012 imagery. Streaky, sub-parallel runoff channels are present in the valley south of the road, as well as upslope along the proposed all-season route.

The proposed all-season route avoids the apparent slope instabilities seen along the winter road by staying above the crests of the steeper gullies/drainages (gradients locally to 40%), and on the ridges (gradients of 20% or less). From about KP080.8, the route descends a ridgeline south, switching back at about KP081.7, heading northeast and skirting above the steeper ground on the descent towards KP083, where the slope gradient lessens. The road is well-placed along the ridgeline, by staying on the higher ground. Areas that have few or no trees at about KP082.4, KP082.5 and KP082.8 below the route suggest seepage areas and the possibility of instabilities, so good control of water drainage will be needed along the road. The first two of these areas are seen on the 1994 air photos and the 2012 imagery, while the latter is on less-steep ground and is visible only on the 1994 air photos, so the vegetation has been able to grow back in the 18 years between sets of images. Between KP083 and KP083.9, slope gradients range between 7 and 13% in streaky terrain, becoming gentler eastbound. The streaky terrain is because of mostly inactive surface water drainage channels, but there are a few active streams too. Here, the all-season route is roughly parallel to and south of a small stream. The forest appears in decay here, with jack-strawed trees across the stream and considerable old and new deadfall.

From about KP083.9 to KP085.9, slope gradients range from about 4 to 7%. Potential slope issues exist near the crest of a north-facing slope above the Tetcela River tributary, which is mapped entirely as colluvium (Hawes, 1975). Most of this slope is off the LiDAR, but numerous slide paths are visible on the 1994 air photos. A recent ("fresh") slide path is clearly visible near KP084 on the 1994 air photos (A28094-259-260). From the air, it appears that there may be tension cracks above the crest of slope, areas of seepage and apparently slumping soil. Tension cracks have been interpreted along the crest of the slope on the 1994 air photos as well. Active slope erosion of the Tetcela River slope was interpreted between KP085.5 and KP086.5 - patches of the slope are devoid of trees. There is evidence of downslope block movement (Figure 8). The route is proposed to stay well south of the crest of slope above the Tetcela River, south of the small stream, and therefore is expected to avoid the slope stability issues that are seen on the slope below. The condition of the slope features will be confirmed during detailed design and layout. Despite much of the slope drainage running from west to east, the streams nearest the Tetcela River slope tend to veer north and run downslope to the river, including a drainage path interpreted on the 1994 air photos between KP085.2 and KP085.5, and mapped as a stream by Allnorth. There may be more streams or swales that similarly direct drainage over the slope that are as yet unmapped. Close attention to surface water drainage will be needed during road layout.

Soils encountered by Tetra Tech EBA in this road section included PEAT, to a thickness of 50 to 150 mm along a small stream about 50 m north of the proposed road. The peat was much thicker at 400 mm in the wet meadow at HP85, located northwest of the small stream at about KP083.5. Beneath the peat, SILT was encountered. The silt generally had a trace to some sand, and a trace of clay. Clay content and plasticity seemed to increase with depth, with clay content varying from some clay to clayey near the bottom of the deeper test holes. Traces of angular gravel, oxides and sand pockets were also noted in TP-12/BH-06, suggesting a till-like soil. The silt was stiff to hard, becoming very stiff by about 1 m depth with a slightly higher moisture content. Silty CLAY, with traces of sand and gravel were encountered just below 1 m depth in TP-13/BH-07, with the same gradation as the clay at the base of the thaw slump/flow at KP054. Moisture contents varied from about 11% in the silt to about 21% in the clay, with

moisture contents at about the plastic limit for the clay. The clay was determined to be medium plastic, and stiff to hard in consistency. No free water or frozen soil was encountered in Tetra Tech EBA's test holes in this area.

SLI encountered silty CLAY in their boreholes for the TTF just north of the winter road, noting a firm to stiff consistency, becoming very stiff by 2.7 m depth (SLI 2012a). They also noted GRAVEL (loose rocks) below 3 m depth in their TTF-01, resulting in refusal at 3.16 m depth. A trace of shale fragments was encountered in SLI's TTF-02, but this borehole continued in clay until the end of hole at 4.6 m depth. The gravel could be indicative of shallow bedrock, or it could be just a gravel lens in till-like soils. Similarly, the shale fragments within the clay could also be indicative of till-like soils. A moisture content of about 27% was noted in the frozen clay, just below the water table. This moisture was well above the plastic limit of about 18, but still well below the liquid limit of 49. Thus, while it is wetter than would be useable for backfill without drying it, it is not necessarily indicative of excess ice.

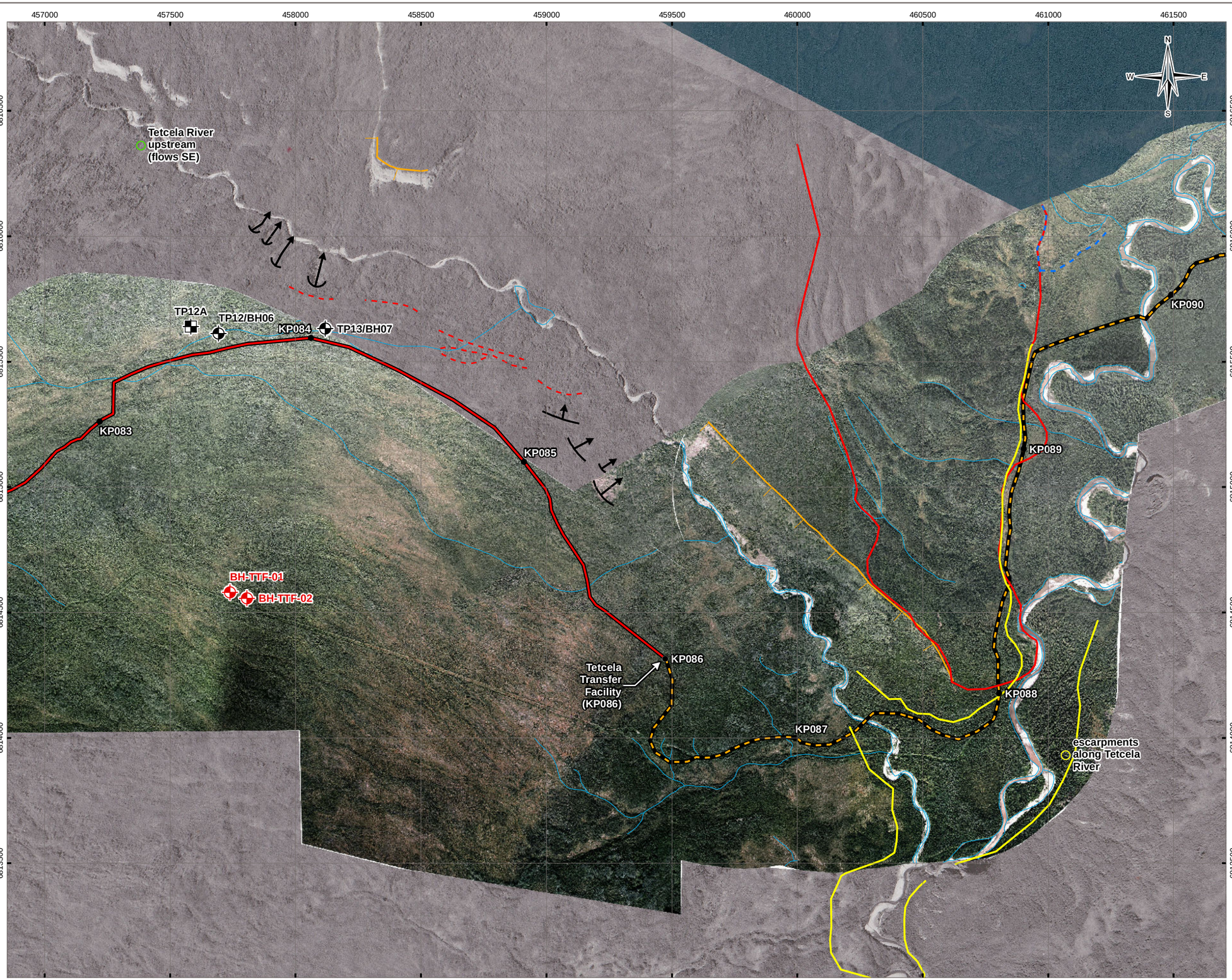
The route is intended to stay well back from areas of potential instability on or just above the Tetcela River tributary slope, including areas with tension cracks, significant seepage, large areas of die-off or fallen trees, or exposed soils or sloughing slope sections. Once the final road alignment has been confirmed, areas that appear potentially problematic will need to be confirmed and avoided where necessary. Care will be required to optimize drainage across the road, as there are a few streams that parallel the road and then cross it to flow down to the Tetcela River tributary.

5.1.8.4 Permafrost

This section of the road descends a gentle east-facing slope, so is not expected to be particularly warm. On the other hand, gradients on the main slope are relatively gentle (4 to 13%), so the shading effect is probably not as dramatic over much of the reroute as it would be on a steeper slope. North of the route, the slope down to the Tetcela River tributary has a north-northeast aspect, and therefore is expected to be cold.

Tetra Tech EBA did not encounter frozen soils. SLI, on the other hand, encountered frozen soils in both of their boreholes, with very cold soils noted near the surface of borehole TTF-01, and frozen soils noted at 1.07 m depth. No other remark noting that the soil was again unfrozen was recorded. However, the soil was again described as firm at 1.15 m below grade and the SPT N blow counts below are not indicative of frozen soils (ranging from 8 at 1.5, to 23 at about 2.2 m, and 22 at about 3 m depth), so this appears to have been a very thin frozen layer. However, it is also possible that the soils were only marginally frozen in this zone and that the act of drilling and sampling was enough to thaw them. More convincing was the record in TTF-02, where frozen soils were recorded at a depth of 1.5 m and unfrozen soils again at 3.5 m. It was late enough in the thaw season at the time of drilling (September 22, 2012), that the top surface of these frozen soils are considered to be probably top of permafrost. Again, SPT N blow counts are not extremely high, ranging from 19 to 34 in the frozen zone, suggesting that the soils were only marginally frozen. Interestingly, near the end of hole, the SPT N blow count was reported as 48, but there is no corresponding remark to suggest why it was significantly higher than the other tests. Water was encountered in both SLI's boreholes, at 1.07 m (top of frozen soil) in TTF-01 and 1.2 m (about 0.3 m above top of frozen soil) in TTF-02 (SLI 2012a).

SLI's field findings suggest that permafrost is likely present on this slope. Where water potentially runs year-round (perhaps in the Tetcela River or its tributary), there is probably a talik or unfrozen zone beneath the stream. SLI's findings suggest that the permafrost may only be about 1.1 to 1.5 m thick or slightly thicker on this slope. However, no peat was recorded at the surface of their boreholes, so it is likely that in areas where peat is present, such as on undisturbed slope sections and away from streams, permafrost may appear at a much shallower depth (possibly less than 1 m, depending on the peat thickness), and that permafrost may extend much deeper. Where permafrost is present, the ground temperature is likely to be only slightly below 0°C, especially in areas where the permafrost is quite thin as was encountered by SLI, because it is likely in the process of slowly thawing.



LEGEND

- Landmark
- Observation Point
- Borehole
- Testpit
- SLI Borehole
- Tension Crack
- Escarpment
- Slump
- Alluvial Plain
- Alluvial Fan
- Slide
- Watercourse (derived from LiDAR)

Proposed All-Season Road

- Phase 1
- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by:
- Canadian Zinc Corporation: Roll A28094, Photos 258-261. Scale 1:20,000. Black and white. Date: 1994-06-16 .
- Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Slope Instabilities above Tetcela River KP083 to KP090

PROJECTION UTM Zone 10				**DATUM** NAD83	**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:15,000 200 100 0 200 Metres					TETRA TECH EBA
FILE NO. Y14103320-01_Figure08.mxd					
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0	**Figure 8**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015				

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The soils encountered probably have a low to moderate sensitivity to thaw, because these soils have moisture contents that are either at the plastic limit, or above the plastic limit but below the liquid limit. This means that the soils could still creep or possibly fail if they thaw, for example, in the form of a slope failure, but the types of failures occurring would be much more limited than failures that would occur if the soils were ice-rich and hence wetter than the liquid limit.

Fires may affect ground temperature regimes and permafrost in the same way as has been observed at the KP054 thaw slump/flow, because similar soils appear to be present in this section, as well as streams on the slope, and the presence of frozen soils, apparently permafrost. This road section is within the area understood to have been affected by a fire sometime between 1940 and 1950. No recent fire has been noted in this section, but Tetra Tech EBA did observe that the forest in the area traversed on foot appears to be in decay, with many jack-strawed trees across the stream, and considerable old and new deadfall, with old deadfall being moss-covered. If a fire were to occur, it seems likely that there would be plenty of fuel for it.

While no obvious thaw slumps are present on or immediately adjacent to the route, the entire slope above the Tetcela River tributary north of the road appears to be subject to slope movements, which may or may not be related to permafrost thaw (Figure 8).

As noted above, the observed soil moisture contents are not extremely high, but conditions are similar enough to the KP054 area to be cause for concern. One anticipated benefit of keeping the all-season road on a gentle to moderate slope is to reduce the length of the road on slopes that might be more prone to failure upon thawing.

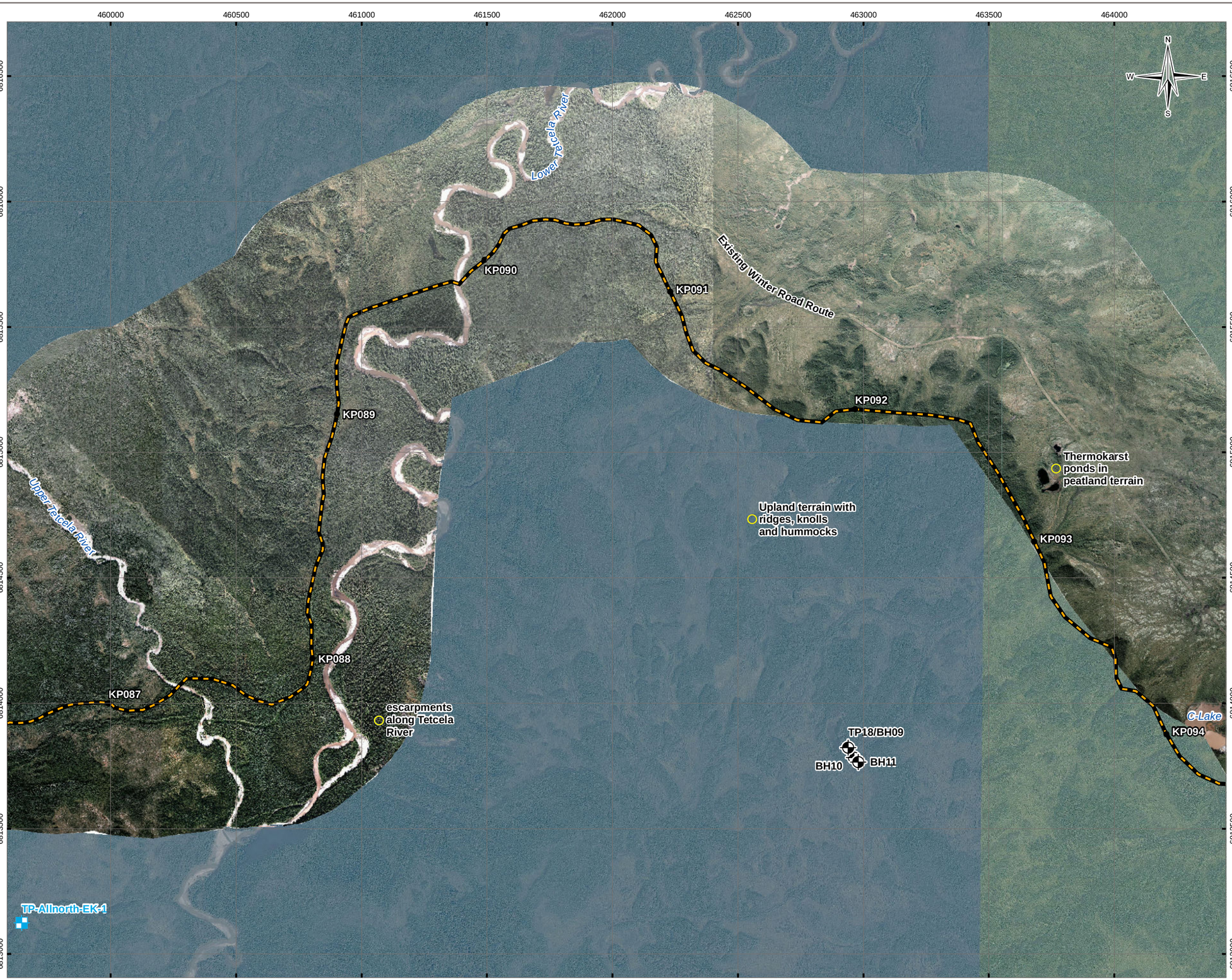
5.1.8.5 Borrow

The silty soils encountered along this section of the route are considered to be highly frost-susceptible, and the clay soils moderately so. Allnorth currently has proposed no borrow sites for this area, except near KP086.4 (sand) and KP086.5 (gravelly sand). If frost-stable fill is required here, it may need to be imported from elsewhere, if the supplies at these two sites are insufficient or prove unsuitable for the desired use. The active layer is likely to be deeper in the granular borrow than in the finer-grained soils upslope along the route. Further study is recommended for these sites as they are sandwiched between streams and are mapped within an area with the potential for slope movements. A buffer zone is advisable between the borrow areas and the road. No sample/test data is currently available for these sites.

5.1.9 KP086 to KP095.7

5.1.9.1 General

The south Tetcela re-route, south of the existing winter route was initially proposed to avoid one stream crossing and keep the route mostly on an upland area (Figures 9 and 10). Leaving the TTF at KP086, the all-season route rejoins the winter route at about KP 86.6. As a result of the September 2014 field work, this section was subsequently divided into two sections by Allnorth: KP 86.6 to 90.6 (staying on the winter route from Tetcela River up to KP 90.6) and about KP 90.6 to 95 (reroute south to toe of uplands area, skirting around the west and south sides of C-Lake and then east to the existing winter alignment). Tetra Tech EBA logged six test holes in this section, including one on the currently proposed route. From west to east, the test holes included TP-14, BH-08, TP-18/BH-09, BH-10, BH-11, and BH-12.



LEGEND

- Observation Point
- Borehole
- Allnorth Testpit

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Tetcela to Fishtrap Reroute
Tetcela River to C-Lake
KP087 to KP094

PROJECTION UTM Zone 10	**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:15,000 — 200 100 0 200 Metres				TETRA TECH EBA
FILE NO. Y14103320-01_Figure09.mxd				
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 11, 2015			**Figure 9**

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5.1.9.2 Geology

Over half of the route between KP086 and KP095 is located on the existing winter road (Figures 8, 9 and 10). One section where the underlying bedrock may be playing a role in slope stability is the section from the crossing of the Tetcela River tributary valley, to the crossing of the Tetcela River main stem, from about KP088 to KP089.4. The bedrock in the section immediately west of the river is mapped as a narrow north-south strip of calcareous siltstone and silty mudstone, possibly partly Mississippian (Douglas and Norris, 1976a). This layer continues east under the Tetcela River in a syncline beneath a formation including shale, mudstone, and limestone, and eventually under the Silent Hills. Upslope to the west, bedrock layers are as described in the previous section. Depth to bedrock is not known in this section, as no test holes are available.

A large old slump in sands and silts is mapped extending a considerable distance upslope of the road, between about KP088 and KP089.4 (Hawes, 1975) and is readily visible on both the 1994 air photos and the 2012 imagery. It is notable that while a scarp is marked on the east side of the valley in this section, no similar scarp appears on the west side, though there are also scarps marked further upstream on the west side. The scarp in this area may have been obscured by soils sloughing over the scarp, materials which are now being traversed by the winter road and/or have been modified by the Tetcela River. This slumped material will be further discussed in the next section.

5.1.9.3 Surficial Materials and Soils

Between KP086 and KP090.6, the all-season route follows the existing winter road, crossing a large Tetcela River tributary at about KP087.4 (Figures 8 and 9). From about KP088.0 to KP089.4, the route skirts the lower edge of a large slump (mentioned in the previous section) and the outside edge of the Tetcela River floodplain, up to the crossing of the Tetcela River main stem. KP088 is just north of a knife-edge ridge along the north crest of the Tetcela River tributary. At the valley bottom, the existing winter road heads north along the Tetcela River, over the toe of the debris from the large slump originating upslope and to the west. The main Tetcela River channel has cut into the toe of the debris east of the road. Sands and silts are anticipated here (Hawes, 1975). The floodplain is generally well-vegetated, and shows some scrolling and the occasional oxbow.

There are no obvious signs of distress along the winter road itself in this section, although there are two short bare sections at KP088.1 and KP088.3 possibly related to short steep rolling grades on essentially disturbed and possibly looser soils due to the slump (likely the same bare patches noted by Mollard in their 1995 report).The slope above appears generally well-vegetated, with some openings or areas with smaller trees and brush along streams and apparent slump scarps. These appear also to be related to areas of possible seepage or local wetter topographic lows. The adjacent stream and stream crossings show considerable movement/deposition of bed material. At about KP088.8 to KP089.2, there is a possible old incursion from the large slump to the west into the Tetcela River floodplain, although there is little change in elevation here, suggesting subsequent modification by the river. A few more recent instabilities are evident, with apparent exposed soil noted on the steep north sideslope of the stream gully at KP089.2, about 300 m upslope. As well, between about KP088.3 and KP088.9, the lower slope of the slump above the road shows numerous narrow fall-line strips that indicate the potential for periodic debris slumps or flows, although there is little evidence of debris on the existing winter road along most of this section (Figure 8). At about KP089.4, the road bends east towards the river, crosses the floodplain, and crosses the river at about KP089.9. There appears to be more than one existing route approaching the east bank of the Tetcela River. The road route threads between these apparent old approaches and what appear to be abandoned channels on the east side of the river. The road leaves the floodplain at about KP090.2.

The all-season route leaves the winter road at about KP090.6, heading upslope and southeast into higher, drier terrain. The route is directed to run primarily along ridges, knolls and hummocks along the periphery of this upland area, skirting around the crests of suspected old slope failures and local steep slope sections. Drainage is to the north and northeast, with crossings of streams or swales generally made near the crests of steeper slope sections.

Terrain is similar to that characterized further south. The route hereby avoids the more significant thermokarst ponds observed within the peatland terrain downslope of the proposed all-season route from KP092.8 on. At about KP093.9, just north of the north end of C-Lake, the route gradually descends and bends to the east around the south end of C-Lake. The route crosses into the alluvial plain and thermokarst terrain at about KP094.2, rejoining the winter road just west of the crossing of Fishtrap Creek and KP095 (Figure 10).

The hummocks and ridges along the upland section are anticipated likely to consist of SAND with silt content varying from trace to some silt to silty, with a trace of gravel, and silts with a trace to some sand. SILT is also likely to be encountered in the lower-lying areas between hummocks, with CLAY encountered at depth. These materials appear till-like, particularly the underlying clays (BH-08, TP-18/BH-09, BH-10, BH-11, and BH-12. The upper soils may be reworked tills, since the upslope area is mapped as sand/silt glaciolacustrine, ridged and hummocky. This deposit may be 2 to 5 m thick.

5.1.9.4 Permafrost

Permafrost and ice-rich soils have not been identified in the road section between KP086.6 and KP090.6, and although permafrost may be present, the winter route seems to have been performing reasonably well in this section. Ground temperatures may be moderated by the presence of the adjacent Tetcela River, and this section may also have some coarser-grained soils. The intent of the KP090.6 to KP095 reroute is to avoid most of the ice-rich and thermokarst-prone areas along the existing winter road to the northeast.

Most of the current reroute between KP090.6 and KP95 follows just above the toe of slope on higher ground, with the intent of accessing better-drained terrain with lower ice contents. No obvious patterned ground has been noted in the reroute, suggesting thermokarst issues should be minor here. The only potential exception noted on the aerial coverage is located in the vicinity of KP094.2 where the route crosses back into thermokarst terrain in order to cross the Fishtrap Creek valley and reach the Silent Hills (Figure 10). The potential of thermokarst terrain in this area seems to be confirmed in the soils encountered at the base of BH-12 at about KP094.4, with 10 to 20% excess ice observed.

However, despite the lack of visual indicators of thermokarst terrain upslope, permafrost may also be encountered along the upslope part of the reroute. Ice crystals (5 to 10% by volume) were noted in frozen peat in TP-14, located on a north-facing aspect east of the Tetcela River tributary, along a Tetcela reroute option considered earlier, well south of the current reroute. Ground temperature measured in the frozen peat in TP-14 was approximately 0°C at 0.6 m depth and, this late in the season, is indicative of permafrost, not just seasonal frost, despite the shallow depth. Soil moisture in the peat was measured at 298%. Because the ground temperature was essentially at the freezing point, this result probably reflects significant unfrozen soil moisture content. Suspected permafrost was also encountered at a depth of 1.2 m in BH-08, also located near the west end of the proposed earlier reroute, but a little higher on a west-facing slope. The base of BH-11 was frozen, with an estimated 10% excess ice in the form of laminations in sandy, silty clay soils.

Relatively well-drained soils on ridges and hummocks may mean that the top of the permafrost, where present, may be at depths of up to about 1.8 to 2.0 m. Permafrost depth in the low-lying areas will likely be consistent with other areas having similar soils and peat coverage, often in the range of about 1.1 m as seen on the uplands south of the route in BH-11 (Figure 9) and, as shown by TP-14, potentially as shallow as 0.6 m depending on peat thickness and slope aspect.

The primary area along the existing and proposed route with soils that are the most thaw-sensitive in the section is the portion between about KP094.2 and KP095, where the route re-enters the thermokarst area. The “inter-mound” soils between ridges and hummocks, however, should also be approached with caution, using embankment fill-only, as the frozen soils at the base of BH-11 were visually identified as having up to 10% excess ice, as noted

above. This observation is consistent with the mapping of “low” ice-content soils (Heginbottom, 1995), but still potentially high enough to be problematic if not managed with appropriate construction techniques. Permafrost with similar characteristics may also be present at depth within the ridges and hummocks, but there the buffer thickness is likely to be somewhat greater due to a thicker active layer and better-draining soils.

Ice contents are not known in the borrow areas, nor is it known whether permafrost will be encountered at the proposed borrow sites. The Tetcela River floodplain may or may not have permafrost, depending on proximity to the river and continuity of coarse-grained materials that would allow groundwater to easily reach the proposed borrow area. Upland areas may also have permafrost, but this will depend on thickness of peat, slope aspect, and soil characteristics which will be confirmed for specific sites when borrow requirements are better known. Borrow types consisting of sand or gravel mean that the active layer is likely to be deeper, hence more borrow would be available for extraction and use in one season.

This road section is within the area understood to have been affected by a fire sometime between 1940 and 1950. No recent fire has been identified in this section, and no obvious fire-related evidence of changes in the organic layer were seen in the test holes in this road section.

5.1.9.5 Borrow

Other than the above-noted sands and silts on both the alluvial plain and the glaciolacustrine uplands, alluvial gravels and sands are likely to be encountered at and near the crossings of the Tetcela River. Allnorth proposes borrow sites at the following locations: about KP087.5, just east of the Tetcela River tributary, consisting of alluvial gravel and cobbles, and at about KP090.4 (BP 90), KP091.5 (BP 92), KP093 (BP 93A and 93B), KP093.6 (BP 93C) and KP094.2 (BP 94), all consisting of sand/silt mixtures. Permafrost, including thaw-sensitive permafrost, is more likely to be found at these latter sites than at the river. Other limitations for this material type include the possibility of too-wet material at depth that would need drying to be usable, and use of this material being practical only in summer when it can be properly compacted. These scenarios become more likely with higher silt or clay contents.

5.1.10 KP095.7 to KP101.7

5.1.10.1 General

The road is to be re-routed on the west flank of the Silent Hills, west of Wolverine Pass, and incorporating some switchbacks, where small- to large-sized slope failures were noted by Golder. In 2012, SLI advanced 10 shallow boreholes in this section, designated “Silent Hills Switchbacks” (SLI 2012a). Tetra Tech EBA logged two confirmatory test holes in this section (BH-13 and BH-14; Figure 10). We noted that the pond at the HP99 helipad appears to be a sinkhole, and that another pond and a marshy area nearby may also be sinkholes. Because these features have the potential to affect a road in this area, the route was realigned to avoid them. Various slope instabilities and locations of suspected sinkholes are shown on Figure 11.

5.1.10.2 Geology

Topography and geology in this section are important in terms of karst features. Geology on this west-facing slope is mapped as approximately the eastern half of a large syncline. The two major units that may affect the likelihood of sinkholes are the Clausen formation (shale and thin limestone), and the Flett formation (argillaceous limestone, shale, sandstone and dolomite). Sinkholes have proved to be an important consideration along the proposed all-season road, which needed to be routed to avoid these features (Figure 11). Several sinkholes were successfully avoided with the previously proposed route. As a result of the 2014 work, further realignment of the switchbacks was done. The new route now also avoids the sinkhole identified in the pond at the helipad north of the route (HP99).

The suspected sinkholes at the nearby marshy area to the northwest and the marshy pond to the north are also avoided.

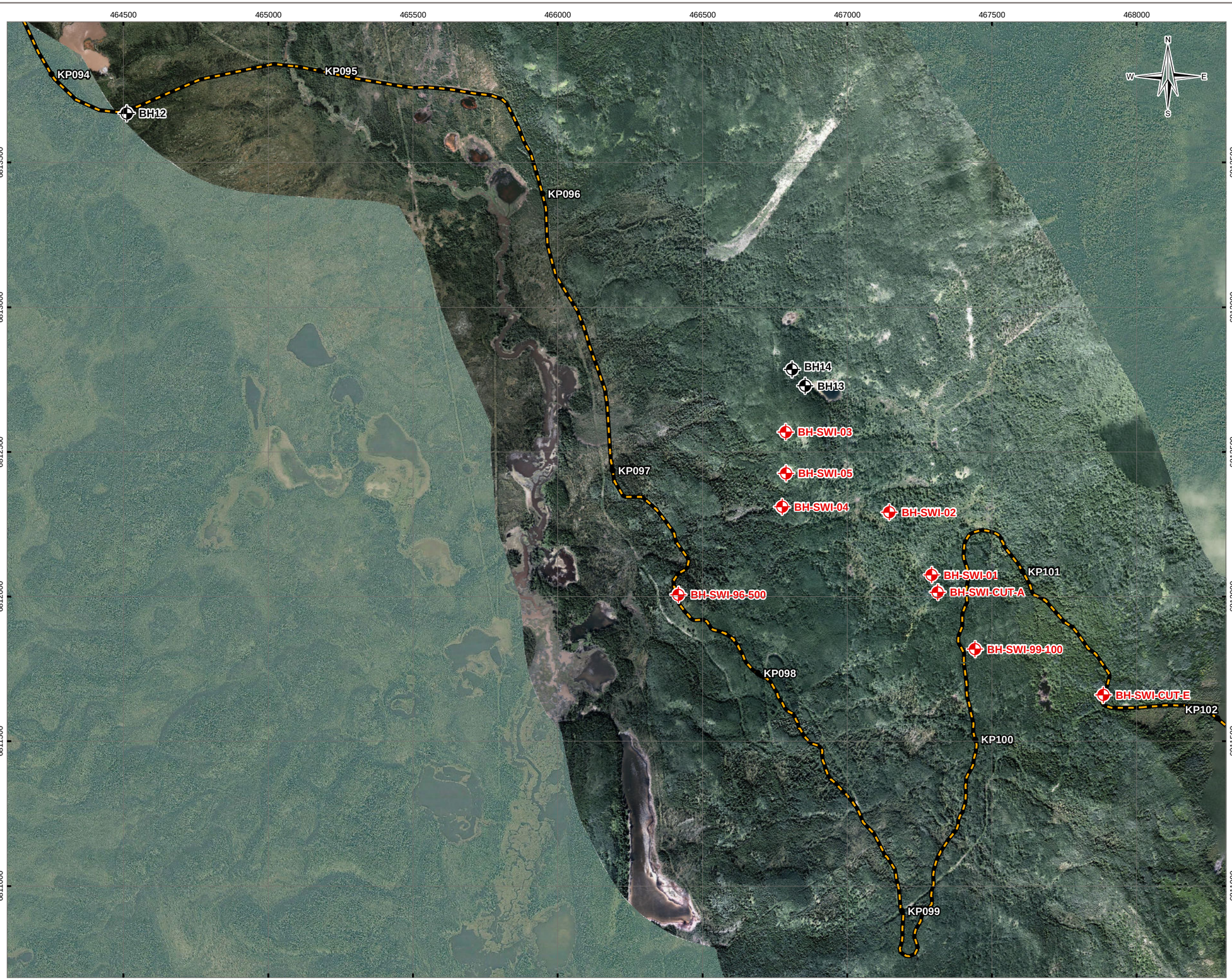
Bedrock also proves to be important in that bedrock outcrops and ridges are generally steeper, and where there is near-surface bedrock, such features tend to be trigger points for sloughing of shallow soils and potentially of weathered rock, which then tend to contribute to debris flows. Numerous features of this type are noted on the slope, most of which are minor, but some of which are significant. All of these features seem to be long-lasting, as all the features seen on the 1994 air photos are still visible on the 2012 imagery, and some new features are noted as well. The proximity of bedrock may also be related to the large numbers of debris flow features on the slope, including a few major ones. To the north of the route, for example, a large debris flow runs diagonally downslope. This is a reactivated feature mapped previously by the Geological Survey of Canada (Hawes, 1975), and mentioned as a recent event in Golder's 2010 report. Similar large features exist south of the route, and also appear to be related to near-surface bedrock at the head of gully features. Within the route, one debris flow gully that crosses the road at KP097.4 also has near-surface bedrock suspected within the starting zones (Figure 11). The upper reaches of this gully have been avoided with the realignment of the switchbacks.

Depth to bedrock is not known. GSC mapping shows the Silent Hills as having shale and limestone bedrock, overlain by a discontinuous residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels (Hawes, 1975). Fractured shale rocks were also noted within the soil samples recorded by SLI, with borehole depths ranging between 1.0 to 4.8 m (SLI 2012a). The presence of these fractured rocks suggests possible shallow bedrock, but bedrock has thus far not been proved in any test holes. Bedrock outcrops can be expected on ridgelines as evidenced by subparallel linear features seen on the aerial imagery, and it is likely that bedrock is near-surface on the steeper convex slopes. Hollows in the bedrock, or toes of slopes where the gradient flattens have likely become infilled with soils, whether till or colluvium. Since the road route is avoiding the steeper slopes, it is also likely avoiding the shallowest bedrock areas.

5.1.10.3 Surficial Materials and Soils

Peat/organic soils are generally encountered at ground surface in this route section. Tetra Tech EBA encountered fibrous peat with layer thicknesses of up to 0.25 m. In most cases, SLI's boreholes encountered organic soils with thicknesses ranging from less than 0.1 m, up to 0.3 m, but in the case of the BH-SWI-04 series of boreholes located just north of the KP097.4 debris flow gully, a thickness of up to 0.8 m of very loose, silty "topsoil" was noted (SLI 2012a). Despite this great thickness, only cold soils were noted, not frozen ones. Again, this may be a result of warm permafrost thawing upon drilling and thus not being observed, but SPT N blow counts are also quite low (7 to 11). Beneath the peat/organics, Mollard (1995) describes the surficial material as till, and soil descriptions by SLI in 2012 and observations by Tetra Tech EBA in 2014 indeed suggest a till-like material. Soils encountered included various silt and clay mixtures, with varying proportions of sand and gravel, gravel increasing with depth. Gravel sizes of up to 100 mm were noted by Tetra Tech EBA at shallow depths, with a flat and elongated configuration. Thickness of this unit is not known, but likely varies locally. As noted above, the presence of fractured rocks in the soil suggest possible near-surface bedrock, but some of SLI's boreholes noting such rocks were advanced up to 4.8 m deep.

Aside from the above-mentioned soil debris slides and debris flows, which appear to be associated with near-surface bedrock, there are also numerous wet or seeping areas, typically with slope gradients of 20% or less (Figure 11). Occasionally, these appear to be oriented in the same direction as nearby apparent bedrock exposures, so there may be preferential planes, bedding or jointing planes, along which the underlying bedrock has weathered or been eroded or scoured (for example, by glaciers), and subsequently infilled again with till or colluvial soils. Level or gently-sloped areas may then become wet or marshy, particularly if drainage from upslope leads into them. The switchback between KP098 and KP101 does cross a few small streams and some possibly wet areas, but these are considered less risky than sinkholes and multiple debris-flow gully crossings.



LEGEND

- Borehole
- SLI Borehole

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Fishtrap Creek and Silent Hills Switchbacks KP094 to KP102

PROJECTION UTM Zone 10	**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:13,000 — 200 100 0 200 Metres				TETRA TECH EBA
FILE NO. Y14103320-01_Figure10.mxd				
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 11, 2015			**Figure 10**

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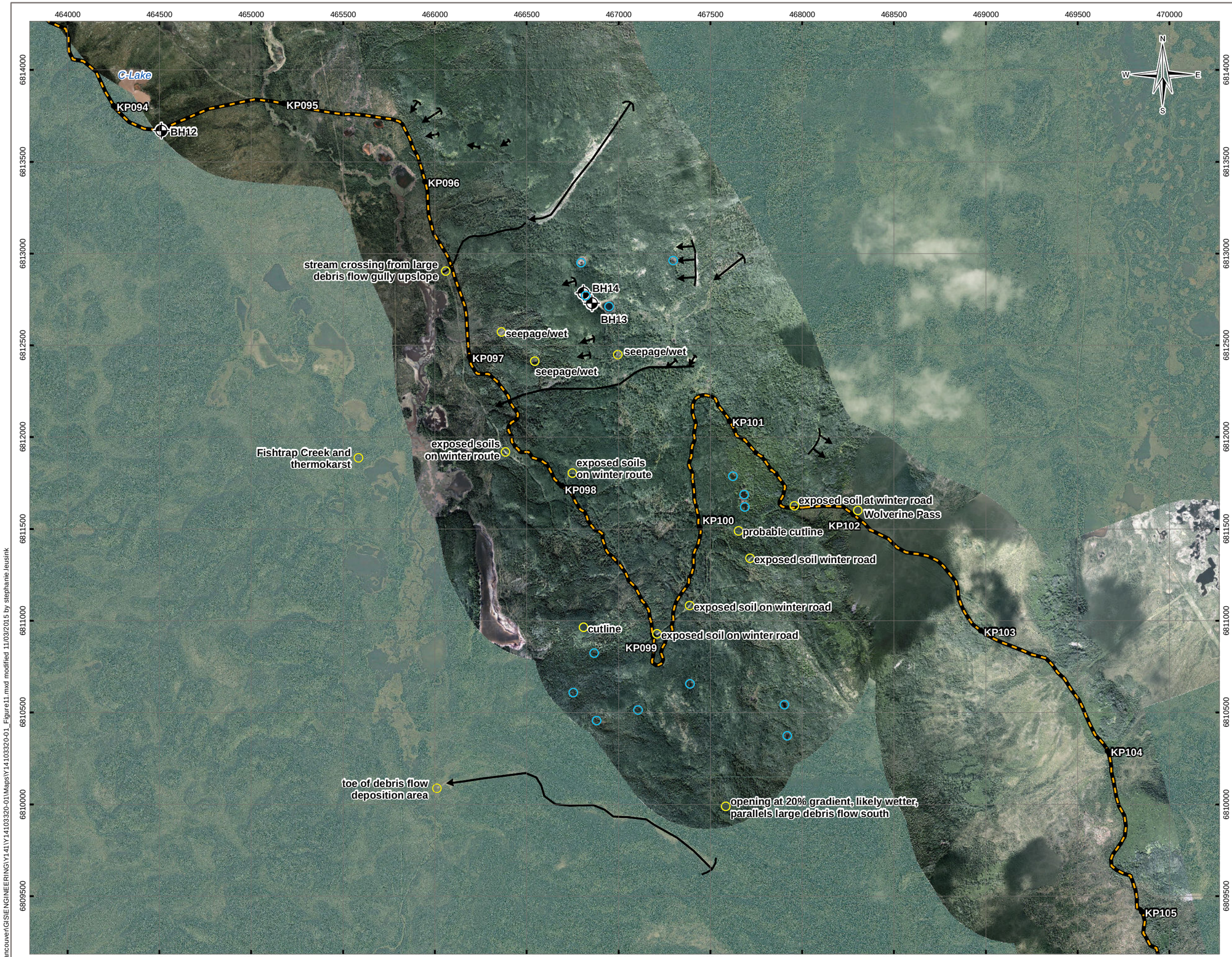

LEGEND

- Observation Point
- Sinkhole
- Borehole
- Slide

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Fishtrap Creek and Silent Hills Switchbacks KP094 to KP105

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:20,000 (400 200 0 400 Metres)		TETRA TECH EBA
FILE NO. Y14103320-01_Figure11.mxd		
PROJECT NO. Y14103320-01	**DWN** SL / **CKD** MEZ / **APVD** RKO / **REV** 0	**Figure 11**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015	

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5.1.10.4 Permafrost

Permafrost may be present in areas with thick peat cover, and in locally low-lying areas. The route generally appears to stay out of low wet areas, while also staying off the steeper ground. The presence of thick peat and fine-grained soils tends to favour the development of permafrost. Therefore, the apparent lack of permafrost in holes advanced so far could be due to the slope's west-facing aspect as mentioned above, or because the route is already avoiding the areas most likely to experience permafrost conditions. If encountered, permafrost temperatures are likely to be just below freezing, and the soils may be slowly thawing.

Active layer thickness (and/or depth of seasonal frost) is expected to range from about 1 m to 2.5 m depending on organic cover, soil types and aspect. Some sections of the route may be shaded at least part of the time by local topographic features such as knolls. Soils encountered to date in this road section appear to have moisture contents at or below the plastic limit, so it is anticipated that they should not be thaw-sensitive.

Thaw slumps have not been specifically noted in this road section.

Ice content and presence/absence of permafrost are not yet determined at the borrow sites. Cold soils were noted in several of SLI's boreholes along the proposed route, but none were identified as encountering frozen soils or permafrost (SLI 2012a). It is noted that these sites are on a slope with a west-facing aspect and as such are likely relatively warm. Permafrost, if present, may be fairly deep, especially in areas with thin organic cover. As well, the drilling method may have obscured the presence of permafrost. If the permafrost is only marginally frozen, the action of the drill or sampler can thaw the soil before the logger is able to observe it.

This road section is within the area understood to have been affected by a fire sometime between 1940 and 1950. No recent fire has been identified in this section, and no obvious fire-related evidence of changes in the organic layer were seen in Tetra Tech EBA's test holes in this road section.

5.1.10.5 Borrow

A few borrow sites are proposed by Allnorth on this section of road, and they have anticipated the types of materials likely to be encountered based on material types encountered nearby and/or photos. These sites are located at KP096 (BP96, likely silty sand), just south of KP097 (BP97, likely silty sand), KP102 (BP102, likely fine sand, based on photo of cutslope by SLI) and east of KP101.7 (BP102B, likely silty sand). These sites have not been investigated by Tetra Tech EBA. Allnorth is understood to have field-checked BP102, which on the air photos appears to have an exposed soil area alongside the winter road, and SLI drilled a borehole in 2012 just west of BP102 which encountered silt with a trace of gravel (BH-SWI-CUT-E, Figure 10). It is noted that the local silt soils are frost-susceptible, however, and the sandy soils can also be frost-susceptible if they have more than 10% silt. Proposed borrow areas should be tested to confirm suitability for their proposed uses.

5.1.11 KP101.7 to KP118.0

5.1.11.1 General

The all-season road is to be relocated west of the old winter road and along the east flank of the Silent Hills so as to avoid much of the ice-rich terrain anticipated by Golder along the valley bottom. Allnorth obtained some soil samples in this section on behalf of Tetra Tech EBA after our departure from site (Allnorth testpits EK-1, EK-2, and EK-3, located as shown on Figure 12). Note that due to recent changes in the route in the KP095.7 to KP101.7 (old KP102) section, some of the station numbering referenced in the following sections may be offset by up to 0.3 km. However, locations are identifiable by landmarks.

5.1.11.2 Geology

Bedrock in this road section is part of the Yohin Syncline. Based on topographic mapping superimposed on the geology mapping, it appears that the ridgeline along the top of the Silent Hills consists of thinly-bedded sandstone of the Yohin formation, which is a relatively resistant layer that results in the outcrops seen upslope at various points along this section of the route. Immediately east of the sandstone and underlying it, are black fissile shale, mudstone and limestone, possibly partly Mississippian. This layer is not evident at ground surface.

Progressing further to the east, and in turn beneath the possibly-Mississippian layer, there is a layer of calcareous siltstone and silty mudstone. This layer is at about the correct distance from the ridgeline such that the knolls seen along the proposed road route are probably the remnants of this relatively more-resistant layer outcropping near the downslope edge of the main slope. Further confirmation of rock types can be anticipated if and when specific knolls are selected for potential borrow areas. Finally, the Fort Simpson formation, consisting of shale and siltstone, is mapped east and beneath these layers.

Limestone appears to be a minor enough component of the anticipated rock types that karst topography is considered unlikely in this section. No obvious sinkholes or other characteristics were noted in the area for which stereo coverage is available (to about KP115, at the edge of the air photos). A small bedrock outcrop is mapped just east of the alignment within the floodplain at about KP117.1 (Figure 12), and is visible on Bing coverage (Hawes, 1975; Bing 2014). The bedrock at this location is likely part of the Fort Simpson formation. A potential borrow source is proposed there (BP 117).

Depths to bedrock are not known in soil-covered areas, but there are numerous bedrock outcrops along this route section.

5.1.11.3 Surficial Materials and Soils

From about KP102.2, the route follows the southerly turnoff of the winter road to KP102.4, where it departs from the winter route, crossing it again three times by about KP103.9, and then heading south while the winter route turns east (Figure 11). The existing winter road tends to skirt along toes of steeper slope sections, and the all-season route is on higher ground. From about KP102.7 to KP103, and KP103 to KP103.3, the proposed all-season route skirts across the toes of two small alluvial fans originating from upslope, first staying a little lower on the slope and then a little higher on the slope compared to the winter route, staying closer to on-contour between KP102.7 and KP103, and thereafter descending and crossing the winter route again to meet the next low ridge. The alluvial fans are mapped as consisting of silt, sand and gravel. They are reasonably well vegetated but there are some areas with little or no trees. Exposed rock near the peak of the ridge suggests activity could resume under the right conditions.

From KP103.3 to KP109.5, the route runs upslope of the knolls. Surficial geology is mapped on the upper slopes and near the knolls as residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels, and between and/or upslope of the knolls as colluvium (Hawes, 1975). Based on similar mapping along the Front Range (Hawes, 1975) and soil samples obtained there and along the upper proposed route at KP116, till-like soil textures are anticipated on this slope.

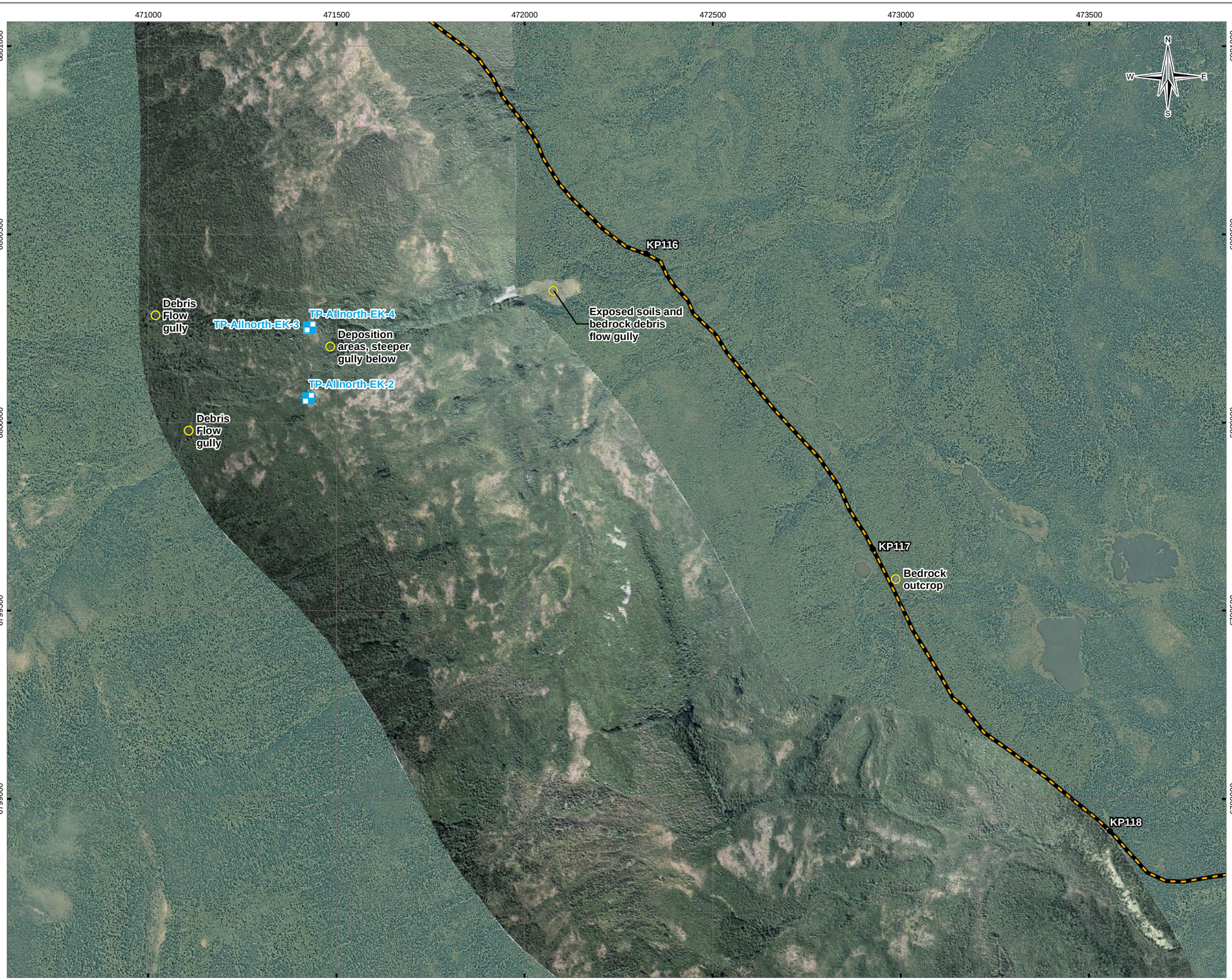
From KP103 to KP105.8, the route stays on the higher ground where possible and skirts the upslope toes of the knolls. Between KP105.8 and KP106.6, the route is just above the toe of the knoll and just below some apparent surface sloughs. Probably these sloughed areas are bedrock-controlled, given the location, and they appear to be relatively small. It is anticipated that some of the hazard will likely be removed when the bedrock is utilized for borrow, reducing the slope height and proximity to the alignment. From KP106.6 and KP107.1, the route minimizes its length in the drainage crossing, which could be related to an old cross-slope meltwater channel starting at

KP105.9 above the knoll and draining south, subsequently modified by downslope flow and possibly slope movements, leading to a gully at KP106.8 (old KP107). Topographic mapping (NTS 1:50,000) shows this gully to have a large bowl-shaped area draining to it from the south and west, which appears to be mapped as colluvium. Vegetation in the bowl is patchy, with areas of little or no trees or brush, and some very occasional small areas that might be exposed soil, mostly along the main channel. The west fork of the stream appears steeply gullied with exposed ground at about 2 km upstream of the road route, which suggests that this stream could experience debris flows at times. This is a case where a feature is not easily avoided. However, the crossing is in a reasonable location away from the steepest ground. The possibility of debris flows will have to be accounted for in the detailed design. Between KP107.1 to KP109.5, the route skirts the upslope toes of knolls and stays above gullied terrain.

From about KP109.5 to KP115, the route runs upslope of the large knolls, and soils mapping continues as described above. Between KP109.5 to KP110, the route skirts the upslope toes of knolls and stays above gullied terrain. From about KP110 to KP110.8, the route skirts around the lower edge of a bowl-shaped area. This area may be an old slope failure scar, from KP110 to KP110.2, but may also be bedrock-controlled, due to a ridge just north and the knoll south. The route continues on the upslope side of the knoll, and upslope of drainage gullies at about KP110.6 and KP110.8. Between KP110.8 and KP112, the alignment avoids a wet area and climbs on and off the north end of a large knoll, crossing an upslope swale at about KP111.8. From KP112 to KP114, the route skirts around the upslope toes of knolls and stays just upslope of gullied terrain. Good control of drainage will be required in this section. Between about KP114 and KP114.5, the route traverses along the crest of a small ridge and then descends to a stream crossing. Near-surface bedrock is suspected on this ridge, as its orientation is sub-parallel with the exposed crest of the knoll at KP113. A slight realignment just west of the ridge-top could be considered to increase the distance from an apparent slough on the downslope side. This can be fine-tuned during final design and layout.

Between KP115 and KP116, the route descends from just above the large knolls down to the glaciofluvial plain, crossing a swale with probable multiple small streams in it at about KP115.5. Soils encountered during terrain-typing upslope of KP116 were identified as silty sandy CLAY with trace gravel. These soils are consistent with the mapping and the expectation of till-like soils. The clay is low plastic, with a plastic limit of 15 and a liquid limit of 27. Soil moisture content varies from 15 to 18 to 26%. It is further noted that the area visited for terrain-typing (Figure 12) is within a suspected local deposition area on two upslope forks of a large debris flow gully. The highest moisture content of 26% suggests that this material could remobilize if additional water is added, due to infiltration from rainfall, for example. Since it is already in a deposition area, this probably means further spreading out of the deposit, but also potentially means that it could continue downstream. Downstream reaches of the gully are also prone to scouring, and effects of debris flows could occur well onto the floodplain. A large area of exposed soil and layers of apparent bedrock is noted along the north slope of the gully, just upslope and west of the proposed road route. This scoured and/or failed slope is up to about 220 m long by 75 m wide (Appendix C, KP115 to KP116). The exposed rock may be composed of calcareous siltstone, which may be why it appears relatively resistant to scouring.

The immediate vicinity of the KP116 stream crossing and further downstream currently appears well-vegetated, but the prevalence of deciduous vegetation in this area suggests these vegetation types are likely indicators of disturbed terrain at this location (Figure 12). Therefore, the road design will need to consider suitable plans for managing a debris flow at some point during its service life, whether it is to build a bridge, or install a crossing over which debris flows can flow without either scouring out the road or having it inundated with debris, install upslope containment measures, or even to install a sacrificial crossing. The most suitable design will depend on the type of event most likely to be experienced at the crossing – scour or deposition – and whether the likelihood of scour or deposition may vary according to the size of event or according to whether successive events change the site configuration, requiring further adaptations in the future. It is noted that ortho-imagery and LiDAR are not available over the full length of the gully, and more detailed topographic data will be needed for detailed design. The route skirts the edge of the glaciofluvial floodplain between KP116 and KP117.5, where the terrain begins to moderate.



LEGEND

- Observation Point
- Allnorth Testpit

Proposed All-Season Road

- Phase 2

NOTES
Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

East Side of Silent Hills
KP116 Debris Flow

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH EBA

FILE NO. Y14103320-01_Figure12.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01	SL	MEZ	RKO	0

OFFICE Tt EBA-VANC
DATE March 11, 2015

Figure 12

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From KP117.5 to about KP118.5, the route crosses the glaciofluvial plain (gravels and sands) between the slopes of the Silent Hills to the west and a large meltwater channel to the east. The ascent/descent on the west approach to the meltwater channel is from about KP117.9 to KP118.5 alongside the stream south of the road.

As noted above, there are debris slides and slumps, as well as debris flow gullies on this slope, but most of these features are either avoided, or crossed in what appears to be the most manageable location, that is neither a main scour area, nor a main deposition area. Where such features are unavoidable, mitigations can be designed on a site-specific basis, and good surface water management will assist in this effort. It is noted that not all slope events can be controlled. For example, debris flows from upslope are entirely natural events, and it may not be possible to prevent all possible impacts from such events on the road route.

5.1.11.4 Permafrost

There are no obvious signs of permafrost patterned ground or thermokarst in this road section; however, there is a small round pond just southwest of KP117 that may be of thermokarst origin. Other nearby ponds to the east in this area seem to be associated with meltwater channels. There is a small opening at KP118 which could be a low wet area, and a small pond just north of KP118.2.

This east-facing slope is likely to be somewhat cooler than the west-facing slope of the Silent Hills. Permafrost is therefore more likely. Locally, low-lying areas would have thinner active layers, with permafrost potentially present at depths of about 1 m in fine-grained soils such as silts and clays, possibly shallower if a thicker peat layer is present, or deeper if there is less peat. In coarser-grained soils, active layers of 2 to 3 m could be anticipated, more if there is little or no organic cover. The active layer in bedrock is likely to be much thicker due to higher conductivity, but in most cases, it is less important whether the bedrock is frozen or not. Ground temperatures in permafrost are likely to be slightly below freezing.

There is no obvious evidence suggesting the presence of ice-rich soils in this section of the proposed road. Thaw slumps do not appear to be present in this road section.

Given the anticipated bedrock types, there is potentially more weathering and thus potentially higher ice content. For the currently-proposed bedrock borrow sources, however, most of these sources are elevated above the surrounding terrain, so would be less likely to contain excess ice. At BP 103, however, the characteristics of the clay till material anticipated by Allnorth are not known. If thaw-sensitive permafrost is present here, this will affect the usability of this source.

The north end of this road section, up to about KP110, is within the area understood to have been affected by a fire sometime between 1940 and 1950. No recent fire has been identified in this section.

5.1.11.5 Borrow

Generally, Allnorth is proposing that the knolls downslope of the route be used for borrow. These sites are anticipated to consist mainly of bedrock, but may have some useable surficial deposits as well. Several proposed sites are located at about KP102 (BP 102), KP102.2 (BP 102B), KP103.7 (BP 103), KP104 (BP 104), KP106.6 (BP 107), KP111.7 (BP 111), KP116 (BP 116), and (BP 117).

It is noted that BP 103 was observed by Allnorth to consist of potential clay till material overlying probable carbonate rock. Aside from the potential for thaw-sensitive permafrost within the clay, other limitations for this borrow source include the possibility of too-wet material that would need drying to be usable, and use of this material being practical only in summer when it can be properly compacted. Since the priority at BP 103 is the underlying carbonate rock source, overburden material that is not suitable for fill will be stockpiled for re-use in reclamation.

A borrow area is proposed between the road and the scoured slope along the debris flow gully at KP116 (BP 116), but this site will have to be further investigated to confirm whether suitable borrow materials are present, and whether they can be excavated without increasing the risk to the road from future debris flows.

5.1.12 KP118 to KP159.4

5.1.12.1 General

This road section extends from west of Grainger Gap, east through the Gap (Figure 13), then south to the Liard River (Figures 14, 15, and 16), so as to meet the old Nahanni Logging Road east of the Liard River. Tetra Tech EBA logged 14 test holes along this section (TP-04, TP-05, and TP-15 as shown on Figure 13; TP-16, TP-17, TP-25, BH-15, and BH-16 as shown on Figure 14, TP-22, TP-23, and TP-24 as shown on Figure 15; and TP-19, TP-20, and TP-21 as shown on Figure 16). Note that due to recent changes in the route, some of the station numbering in the following sections may be offset by up to 0.4 km; however, locations are identifiable by landmarks.

5.1.12.2 Geology

Bedrock exposed at Grainger Gap from west to east consists of the Nahanni formation, the Landry formation, and the Arnica formation. The Nahanni formation consists of limestone, grey, finely crystalline to bioclastic, thickly bedded; and dolomite, finely crystalline. The Landry formation consists of limestone, grey, finely crystalline, thickly bedded. The Arnica formation consists of dolomite, finely crystalline, partly finely porous and vuggy (coarse pores lined with crystals of other minerals), banded dark and medium grey weathering; brecciated in part (Douglas and Norris, 1976a). Colluvium above the route at about KP123 may be due in part to steeply-dipping bedding planes in the Nahanni formation above the route at this location.

On the east side of the Nahanni Range, and east of Grainger Gap, there is a thrust (reverse) fault running roughly north-south, with the above-described carbonate strata thrusting over the shale and siltstone to the east (Douglas and Norris, 1976a). This thrust fault conceivably contributes to periodic toppling failures of the carbonate strata located upslope to the west of the road alignment, although such failures may also have other contributing factors including erosion by water and loosening of talus blocks due to frost-shattering. On occasion, such failures can also result in debris flows, with the most likely contributing factor being seepage from groundwater recharge along the ridge entering open joints and bedding planes. Seepage could also contribute to additional ice building up in debris deposits, leading to the deposit slowly creeping downslope. One example of this type of failure includes the rock glacier at about KP126.4, where new material falling at the top tends to push the earlier debris further downslope. Groundwater seepage has likely frozen in the debris, allowing creep of the ice in the interstices of some potentially very coarse-grained materials, based on the sizes of talus blocks seen at various locations on the slope (some blocks of up to 1.5 m by 2 m by 5 m were noted). More such features are present heading south along the Front Range. While much of the carbonate strata seem to be exposed, most of the shale strata seem to be obscured by surficial sediments.

The bedrock strata become more complex further south along the route. Just north of Bluefish Lake, upslope of about KP144.5, for example, another north-south thrust fault begins. Here, the Landry formation becomes the Manetoe formation, which is its approximate equivalent, being formed of dolomite that is coarsely crystalline, vuggy, and massive. The double thrust along with various anticlines and synclines have resulted in multiple exposures of the same rock types, continuing south for about 10 km with the thrust faults eventually meeting upslope of about KP153. Here, a new thrust fault begins to the west, resulting in another double set of rock exposures, as well as a new exposure of the Horn River formation between the two sets of exposures, forming Nahanni Butte (mountain). The exposed L-shaped bluff above the route between about KP157 and the Liard River is another source of debris falling on the slopes below, with faulting resulting in a rotational slide (and potentially also toppling along this steep

bluff), and subsequent debris flows downslope (Hawes, 1975; Douglas and Norris, 1976a). Again, seepage from groundwater recharge originating upslope probably drives the debris flow process.

Such rockfall or rotational rock slides, and the accompanying debris flows are natural features, and will occur whether or not the road exists.

Except where exposed as outcrops, depth to bedrock is not known along the route, as none of the test holes were deep enough to penetrate to it.

5.1.12.3 Surficial Materials and Soils

Between KP118 and KP122.9, the all-season route traverses a wide glaciofluvial plain (gravel, sand) and skirts below the toe of a large alluvial fan to the southeast (Hawes, 1975). Significant ridged features are not obvious, but the route crosses relatively high ground compared to the terrain northwest and southeast, avoiding bogs. There is one significant stream crossing at about KP122.4, which appears to originate from the boggy area upslope, above which is a large alluvial fan (Figure 13).

Between KP122.9 and KP123.3, there is a small elongated lake to the west, whose outlet drains east. This area drains a larger lake (Gap Lake) located to the northwest of Grainger Gap. The outlet stream has three beaver dams south of a large alluvial fan originating from the north (current winter road route and north of the all-season route), located between about KP122.85 to KP123.3, and these dams tend to cause flooding in the local drainage to the west. The all-season road will not be affected by the beaver dams as it will be well upslope to the south. The currently-proposed stream crossing is about 50 m downstream east of the eastern-most beaver dam and adjacent to a large rock bluff. Allnorth proposes a full bench cut in rock. The affected slope is densely treed with small trees, most of which are less than 5 cm in diameter and generally less than 10 to 15 cm in diameter. Tetra Tech EBA logged two test holes on this slope, with peat varying from 50 to 300 mm in thickness, and mineral soils varying from silty gravelly SAND to SILT with a trace to some gravel and a trace of sand. At the east end of the bluff, a steep bedrock outcrop was noted. The streambed is formed of cobbles, whereas the floodplain is silt, sand, and gravel and is overgrown with willow where vegetated. The winter route meets/separates from the all-season route at about KP122.5 at the west end. The all-season route crosses apparent colluvial terrain from upslope south between about KP122.9 and KP123.2. This area is a series of old failures, probably post-glacial. From about KP123.2 to KP123.3, the terrain may also be colluvial but there appears to be shallow bedrock control at the edge of the feature (Figure 13). Due to the bedrock control, the road appears to be ideally situated in this section.

The all-season road turns south at KP124.8, leaving Grainger Gap (Figure 14). The overall intent of the all-season road is to stay above the low wet ground along the Grainger River, as well as to obtain a more direct route to the Nahanni Butte Access Road. The route will more closely follow the winter route for about 2 km south of Grainger Gap, to about KP126.4 on the Grainger River floodplain, then climbing gradually south and away from the winter route, out of the floodplain. The floodplain is mapped as a gravel alluvial plain, with materials consistent with those seen upstream in the meltwater channel forming the Grainger Gap. For a few kilometres south of KP126.4, the winter road roughly parallels the all-season route, as further described below.

Soils upslope and west of the Grainger River floodplain are mapped as a discontinuous residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels (Hawes, 1975). SAND with some gravel, to gravelly, was encountered at TP-15, in a slope failure at the toe of slope just west of about KP124.8. Layers or lenses of silty sand and cobbles/boulders were also noted. Talus and scree were noted further south along the toe of slope. Ravelling is expected from upslope, especially between about KP125.2 and KP125.6. There is potential also for larger rocks tumbling or toppling from the bedrock exposed above the scree/talus slope. Periodic debris flows are anticipated on the alluvial fan at KP125.6 to KP126.

LEGEND

- Observation Point
- Testpit
- Peatland Permafrost
- Slide

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Grainger Gap
KP121.5 to KP125.5

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	CANADIAN ZINC CORPORATION

Scale: 1:10,000
100 50 0 100
Metres

TETRA TECH EBA

FILE NO. Y14103320-01_Figure13.mxd

PROJECT NO.	DWN	CKD	APVD	REV
Y14103320-01	SL	MEZ	RKO	0

OFFICE Tt EBA-VANC
DATE March 11, 2015

Figure 13

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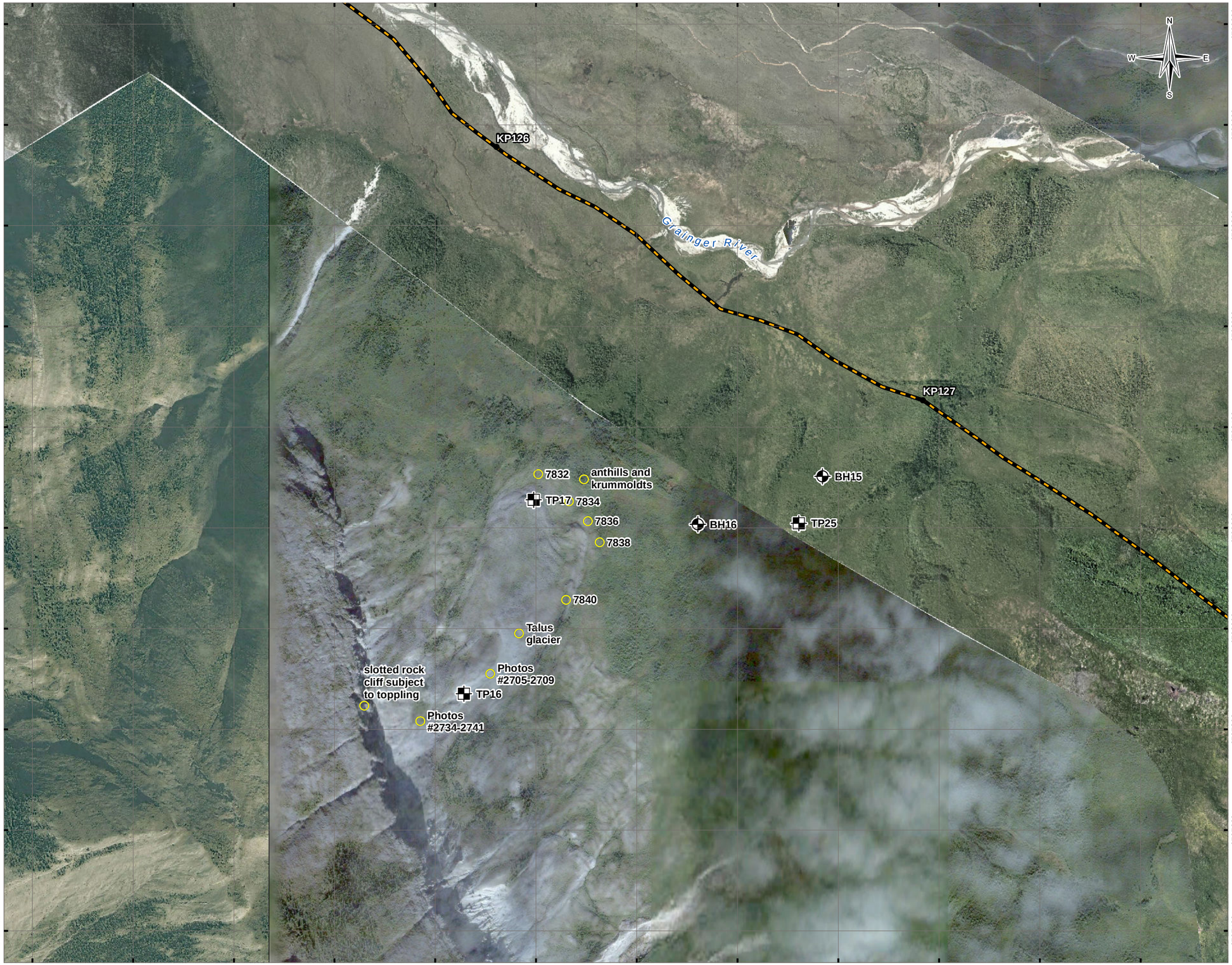

LEGEND

- Observation Point
- Borehole
- Testpit

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Google; DigitalGlobe (2007); Microsoft Bing Maps Imagery Service for ArcGIS.

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Proposed Borrow on Talus Glacier Near KP126.4 and Terrain Units to KP127

PROJECTION UTM Zone 10		**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:7,500 (100 50 0 100 Metres)					TETRA TECH EBA
FILE NO. Y14103320-01_Figure14.mxd					
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0	**Figure 14**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015				

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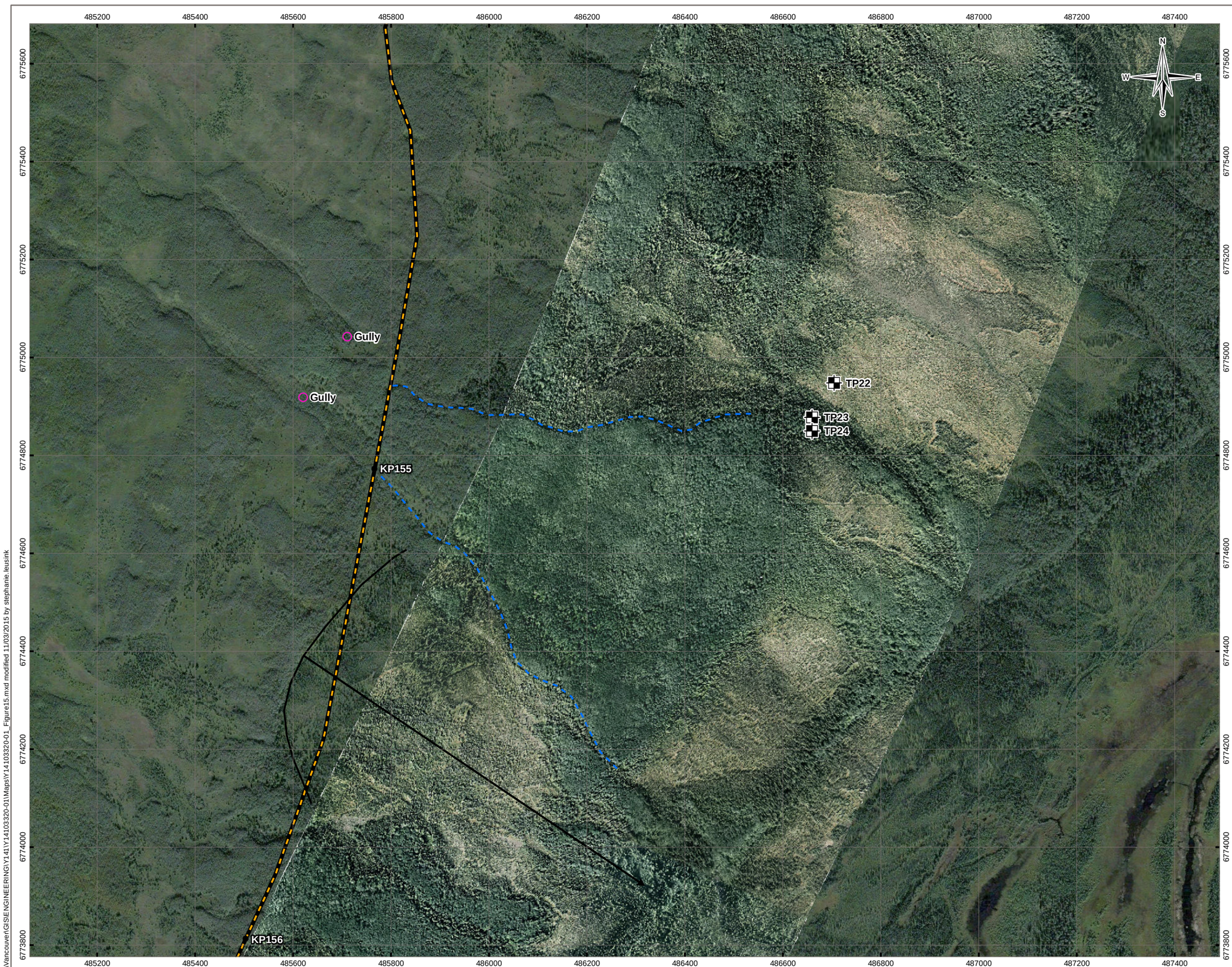
For these reasons, it appears that the route of the winter road would be more favourable between about KP124.8 and KP126.4, in order to avoid what are likely to be ongoing upslope hazards. Allnorth has therefore made some alterations to the route in this area to avoid some problematic terrain features, both upslope and downslope, but is considering the area along the toe of slope as possible locations for granular borrow and/or a quarry (telephone correspondence, January 20 and 22, 2015; E.Kragt, R.Kors-Olthof). Since these slopes are already ravelling, extraction of borrow might mean additional ravelling or outright slope failures in talus/scree, as well as failures in bedrock. If the sources are proposed for use, detailed plans would be needed to extract materials safely.

Near-surface soils encountered during terrain-typing upslope of the route between about KP126 and KP126.8 (Figure 14) include SANDs in ridges (TP-25), silty sand CLAYs or clayey sandy SILTs with some gravel in lower-lying areas, and increasing gravel with depth; till-like (BH-15, BH-16). These soils appear to be generally consistent with the above-mentioned mapping, though finer-grained near the ground surface. Granular debris was encountered further upslope, varying from crush-like GRAVEL near the upslope end of the rock glacier at TP-16 and BLOCKS and BOULDERS in a talus mound within the rock glacier at TP-17. The rock glacier is about 200 m wide and 700 m long, with the toe about 380 m upslope of the proposed route and the TP-17 area about 550 m above the route.

After crossing a tributary of the Grainger River at about KP126.6, the route gradually climbs out of the floodplain into till moraine terrain with flutings and drumlins, crossing another tributary at about KP127.1. The route remains in till terrain to about KP128.3, skirting along the downslope side of a long ridge, just below the transition between near-surface bedrock and residual/colluvial soils upslope and the till terrain downslope, then traverses across a swale on the upslope side of the ridge. Due to the variable terrain, good control of surface water drainage will be important in this section; however, the road generally avoids low wet terrain in this traverse.

From about KP128.3 to about KP140.0, the alignment generally skirts along and across the transition between terrain units mapped as near-surface dolomite or limestone bedrock (as described in the previous section) with residual or colluvial veneers or rubble of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels upslope, and thicker tills downslope. The tills generally vary from drumlinized and fluted, to subdued rolling moraine with hummocks and ridges. Gravel is common in the upslope tills. The route skirts along the toes of alluvial fans and cones, as well as rock slumps or rock glaciers similar to the above-mentioned KP126.5 rock glacier (Hawes 1975). Mollard (1984) also mapped some low flat-topped ridges between about KP131 and KP134.5 that may be till and/or granular materials, and some possible slumped kame terraces between about KP134.5 and KP141.

The all-season route was re-aligned to avoid two possible slope failures about 100 m upslope of the road at KP129.6 to KP129.8 and KP129.8 to KP130.0). Possible exposed soil along a stream about 550 m upstream of KP136.5 indicates the potential for debris flows. However, slope gradients are less than 7% above the road to the suspect area, and the stream channel otherwise looks well-vegetated, so such events probably do not reach the road elevation very often. Exposed ground (soil or rock) along upstream reaches of the channel above KP137.2 is probably more indicative of near-surface bedrock there, but could result in debris flows. Slope gradient is about 10% for 200 m above the road. Debris flows at KP136.5 and KP137.2 can affect the road by either scouring or deposition, depending on the mobility of the material. Aerial coverage indicates old slope movements ended below the road (Google Earth 2007). Debris flow channels may also shift from current locations. The route skirts along/over the toe of possible rubble in a talus lobe at KP137.2 to KP138, mapped by Hawes (1975). This site may overlap with Mollard's (1984) mapping of a slumped kame terrace. If this material is ice-rich, then the road should be constructed with embankment fill only, but if it is not ice-rich, it may be a useful source of borrow material. A possible debris flow lobe is seen at about KP138.1.



LEGEND

- Gully
- Testpit
- Alluvial Fan
- Slide

Proposed All-Season Road

- Phase 2

NOTES

Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Google; DigitalGlobe (2007).

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Terrain Units and Slope Features Near KP155

PROJECTION UTM Zone 10	**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:7,500 — 100 50 0 100 Metres				TETRA TECH EBA
FILE NO. Y14103320-01_Figure15.mxd				
PROJECT NO. Y14103320-01	**DWN** SL	**CKD** MEZ	**APVD** RKO	**REV** 0
OFFICE Tt EBA-VANC	**DATE** March 11, 2015			**Figure 15**

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Between about KP140 and KP144.5, the route traverses a moraine plain with drumlins to the outlet of Triangle Lake, and then a moraine plain with flutings to KP146.8. The road route follows the east side of a small meltwater channel between the south end outlet of a small lake north of Triangle Lake at KP142.3 and the north end of Triangle Lake at KP143.4. A smaller meltwater channel with a pond upslope of the road joins the channel at the south end of the small lake. Allnorth's sampling at the road crossing over the channel indicates sandy gravel soils, but the drainage appears poorly defined. The route generally stays out of the meltwater channels except for the crossing area. A drumlinoid ridge or fluting is mapped sub-parallel and southeast of the small lake between about KP142 and KP143, and east of the alignment. The contours suggest that there may be some water drainage towards the road between ridges or flutings. Drainage locations and directions will be confirmed during detailed design and layout in this area.

From about KP146.8 to KP150, the route crosses a till moraine plain. At KP146.9, the road crosses a stream draining east from a wetland to the west.

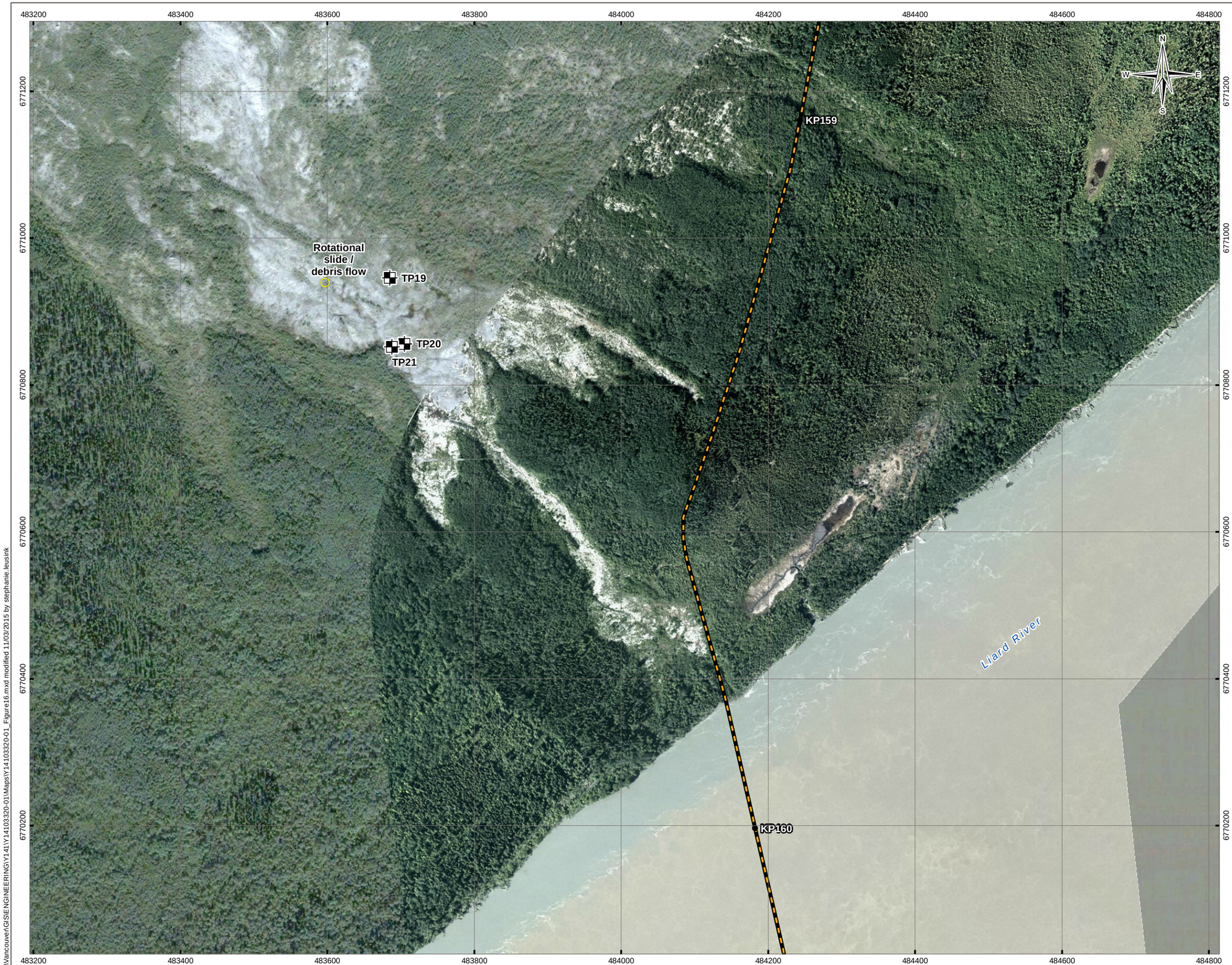
From about KP150 to KP159.5, the route is primarily within till moraine veneer of less than 1.5 m in thickness, with 16 to 49% of the terrain mapped as colluvial complex of 1 to 6 m in thickness. Colluvium can be derived from all types of surficial deposits (Hawes 1975). Between about KP151 and KP154, the route runs approximately parallel to, and 300-400 m downslope of, a mapped linear escarpment. The transition between till veneer and colluvium upslope and till moraine plain downslope is not certain here (Hawes 1975). The linear escarpment is clearly visible on Google Earth 2007 imagery. The proposed road crosses near the apexes of alluvial fans at KP151.6 and KP152.6, the former of which is proposed as borrow. The presence of these fans indicates the likelihood of future debris flows. Crossing at the apexes is good for limiting the length of road potentially subjected to impact by debris, but does include a possibility of the road being scoured out at these crossings.

A suspected old alluvial fan is present below about KP155, with two gullies crossed near the apex at this location (Figure 15). There is a possible old slope failure from about KP155.2 to KP155.7 where the road route crosses below and then above the suspected headscarp. Indications of a fairly recent debris-flow crossing the road alignment occurs at KP158.9 to KP159.0 (Figure 16).

A rotational slide / debris flow is mapped above the road alignment near the Liard River, originating from Nahanni Butte at the southeast peak, flowing down in a three-pronged fork almost to the road alignment and alongside it (Figure 16; Aylsworth and Traynor 2001). The northeast prong ends about 25 m above the road alignment according to 2007 Google Earth coverage, and its extent appears to be similar on the 2012 imagery. The toe of the prong is presumably a deposition area, but future flows could overrun the road or plug culverts, resulting in maintenance and/or safety issues. The middle fork has a stream mapped in it on the LiDAR. Repeated slide / debris flow events have potential to reach the road and/or the Liard River. The 2012 imagery suggests recent events have come within 50 m of the river, and a less recent event (revegetated) has reached the river. The route skirts the left (northeast) flank of the debris toe for about 150 m, climbing out of the valley bottom. The road is likely to be a deposition area or it may be subject to scour from debris flows.

5.1.12.4 Permafrost

The north- and east-facing slopes and/or shaded areas along this route section are likely to be somewhat cooler than west-facing slopes at the same elevation, similar to the east-facing slope of the Silent Hills. Permafrost is therefore more likely than on west-facing slopes, particularly at the higher elevations, since the road climbs up from the Grainger River at 480 m to a high point above about 640 to 670 m between about KP132 to KP138 before it descends again to the Liard River at about 180 m.



LEGEND

- Observation Point
- Testpit

Proposed All-Season Road

- Phase 2

NOTES
Base data source:
LiDAR imagery provided by McElhanney (2012).
Background imagery provided by Google; DigitalGlobe (2007).

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL-SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Proposed Borrow Upslope of KP159.4

PROJECTION UTM Zone 10	**DATUM** NAD83	**CLIENT** CANADIAN ZINC CORPORATION	
Scale: 1:5,000 (100 50 0 100 Metres)		TETRA TECH EBA	
FILE NO. Y14103320-01_Figure16.mxd			
PROJECT NO. Y14103320-01	**DWN** SL / **CKD** MEZ / **APVD** RKO / **REV** 0		**Figure 16**
OFFICE Tt EBA-VANC	**DATE** March 11, 2015		

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The lower the elevation, the greater the depth of the active layer. Locally, peat-covered low-lying areas would have thinner active layers, with permafrost potentially present at depths of about 1 m in fine-grained soils such as silts and clays, possibly shallower if a thicker peat layer is present, or deeper if there is less peat. In coarser-grained soils, active layers of 2 to 3 m could be anticipated, more if there is little or no organic cover. The active layer in bedrock is likely to be much thicker due to higher conductivity, but in most cases, it is less important whether the bedrock is frozen or not. Ground temperatures in permafrost are likely to be slightly below freezing.As the road descends toward the Liard River, the proportion of terrain underlain by permafrost is likely to decrease, and this is apparent in the decrease of permafrost-related features, particularly in about the last 10 km north of the river.

About 60 m south of the proposed road, and south of HP123, the KP122.4 stream becomes wider for about 200 m. This area could potentially be thermokarst (Figure 13). The upslope bog area is identified as peatland (potentially ice-rich permafrost) between KP122 and KP123 southeast of the proposed alignment. The alignment avoids this sensitive organic terrain.

There is also a cross-slope drainage feature between the alluvial fan and the bog that looks like a possible small meltwater channel. A narrow untreed area about 50 m long is noted just north of the alignment at about KP122.5. Contours suggest a local low area that could be a pond or possibly thermokarst that drains to the stream just west at KP122.4. The areas in question can be checked during layout and detailed design. Otherwise, there is no obvious patterned ground or thermokarst in the road section between KP121.5 and KP123.3.

From about KP125.5 to KP126.7, a series of small beaded streams are seen between the toe of slope and the Grainger River. The currently-proposed all-season route approximately follows the existing south branch of the winter road and avoids the streams (Figure 14). These beaded streams are indicative of thermokarst and hence ice-rich permafrost ground. Otherwise, no obvious thermokarst or patterned ground is noted.

There is possible thermokarst at and near the lake outlet from about KP141.9 to KP142.3 in beaded channels parallel to the lake shore and longitudinally along the outlet, about 80 to 160 m east of the road. However, these features may in this case merely be due to wetlands filling in a shallow lake. The route appears to avoid this terrain. A beaver dam is noted about 260 m west of the road at about KP143.5, at the south end of a pond within the meltwater channel north of Triangle Lake. Potentially, flooding from beaver activity can affect permafrost integrity if frozen areas are inundated with water.

No obvious evidence of forest fires was noted in the field, except upslope of KP127, where 40% of the terrain burned in 1994 (RES 1994). Based on the fire and vegetation mapping in this area, the area of the forest fire extended as far south as about KP130.5.

Recent thaw slumps do not appear to be present in this road section; however, there are some debris slides and slumps, as well as debris flow gullies on this slope. Where such features are unavoidable, mitigations can be designed on a site-specific basis, and good surface water management will assist in this effort. It is noted that not all slope events can be controlled. For example, debris flows from upslope are entirely natural events, and it may not be possible to prevent all possible impacts from such events on the road route.

Tetra Tech EBA's test holes at the proposed borrow site above KP159.4 did not encounter frozen soils, so it is not known whether or not permafrost may be encountered at depth. Important considerations will include whether or not materials can be extracted without affecting the adjacent road sections and downslope terrain.

5.1.12.5 Borrow

An alluvial fan deposit at KP151.6 and debris slide/flow deposits upslope of KP158, KP159, and KP159.7 are proposed as borrow sources. Current field work results are inconclusive, as deeper test holes are needed to assess the quality of the materials and feasibility of development. Only shallow test holes have been advanced so far in the apparent deposition area upslope of the road at KP159.4.

5.1.13 KP160 to KP174.1

5.1.13.1 General

From the south side of the Liard River crossing at KP160, the route follows the old Nahanni logging road to KP174.1 where it meets the Nahanni Butte Access Road. The logging road parallels the east/south side of the Liard River for most of this section.

5.1.13.2 Surficial Materials and Soils

Prominent scrolling is noted on the Liard River floodplain in this road section. Occasional areas of fenland are present in narrow scrolled strips from about KP167.6 to KP169.2. Fenland is present on the north side of Bay Creek between KP169.2 and KP170.3. The creek itself, between KP170.3 and KP174.1 also modifies the terrain with its meanders and oxbows.

Soil types encountered along the Nahanni logging road are likely to be similar to those in the community of Nahanni Butte, including clays, silts and sands as follows:

Clay: This layer contained between 65 to 84 percent silt and 5 to 24 percent clay, and was generally classified as a silty clay based on behaviour, with Atterberg limits indicating that the material is low to medium plastic. The clay ranged from 1.2 to 3.0 m in thickness, with moisture contents ranging from 13 to 37 percent. The material was classified as stiff to very stiff based on Standard Penetration Test (SPT) N values of 11 to 17, with an average of 14 in unfrozen materials. This layer grades into silt in many areas of the community, usually containing enough clay to be considered low plastic. Lenses of silt or sand may also be present within the clay.

Sand: The sand was fine to medium-grained, with silt content varying from trace to some silt, with a trace of clay being specifically noted only occasionally. Two distinct units were noted in the sand: an upper, damp to moist, unfrozen layer; and a lower, frozen to unfrozen layer. The upper sand unit had moisture contents that ranged from 3 to 11% and averaged 5%, and SPT N values of 10 to 26, and an average of 18 above the water table and an adjusted N of 16 below the water table, indicating compact soils. The lower sand unit extended to the full depth of the boreholes, and included both frozen and unfrozen soils.

5.1.13.3 Permafrost

Permafrost has been encountered in various locations in Nahanni Butte. Ground temperature measurements have been rare in previous geotechnical investigations. Where ground temperatures have been measured, the permafrost has been very warm. For example, a hand-probe soil temperature of -0.13°C was measured in frozen soil samples at the Community Assembly Building (current Band Office) in 1993. Likely the measured temperature was somewhat warmer than the actual temperature, due to the heat generated from auger drilling. But, because the mean annual air temperature has been estimated at only -2.6°C over the past 30 years, and there has been an estimated 1.2°C of warming over the past 20 years; it is anticipated that some of the areas that had permafrost at the time of drilling may no longer have permafrost, or the permafrost may be slowly thawing.

Permafrost is likely to be relatively deep along the logging road and if consistent with the community, the top of the permafrost could be up to about 6 m deep, and the base of the permafrost may be only 9 m deep, the depth at which groundwater was encountered in the community. The relative elevation of the river in comparison to the road will affect the depth of groundwater, as groundwater is likely very close to river level.

5.2 Borrow – General Observations

Borrow sources identified by Allnorth are highly variable in material type. Site soils consisting of silts and clays are frost-susceptible. If they are frozen with a high soil moisture content, these soil types are also likely to be thaw-sensitive. Coarse-grained soils such as sands and gravels should be frost-stable, as long as they contain less than 10% fines. Similarly, bedrock is likely to be frost-stable and not thaw-sensitive, unless weathered bedrock has ice in it. Ice in bedrock can be present in joints or bedding planes or between fissile laminations.

5.3 Climate

Trends in climate are anticipated to be similar to the climate in Fort Simpson since it is nearly at the same latitude; however, some differences in absolute temperature are expected as a result of local mountain climate variations as well as the differences in elevation along the route.

Climate data for Fort Simpson has been available since 1964 and is taken for the purpose of this study to be the closest approximation of climate between the Prairie Creek Mine and Nahanni Butte. Climate data is available for the Prairie Creek Mine site from 2005, but the record is not long enough to discern long-term trends. Tetra Tech EBA has evaluated climate conditions at Nahanni Butte and at Rabbitkettle River in Nahanni National Park Reserve for two recent projects carried out in 2014 (Tetra Tech EBA 2014a, 2014b). These two sites bracket the route and are expected to be reasonably representative of the variation in climate conditions along the route at similar elevations (180 to 615 m). Colder winter conditions would generally be expected at higher elevations, up to about 1525 m at the Funeral Creek to upper Sundog Creek pass near KP017. Local effects of water bodies on terrain and permafrost will be important for bridge foundations and other stream crossing types.

The mean annual temperature in the Boreal Cordillera High Boreal Ecoregion, where the proposed route is located, is reported as ranging from -4 to -5°C (ECG, 2010), but the timeframe of measurement is not defined. The mean annual temperature in the Boreal Cordillera (Ragged Range Valley Mid-Boreal) Ecoregion at Rabbitkettle River is reported in the same range, and the temperature in the Taiga Plains Ecoregion (as far south as the British Columbia and Alberta borders) is reported as ranging from about -1.0 to -4.4°C depending on location (ECG 2009b). Over the period of record, the mean annual air temperature at Fort Simpson has averaged -3.1°C. However, the climate has exhibited a warming trend over that time. The mean annual air temperature has averaged -2.6°C over the 30 years ending 2012.

Over the period of record, the rate of warming has averaged 0.06°C per year. This trend is consistent with other sites in the western Northwest Territories, with trends ranging between 0.02°C per year and 0.08°C per year depending on the community and the period of record. Rates of warming are significantly higher in the last 30 years than over the period of record. This observation was confirmed by Nahanni Butte elders in recent conversations with CZN. It is anticipated that similar warming trends exist everywhere along the proposed road route, irrespective of the probable variations in local temperatures along the route at the time of this study. The noted climate warming has come about primarily as a decrease in winter temperatures, and summer temperatures have remained more consistent. Over the 30 years ending 2012 in Fort Simpson, the average freezing index has been about 2940°C-days per year, and the average thawing index has been about 2030°C-days per year. Over the period of record, we note that there is a decrease in the freezing index of about 15 C°-days per year and a smaller increase in the thawing index of about 6 C°-days per year over the period of record.

As for precipitation, snow seems to be becoming wetter and denser than it used to be in Canada's North, based on data from sites where the snow water equivalent is actually measured (Auld, 2010). This phenomenon tends to result in a thicker snowpack that lasts longer into late winter / early spring. Tetra Tech EBA has confirmed this phenomenon at other sites in the Northwest Territories (EBA 2011, 2013), although Nahanni Butte elders reported to CZN in January 2015 that snow cover disappears earlier than in the past (personal communication: D.Harpley, R.Kors-Olthof; March 9, 2015).

The practical implications of an increased snowpack thickness along the Prairie Creek road include potentially increased snowmelt in spring, and correspondingly greater surface water runoff and infiltration. As well, a thicker snowpack suggests the possibility of a thicker insulating layer over the permafrost (where present), resulting in less cooling over the winter and hence progressively warmer permafrost and a thicker active layer. In areas where the permafrost is already close to thawing, this change may be enough to eventually trigger thawing.

5.4 Permafrost

Nahanni Butte is mapped near the southern boundary of the "extensive discontinuous" permafrost zone and the route appears to be entirely within that zone (Heginbottom et al. 1995). Within this zone, 50 to 90% of the land area may be underlain by permafrost. Locally, the likelihood of permafrost will depend on elevation, but also on local soil and ground cover conditions. The very small scale of Heginbottom et al.'s permafrost map makes it difficult to discern the transitions between the areas where anticipated ground ice content is mapped as low (<10%), and where it is mapped as medium (10-20%), or low to medium. Based on estimated landmark locations, it appears that the terrain on the east side of the Front Range is more likely to have a low to medium ice content, and the terrain between the Front Range and the Tetcela River is more likely to have a medium ice content. However, there is enough local variation that actual ice content will depend on a series of local factors including the grain size of the soils encountered, ground cover, and local slope aspects.

Where present, the average temperature of the permafrost is expected to be very close to 0°C in the lower elevation areas, and probably less than about -2°C at higher elevations along the route. Therefore, in silty or clayey soils, there may be high unfrozen moisture content (Heginbottom et al. 1995). As well, it is anticipated that locally silty/clayey soils may incorporate some ice lenses or laminations, while granular soils should have relatively low ice content. Rivers or streams or lakes and ponds that have unfrozen water year-round likely moderate the local ground temperature (typically within 10 to 50 m of the shoreline), as well as providing a potential source of water for ice lens formation. Depending on the type of groundcover, thickness of organic soils, underlying soil types (fine-grained or coarse-grained), degree of site disturbance, and proximity to waterbodies, the active layer is estimated to range between 0.6 and 3 m thick.

Where streams or ponds are ephemeral or freeze to the bottom every winter, it is anticipated that permafrost could be present regardless of soil or rock type. Where water flows and/or is deep enough to remain unfrozen year-round, a talik or unfrozen zone is likely to be present beneath the stream. The smaller creeks evaluated by Hatfield Consultants Ltd. were considered to have the potential to freeze to the bottom every winter. Even the larger channels were considered to have a high potential of freezing, although these streams might also have some deeper, unfrozen pools, for example, Sundog Creek, Polje Creek, Tetcela River, and Grainger River. Locations where there is a bedrock substrate would be more likely to retain unfrozen pools. Streams in gravel along the route appear to have greatly-reduced water levels even before the onset of winter (email communications, March 5, 2015; D.Harpley, C.Jaeggle, R.Kors-Olthof).

As noted above, fires may affect ground temperature regimes and permafrost due to changes to the protective organic layer over the frozen mineral soils, particularly if the fire burns hot and damages the organic layer. The loss of a forested canopy can also reduce shade and allow the ground to become warmer, accelerating thaw. On steeper slope sections, it is also important to consider the potential for fires resulting in dead trees and the subsequent loss of root strength in helping to retain near-surface soils.

Climate warming can also affect ground temperatures and permafrost characteristics, and might be expected to have a greater effect on a usually cool slope than on a slope that is already warmer due to slope aspect, especially if that warm slope already has less permafrost.

6.0 CLIMATE CHANGE CONSIDERATIONS

The impacts of potential climate change need to be considered in the final design of the all-season road. Climate change considerations are referenced in MVEIRB's TOR Section 8, Items 1 and 4, with respect to the potential effects of climate change on the permafrost regime. Climate change considerations are also a normal part of Tetra Tech EBA's geotechnical assessments in permafrost regions.

The generally adequate performance of the existing winter road over the past 35 years should not be misinterpreted as an indication that the route is resilient to climate change, nor as an indication that the terrain beneath an all-season road will perform similarly, irrespective of whether or not it is influenced by climate change. Both types of road potentially affect the ground temperature regime due to the removal of vegetation and/or disturbance of the organic layer whether it is stripped off (something to be avoided in thaw-sensitive areas), or merely compacted by traffic or placement of fill, depending on the road type. However, an all-season road embankment has numerous different effects on permafrost compared to a winter road, and the effects of an embankment can be much more far-reaching. Items including poor drainage, inadequate embankment thickness, ground disturbance, and other design and construction issues in thaw-sensitive areas, snow-drifting on embankment side-slopes warming the underlying permafrost, or even the change in reflectivity of the ground surface due to the presence of the road can result in permafrost thaw even without climate warming. Climate change merely increases the potential for permafrost thaw. Potential effects of the road on permafrost, irrespective of climate change, are further discussed later in this report.

That said, two key factors play a role with respect to climate change and its probable effects on permafrost along proposed all-season road:

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

A procedure for screening the vulnerability of a development to climate change is outlined by the Canadian Standards Association (CSA, 2010).

The sensitivity of an area to climate change is governed by the characteristics of the permafrost in that area. The all-season road route is in an area of extensive, discontinuous permafrost, with average anticipated ground temperatures just below 0°C at lower elevations and likely warmer than -2°C at higher elevations along the route. The subsurface soils are of highly variable origin along this 184.5 km route, but permafrost with possible ice-rich lenses or layers has been encountered at various locations along the route. Tetra Tech EBA therefore characterizes the site sensitivity to be "high" along route sections with fine-grained soils. This entails most of the route, except for the initial 39 km from the Mine to Cat Camp, and about 2 km in Grainger Gap where granular soils are more

prevalent. Along the remainder of the route, some short sections within granular soils likely have “moderate” to “low” sensitivities to climate change, particularly where ground temperatures are likely to be moderated by nearby large water bodies, and where permafrost is less likely to be present. Tetra Tech EBA estimated that about 73 km likely has least some thaw-sensitive permafrost, and another 24 km may also have thaw-sensitive permafrost, but slope aspect or elevation makes it slightly less likely.

Under a “moderate” green-house gas scenario, the mean annual air temperature is estimated to increase about 0.8 °C over the next 30 years. For the proposed 20-year service life for the road, the mean annual air temperature would rise by a total of about 0.5 °C. Under a “high” green-house gas scenario, the mean annual air temperature is estimated to increase about 1.1 °C over the next 30 years. For the 20-year proposed service life for the road, the mean annual air temperature would rise by a total of about 0.7°C (CSA, 2010).

Road embankment and structure design and construction need to account for the likely change in ground temperature over the service life of the project. In cases where direct correlations between air temperature and ground temperature are not available, ground temperature is assumed to change in step with air temperature. Therefore, the ground temperature in 20 years could be at 0°C or potentially warmer than 0°C where permafrost is currently very close to 0°C, and may be warmer than -1.5°C where the permafrost is currently estimated to be warmer than -2°C.

For the “moderate” green-house gas scenario, the increase in air and ground temperatures may be enough to encourage the start of thawing where the permafrost along the route is already near-thawing. Where permafrost is already slowly thawing, further thawing is expected. Such thawing is less important in areas with near-surface bedrock, coarse-grained soils with relatively low soil moisture contents, or even finer-grained soils with relatively low moisture contents, because thawing probably will not result in much noticeable change in the ground conditions in those areas. Areas that have higher soil moisture contents in the form of ice can be affected in two general ways. On the one hand, thawing will probably be slower, because extra energy is required to turn ice to water. On the other hand, areas that do thaw may experience slope instabilities, similar to the retrogressive thaw slump/flow at KP054, or settlement and ponding of water.

Other areas may not actually thaw during the life of the road, but could be prone to higher rates of soil creep, potentially pushing road sections out of alignment or, more seriously, pushing bridge abutments out of alignment and causing distress to the structure. This is a phenomenon which has also been considered in ground that is colder than the project site, for example, on the Inuvik to Tuktoyaktuk Highway.

Based on the review of available information and the 2014 ground-truthing, it is anticipated that the permafrost in some sections of the route may contain layers or lenses of soil that have excess ground ice. The practical implication is that thawing with resulting settlement and ponding could occur in the subgrade along the toes of the road embankment, the numbers or areas of thaw-related slope failures could increase, thaw settlement beneath culverts could cause water flow to be blocked with potential accompanying slope stability issues, and settlements or potentially even failures of road grades could occur. Settlement and ponding are common along the toes of road embankments in warm permafrost, for example, along the reconstructed section of Yellowknife Highway 3 between Behchoko and Yellowknife, where there are also several road sections with relatively severe differential settlements. The nearby Liard Highway 7 has had significant issues and requires significant maintenance efforts, and is constructed in very similar terrain in terms of ground and permafrost conditions as much of the proposed route. Although it is recognized that the territorial highways have different operating and service life requirements as compared to a resource road, and they have not necessarily all experienced the same construction methods and conditions, they do offer some useful comparisons. Accordingly, potential issues with thaw-sensitive permafrost along the proposed Prairie Creek all-season road would be expected to become more frequent as the permafrost becomes warmer, and more likely to start gradually thawing.

Therefore, the consequences of permafrost thaw can be potentially significant, and they are characterized as potentially "major" for structures supported by shallow or deep foundations within fine-grained permafrost with excess ice, but likely "minor" for structures supported on frost-stable granular soils or bedrock beneath the surficial sediments. Such structures would include bridges and culverts along the route in locations where permafrost is present. For road embankments, the consequences of permafrost thaw could be "major" where thaw settlement under culverts goes unnoticed for a long period of time potentially blocking natural water flow, and "minor" for road surfaces that can be readily re-levelled with more fill. These consequences can be mitigated by a reasonable inspection and maintenance schedule.

Considering the site-specific permafrost sensitivity and the associated consequences together results in a risk level "C" (low risk) as defined in CSA (2010) for structures such as bridge and major culverts supported by foundations on or in frost-stable soils or bedrock. With respect to permafrost, this level of risk warrants a qualitative analysis and the use of expert judgement to develop design parameters for a project with routine design parameters.

For structures supported by foundations on or in thaw-sensitive soils, the site-specific permafrost sensitivity and associated consequences together results in a risk level "A" (high risk) as defined in CSA (2010). This level of risk warrants a quantitative analysis to evaluate the ground thermal regime expected to develop beneath the proposed structure over its lifetime. The initial step to proceed with this level of analysis would be to improve the site characterization by conducting a site investigation with boreholes deep enough to determine depths and thicknesses of permafrost. This type of analysis is also useful in optimizing embankment designs in road sections traversing permafrost. It is anticipated that major structures will require a site investigation to determine geotechnical design parameters in any case, irrespective of the anticipated absence or presence of permafrost.

7.0 EFFECTS ASSESSMENT – ACCIDENTS AND MALFUNCTIONS

7.1 Environmental Causes

- 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. Climate change itself is relatively slow, but climate change effects tend to result in events that happen with little or no warning in areas previously not subject to such events, for example, thaw slumps or flows. Climate change considerations are discussed in the preceding section.

- **Flooding:** Flooding is relevant to stream crossings, road sections along low-lying areas that may be prone to flooding, as well as the crossing of the Liard River. Tetra Tech EBA has undertaken specific studies of flood levels for the major crossings along the route (see elsewhere in the DAR), providing 1-in-100 year design flows and water levels (Tetra Tech EBA 2014c; EBA 2012). The Government of the Northwest Territories, Municipal and Community Affairs (MACA) has an online mapping resource (MACA, 2014) that provides some useful information for the nearby community of Nahanni Butte. Since the elevation of the proposed ferry crossing is at essentially the same elevation as the community, this information is directly relevant. Nahanni Butte is known to be flood-prone. Normal summer water levels are mapped a little below 177 m elevation, whereas the 2012 LiDAR carried out for the project indicates water levels of about 180 m at the community and at the Liard River crossing, indicating at least 3 m of flood waters at that time. Portions of the Nahanni Butte access road were also inundated at the time of the LiDAR. MACA's flood mapping suggests that terrain below an elevation of

182 m is within the floodway, and terrain up to 183 m elevation is in the floodway fringe, where the ground elevation is 1 m or less above floodwater elevation. Ice-jamming is a common cause of flooding, and it is quite possible that higher water levels can occur due to ice-jamming than occurs during floods without ice effects. Water levels cannot be directly correlated to flow when there is ice in the stream (WSC 2014a). Parks Canada also reports that while the South Nahanni River usually has its highest flows in June, associated with the spring thaw, high flows also occur in July, August and September, when the river is also subject to flash floods due to precipitation. The tributaries of the South Nahanni River are understood to have similar characteristics, with peak flows in late June due to snow melt (Parks 2009). Although not specifically mentioned by Parks in this reference, some of the north-flowing streams and associated tributaries along the route have visually similar characteristics to the South Nahanni River and its tributaries, and should be considered likely to experience similar conditions.

CZN observed high water levels in 2006 and 2007 on Prairie Creek with estimated flows of 200 to 400 m^3/s in 2006. A return period of 200 years for a flood of 250 m^3/s had been previously estimated for Prairie Creek. The Probable Maximum Flood (PMF) was subsequently re-evaluated, and CZN noted that the observed flow was not as high as the re-evaluated PMF. Due to the short period of record at the measuring station (WSC 2014b, 2014c), there was some uncertainty as to the return period of the observed flood flows (NRCan 2011). There is some anecdotal evidence suggesting that 2006 and/or 2007 may have been record years for precipitation, depending on location, based on the climate summaries that Tetra Tech EBA compiled for geotechnical projects in a few other communities in the Northwest Territories, including Fort Liard (Tetra Tech EBA 2014d, EBA 2011).

Flooding may also occur along other low-lying road sections, for example, along Polje Creek and the Tetcela River, as can be seen by comparing the 1 in 100-year flood events at the stream crossings to the adjacent terrain elevations along the road (Tetra Tech EBA 2014c, EBA 2012). Some areas of the winter road were noted to have ponded water on them, particularly in the Tetcela to Fishtrap Creek section, and it is possible that sections of the route could be periodically flooded at natural grade, since the elevations appear to be consistent with elevations at the Tetcela River. However, the higher ground along the Tetcela to Fishtrap realignment appears unlikely to flood.

In addition to roads, culverts, and even bridges being inundated with floodwater, there is also the possibility of damage to road fills and bridge foundations from scouring, and to crossing structures as a result of debris being washed downstream and jamming against foundations or under or within crossing structures. Streambed movement is common and can result in building up of sediment or woody debris in new areas that can then flood more easily in following years, due to reduced stream capacity in those areas. High water levels and rapid runoff can also result in erosion that causes the loss of road sections, even when the water is not high enough to inundate the road. Such events appear to be more likely in the Funeral, Fast and Prairie Creek drainages, and also potentially in the Sundog Creek drainage. The Tetcela River, Grainger River and other streams powerful enough to move gravel, cobbles and boulders have enough energy to be erosive when moving their bedload.

- **Overland flow:** Overland flow is relevant to the possibility of surface water drainage backing up at culverts or running in unanticipated or undesirable places, potentially causing physical/thermal erosion and/or slope stability issues. Slopes that already have existing slope instabilities and the potential for new instabilities, including areas such as the Silent Hills west slope, and the Polje reroute can be affected. Even relatively gentle or flat areas can be potentially affected, as there may be subtle terrain features that influence water flow that are not easily seen on the ground or from the contour data. Sections of road fill that become saturated due to ponded water could become too soft or unstable to hold the anticipated truck loads, or sections of road could flood if the ponded area becomes too deep.

- **Landslides and ground movement:** Landslides and ground movement that impact road sections or stream crossings can result from rock slides, rock fall, debris slides, slumps and flows that do not involve permafrost but that could involve higher than normal inputs of ground surface water, either from natural events occurring above the road, or due to some event along the road. For instance, debris flows can scour out road sections located on steeper ground, or deposit debris on the road in gentler ground, or plug culverts preventing upslope drainage along the road. Ground movements can also be related to thaw slides, slumps or flows retrogressing into the road alignment, or new thaw slides or flows forming upslope or downslope that affect the road alignment. Ground movements can also result from settlement or loss of ground at areas of suffosion or subsidence in karst terrain. Changes in the ground surface and/or slope failures can also occur as a result of flooding, for example, from deposition, or scouring, or rapid drawdown.

- **Seismic activity:** Seismic activity potentially could disrupt the road grade through ground displacement, or loss of the road grade due to fill slope failure, or collapse of upslope materials onto the road grade. While the road route does cross terrain with a relatively high seismic hazard with a peak ground acceleration (PGA) of 0.246g at the Mine and 0.241g at Nahanni Butte (NBCC, 2014), no large seismic-related failures of rock slopes have been documented on the existing route along Prairie Creek, Funeral Creek or Sundog Creek (Golder, 2010). Golder remarks that while smaller rock slope failures may have a seismic-related component, such failures would be difficult to distinguish from rock slope failures occurring for other reasons. Golder considers the likelihood of large-scale rock slope failures occurring as a result of seismic activity to be very remote along the route. Though not specifically mentioned in the context of seismic activity, Grainger Gap is also included in Golder's overall assessment of anticipated rock fall activity.

  The 1985 North Nahanni earthquakes had a significant effect on rock slopes in the North Nahanni River valley, at the English Chief Anticline (part of the Nahanni Formation), and on a till-like colluvial slope at Little Doctor Lake where saturated sand and silt soils liquefied (BGC, 2005), however, suggesting that such events are not impossible along the all-season route. This judgment is supported by the similarities in peak ground acceleration in this region, with a PGA of 0.239g at Little Doctor Lake, and a PGA of 0.245g further north along the North Nahanni River and English Chief River (NBCC, 2010). Local factors including rock types and bedding/jointing characteristics will play a role in possible rock slope failures, of course, as will soil characteristics at any particular location along the route. Tetra Tech EBA anticipates that seismic site class as defined in the National Building Code of Canada can vary considerably along the route with a probable range from Site Class B in competent bedrock (limestone, dolomite, some sandstones); Site Class C with very dense soils (sandy, gravelly tills) and/or soft rocks (mudstone, shale), or well-bonded frozen soils; Site Class D with stiff or dense soils including silty clays, dense well-graded sands and gravels; and Site Class E on any site that has more than 3 m of very wet soft soils, particularly fine sands and silts that are prone to pumping and liquefaction. The latter case may be more likely in areas of wet thermokarst terrain, or generally wet valley bottoms outside the alluvial plains where gravels and sands are more common. Where the bedrock is fractured, weathered and/or has unfavourably-dipping bedding or jointing planes, the site class may not be as favourable as it might appear at first glance.

  Based on the review of site overview photos and a paper on the English Chief failure, it is noted that of two seismic-related rock slope failures documented after the 1985 North Nahanni earthquakes, the North Nahanni River valley failure may be a toppling failure, with the bedding planes nearly level or slightly dipping into the slope, resulting in the addition of debris to what appears to have been an existing talus/scree slope. The rock slope at the English Chief Anticline failed along a fault that cuts through the out-dipping bedding planes on the upper part of the failure, and along the bedding planes on the lower part of the failure, resulting in a large slab of the mountain sliding downslope to the northeast (BGC, 2005; Evans et al, 1987). One of the outcomes in studies of the 1985 earthquakes was the realization that faults previously considered inactive might not be inactive after all.

Comparing to a few of the bedding plane orientations seen along the proposed road route, toppling failures might be more common along the Front Range and at the east end of Grainger Gap, while bedding plane sliding failures might be anticipated along Prairie Creek, at the west end of Grainger Gap, and portions of the route through the Gap. Anticipating the more-likely types of events becomes more complicated as the stratigraphy becomes more complicated, with faulting and folding producing multiple layers of the same rock types, dipping in different directions. For example, rotational slides are also mapped on the Front Range (Hawes, 1975). The bedrock mapping shows much more faulting at the west end of the route in the mountains, between about KP000 and KP039, resulting in the potential for toppling, slab-type or other failure types (Douglas and Norris, 1976b). One possible benefit in this road section might be that because much of the road runs along east-west valleys, at least some of the out-dipping bedrock may be avoided. Nevertheless, just as the possibility of small-scale rock fall/slide events cannot be ignored in this section, the possibility of large-scale events should not be discounted either. Seismic considerations also need to be accounted for in structural and foundation design for bridges and other major stream crossing types along the route.

- **Avalanche activity:** Avalanche activity is important to consider, particularly in the Prairie Creek, Funeral Creek and Sundog Creek areas, from about KP000 to KP039. An avalanche assessment and maps (Appendix D) were prepared previously by Alpine Solutions Avalanche Services (2012). Alpine Solutions concluded that avalanche hazard potentially affecting the road exists from the Mine site to Cat Camp at Km 40, and on the east side of the Grainger River at Grainger Gap, but avalanches were not estimated to affect the road alignment there.

Given the possible types of events or hazards described above, a qualitative risk assessment is useful to evaluate their likelihoods, consequences and resulting risks. Appropriate road design and construction considerations will help to reduce or mitigate many of the risks. There may be some residual effects, as discussed below.

7.2 Qualitative Risk Assessments

7.2.1 Definitions of Assessment Parameters

Tetra Tech EBA has carried out a qualitative risk assessment for the Project. With respect to slope stability, we have evaluated the stability of various slopes along the route on the basis of the following types of information, where available: a review of 1994 air photos and the 2012 LiDAR and ortho-imagery coverage, on slope characteristics based on topographic mapping and measured slope angles at selected locations, and on the basis of field and laboratory observations of shallow soils only, carried out by Tetra Tech EBA and others. Exposed soils were logged by Tetra Tech EBA within the KP054 retrogressive thaw slump/flow area and at the KP124.8 soil debris slide. Similarly, aerial coverage and field observations were utilized in evaluating the potential for ground subsidence or suffosion at specific locations along the route. Seismic site class was determined for several locations along the route, based on typical anticipated soil characteristics and thicknesses; and the seismic hazard value for the region is noted (NBCC, 2010). Tetra Tech EBA defers to the expertise of Alpine Solutions Avalanche Services and their assessment of avalanche activity as presented in the avalanche hazard index map (2012). Modelled stream flood levels were compared to nearby sections of the existing or proposed road route for a rough estimate as to whether those road sections might be likely to experience flooding. Overall topography, slope gradients and anticipated soil types were evaluated to determine which sections of road might be more likely to experience problems due to overland flow.

As recommended in MVEIRB's TOR Section 7.2.2, Item 8, Tetra Tech EBA referred to the document "Failure Modes and Effects Analysis (FMEA)" (Robertson and Shaw, undated) for this risk assessment, modifying the charts to make them specific to the types of failure modes being evaluated and the qualitative level of risk assessment. Definitions for the following discussion (adapted from British Columbia, Ministry of Forests, 2004, and consistent

with the methodology presented in CSA PLUS 4011-10) are presented as follows, using ground and slope conditions as the source of the hazard potentially affecting the road in this example:

- Hazard – a source of potential harm, or a situation with a potential for causing harm in terms of human injury, and/or damage to property, the environment or other things of value. In the case of the proposed road, hazards include slope instabilities along or adjacent to the route, areas of subsidence or suffosion due to underlying karst topography, and thawing of ice-rich permafrost.

- Likelihood – a qualitative estimate of the probability that a landslide, subsidence, or thermokarst area will occur, or expand, referred to as a probability rating, and described with relative qualitative terms such as "low" to "high."

- Elements of value (valued components), or elements at risk – including human life and well-being, public and private property (such as buildings or land), transportation or utility rights-of-way, domestic water supply, and/or parts of the environment such as wildlife habitat. In our case, land and streams along the road route; the all-season road itself; and proposed structures enroute, for example, the Tetcela Transfer Facility, and/or construction camp(s); and the people working or visiting there are the "elements."

- Consequence – the effect on human well-being, property and/or the environment, that is, the change, loss or damage caused to the elements by a landslide, subsidence, or thermokarst event. For example, what could happen to the road if a retrogressive thaw slide reaches it?

- Risk – the qualitative evaluation of a potential loss, defined as a measure of the likelihood of an adverse event and the consequence of that adverse event.

- Risk tolerance – the inclination for land managers, authorized road users, and/or the general public to accept or not accept a particular risk. Risk tolerance is not addressed in the risk matrix, but should be recognized as a necessary component in making land management decisions, particularly in co-management areas where there may be several stakeholders.

The following table is applicable to determining risk from hazard and consequence, where hazards and consequences are determined to be low, moderate or high. Likelihoods of hazards are listed along the left-hand side of the table, consequences across the top, and the resulting risk within the table. These are qualitative values based on a review of the existing information and the 2014 field work where applicable. Colour-coding is as follows: red indicates "very high" risk, orange is "high" risk, yellow is "moderate" risk, green is "low" risk, and blue is "very low" risk (adapted from British Columbia Ministry of Forests, 2002).

Table 7.2.1-1: Risk Matrix – General

Risk to Element		**Consequence of hazard if event occurs**		
		Low	**Moderate**	**High**
Likelihood of hazard affecting the element	**Low**	Very Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	Very High

7.2.2 Risk Matrix

The following Table 7.2.2-1 summarizes the residual risks to the road associated with hazards related to flooding, overland flow, landslides and ground movement and seismic activity, assuming that mitigative measures have been taken. For instance, if flooding risks can be reduced by designing appropriate road grade elevations above estimated flood levels, this is assumed to be done in detailed design. Similarly, if risks from thaw slumps or flows can be mitigated by moving the road or if rock fall risks can be reduced with scaling and/or signage and awareness training, these are assumed to be done. If risks from avalanches can be mitigated with an avalanche control program incorporated into the road operations plan, this is assumed also to be done, and so on. These are just a few examples of possible mitigative strategies that can be considered to reduce the risk of environment-related events affecting the road. Strategies are further described in Section 7.2.3 following the risk summary.

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.

It is further noted that this risk matrix is based on the assumption of the current route alignment being within +/-50 m of what will be the eventual route location, based on Allnorth's current proposed route (Allnorth, 2015). To facilitate the overview, the route has been divided into sections by approximate terrain-type boundaries or zones, marked by kilometre posts. For each road section, the likelihood of the specified **hazard (H)**, the **consequence (C)**, and the resulting **risk (R)** are shown in the column for that hazard with the colour codes applied as shown in the general risk matrix in Table 7.2.1-1 above. In cases where a range of hazards or consequences is possible, the average is presented. Some hazards tend to be seasonal, for example, avalanches in winter or early in spring, flooding and overland flow in spring and summer, debris flows or thaw slumps in summer or early autumn.

Generally, the table shows that although the likelihood of a hazard affecting the road can be high in some areas, with the appropriate mitigative measures, the consequences of those hazards can often be reduced sufficiently so that the risk remains low to moderate. There are only a few high risk areas noted, all related to potential slope stability issues. With further adjustment of the road alignment ROW within the currently-proposed 100 m wide corridor, it may be possible to further reduce the risk in some of these areas.

In the case of seismic activity, the overall likelihood of the hazard is considered low, but consequences of a seismic event can be moderate or high in some instances. The consequences are considered more likely to be high in places where the bedding planes dip out of the slope, such that larger volumes of failed rock could potentially fall onto the road. Due to the anticipated relative rarity of large seismic events, this results in a low to moderate risk from seismic activity. As mentioned in Table 7.2.2-1, the slope failures that were attributed to seismic events in 1985 were less than 10 to 15 km from the epicentre. The largest of these events were of magnitude 6.6 and 6.9. The nearest point on the proposed road (about KP054) was 65 km from the 1985 epicentres; therefore, effects on the road would have been unlikely. Since 1985, only events smaller than magnitude 4.0 have been recorded near the Mine and road route. Since the area of the 1985 seismic events has the same seismic hazard rating as the road route (NBCC, 2010), however, larger seismic events could also happen near the road route. If a similar-sized seismic event were to be centred closer to the road, then there would be a greater likelihood of noticeable effects.

Table 7.2.2-1: Risk Matrix Summary (Residual Risks with Mitigative Measures in Place)

Kilometre Posts	Valued Components (Elements, as applicable)	Flooding		Overland Flow		Landslides/ Ground Movements		Seismic Activity		Avalanches[2]		Comments
KP000 – KP006.5	▪ Camp & Mine ▪ Road & bridge ▪ Personnel	H[1] C[1]	R[1]	H C	R	H C	R	H C	R	H C	R	Prairie Creek, Fast Creek, and Funeral Creek all seem to have sections prone to erosion by flood flows, with some sections also prone to the effects of debris flows and/or alluvial deposits originating from streams upslope. The Casket Creek bridge crosses an alluvial fan where the existing main channel is prone to shifting, and where material carried downstream could overrun the road. Erosion would be dealt with by placing riprap. Otherwise, coarse-grained materials in the mountains suggest this road section is less prone to erosion or other effects of overland flow not going where it should. Mapping and photos suggest out-dipping bedrock, so if a seismic event happens, it is more likely that consequences will include rock landing on the road. The recorded seismic-related rock slope failures that affected English Chief and North Nahanni River in 1985 were less than 10 km from the epicentre, with several small mudflows recorded as far away as 15 km. The nearest point along the proposed road (about KP054) was 65 km from the 1985 epicentre. If a similar-sized seismic event were to be centred closer to the road, then there would be a greater likelihood of noticeable effects.
KP006.5 – KP013.4	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Estimated according to the avalanche mapping as to extent of avalanche terrain and “potential” avalanche terrain on the route. More avalanche terrain means higher hazard. Consequence stays low if CZN et al carry out avalanche control and release avalanches while they’re still small. If we consider this section as “high” hazard, because avalanches from slopes on north side can run up onto south side, and we therefore have potential hazards originating from both sides of creek, then risk would be “moderate.”
KP013.4– KP017.1	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Road cuts through steep active talus/scree.
KP017.1– KP023.1	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	The hydrotechnical analyses suggest that much of Sundog Creek and its tributaries are less prone to flooding than the streams to the west. Half of this section is up to moderate hazard for landslides/debris flows where road is on terraces. High hazard where road cuts talus/scree and/or rock fall above.
KP023.1 – KP028.4	▪ Road & bridges ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Ice plug builds at Sundog Canyon (KP023.4 crossing), causes spring flows at higher elevation. High crossing elevation allows passage of high water, thus low hazard. Hazard due to landslides/ground movements/avalanches would be high if we hadn’t moved 4 km of road to the south side of Sundog (away from talus/scree). Avalanche hazard remains moderate, due to potential run-up from north side avalanches, which appear to cross creek on mapping.
KP028.4 – KP033.55	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	This road section is scree/talus nearly end-to-end, plus a few debris flows. However, bedrock looks nearly level. Allnorth observed that the KP029 to KP030 section may be more prone to flooding based on the lack of vegetation along the existing route, and proximity of floodplain / road elevation to channel elevation.
KP033.55 – KP036.5	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Continued steep talus/scree interspersed with bedrock outcrops.
KP036.5 – KP038.9	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Talus lobes and apparent bedrock failure scarps suggest high hazard in this section.
KP038.9 – KP039.9	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Slightly elevated due to higher flood level at tributary compared to Sundog Creek.
KP039.9 – KP040.1	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	
KP040.1 – KP041.5	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Because this section is mapped with an old slump, it may be more susceptible to movements. Control of surface water runoff will be important.
KP041.5 – KP045.5	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	A few minor creeks, anticipate small road lengths affected.
KP045.5 – KP046.3	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	A few minor creeks, anticipate small road lengths affected.
KP046.3 – KP048.8	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Sections on steep slope above creek, some with undermining at creek.

[1] H = Likelihood of specified hazard, C = Consequence, R = Risk. Colour codes are defined as follows:

Very Low	Low	Moderate	High	Very High

[2] Avalanche hazard based on existing avalanche hazard maps (ASAS 2012)

Table 7.2.2-1: Risk Matrix Summary (Residual Risks with Mitigative Measures in Place)

Kilometre Posts	Valued Components (Elements, as applicable)	Flooding		Overland Flow		Landslides/ Ground Movements		Seismic Activity		Avalanches[2]		Comments
KP048.8 – KP050.8	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Sections on steep slope above creek, some with undermining of slope toe at creek.
KP050.8 – KP053.5	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Overland drainage on alluvial fans.
KP053.5 - KP053.7	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Wide floodplain at Polje Creek.
KP053.7 – KP054.6	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Area of thaw slump/flow at KP054 is sensitive to overland flow, and prone to further movements.
KP054.6 – KP055.8	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	
KP055.8 – KP057.7	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Slope instabilities above and below road (above Third Polje).
KP057.7 – KP059.9	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Slope instabilities below road, and possibly above road (above Second Polje & upstream).
KP059.9 – KP062.6	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Southeast approach to gully at ~KP060.5 runs in swale with tributary stream, slope sensitive to overland flow. Another steep-sided gully ~KP061.6.
KP062.6 – KP066.3	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	
KP066.3 – KP071.7	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Some steeper slopes with marginally vegetation or exposed soils, or raveling.
KP071.7 – KP079	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	
KP079 – KP083.9	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Traversing near crests of steeper slopes, swales or gullies.
KP083.9 – KP087.3	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	All flagged items are due to mapping of colluvium, lots of surface water, evidence of slope failures downslope.
KP087.3 – KP088	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Tetcela River tributary and floodplain
KP088 – KP089.4	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	All flagged items due to mapping of large slump upslope west of route.
KP089.8 – KP090.2	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Tetcela River Crossing
KP090.2 – KP094.2	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	All flagged items due to likelihood of at least some thaw-sensitive permafrost.

[1] H = Likelihood of specified hazard, C = Consequence, R = Risk. Colour codes are defined as follows:

Very Low	Low	Moderate	High	Very High

[2] Avalanche hazard based on existing avalanche hazard maps (ASAS 2012)

Table 7.2.2-1: Risk Matrix Summary (Residual Risks with Mitigative Measures in Place)

Kilometre Posts	Valued Components (Elements, as applicable)	Flooding		Overland Flow		Landslides/ Ground Movements		Seismic Activity		Avalanches[2]		Comments
KP094.2 – KP095.7	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Thaw-sensitive permafrost, low-lying wetlands.
KP095.7 – KP101.7	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Most slope and sinkhole issues avoided by new route, still some residual issues and uncertainties re permafrost.
KP101.7 - KP106.75	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Alluvial fans between Wolverine Pass and ~KP103. Small surficial sloughs in borrow area ~KP106.
KP106.75 – KP106.85	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Debris flow gully originating upslope.
KP106.85 – KP115.7	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Skirting above or below gullied terrain.
KP115.7 – KP115.9 (was KP116)	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Major debris flow gully originating upslope.
KP115.9 – KP123	▪ Road & bridge ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Some low wet areas, areas of potential thermokarst, and where overland flow may be important. East end of this road section has high seismic consequence due to out-dipping bedrock layers at beginning of Grainger Gap section, but average for section moderate.
KP123 – KP126.2	▪ Road & bridges ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Avoiding beaded streams and upslope hazards. Consequence high for seismic due to some sections of out-dipping bedrock layers.
KP126.2 – KP133	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Seismic consequence slightly elevated due to presence of existing slope features that may be more prone to movements.
KP133 – KP138	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H	R	Due to debris flow features and edge of debris/deposits of uncertain origin and behaviour.
KP138 – KP150	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Seismic consequence slightly elevated due to presence of existing slope features that may be more prone to movements.
KP150 – KP154	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Due to debris flow features where debris can be deposited on the road or plug culverts.
KP154 – KP159.4	▪ Road, drainage ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Due to debris flow features that can either deposit at road or scour out road, plus some other slope issues.
KP159.4 - KP160 Liard R	▪ Ferry landings, ice bridge	H C	R	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Installations on the Liard River are likely to be subject to flooding and possibly ice-jamming (scouring), and almost certainly elevated water levels due to ice-jamming downstream.
KP160 – KP174.15	▪ Road & bridges ▪ Personnel	H C	R	H C	R	H C	R	H C	R	H C	R	Based on flooding seen along Nahanni Butte Access Road and contour elevations in this area.

[1] H = Likelihood of specified hazard, C = Consequence, R = Risk. Colour codes are defined as follows:

Very Low	Low	Moderate	High	Very High

[2] Avalanche hazard based on existing avalanche hazard maps (ASAS 2012)

Based on the qualitative risk assessment, Tetra Tech EBA estimated that about 7.2 km of the terrain along the proposed all-season route represents a high risk to the road route with respect to slope instabilities or other ground movements (by thawing, sliding, flowing, falling, settling or collapsing), and 54.9 km represents a moderate risk, out of a total of 174.1 km evaluated. The Liard River crossing represents a high risk with respect to flooding, and 20.65 km of the route represents a moderate risk. Other moderate risks included 4.3 km of the route for overland flow, 29.6 km for seismic activity, and 17.8 km for avalanche activity. Since there is considerable overlap in the moderate risk designations, a total of 76.7 km was estimated to represent a moderate risk to the road, and 7.4 km was estimated to represent a high risk to the road.

7.3 Mitigation and Residual Effects

7.3.1 General

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.

7.3.2 Anticipated Mitigations Incorporated into Road Design

Numerous mitigations can be incorporated into the road design and construction. Although these mitigations can provide no guarantee that no failures will occur, they are consistent with Best Management Practices for construction, including erosion and sedimentation control measures, and Best Management Practices specific to permafrost and the mitigation of thermal erosion (TAC, 2005 and 2010).

- **Flooding:** A hydrotechnical engineer has been consulted for the major stream crossings to evaluate the local and regional hydrology of the streams and provide information useful in determining recommended minimum bridge elevations and freeboard, as well as sizing for major culverts and arch culverts (Tetra Tech EBA, 2014c; EBA 2012). Tetra Tech EBA understands that the September 2014 field survey program looked for out-of-channel high water marks such as debris or damaged vegetation, but did not find any. Tetra Tech EBA considers that although there is no evidence to indicate that conditions with ice will govern, the potential for such effects should be considered further during detailed design. To check areas that may be subject to periodic flooding, it is anticipated that projected stream design water levels (Tetra Tech EBA 2014c; EBA 2012) can be used to help design suitable road embankment elevations along adjacent road sections. Sections of road in low-lying areas along the route, or along sections of streams prone to flooding, should be designed to protect against flooding under design flood conditions. Similar provisions will be needed along the section between the Liard River crossing and the junction with the Nahanni Butte Access Road. Actual required fill thicknesses and designs will depend on available fill types and behaviour under anticipated flooding and loading conditions. Such provisions may complement the thicker road sections initially suggested to help protect crossings of potential thermokarst or generally ice-rich subgrade soils, and vice versa, subject to the results of further investigation. Some route sections may need further upgrading in the future if fill thicknesses prove insufficient. Road sections directly adjacent to streams that have proven to be prone to erosion will benefit from riprap erosion protection to reduce the likelihood that part of the road may need repair as a result of heavy spring or storm runoff, and to reduce the likelihood of erosion and sedimentation in excess of background levels. Appropriate erosion protection may also help protect the road grade even if it is overtopped by flooding at such locations.

- **Overland flow:** Generally, surface water drainage across the road needs to be sufficient to appropriately manage overland flow. Good practice is to install sufficient drainage measures such that water does not flow in channels where water would naturally flow as sheet flow. Where water naturally flows in channels, the channel should not be overwhelmed with much more water than it would ordinarily have carried prior to development. This means that stream channels will consistently need culverts, and many swales without permanent streams will likely also need culverts. Careful culvert placement and sizing will be especially important on slopes that already have significant existing slope instabilities and the potential for new instabilities.

  In areas of switchbacks, any road location that receives a culvert on an upslope reach of a stream should also receive a culvert or culverts on the road sections downslope that re-cross the same stream, and water should not be allowed to flow off the ends of switchbacks into inappropriate areas. In road sections where culverts may be prone to plugging with debris or freezing in, a series of multiple culverts at different levels may be useful to maintain seasonal flow. This technique may be particularly valuable in road sections where existing stream locations may not always be reliably in the same place, such as on or along alluvial fans. In long sections of road without obvious drainage crossings, additional culverts may also be needed to prevent ponding of water on either side of the road. Hydrotechnical engineering will also be necessary for stream crossings not involving bridges or major culverts.

  Areas of flat ground also need good management of overland flow, even where the direction of flow is not easily seen. Regular placement of drainage measures including permeable embankments and culverts will help to reduce the likelihood of hazards relating to ponding water and associated problems of flooding or subgrade integrity.

- **Landslides and ground movement:** Where possible, the road routing attempts to avoid such features as rock slides, rock fall, debris slides, slumps and flows, and thaw slumps/flows, as well as sinkholes. For example, the route has been moved north and east to avoid the thaw slump/flow at KP054. Other locations include avoiding upslope impacts from rock slides, by moving the road out from the slope toe between KP125 and KP126, for example, or moving either up or down alluvial fans to avoid long stretches of road that could be subject to repeated and unpredictable debris flows, between KP29 and KP32, for example. Other management techniques include the above-mentioned control of overland flow, particularly as it relates to the preservation of relatively natural water flow patterns, because water has an enormous influence on stability. In areas of anticipated rock fall where moving the road is not possible, physical mitigations (engineering controls) may be required.

- **Seismic activity:** The likelihood of large-scale rock slope failures occurring as a result of seismic activity was considered by Golder (2010) to be remote along the route. However, Tetra Tech EBA notes that large-scale seismic events are difficult to predict, and equally difficult to protect against. The possibility of such events occurring along the road should be taken into account. Routing for the avoidance of smaller-scale rock fall or rock slide events may help to some extent to protect against somewhat larger events, and this approach has been employed on numerous sections of road. Known trouble spots will also be avoided where possible on slopes that have soils instead of bedrock at ground surface.

However, there may be no reasonable preventative means of protecting the road from a truly large-scale event, particularly in the tight rocky valleys from KP000 to KP039, and in Grainger Gap and its approaches, though there is slightly more room there. Therefore, if a significant seismic event occurs, it would be prudent for a pilot vehicle to inspect the road before trucks resume travelling on it, just as the road would be inspected following prolonged and intense rainfall, for example. It is understood that structures will be designed in accordance with current design codes. During detailed design, additional mitigation options may present themselves for further consideration according to site-specific requirements.

- **Avalanche activity:** It is anticipated that the avalanche assessment and map prepared previously for the road by Alpine Solutions Avalanche Services (2012) will be incorporated into an appropriate Road Operations Plan.

It is noted that the above-described mitigations are useful not only for reducing the likelihood of risks due to environment-related triggers of spills, accidents and malfunctions, but are also integral to the overall performance and safety of the road and its immediate surroundings. Additional discussion of effects of the road on the environment and related mitigations are presented in Section 8.0 below.

7.3.3 Residual Effects and Site-Specific Contingencies for High Risk Zones

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.

8.0 EFFECTS ASSESSMENT – OTHER

8.1 Terrain, Soils, Permafrost and Karst

8.1.1 Potential Effects Due to Road Construction Activities

The proposed road development is described in detail in earlier sections of this report. In general, construction activities will include:

- Development of winter access roads;
- Road construction in winter, summer or fall;
- Set up and operation of camps;
- Drilling for geotechnical investigation along the alignment and in the borrow sources and quarries;
- Stripping and stockpiling of organic material from borrow sources and quarries;
- Removal of material from borrow sources and quarries; preparation of material if/as needed for use; stockpiling;
- Hauling and placing of borrow material for the all-season road;
- Installation of bridges and culverts;
- Grading and compaction of constructed embankment; and
- Placement of surfacing gravel.

All of these activities require travel across the ground (as described above in terms of the terrain, geology, soils and permafrost) along the route and to borrow sources, or working in an area of open cut in a borrow source. The ground is in its most vulnerable state in the spring, summer and fall when the air/surface temperature is increasing, and the active layer is thawing or thawed. Travel over ground with tracked or wheeled equipment when the ground is in this vulnerable state can potentially cause deformation of or damage to the soil and vegetative surface (particularly in areas of soft, fine-grained soils and peat), compaction of organic peatlands, pumping of water to the surface or collection of surface water in deformations to form areas of standing water.

In areas of ice-rich permafrost, the change in ground surface characteristics could result in an increase in ground surface temperature and a corresponding increase in the depth of the active layer and subsequent thaw slumps, thawing of ice-rich soil, slope and soil instability, erosion and subsidence in the permafrost. Subsidence or the presence of new low-lying areas or surface channels can also change the surface water drainage, even beyond the area of vehicle travel. With thermal and physical erosion comes the likelihood of sedimentation.

Constructing roadway cutslopes in thaw-sensitive permafrost would require the removal of the organic layer, and cutting into the ground, both of which potentially expose permafrost, which in areas of ice-rich permafrost could cause subsidence and water ponding along the cutslope and embankment toe, excessive erosion and sedimentation, thaw that progresses from the cutslope and then under the road, causing excessive settlement or complete loss of the road embankment, or even a retrogressive thaw slump or flow that results in the ongoing failure of the slope continuing above the original cutslope. The same issue applies to the extraction of construction materials from borrow sites. If such borrow sites are located adjacent to the road, these issues are likely to also affect the road. Where borrow areas are not located in permafrost, there may still be the potential for erosion and sedimentation occurring, or sloughing and collapse of over-steepened borrow pit slopes.

The all-season road has the potential to disturb existing slope instabilities or to create new instabilities, both large and small. Although such features can reactivate on their own, disturbance can increase the likelihood of reactivation. For example, if the road reroutes surface water drainage into a marginally-stable area, slope instabilities could result. Or, if the road cuts into the supporting toe of an old landslide, that cut could result in the slide reactivating, even if it is not a slope in permafrost soils. Cuts in rock slopes or talus or scree can also result in loss of toe support. As well, if large fills are placed in marginally-stable areas, the additional weight of the fill may reactivate old instabilities, whether it is an outright slope failure, or merely an increased rate of slope creep.

Road construction can also result in general soil disturbance and an increase in erosion and sedimentation compared to natural levels.

8.1.2 Potential Effects Due to the Physical Presence and Operation of the Road

The ground (terrain, geology, permafrost and karst) can also be affected by the physical presence of the all-season road including embankment, bridges and culverts after it is built. There are significant issues and challenges in constructing and operating a road in discontinuous permafrost terrain.

The perception that the existing winter road is in relatively good condition may suggest that much of the ground is not too sensitive to permafrost thaw. However, a properly constructed and operated winter road, even in highly thaw-sensitive permafrost terrain, should lead to little or no disturbance of the ground surface and no permafrost degradation. There are numerous examples of successful winter roads throughout northern Canada, many on winter road routes that have been operated for decades. In contrast, places where disturbance from winter road operation has been observed can all be linked to terrain disturbance during either winter road construction when there is still insufficient snow cover, or operation of the road too late into spring, after thawing has already started. The relatively good condition of the existing winter road is probably more indicative of the two winters of use it experienced, along with reasonable winter road construction and operating practices, followed by 33 years of vegetation regrowth.

As noted above, permafrost and ice-rich soils are highly sensitive to changes in ground temperature, and this is particularly true of the warm permafrost found along the route. Even slight changes can cause an increase in the thickness of the active layer, instability, thaw settlement and subsidence due to loss of permafrost. Introducing a new material on the ground surface could change this balance. For example, in warm permafrost, the edges of the embankment tend to allow the permafrost beneath to thaw, typically causing ponding along the embankment toe, while in the middle of the embankment, the permafrost may be preserved or even grow. Snow drifting tends to increase this effect. Although the road grade is plowed, the sides of the embankment tend to build up drifted or plowed snow, which insulates the ground and reduces the amount of heat escaping from the ground in winter. This means that the permafrost on the edges of the fill does not cool as much in winter as it would without an embankment, while in the middle of the road, it might even be colder than normal because it is plowed all winter. The snow drifting/plowing effect can potentially reach well past the toe of the embankment.

The road fill can also form a barrier to the movement of unchannelized surface water, resulting in another source of surface water that can accumulate or pond along the toe of the embankment, which in turn can contribute to additional thermal erosion (thawing), and also potentially to slope stability issues. Similarly, the embankment can also create preferential paths for surface water drainage that do not match with the natural surface water drainage pattern, where water runs along the toe of the road fill for some distance instead of across it. In this case, the water can also contribute to physical erosion. Locations where the water is finally directly downslope can also be affected, by erosion and even slope instabilities. Even subsurface water flow in the active layer can be affected if the depth of thaw is greater at the edges of the embankment than at the middle, as this creates another way in which cross-road drainage can be blocked. Culverts can also contribute to heave in the winter and thaw settlement in the summer in soils that are frost-susceptible and thaw-sensitive, and can result in thermal erosion in ice-rich terrain.

As mentioned previously in the discussion on climate change, the challenges of constructing and operating roads in warm discontinuous permafrost terrain are very evident on Highway 3 (Yellowknife to Behchoko) and Highway 7 (Liard Highway), both of which have been plagued by continuous settlement issues and instabilities, even after a significant reconstruction in the case of Highway 3. While it is noted there are some differences in the operational, service life and construction characteristics of the territorial highways as compared to the proposed Prairie Creek all-season road, there are some useful comparisons. The similarities in permafrost characteristics and terrain characteristics indicates that particular care needs to be taken in the design and construction of the all-season road, in order to mitigate the anticipated effects of road presence and operations.

8.1.3 Mitigative Measures

Numerous mitigation strategies are provided in documents from the Transportation Association of Canada (TAC 2005 and 2010) and from AANDC (INAC 2009, 2010a) to avoid or reduce adverse environmental effects due to road construction and borrow acquisition in the North. AANDC also has guidelines for camp and support facilities (INAC 2010b). Numerous resources are also available in the form of guidebooks, reports and other publications from the British Columbia Ministry of Forest, Lands and Natural Resource Operations (BCMF 2014a, 2014b), which include such topics as forest road engineering, best management practices for hillslope restoration, and karst management. The Karst Management Handbook may be particularly useful in parts of the route that traverse on or close to karst terrain (BCMF 2003). Parks is also preparing a National Parks Caving Directive which may have further information of value in karst terrain. Staff from NNPR should be contacted directly for information, since the directive is currently in draft form.

Construction will be managed such that travel across the ground does not occur when it is in its most vulnerable state. Currently, winter construction is proposed to take place when the ground is frozen, and construction access will be by winter road. Most of the existing winter road alignment in the vicinity of the proposed all-season route appears to have performed very well. Portions of the road that could have performed better provide good information on the types of terrain that require extra caution for the construction of the all-season road, for example, in the thermokarst terrain in the Fishtrap Creek drainage between about KP094.2 and KP095.7. Embankment fill-only (overlanding) techniques are proposed for these thaw-sensitive permafrost areas, meaning that no cut will take place and that the entire road grade will be composed of fill soils (TAC 2010).

Summer/fall construction is proposed to take place when the ground is seasonally more likely to be relatively dry. The benefit of summer/fall construction in terrain that is not thaw-sensitive is that the construction team will be able to see more clearly where the cross-drainage installations should be placed, and backfill placement and compaction will be greatly improved.

Summer/fall construction of the subgrade is not recommended for thaw-sensitive permafrost terrain, however. If construction of a working pad in thaw-sensitive permafrost terrain does not take place in winter, the only other opportunity to access that terrain would be very early in the thaw season. That is, the initial fill placement for a working pad along the route potentially could be done after the snow has gone, but before the subgrade starts to thaw. It should be noted, however, that the success of this method depends greatly on the contractor's ability to control his schedule, and leaving the construction of thaw-sensitive sections until winter is anticipated to be more reliable for protecting thaw-sensitive permafrost, and is therefore preferred. Fill material would be forward-hauled and placed so that no machinery comes into direct contact with the organic layer to be protected.

Because the road embankment can itself affect permafrost, the first strategy is to avoid thaw-sensitive terrain, where possible. If thaw-sensitive terrain cannot be avoided, embankments can be designed and constructed with thickness and width based on terrain type. In warm permafrost, a thicker embankment may not stop thaw of the permafrost, but it provides an additional buffer to reduce flexing of the underlying subgrade, and the additional width will help to keep early thaw at the embankment toes further away from the highest loaded area.

In areas where snow drifting proves to be an issue along the road, strategies to reduce snow drifting can be examined, designed and installed. It should be recognized that permafrost thaw is unlikely to be prevented, but it may be possible to mitigate the effects of thaw and settlement (TAC 2010).

Cutslopes in thaw-sensitive terrain should be avoided if at all possible. If cutslopes in thaw-sensitive terrain are unavoidable, mitigative solutions are limited and are accompanied by a much greater need for vigilance in monitoring and maintenance to avoid the types of situations described in Section 7.1.1 above. Depending on the site characteristics, it may be possible to protect some cutslopes with a drainage blanket to help mitigate the effects of thaw and meltwater (TAC 2010), or design near-vertical cutslopes to allow the organic layer to be draped over the cutslope to shade and protect it (INAC 2010a). However, these possibilities are not considered to be universal solutions.

Careful placement of culverts even where there are no obvious stream channels will help reduce the likelihood of ponding water alongside the road embankment. Permeable embankments may also be an option in some locations, particularly in areas of ice-rich permafrost, and these can be supplemented with an overlying culvert to pass spring flows (TAC, 2010). It is anticipated that regular inspections of drainage measures after installation will help to identify areas that might unexpectedly pond water, and corrective actions can be taken. The same applies to flowing surface water, and regular inspections will help identify areas where surface water drainage provisions need to be changed or improved.

The development, working and restoration of borrow sources will be carefully planned and carried out to reduce or avoid negative effects including permafrost thaw and soil erosion, in accordance with regional and national guidelines (INAC 2009, TAC 2010). Some general guidelines for borrow sources are as follows:

- Minimize the surface area of the open cut;
- Grade slopes to reduce slumping;
- Grade material storage and working areas to promote drainage and avoid standing water;
- Restore the borrow source when construction is completed by grading slopes to match the natural ground and drainage of the surrounding area, and replacing overburden.

A Sediment and Erosion Control Plan (SECP) can be prepared for the project. The proximity of watercourses, as well as fish habitat, wildlife habitat, and riparian areas downslope and within the road alignment reinforce the need for good erosion and sedimentation control during the course of construction and through the service life of the project. As well, disturbance of permafrost terrain, and subsequent permafrost thaw, are typical consequences of site development, so the SECP needs to mitigate the potential results of that disturbance.

The SECP would be based on the regulatory and Best Practices guidelines applicable to the project. It includes the following elements:

- A review of the applicable regulatory guidelines;
- An evaluation of existing site conditions and a summary of proposed conditions upon the completion of construction;
- Requirements for environmental monitoring including personnel, frequency of inspections, reporting and corrective actions;
- Best Management Practices for construction, including erosion control measures and sedimentation control measures; and

- Best Management Practices specific to permafrost and the mitigation of thermal erosion.

In general terms, all work needs to be conducted and completed in such a manner as to prevent the release of silt, sediment or sediment-laden water, construction wastes or other deleterious substances into streams, ponds or lakes.

8.1.4 Residual Effects

The road alignment, design and construction practices proposed are intended to help reduce the footprints required for the various construction requirements and operations, including borrow sources. As well, the currently proposed alignment is intended to take advantage of the most competent and least sensitive ground available along the general route, which should help to further reduce the impact.

It is anticipated that with careful surface water management that most if not all of the residual effects will be restricted to the footprint of road and borrow areas. Even the on-road effects can be reduced by good decommissioning practices that will allow the relatively rapid regrowth of vegetation, including scarifying the road surface to loosen the soil and allow moisture to infiltrate and rooting to occur more easily. The existing winter road also shows that where moisture and nutrients are available, excellent opportunities for regeneration are present and vigorous regrowth of trees is seen.

9.0 CUMULATIVE EFFECTS ASSESSMENT

Effects to terrain, soils, permafrost and karst from construction and operation of the all-season road may be cumulative to those from winter road construction and operation. However, for the most part, if the all-season road is approved, the winter road alignment will also be the all-season road alignment, and therefore there will be no cumulative aspect. As noted above, there will be approximately 9.4 km of winter road alignment that would not become the all-season road alignment. The KP024.3 to KP028.3 reroute will leave a winter road section on the north side of Sundog Creek. This section mostly crosses talus that naturally ravels, and thus is self-reclaiming for the most part, as has occurred since 1981. The KP090.6 to KP095 realignment avoids wetland terrain, and will leave a winter road section crossing sparsely vegetated wetland. This section appears to be naturally reclaiming by gradual encroachment of vegetation from both sides of the ROW, and would do so again after renewed winter use. The KP122 to KP123 realignment also avoids wetland terrain, whereas the winter route will naturally revegetate when no longer in use. In addition to these realignments, there is the original winter road footprint marked by absent or different vegetation which has long wetland sections that will not be used for the new winter road. In general, these appear to be naturally reclaiming by gradual encroachment of vegetation from the sides of the ROW. Therefore, in summary, no significant cumulative impacts to terrain, soils, permafrost and karst are anticipated from the all-season road.

10.0 CLOSURE

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

Respectfully submitted,
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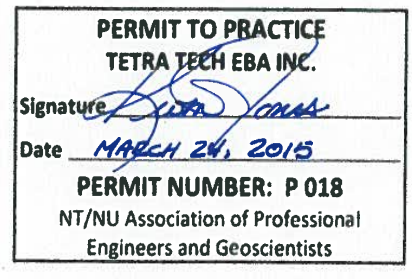

REFERENCES

Aerial photographs:

_____, 1994. Roll A28094 – Line 7, Photos 248-278; Line 8, Photos 216-218, 223-228, 232-237, 239, 241-242; Line 9, Photos 189-197. Approximate scale 1:20,000. Black and white. Date: 1994-06-16.

_____, 1994. Roll A28099 – Line 1, Photos 136-140; Line 2, Photos 106 and 108; Line 3, Photos 85, 87, and 88; Line 4, Photos 66 and 68; Line 10A, Photos 34-41; Line 10B, Photos 9-11. Approximate scale 1:20,000. Black and white. Date: 1994-07-12.

Alpine Solutions Avalanche Services (ASAS), 2012. Avalanche Hazard Maps, Drawings 1 to 6, Index Map at 1:75,000 scale, Hazard Maps at 1:20,000 scale. Prepared for Canadian Zinc Corporation. May, 2012.

Auld, Heather, 2010. Personal communications with Associate Director of the Adaptation and Impacts Research Division at Environment Canada, November 15, 2010.

Aylsworth, J.M. and Traynor, J.A., 2001. Landslide inventory, Mackenzie corridor (southern part), Northwest Territories; Geological Survey of Canada Open File 3915.

Bates, R.L. and Jackson, J.A. (Editors), 1984. Dictionary of Geological Terms, 3rd Edition.

BGC Engineering Inc., 2005. Mackenzie Gas Project, Review of Strain-Based Design – Loadings. Prepared for Department of Indian Affairs and Northern Development, Yellowknife, NWT. June 2005.

Bing, 2014. Microsoft Bing Maps Imagery Service for ArcGIS. 2014.

British Columbia Ministry of Forests, Lands and Natural Resource Operations (BCMF), 2014a. Reports and Publications. http://www.for.gov.bc.ca/pscripts/pab/whatsnew/index.asp. Various dates of publication. Access date: January 23, 2015.

BCMF, 2014b. Forest Practices Code Guidebooks. http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm. Various dates of publication. Access date: January 23, 2015.

BCMF, 2013. Engineering Manual. Prepared by British Columbia Forest Service, Engineering Branch. http://www.for.gov.bc.ca/hth/engineering/documents/publications_guidebooks/manuals_standards/eng-manual.pdf. Revision date: November 15, 2013. Access date: January 23, 2015.

BCMF, 2003. Karst Management Handbook for British Columbia. British Columbia Ministry of Forests. ISBN 0-7726-4922-7. http://www.for.gov.bc.ca/hfp/publications/00189/Karst-Mgmt-Handbook-web.pdf. May 2003. Access date: January 23, 2015.

British Geological Survey, NERC, 2015. Dolines and sinkholes. British Geological Survey, Natural Environment Research Council. http://www.bgs.ac.uk/mendips/caveskarst/karst_3.htm. Access date: March 10, 2015.

Canadian Standards Association (CSA), 2010. Technical Guide – Infrastructure in Permafrost. A Guideline for Climate Change Adaptation. CSA Reference Number: Plus 4011-10.

De Guzman, E.M. and Alfaro, M., 2014. Numerical and Physical Modelling of Road Embankments on Seasonally-Frozen Peat. Prepared for GeoRegina 2014.

De Leuw Cather, Western Ltd. (DeLCan), 1983. Engineering Assessment of Proposed All Weather Access Road, Mine Site to Liard Highway, Prairie Creek Project, N.W.T. Prepared for Procan Exploration Company. July, 1983.

D. Mollard and Associates Ltd., 1995. Remotely Sensed Terrain Analysis and Assessed Impact of the Existing Roadway along and near the 185-km-Long Prairie Creek Existing Winter Haul Route from 1:20,000 Scale Stereoscopic Airphotos. Prepared for Bruce Geotechnical Consulting Inc. and J.D. Mollard and Associates Ltd. September 1995.

Dillon Consulting, 2009. Prairie Creek Mine Winter Road Re-Alignment A, B, C, Re-Routing to Nahanni Butte, Polje Creek Bypass Air and Ground Stream Crossing Fish Habitat Assessments. November 25, 2009. Dillon File: 092438.

Douglas, R.J.W. and Norris, D.K., 1976a. Geology, Sibbeston Lake, District of Mackenzie. Geological Survey of Canada, Map 1377A, scale 1:250,000, compiled 1960, 1974.

Douglas, R.J.W. and Norris, D.K., 1976b. Geology, Virginia Falls, District of Mackenzie. Geological Survey of Canada, Map 1378A, scale 1:250,000, compiled 1960, 1974.

Duk-Rodkin, A., Huntley, D., and Smith, R., 2007. Quaternary geology and glacial limits of the Nahanni National Park Reserve and adjacent areas, Northwest Territories, Canada, *in* Mineral and Energy Resource Assessment of the Greater Nahanni Ecosystem Under Consideration for the Expansion of the Nahanni National Park Reserve, Northwest Territories, (ed.) D.F. Wright, D. Lemkow, and J.R. Harris. Geological Survey of Canada, Open File 5344, p. 125-129.

EBA, A Tetra Tech Company (EBA), 2013. Geotechnical Evaluation for Bridge West of Aklavik, NT. Prepared for the Hamlet of Aklavik, NT. (EBA File: Y14101360.)

EBA, 2012. High Water Levels for Prairie Creek Mine Access Road Stream Crossings, Northwest Territories. Prepared for Canadian Zinc Corporation. December 2014. (EBA File: E22102082.)

EBA, 2011a. Slope Stabilization at Liard Highway No. 7, km 5.9, NT. Prepared for the Government of the Northwest Territories, Department of Transportation. (EBA File: Y14101311.)

EBA, 2011b. Slope Stability Review and Evaluation of Stabilization Options, Church Hill, Tsiigehtchic, NT. Prepared for Ecology North. June 2011. (EBA File: Y14101275.)

EBA Engineering Consultants Ltd. (EBA), 2008a. Geotechnical Evaluation for Various Housing Lots, Nahanni Butte, NT. Report submitted to the NWT Housing Corporation, Fort Simpson, NT. (EBA file: Y14101079).

EBA, 2008b. Geotechnical Services for GNWT Education Centre, Fort Simpson, NT. Report submitted to Rowe's Construction Ltd. January, 2008. EBA File: Y14101003.

EBA, 2006a. Geotechnical Evaluation for New Gymnasium, Nahanni Butte, NT. Report submitted to Department of Public Works and Services, Government of the Northwest Territories, Hay River, NT. (EBA file: 1700202).

EBA, 2006b. Geotechnical Evaluation for New Fuel Facility, Nahanni Butte, NT. Report submitted to Earth Tech Canada Inc., Yellowknife, NT. (EBA file: 1700200).

EBA, 1996. Geotechnical Evaluation for Two Bay Parking Garage, Nahanni Butte, NT. Report submitted to Department of Public Works and Services, Government of the Northwest Territories, Fort Simpson, NT. (EBA file: 0701-96-12309).

EBA, 1993. Geotechnical Evaluation for Proposed Community Assembly Building, Nahanni Butte, NT. Report submitted to Department of Public Works and Services, Government of the Northwest Territories, Fort Smith, NT. (EBA file: 0701-11273).

Ecosystem Classification Group (ECG), 2010a. Cordillera Map, Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. http://www.enr.gov.nt.ca/sites/default/files/reports/2010_cordillera_map.pdf. March 2010. Access date: January 26, 2015.

ECG, 2010b. Boreal Cordillera High Boreal (HB) Ecoregion, Descriptions for Regions 6.1.5.3, 6.1.5.4, 6.1.5.5, and 6.1.5.6. Excerpts from Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. 245 pp. + insert map. http://www.enr.gov.nt.ca/sites/default/files/reports/2010_cordillera_report_web2.pdf. Access date: January 26, 2015.

ECG, 2009. Taiga Plains Map, Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. http://www.enr.gov.nt.ca/sites/default/files/reports/2010_cordillera_map.pdf. March 2009. Access date: January 26, 2015.

ECG, 2009. Description, 3.3.4.2 Taiga Plains Mid-Boreal (MB) Ecoregion. Excerpt from Ecological Regions of the Northwest Territories – Cordillera. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. 173 pp. + insert map. http://www.enr.gov.nt.ca/sites/default/files/reports/nwt_taiga_plains_enrdoc_full_report_ver9_revisions2009_2ndprintingerrata_corrected_april2013web.pdf. Access date: January 26, 2015.

Environment Canada, 2014. National Climate Data and Information Archive, Historical Weather. http://climate.weather.gc.ca/climateData/dailydata_e.html?StationID=1635, http://climate.weather.gc.ca/climateData/dailydata_e.html?StationID=1656, http://climate.weather.gc.ca/climateData/dailydata_e.html?StationID=10687 (Nahanni Butte, Fort Simpson, Fort Liard). Access date: February 11, 2014.

Evans, S.G., Aitken, J.D., Wetmiller, R.J., and Horner, R.B., 1987. A rock avalanche triggered by the October 1985 North Nahanni earthquake, District of Mackenzie, N.W.T. Canadian Journal of Earth Science, Volume 24, pp. 176-184.

Ford, D., 2009. Mapping Known and Potential Karst Areas in the Northwest Territories, Canada. Prepared for Government of the Northwest Territories, Environment and Natural Resources. August 2009. Accompanying Maps of Karst Features in the NWT. http://www.nwtpas.ca/science-karst.asp. Access date: December 4, 2014.

Ford, D.C, 2006. Karst Landform. Prepared for *The Canadian Encyclopedia*, Historica Foundation. http://www.thecanadianencyclopedia.ca/en/article/karst-landform/. Last revised March 6, 2015. Access date: March 10, 2015.

Golder Associates Ltd. (Golder), 2010a. Terrain Assessment Report, Prairie Creek Mine, Northwest Territories. Prepared for Canadian Zinc Corporation. March 2010. Golder File: 0913761009.

Golder, 2010b. Vegetation and Wildlife Assessment Report, Prairie Creek Mine, Northwest Territories. Prepared for Canadian Zinc Corporation.

Google, 2014. Google Earth imagery. August 16, 2007 and April 9, 2013.

Government of the Northwest Territories, Department of Justice (GNWT), 2014. Mine Health and Safety Regulations R-125-95 (last amended by R-095-2014). http://www.justice.gov.nt.ca/PDF/REGS/MINE%20HEALTH%20AND%20SAFETY/Mine_Health_and_Safety.pdf Access date: February 3, 2015.

Hawes, R.J. et al, 1975. Surficial Geology and Geomorphology, Sibbeston Lake, District of Mackenzie. Geological Survey of Canada, Map 10-1979, scale 1:125,000, 1975.

Heginbottom, J.A., Dubreuil, M.A., and Harker, P.A., 1995. Canada - Permafrost. National Atlas of Canada, 5th Edition, National Atlas Information Service, Natural Resources Canada, Ottawa, Plate 2.1, MCR 4177.

Indian and Northern Affairs Canada (INAC), 2010a. Northern Land Use Guidelines, Roads and Trails. Prepared by INAC (now Aboriginal Affairs and Northern Development Canada). ISBN: 978-1-100-14743-7. https://www.aadnc-aandc.gc.ca/eng/1100100023568/1100100023583. Access date: January 23, 2015.

INAC, 2010b. Northern Land Use Guidelines, Camp and Support Facilities. Prepared by INAC. ISBN: 978-1-100-18250-6. https://www.aadnc-aandc.gc.ca/eng/1319659277961/1319659384862

INAC, 2009. Northern Land Use Guidelines, Pit and Quarries. Prepared by INAC. ISBN: 978-1-100-14254-8. https://www.aadnc-aandc.gc.ca/eng/1100100023585/1100100023587. Access date: January 23, 2015.

J.D. Mollard and Associates Ltd. (JDMA), 1984. Office Airphoto Search for Foundation and Surfacing Materials for Nahanni Butte Airstrip, Vicinity Nahanni Butte Settlement, N.W.T. Prepared for Government of the Northwest Territories, Public Works – Highways Division. March, 1984.

Kors-Olthof, R.I., Hoeve, T.E., and Patrick, R.A., 2014. Evaluation and Stabilization of a Slope Failure at Liard Highway No. 7, km 5.9 (Case Study). Paper prepared for and presented at GeoRegina, 2014; also presented at the 2014 Yellowknife Geoscience Forum. September 2014.

McElhanney, 2012. Orthoimagery and LiDAR for Prairie Creek Winter Road. 2012.

National Building Code of Canada, 2010. 2010 National Building Code Seismic Hazard Calculation. http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2010-eng.php. Access date: January 24, 2015.

Natural Resources Canada (NRCan), 2015. Earthquakes Canada, GSC, Earthquake Search (On-line Bulletin), http://www.earthquakescanada.nrcan.gc.ca/stndon/NEDB-BNDS/bull-eng.php, Natural Resources Canada. Access date: March 9, 2015.

NRCan, 2011. Technical Submission, Environmental Assessment of Canadian Zinc Corporation's Proposed Prairie Creek Mine. June 3, 2011.

Parks Canada Agency (Parks), 2009. Hydrology, Geology and Geomorphology. Nahanni National Park Reserve of Canada. http://www.pc.gc.ca/ eng/pn-np/nt/nahanni/natcul/natcul1d.aspx. June 2009. Access date: January 26, 2015.

Parks, 2006. Proposed Expansion of Nahanni National Park Reserve, The Nahanni North Karst, Map: Karst Features in the Greater Nahanni Ecosystem. http://publications.gc.ca/collections/collection_2007/pc/R63-342-7-2006E.pdf. November 2006. Cat. #R63-342/7-2006E. ISBN: 978-0-662-44759-7. Access date: December 21, 2014.

Robertson, A., and Shaw, S., undated. Failure Modes and Effects Analysis (FMEA). Presented on EnviroMine: Environmental Technology for Mining. http://technology.infomine.com/enviromine/issues/cls_fmea.html. Access date: January 23, 2015.

SNC Lavalin Inc. (SLI), 2012a. Prairie Creek Access Road – Geotechnical Investigation. Prepared for Canadian Zinc Corporation. November 2012. SLI File No. 610984-8000-4GER-0002.

SLI, 2012b. Preliminary Geotechnical Site Reconnaissance, Prairie Creek Mine Winter Road, Bridge Crossings and Transfer Station Location – July 2012. Prepared for Canadian Zinc Corporation. August 2012. SLI File No. 334518-8000-4GCB-0001.

Savigny, K.W., 1995. Notations on 1:250,000 scale maps for Prairie Creek winter road. Provided to J.D. Mollard and Associates. September 7, 1995.

Smith, I.R., Bednarski, J.M., Deblonde, C., Duk-Rodkin, A., Huntley, D., and Kennedy, K.E. 2011: Potential granular aggregate resources in Northwest Territories and northern Yukon: an updated assessment integrating seismic shothole drillers' logs and surficial geology maps. Geological Survey of Canada, Open File 6849, 1 DVD-ROM. doi:10.4095/288804.

Transportation Association of Canada (TAC), 2010. Development and Management of Transportation Infrastructure in Permafrost Regions.

TAC, 2005. National Guide to Erosion and Sediment Control on Roadways Projects.

Tetra Tech EBA, 2014a. Technical Memo. Desktop Geotechnical Evaluation and Preliminary Foundation Recommendations, Proposed Communications Tower, Nahanni Butte. NT. Prepared for Bell Mobility. February 2014. Tetra Tech EBA File: Y14103254-02.

Tetra Tech EBA, 2014b. Geotechnical and Hydrotechnical Evaluation for Replacement of Rabbitkettle River Ferryway, Nahanni National Park Reserve, NT. Prepared for Parks Canada Agency. June 2014. Tetra Tech EBA File: Y14103255-01.

Tetra Tech EBA, 2014c. Stream Crossing Design Water Levels for Prairie Creek Mine Access Road, Northwest Territories. Prepared for Canadian Zinc Corporation. December 2014. Tetra Tech EBA File: ENVMIN03009-01.

Waltham, T., Bell, F.G., Culshaw, M., 2004. Sinkholes and Subsidence: Karst and Cavernous Rocks in Engineering and Construction. ISBN-13: 978-3540207252.

Warren, J.K., 2006. Evaporites: Sediments, Resources and Hydrocarbons. Springer. ISBN-13: 978-3540260110.

Water Survey of Canada (WSC), 2014a. Info Notes on Ice Conditions and Data Spikes/Dips. http://www.wateroffice.ec.gc.ca/ice_conditions_e.html. Access date: August 17, 2014.

WSC, 2014b. Prairie Creek at Cadillac Mine (10EC002), Daily Water Level (m), 1974-1990 (flow), 2013-2015 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10EC002&mode=Graph&type=h2oArc&dataType=Daily&parameterType=Flow&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014c. Prairie Creek at Cadillac Mine – Site 2 (10EC003), Daily Water Level (m), 2013-2015 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10EC003&mode=Graph&type=h2oArc&dataType=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014d. Liard River Near the Mouth (10ED002), Daily Water Level (m), 1972-2012 (flow), 2002-2012 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10ED001&mode=Graph&type=h2oArc&dataType=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014e. Liard River at Fort Liard (10ED001), Daily Water Level (m), 1942-2012 (flow), 2002-2012 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10ED002&mode=Graph&type=h2oArc&dataType=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014f. South Nahanni River above Virginia Falls (10EB001), Daily Water Level (m), 1960-2015 (flow), 2002-2015 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10EB001&mode=Graph&type=h2oArc&data Type=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014g. Blackstone River at Highway No. 7 (10ED007), Daily Water Level (m), 1991-2015 (flow), 2002-2015 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10ED007&mode=Graph&type=h2oArc&data Type=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

WSC, 2014h. Flat River near the Mouth (10EA003), Daily Water Level (m), 1960-2015 (flow), 2002-2015 (flow & level). http://wateroffice.ec.gc.ca/report/report_e.html?stn=10EA003&mode=Graph&type=h2oArc&dataType=Daily&parameterType=Level&year=2013&y1Max=1&y1Min=1. Access date: January 26, 2015.

APPENDIX A
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

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

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

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

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

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

5.0 LOGS OF TESTHOLES

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

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

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

7.0 PROTECTION OF EXPOSED GROUND

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

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

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

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

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

10.0 OBSERVATIONS DURING CONSTRUCTION

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

11.0 DRAINAGE SYSTEMS

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

12.0 BEARING CAPACITY

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

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

TESTHOLE LOGS AND LABORATORY TEST RESULTS

TERMS USED ON BOREHOLE LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on 0.075mm sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as inferred from laboratory or in situ tests.

DESCRIPTIVE TERM	RELATIVE DENSITY	N (blows per 0.3m)
Very Loose	0 TO 20%	0 to 4
Loose	20 TO 40%	4 to 10
Compact	40 TO 75%	10 to 30
Dense	75 TO 90%	30 to 50
Very Dense	90 TO 100%	greater than 50

The number of blows, N, on a 51mm O.D. split spoon sampler of a 63.5kg weight falling 0.76m, required to drive the sampler a distance of 0.3m from 0.15m to 0.45m.

FINE GRAINED SOILS (major portion passing 0.075mm sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as estimated from laboratory or in situ tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH (KPA)
Very Soft	Less than 25
Soft	25 to 50
Firm	50 to 100
Stiff	100 to 200
Very Stiff	200 to 400
Hard	Greater than 400

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or cracks in the soil.

GENERAL DESCRIPTIVE TERMS

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.
Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.
Laminated - composed of thin layers of varying colour and texture.
Interbedded - composed of alternate layers of different soil types.
Calcareous - containing appreciable quantities of calcium carbonate.;
Well graded - having wide range in grain sizes and substantial amounts of intermediate particle sizes.
Poorly graded - predominantly of one grain size, or having a range of sizes with some intermediate size missing.

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MODIFIED UNIFIED SOIL CLASSIFICATION

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE - GRAINED SOILS More than 50% retained on No. 75 µm sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines GW, GP, SW, SP GM, GC, SM, SC Borderline classification requiring use of dual symbols Less than 5% pass 75 µm sieve More than 12% pass 75 µm sieve 5% to 12% pass 75 µm sieve	$C_U = D_{60} / D_{10}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below 'A' line or plasticity index less than 4 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines		$C_U = D_{60} / D_{10}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly-graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot above 'A' line and plasticity index less than 4 — Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above 'A' line and plasticity index greater than 7
FINE-GRAINED SOILS (by behavior) 50% or more passes 75 µm sieve*	SILTS Liquid limit <50		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of slight plasticity	PLASTICITY CHART For classification of fine-grained soils and fine fraction of coarse-grained soils Equation of 'A' line: PI = 0.73(LL-20) PLASTICITY INDEX LIQUID LIMIT CH 'A' line CL CI MH or OH CL-ML ML or OL	
	SILTS Liquid limit >50		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
	CLAYS Above "A" line on plasticity chart negligible organic content Liquid limit <30		CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays		
	CLAYS Liquid limit 30-50		CI	Inorganic clay of medium plasticity, silty clays		
	CLAYS Liquid limit >50		CH	Inorganic clay of high plasticity, fat clays		
	ORGANIC SILTS AND CLAYS Liquid limit <50		OL	Organic silts and organic silty clays of low plasticity		
	ORGANIC SILTS AND CLAYS Liquid limit >50		OH	Organic clays of medium to high plasticity		
HIGHLY ORGANIC SOILS			PT	Peat, muck and other highly organic soils		

* Based on the material passing the 75 mm sieve

† ASTM Designation D 2487, for identification procedure see D 2488 USC as modified by PFRA

GROUND ICE DESCRIPTION

ICE NOT VISIBLE

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
N	Nf	Poorly-bonded or friable	
	Nbn	No excess ice, well-bonded	
	Nbe	Excess ice, well-bonded	

VISIBLE ICE LESS THAN 50% BY VOLUME

GROUP SYMBOL	SYMBOL	SUBGROUP DESCRIPTION	
V	Vx	Individual ice crystals or inclusions	
	Vc	Ice coatings on particles	
	Vr	Random or irregularly oriented ice formations	
	Vs	Stratified or distinctly oriented ice formations	

VISIBLE ICE GREATER THAN 50% BY VOLUME

ICE	ICE + Soil Type	Ice with soil inclusions	
	ICE	Ice without soil inclusions (greater than 25 mm thick	

NOTES:

1. Dual symbols are used to indicate borderline or mixed ice classifications.
2. Visual estimates of ice contents indicated on borehole logs ± 5%
3. This system of ground ice description has been modified from NRC Technical Memo 79, Guide to the Field Description of Permafrost for Engineering Purposes.

LEGEND: Soil ☐ Ice ■

TETRA TECH

KP024.3 TO KP028.3

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP025.5 EAST SIDE OF TRIBUTARY	DRILL: PICK AND SHOVEL	Y14103320-01-TP08
NEAR NAHANNI BUTTE, NT	6828718N; 417869E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - silty, sandy, trace to some cobbles, trace of boulders at ground surface, (150 mm thick)						0
	GRAVEL (GLACIOFLUVIAL) - trace to some sand, trace to some cobbles, trace of boulders, trace of silt and clay, trace of organics - trace of organics, gravel to 38 mm diameter, sample 150 mm minus		S1				
	END OF TESTPIT (0.30 m) Note: East side tributary crossing, near top edge of proposed full bench cut.						
1							
2							5
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Prarie Creek All Season Road

Project Number: Y14103320-01

Date Tested: November 10, 2014

Borehole Number: TP-08

Depth: 0.2-0.3 m

Soil Description: GRAVEL, some sand, trace fines (silt/clay)

Cu: 4.6

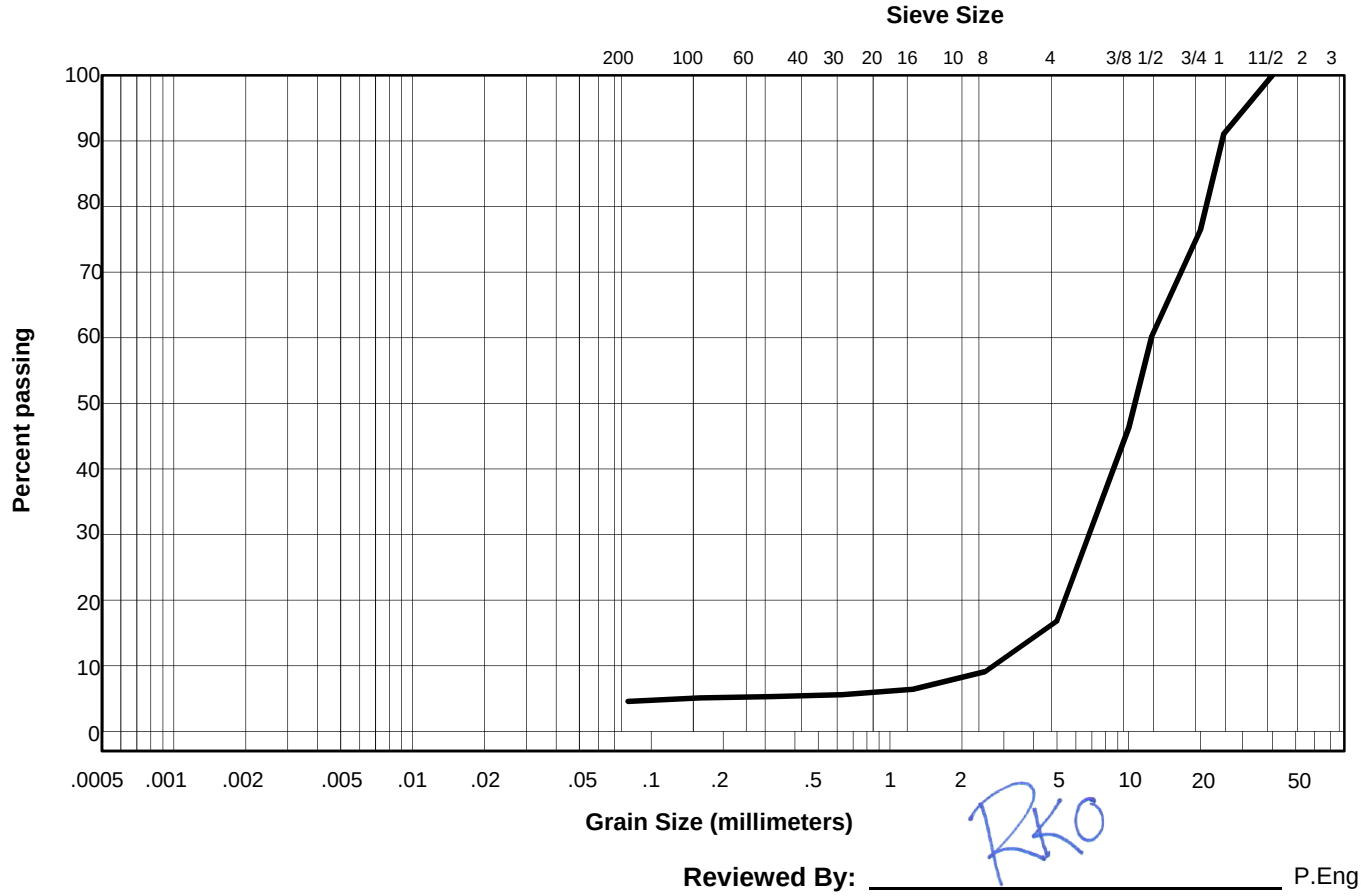
Cc: 1.4

Natural Moisture Content: 3.2%

Remarks:

Sieve Size (mm)	Percent Passing
50	#N/A
40	100
25	91
20	76
12.5	60
10	46
5	17
2.5	9
1.25	6
0.63	6
0.315	5
0.160	5
0.080	4.6

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



Reviewed By: RKO P.Eng.

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TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP025.54 EAST SIDE OF TRIBUTARY	DRILL: PICK AND SHOVEL	Y14103320-01-TP08A
NEAR NAHANNI BUTTE, NT	6828714N; 417896E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - (50 mm thick)					0
	SAND AND GRAVEL (GLACIOFLUVIAL) - cobbles to 120 mm diameter, coarse grained sand, gravel and cobbles are flat and elongated					
	END OF TESTPIT (0.30 m) Note: East side of tributary crossing, just above heli landing area.					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP025.3 WEST SIDE OF TRIBUTARY	DRILL: PICK AND SHOVEL	Y14103320-01-TP09
NEAR NAHANNI BUTTE, NT	6828766N; 417746E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - sandy, rootlets, (250 mm thick)						0
	GRAVEL AND COBBLES (GLACIOFLUVIAL) - some sand, trace of silt and clay, trace of organics, subangular cobbles to 150 mm diameter, samples 150 mm minus						
			S1		●	●▲ ■	
	END OF TESTPIT (0.45 m) Note: West side tributary crossing, road crest, est. ~4 m cut on top of bench.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Prarie Creek All Season Road

Project Number: Y14103320-01

Date Tested: November 10, 2014

Borehole Number: TP-09

Depth: 0.4-0.45 m

Soil Description: GRAVEL, some sand, trace fines (silt/clay)

Cu: 39.0

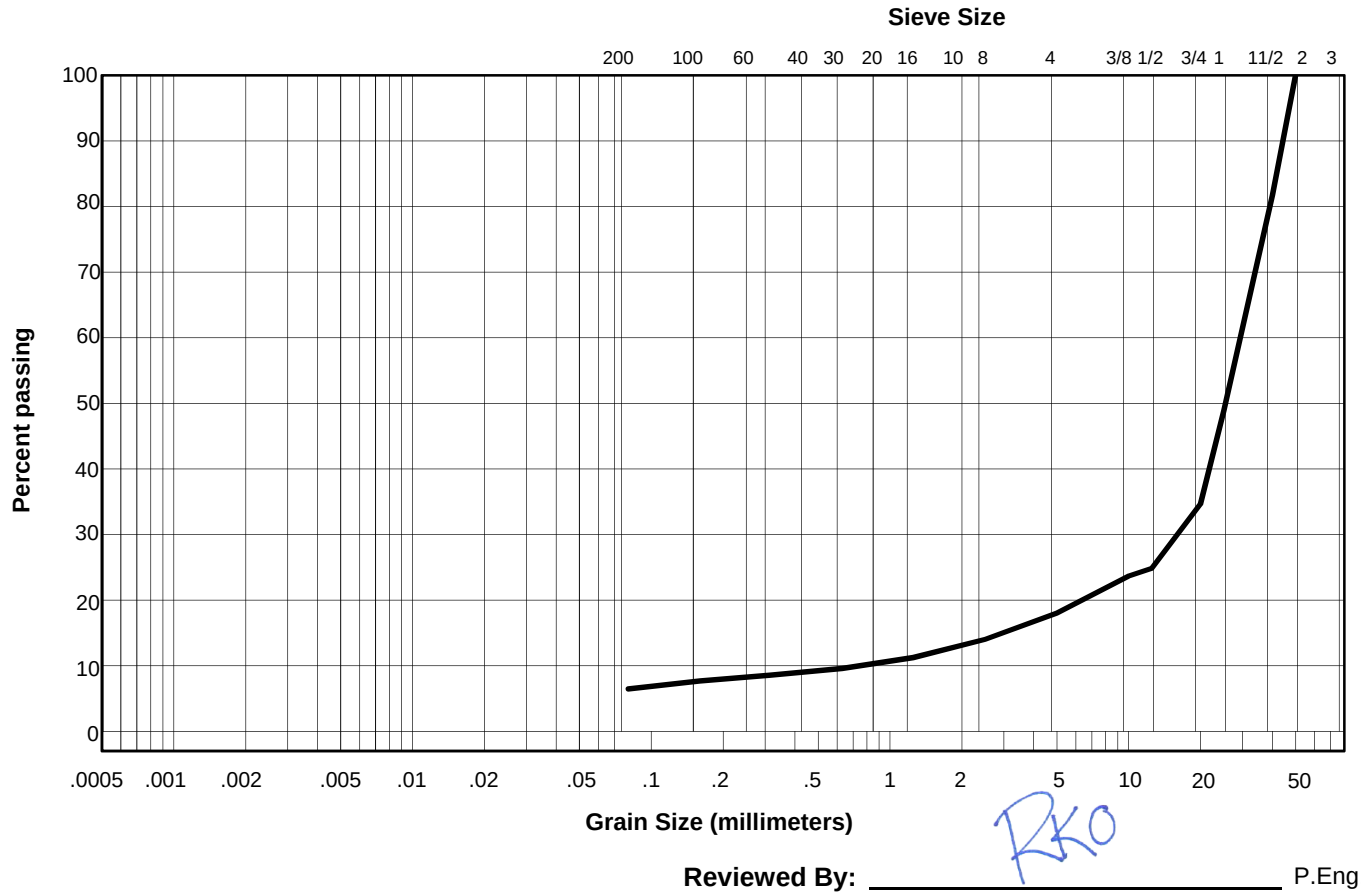
Cc: 11.6

Natural Moisture Content: 6.6%

Remarks:

Sieve Size (mm)	Percent Passing
50	100
40	82
25	49
20	35
12.5	25
10	24
5	18
2.5	14
1.25	11
0.63	10
0.315	9
0.160	8
0.080	6.5

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP025.65 ON TREED TERRACE/LEDGE	DRILL: PICK AND SHOVEL	Y14103320-01-TP10
NEAR NAHANNI BUTTE, NT	6828645N; 418005E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - (50 mm thick)						0
	SILT (probable COLLUVIUM) - trace of sand, trace of clay, moist, light brown, organic pockets						
	- some sand, some gravel to 75 mm diameter, no visible organics, light yellowish brown						
	- brown		S1				
	END OF TESTPIT (0.45 m) Note: Along forested bench east of tributary.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP025.6 ON TREED TERRACE/LEDGE	DRILL: PICK AND SHOVEL	Y14103320-01-TP11
NEAR NAHANNI BUTTE, NT	6828658N; 417973E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	SAND AND SILT (probable COLLUVIUM) - trace of clay, damp, light brown						0
	SILT (probable COLLUVIUM) - trace to some sand, trace of clay						
1	- trace to some gravel to 38 mm diameter - becoming gravelly		S1				
	END OF TESTPIT (1.20 m) Note: Located in suspected suffosion hole near west end of treed bench.						5
2							
3							10

TETRA TECH EBA

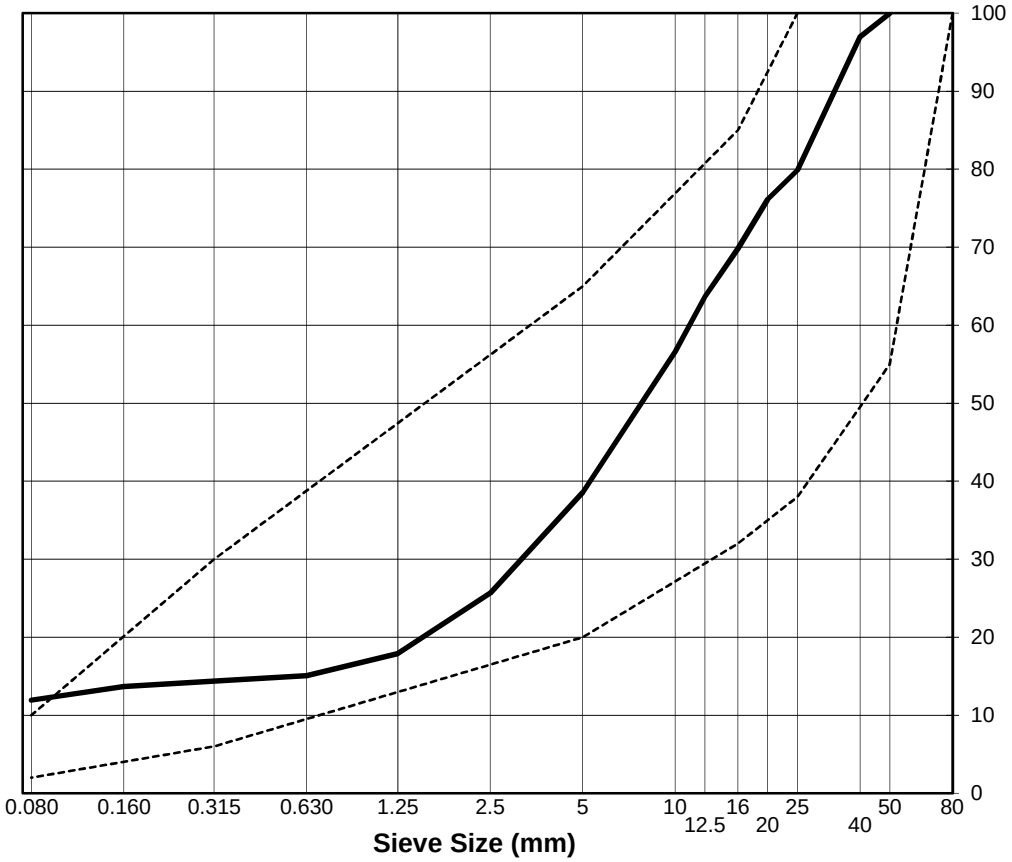
LOGGED BY: RKO	COMPLETION DEPTH: 1.2m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103320-01	Sample No.:	6161 / Allnorth KP026
Project:	Prairie Creek All-Season Road	Date Received:	October 9, 2014
Client:	Canadian Zinc Corporation	Sampled by:	EK (Allnorth)
Attention:	David Harpley	Date Tested:	December 5, 2014
Email:	david@canadianzinc.com	Tested by:	JD Office: Yellowknife
Description:	GRAVEL, sandy, some silt/clay	Moisture Content (as received):	6.6%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	BP 25	By Particle Mass:	
Supplier:	n/a		
Sample Location:	Proposed borrow area at about KP025.6		
Specification:	GNWT 80mm Gravel Fill		

Sieve Size	Percent Passing
50	100
40	97
25	80
20	76
16	70
12.5	64
10	57
5	39
2.5	26
1.25	18
0.630	15
0.315	14
0.160	14
0.080	11.9



Remarks: Sampled from alluvial mound at 61.583084°N, 124.546565°W.

Sampled 50 mm minus. Cobbles up to 120 mm present, gravel/cobbles are flat/elongated. Oversize on slope.

Reviewed By: RKO P.Eng.

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TETRA TECH

KP048.8 TO KP058.6

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP049.7 UPPER CROSSING POLJE REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH01
NEAR NAHANNI BUTTE, NT	6829758.7N; 436880E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	SILT - some fine grained sand, some clay, wet, brown grey, likely slough from scarp upslope		S1				0
	CLAY (possible TILL) - silty, some fine grained sand, free water, medium plastic, sand lenses		S2				
1							
			S3				
	END OF BOREHOLE (1.20 m) Note: Burn area. Slope failure on west side of creek near HP50, upper proposed crossing.						5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.2m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP049.9 POLJE REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH02
NEAR NAHANNI BUTTE, NT	6829694N; 437305E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) / SILT (%) / SAND (%) / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TURF AND TOPSOIL - (100 mm thick)						0
	SAND - trace to some silt, fine to medium grained, damp, reddish brown, trace of oxides		S1				
	- fine grained, brown		S2				
1	- damp to moist		S3		●		
	END OF BOREHOLE (1.15 m) Note: Burn area.						5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.15m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP049.95 POLJE REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH03
NEAR NAHANNI BUTTE, NT	6829733N; 437383E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND DUFF - sandy, (80 mm thick)						0
	SAND - trace to some silt, fine to medium grained, damp, reddish brown						
1			S1				
	END OF BOREHOLE (1.15 m) Note: Burn area.						
2							5
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.15m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS REPORT

ASTM C136 & C117

Project: Prairie Creek All-Season Road

Project Number: Y14103320-01

Date Tested: December 5, 2014

Borehole Number: BH 3, S1

Depth: 1.05m - 1.15m

Soil Description: SAND, some silt, damp, brown

Cu:

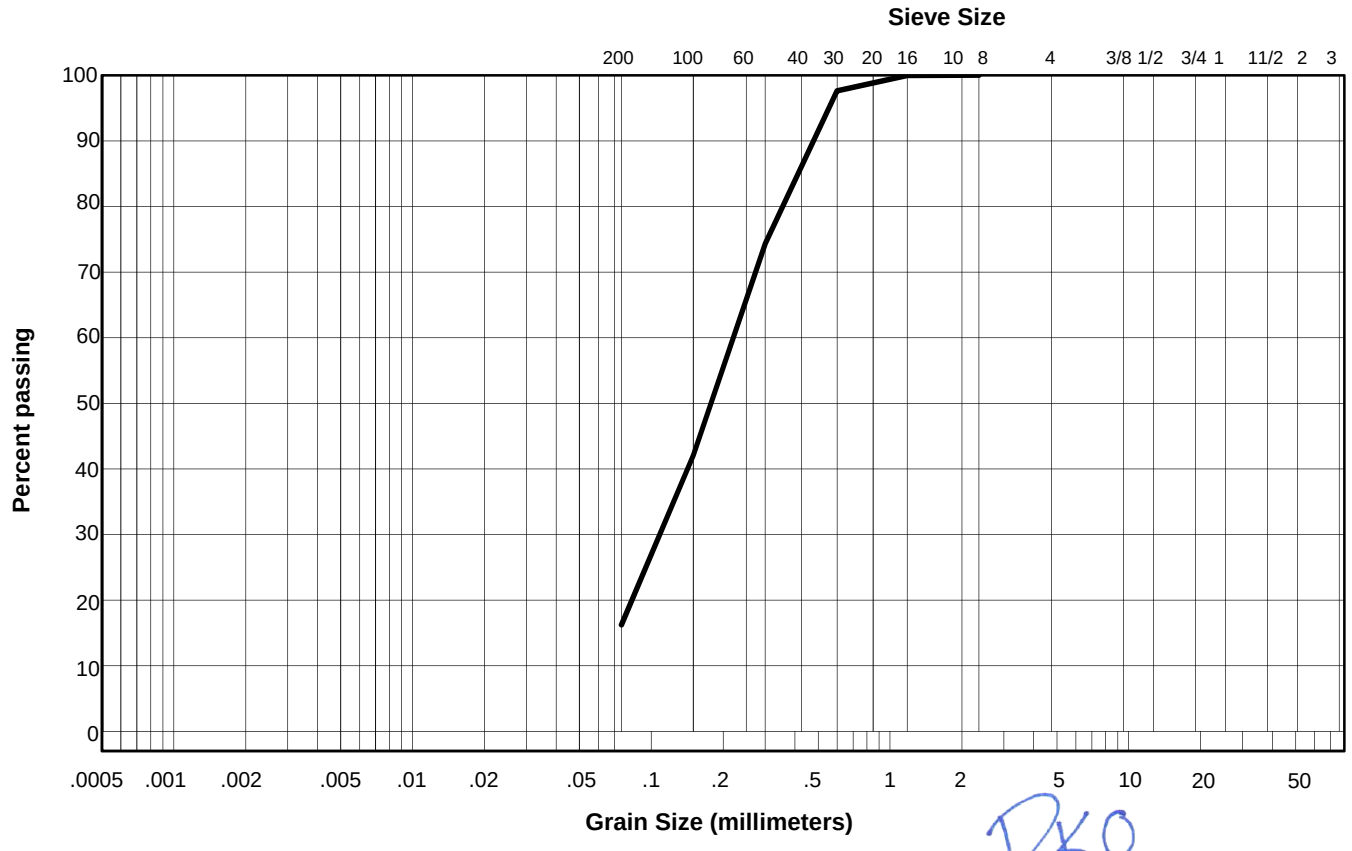
Cc:

Natural Moisture Content: 5.0%

Remarks:

Sieve Size (mm)	Percent Passing
50.000	
37.500	
25.000	
19.000	
12.500	
9.500	
4.750	
2.360	
1.180	100
0.600	98
0.300	74
0.150	42
0.075	16.2

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP050.5 POLJE REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH04
NEAR NAHANNI BUTTE, NT	6829960N; 437825E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND TURF - (100 mm thick)						0
	SAND - fine to medium grained, damp to moist, grey brown becoming reddish brown						
	- slightly coarser grained						
	- grey brown						
1	- trace of silt, damp to moist, clay lumps		S1		●		
	END OF BOREHOLE (1.10 m) Note: Tributary valley slope.						
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.1m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

MECHANICAL SIEVE ANALYSIS

Sample No.	**N/A**	Date Sampled	**October 2012**	By **M.L.**	of	**SNC Lavalin Group Inc.**	
Location	**Prairie Creek Mine**			Sample Type	**Bag**	Natural Moisture	**3.9** %
Description	**Sand, trace clay, trace silt (Marked as "Km 52 Sand Pit")**					Tech	**G.S.**

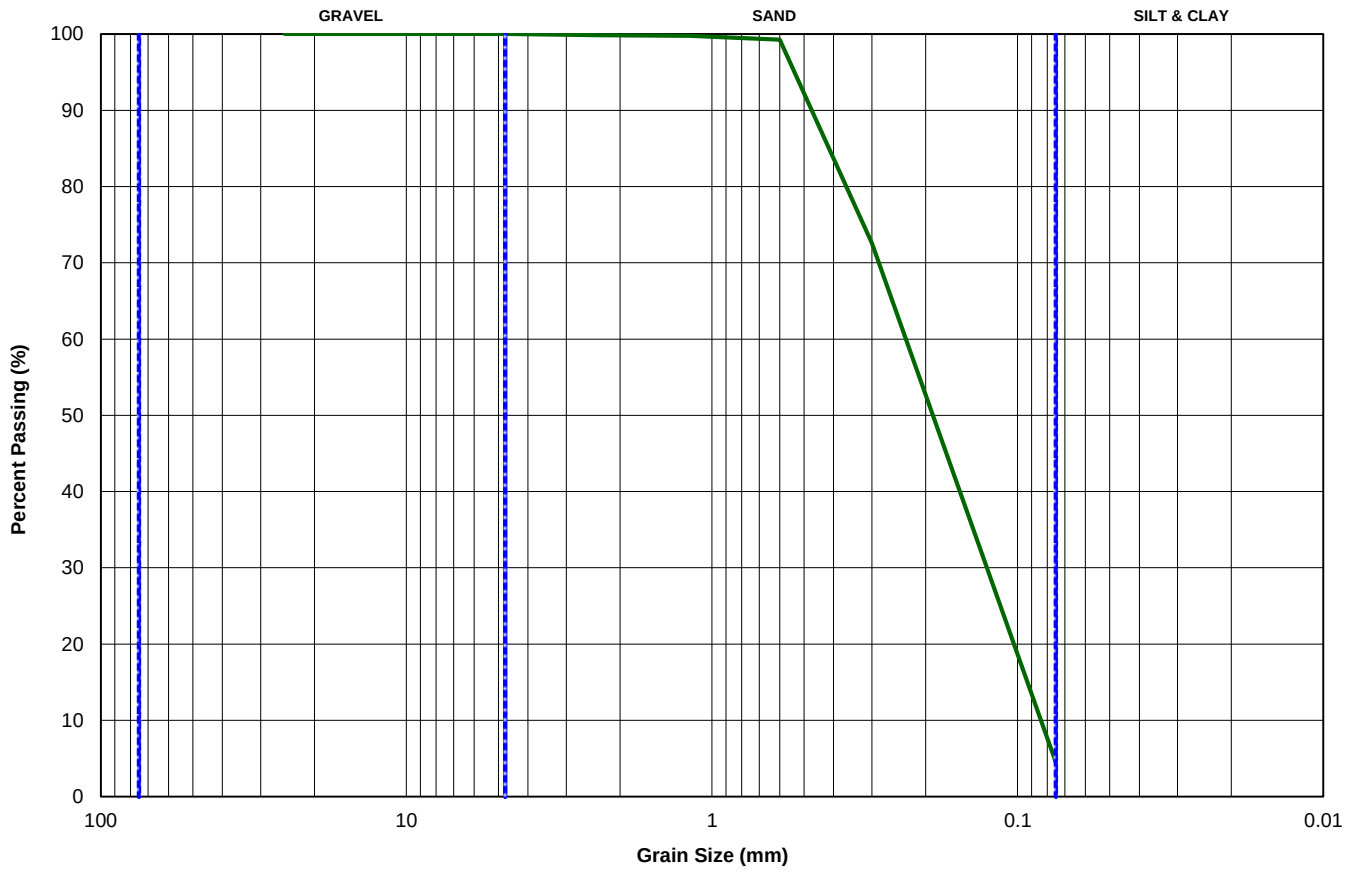
Specifications

Comments	Fracture	Method
Sample "Km 52 Sand Pit"	**N/A**	**N/A**

Sieve Results

Sieve mm	25	19	9.5	4.75	2.36	1.18	0.60	0.30	0.075
% Passing	100.0	100.0	100.0	100.0	99.8	99.7	99.2	72.6	4.5

By Type Gravel = **0.0%** Sand = **95.5%** Silt & Clay = **4.5%**



Harder Associates engineering consulting inc.
Member of the SNC•LAVALIN Group

Client	**SNC Lavalin Group Inc.**	Date	**20-Oct-12**
Project	**2012 Materials Testing**	File No.	**FN364**
Location	**Fort Nelson, British Columbia**	Sample No.	**N/A**

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP053.95 ABOUT 30 m SOUTH OF ROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH05
NEAR NAHANNI BUTTE, NT	6830925N; 440985E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - fibrous, (300 mm thick)						0
	SILT (possible GLACIAL OUTWASH) - sandy, trace of clay, damp, light brown						
			S1				
	- nuggetty, moist						
	SAND (POSSIBLE GLACIAL OUTWASH) - some silt, trace of clay, moist						
1	- silty, moist to wet						
	- wet, grey, cold		S2				
	END OF BOREHOLE (1.20 m) Note: Southwest of bedrock outcrops, about 90 m north of slump. Permafrost probably close to end of borehole.						
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.2m
REVIEWED BY: KJ	COMPLETE: 14/09/22
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP049.75 POLJE REROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP01
NEAR NAHANNI BUTTE, NT	6829644N; 437158E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TURF - (150 mm thick)						0
	SAND - silty, fine to medium grained, reddish grey brown, silt or clayey silt laminations		S1				
	END OF TESTPIT (0.45 m) Note: Lower crossing below HP50, east sideslope in burn area.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP049.8 POLJE REROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP02
NEAR NAHANNI BUTTE, NT	6829656N; 437195E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TURF - (100 mm thick)						0
	SAND - silty, fine to medium grained, reddish grey brown						
			S1				
	END OF TESTPIT (0.35 m) Note: East side of swale ~KP50.5, burn area						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.35m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP049.85 POLJE REROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP03
NEAR NAHANNI BUTTE, NT	6829701N; 437244E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TURF - (100 mm thick)						0
	SAND - some silt, trace to some organics, trace of clay		S1				
	- occasional gravel or cobble		S2				
	END OF TESTPIT (0.55 m) Note: Burn area						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.55m
REVIEWED BY: KJ	COMPLETE: 14/09/21
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP053.8 ABOUT 100 m SOUTH OF ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP06
NEAR NAHANNI BUTTE, NT	6830777N; 440912E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND TURF - (300 mm thick)						0
	SILT (possible GLACIAL OUTWASH) - clayey, low plastic		S1				
1	CLAY (possible TILL) - silty, moist, firm, medium to high plastic		S2				
	- some sand, wet, dark grey, sliding surface		S3				5
2	END OF TESTPIT (2.00 m) Notes: Intermediate scarp in Polje permafrost thaw slump/flow in burn area, about 30 m upslope (east) of Polje Creek. Sliding surface, backscarp is bowl-shaped, debris flow type behaviour.						
3							10

TETRA TECH EBA

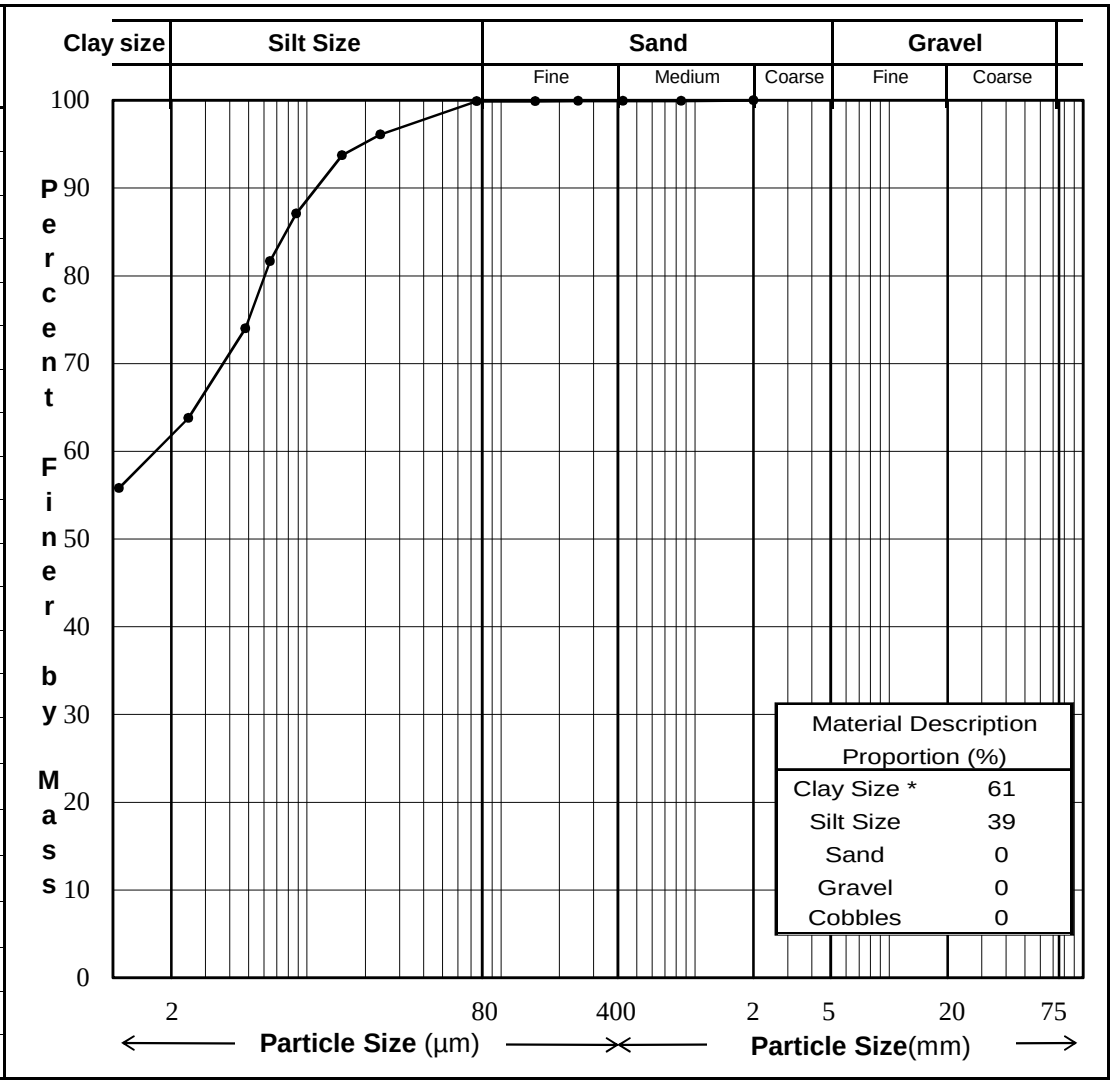
LOGGED BY: RKO	COMPLETION DEPTH: 2m
REVIEWED BY: KJ	COMPLETE: 14/09/22
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	
Client:	Canadian Zinc Corp.	Borehole/ TP:	TP06
Project No.:	Y14103320-01	Depth:	1.9m - 2.0m
Location:	~30 m above toe of thaw slump/flow at KP054	Date Tested	December 8, 2014
Description **:	CLAY, silty, brown	Tested By:	MC

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 µm	100
425 µm	100
250 µm	100
150 µm	100
75 µm	100
34 µm	96
22 µm	94
13 µm	87
9 µm	82
6 µm	74
3 µm	64
1 µm	56



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech EBA. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech EBA will provide it upon written request.

TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP054.2 ABOUT 100 m WEST OF ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP07
NEAR NAHANNI BUTTE, NT	6830823N; 441132E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT AND TURF- (300 mm thick)						0
	SILT (possible GLACIAL OUTWASH) - some sand to sandy, trace of angular, flat and elongated gravel to 120 mm diameter, trace of clay, dark brown to black, layers, lenses, varving, interspersed coarse particles oriented with layers		S1				
1							
	SAND (GLACIOFLUVIAL or OUTWASH) - trace of gravel, medium to coarse grained, damp, brown, occasional grey brown layer		S2				5
	SHALE (GLACIOFLUVIAL or OUTWASH) - boulders, discontinuous, thinly laminated, moist, black		S3A				
	CLAY (possible TILL) - silty, nuggetty, moist, firm, medium to high plastic		S3	CH			
2	- soft						
	- soft to firm, apparent sliding surface now thawed						
	- high plastic						
	END OF TESTPIT (2.50 m) Note: Headscarp of Polje permafrost thaw slump/flow. Stopped due to auger refusal on suspected permafrost. Upper 2.25 metres is mapped headscarp. Lower 0.25 metres is borehole.						
3							10

BULK DENSITY (kg/m³) 1400 1600 1800 2000 | SPT (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | CLAY (%) 20 40 60 80 | SILT (%) 20 40 60 80 | SAND (%) 20 40 60 80 | GRAVEL (%) 20 40 60 80

TETRA TECH EBA

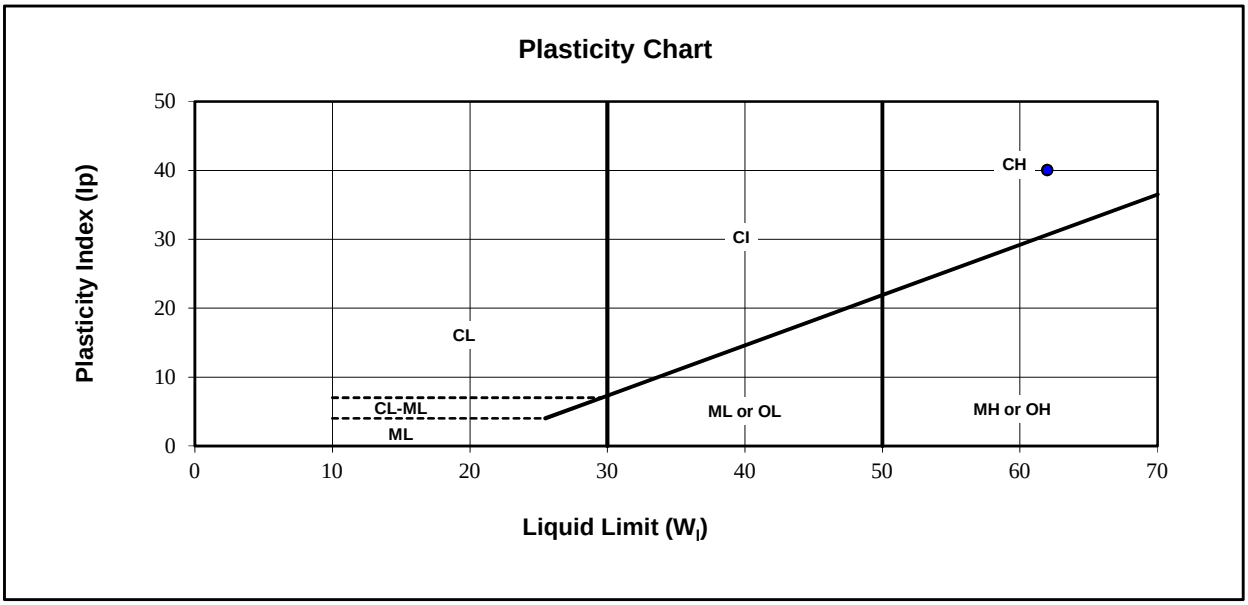
LOGGED BY: RKO	COMPLETION DEPTH: 2.5m
REVIEWED BY: KJ	COMPLETE: 14/09/22
DRAWING NO:	Page 1 of 1

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Prairie Creek All-Season Road	Sample Number:	S3
		Borehole Number:	TP 07
Project No:	Y14103320-01	Depth:	1.85 - 1.95 m
Client:	Canadian Zinc Corp.	Sampled By:	RKO Tested By: MC, KTP
Attention:	David Harpley	Date Sampled:	September 22, 2014
Email:	david@canadianzinc.com	Date Tested:	January 12, 2015

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



Liquid Limit ($W_{1)}$) :	62	Natural Moisture (%)	
Plastic Limit :	22	Soil Plasticity:	High
Plasticity Index (Ip) :	**40**	Mod.USCS Symbol:	CH

Remarks:

Reviewed By: RKO P.Eng.

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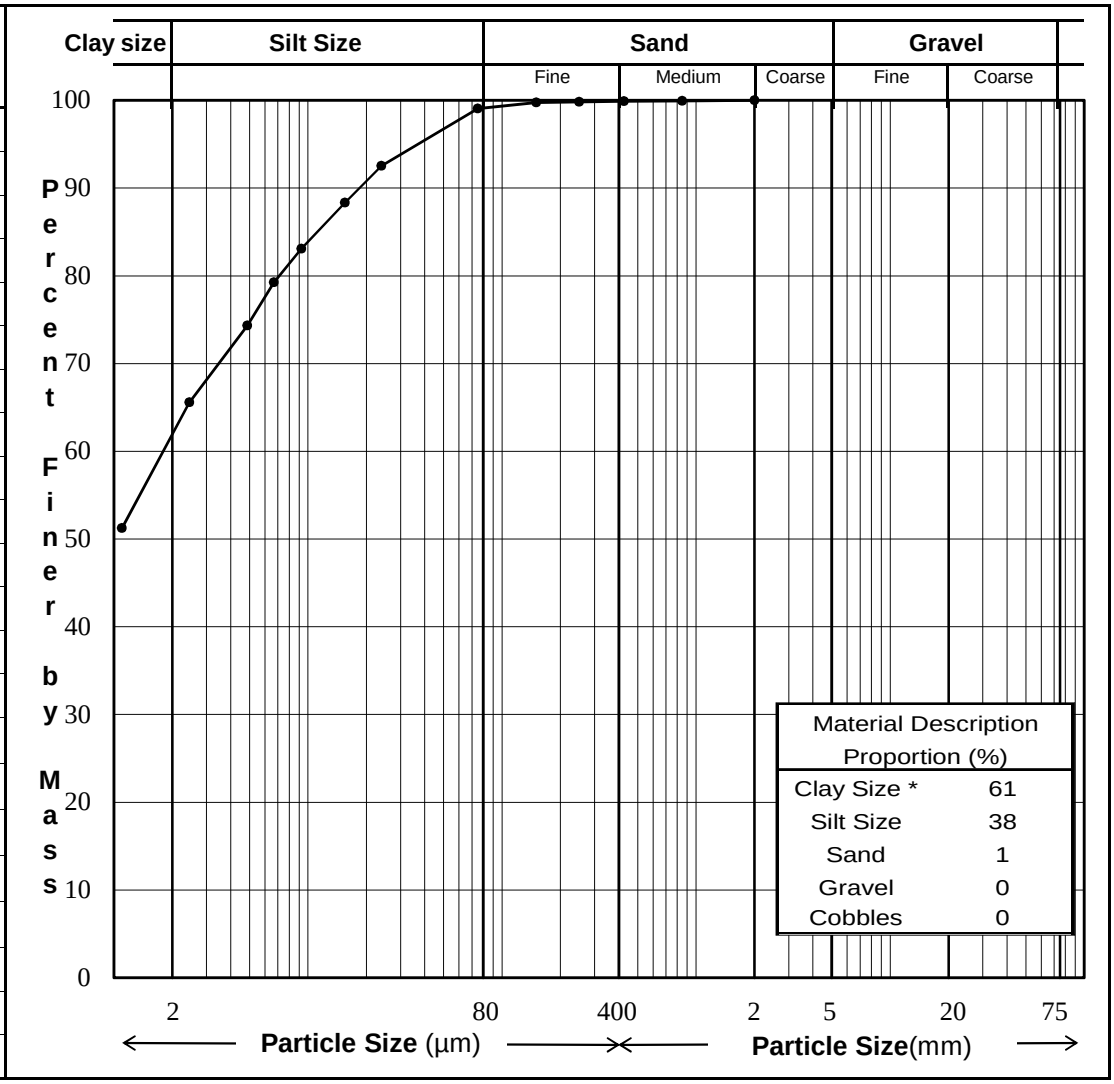
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	
Client:	Canadian Zinc Corp.	Borehole/ TP:	TP07
Project No.:	Y14103320-01	Depth:	1.85m - 1.95m
Location:	Headscarp of thaw slump/flow at KP054	Date Tested	December 8, 2014
Description **:	CLAY, silty, trace sand, brown	Tested By:	MC

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
850 µm	100
425 µm	100
250 µm	100
150 µm	100
75 µm	99
34 µm	93
22 µm	88
13 µm	83
9 µm	79
6 µm	74
3 µm	66
1 µm	51



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

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TETRA TECH

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJ-01**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Polje crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-28** (yyyy-mm-dd)
Coordinates	6830794 N, 440704 E	Elevation (m)	**710 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; Field Vane Intact ▲ / Remold ◆; Lab. Vane Intact △ / Remoulded ◇; 100–400 kPa; Water Content (%) ⊗; Plastic Limit (%); Liquid Limit (%); 20–80							
	709.5 / 0.5	TOPSOIL Black silty sandy organics, dry										
1	709.1 / 0.9	SAND Very loose, light brown, fine SAND, poorly graded, moist Medium to coarse, trace gravel		▼	⊗			0 0 3 6 5	3			8 83 9
		GRAVEL Compact, light brown, coarse sandy GRAVEL						0 5 6 5 5	11			
2	707.9 / 2.1	END of BOREHOLE at 2.1 m						5 7 7 6	14			

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJ-02**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Polje Crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-28** (yyyy-mm-dd)
Coordinates	6830799 N, 440704 E	Elevation (m)	**710 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ 100 200 300 400 kPa; Field Vane ▲ Intact ◆ Remold; Lab. Vane △ Intact ◇ Remoulded; Water Content (%) ⊗ 20 40 60 80; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣							
	709.9 / 0.2	TOPSOIL Silty organics, moist										
		SAND Very loose, brown, coarse SAND, some gravel, moist						1 1 2 3 2	3			
1	709.0 / 1.0	Wet, trace silt, some cobbles		▼								
		GRAVEL Loose, dark grey, coarse, sandy GRAVEL, trace silt, some cobbles, wet						2 3 4 9 11	7			
2	707.9 / 2.1	Compact at 1.9 m						12 11 7 5 8	18			
		END of BOREHOLE at 2.1 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJ-03**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Polje Crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-28** (yyyy-mm-dd)
Coordinates	6830795 N, 440704 E	Elevation (m)	**710 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
	709.9 / 0.1	TOPSOIL Black, organics										
1		SAND Loose, brown, fine SAND, poorly graded, moist to wet		▼								
	708.7 / 1.3	HOLE COLLAPSED			⊗ Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80							57 40 3
	708.1 / 1.9	END of BOREHOLE at 1.9 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJW-01**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Polje Crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-28** (yyyy-mm-dd)
Coordinates	6830788 N, 440673 E	Elevation (m)	**710 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100–400 kPa; Water Content (%) ⊗; Plastic Limit (%); Liquid Limit (%); 20–80							
	709.9 / 0.2	TOPSOIL Soft, grey, organic, silt, moist						0				
		SAND Very loose, light brown, fine SAND, trace silt, moist						0				
1								0	1			
								1				
								2				
	708.5 / 1.5			▼				2				
	708.3 / 1.7	SILT Loose, light brown SILT, wet						2	5			
								3				
								3				
2		GRAVEL Very loose, dark grey, coarse, sandy GRAVEL, trace shale, wet			⊗			1				1 29 70
								1				
								3	4			
								13				
								13				
		Compact at 2.65 m						9				
								9				
3	707.0 / 3.0							9	18			
		END of BOREHOLE at 3.0 m						6				
								3				

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJW-02**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Polje Crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-28** (yyyy-mm-dd)
Coordinates	6830790 N, 440673 E	Elevation (m)	**710 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
					Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
	709.8 / 0.3	TOPSOIL Brown, silt, trace organics, moist										
		SAND Very loose, light brown, fine SAND, moist						0 0 1 1 2	1			
1												
		Loose at 1.15 m						7 5 5 12 13	10			
	708.6 / 1.4	Trace silt										
		GRAVEL Compact, dark grey, coarse, sandy GRAVEL, wet		▼				11 10 9 10 9	19			
2												
	707.7 / 2.3	END of BOREHOLE at 2.3 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-PJW-03**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Polje Crossing**	Start Date	**2012-09-28** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012/09028** (yyyy-mm-dd)
Coordinates	6830792 N, 440673 E	Elevation (m)	**710 m**

Sample Condition: Disturbed | Undisturbed | Lost

Sample Types: SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core; CS - Core Sample; WS - Wash Sample; BU - Bulk; AU - Auger

Abbreviations: PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test; PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU); K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	710.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remolded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80							
	709.6 / 0.5	TOPSOIL Light brown, organic sandy silt, moist			⊗							0 33 67
1		SAND Light brown, fine SAND, some silt, moist			⊗							0 77 23
	708.7 / 1.3	SILT Loose, light brown, SILT, wet										
	708.5 / 1.5											
	708.3 / 1.7	SAND Light brown, SAND, wet		▼	⊗							60 37 3
2	708.0 / 2.0	GRAVEL Loose, dark grey, coarse, sandy GRAVEL, wet										
		SAND Light brown, medium to fine, SAND, trace shale, wet										
		END of BOREHOLE at 2.0 , Blocked on a 76 mm shale fragment										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky mountain**	Borehole ID	**BH-M-01**
Method	**2 inch Pionjar**	Page	**1 of 1**
Location	**M Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6829038 N, 442339 E	Elevation (m)	**456 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	456.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane: Intact ▲ Remold ◆ — Lab. Vane: Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) — Liquid Limit (%) — 20 40 60 80							
	455.9 / 0.2	SILT Loose, grey and light brown, SILT, slightly moist										
	455.3 / 0.7	CLAY Silty CLAY, trace shale, organic, slightly moist										
1		SAND Brown, coarse, gravelly SAND, trace silt and shale, organic, moist Some silt and shale										
	454.0 / 2.0	Some gravel										
		END of BOREHOLE at 1.98 m 2 inch and 3 inch Pionjar refusal at 1.98 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-M-02**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**M Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6829110 N, 442365 E	Elevation (m)	**455 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	455.00	Ground Surface			Lab UCS; Q Test; P.P. (US); *Field Vane* Intact, Remold; *Lab. Vane* Intact, Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80							
	454.7 / 0.3	TOPSOIL Black and brown, organics and gravelly organic clay, trace shale, moist, cold										
1		SAND Brown, coarse SAND, trace shale, moist, cold										
2		Frozen at 1.96 m										
3												
	451.2 / 3.8	END of BOREHOLE at 3.8 m		▼								

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-M-03**
Method	**3 inch pionjar**	Page	**1 of 1**
Location	**M Switchbacks**	Start Date	**2012/23/09** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6829298 N, 442400 E	Elevation (m)	**455 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	455.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100 200 300 400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20 40 60 80							
1	453.7 / 1.3	TOPSOIL Black, TOPSOIL, some clay, some gravel, moist										
2	452.4 / 2.6	GRAVEL Dark grey, GRAVEL, some coarse sand, trace silt, moist										
		END of BOREHOLE at 2.57 m 3 inch Pionjar Refusal										

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-M-04**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**M Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6829475 N, 442352 E	Elevation (m)	**827 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	827.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa; Water Content (%) ⊗; Plastic Limit (%); Liquid Limit (%); 20 40 60 80							
	826.8 / 0.2	TOPSOIL Soft, black and light brown, organics and organic silt, trace shale, moist										
		SILT Very loose, light brown, grey, SILT										
1	826.1 / 0.9	Some shale										
		SAND Loose, black, coarse silty SAND, some shale, moist										
2		Dark grey and brown Cold										
		Some gravel and shale										
3		Large gravel										
	823.5 / 3.5	END of BOREHOLE at 3.35 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

KP080.3 TO KP086

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP083.5 AT HELIPAD HP85	DRILL: PICK AND SHOVEL	Y14103320-01-TP12A
NEAR NAHANNI BUTTE, NT	6815639N; 457583E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - black					0
	SILT (possible COLLUVIUM or TILL veneer) - some organics, trace of clay, trace of sand, wet					
	END OF TESTPIT (0.60 m)					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.6m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP083.65 NEAR STREAM NORTH OF ROUTE	DRILL: PICK, SHOVEL AND HAND AUGER	Y14103320-01-TP12/BH06
NEAR NAHANNI BUTTE, NT	6815646N; 457692E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - (50 mm thick)						0
	SILT (possible COLLUVIUM or TILL veneer) - trace to some sand, trace of clay, dry, light brown						
	- some clay, dry, poor sample recovery						
	- trace to some clay, trace of sand, nuggetty, damp, stiff to hard, trace of oxides		S1				
			S2				
	- trace of angular gravel, damp		S3				
1							
	- some clay, very stiff, trace of sand pockets, trace of rootlets		S4		●		
	END OF TESTPIT (1.10 m) Note: KP080.3 to KP086.6 reroute north, typical mound with aspen, paper birch and white spruce. About 100 m north of route along stream parallel to crest of valley slope above Upper Tetcela River.						
							5
2							
3							10

TETRA TECH EBA

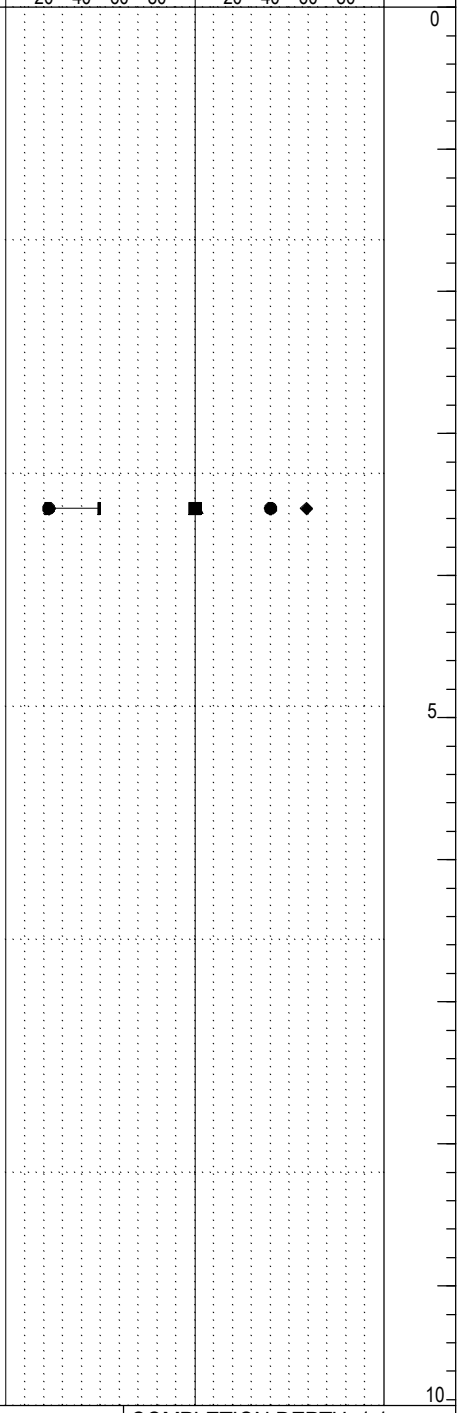
LOGGED BY: RKO	COMPLETION DEPTH: 1.1m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP084 NEAR STREAM NORTH OF ROUTE	DRILL: PICK, SHOVEL AND HAND AUGER	Y14103320-01-TP13/BH07
NEAR NAHANNI BUTTE, NT	6815665N; 458117E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT - roots and rootlets, (150 mm thick)						0
	SILT (COLLUVIUM) - trace of clay, trace of sand, dry, light brown						
			S1				
	- clayey, stiff to hard, low plastic		S2				
1							
	CLAY - silty, stiff to hard, low plastic		S3	CI			
	END OF TESTPIT (1.10 m)						
	Note: About 90 m northeast of reroute along stream parallel to crest of valley slope above Upper Tetcela River.						
							5
2							
3							10



TETRA TECH EBA

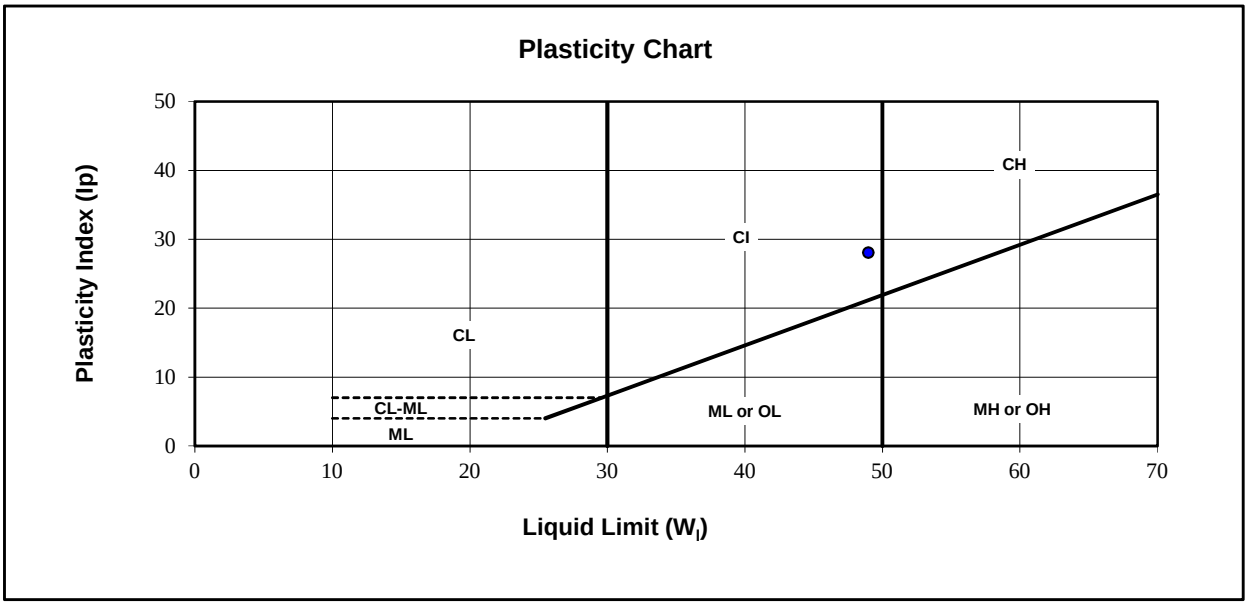
LOGGED BY: RKO	COMPLETION DEPTH: 1.1m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Prairie Creek All-Season Road	Sample Number:	6161
	Near KP084	Borehole Number:	TP-13/BH-07, S-3
Project No:	Y14103320-01	Depth:	1.05-1.10m
Client:	Canadian Zinc Corporation	Sampled By:	RKO Tested By: NR
Attention:	David Harpley	Date Sampled:	September 23, 2014
Email:	david@canadianzinc.com	Date Tested:	November 14-17, 2014

Sample Description: CLAY, silty, stiff to hard, medium plastic



Liquid Limit ($W_{1)}$) :	49	Natural Moisture (%)	22.6
Plastic Limit :	21	Soil Plasticity:	Medium to High
Plasticity Index (Ip) :	**28**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: RKO P.Eng.

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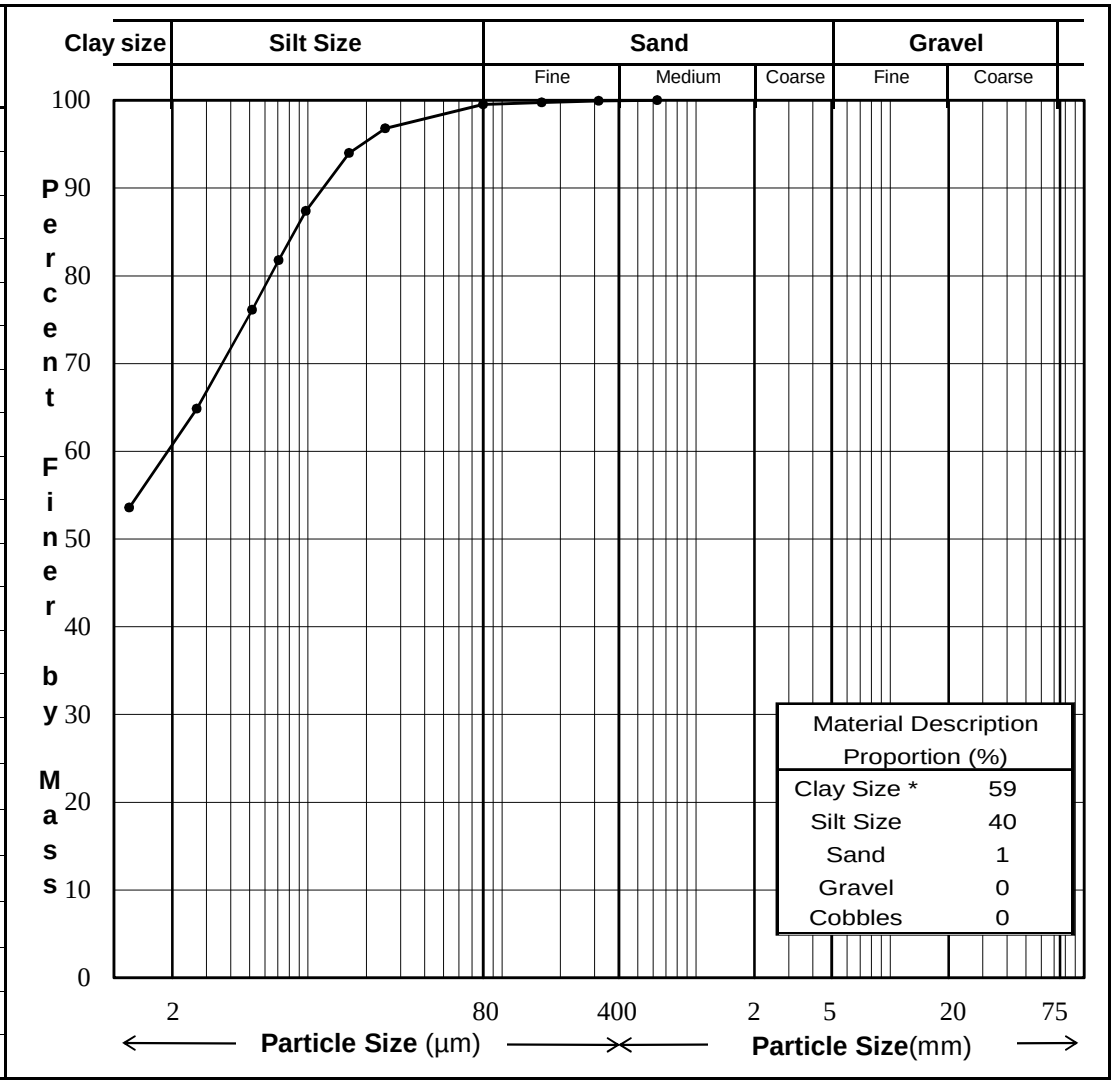
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	6161
Client:	Canadian Zinc Corporation	Borehole/ TP:	TP-13/BH-07, S3
Project No.:	Y14103320-01	Depth:	1.05-1.10m
Location:	Near KP084	Date Tested	Nov 18-20, 2014
Description **:	CLAY, silty, trace sand, with organic material	Tested By:	NR

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
16 mm	
13 mm	
10 mm	
5 mm	
2 mm	
1.3 mm	
630 µm	100
315 µm	100
160 µm	100
80 µm	100
25 µm	97
16 µm	94
10 µm	87
7 µm	82
5 µm	76
3 µm	65
1 µm	54



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

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TETRA TECH

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-TTF-01**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Tetcela facility footprint, west**	Start Date	**2012-09-22** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-22** (yyyy-mm-dd)
Coordinates	6814581 N, 457739 E	Elevation (m)	**835 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m³)

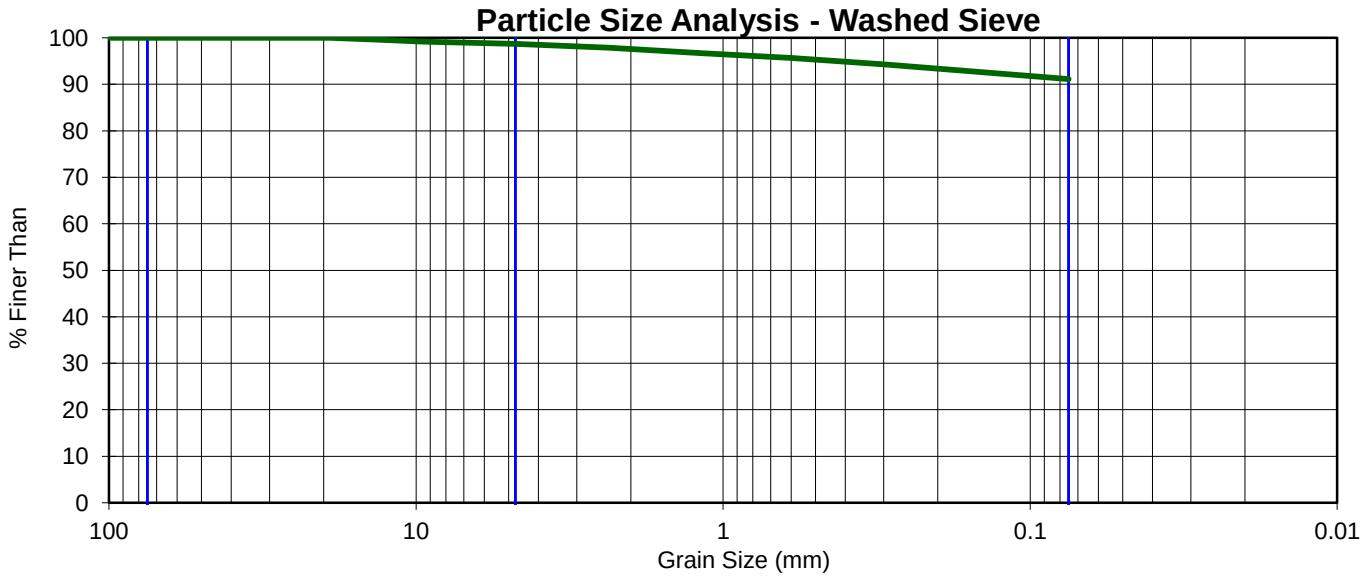
Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	835.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80							
1		CLAY Soft, grey, CLAY, trace sand, high plasticity, moist, very cold		▼				0 0 0 2 3				
		Frozen at 1.07 m Firm at 1.15 m			⊗			3 3 5 8 8	8			1 8 91
2		Very stiff at 1.90 m						9 9 14 17 18	23			
3	832.0 3.0							9 10 12 15 16 30	22			
	831.8 3.2	GRAVEL Loose rocks										
		END of BOREHOLE at 3.16 m Refusal at 3.16 m										

UNIFIED SOILS CLASSIFICATION

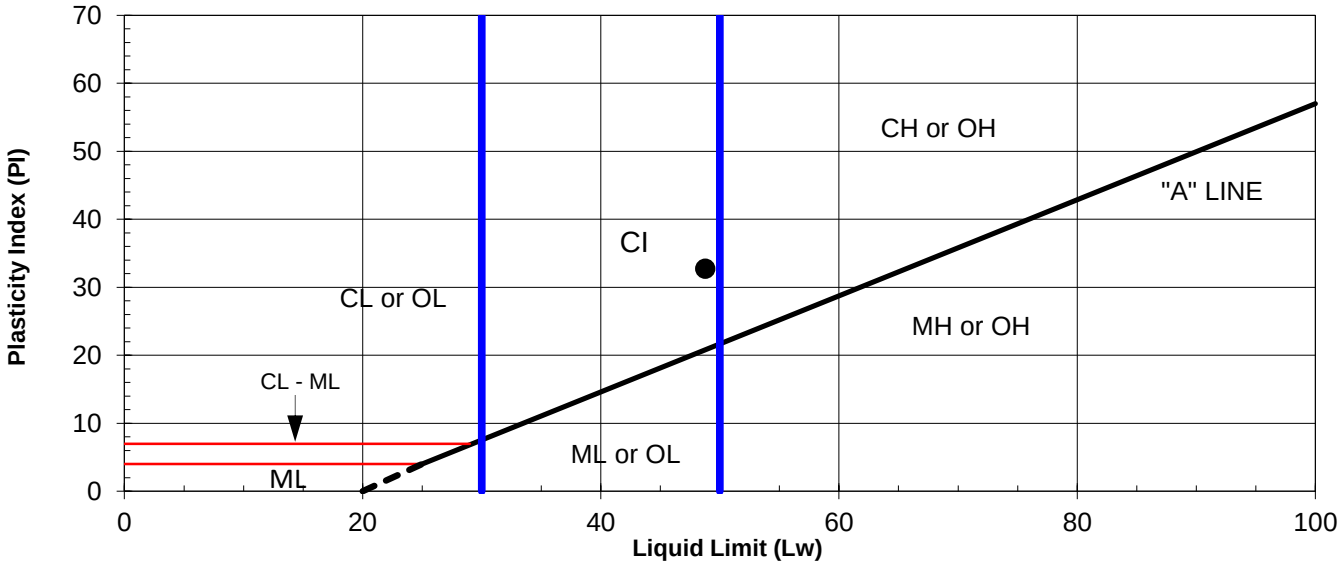
Sample: BH-TTF-01 Date Sampled **Oct. 2012** By **M.L.** of **SNC Lavalin Group Inc.**

Borehole No. **N/A** Depth **0" to 90"** Specification **ASTM D 2487**

Description **Clay, silty, trace gravel, trace sand.** Tech./ Eng. **G.S./M.L.**



Gravel = **1.3%** Sand = **7.6%** Silt and Clay = **91.1%**



Pw = **16.06%** Group Index: **18**

Lw = **48.79%** Soil type: **Inorganic**

PI = **32.72%** Fines type: **Cl**

Unified Soils Classification: **Cl - Medium clay**

Harder Associates engineering consulting inc.
Member of the SNC•LAVALIN Group

Client	**SNC Lavalin Group Inc.**	Date	**26-Oct-12**
Project	**Geotechnical Investigation**	File No.	**FN364**
Location	**Prairie Creek Mine, NWT.**	Sample No.	**BH-TTF-01**

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-TTF-02**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Tetcela facility footprint, east**	Start Date	**2012-09-22** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-22** (yyyy-mm-dd)
Coordinates	6814557 N, 457806 E	Elevation (m)	**836 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	836.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane ▲ Intact ◆ Remold — Lab. Vane △ Intact ◇ Remoulded — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
		CLAY Soft, grey CLAY, medium plasticity, moist						0 0 2 3 4	2			
1		Light brown, silty CLAY Trace shale fragments Firm at 1.15 m		▼				2 2 6 6 6	8			
		Frozen at 1.5 m										
2		Very stiff at 1.9 m						7 9 10 12 14	19			
3								13 13 14 16 18	27			
		Not frozen at 3.5 m						17 16 18 19 23	34			
4								20 24 24 26 28	48			
	831.4 4.6	END of BOREHOLE at 4.6 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

KP086 TO KP095.7

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
NEAR WEST END OF SOUTH TETCELA REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH08
NEAR NAHANNI BUTTE, NT	6812485N; 460364E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT - (180 mm thick)						0
	CLAY (possible GLACIOLACUSTRINE) - silty						
	SILT (probable TILL) - sandy, trace to some clay, trace of gravel		S1				
1	CLAY (probable TILL) - silty, trace of gravel, moist, firm to stiff, medium plastic, sandy lenses, cold		S2				
	- stiff to very stiff						
	- sandy, low plastic		S3	CI			
	END OF BOREHOLE (1.20 m) Note: KP86 reroute south, east of Tetcela River tributary, on gentle slope. Stopped due to refusal on probable frozen soil. (Route not used).						
							5
2							
3							10

BULK DENSITY (kg/m³) 1400 1600 1800 2000 | SPT (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | CLAY (%) 20 40 60 80 | SILT (%) 20 40 60 80 | SAND (%) 20 40 60 80 | GRAVEL (%) 20 40 60 80

TETRA TECH EBA

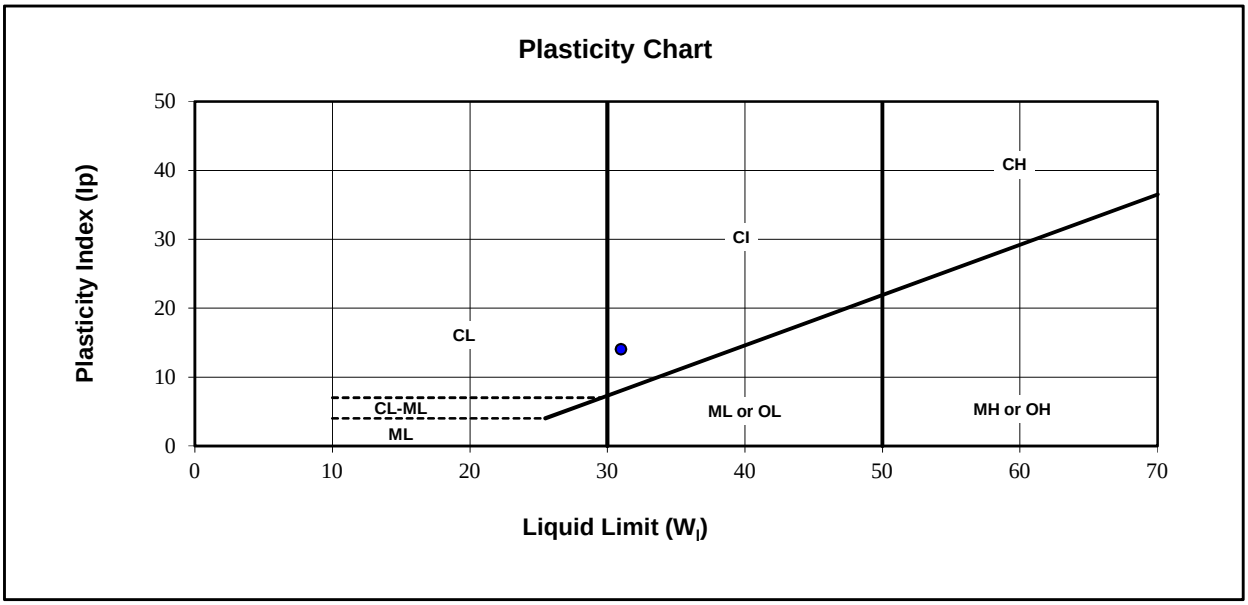
LOGGED BY: RKO	COMPLETION DEPTH: 1.2m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Prairie Creek All-Season Road	Sample Number:	6161
	Northwest of Nahanni Butte, NT	Borehole Number:	BH-08, S-1
Project No:	Y14103320-01	Depth:	1.05-1.10m
Client:	Canadian Zinc Corporation	Sampled By:	RKO Tested By: NR
Attention:	David Harpley	Date Sampled:	September 23, 2014
Email:	david@canadianzinc.com	Date Tested:	November 14-17, 2014

Sample Description: CLAY, silty, sandy, trace gravel, stiff to very stiff, moist



Liquid Limit ($W_{1)}$) :	31	Natural Moisture (%)	22.0
Plastic Limit :	17	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**14**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: RKO P.Eng.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech EBA. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech EBA will provide it upon written request.

TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
1.35 km SOUTH OF KP092	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH10
NEAR NAHANNI BUTTE, NT	6813784N; 462962E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT					0
	SAND (GLACIOLACUSTRINE) - silty, trace of sand, fine to medium grained, dry					
	- trace of fine gravel					
	- dense, hard drilling, poor return					
	END OF BOREHOLE (0.75 m) Note: Sidehill 60% at edge of mound. Spruce, occasional pine, birch. Proposed South Tetcela reroute on uplands section. (Route not used).					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.75m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
1.35 km SOUTH OF KP092	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH11
NEAR NAHANNI BUTTE, NT	6813766N; 462980E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT - fibrous, moist, brown				0
	- fibrous to decayed, black				
	SILT (GLACIOLACUSTRINE) - some sand, trace of clay, moist, brown				
	CLAY (possible TILL) - silty, trace of sand, wet		S1		
	- very cold				
1	- frozen, probable permafrost				
	sandy, trace of fine gravel		S2	Frozen, laminated ice Nf to Nbe, est. 10% excess ice	
	END OF BOREHOLE (1.10 m) Note: "inter-mound" flat lands. Proposed South Tetcela reroute on uplands section (Route not used).				
					5
2					
3					10

BULK DENSITY (kg/m³): 1400 1600 1800 2000

SPT (N): 20 40 60 80

PLASTIC M.C. — LIQUID: 20 40 60 80

CLAY (%): 20 40 60 80

SILT (%): 20 40 60 80

SAND (%): 20 40 60 80

GRAVEL (%): 20 40 60 80

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.1m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP094.4 SOUTHEAST OF C-LAKE ON REROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH12
NEAR NAHANNI BUTTE, NT	6813670N; 464512E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT - fibrous, moist, brown				0
	- partly decomposed, black				
	SILT (GLACIOLACUSTRINE) - clayey, dilatant, wet, soft, low plastic, grey brown		S1		
	CLAY (possible TILL) - silty, sandy, trace of oxides		S2	Ice rich, 10-20% excess ice (est.), Nf becoming Nbe	
	END OF BOREHOLE (0.85 m)				
	Note: Proposed alignment south of C-shaped lake, in thermokarst terrain of Fishtrap Creek drainage.				
1					
					5
2					
3					10

BULK DENSITY (kg/m³) 1400 1600 1800 2000 | SPT (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | CLAY (%) 20 40 60 80 | SILT (%) 20 40 60 80 | SAND (%) 20 40 60 80 | GRAVEL (%) 20 40 60 80

TETRA TECH EBA

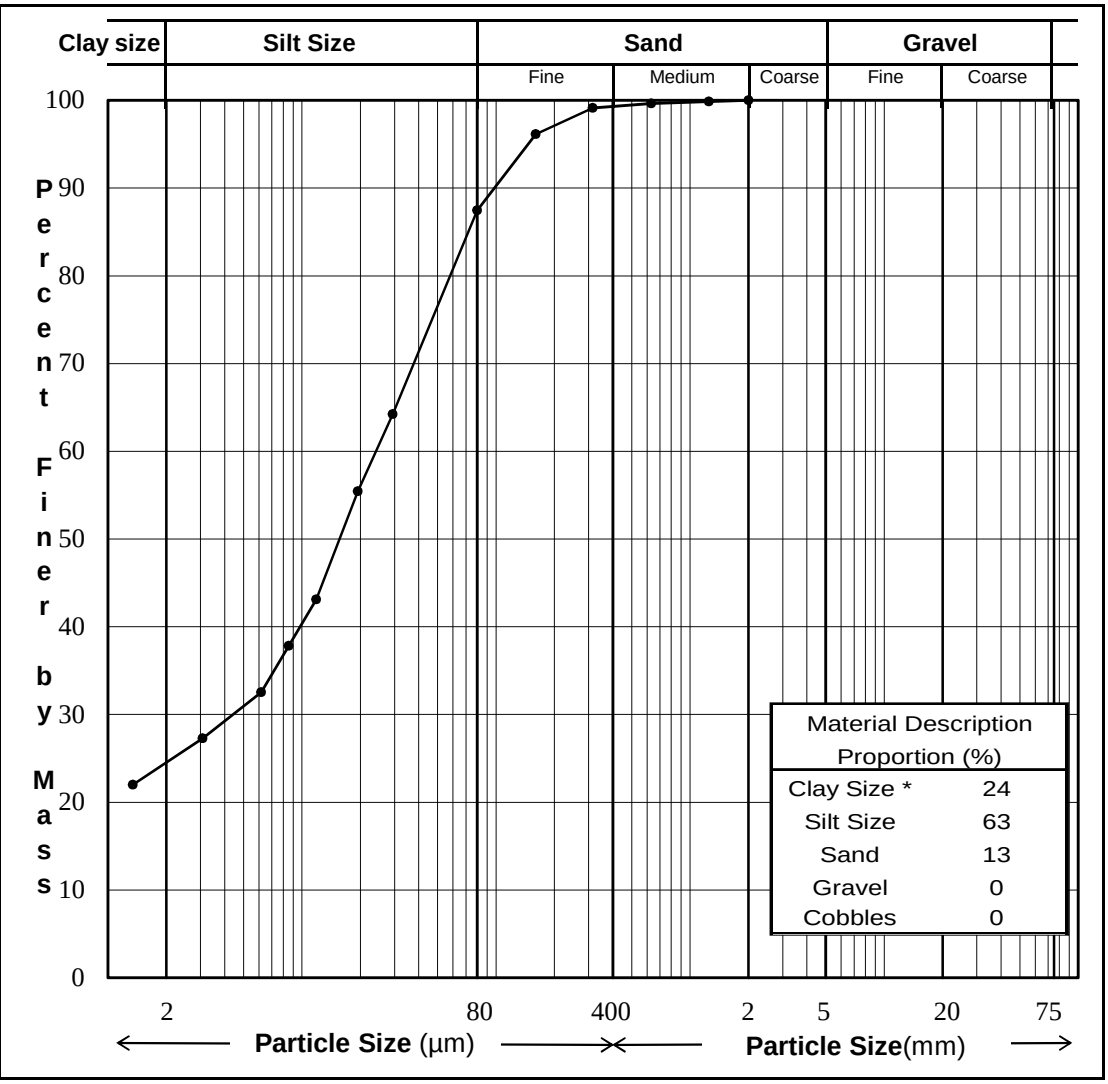
LOGGED BY: RKO	COMPLETION DEPTH: 0.85m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	6161
Client:	Canadian Zinc Corporation	Borehole/ TP:	BH-12, S2
Project No.:	Y14103320-01	Depth:	0.80-0.85m
Location:	~KP094.3	Date Tested	Nov 18-20, 2014
Description **:	CLAY, silty, some sand, with organic material	Tested By:	NR

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
16 mm	
13 mm	
10 mm	
5 mm	
2 mm	100
1.3 mm	100
630 µm	100
315 µm	99
160 µm	96
80 µm	87
29 µm	64
19 µm	55
12 µm	43
9 µm	38
6 µm	33
3 µm	27
1 µm	22



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

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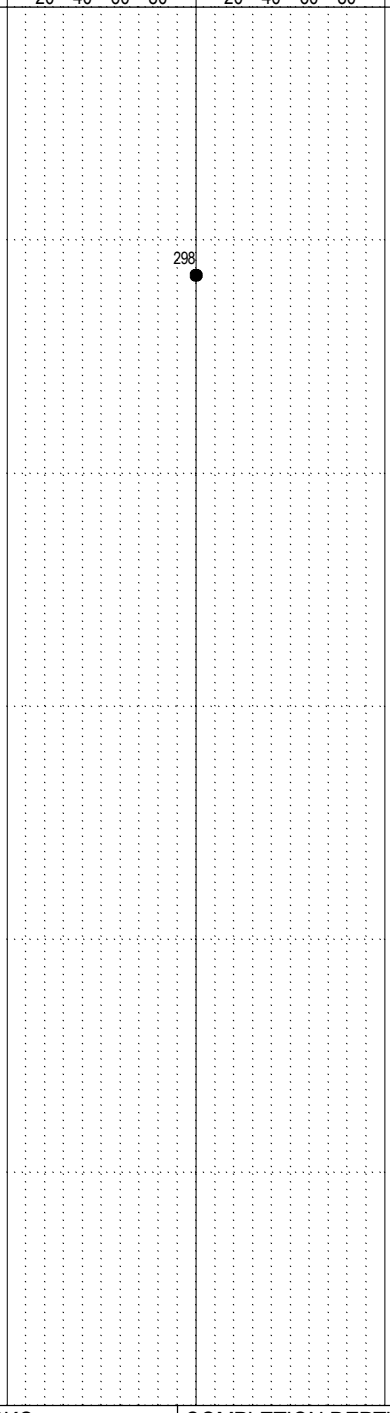
TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
WEST END OF SOUTH TETCELA REROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP14
NEAR NAHANNI BUTTE, NT	6812367N; 460281E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS
0	PEAT - weathered, friable, occasional woody inclusions			
	- frozen, 5-10% visible ice, probably permafrost		S1	Vx & Vx = 5-10%, Nf to Nbn, becoming Nbe by end of hole GTC515 = 16.32 kohm
	END OF TESTPIT (0.60 m) Note: KP86.3 to KP94 proposed reroute south, across Tetcela River tributary, on northwest facing slope above floodplain. (Route not used).			
1				
2				
3				



Depth (ft)
0
5
10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.6m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
1.35 km SOUTH OF KP092	DRILL: PICK, SHOVEL AND HAND AUGER	Y14103320-01-TP18/BH09
NEAR NAHANNI BUTTE, NT	6813823N; 462940E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - fibrous, (100 mm thick)						0
	SILT (GLACIOLACUSTRINE) - trace of sand, damp, light brown						
	- 200 mm thick clay lens - silty, trace of sand, moist, low plastic						
	- trace of clay, moist		S1				
	SAND (GLACIOLACUSTRINE) - trace to some silt, trace of clay, fine grained, moist, grey brown						
			S2				
	- few fines, fine to medium grained, damp, grey brown						
1	- clean, medium grained						
	SILT (GLACIOLACUSTRINE) - trace to some clay, trace of sand, moist, grey brown		S3		●		
			S4		●		
	END OF TESTPIT (1.25 m) Note: On aspen mound above swampy helipad. Proposed South Tetcela reroute on uplands section. (Route not used).						
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.25m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

KP095.7 TO KP101.7

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
WEST OF POND AT HELIPAD HP99	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH13
NEAR NAHANNI BUTTE, NT	6812729N; 466855E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - fibrous, dry to damp, brown, (250 mm thick)					0
	SILT (probable TILL) - trace of sand, trace of clay, trace of gravel to 10 mm diameter, dry to damp, light brown					
	- increasing gravel					
	- more gravel					
	END OF BOREHOLE (0.60 m) Note: Just west of outlet of pond at HP99. Refusal on gravel.					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.6m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
WEST OF POND AT HELIPAD HP99	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH14
NEAR NAHANNI BUTTE, NT	6812785N; 466810E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND DUFF - fibrous, dry to damp, brown, (150 mm thick)						0
	SILT (probable TILL) - some sand, trace of clay, trace of flat and elongated gravel to 100 mm diameter, hard		S1		●		
	END OF BOREHOLE (0.60 m) Note: On ridge at switchback west of pond. Refusal on gravel.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.6m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-01**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-22** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012/09/252** (yyyy-mm-dd)
Coordinates	6812075 N, 467292 E	Elevation (m)	**481 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	481.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane ▲ Intact ◆ Remold — Lab. Vane △ Intact ◇ Remoulded — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
	481.0 / 0.1	TOPSOIL Black organics										
		SILT and CLAY Grey and light brown SILT and CLAY, some gravel, dry			⊗ ⊢							16 13 71
1	480.0 / 1.0	END of BOREHOLE at 1.0 m Refusal on possible cobble at 1.0 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-01-02**
Method	**Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-22** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-22** (yyyy-mm-dd)
Coordinates	6812075 N, 467292 E	Elevation (m)	**481 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	481.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
	480.9 / 0.1	TOPSOIL Black organics			Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
1		CLAY Hard, grey and light brown, silty CLAY, some fractured shale and gravel, some sand, dry Moist			⊗ ⊢							22 14 64
	479.2 / 1.8	END of BOREHOLE at 1.8 m Refusal on possible cobble at 1.8 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-01-03**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-23** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6812075 N, 467292 E	Elevation (m)	**481 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	481.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — *Field Vane* Intact ▲ Remold ◆ — *Lab. Vane* Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
	481.0 / 0.1	TOPSOIL Black organics										
1		SILT Soft, light brown, SILT, some organics, dry										
	479.9 / 1.1	END of BOREHOLE at 1.1 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-01-04**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-23** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6812075 N, 467292 E	Elevation (m)	**481 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	481.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane Intact ▲ Remold ◆ — Lab. Vane Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
	481.0 / 0.1	TOPSOIL Black organics										
1		SILT Loose, light brown and grey, SILT, some fractured shale and gravel, trace organics, dry						3 6 8 11	9			
		Dense at 1.15 m						7 18 24 24 22	42			
	479.1 / 1.9	END of BOREHOLE at 1.9 m Refusal on shale fragment at 1.9 m						20 17 23 23 21 30	37			

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-02**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-22** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-22** (yyyy-mm-dd)
Coordinates	6812292 N, 467146 E	Elevation (m)	**306 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	306.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane Intact ▲ Remold ◆ — Lab. Vane Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
	305.9 / 0.1	TOPSOIL Black, organics			⊗ ⊢							5 16 79
		SILT Firm, light brown, clayey SILT, some sand, dry Trace shale						0 2 3 5 6	5			
1					⊢							28 35 37
		Very stiff at 1.15 m						8 10 12 8 8	22			
		Cold			⊗							
2								8 8 8	16			
		Moist						12 17 9 9 13	22			
3												
								10 9 8	19			
4												
								7 9 9 11 8	18			
	301.4 / 4.6	END of BOREHOLE at 4.6 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-03-03**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812569 N, 466788 E	Elevation (m)	**391 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	391.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80							
	390.9 / 0.2	TOPSOIL Black, organics, dry						0 0 0 4 1				
1		CLAY Very soft to soft, grey, silty CLAY, some gravel, moist						1 1 1 1.5 1.5	2			
2	388.7 / 2.3	SILT Soft, grey, SILT, some gravel, low plasticity, dry						2 2 2 3 5	4			
3	388.0 / 3.0	CLAY Stiff, grey, CLAY, wet		▼				4 2 2 2 5	4			
4		Sandy, some fractured rocks and some gravel						5 5 6 5 4	11			
	386.4 / 4.6	END of BOREHOLE at 4.6						4 6 6 5 7	12			

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-04**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812310 N, 466776 E	Elevation (m)	**383 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	383.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80							
	382.2 / 0.8	TOPSOIL Very soft, black organics Silty, moist						0 0 4 5 6	4			
1		SILT Stiff, grey, SILT, trace clay, trace fractured rock, moist, cold Firm at 1.15 m						5 5 6 5 6	11			
2	381.0 / 2.0				⊗			2 4 3 4 3	7			40 34 26
	380.7 / 2.3	GRAVEL Sandy GRAVEL, some silt, some clay										
		LOST SAMPLE						4 3 5 5 5	8			
3	380.0 / 3.0	END of BOREHOLE at 3.0 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-04-02**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812310 N, 466776 E	Elevation (m)	**383 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	383.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ 100 200 300 400 kPa; Field Vane ▲ Intact ◆ Remold; Lab. Vane △ Intact ◇ Remoulded; Water Content (%) ⊗ 20 40 60 80; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣							
		TOPSOIL Very loose, black, organics Silty, moist						0 11 3 3 4	6			
	382.2 0.8											
1		SILT Loose, grey SILT, some fractured rock, moist						3 3 4 3 3	7			
	381.5 1.5											
2		LOST SAMPLE						3 4 4 5 6	8			
3	380.0 3.0							0 4 5 4 4	9			
		END of BOREHOLE at 3.0 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-04-03**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812310 N, 466776 E	Elevation (m)	**383 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	383.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ Field Vane Intact ▲ Remold ◆ Lab. Vane Intact △ Remoulded ◇ 100 200 300 400 kPa; Water Content (%) ⊗ Plastic Limit (%) ⊢ Liquid Limit (%) ⊣ 20 40 60 80							
	382.8 / 0.3	TOPSOIL Loose, black, silty organics										
1		SILT Loose, grey SILT, some fractured rock, moist, cold										
	381.7 / 1.3	CLAY Soft, grey, silty CLAY, some gravel, moist, cold										
2		Some fractured rock										
3		Becoming firm and wet										
4				▼	⊗⊢⊣							26 35 39
	378.2 / 4.8	END of BOREHOLE at 4.8 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-05**
Method	**SPT Tripod**	Page	**1 of 1**
Location	**Silent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812426 N, 466789 E	Elevation (m)	**398 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	398.00	Ground Surface			Lab UCS; Q Test; P.P. (US); Field Vane Intact/Remold; Lab. Vane Intact/Remoulded; 100–400 kPa; Water Content (%); Plastic Limit (%); Liquid Limit (%); 20–80							
	397.9 / 0.1	TOPSOIL Loose, black organics										
		CLAY Firm, grey silty CLAY, some gravel, trace fractured rock, slightly moist, cold						0 2 3 10 15	5			
1					⊗							16 23 61
		Hard at 1.15 m						15 19 19 22 23	38			
2	396.0 / 2.0							20 22 30	52			
		END of BOREHOLE at 2.0 m										

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-96-500**
Method	**3 inch Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6812007 N, 466417 E	Elevation (m)	**480 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	480.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
					Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
1		SILT Light brown, SILT, some clay, trace organics, dry Grey, SILT, some gravel, some clay, medium plasticity, dry										
2		Moist and cold										
	477.3 2.7											
3		CLAY Firm, grey, silty CLAY, some gravel, medium plasticity, moist, cold										
	476.6 3.4											
		GRAVEL GRAVEL, some silty clay										
	476.3 3.7											
		END of BOREHOLE at 3.7 m Auger Refusal at 3.7 m										

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Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-99-100**
Method	**Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-23** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6811818 N, 467442 E	Elevation (m)	**-77 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	-77.00	Ground Surface			Lab UCS ■ Q Test □ P.P. (US) ○ — Field Vane Intact ▲ Remold ◆ — Lab. Vane Intact △ Remoulded ◇ — 100 200 300 400 kPa; Water Content (%) ⊗ — Plastic Limit (%) ⊢ — Liquid Limit (%) ⊣ — 20 40 60 80							
	-77.1 / 0.1	TOPSOIL Loose, black organics										
		SILT Grey and light brown, SILT, trace gravel, dry										
1		Becoming compact, moist										
2												
3												
4												
		Trace gravel, cold										
	-81.6 / 4.6	END of BOREHOLE at 4.6 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-CUT-A**
Method	**Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-23** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6812015 N, 467313 E	Elevation (m)	**471 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	471.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
	470.9 / 0.2	TOPSOIL Black and grey, orgranic clay, moist			Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
1		SILT Loose, grey, SILT, some fractured shale, dry										
2												
3												
4				▼								
	466.4 / 4.6	END of BOREHOLE at 4.6 m										

PRAIRIE CREEK 610984 PRAIRIE CREEK.GPJ GEOTECH.GDT 11/14/12

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-CUT-E**
Method	**Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-23** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-23** (yyyy-mm-dd)
Coordinates	6811660 N, 467885 E	Elevation (m)	**505 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	505.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ / Remold ◆; *Lab. Vane* Intact △ / Remoulded ◇; 100 200 300 400 kPa							
	504.9 / 0.1	TOPSOIL Soft, black organics			Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
1		SILT Loose, brown, SILT, trace gravel, moist										
2												
	502.7 / 2.3	END of BOREHOLE at 2.3 m Blocked by possible cobble at 2.3 m										

SNC·LAVALIN

Borehole Log

Project **Prairie Creek, Northwest Territory**
Contract **610984**

Drilling Company	**Rocky Mountain**	Borehole ID	**BH-SWI-CUT-E-02**
Method	**2 inch Pionjar**	Page	**1 of 1**
Location	**Sillent Hills Switchbacks**	Start Date	**2012-09-24** (yyyy-mm-dd)
Logged/Reviewed by	**MP Lachance**	End Date	**2012-09-24** (yyyy-mm-dd)
Coordinates	6811660 N, 467885 E	Elevation (m)	**505 m**

Sample Condition
Disturbed | Undisturbed | Lost

Sample Types
SS - Split Spoon; ST - Thin Walled Open (Shelby); RC - Rock Core
CS - Core Sample; WS - Wash Sample; BU - Bulk
AU - Auger

Abbreviations
PP - Pocket Penetrometer; RQD - Rock Quality Designation; SPT - Standard Penetration Test
PT - Standard Proctor Test; DS - Direct Shear; Q test - Triaxial Compression Test (UU)
K - Hydraulic Conductivity (cm/s); GS - Grain Size Analysis; U - Wet Unit Weight (kN/m^3)

Depth (m)	Elevation (m) / Depth (m)	Description	Stratigraphic Plot	Piezometer Installation and Water Level	Field Undrained Shear C_u/Lab Tests	Sample Condition	Type & Number	SPT Blow Counts	N-value (# blows/0.3m)	Recovery %	RQD %	Gr Sa Si/Cl
	505.00	Ground Surface			Lab UCS ■ / Q Test □ / P.P. (US) ○; *Field Vane* Intact ▲ Remold ◆; *Lab. Vane* Intact △ Remoulded ◇; 100 200 300 400 kPa							
	504.9 / 0.1	TOPSOIL Soft, black organics			Water Content (%) ⊗; Plastic Limit (%) ⊢; Liquid Limit (%) ⊣; 20 40 60 80							
1		SILT Loose, brown, SILT, trace gravel, moist										
2	502.7 / 2.3	SILT Firm, grey, SILT, some gravel, moist, cold										
3		Some fractured shale										
4	500.7 / 4.3	END of BOREHOLE at 4.3 m										

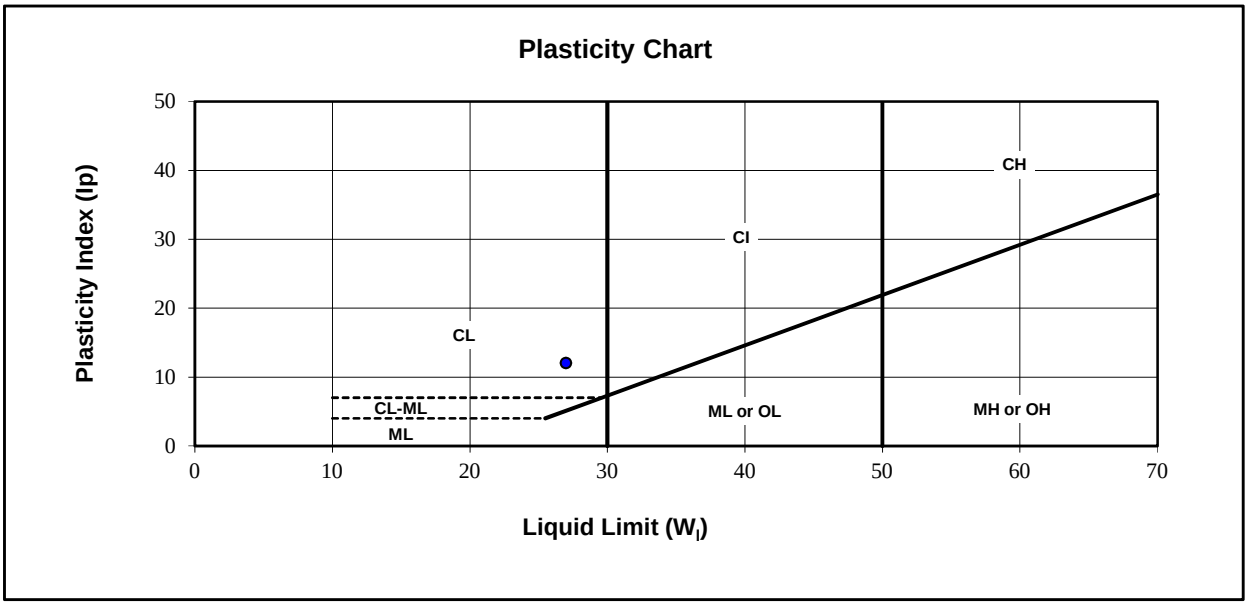
KP101.7 TO KP118

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Prairie Creek All-Season Road	Sample Number:	EK-3, S1
	Northwest of Nahanni Butte, NT	Sample Location:	471430m E, 6800254m N
Project No:	Y14103320-01	Depth:	0.4 m
Client:	Canadian Zinc Corporation	Sampled By:	Allnorth Tested By: MC
Attention:	David Harpley	Date Sampled:	September 28, 2014
Email:	david@canadianzinc.com	Date Tested:	January 8, 2015

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



Liquid Limit ($W_{1)}$) :	27	Natural Moisture (%)	18.4
Plastic Limit :	15	Soil Plasticity:	Low
Plasticity Index (Ip) :	**12**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: RKO P.Eng.

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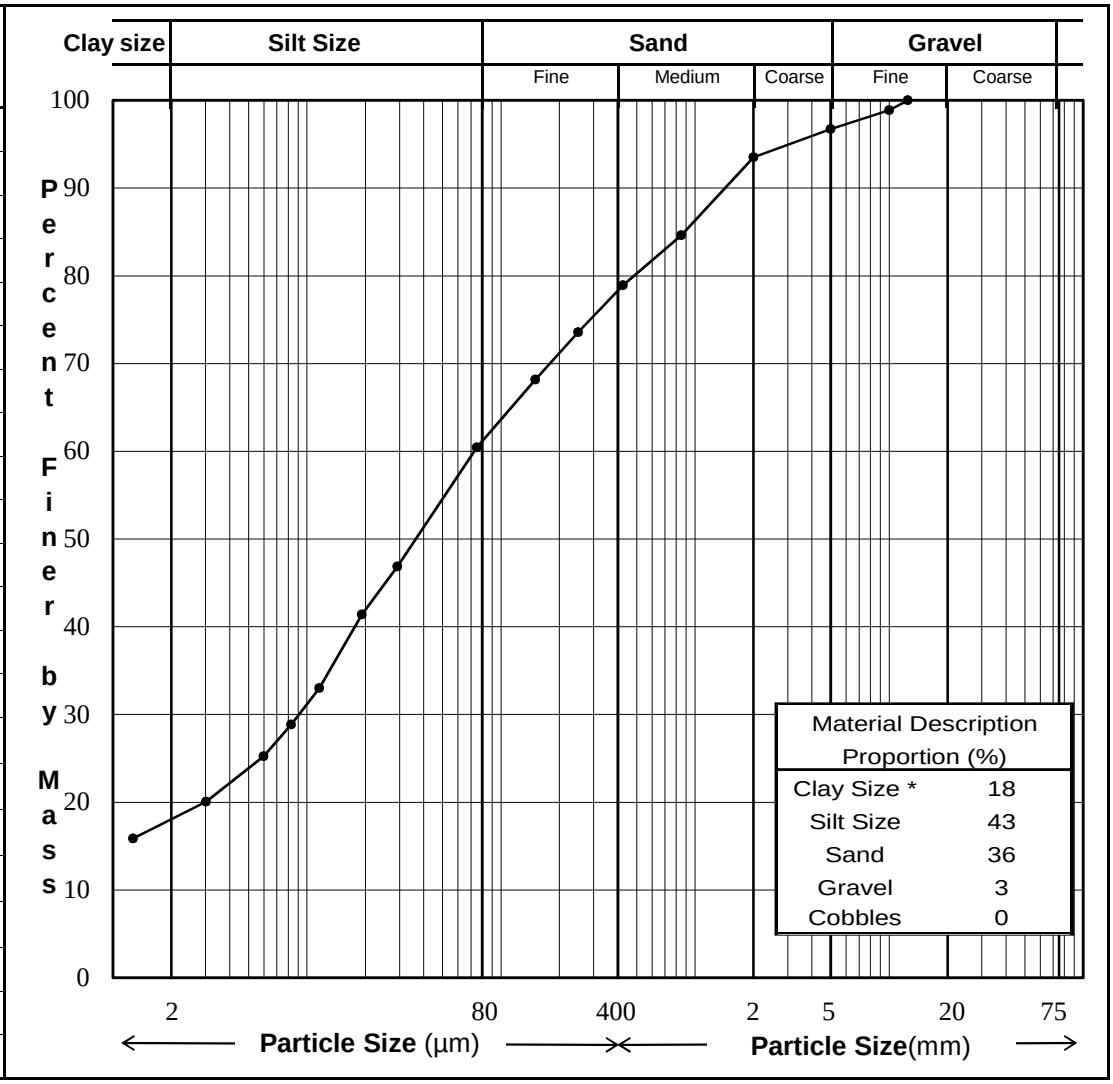
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	S1
Client:	Canadian Zinc Corp.	Borehole/ TP:	EK-3
Project No.:	Y14103320-01	Depth:	0.4m
Location:	471430m E, 6800254m N	Date Tested	January 8, 2015
Description **:	CLAY, silty, sandy, trace gravel, brown**	Tested By:	MC

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	100
10 mm	99
5 mm	97
2 mm	94
850 µm	85
425 µm	79
250 µm	74
150 µm	68
75 µm	60
34 µm	47
22 µm	41
13 µm	33
9 µm	29
6 µm	25
3 µm	20
1 µm	16



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Prairie Creek All-Season Road	Sample No.:	EK (Allnorth)
Project No.:	Y14103320-01	Date Tested:	January 8, 2015
Client:	Canadian Zinc Corp.	Tested By:	MC
Address:	david@canadianzinc.com	Location:	KP116, upslope gullies

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
EK-1	0.39	6.8	SAND
EK-2	0.4	15.1	CLAY, silty, sandy, trace gravel, mottled brown and black
EK-3	0.4	18.4	CLAY, silty, sandy, trace gravel, brown
EK-4	0.3	25.7	CLAY, silty, sandy, trace gravel, brown and grey, trace rootlets

Reviewed By: RKO P.Eng.

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TETRA TECH

KP121.5 TO KP159.4

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP126.9 ABOUT 200 m ABOVE ROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH15
NEAR NAHANNI BUTTE, NT	6798302N; 480769E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TOPSOIL - organic, (300 mm thick)						0
	SILT (probable TILL) - some clay to clayey, trace to some sand and gravel, damp, light brown, (150 mm thick)						
	CLAY (probable TILL) - silty, sandy, some gravel, moist, low plastic, light olive brown		S1				
	- 50 mm thick clay (till-like) lens - higher silt and medium to coarse grained sand content, stiff		S2		●		
	SAND (GLACIOFLUVIAL, or sand pocket in till), some gravel, medium to coarse grained						
1			S3				
	END OF BOREHOLE (1.00 m) Note: Burn area. Refusal on gravel.						
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - BOREHOLE NO.
KP126.8 AOUBT 400 m ABOVE ROUTE	DRILL: EDELMAN-TYPE HAND AUGER	Y14103320-01-BH16
NEAR NAHANNI BUTTE, NT	6798207N; 480521E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND TOPSOIL - decomposed, black, rootlets, (200 mm thick)						0
	CLAY (probable TILL) - silty, trace to some sand, trace of fine gravel, moist, stiff, light olive brown, trace of oxides						
	- more gravel		S1				
	- some gravel		S2		●		
	END OF BOREHOLE (0.70 m) Note: Low shrubby patch to northwest of ridge top heli landing site. Grinding on gravel at end of borehole.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.7m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP123.35 STEEP SLOPE ABOVE STREAM	DRILL: PICK AND SHOVEL	Y14103320-01-TP04
NEAR NAHANNI BUTTE, NT	6798920N; 477942E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - (300 mm thick)						0
	SAND (probable COLLUVIUM) - silty, gravelly, some cobbles to 125 mm diameter, gap graded, dry to damp - some organics, moist, reddish brown, rootlets		S1				
	END OF TESTPIT (0.45 m) Note: On rocky knoll south of stream at Grainger Gap.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/22
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP123.3 ON BLUFF ABOVE STREAM	DRILL: PICK AND SHOVEL	Y14103320-01-TP05
NEAR NAHANNI BUTTE, NT	6798868N; 477947E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	TURF AND DUFF - (50 mm thick)						0
	SILT (probable COLLUVIUM) - trace to some subangular gravel to 35 mm diameter, trace of sand increasing with depth, trace of clay, dry, light reddish brown		S1				
	END OF TESTPIT (0.40 m) Note: West end of bluff, Grainger Gap.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.4m
REVIEWED BY: KJ	COMPLETE: 14/09/22
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP124.8 AT EAST END OF GRAINGER GAP	DRILL: PICK AND SHOVEL	Y14103320-01-TP15
NEAR NAHANNI BUTTE, NT	6799534N; 479230E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) / SILT (%) / SAND (%) / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT AND TURF - mat overhanging 5-6 m high, 12 m wide slope failure below to Grainger River floodplain						0
	SAND (possible GLACIOFLUVIAL remnant) - some gravel to gravelly to 75 mm diameter, some cobbles and boulders under overhand, fine to medium grained, damp to moist, brown, trace to some silt lenses						
			S1				
1							
	- more gravel to east, less gravel to west on soil surface, little fines		S2				
	END OF TESTPIT (1.20 m) Note: South side of Grainger Gap, east end at slope failure. Mapped headscarp of failed slope.						
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 1.2m
REVIEWED BY: KJ	COMPLETE: 14/09/23
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP126.6 ABOUT 950 m UPSLOPE	DRILL: PICK AND SHOVEL	Y14103320-01-TP16
NEAR NAHANNI BUTTE, NT	6797870N; 480057E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	GRAVEL AND SAND (COLLUVIUM) - few fines, appearance of crushed gravel to 10 mm diameter, gravel to 75 mm diameter, cobbles and boulders at ground surface					0
	END OF TESTPIT (0.30 m) Note: ~KP126.6 on rock glacier mapped by J.D. Mollard. Toe of small gully within upper end feature.					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP126.5 ABOUT 550 m UPSLOPE	DRILL: PICK AND SHOVEL	Y14103320-01-TP17
NEAR NAHANNI BUTTE, NT	6798255N; 480195E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	ROCK FRAGMENTS (TALUS) - sandy, silty, some organics in interstices, coarse grained (est.)					0
	END OF TESTPIT (0.30 m) Note: ~KP126.5 on rock glacier at proposed borrow site (debris/rubble ridge)., near lower end.					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/24
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP159.4 ABOUT 500 m ABOVE ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP19
NEAR NAHANNI BUTTE, NT	6770946N; 483685E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	☐ BULK DENSITY (kg/m³) ☐ 1400 1600 1800 2000 ■ SPT (N) ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	◆ CLAY (%) ◆ 20 40 60 80 ● SILT (%) ● 20 40 60 80 ▲ SAND (%) ▲ 20 40 60 80 ■ GRAVEL (%) ■ 20 40 60 80	Depth (ft)
0	GRAVEL (COLLUVIUM) - cobbly, bouldery, occasional talus block at ground surface, (200 mm thick)						0
	CLAY (probably COLLUVIUM/ALLUVIUM over TILL) - silty, sandy, gravelly, cobbly, moist		S1		●		
	- very hard						
	END OF TESTPIT (0.45 m) Note: Broad flat deposition area at ~KP159.4, upslope of debris flow prongs, proposed borrow near Liard crossing.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP159.5 ABOUT 450 m ABOVE ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP20
NEAR NAHANNI BUTTE, NT	6770856N; 483705E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	GRAVEL (COLLUVIUM) - sandy to some sand, trace of silt (est. <5% near surface)					0
	END OF TESTPIT (0.30 m) Note: Broad flat deposition area at ~KP159.5 near Liard crossing, close to heli landing area.					
1						
						5
2						
3						10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP159.5 ABOUT 470 m ABOVE ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP21
NEAR NAHANNI BUTTE, NT	6770852N; 483688E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	GRAVEL (COLLUVIUM) - sandy, trace to some silt (<5% near surface), fine to coarse grained, angular to subangular						0
			S1				
	END OF TESTPIT (0.45 m) Note: Broad flat deposition area at ~KP159.5 near Liard crossing, 10 m north of small stream.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.45m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP154.8 ABOUT 900 m BELOW ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP22
NEAR NAHANNI BUTTE, NT	6774948N; 486705E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	GROUND ICE DESCRIPTION AND COMMENTS	Depth (ft)
0	PEAT - (200 mm thick)						0
	SILT (TILL veneer or COLLUVIUM) - some sand, trace of clay, trace of organics, wet, soft, dark grey to black						
	CLAY (probably TILL) - silty, sandy, trace of gravel, wet, high plastic, light grey brown		S1	CI			
	END OF TESTPIT (0.55 m) Note: Next to HP154, in low black spruce unit, near lower proposed route.						
1							
							5
2							
3							10

BULK DENSITY (kg/m³) 1400 1600 1800 2000

SPT (N) 20 40 60 80

PLASTIC M.C. LIQUID 20 40 60 80

CLAY (%) 20 40 60 80

SILT (%) 20 40 60 80

SAND (%) 20 40 60 80

GRAVEL (%) 20 40 60 80

TETRA TECH EBA

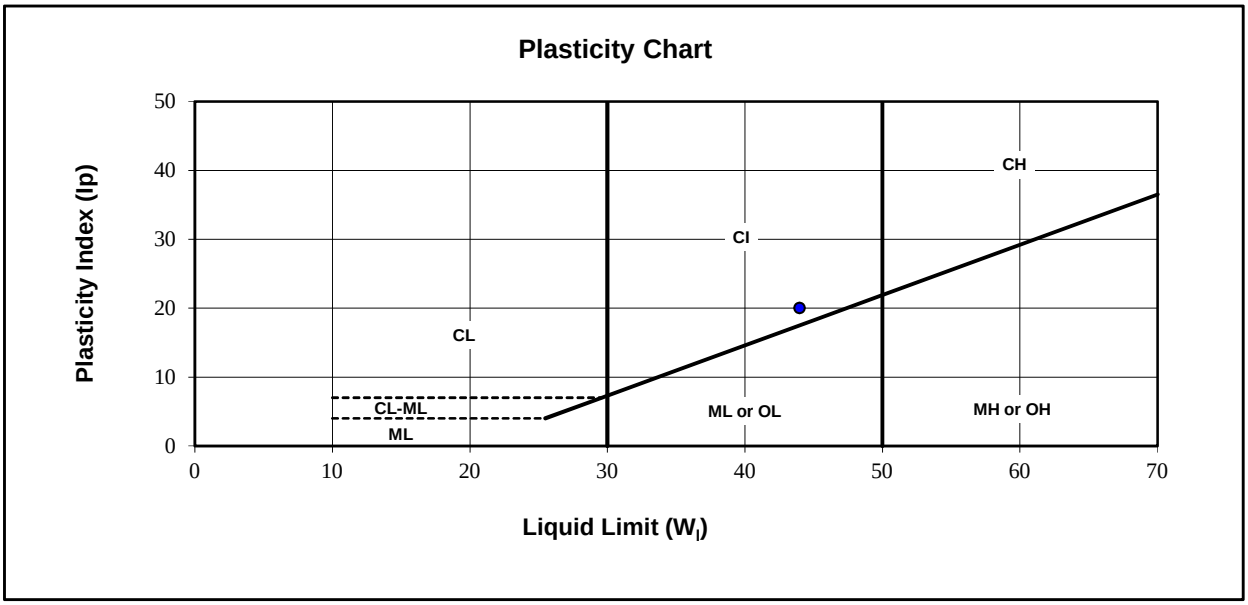
LOGGED BY: RKO	COMPLETION DEPTH: 0.55m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Prairie Creek All-Season Road	Sample Number:	6161
	Northwest of Nahanni Butte, NT	Borehole Number:	TP-22, S-1
Project No:	Y14103320-01	Depth:	0.50-0.55m
Client:	Canadian Zinc Corporation	Sampled By:	RKO Tested By: NR
Attention:	David Harpley	Date Sampled:	September 26, 2014
Email:	david@canadianzinc.com	Date Tested:	November 13-15, 2014

Sample Description: CLAY, silty, sandy, trace gravel



Liquid Limit ($W_{1)}$) :	44	Natural Moisture (%)	34.1
Plastic Limit :	24	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: RKO P.Eng.

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TETRA TECH

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP154.9 ABOUT 900 m BELOW ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP23
NEAR NAHANNI BUTTE, NT	6774878N; 486660E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - fibrous to partly decomposed, brown to dark brown, (300 mm thick)						0
	SILT (probably TILL veneer) - sandy, trace of gravel to 10 mm diameter, trace of clay forming 1 mm diameter peds, moist, low plastic		S1		●		
	- increasing oxides - trace of subangular grained to 60 mm diameter		S2				
	END OF TESTPIT (0.55 m) Note: South of stream on south side of HP154, in tall black spruce unit, near lower proposed route.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.55m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP154.9 ABOUT 900 m BELOW ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP24
NEAR NAHANNI BUTTE, NT	6774850N; 486660E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	PEAT - partly decomposed, damp to moist, brown to black, (200 mm thick)						0
	SILT (TILL veneer or COLLUVIUM) - trace of clay, dry, light brown						
	- brown						
	- sandy, some fine gravel		S1		●		
	END OF TESTPIT (0.50 m)						
	Note: South of stream on south side of HP154, in aspen unit, near lower proposed route.						
1							
							5
2							
3							10

TETRA TECH EBA

LOGGED BY: RKO	COMPLETION DEPTH: 0.5m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PRAIRIE CREEK ALL-SEASON ROAD	CANADIAN ZINC	PROJECT NO. - TESTPIT NO.
KP127 ON RIDGE 350 m ABOVE ROUTE	DRILL: PICK AND SHOVEL	Y14103320-01-TP25
NEAR NAHANNI BUTTE, NT	6798209N; 480722E; Zone 10	

SAMPLE TYPE: DISTURBED | NO RECOVERY | SPT | A-CASING | SHELBY TUBE | CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	GROUND ICE DESCRIPTION AND COMMENTS	BULK DENSITY (kg/m³) 1400 1600 1800 2000 / SPT (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	CLAY (%) 20 40 60 80 / SILT (%) 20 40 60 80 / SAND (%) 20 40 60 80 / GRAVEL (%) 20 40 60 80	Depth (ft)
0	SAND (possible TILL) - some silt to silty, trace of clay (not sampled)					0
	END OF TESTPIT (0.30 m) Note: Ridge top at heli landing ~KP127.					
1						5
2						
3						10

TETRA TECH EBA

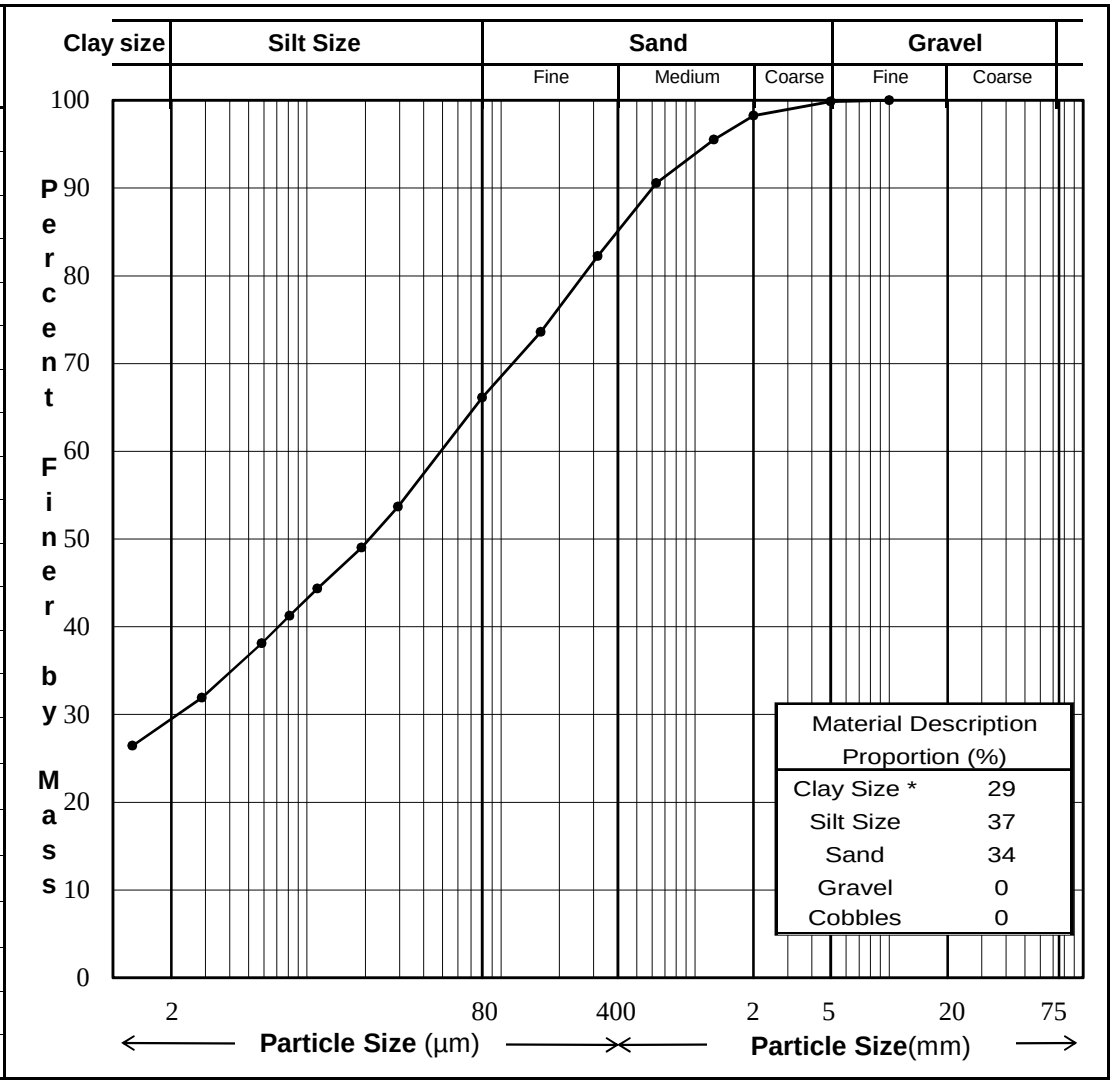
LOGGED BY: RKO	COMPLETION DEPTH: 0.3m
REVIEWED BY: KJ	COMPLETE: 14/09/26
DRAWING NO:	Page 1 of 1

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Prairie Creek All-Season Road	Sample No.:	6161/Allnorth KP144.7
Client:	Canadian Zinc Corporation	Borehole/ TP:	KP144.7, S-1
Project No.:	Y14103320-01	Depth:	0.20-0.30 m
Location:	Outlet of Triangle Lake, NT	Date Tested	December 9-10, 2014
Description **:	CLAY, silty, sandy, with organic material	Tested By:	NR

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
16 mm	
13 mm	
10 mm	100
5 mm	100
2 mm	98
1.3 mm	96
630 µm	91
315 µm	82
160 µm	74
80 µm	66
30 µm	54
19 µm	49
11 µm	44
8 µm	41
6 µm	38
3 µm	32
1 µm	26



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: RKO P.Eng.

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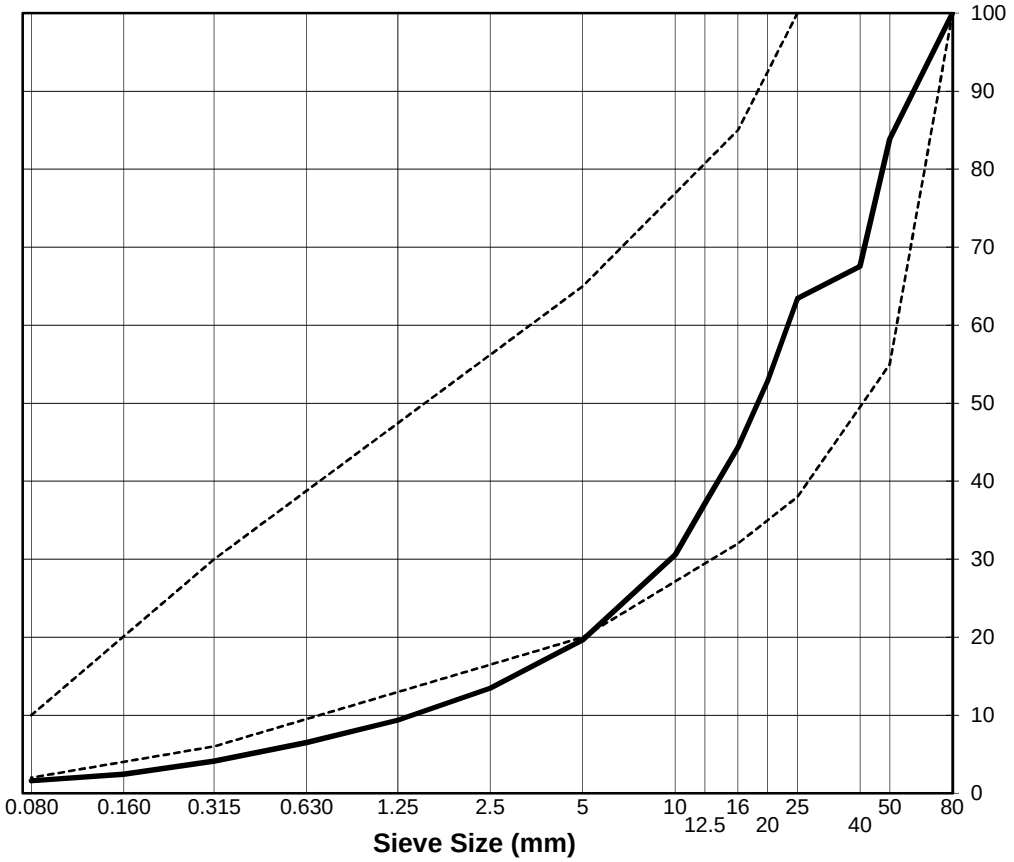
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103320-01	Sample No.:	6161 / Allnorth KP151
Project:	Prairie Creek All-Season Road	Date Received:	October 9, 2014
Client:	Canadian Zinc Corporation	Sampled by:	EK (Allnorth)
Attention:	David Harpley	Date Tested:	December 5, 2014
Email:	david@canadianzinc.com	Tested by:	JD Office: Yellowknife
Description:	GRAVEL, some sand, trace silt/clay	Moisture Content (as received):	2.6%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	BP 151A / 151B	By Particle Mass:	
Supplier:	n/a		
Sample Location:	Proposed borrow area		
Specification:	GNWT 80mm Gravel Fill		

Sieve Size	Percent Passing
	100
80	100
50	84
40	68
25	63
20	53
16	44
12.5	37
10	31
5	20
2.5	13
1.25	9
0.630	7
0.315	4
0.160	2
0.080	1.6



Remarks: Sampled from alluvial fan at 61.134787°N, 123.239557°W.

Described as cobbles and gravel. Sampled 75 mm minus.

Reviewed By: RKO P.Eng.

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TETRA TECH

APPENDIX C

STATION-BY-STATION SUMMARY OF FIELD OBSERVATIONS

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
0	0.4	-	First 400 m of road route adjacent to Prairie Creek Mine and Camp, just south of southeast end of water retention pond. Steep high slopes, mostly treed in the first 100 m along road, then few trees in prominent area of slope ravelling next 200 m, then essentially untreed. Streams marked on orthophotography are likely ephemeral as a result of surficial erosion in shallow ridge-gully features. Air photos A28099- 137-138.	Looking north at first 600 m of road from just southeast of Admininistration building (blue building mid-photo) to BP 1 (top left of photo). (Photo credit: CZN)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
0.40	2.60	-	Last station of Mollard's route is partly marked on A28099 - 137; probably km 185. If so, km 185.4 would be about the SE end of the pond, just before Prairie Creek Mine/Camp. This means Mollard's km 185.4 = our KP000.4 and KP001 is approx. NW end of pond. Road skirts toe of steeper slope, and berm of pond is immediately downslope south between KP000.4 and KP001. Upslope of ~KP000.55 to KP000.7 is proposed borrow BP 1. From KP000.7 to corner at ~KP001.1, is steep cutslope above road. From KP001.1 to KP001.4, road skirts steep toe of slope to south end of airstrip, some ravelling apparent on slope. Prairie Creek is tight on road toe to the south, then west as road rounds the corner heading north. From KP001.4 to KP002.6 is airstrip, with Prairie Creek along west edge. More room, slopes above less steep. Stream at about KP002 has the potential to carry debris flows, but no recent deposits are obvious on the air photos or imagery. Air photos A28099- 137-139.	Looking south from north end of airstrip at about KP002.6. Steep slope above road in background is at about KP001.1 to KP001.4. Some ravelling talus/scree at corner. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
2.60	4.20	-	North end of airstrip is where valley becomes tight upstream. Small borrow proposed upslope east from ~KP002.7 to KP002.8 at existing borrow area. Creek crossing at ~KP002.9. Stream has potential to carry debris flows, but no recent deposits noted on air photos or imagery. Road is tight along toe, with wide and highly braided Prairie Creek to the west. Especially tight between creek and slope between KP003.4 and KP004.2, with very steep gradients upslope. Air photos indicate ravelling of slope above road in this section. Slope failure KP004.1 to KP004.2 likely due to toe erosion from Prairie Creek before the road was there; overflow channel still visible on air photos. Outside bend of creek means adequate erosion protection needed along road. Strip borrow proposed upslope of road understood to be as a result of cutslope for road widening; however, consider potential for exacerbating slope ravelling by adding to rock cut. This area is also mapped as avalanche terrain. Air photos A28099- 137-139.	Looking south from KP003.8 at possible bedrock outcrop, plus talus/scree along road. (Photo credit: Allnorth) Looking south at KP004.1 slope (Photo credit: Allnorth)

4.20	4.80	-	Route on floodplain to about KP004.8, where road tucks in along toe of slope again. Proposed borrows ~KP004.2 to KP004.35 and ~KP004.4 to KP004.7 (BP 4A and 4B). Long steep unvegetated slope on north side of KP004.4 stream indicates likelihood of periodic debris flow deposits that may impact road. Small debris flow deposit seen on air photos between toe of slope and road embankment, less obvious on imagery. Long unvegetated slope above BP 4B. Slope gradients 55% for about 150 m (horizontal), then steeper to 85% plus in long concave configuration to ridge crest above. Based on slope gradients in starting zones and lack of trees, this could be avalanche terrain but is not mapped as such. Gentler gradients in borrow area (mound at toe) might serve as deposition zone (and is itself the deposition zone of old slope failure), but doesn't show obvious effects. Lack of snow? Sinking streams on slope suggest freezing seepage as possible contributor to slope failures. These also correlate with narrow gully-ridge features in upper half of slope that suggest ravelling, surface erosion and possible debris flows on slope. No obvious recent events on air photos or imagery. Deposits from older events would likely have been obscured or obliterated by Prairie Creek at high water. Treed on steeper slopes above road again north of ~KP004.7, and slopes not as steep as untreed section immediately south. Air photos A28099- 138-140.	 Looking upstream at KP004.4 alluvial fan; note material to cobble/boulder size. (Photo credit: Allnorth) From KP004.85, looking south. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
4.80	6.20	-	Sloughing on road just south of KP005 suggests possible toe erosion due to Prairie Creek braided channel. Erosion protection required. From KP005 to KP005.4, route is tight against toe of talus cone, with steep cut slope. North of KP005.4, route shortcuts pre-1994 detour around mound, staying on higher ground near toe of steeper slope. North of mound, route stays above pre-1994 winter road, skirting toe of slope from KP005.7 to KP006.1 where crossing of Casket Creek begins. Casket Creek is braided, with main channel currently on south side of floodplain. Locations and numbers of channels should be expected to vary in this stream, as the 1994 air photos indicate 4 streams of about equal width in middle of channel at that time. Casket Creek carries significant coarse-grained material which is deposited in the Prairie Creek drainage as an alluvial fan, and which on the 1994 air photos over-ran the road. Prairie Creek is wide and highly braided from ~KP005.4 to KP006.2. Route rejoins winter road on north side of crossing, about KP006.2. Air photos A28099- 138-140.	 At KP005, ravelling cut slope, tension cracks on fill slope. (Photo credit: Allnorth) Looking north at KP006.1 Casket Creek (Photo credit: CZN)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
6.20	6.75	-	Road closely follows toe of steep slope in narrow section of Prairie Creek, which remains braided in this section. Slope at corner just before turn into Fast Creek drainage is treed but steep. Air photos A28099- 138-140.	Looking south from KP006.75. (Photo credit: Allnorth)
6.75	7.60	-	Starts at confluence of Prairie Creek from NW and Fast Creek from NE. Fast Creek has a wide braided streambed. Scalloped appearance of slope above Fast Creek suggests past erosion from creek has triggered occasional slope failures. Anticipate some talus block and scree shedding to continue, but there is also significant tree growth on this section. Turns up the Funeral Creek drainage at about KP007.4, and stream bed is still braided and relatively wide (est. >50 m) until about KP007.6. Road closely follows toe of slope along southeast side of Fast Creek floodplain, then southwest side of Funeral Creek floodplain. Air photos A28099- 138-140 (missing 141).	Looking south from KP007.25, Fast Creek on right. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

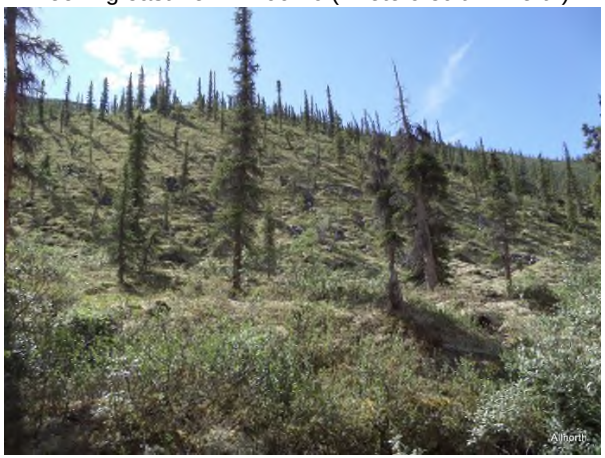
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
7.60	9.95	-	Road continues along south side of Funeral Creek along toe of slope. Very tight V-shaped valley. Talus/scree with some tributary streams between slope sections. Stream is braided from about KP008.6 to KP009.3., then occasional braids continuing eastbound. Several talus cones above road ~KP008.6 to KP010, less active than next road section. Possible slope failures above KP008 to KP008.25 and KP008.5 to KP008.65 (ragged configuration suggests possible headscarps in sloughing talus). Some treed areas, esp. gullies. Cones that reach road with few trees include ~KP009.15 to KP009.3, ~KP009.5 to KP009.6, and ~KP009.85 to KP009.95. Air photos A28099- 138-140 (missing 141, stereo coverage on edge of photo), A28099 - 106, 108 (missing 107, 109-112, no stereo coverage).	Looking east from KP007.6 (Photo credit: Allnorth)  Looking upslope from KP009.25 at talus cone. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
9.95	12.75	-	Route continues on south side of Funeral Creek along toe of slope. Funeral Creek very narrow in tight V-shaped valley to about KP012, where valley bottom begins to widen eastbound. Road curves around prominent talus cone from ~KP009.95 to KP010.23. Small borrow at toe of slope above road at KP10.1 in talus. Talus slope above road ~KP010.23 to KP010.6. Immediately upslope of KP011, there is a series of small parallel trails up to 250 m long and up to 150 m (horizontal) above the road. Talus above road KP011.1 to KP012 appears more recent than sections immediately west and east. Another more recent section appears ~KP012.34 to KP012.5. Air photos A28099 - 106, 108 (missing 107, 109-112).	Looking west from KP010.5, talus cone in background. (Photo credit: Allnorth) Looking west from KP012. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
12.75	13.85	-	Route enters tributary drainage at start of hairpin. Skirts below talus for about 100 m, then treed 50 m, then skirts toe of talus to W tributary at about KP13.3, tight hairpin curve at KP013.36, then crosses E tributary ~KP013.4. Hairpin a little tighter and lower in E tributary valley than it is on existing winter road, but more rounded at switchback. Then route climbs out of tributary valley along treed slope below winter road, rejoining winter road again at main Funeral Creek valley slope at ~KP013.7. Three narrow slides below winter road at ~KP013.54, KP013.57, KP013.59, possibly due to fillslope failures in sidecast fill. Slope much steeper below route than above. Some trees on main valley sideslope until about KP013.85. No stereo coverage. Air photos A28099 - 106, 108 (missing 107, 109-112).	 Looking downstream north from existing hairpin at ~KP013.4. Two streams at crossing. (Photo credit: Allnorth) Looking west from ~KP013.57. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

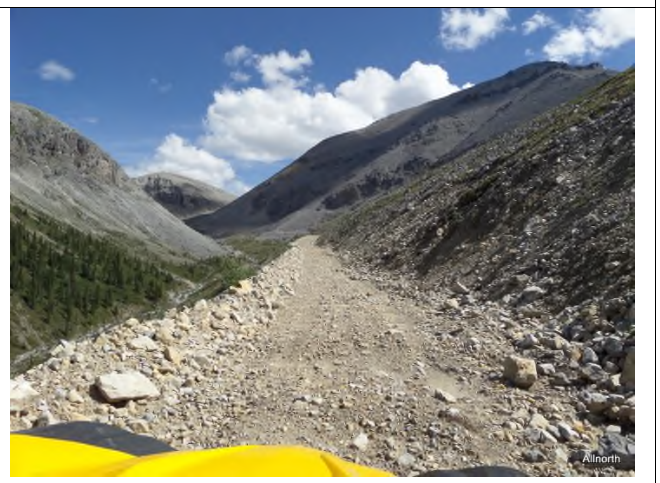
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
13.85	15.75	-	Now route cuts through apparently active talus slope (very light coloured and linear fall lines seen) from ~KP013.85 to ~KP014.2, then ~50 m treed, and back into talus. Air photos indicate possible fillslope failure below about KP014, about 30 m wide and 40 m long. Steep challenging terrain along climb to the pass. From about KP014 to KP020, Duk-Rodkin et al (2007) map the valleys as having been glaciated by a cordilleran glacier. Since the Funeral Creek valley at this location still appears more V-shaped than U-shaped, there may not have been much movement of the glacier. No stereo coverage. Air photos A28099 - 106, 108 (missing 107, 109-112), A28099 - 87-88 (missing 86).	 Looking east from KP014.1. (Photo credit: Allnorth) Looking upslope from just west of KP014.8, at terrain seen in background from KP014.1. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
15.75	16.90	-	From crossing of Funeral Creek at ~KP015.75, hairpin up to tributary creek into Funeral Creek from the northeast at ~KP016.1, and eastbound to KP016.9 along cut in steep talus slope. Route bypasses existing switchback and continues west to skirt around knoll just east of tributary creek (using part of that acccess trail), then switches back east to rejoin winter road at ~KP016.3. The knoll appears to have two cuts in it, roughly on contour (borrow? exploration?). Mollard noted a small slide in the vicinity, which may be the slope feature seen below proposed route ~KP016, but that also appears more like a man-made cut on both air photos and imagery, particularly as it is not a fall-line feature. More likely, Mollard noted the largest of a series of apparent fillslope failures (or merely bladed fill from pushing the road) that has deposited near the Funeral Creek crossing. This particular feature may have in some form also predated the road, as there is also a narrow slough from the ridge upslope of the road at this location. The fillslope failures are prevalent on the steeper sideslopes from ~KP016.25 at the top of the existing switchback to ~KP016.75. No obvious changes on the imagery. Air photos A28099 - 87-88 (missing 86).	 Looking northeast from KP014.8. Note cuts in and below knoll near KP016.1 (pale orange). (Photo credit: Allnorth) Looking east at existing switchback east of knoll inside proposed switchback at ~KP016.1. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

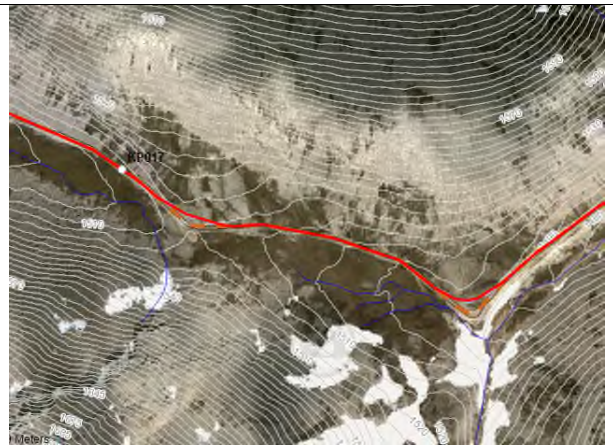
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
16.90	17.50	-	Route skirts toe of active talus slope on north side of Funeral Creek and Sundog Creek watersheds. Height of land between Funeral Creek and Sundog Creek drainages is at about KP017.1 (understood also to be the NNPR boundary). Duk-Rodkin et al (2007) map a Cordilleran ice cap along the height of land in this location, with approximate extents to KP014 to the west and KP020 to the east. It is not known if glaciofluvial deposits noted downstream at KP025.4 may originate from this glaciated area, or from a previous glaciation. Air photos A28099 - 87-88 (missing 86).	 Talus lobes and rock bluffs north of road. (Allnorth website)
17.50	19.10	-	Route follows winter road on north side of Sundog Creek, along toe of talus or cutting into toe on steady downgrade. Cuts across alluvial cones. Valley tight until ~KP018, where it gradually begins to widen, until ~KP018.4 where valley is wide enough for terraces. Route continues to skirt toe of talus until ~KP019.1. Air photos A28099 - 66, 68 (missing 67, no stereo coverage).	Looking west from ~KP018.4 towards the pass. Sharp bend right ~KP017.4 (top of photo). (Photo credit: Golder 2010)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
19.10	20.60	-	Route continues on northeast side of Sundog Creek on gravelly terraces between stream and toe of talus slopes, crossing alluvial fans at ~KP019.9, ~KP020.1, and ~KP020.5 at proposed crossing of Sundog Creek, ~90 m upstream of winter road crossing. Road climbs onto terrace on southwest side of Sundog at ~KP020.6, about 200 m west of winter road crossing (due to crossing with less skew than winter road) southwest. Rock glaciers from ~KP019.7 to KP020.1, most prominent of which is at ~KP019.9 on upper slope south of stream. Air photos A28099 - 66, 68 (missing 67, no stereo coverage).	 View northwest from ~KP020.8. (Photo credit: Golder 2010) Looking upstream at Sundog Creek crossing ~KP020.5 (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
20.60	21.70	-	Route on narrow terrace with large eroded talus cones just upslope, and cutting through a series of smaller cones at ~KP021.2 to KP021.5. Terrace is a little wider at ~KP021.5 to KP021.7, narrowing again so that road is again tight along toe by KP021.8. Air photos A28099 - 66, 68 (missing 67, no stereo coverage).	View northwest from ~KP021.1. (Photo credit: Golder 2010)
21.70	23.15	-	Sundog Creek forms steep-sided V-shaped gully in this section, where route closely follows toe of talus, with some cuts (~KP021.8 to KP021.9, ~KP022.2 to KP022.6). Valley bottom widens out again at about KP022.6, where road also descends away from the steeper talus. Air photos A28099 - 66, 68 (missing A28099-67, A28099 - 46-48).	View southwest from ~KP023 at knoll left to KP022.65 right.

Table C-1: Summary of Mapping and Field Observations

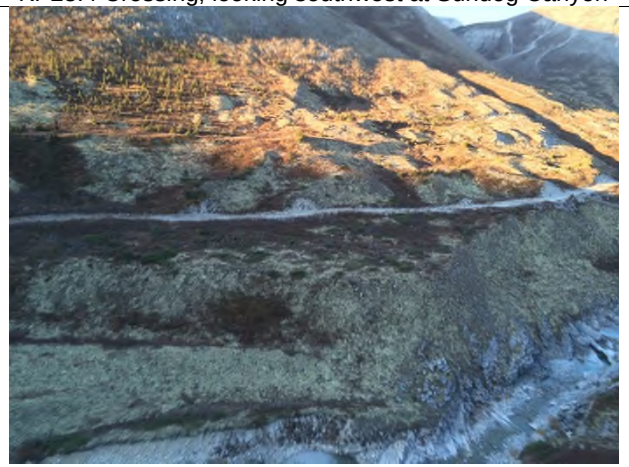
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
23.15	23.65	-	KP023.15 (old KP022.9) is start of existing hairpin on north approach to Sundog Canyon crossing. Two more hairpin approaches at floodplain, one per side. Ice plug builds at Sundog Canyon, blows out with spring flows. Old KP023.5 is south edge of braided floodplain, just before climb east up out of drainage. Talus most prevalent on NW side of stream and upstream. Proposed reroute removes hairpins and is further from talus, but closer to confluence with stream from northwest. Re-route KP023.05 to KP023.65 (old KP22.8 km to KP24.1). Reroute skirts around large debris slide in gravel north of ~KP023.6. Air photos for this section are missing (A28099 - 46-48).	 KP23.4 Crossing, looking southwest at Sundog Canyon
23.65	24.65	-	Possibly glaciofluvial on high-level terraces, fluvial on low-level terraces below road. Bedrock exposed in channel bottom. Talus mounds above road; road cuts through some of these.	 KP023.7 Looking south at southeast side of Sundog Canyon stream crossing.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
24.65	25.6	-	Mollard's description follows existing winter road to north side of Sundog Creek Tributary. KP024.2 (old KP24.6) is approximate start of proposed reroute on south side of Sundog Creek Tributary. Avoids one crossing of Sundog Creek Tributary, but adds a crossing of a tributary at ~KP025.4 (old KP25.8). Until that crossing, route stays in the trees which grow in densely-vegetated elongated depressions winding between older talus (light areas with trees) and recent alluvial mounds. These look older than more-active talus further upslope, which is also further from reroute than active talus is on existing route. Anticipate evidence of creep on steeper sections. Upper terraces are probably glaciofluvial, lower terraces may be fluvial, west and east of KP025.4 tributary crossing.	Looking west from KP025.4 crossing, glaciofluvial terraces and U-shaped valley upstream. (Photo credit: Allnorth) Looking west to KP025.4 from ~KP025.8. Route on treed bench top left. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
25.6	26.65	-	Terrain unit becomes glaciofluvial veneer and colluvial veneer where bedrock is near-surface. Anticipate talus forming aprons, cones, blankets and veneers on top of terraces. A cluster of shallow depressions (up to 0.6 m deep and up to 1.5 m in diameter) possibly formed by piping, i.e. tunnel erosion (suffosion) were observed in the field at KP25.6. Two well-defined round depressions of ~5 m diameter, indicative of such piping, were interpreted from the hi-res imagery between KP026 and the creek channel. Reroute looks more favourable after KP026. Air photos for this section are missing (A28099 – 46-48).	 Suspected suffosion feature at about KP025.6 KP26 at mid-left, looking upstream. Transition of glaciofluvial terrace to veneer (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

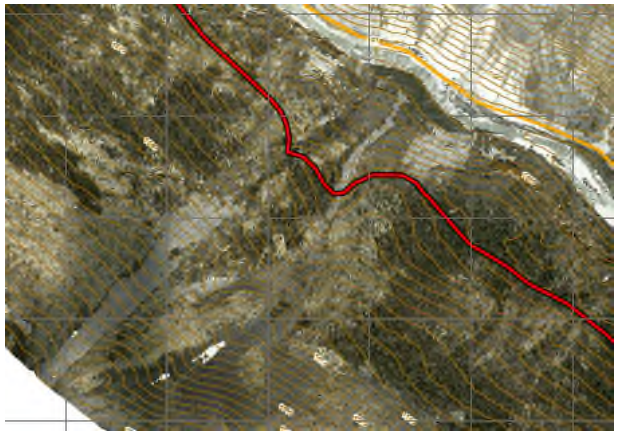
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
26.65	28.25	-	At KP026.6, route avoids another crossing of Sundog Ck Trib (still on S side), but at KP026.7 must cross another tributary. Route stays high, out of the creek bottom continuing ESE. Large debris flow with three crossings within about 120 m beginning at ~KP027.2. Bedrock exposed as cliffs on lower slopes at debris flows and in creek area; should be fairly stable. The first two (NW) debris flow channels look less recent (avulsion) and/or grown in with trees (main channel), but new debris toe is only about 100 m upslope. The next (SE) debris channel is recently active. Two more streams marked at about KP027.55 km and KP027.65 that appear to be intermittent debris flows, with two smaller adjacent features that could be avulsions. Debris flows in these channels are possible at any time due to exposed talus above, and avulsions should also be expected. Creep probable but no obvious evidence of permafrost. Big rocky bluff below road begins ~KP027.45 and peters out ~KP027.8 at HP28. Air photos for this section are missing (A28099 - 46-48; A28094 - 200-202 est.).	 Debris flow channels from KP027.2 to KP027.65

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
28.25	33.55	-	Route descends at ~KP028.25 to coarse gravelly floodplain of Sundog Creek Tributary, crossing the creek and rejoining the winter route on the north side at about KP028.35. The winter route crosses along the toes of some large talus/scree slopes and alluvial cones/fans. Route crosses main creek again at ~KP028.85, continuing on winter route on floodplain. Crosses tributary stream at ~KP029.13 and skirts toe of alluvial fan to about KP029.23, following winter route to ~KP030.6, closer to stream than to slope toe, then upslope near slope toe, rejoining winter route at ~KP031.4. Route is subject to debris flows or rock slides between ~KP029.6 and KP029.8. Alluvial fans between ~KP030.6 and KP031.8 may be subject to debris flows, and location of creek crossings may not stay the same. Route skirts just below toes of fans, except at KP031.3 where it crosses mid-fan. Route then skirts toe of tributary fan at ~KP032.4. New route stays on S side of Sundog at ~KP032.9. From here to ~KP039, rock fill section proposed in creek. Air photo and imagery east of KP032 shows series of steep bluffs above ridge/gully features within large concave bowl or scalloped feature which could be post-glacial failure, almost top to bottom of slope. Air photos for this section are missing (A28099 - 46-48; A28094 - 201-204 est.).	Looking south (downstream) along winter road at ~KP028.9. Rock bluff east and alluvial fan at ~KP029.13 from southwest in middle ground. (Photo credit: Allnorth) At KP032.4 looking downstream. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

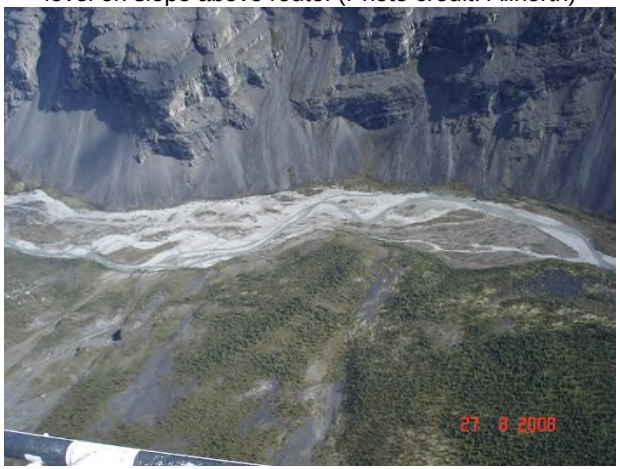
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
33.55	35.0	-	Mollard's description is for winter route crossing stream from KP033 on south side to KP033.5 on north side, back again to south side at KP034, and back again to the north by KP034.7. All-season route stays on southeast side, skirting toe of slope in left side of photo. Talus/scree is prevalent in this section, as are large bedrock bluffs. At ~KP034.6, there is a large bedrock bluff about 150 m wide and about 90 m (horizontal) above the toe of slope, which appears to have bedding or jointing different from the nearby outcrops south and north, but similar to the outcrops north of KP035. Air photos A28094 - 209; other air photos missing for this section.	Looking southwest upstream from KP34.3 towards KP032. Bedrock bluffs on southeast side above road appear nearly level on slope above route. (Photo credit: Allnorth)  Looking east at outcrops between KP033.3 (RHS) and KP034.1 (LHS). (Photo credit: CZN)

Table C-1: Summary of Mapping and Field Observations

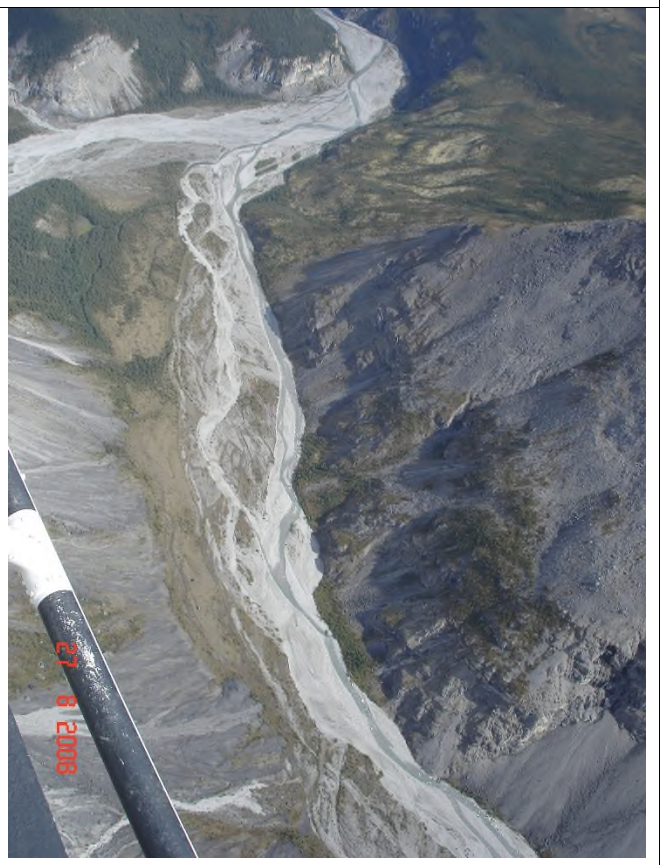
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
35.0	36.5	-	Mollard's description is for winter route on floodplain on north side of Sundog. All-season route stays on south side of Sundog throughout this section, skirting toe of steep slope. Bedrock or rocky bluffs prevalent northeast of ~KP035 along southeast shore of Sundog Creek, which are parallel to the stream direction in this section. There are some smaller scree/talus sections between outcrops and upslope of outcrops. Small borrow proposed at about KP035.4 between road and toe of slope (BP 35). A few debris flows features along this section, with a sizeable alluvial fan at KP035.7 where the road skirts around the toe of the fan. Northeast of ~KP036.3 appears to be older talus mounds. Bend in creek at top middle of photo is at about KP037.5. Air photo A28094 - 209; other air photos missing for this section.	 Looking downstream east-northeast from ~KP034.9. Bend in creek at ~KP036.5. (Photo credit: CZN)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
36.5	39.7	-	At ~KP036.5, at approx. bend in stream heading east-southeast, winter route crosses eastbound from north side of Sundog to south side. All-season route skirts along toe of steep slope on south side of Sundog floodplain, except at borrow BP 37 (~KP037.4 to KP037.7) where it follows edge of floodplain. Apparent talus mounds to ~KP037.2. Steep scarp upslope of road from ~KP037.2 to KP037.8, probably in bedrock. Bedrock bluffs above route ~KP038 and KP038.9. Proposed borrow between route and toe of bluffs, KP038-KP038.45 (BP 38). Air photos A28094 - 272-278 for KP038-KP049, A28094 - 209, 211. No stereo coverage south of ~KP038. See also photo in previous section for KP036.5 to KP037.8 view.	Looking south at KP039.4 tributary into Sundog Creek. Bluff on right is above ~KP038.8. (Photo credit: Allnorth)
39.7	40.1	-	Edge of Sundog floodplain just before climb east out of valley bottom. Proposed borrow on vegetated terrace on upslope side of route (BP 40). Remnants of Cat Camp to be disposed of. Air photos A28094 - 277-278.	Looking northeast along route. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
40.1	41.5		Route climbs out of Sundog drainage just south of apparent rocky headland jutting into river. Road crosses a series of swales and gullies along the climb east. Three small borrow areas enroute, which Allnorth hopes to be glaciofluvial sand but hasn't yet confirmed. Terrain looks quite different here than further east, and is well west of granular terrace beginning KP041.5. Mollard's suggestion of old mass-wasted till seems more likely. No obvious distress, but patchy trees on this irregular north-facing slope suggest possibly wet seeping areas in mid-slope and slopewash colluvium in areas of "mottled" looking terrain (patchy trees and areas of open-slope drainage). Air photos A28094 - 276-278.	Just northeast of KP041, looking east at transition between slopewash colluvium and terrace. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
41.5	45.5		Route climbs onto flat granular terrace ~KP41.5, descending again at ~KP042.7. Borrow at KP043 (BP 43A) appears to be within the east-facing sideslope of the granular terrace. Determined by Allnorth to be fine glaciofluvial sand. Road continues east descending from borrow, down to stream crossing at about KP043.2. Possible flooding to 70 m from 5 m wide stream, but only 1 m deep at 1:100 year flood. Stream bed and overflow is gravel to cobbles, with areas of sand-silt. Slight reroute west of winter road on east side of stream for slightly wider corner at bend east at ~KP043.4. Granular terraces continue eastbound, with more of this terrain north of the road than south. Ground surface is more rugged than the KP041.5 to KP043 terrace, as a result of dune ridges prevalent north of road, but also present though more subdued south of road. Some sections of soil are exposed along this part of the route; probably similar to the borrow anticipated by Allnorth (glaciofluvial fine sand). Road descends off the main terrace at about KP045.5, leaving the granular terraces/dunes altogether at about KP45.7. In the section between KP045.5 and KP045.7, there may be little or no granular thickness beneath the road, which follows along the south side of a small stream here. There are still terraces beside the road, north and south. Air photos A28094 - 275-277.	West of KP043, view southeast across route just below edge of terrace and stream below. (Photo credit: Allnorth) KP045: view northeast, exposed soil (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
45.5	46.3		"Mottled" slope appearance due to patchy trees and open-slope drainage features in area of slopewash colluvium. Mollard notes moderate slope with slopewash colluvium possibly over old till. Exposed soil at HP47, at about KP046.1. No obvious reason for it, may just be a borrow area in small knoll just north of route. Creek crossing immediately east looks washed out on air photos, but there likely was little or no fill there anyway, so this may just be stream incised into original grade (0.5 m wide by 0.5 m deep on vegetated floodplain). No exposed soil at stream. No apparent distress on imagery. Stream crossing study suggests potential for 1:100 year flood to 806.5 m elevation and width of 24 m. Air photos A28094 - 273-275.	Looking northeast across route, exposed soil at HP47. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

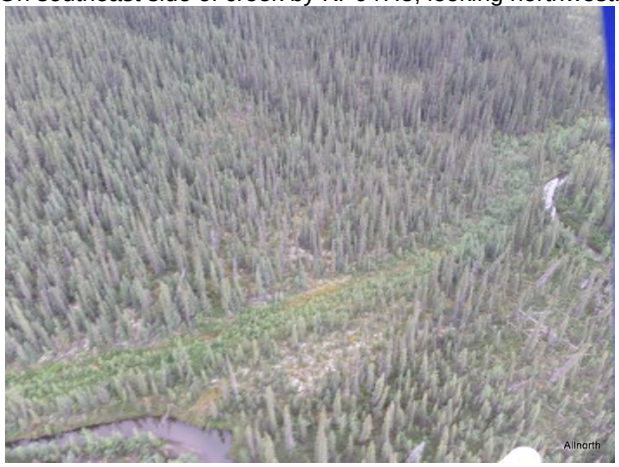
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
46.3	48.8	-	On winter road route. ~KP046.5 is Mollard's ~km 140. Terrain eastbound is now steeper, road winds its way around steep toes of knolls, especially between ~KP047 and KP048, where there are some areas of exposed soils on the air photos at each cut location on knolls, and on a steep slope section above an outside bend of the creek between ~KP047.4 and KP047.6. From KP047.6 to KP047.65, a very tight outside bend of the creek has resulted in erosion at the slope toe and a slope failure below the road. The sloughing has not retrogressed to the road yet, even in the 2012 imagery, but some consideration should be made to protecting this slope from further erosion. A similar situation is present at ~KP048.5, at KP49b, where another outside bend of the creek comes very close to the road. There is little vertical difference between road and creek here though, so it may be easier to protect. Air photos A28094 - 273-275.	On southeast side of creek by KP047.5, looking northwest.  From KP048.35 looking northeast, road close to creek bends here and at KP048.5. (Photo credits: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
48.8	49.1	-	The 2014 all-season route begins at ~KP048.8 (old KP49.3, and Mollard's km 137.5), heading NE to avoid karst area to east, and staying northwest, then north, of creek (referred to in Golder 2010 as a tributary of Polje Creek). Almost the entire reroute is within an area burned by a forest fire in 1996, within only some short lengths of valley bottom and gullies typically preserved, as well as the western ~0.5 km of the reroute. Soils appear to be slopewash colluvium, possibly over old till, resulting in mottled appearance of terrain where knolls and ridges are dark (typically treed) and drainage paths around and between the knolls and ridges are light (fewer or smaller trees, brush or other groundcover, sometimes bare ground). Much of this terrain appears relatively benign, with only the difference in vegetation to indicate slope processes; however, when pursuing such drainage paths to the crest of slope, there are typically identifiable headscarps. Though most of these appear to be inactive, they can reactivate under the right conditions. For example, about 2.2 km due north of HP46, there is a readily identifiable example of a reactivated debris slide, with two headscarps of 300 m and 130 m in width resulting in exposed soil along a 400 m length of drainage. Air photos A28094 - 272-274, and 217-218-219 (missing 219). No stereo coverage north of ~KP049. All-season route is at edge of photos, thus some distortion.	Looking northeast from KP048.8 along reroute north of Poljes. KP050.5 failure top right. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
49.1	49.8	-	BH-01 west of creek at upper HP50 indicates till-like textures in sloughed soils (silt with some sand and clay) and underlying apparently-intact soils (silty clay with some sand and sand lenses). In contrast, shallow TPs and BHs east of the creek at HP50 to 1.2 m maximum depth indicate 0.1 - 0.15 m peat/organics over SAND, trace to some silt to silty on the main portion of the reroute. Comparing upper and lower tributary creek crossings at HP50, the better crossing is the lower one at ~KP049.7. The upper one entails crossing tributary sideslopes which are already failing - shallow slips in active layer, with heavy seepage throughout this slope. At ~KP049.8 (old KP50.5), terrain no longer mottled upslope of route, suggesting slopewash processes are not as prevalent, but slope instabilities are more prevalent downslope of realignment, extending to creek floodplain. For the most part, these instabilities appear to be related to undercutting of slope toe at outside bends of stream, but a contributing factor is probably the 1996 forest fire damaging the organic layer, subjecting the underlying fine-grained soils to additional infiltration and erosion, and possibly thaw of permafrost if present. Since this is a warm south-facing slope, permafrost may or may not be present, but was not encountered in the shallow testholes. Also a factor in near-surface soils, due to the forest fire, is the loss of integrity of roots of mature trees, as well as the loss of tree trunks in reducing avalanche activity on local steep gradients, both of which can result in increased susceptibility to soil disturbance.	Looking west at slope failure along gully bottom near proposed upper crossing at KP049.7 (BH-01).

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
49.8	50.8	-	Crossing sidehill above creek, but climbing early onto successive benchy areas. Slope instabilities noted downslope of realignment - especially beginning at KP050, where there is a slope failure at the outside bend of the creek below due to undercutting, and at KP050.1 (old KP51 area) where the available 1994 air photo (#218) shows series of small slides that seem to have grown over in the 2012 LiDAR. On the ground, these narrow features proved to be ridge/gully features, sliding in linear fashion downslope, with depths of about 1 to 1.5 m. Same soil constituents as encountered upslope - essentially sand. The road has been routed a little further upslope to stay further back from the steeper slopes above the creek. A slope failure at ~KP050.5 (old KP51.5) as seen on 2012 LiDAR has grown larger since the 1994 air photos. A revegetated slope failure is also noted immediately west and upstream of this large open slope, along with an abandoned stream channel at the toe, indicating the close correlation between slope stability and stream channel behaviour. Two routes were considered upslope of the KP050.5 slide area, with an alternative further northeast to avoid possible road failure due to progressive slope headscarp retrogression. However, the headscarp is near local height of land now, along what turns out to be a ridge with a swale behind it, and away from the road. Shallow soils are identified as sand throughout this rerouted section to at least as far as heli pad at creek (HP52), at about KP50.8 along route. Presence or absence of permafrost could not be determined on the basis of the 2014 testholes, but based on slope aspect, the slope should be locally warmer than adjacent terrain.	Left side is ridge-gully features at KP050.1 (within area of yellow vegetation), right side is large slope failure at KP050.5, treed area immediately left of large failure is revegetated old failure. Looking northwest.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
50.8	53.6	-	Crossing tributary floodplain from just west of ~KP050.8 to ~KP50.9 (about 80 m), short climb northeast out of floodplain, then on contour on sideslopes of 10-15% above the apexes of several apparent alluvial/colluvial fans. Road grade situated on fine sand, with proposed borrow sites between floodplain and KP051, and at ~KP051.7 (Allnorth data). Then, from ~KP51.8 to ~KP052.2, the route crosses a large alluvial/colluvial fan about halfway down from the apex and, depending on location, about 380 to 500 m from the floodplain of the main creek (referred to as a tributary of Polje Creek in Golder 2010). Slope gradient below the road at KP052 is about 3%. At ~KP052.2, the edge of another newer fan appears to overrun the upper part of the large fan. Different events can be discerned from the colour variation in the streaking of the fan materials. Small streams are running on the fans to the south and east, and then northeast; all joining and running towards Polje Creek, where the creek downslope meets the stream flowing from the Poljes, becoming a larger meandering S-N stream at ~KP053.6 (old KP54.5). The road crosses a couple of tributaries just west of Polje Creek, including one consisting of the streams from the fans, just as the road enters the main floodplain of Polje Creek at ~KP053.4. Need air photos A28094 - 218-223. (Missing 219-222)	Looking west-southwest from KP051.7, in proposed borrow area along route. Ridge on horizon just right of centre is ridge west of KP049.7, upslope of BH-01. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
53.6	54.6	-	A recent slope failure is marked on the LiDAR south of the proposed route (beside route between ~KP053.8 and KP054.1, and below the route at KP054.2) as the route climbs east-northeast and then turns south-southeast. Slump/flow is ~300 m long and ~80 m wide, and may be associated with a small stream draining west to Polje Creek, as well as effects of 1996 forest fire on permafrost. Site visit September 22, 2014: Retrogressive thaw slump/flow has potential to spread; diagonal feature in photo top right may limit retrogression. Seepage, water flow and standing water are confirmed in the slide area. Apparent bedrock control north side may help limit lateral progression to the north, where the road is presently proposed. Similar terrain continues outside the perimeter of the bedrock outcrop / near-surface bedrock. Trees associated with bedrock / higher ground appear to be mostly straight, whereas trees outside this area are leaning in towards the main slide or leaning upslope, and there are a few "drunken forest" trees. Below (west-southwest of) bedrock area, slopes are gentler (~8%), and Allnorth is proposing embankment fill only (overlanding) through this area. Soils exposed on headscarp and sliding surface are peat, silt, sand, and clay (till-like). Head scarp 2.25 m high. Refusal on suspected permafrost at 2.5 m. The soil is ~60% clay and ~40% silt, with <1% sand.	 Looking downslope and southwest at upper end of thaw slump/flow, possibly limited by bedrock control. Headscarp logged in TP-07.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
54.6	57.7	-	From ~KP054.6 to KP057.7, the reroute skirts around bedrock bluffs and drainages flowing to the Third Polje and to Polje Creek. Carbonates identified in the bluffs at ~KP054.6 (Allnorth's BP54), and shale at ~KP055.3 and ~KP055.9 (BP55 and BP56). Sinkhole noted about 80 m SSE and downslope of route at ~KP056, well below shale borrow at BP56 which is along a bluff along the proposed road route. Anticipate residual and colluvial veneer over near-surface bedrock, including some slopewash features downslope (west and south) of the road. SLI noted an historical landslide between about KP056.8 and KP057.4 (current stations), in the vicinity of their boreholes BH-M-01 through BH-M-04. At least some of the boreholes were within their identified slide area. There are several possible scarps along the route in this section, all of which appear relatively well-vegetated on the 2012 imagery. No 1994 air photos to compare to. There is an obvious slope failure downslope of the route between about KP057.4 and KP057.7, above the east end of the Third Polje (probably the same site reported by Dillon in Sept 2009). See Figure 6 for slope failures.	Sinkhole Near KP056, note apparent subsidence cracking Looking north at KP056 shale bluff, note slope issues.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
57.7	58.6 meets winter road	-	All-season reroute towards mine heads NW from ~KP058.6 (old KP59.6) to avoid karst, skirting north and east of swales and drainages at top of slope, specifically to avoid the Poljes southwest of ~KP055.5 to KP058.5, as well as avoiding some but not all potentially unstable ground (Figure 6). Between KP057.7 and KP058.6, the road skirts around the crest of slope above Second Polje. The sand and gravel terrace noted by Mollard in the next road section appears to continue to the north and east of the route, at least as far north along the road as ~KP057.7, based on slope gradients and similarities in surface texture as it appears in the 2012 imagery. Winter road heads south from KP058.6 towards mine. Heading east, all-season alignment is on winter road. Need air photos A29094 - 218-223 (missing 219-222).	At KP059.3, looking west, light low area at KP059. Route bends north with edge of terrace. (Photo credit: Allnorth)
58.6	59.9	-	Route is on winter road alignment. Mollard's description extends east from first switchback where all-season route leaves the winter road heading northwest. This terrain is much flatter than the terrain immediately east and west, with gradients of 0-2%. Some steep and unstable slopes south (Figure 6). Proposed gravel borrow pit BP59 at ~KP059.4, with constituents noted as subrounded shale and sand. Swale along toe of ridge at about KP059.9 resembles a small meltwater channel. No stereo coverage west of ~KP060, no coverage at all west of ~KP058. Need air photos A29094 - 218-223 (missing 219-222).	Looking north from ~KP059.6 at sand and gravel terrace; proposed borrow in foreground.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
59.9	61.3	-	Route is on winter road alignment. Crossing near head of steep-sided gully between ~KP059.9 and KP060.7; section from ~KP060.5 to KP060.7 has some poorly-vegetated and oversteepened slope sections due to seepage and/or sloughing (Mollard's KP123 to 123.2). Main stream at ~KP060.5, but road descends from ~KP061.1 along a tributary swale until ~KP060.6, where the tributary stream turns downslope to meet main stream. Caution required in design and construction so as not to direct water where it would not naturally run. Air photos A28094 - 196-197, 223-224. No stereo coverage west of ~KP060. Missing photos 219 to 222.	From downslope side of road at about KP060.4, looking at cutslopes both sides of KP060.5 stream crossing. From KP060.6 looking east along route, road in swale with stream, road bend at ~KP60.7. (Photo credits: Allnorth)

Table C-1: Summary of Mapping and Field Observations

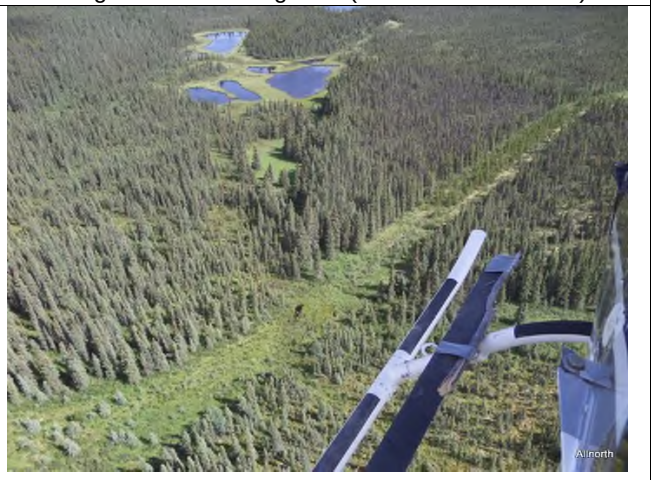
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
61.3	62.6	-	Steep-sided gully crossing at ~KP061.6 (Mollard's ~km 122.1). Bare ground seen upstream along both forks of this gully; potential for debris flows but the most prominent features in the north fork appear to be bedrock-related. North approach appears to be a full bench cut. North end of Mosquito Lake at ~KP062.2. Air photos A28094 - 196-197, 223-224.	Looking south across gully from KP061.3, cutslope with revegetation on road grade. (Photo credit: Allnorth)
62.6	64.3	Sh, Si, L GC-GP H 1,2,3, d (following Mollard)	Route is on winter road alignment. Terrain less rugged and gently sloping along route between ~KP63.3 and KP64.3. South end of Mosquito Lake is due west of ~KP064. Drainage across road from ponds on east side at ~KP063.7. Northwest approach (Mine side) is moderately steep ~KP063.5 to KP063.6. Air photos A28094 - 195-196.	 Wet swale across road at KP063.7. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
64.3	65.0	Sh, Si, L GC-GP H 1,2,3, d (following Mollard)	Route is on winter road alignment. Ponds alongside road are in deep wide bowls. GSC mapping suggests lacustrine, but west of this section are some sharp-edged angular ridges surrounding some very deep unvegetated bowls that appear as though they are sometimes water-filled. These may be like the Poljes, which can fill or drain. More inclined to follow Mollard on terrain type in this section, unless there is also some lacustrine modification in the history. South of ~KP064, in approximate area of old burn (sometime 1940-1950). Considerable revegetation in road, some areas of exposed soil. Air photos A28094 - 195-196.	From KP064.8, looking south. (Photo credit: Allnorth)
65.0	66.3	Sh, Si, L GC-GP H 1,2,3, d	Route is on winter road alignment. Between ~KP065 and KP066.3, the route follows crests of slopes/ridges generally staying out of drainages except to cross them, and usually crossing them high on slope. Detour around east side of a knoll and at about KP065.15 to KP065.4. From KP065.3, detour bends west and south again to follow ridge well above adjacent ponds west and east. Ponds alongside road are in deep wide bowls. Air photos A28094 - 195-196.	Looking south from KP065.3. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
66.3	67.6	Sh, Si, L GC-GP H 1,2,3, d	Route is on winter road alignment. Between ~KP066.3 and KP067, the route follows crests of slopes/ridges generally staying out of drainages except to cross them, and usually crossing them high on slope. From ~KP067 to ~KP068, route skirts northeast toe of ridge, which has either bedrock or near-surface bedrock. Steeper faces appear marginally or unvegetated and may be ravelling. Road grade looks stable. Patchy old burn area ~KP066.5 to KP069.5. Air photos A28094 - 193-195.	Looking east from ~KP067. (Photo credit: Allnorth)
67.6	70.2	Sh, Si, L GC-GP H 1,2,3, d	Route is on winter road alignment. Generally following ridge tops and skirting around drainage features. From ~KP067 to ~KP068, route skirts north toe of ridge. Just south of ridge crest from ~KP068.5 to KP069. Possible old slough in drainage west below ridge ~KP068.5-P069.3? Road appears to be cut into slope. Ridge may be bedrock or near-surface bedrock and parts of cut may also be into rock. No obvious influence of road on stability, aside from possible fill slope disturbance ~KP068.7 that seems well-vegetated. This is also in area of more recent burn (date unknown), up to ~KP069.5. Air photos A28094 - 192-194.	Looking south, bend left ~KP068.7. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
70.2	71.7	Sh, Si, L GC-GP H 1,2,3, d	Route is on winter road alignment. Route skirts around steeper slope below from ~KP070.2 to ~KP071, with steeper ground upslope at KP070.6 to KP070.8. Air photos A28094 - 264-265.	Looking south from KP070. (Photo credit: Allnorth)
71.7	75.6	Sh, Si, L GC-GP H 1,2,3, d	Route is on winter road alignment. Peaty wetland at about KP072.8. Allnorth identified fine sand at adjacent borrow site, at soil exposure along road. Air photos A28094 - 189-192, 263-265.	Looking southeast from KP072.6. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
75.6	80.0	Sh, Si, L GC-GP H 1,2,3, d and (Cx1/tMv1)/ (Sh, Si, L)	All-season road is on winter road, following ridge top. Scattered bare patches seen on cleared ROW on 1994 airphotos. No apparent distress on or immediately adjacent to road on 2012 imagery. Transition from bedrock with residual/colluvial veneer to colluvial/till veneer over bedrock occurs at about KP078.6 according to transition marked on GSC mapping. Visually, on the 2012 imagery, the transition is at about KP079, where terrain has greyish undertone west and brownish undertone east. From ~KP079 to KP080 is also where route traverses along the crest of a broad bowl with streaky terrain (overland runoff channels or seeps, inactive or ephemeral). Narrow ridge between lower bowls about 250 m downslope ~KP079.8 to KP079.9. Air photos A28094 - 261-264.	Looking northeast near KP079. (Photo credits: Allnorth)
80.0	80.3	(Cx1/tMv1)/ (Sh, Si, L)	Traversing along crest of steeper slope south, gentle slopes north. From ~KP080 to KP080.5 (old KP81.0 to about 81.5), the winter road alignment crosses within 140 m of a bowl-shaped feature downslope that appears to be an overgrown slope failure, streaky terrain. All-season route stays upslope of winter route east of KP080.3. Air photos A28094 - 260-261.	Looking east from KP080.1, winter route visible southwest of KP081 at light-coloured strip, upper right of photo.

Table C-1: Summary of Mapping and Field Observations

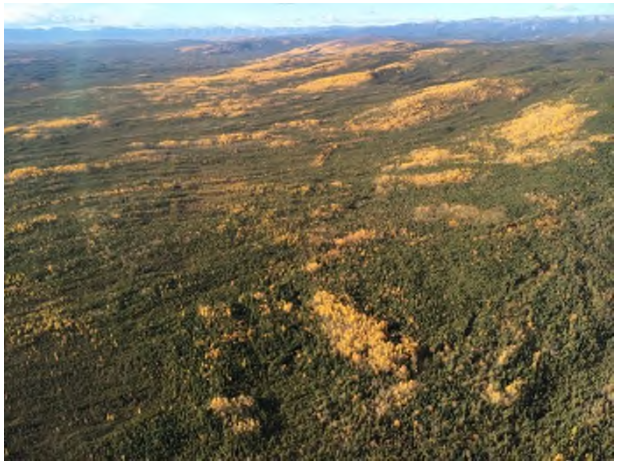
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
80.3	83.0	(Cx1/tMv1)/ (Sh, Si, L)	At ~KP080.3 (old KP81.3) on the winter road, the route begins descent into, then across gully, descending east sidewall of gully, then bending east to follow just above valley bottom. Gully appears to be a shallow earth slide, with smaller old slope instabilities within gully, and at old KP83. Apparent headscarps are more obvious on 1994 air photos than on 2012 imagery. Mottled slope appearance between old KP82.7-82.9 on winter road. Short bare patches noted by Mollard seem to be related to cutslope disturbances. Clearly visible on the 1994 air photos, but not on the 2012 imagery. Streaky, subparallel runoff channels in valley south of road. All-season reroute departs from the winter road at ~KP080.3 (old KP81.3), staying north of the winter road and avoiding these features by staying above the crests of steeper gullies/drainages (locally to 40%), and on ridges (20% or less). From about KP080.8, the route descends a ridgeline south, switching back at about KP081.7, heading northeast and skirting above the steeper ground on the descent towards KP083, where the slope gradient lessens. Openings at ~KP082.4, KP082.5 and KP082.8 below the route along low northeast-running ridge suggest seepage areas and possibility of instabilities at heads of swales. First two of these are seen on 1994 air photos and 2012 imagery, the latter is on less-steep ground and is visible only on 1994 air photos. Care is required to optimize drainage across road. Air photos A28094 - 260-261.	 Looking south-southwest from about KP083.5. Note winter route in upper mid-photo. All-season route stays high along upper right, along and/or just within upper edge of aspen.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
83.0	83.9	(Cx1/tMv1)/ (Sh, Si, L)	Slope gradients between ~7-13% in streaky terrain. Slopes becoming gentler eastbound. All-season route is roughly parallel to and south of small stream. Decadent forest in this area; jackstrawed trees across stream, lots of old and new deadfall, old deadfall is moss-covered. Soils include silts with trace clay to clayey, to silty clays. Trace sand and sand pockets, trace oxides, trace gravel; till-like. (TP-12/BH-06, north of ~KP083.6; TP-13/BH-07, northeast of ~KP084.) Since this area is mapped colluvial or till moraine veneer, anticipate similar soil textures in either terrain type. See Figure 8. Air photos A28094 - 259-261.	Jackstrawed trees and decadent forest along stream between TP-12 and TP-13. Trees straighter away from stream in open aspen/birch/spruce stands.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
83.9	85.9	Cx1	Slope gradients between ~4-7% in streaky terrain. Ends at about HP 86 (just south of winter road) and about KP085.9 along the all-season route (east edge of area). Anticipate similar soil types as upslope. Potential slope issues near the crest of a north-facing slope above upper Tetcela River, which is mapped entirely as colluvium by GSC. Most of this slope is off the 2012 imagery, but numerous slide paths are visible on the 1994 air photos. Recent ("fresh") slide path is clearly visible near KP084 on the 1994 air photos (A28094-259-260). From the air it appears that there may be tension cracks above crest of slope, areas of seepage and apparently slumping soil. Numerous scarps and slide paths along Tetcela River. Tension cracks have been interpreted along the crest of the slope on the 1994 air photos (A28094-259-260) - see Figure 8. Route proposed to stay well south of Tetcela River crest of slope, south of small stream noted in field and mapped by Allnorth. Care needed with drainage across road (drainage path interpreted on the 1994 air photos between KP085.2 and KP085.5. Slope instabilities on 2012 imagery seen in field in KP085 area. Active slope erosion of the Tetcela River slope was interpreted between KP085.5 and 086.5 - patches of the slope are devoid of trees. There is evidence of downslope block movement. Air photos A28094 - 259-261.	Looking southwest from KP084.5. Route skirts upslope edge of aspen patches, then far side of streams near crest. Looking southwest at instabilities downslope of KP085.

Table C-1: Summary of Mapping and Field Observations

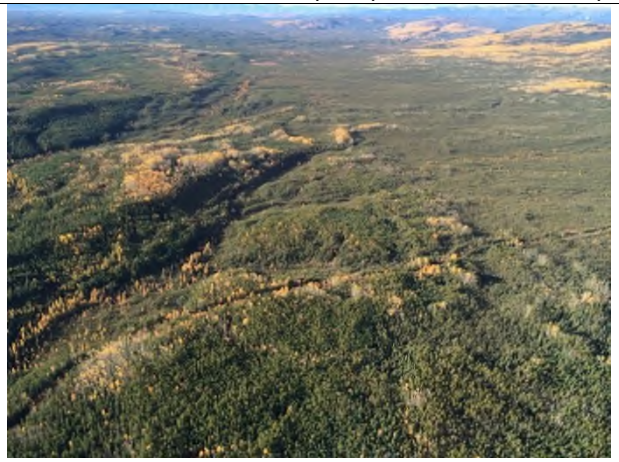
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
85.9	86.3	Cx	Within colluvial soils, downslope and east of streaky terrain. Gentle slope, road route descends south towards winter road. All-season route stays on the higher ground, avoiding unstable areas downslope that appear wetter, with fewer trees. See Figure 8.	From north of KP086.9, looking upstream along Tetcela River; route avoids lower slopes. (Photo credit: Allnorth)
86.3	87.3	Cx	Bare patches on road between ~KP086.6 and KP087.3 seem to be related to descent along sidehill above stream bank - could be sediment from cutslope. GSC mapping indicates colluvium on this slope and transition into gully with scarped edges, so it could also be that this slope is more easily disturbed. All-season route descends from broad gentle slope at ~KP086.3 and crosses winter road at ~KP086.4, rejoining it again at KP086.6 heading east. Gully just south mapped with stream. See Figure 8. Air photos A28094 - 258-260.	 Looking southwest from north of KP086.7. All-season route rejoins winter road at bend.

Table C-1: Summary of Mapping and Field Observations

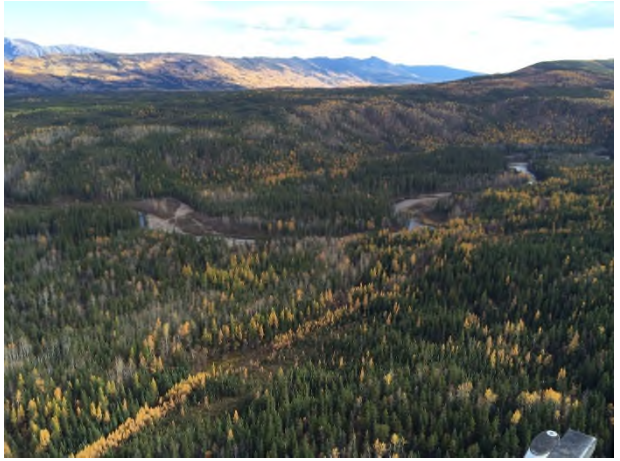
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
87.3	88.0	g,sAp/ s,siCx	Crossing the upper Tetcela River floodplain and turning the corner north into lower Tetcela River floodplain. Terrain is well-treed in this road section. Confluence with tributary is further south, and not encountered on the winter route or all-season route. See Figure 8. Air photos A28094 - 258-260.	Looking north, KP087.6 to KP088.0. (Photo credit: Allnorth)
88.0	88.6	s, siS	On same route as winter road, and N of the upper Tetcela River, KP088 is just N of knife-edge ridge along N crest of river. At valley bottom, existing winter road heads N along lower Tetcela River over toe of debris from slump upslope W. Tetcela River northbound has cut into toe of debris east of road. GSC anticipated sands and silts. Well-vegetated floodplain, which shows some scrolling and the occasional oxbow. This section of road appears generally well-behaved with two short bare sections at KP088.1 and KP088.3 possibly related to short steep rolling grades on essentially disturbed and possibly looser soils due to slump (these are likely the same bare patches noted by Mollard). Adjacent stream and stream crossings show lots of movement/deposition of bed material. See Figure 8. Air photos A29094 - 235-236.	 Looking southeast along existing winter road between about KP088.5 and KP088. Slump mapped right (west).

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
88.6	90.2	g,sAp/ s,siCx and/or s, siS	On winter road route, skirting lower edge of large slump and outside edge of floodplain up to crossing of lower Tetcela River. At ~KP088.8 to KP089.2 is possible incursion from slump into floodplain, although there is little change in elevation suggesting subsequent modification by river. At about KP089.4, the road bends east towards river, crosses the floodplain, and crosses the river at about KP089.9. All-season route threads between apparent old approaches and what looks like abandoned channels on east side of river. The road leaves the floodplain at about KP090.2. See Figure 8. Air photos A28094 - 235-236 and 273-275.	Looking south from KP089.2, slump right, Tetcela River left Looking south at river crossing at KP089.8.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
90.2	90.6	s, siAp	GSC maps as alluvial plain. Thermokarst ponds within peatland terrain continuing SE on the winter road. No thermokarst in immediate vicinity of this road section; well-treed. Photos A28094 - 235-239 (missing 238).	Looking west from KP090.2, existing route is revegetating very well, no sign of thermokarst. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
90.6	94.2	s, siLrh	All-season route leaves the winter road at about KP090.6, heading upslope and southeast into higher, drier terrain. Route is directed to run primarily along ridges, knolls and hummocks along the periphery of this upland area, skirting around the crests of suspected old slope failures and local steep slope sections. Drainage is to the north and northeast, with crossings of streams or swales generally made near the crests of steeper slope sections. Terrain is similar to that characterized further south. Possible thermokarst for about 100 m along winter road downslope of route at about KP091.8, mapped as distributary stream on 2012 imagery, originating south of stream crossing at KP091.3 on all-season route. Not obvious on 1994 air photos. More significant thermokarst ponds noted within the peatland terrain downslope of the proposed all-season route from KP092.8 on. At ~KP093.9, just N of the N end of C-Lake, the route gradually descends and bends to the E around the S end of C-Lake, crossing into the alluvial plain and thermokarst terrain at about KP094.2. Air photos A28094 - 256-259 (E-W) and N side A28094 - 235-239 (missing 238) (W-E).	Looking west from winter road below KP092.5, all-season route stays high left. Thermokarst at KP092.8 avoided by upslope reroute.

Table C-1: Summary of Mapping and Field Observations

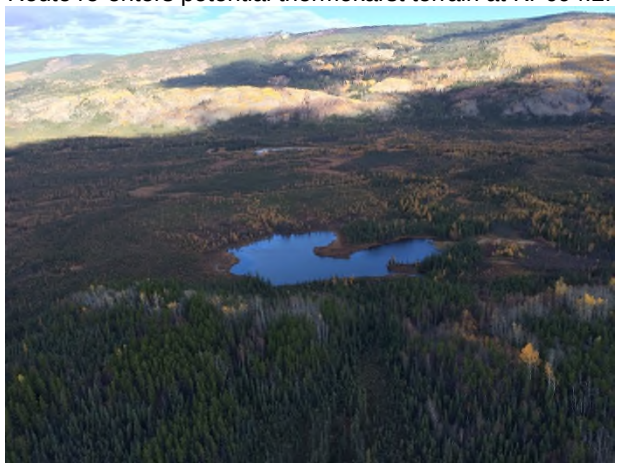
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
94.2	97.0	s, siAp	The all-season route crosses the thermokarst terrain / alluvial plain between ~KP094.2 and KP095.8, rejoining the winter road just W of the crossing of Fishtrap Creek and KP095. Could be thermokarst associated with small stream through area draining into C-Lake, from ~KP094.2 to ~KP094.5. Stream is very steep-sided but narrow. There don't seem to be any particularly actively-thawing or distressed-looking reaches, but the geometry of the stream bends is suspicious, suggesting patterned ground (Photos #2862-2863). Another small stream comes in from the wetland to the west, just before the main stream widens outs into what looks like a delta at the lake. It looks as though the area of lake and stream sometimes has significantly higher water level than at time of work. Outlets of lake appear to be immediately east of inlet in lower leg of C, and also possibly at upper leg of C. This lake may once have been a much larger body of water, maybe during glacial retreat. Photos A28094 - 235-239 (missing 238). From KP095.8, the route skirts the outside edge of the floodplain, climbing a little higher than the winter road beginning at about KP096.6, and maintaining a distance of about 40 m upslope in this section. See further discussion in next section. Beaver dams at ~KP096.2 and ~KP096.8, flooding the stream north of the dams. More dams and remnants of dams are visible further downstream, indicating a natural system that is likely always in flux. Fishtrap Creek drainage flows south. Thermokarst continues in valley bottom, see comments below.	 Route re-enters potential thermokarst terrain at KP094.2.  Looking east-northeast across Fishtrap Creek drainage. Route rejoins winter road at bend heading east.

Table C-1: Summary of Mapping and Field Observations

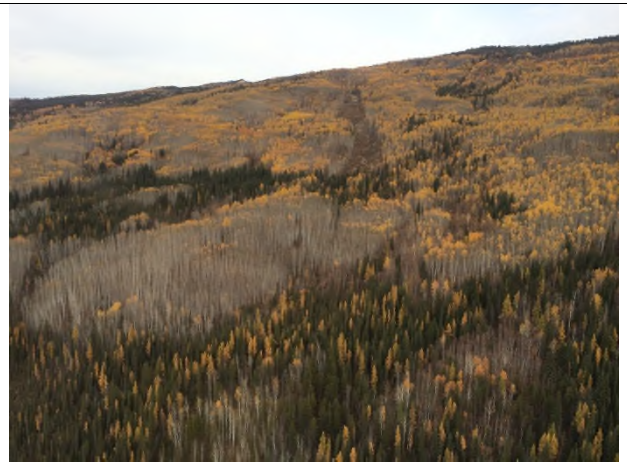
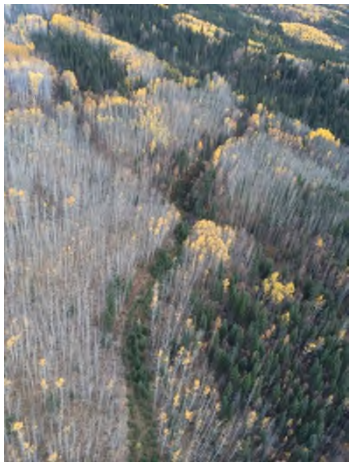
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
97.0	98.0	Sh, L GC-GP H 3,2,4	GSC mapping shows the Silent Hills as having shale and limestone bedrock, overlain by a discontinuous residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels. Mollard describes this material as till, and soil descriptions by SLI in 2012 and observations by Tetra Tech EBA in 2014 suggest a till-like material. Soils encountered included various silt and clay mixtures, with varying proportions of sand and gravel, gravel increasing with depth, and fractured shale rocks also found in the samples. The presence of these fractured rocks suggests possible shallow bedrock, but bedrock has thus far not been proved in any testholes. Downslope of the route in the valley bottom, there is evidence of thermokarst. The stream west of the road from about KP096 to KP099.1 is flooded with some of the lakes on the floodplain now connected with the stream channel. From ~KP096.6 to KP098.0, proposed route climbs subparallel to winter route, within 40-100 m upslope of winter route. At ~KP098 (winter route ~km 84.9), the all-season route crosses the winter route and continues to climb heading southeast until ~KP099.1, then switches back to the north, rejoining the previously-proposed route at ~KP101. Air photos A28094 - 238-240 (W-E), 254-256 (E-W).	 Large debris flow north of helipad HP99 runs into stream crossing at ~KP096.6.  Looking south-southeast along winter road from KP098.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
98.0	101.7 (old 102)	Sh, L GC-GP H 3,2,4	Existing lower switchbacks wind their way around knolls. Old switchbacks are not used for all-season route which is generally routed both further north and south than winter route but ends at the same place at the top of Wolverine Pass. Numerous sinkholes and areas of exposed soils and old or continuously ravelling slope failures originate on steep convex slope sections are avoided with the new route. Route avoids large recent soil debris flows in large gullies north and south of the alignment, mapped by GSC and periodically reactivated (see also mapping on 2012 imagery). Route also avoids multiple crossings of an apparent debris flow gully, north of the upslope section of the route, now crossing only once, low on the slope at ~KP097.4. Other small areas with low vegetation look like seepage areas and possibly small slope failures. Route crosses somewhat wetter area between KP098 and KP101, but avoids possible slope failures seen on the imagery. Air photos A28094 - 238-241 (W-E, north side of switchbacks, missing 238 and 240 - no stereo), 254-256 (E-W, south side of switchbacks).	Looking west at sinkhole (HP99 pond), avoided by route. West of KP101 looking southeast upslope. Route avoids sinkholes between helipads HP101 and HP102, right side.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
101.7 (old 102)	103.3	Sh, L GC-GP H 3,2,4	GSC and Mollard disagree on the mapping of this section, but this is probably a matter of scale. The existing winter road tends to skirt along toes of steeper slope sections, and the all-season route tends to aim for higher ground. From ~KP102.7 to KP103, and KP103 to KP103.3 the proposed all-season route skirts across the toes of two small alluvial fans originating from upslope, first staying a little lower on the slope and then a little higher on the slope compared to the winter route, staying closer to on-contour between KP102.7 and KP103, and thereafter descending and crossing the winter route again to meet the next low ridge (see next section). The alluvial fans are reasonably well vegetated but there are some areas with little or no trees and exposed rock near the peak of the ridge suggests activity could resume under the right conditions. No stereo coverage A28094 - 239-241 (missing 240). A28094 - 254-255 marginally covers this transition, but it is at very edge of airphotos and is subject to distortion.	Looking southeast from KP103. Proposed road generally skirts the upslope toes of the knolls (seen here at KP104 and KP105), avoiding wet areas.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
103.3	109.5	Sh, L GC-GP and Cx	Between ~KP103.3 and KP109.5, the route runs upslope of the knolls. Surficial geology is mapped by GSC on the upper slopes and near the knolls as shale and limestone overlain with residual or colluvial veneer as described below, and between and/or upslope of the knolls as colluvium. Anticipate possible occasional debris flows and slope failures, despite the gentler slopes, particularly events that originate upslope. Based on similar mapping by GSC along Front Range and soil samples obtained there and along upper route at KP116, expect till-like soil textures on this slope. Anticipate seepage in areas with shorter trees. No obvious signs of patterned ground or thermokarst in this section. From KP103 to KP105.8, the route stays on the higher ground where possible and skirts the toes of knolls. Between KP105.8 and KP106.6, the route is just above toe of knoll and just below some apparent surface sloughs, which will be removed when area used for borrow. Probably these are bedrock-controlled. From KP106.6 and KP107.1, route minimizes length in drainage crossing, which looks as though it may be related to an old cross-slope meltwater channel starting at KP105.9 above knoll and leading to gully at KP106.8 (old KP107). Bowl above gully has patchy vegetation, with occasional small areas that might be exposed soil, mostly along the main channel. The west fork, is steeply gullied with exposed ground at about 2 km upstream of the road route, which suggests that this stream could become a debris flow at times. Between KP107.1 to KP109.5, route skirts upslope toes of knolls and stays above gullied terrain. Air photos A29094 - 252-254.	 Looking south from about KP104. Gullies from upslope of knolls drain down to road elevation, here above KP108.5, which drains to KP106.8 gully.

Table C-1: Summary of Mapping and Field Observations

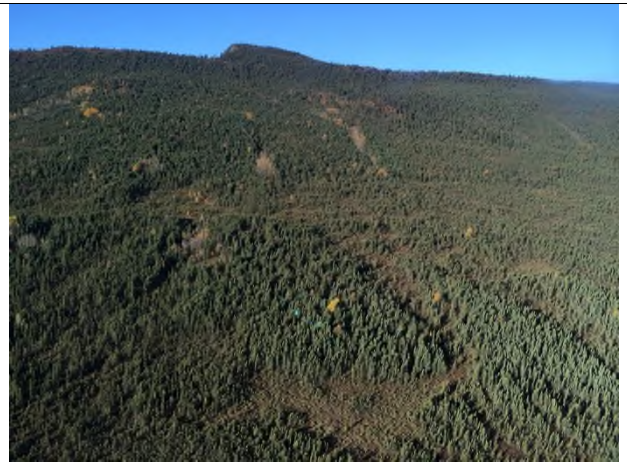
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
109.5	115.0	Sh, L GC-GP	From ~KP109.5 to KP115, the route runs upslope of the large knolls, mapped by GSC as shale and limestone overlain by a discontinuous residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels. Route generally avoids the wetter areas. Anticipate seepage in areas with shorter trees. No obvious signs of patterned ground or thermokarst in this section. Between KP109.5 to KP110, route skirts upslope toes of knolls and stays above gullied terrain. From ~KP110 to KP110.8, route skirts around lower edge of bowl-shaped area (possible old slope failure scar, KP110 to KP110.2, but may be bedrock-controlled, re ridge just north and knoll south), and then on upslope side of knoll, and upslope of drainage gullies at ~KP110.6 and KP110.8. Between KP110.8 and KP112, alignment avoids wet area and climbs on/off north end of large knoll, crossing upslope swale at ~KP111.8. From KP112 to KP114, the route skirts around the upslope toes of knolls and stays just upslope of gullied terrain. Good control of drainage required. Between ~KP114 and KP114.5, the route traverses along the crest of a small ridge and then descends to a stream crossing. Suspect near-surface bedrock on this ridge as its orientation is subparallel with exposed crest of knoll at KP113. Consider slight reroute just west of ridgetop to increase distance from apparent slough on downslope side. Air photos A28099 - 38-41.	 Terrain above KP111, some gullying and seepage areas Looking southeast across stream crossings at about KP114.5 (Photo credit: Allnorth).

Table C-1: Summary of Mapping and Field Observations

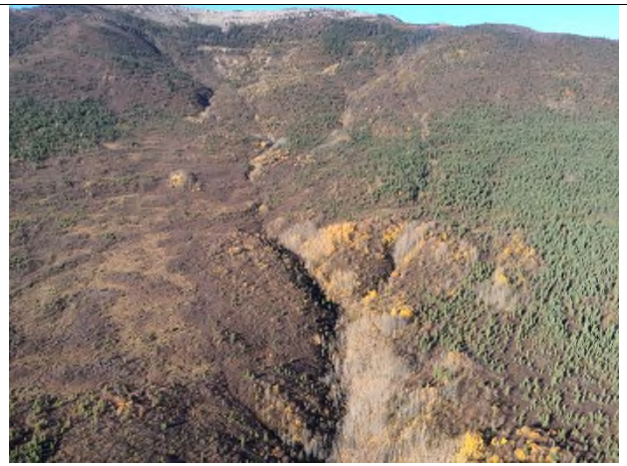
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
115.0	116.0	Sh, L GC-GP	Between KP115 and KP116, route descends from just above the large knolls (mapped as shale and limestone) down to glaciofluvial plain, crossing a swale with probable multiple small streams in it at ~KP115.5. Soils encountered during terrain typing upslope of KP116 were identified as silty sandy clay with trace gravel in debris flow gully upslope deposition areas in tributary gullies above main gully. Both upslope routes rejected in this section – in flatter tributary crossing and in steeper downslope section. Apparent bedrock exposed in scoured gully section further downslope. No stereo air photo coverage.	 Looking upslope at gullied terrain above KP116. Looking downslope at scoured gully section above borrow BP116 and KP116 beyond (Photo credit: Allnorth).

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
116.0	117.5	(gGph-Cx)/ (Sh,L)	Route within glaciofluvial plain, skirting lower edge of Silent Hills. At ~KP116 (old KP115), now crossing downslope of apparent large debris flow gully with major scour on north gully slope upstream of crossing, visible on 2007 Google Earth, more prominent on 2012 imagery. No obvious patterned ground or thermokarst along this section, although there is a small round pond just SW of KP117. This pond could also just be a kettle. Other nearby ponds to the E seem to be associated with meltwater channels. GSC maps a small bedrock outcrop just E of the alignment at ~KP117.1, visible on bing coverage. Road east of LiDAR coverage.	From knoll west of KP117 at small round pond, looking east to Grainger Gap. (Photo credit: Allnorth)
117.5	118.5	g,s,Gpr/Cx	Route crossing glaciofluvial plain between the slopes of the Silent Hills west and large meltwater channel east. Ascent/descent on west approach to meltwater channel is ~KP117.9 to 118.5 alongside stream south of road. No air photo coverage. No obvious patterned ground or thermokarst in this section, although there is a small opening at KP118 which could be a low wet area, and a small pond just N of KP118.2.	From KP118, terrain upslope of route to KP117 (upslope of knoll RHS). (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

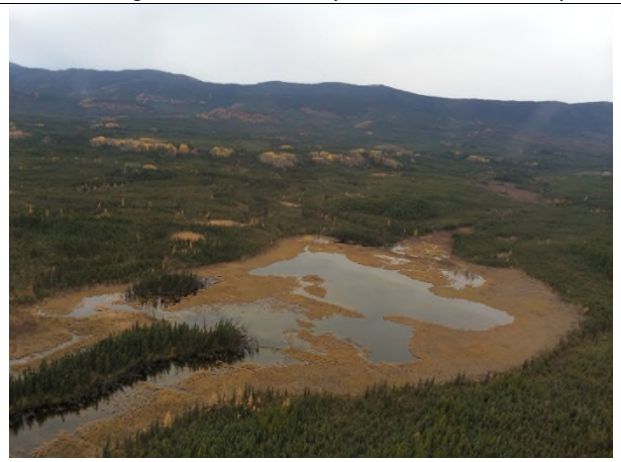
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
118.5	119.2	g,s,Gp	Crossing of large meltwater channel. Ascent/descent approaches into channel on east approach is estimated from ~KP118.9 to KP119.2 based on NTS 1:50,000 scale map and bing coverage. Off LiDAR. No air photo coverage. No obvious patterned ground or thermokarst in this section.	East of route, looking west towards meltwater channel crossing at about KP119. (Photo credit: Allnorth)
119.2	121.2	Cx2/(Sh,L)	Proposed road is just within Cx2/ (Sh,L) traversing the lower slopes of a knoll north of the route, and just north of a large meltwater channel. No air photo coverage. No obvious signs of patterned ground or thermokarst on this section of route, although there are some possible thermokarst features in the meltwater channel to the south. Inconclusive: off orthophotos W of ~KP120.3, bing coverage only.	 Looking west at pond south of KP121 in headwaters of Grainger River. Road just upslope of meltwater channel.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
121.2	121.5	g,s,Gpr/Cx	All-season route traverses wide glaciofluvial plain. No airphoto coverage. Route crosses old N-S cutline at ~KP121.4. No obvious signs of patterned ground or thermokarst on this section of route.	Looking southwest along route from KP121.6, route stays north (right) of large pond centre at KP121. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
121.5	122.9	g,s,Gpr/Cx	All-season route traverses wide glaciofluvial plain and skirts below toe of large gAf feature to SE. Significant ridged features are not obvious, but route crosses on relatively high ground compared to terrain NW and SE, avoiding bogs. One stream crossing at about KP122.4, which appears to originate from boggy area upslope and above that is the large alluvial fan. About 60 m S of road, S of HP123, stream (or opening) becomes wider for about 200 m: possible thermokarst? There is also a cross-slope drainage feature between fan and bog that looks like a possible small meltwater channel. Small pond in it, feature appears to drain to same stream crossing. Bog area is identified as peatland (potentially ice-rich permafrost) between KP122 and KP123 (SE of the proposed alignment). The current alignment avoids this sensitive organic terrain. Narrow opening is noted just north of alignment at about KP122.5, about 50 m long. Contours suggest local low area (pond? thermokarst?) that drains to stream just west at KP122.4, can be checked during layout and detailed design. Otherwise, no obvious patterned ground or thermokarst in this section. See Figure 13. Air photos A28099 - 35-36.	Peatland southwest of tree patch. (Photo credit: Allnorth) Winter road on right side north of ~KP122.7. Note beaver dams and fan edge in both photos. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
122.9	123.3	Cx	There is a lake to the west, whose outlet drains east into Grainger River. Outlet stream has three beaver dams south of the fan and north of the all-season route, from about KP122.85 to KP123.3. All-season road will not be affected by the beaver dams as it will be well upslope to the south. Currently-proposed stream crossing is downstream of the eastmost beaver dam. Site visit September 22, 2014. Water at KP123.3 flows east, beaver dam is ~50 m upstream west of proposed crossing of stream adjacent to large rock bluff. Proposed full bench cut in rock. Thickly treed with small trees, most <5 cm, generally < 10-15 cm in diameter. Top of bluff forms ridge with swale on south side draining west. East end of bluff ends in vertical drop to stream level. Streambed formed of cobbles, floodplain is silt, sand, gravel and is overgrown with willow where vegetated. Winter route meets/separates from the all-season route at about KP122.5 at the west end. All-season route crosses apparent Cx terrain from upslope south between about KP122.9 and KP123.2. Looks like old failures, probably post-glacial. From about KP123.2 to KP123.3 may also be Cx but there appears to be shallow bedrock control at this edge of feature. No obvious patterned ground or thermokarst in this section. See Figure 13. Air photos A28099 - 35-36.	Looking southeast from KP123.3. Road upslope of beaver ponds. Colluvial terrain on bedrock. (Photo credit: Allnorth) Looking west from KP123.4 at proposed stream crossing.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
122.7	123.3	gAf	Water flows east and west off this fan. The fan is split with a rocky knoll, so that water can flow on northeast side to the east (older alluvial fan deposit), and on west side to the south (newer alluvial fan deposit), then east. Temporary winter route (1 km long) will be on newer fan deposit, all-season route will cross to south side of stream just east of east edge of newer fan deposit. Winter route is a little shorter than the all-season route, as it goes direct across the alluvial fan. No obvious signs of distress on newest-looking (southerly) winter route on south side of outlet stream, but it is not clear why there were so many iterations of winter road to climb the south bank. Shoreline of lake appears sharp-edged and steep, so it may be that changes in beaver activity radically changes the water level, thus changing the most suitable access point. No obvious thaw along shoreline. Also note that stream from KP122.4 runs down to old crossing, whereas newer winter road crosses it higher on the bank, and this higher area probably freezes up sooner. Winter route meets/separates from the all-season route at about KP122.5 at the west end. See Figure 13. Air photos A28099 - 35-36.	Looking northeast along west branch of alluvial fan, north of stream at about KP123.3. Winter route crosses fan.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
123.3	124.7	gAf - gAp	Water flows east along this braided channel. Includes old alluvial fan deposit from the north described above between ~KP123.3 and KP124.0. Note that the older (east) fan deposit conceivably could become active again. Large rock bluff on east side of Grainger Gap, and water flows against it. A tributary stream between two parallel ridges on the north joins the main stream. See Figure 13. Air photos A28099 - 35-36.	Looking west along winter road from about KP124. Note low bluff right dividing the fans. (Photo credit: Allnorth)
124.7	124.8	gAp	Considerable braiding around the bend at Grainger Gap. GSC maps the entire pass as a large meltwater channel. Bridge crossing proposed at east end of Grainger Gap, crossing river from north to south, just southwest of existing winter road crossing. TP-15 in debris slide visible at toe of treed slope, above alluvial plain. New crossing reduces distance in stream area. Any record of river icing during previous winter operations? Could be useful for design of bridge and approaches. Air photos A28099 - 34-36.	Looking south at KP124.8 area: bridge crossing and TP-15. Steep slope/alluvial fan avoided. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
124.8	125.6	gAp	Braided stream continues alongside north side of winter road. All-season road turns south at KP124.8 (~60.4 km on Mollard's stations), criss-crossing winter road to about KP126.4. Intent of all-season road is to stay above the low wet ground along the Grainger River, plus obtain more direct route to Nahanni Butte access. Post-field work, the all-season route is proposed to closely follow toe of slope along outside edge of floodplain at north end of this section, but then move out towards winter road to avoid ravelling from upslope, especially between about KP125.2 and KP125.6. Potential also for larger rocks tumbling or toppling from bedrock exposed above scree/talus slope. Upslope areas will be considered for borrow. See Figures 13 and 14. Air photos A28099 - 34-35.	Looking east-southeast, route avoids beaded streams and steep toe along edge of fan. (Photo credit: Allnorth)
125.6	126.0	gAp	Post-fieldwork route crossed the toe of an alluvial fan (gAf) between ~KP125.6 and KP126. Still on approx 500 m contour. Potential for debris deposition along or over road, and/or plugging of culverts. Stream location(s) not necessarily predictable. Apex too high to be practical for routing, and too deep/steep in any case. Keeping route at or just beyond toe might reduce frequency of events potentially affecting road, but might require steeper grades heading south. After further consideration, route remains near winter road on Grainger River floodplain, between beaded streams and Grainger River to avoid thermokarst and upslope hazards. See Figures 13 and 14. Air photos A28099 - 34-35.	Looking north from about KP126.4 at Grainger floodplain.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
126.0	126.6	gAp	Post-field route was in D, L GP-GC, above floodplain (gAp) to KP126.8. After further consideration, route now remains close to winter route on floodplain (gAp) in this section to ~KP126.6. GSC maps bedrock as dolomite and limestone, with discontinuous residual or colluvial veneer of clayey gravels, gravel-sand-silt mixtures, and poorly-graded gravels. Near-surface soils encountered during terrain typing upslope include sands in ridges (TP-25), silty sand clays or clayey sandy silts with some gravel in lower-lying areas, increasing gravel with depth; till-like (BH-15, BH-16). Slope gradients are mapped at generally 26 to 70%, in places >70%, with local relief 150-450 m. Route descends at 2% from 490 to 480 m elevation, climbing again after creek crossing at the end of this section. Except for beaded streams above road, no obvious patterned ground or thermokarst in this section. See Figure 14. Air photos A28099 - 34-35.	Looking east from BH-16 towards TP-25 at helicopter site. Now upslope of KP127. Consistent with terrain further north on slope above floodplain.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
126.4 (upslope of route)	126.6 (upslope of route)	rSx	Intermediate reroute was proposed upslope of winter road and not crossing the rock glacier. Post-fieldwork, part of the rock glacier is proposed by Allnorth as a borrow source, and the road will be about 380 m downslope of the toe of the feature, and about 550 m below TP-17 area. Feature is about 200 m wide and 700 m long. There are some mounds of very coarse-grained materials (TP-17 area), but also some areas with matrix textures resembling fine crushed gravel (TP-16). Further study is proposed by Allnorth to further assess source. Air photos A28099 - 34-35.	Looking upslope at rock glacier (Photo credit: Allnorth) Looking downslope at rock glacier towards road and Grainger River below, note wide variation in materials.

Table C-1: Summary of Mapping and Field Observations

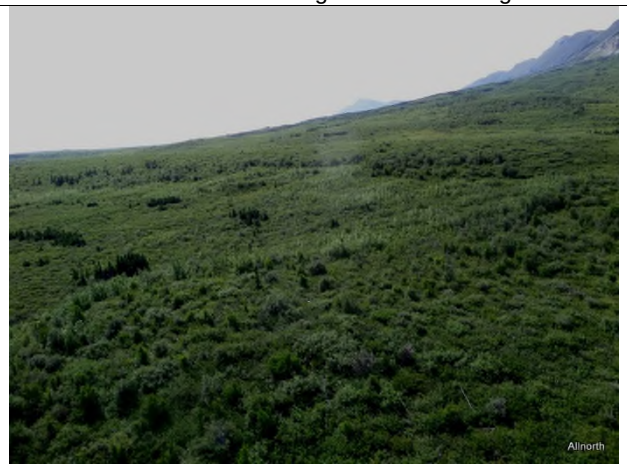
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
126.6	127.3	tMsd	Upper route skirts along transition between D,L GP-GC upslope and tMsd downslope. Crossing a series of mounds and ridges with swales or gullies between, low enough on slope that most of the gully sections are not too steep. One ridge at ~KP127.0 to KP127.1 looks sharp-edged enough upslope of road that it could be exposed rock. Linear feature about 200 m horizontal upslope between ~KP126 and KP127; possible harder bedrock layer? No obvious patterned ground or thermokarst in this section. Careful drainage across the road will be important throughout. Reroute just above winter route is in tMsd, rejoins upper route at ~KP127.3. Route climbs diagonally up 8% or gentler sideslopes in this section. See Figure 14.	Looking downslope from rock glacier. Stream at KP126.6 and winter road visible along near side Grainger River.
127.3	128.3	tMsd	Route skirts along the downslope side of a long ridge, just below transition between D,L GP-GC upslope and tMsd downslope, then traverses across swale on upslope side. Small pond along upslope toe of ridge at about KP127.8. No obvious thermokarst or patterned ground. Most of ridge on air photos A28099 - 10-11; NW end of ridge on A28099 - 34-35.	 From KP127.3 looking southeast along route at ridge. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
128.3	129.0	D, L GP-GC	Route skirts above transition to tMsd downslope, and just downslope of L-shaped ridge KP128.8 to KP129.0. This ridge has a prominent low wet area just upslope. Origin of ridge unclear, but light coloured and blocky enough it could be exposed rock. Proposed as borrow by Allnorth. Route in this section generally on locally higher ground, crossing lower wet areas as needed. Air photos A28099 - 10-11.	Looking downslope at L-shaped ridge KP128.8 to KP130. (Photo credit: Allnorth)
129.0	129.8	D,L GP-GC and/or T,gMmhr	Route skirts along transition between D,L GP-GC upslope and t,gMmhr downslope, also staying just upslope of the more prominent drainage paths. There appears to be a headscarp just below/at road, between KP129.6 and KP129.8. A little more finetuning of road location is necessary here, but should be workable - overall gradients are similar to adjacent terrain. Consider if better to delay the climb and cut across slide path, or start the climb a little further north to attain slightly gentler terrain upslope of scarps. Both have risks: material in slide path (if sloughed material remains) could be softer and less suitable for foundation of road, or future sloughing could result in material piling on uphill side of road or plugging culverts; but building road higher up might mean that continued failures	From KP129 looking southwest along route to about KP129.6. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
			could retrogress into road grade. Allnorth has rerouted about 100 m downslope to avoid feature. Air photos A28099 - 10-11.	
129.8	130.5	gAf upslope, t,gMmhr downslope	Route stays essentially on contour, skirting around the toe of a large fan mapped by GSC. Boundary on S side indistinct; it may on occasion run into the north edge of the next fan to the south, at about KP130.9, where a bowl also begins below the fan and concentrates the surface water drainage further downslope. Again, there is a headscarp just below/at road, between KP129.8 and KP130. This feature appears to have a fairly steep dropoff below the road and edge of alluvial fan, which is not visible on the 2012 imagery due to a shadow, nor on Google Earth due to clouds. Allnorth has rerouted about 100 m downslope to avoid feature. Air photos A28099 - 10-11.	From 300 m west of KP130, looking northeast across series of gullies and fans. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
130.5	133.0	t,gMmhr	All-season route is upslope of the drumlinoid ridges, and skirts around the toes of alluvial fans from upslope. Route climbs diagonally from KP130.7 over a knoll between drainage paths at KP130.5 and KP130.9, and then diagonally up through bowl, traversing across the downslope end of a small ridge between ~KP131.2 and KP131.3. No obvious patterned ground or thermokarst in this section. Air photos A28099 - 10-11. Stereo coverage goes only to about KP131.4. Mollard (1984) maps some low flat-topped ridges between about KP131 and KP134.5 that may be till and/or granular materials.	Looking southwest towards stream at KP131.2; small ridge just south. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

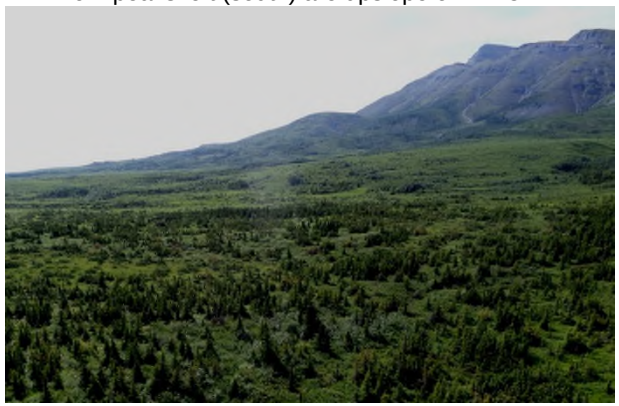
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
133.0	137.2	t,gMmhr	Road upslope of the drumlinized ground terrain, and within the subdued rolling to hummocky terrain. Some of the meltwater channels mapped by GSC in the drumlinized terrain downslope are also seen along the road route, e.g. small present-day stream in apparent wide old channels at KP133.1, KP133.2, KP134.9, KP136.1, KP136.5, KP137.2 (the latter noted on the ground by Allnorth). Possible exposed soil along stream about 550 m upstream of KP136.5 indicates potential for debris flows. However, slope gradients are <7% above road to suspect area, and stream channel otherwise looks well-vegetated so such events may be relatively rare. Exposed ground (soil or rock) along upstream reaches of channel above KP137.2 is probably more indicative of near-surface bedrock there, but could result in debris flows. Gradient of ~10% for 200 m above road. Debris flows at KP136.5 and KP137.2 can affect road by either scouring or deposition, depending on mobility of material. Aerial coverage indicates old slope movements ended below road (Google Earth 2007). Debris flow channels may also shift from current locations. Mollard (1984) maps some low flat-topped ridges between about KP131 and KP134.5 that may be till and/or granular materials, and a series of possible eroded slumped glaciofluvial ice contact deposits (kame terraces) from deglaciation, mainly upslope of the road, from about KP134.5 to KP141.	Looking west from just above lower route. Prominent gullies from peaks left (south) are upslope of KP137.2.  Looking south at ridge and mound above KP137.2 to KP139.5. (Photo credits: Allnorth)

Table C-1: Summary of Mapping and Field Observations

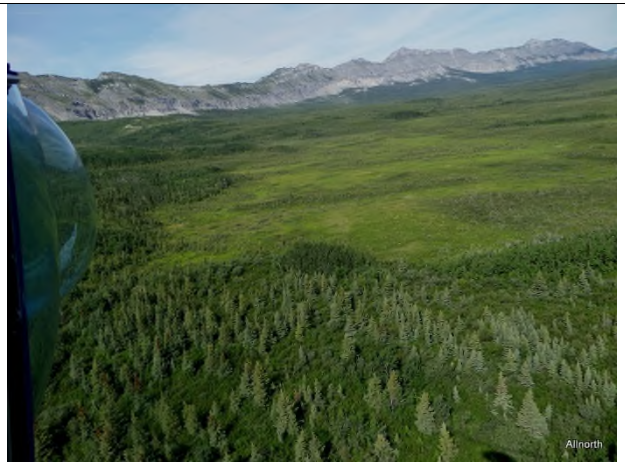
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
137.2	138.0	D,L GP-GC; rSx2	Road skirts along/over toe of possible rubble in talus lobe at 137.2 - 138 - This appears to be the feature mapped rSx2 on GSC Map 10-1979, and elevation on LiDAR and on GSC mapping checks out also (610 m). GSC maps D,L GP-GC well upslope of road along top of ridge - bedrock peaks. Debris flow lobe or part of rSx2 at ~KP138.1? Could also be part of melted-out ice-contact deposit. Mollard (1984) maps a series of possible eroded slumped glaciofluvial ice contact deposits (kame terraces) from deglaciation, mainly upslope of the road, from about KP134.5 to KP141. There is a series of four circular features in a row over a distance of about 200 m located about 500 m downslope of KP136.7, readily visible on 2012 imagery, barely visible on Google Earth 2007. Not found in the field due to weather, so not further investigated. Not expected to affect road.	 From southeast of KP138, looking west-northwest along route, along toe of deposits upslope west (left). (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
138.0	140.0	t,gMmhr	Terrain more subdued now, fewer elongated features and more subdued hummocks and gently rolling, compared to terrain further south on route. Gravel anticipated. No obvious patterned ground or thermokarst. Mollard (1984) maps a series of possible eroded slumped glaciofluvial ice contact deposits (kame terraces) from deglaciation, mainly upslope of the road, from about KP134.5 to KP141. There is a small pond in the debris about 360 m upslope of the road at about KP138.5.	Looking upslope from lower route towards KP138 along north side of strip of trees. Where trees extend cross-slope mid-photo right is just below route location north. Route gradually descends south. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
140.0	144.5	tMpd	Moraine plain with drumlins to outlet of Triangle Lake. Road route follows east side of small meltwater channel between south end outlet of small lake north of Triangle Lake at KP142.3 and north end of Triangle Lake at KP143.4. Smaller meltwater channel with pond upslope of road joins channel at south end of small lake. Possible thermokarst at and near lake outlet about KP141.9 to KP142.3 in beaded channels parallel to lake shore and at outlet, about 80 to 160 m east of road. This may also be merely wetlands filling in shallow lake area. Beaver dam ~260 m west of road at about KP143.5 along pond within meltwater channel. Drumlinoid ridge mapped subparallel and visible on Google Earth SE of small lake between KP142 and KP143, east of road.	From west of upper route at KP142.7, looking northeast at meltwater channel and lake north of Triangle Lake. Current proposed route is downslope east of meltwater channel, then upslope west of lake.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
144.5	146.8	tMps	Moraine plain with flutings from outlet of Triangle Lake to stream from wetland between road and Bluefish Lake to the west.	Looking west-southwest at Triangle Lake. Outlet at about KP144.7 is in silty sandy clay.
146.8	150.0	tMp	About 275-700 m downstream of route at KP146.9 stream crossing, there is a series of small ponds that appear to be created by beaver dams. Looks similar on 2007 Google Earth as on 2012 imagery, although two smaller features immediately downstream of the 400 m feature look larger in 2012. Faint trail visible on Google Earth between 0.3 and 1.3 km above the road between ~KP147 and KP149.	From downslope of KP146.7, looking southeast at ponds downstream of KP146.9 road crossing. (Photo credit: Allnorth).

Table C-1: Summary of Mapping and Field Observations

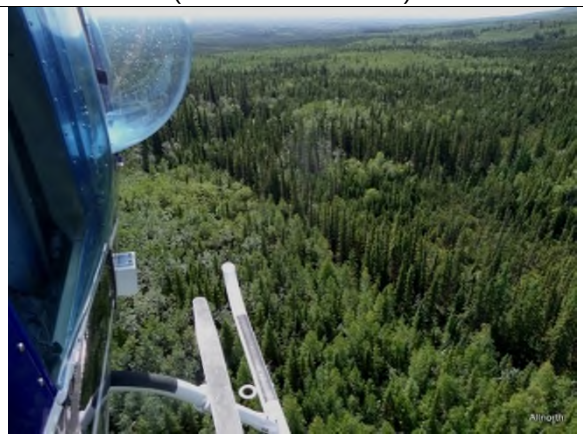
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
150.0	151.0	tMv-Cx and/or tMp	Route ascends from the south out of escarpment area, GSC mapping transition still uncertain.	Looking south from KP150.6 to KP151. (Photo credit: Allnorth)
151.6	-	gAf	Road alignment has been rerouted higher on slope and crosses at the apex of the fan. Fan is proposed as borrow. See description below.	 Downslope of KP151.3, looking south-southwest at proposed borrow area. (Photo credit: Allnorth)
152.6	-	gAf	Fan below road route.	

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
151.0	154.0	tMv-Cx and/or tMp	Route runs approximately parallel to, and 300-400 m downslope of mapped linear escarpment. Transition between tMv-Cx upslope and tMp downslope is not certain here according to GSC. Linear escarpment is clearly visible on Google Earth 2007 imagery. Proposed road now crosses near apexes of alluvial fans at KP151.6 and KP152.6. KP151.6 area is proposed as borrow. Presence of fans indicates likelihood of future debris flows. Crossing at apex is good for limiting length of road subjected to impact by debris but does include possibility of road being scoured out at these crossings.	Looking upslope from below route at KP152.1. Large gullies right and centre along peaks lead to KP151.6 and KP152.6. (Photo credit: Allnorth)
153.6 (old 154)	159.0 (old 159.4)	tMv-Cx	Route climbs in the moraine veneer - colluvial complex, upslope of previously-proposed route. Hazard continues from debris slides/debris flows from upslope, including a suspected old alluvial fan is present below about KP155, with two gullies crossed near the apex at this location, and a possible old slope failure from about KP155.2 to KP155.7 where the road route crosses below and then above the suspected headscarp (Figure 15); a section with a fairly recent crossing of the road alignment at KP158.9 to KP159.0 (previous route downslope skirted just below debris toe); and just at/upslope of the road for 50 m at about KP159.1 (Figure 16).	Terrain units at HP154, downslope of KP155.

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
159.0 (old 159.4)	159.1 (old 159.5)	tMv-Cx	Route climbs steeper now, in the moraine veneer - colluvial complex sooner. KP159.0 is at northeastmost prong of forked feature noted below, which ends about 24 m above road alignment according to 2007 Google Earth coverage. Looks about the same on 2012 imagery, at about 27 m distance. Terrain in deposition zone above was potential proposed borrow, not currently designated. Testpits TP-19, TP-20, and TP-21 upslope show variable material; see also next section. Toe of prong is presumably deposition area, but future flows could overrun road or plug culverts, resulting in maintenance and/or safety issues. See Figure 16.	Looking upslope from route about KP159.0 at debris flow at northeast prong. (Photo credit: Allnorth)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
159.1 (old 159.5)	159.4 (old 159.8)	s, siAp	Rotational slide / debris flow above road alignment at Liard River off Nahanni Butte from SE peak, flowing down in three-pronged fork almost to road alignment or alongside it (OF3915). Middle fork has stream mapped in it on LiDAR. Repeated slide / debris flow events have potential to reach road and/or Liard River. 2012 imagery suggests recent events within 50 m of river, and less recent event (revegetated) reaching the river. The route skirts the left (NE) flank of the debris toe for about 150 m climbing out of the valley bottom. Hazard to traffic and road grade. Road likely to be a deposition area or it may be subject to scour from debris flows. Debris slide deposits proposed as borrow; field work inconclusive, as deeper testholes are needed to assess quality and feasibility. Only shallow testpits so far in apparent deposition area upslope of road. See Figure 16.	Terrain upslope of road in debris flow deposition area. Stream southwest of TP-21 at edge of debris flow prong.

Table C-1: Summary of Mapping and Field Observations

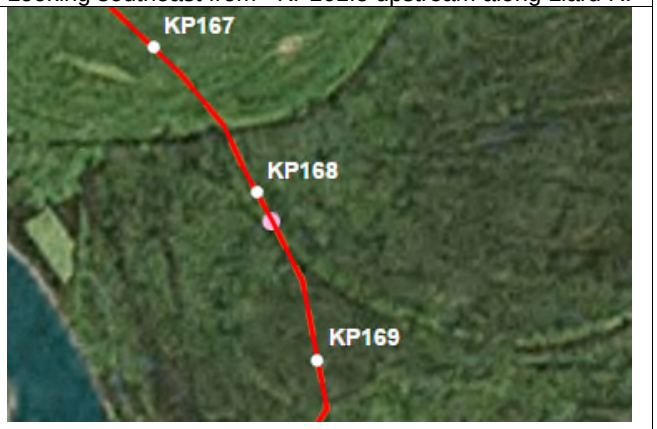
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
159.4	160.0	-	Liard River crossing (ferrry or ice road). Note 400 m offset from previous road stations (was KP159.8 to KP160.4).	
160.0 (old 160.4)	167.6 (old 168.0)	si,sApc-fO	Old Nahanni Logging Road parallels the east/south side of the Liard River south of proposed crossing of Liard River. Prominent scrolling on Liard River floodplain, easily visible in autumn by prominent vegetation colour differences. The proposed road follows sections of the Old Nahanni Logging Road, but goes further inland for part of the route, and straightens part of the route.	Looking southeast from ~KP161.5 upstream along Liard R.
167.6 (old 168.0)	169.2 (old 169.6)	si,sApc	Old Nahanni Logging Road parallels the east/south side of the Liard River south of proposed crossing of Liard River. Prominent scrolling on Liard River floodplain continues. Occasional areas of fenland in narrow scrolled strips.	 Scrolling on Liard River floodplain (Bing coverage).

Table C-1: Summary of Mapping and Field Observations

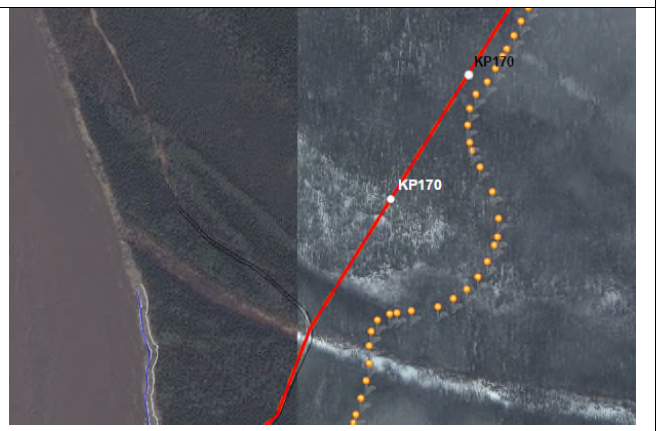
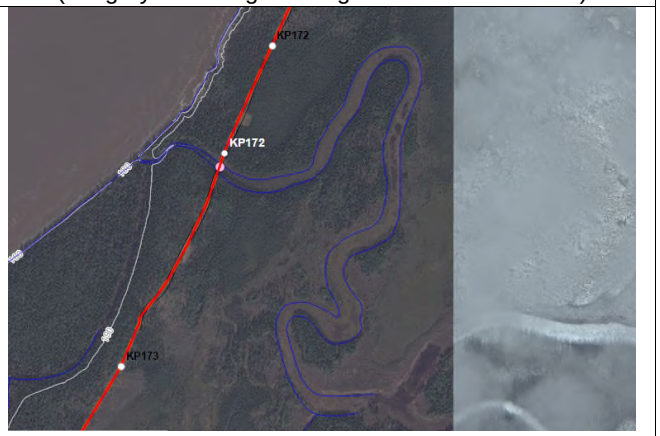
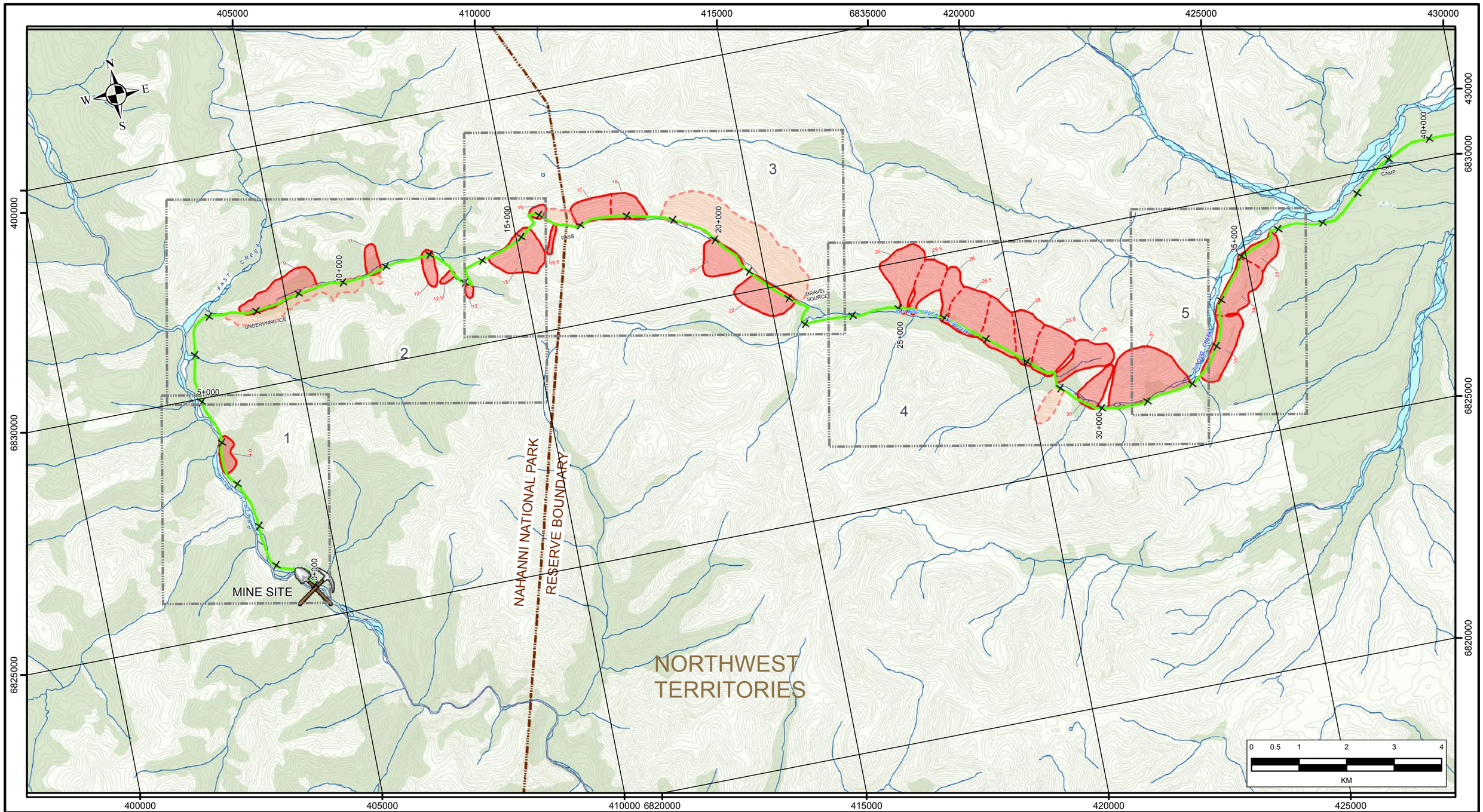
Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
169.2 (old 169.6)	170.3 (old 170.7)	-	Old Nahanni Logging Road parallels the east/south side of the Liard River south of proposed crossing of Liard River. Prominent scrolling on Liard River floodplain continues. Road crosses fenland along north side of Bay Creek. (Off south edge of GSC Map 10-1979; can see continuation of terrain types on bing coverage.)	 Fenland and scrolling (new stations = white markers). (Imagery from bing coverage on Allnorth website.)
170.3 (old 170.7)	174.1 (old 174.5)	-	Old Nahanni Logging Road parallels the east/south side of the Liard River south of proposed crossing of Liard River. Prominent scrolling on Liard River floodplain continues, here modified by Bay Creek drainage - meandering stream with numerous oxbows.	 Bay Creek drainage and Liard River. (Imagery from bing coverage on Allnorth website.)

Table C-1: Summary of Mapping and Field Observations

Start of Interval (km)	End of Interval (km)	Terrain Unit (Hawes, 1975)	Route Description	Photos
174.1 (old 174.5)	177.8 (old 178.2)	-	Existing Nahanni Butte access road from intersection of old Nahanni Logging Road to Liard Hwy. Still within Bay Creek drainage area.	-
177.8 (old 178.2)	184.17 (old 184.5)	-	Along existing access road to Nahanni Butte to Liard Hwy. Crossing fens and bogs.	-

APPENDIX D

AVALANCHE MAPPING (DONE BY OTHERS)



LEGEND

- AVALANCHE PATH
- POTENTIAL AVALANCHE PATH
- PROPOSED ACCESS ROAD
- 100 FOOT CONTOUR
- STREAM

NOTES:

1) DATUM: NAD 1983 ZONE 10U
PROJECTION: UNIVERSAL TRANSVERSE MERCATOR

2) THIS MAP SHOULD ONLY BE READ WITH THE ACCOMPANYING REPORT.

3) ACCESS ROAD LAYOUT DIGITIZED FROM: SNC LAVALIN DRAWING "PRAIRIE CREEK MINE PROPOSED ACCESS ROAD PLAN AND PROFILE" REV. PC - OCT 12, 2006.

4) SMALL AVALANCHE PATHS (SIZE ≤ 2) EXIST OUTSIDE OF THE AREAS DELINEATED BUT THOSE ARE TOO SMALL TO BE MAPPED AT THIS SCALE.

5) BASE MAPPING SOURCE: HTTP://ARCGISONLINE.COM

6) ONLY AVALANCHE PATHS WHICH ARE ESTIMATED TO AFFECT THE ACCESS ROAD AREA SHOWN. BOUNDARIES OF AVALANCHE PATHS OR AREAS REPRESENT A TRANSITION FROM HAZARD TO NO HAZARD. ANY FACILITIES PROPOSED ADJACENT TO MAPPED BOUNDARY LINES SHOULD BE EXAMINED WITH RESPECT TO AVALANCHE HAZARDS.

7) THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN TOPOGRAPHY THROUGH FILL PLACEMENT, CUTSLOPES, GLACIAL RETREAT OR ADVANCE LANDSLIDING, AS WELL AS TREE REMOVAL MAY REQUIRE REDRAWING OF AVALANCHE ZONES IN THOSE AREAS.

8) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE

SCALE:	1:75000
DATE:	MAY 18, 2012
DESIGNED:	BG
DRAWN:	JN
CHECKED:	
APPROVED:	

PROFESSIONAL SEAL:

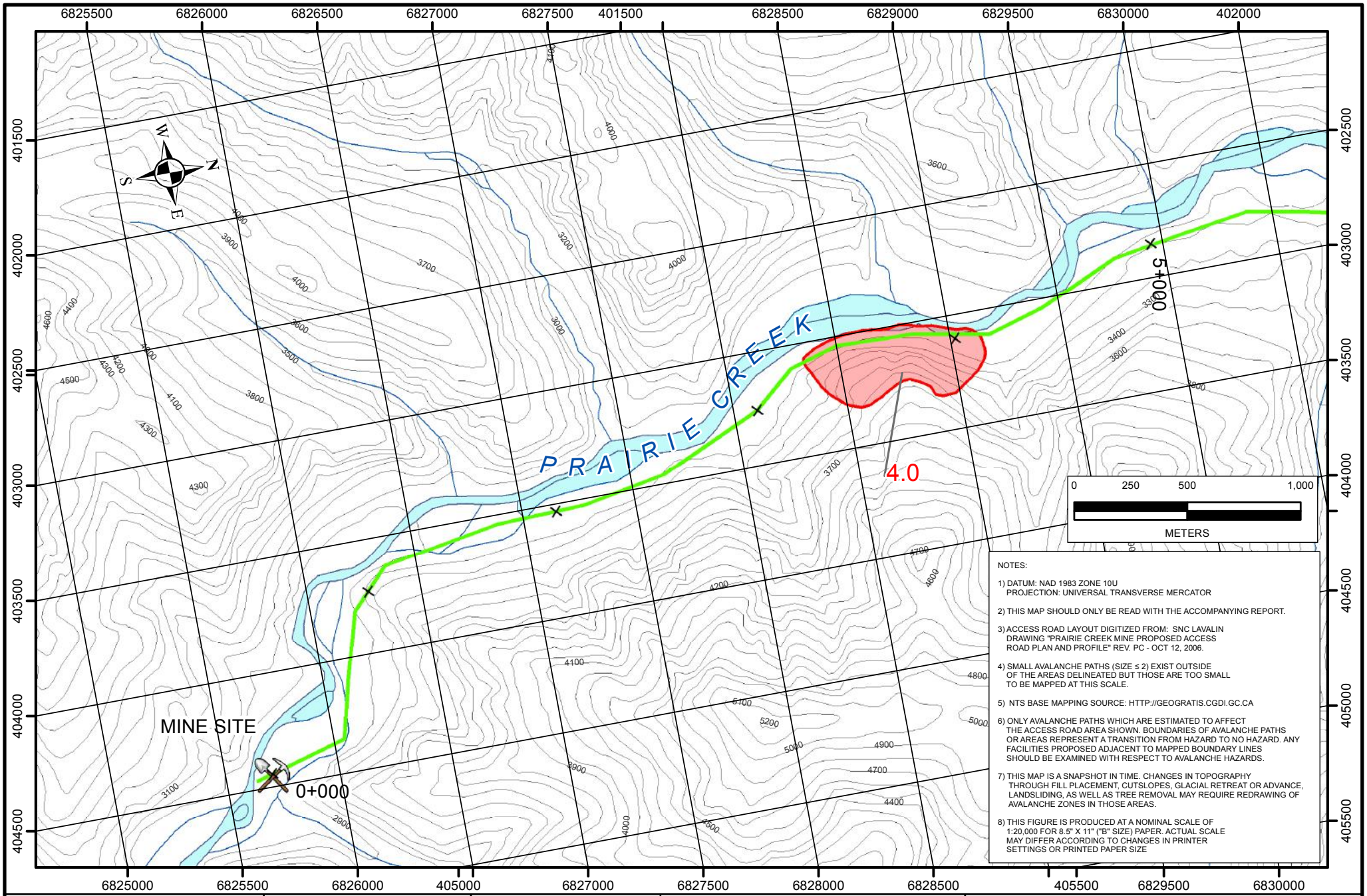
CLIENT: CANADIAN ZINC CORPORATION

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: PRAIRIE CREEK MINE WINTER ACCESS ROAD

TITLE: AVALANCHE HAZARD INDEX MAP

PROJECT NO:	DWG NO:	REV:
	1	A



NOTES:

1) DATUM: NAD 1983 ZONE 10U
PROJECTION: UNIVERSAL TRANSVERSE MERCATOR

2) THIS MAP SHOULD ONLY BE READ WITH THE ACCOMPANYING REPORT.

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LEGEND

- AVALANCHE PATH
- POTENTIAL AVALANCHE PATH
- PROPOSED ACCESS ROAD
- 100 FOOT CONTOUR
- STREAM

SCALE: 1:20,000
DATE: MAY 21, 2012
DESIGNED: BG
DRAWN: JN
CHECKED:
APPROVED:

PROFESSIONAL SEAL:

CLIENT: CANADIAN ZINC CORPORATION

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

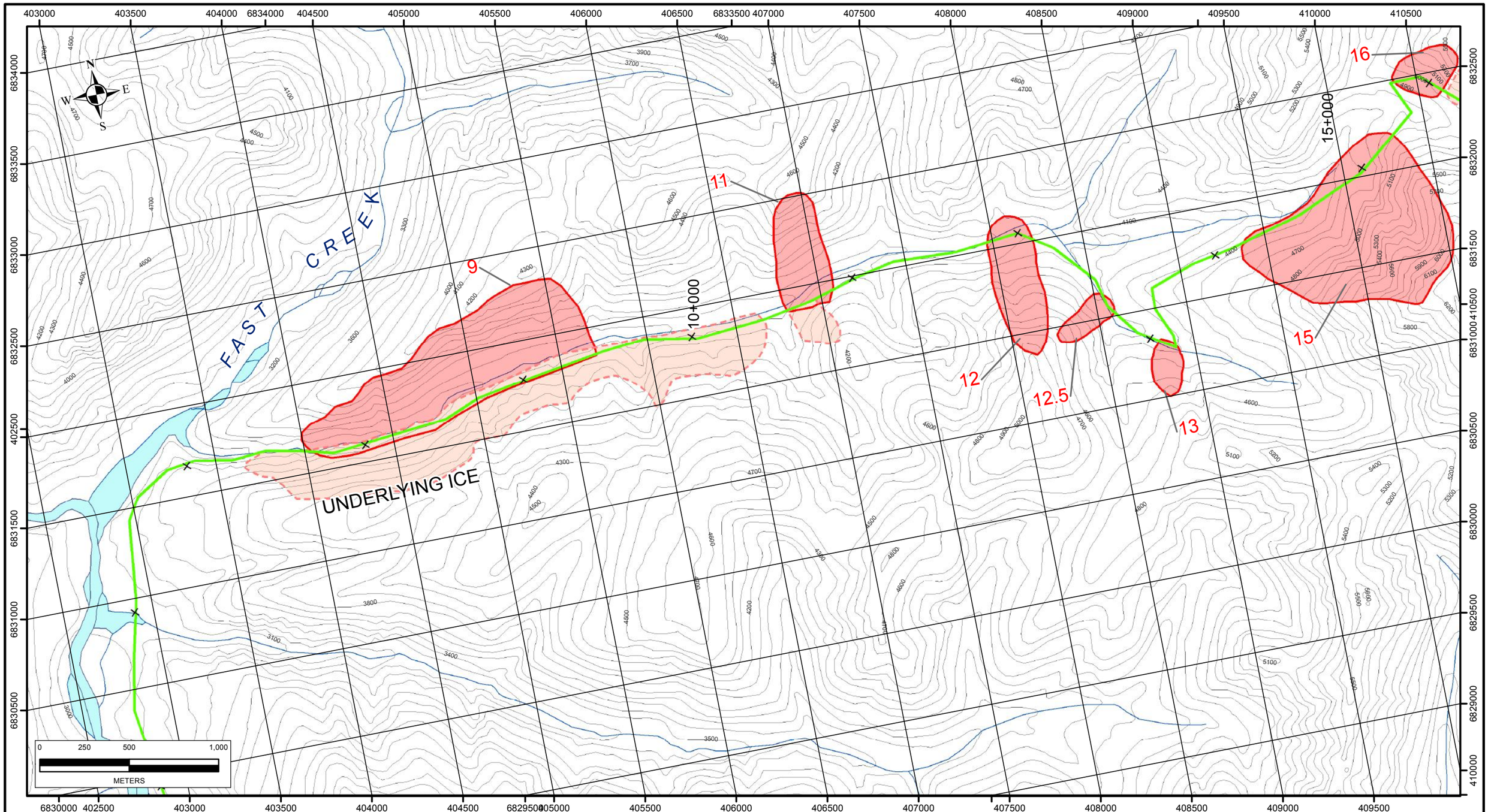
PROJECT: PRAIRIE CREEK MINE WINTER ACCESS ROAD

TITLE: AVALANCHE HAZARD MAP

PROJECT NO:

DWG NO: 2

REV: A



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- AVALANCHE PATH
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- PROPOSED ACCESS ROAD
- 100 FOOT CONTOUR
- STREAM

NOTES:

1) DATUM: NAD 1983 ZONE 10U
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PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: PRAIRIE CREEK MINE WINTER ACCESS ROAD

TITLE: AVALANCHE HAZARD MAP

PROJECT NO:	DWG NO:	REV:
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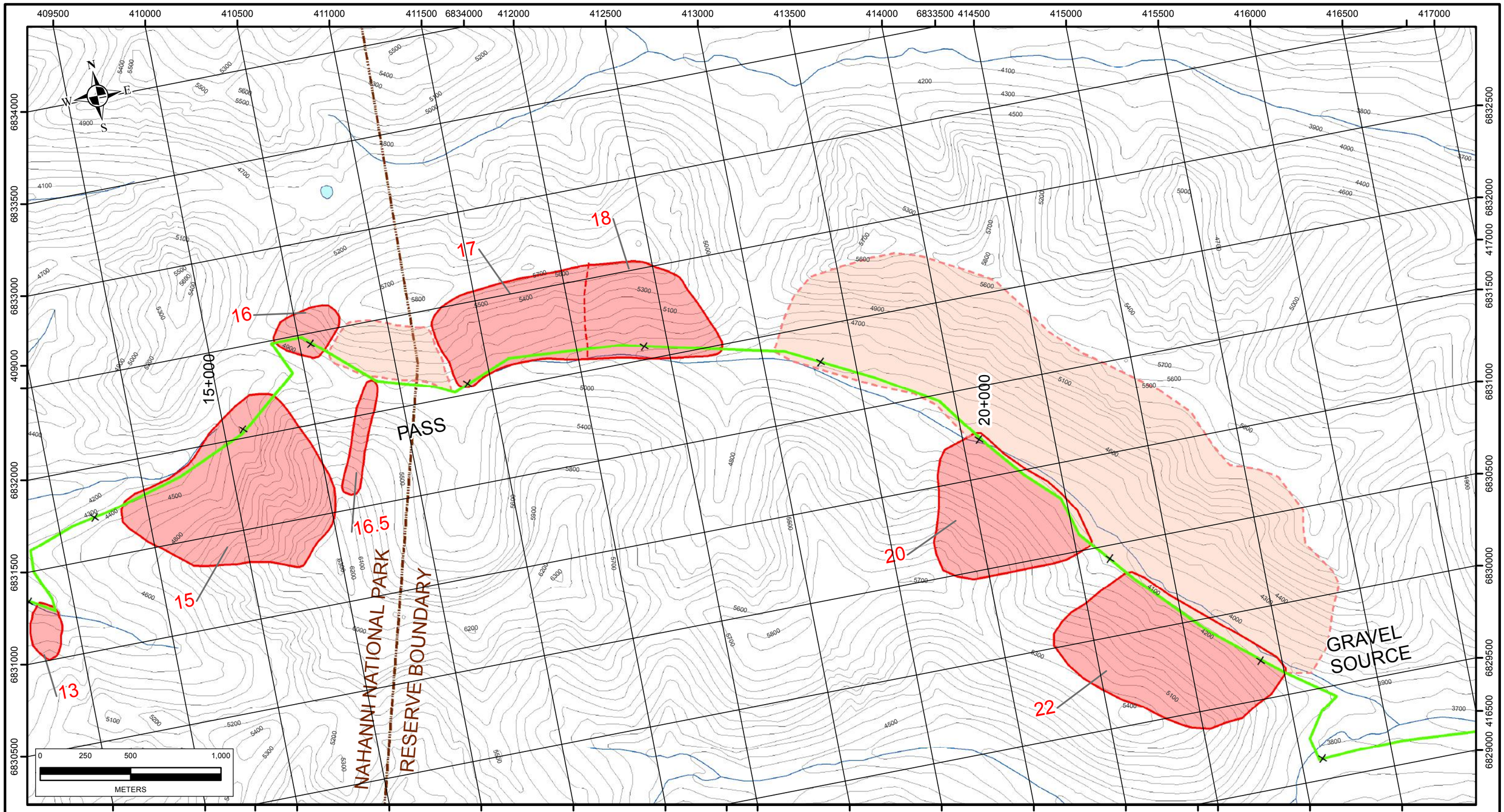

LEGEND

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TITLE: AVALANCHE HAZARD MAP

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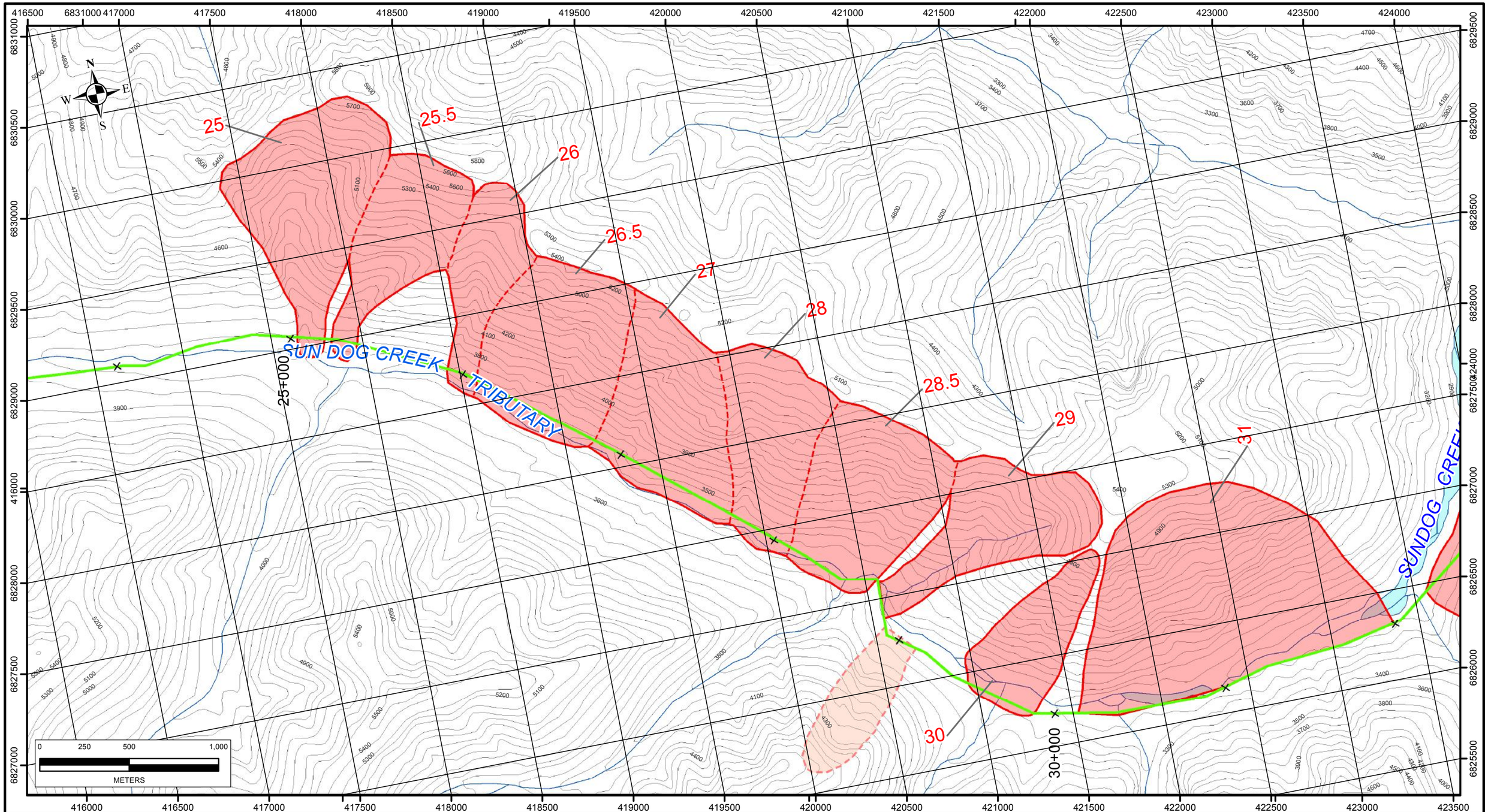

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PROJECT: PRAIRIE CREEK MINE WINTER ACCESS ROAD

TITLE: AVALANCHE HAZARD MAP

PROJECT NO:	DWG NO:	REV:
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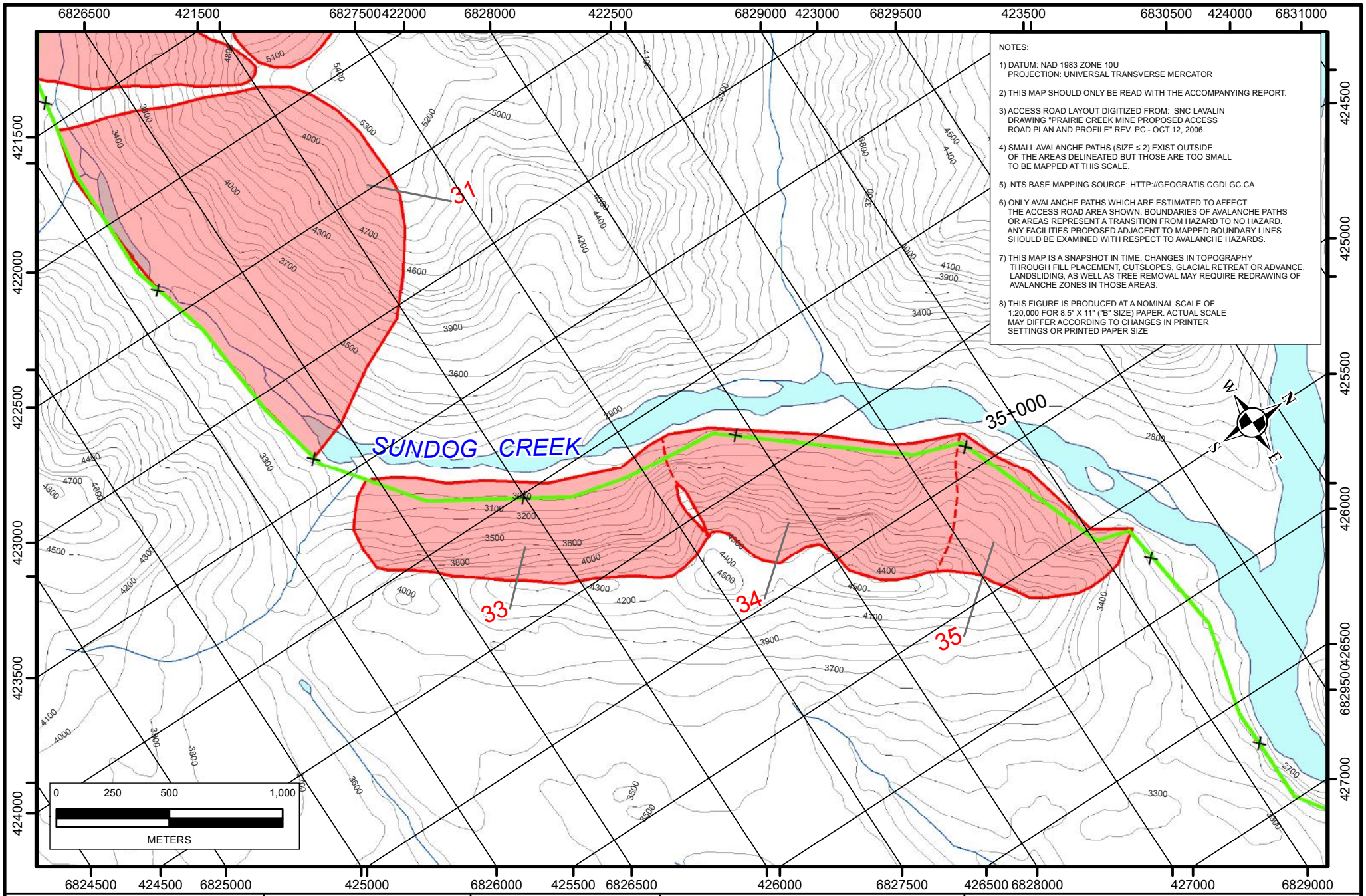

LEGEND

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PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: PRAIRIE CREEK MINE WINTER ACCESS ROAD

TITLE: AVALANCHE HAZARD MAP

PROJECT NO:	DWG NO:	REV:
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APPENDIX 3

A TETRA TECH COMPANY

November 19, 2012

ISSUED FOR USE
EBA FILE: E22102082
Via Email: david@canadianzinc.com

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

Attention: Mr. David Harpley

Subject: High Water Levels for Prairie Creek Mine Access Road Stream Crossings
Northwest Territories

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA), is pleased to provide the following report with design open water levels for seven stream crossings along the access road from the Canadian Zinc Corporation (CZN) Prairie Creek Mine to the Liard Highway #7 east of Nahanni Butte, NWT. This work was performed at the request of CZN. The work was performed under the direction of Mr. Bill Rozeboom who has provided water resources engineering support for the Prairie Creek Mine Project since 2008, and has participated in aerial and ground inspections of the Sundog Creek segment of the mine access road.

Design high open water levels were requested for the following locations where bridges are proposed:

(1) Sundog Creek at Road KM 23 – Permanent Bridge Span

(2) Sundog Creek at Road KM 24 – Temporary Crossing 1 (Removable Span)

(3) Sundog Creek at Road KM 26.4 – Temporary Crossing 2 (Removable Span)

(4) Sundog Creek at Road KM 26.8 – Temporary Crossing 3 (Removable Span)

(5) Sundog Creek at Road KM 28.7 – Temporary Crossing 4 (Removable Span)

(6) Unnamed Creek at Road KM 43 – Temporary Crossing 5 (Removable Span)

(7) Polje Creek at Road KM 53 - Permanent Bridge Span

Design water levels were determined on the basis of HEC-RAS modelling of open water 100-year peak flows. For most crossings, channel geometry and gradient were determined from high-resolution LiDAR elevation data obtained (flown) in June 2012 with 15 cm vertical accuracy and horizontal point density at around one point per square metre. In wetted areas (such as streams), LiDAR elevation data reflects the water surface and does not provide channel bottom elevations. In the absence of bathymetry in combination with apparent shallow flows, a single LiDAR-derived section was used to represent channel geometry for the channel reach at each crossing. LiDAR data was supplemented by results of ground surveys conducted by others which included water edge profiles and mid-channel water depths for most

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crossings. Relatively detailed ground surveys of channel and floodplain sections were available (and used) only for the Polje Creek crossing. For all crossings, aerial and ground photographs were provided by CZN (see attachment) which showed local channel and floodplain characteristics at the crossing locations, and these were used to estimate the Manning "n" hydraulic roughness of the channel and floodplain.

As indicated, the water levels provided herein are for open water flow conditions. There is a possibility of ice-influenced high water levels which should be investigated by field observations at breakup when ice influences will be at their greatest. Ice accumulation has been observed in the box canyon upstream of permanent crossing location (1), but the span elevation at this location is proposed to be well above the creek and the crossing design should not be affected. At the second permanent crossing location (7), the open water high water level is associated with considerable flow over floodplain areas which would not be susceptible to ice effects. While it is unlikely that ice effects will control any of the crossing designs, field observations are needed to rule out this possibility. The design high water level for the bridge crossings based on open water will need to be amended if field observations at breakup identify significant ice effects.

2.0 100-YEAR HIGH WATER LEVELS

Tributary basin areas for each of the crossing locations were determined from digital analysis of GeoBase 1:50,000 scale Canadian Digital Elevation Data derived from the National Topographic Data Base. The watershed analysis was done using Global Mapper software, with a visual inspection of the delineation results to confirm that the results were reasonable.

A regional hydrology analysis was performed by Northwest Hydraulic Consultants (NHC) using the Water Survey of Canada peak flow data for Prairie Creek at Cadillac Mine (495 km^2), Flat River near the Mouth (8,560 km^2), and South Nahanni River above Virginia Falls (14,500 km^2). A best fit trend line of drainage area to 100-year discharge was determined on the basis of these three stations and used to estimate 100-year discharges at the crossing locations. The trend line equation is given below, with discharge (Q) in m^3/s and basin area (A) in km^2.

$$Q_{100} = 1.888\ A^{0.751}$$

A summary of basin areas and 100-year design flows for each of the crossing locations is provided in Table 1.

Table 1: Basin Areas and Design Flows

Crossing	Road KM post	Basin Area Km^2	100-Year Design Q, m^3/s
Sundog permanent	23	14.5	14.1
1st temp Sundog	24	27.24	22.6
2nd temp Sundog	26.4	37.27	28.6
3rd temp Sundog	26.8	38.62	29.4
4th temp Sundog	28.7	45.22	33.0
5th temp, Unnamed	43	17.92	16.5
Polje permanent	53	99.32	59.7

3.0 DESIGN 100-YEAR WATER LEVELS

3.1 KM 23, Sundog Creek Permanent Crossing

A permanent span bridge crossing is proposed over Sundog Creek at Road KM 23. The crossing will be constructed on a bedrock outcrop just downstream of a small (0.5 m high) waterfall which acts as a channel hydraulic control. Figure 1 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was used "as-is" without adjustment for bathymetry. The available bed elevation point suggested a depth of about 0.3 m, but this may have been in the plunge pool and not representative of channel hydraulic performance. From prior field observations, the base of the LiDAR cross section is believed to be very similar to the channel bottom elevation at the plunge pool outlet.

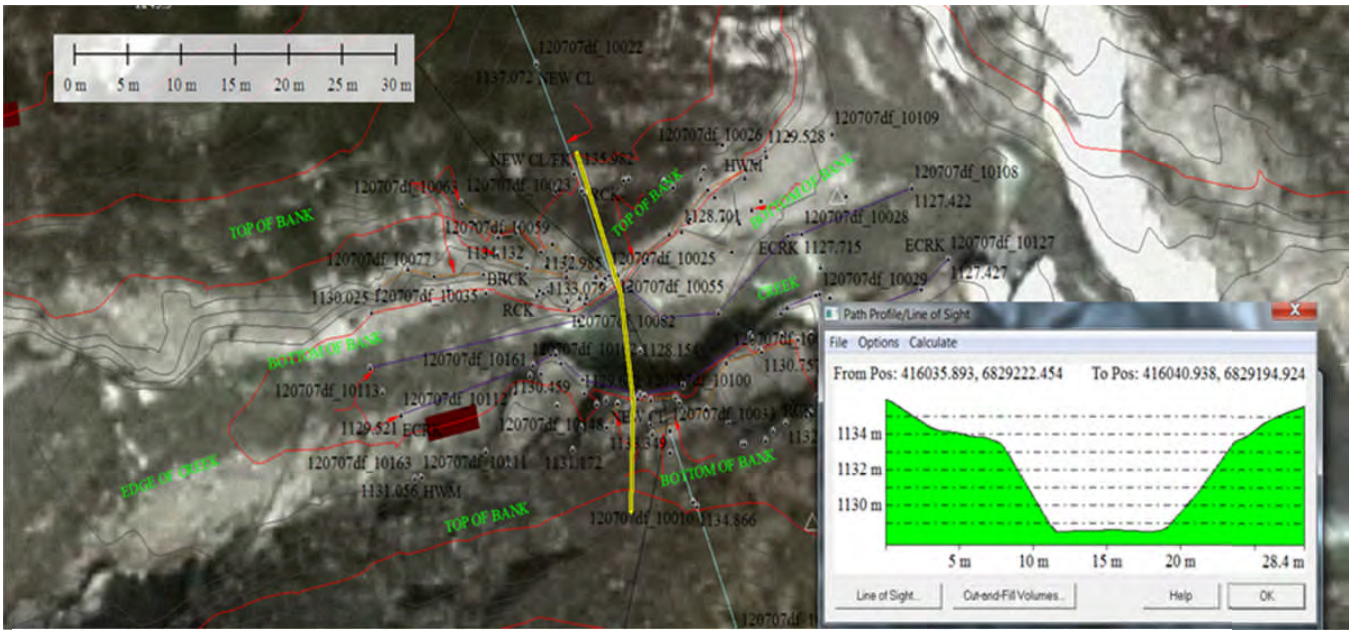


Figure 1: Sundog Creek at KM 23. Flow is from left to right. Section plot is viewing downstream

The crossing is located above a plunge pool and water levels will be controlled by the capacity of the 7 m wide channel at the pool outlet. The channel slope is 0.040 and a Manning's n value of 0.055 was assumed based on the observed channel bed material (D_{84} assumed to be 0.3m) and preliminary hydraulic calculations.

The computed water level at this crossing is 1129.32 m for the 100-year discharge of 14.1 m^3/s. The flow velocity in the main channel is 2.54 m/s and the maximum depth of flow is approximately 0.8 m.

3.2 KM 24, Sundog Creek Temporary Crossing 1

A temporary span bridge crossing is proposed over Sundog Creek at Road KM 24. Figure 2 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was used "as-is" without adjustment for bathymetry. The available bed elevation point suggested a depth of

about 0.15 m, apparently taken between the larger rocks in the channel that have exposed (out of water) surfaces under summer low water conditions.

On the north side of the crossing, (the left side of the plotted cross section) there is a low area which may convey water at times or is possibly an abandoned channel. To be conservative in estimating the design water level, this left bank area was obstructed such that no flow was allowed below elevation 1099.75 m. The channel slope through the crossing reach is 0.016 and a Manning's n value of 0.055 was assumed.

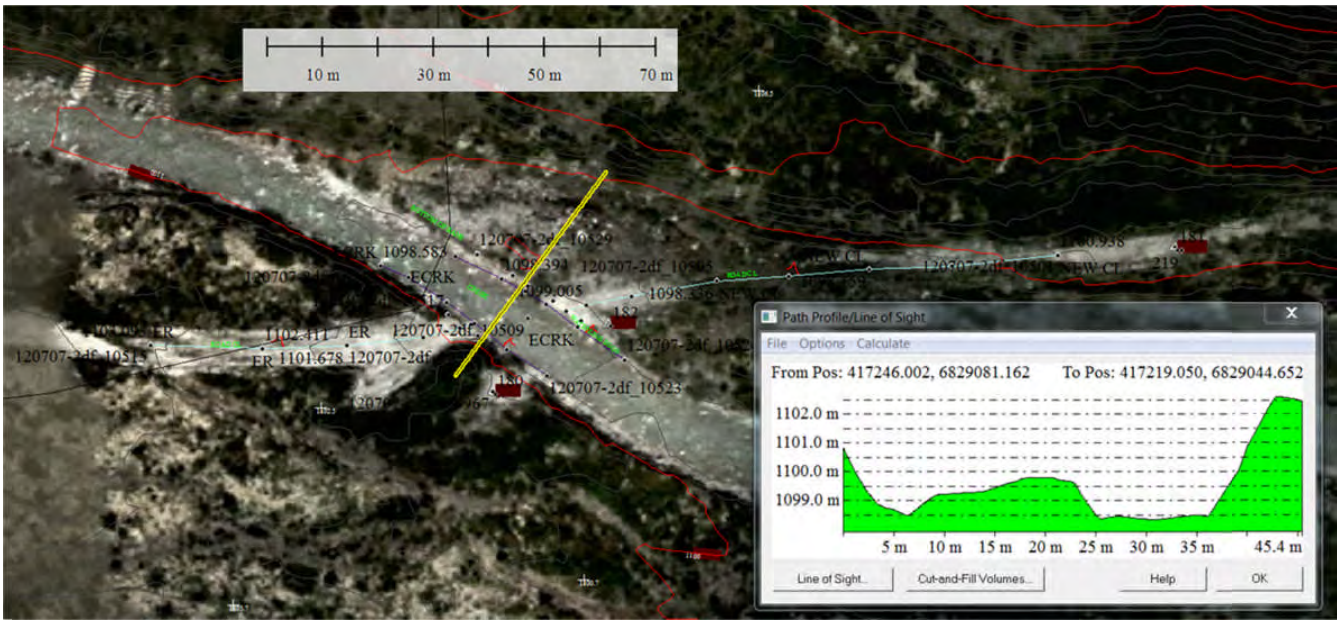


Figure 2: Sundog Creek at KM 24. Flow is from left to right. Section plot is viewing downstream

The computed water level at Sundog Creek Temporary Crossing 1 is 1099.35 m for the 100-year discharge of 22.6 m^3/s. The flow velocity in the main channel is 2.02 m/s and the maximum depth of flow is approximately 1.0 m.

3.3 KM 26.4, Sundog Creek Temporary Crossing 2

A second temporary span bridge crossing is proposed over Sundog Creek at Road KM 26.4. Figure 3 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was used "as-is" without adjustment for bathymetry. Based on ground photos, the flow was very shallow with frequent riffles.

The channel slope through the crossing reach was assumed to be 0.015, considering a surveyed water edge slope of 0.013 and slightly steeper downstream conditions. A Manning's n value of 0.055 was assumed.

The computed water level at Sundog Creek Temporary Crossing 2 is 1030.27 m for the 100-year discharge of 28.6 m^3/s. The flow velocity in the main channel is 2.07 m/s and the maximum depth of flow is approximately 1.1 m.

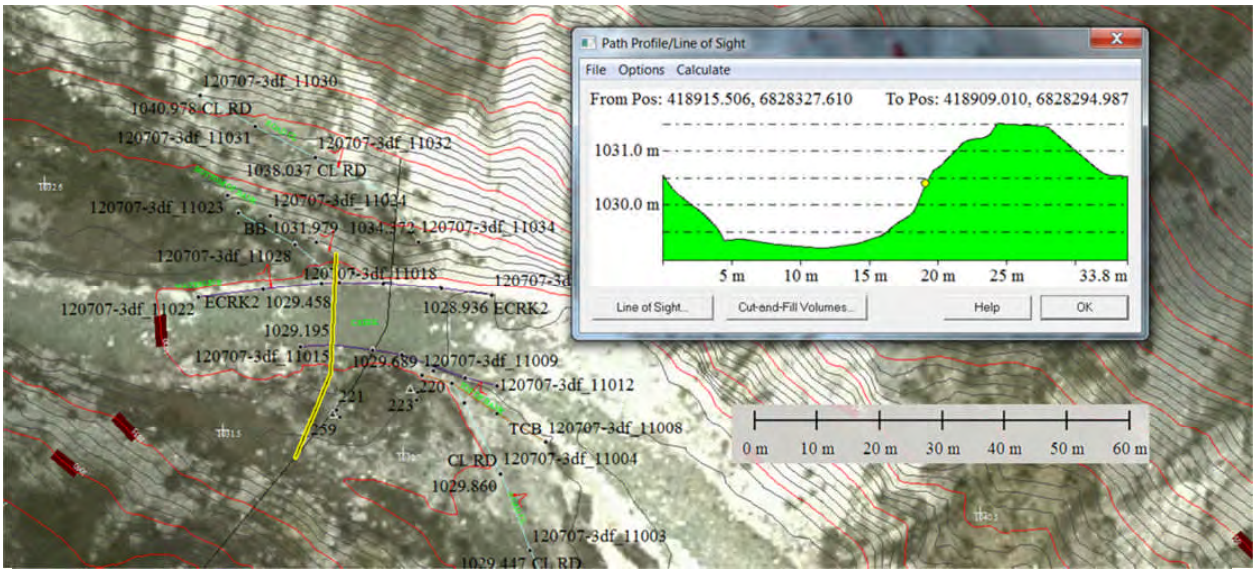


Figure 3: Sundog Creek at KM 26.4. Flow is from left to bottom right. Section plot is viewing downstream

3.4 KM 26.8, Sundog Creek Temporary Crossing 3

The third temporary span bridge crossing is proposed over Sundog Creek at Road KM 26.8. Figure 4 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was used "as-is" without adjustment for bathymetry. Based on ground photos, there are frequent huge boulders which have apparently fallen into the creek from the adjacent hillslope. The boulders are sufficiently large to be observable in the Figure 4 orthophoto image.

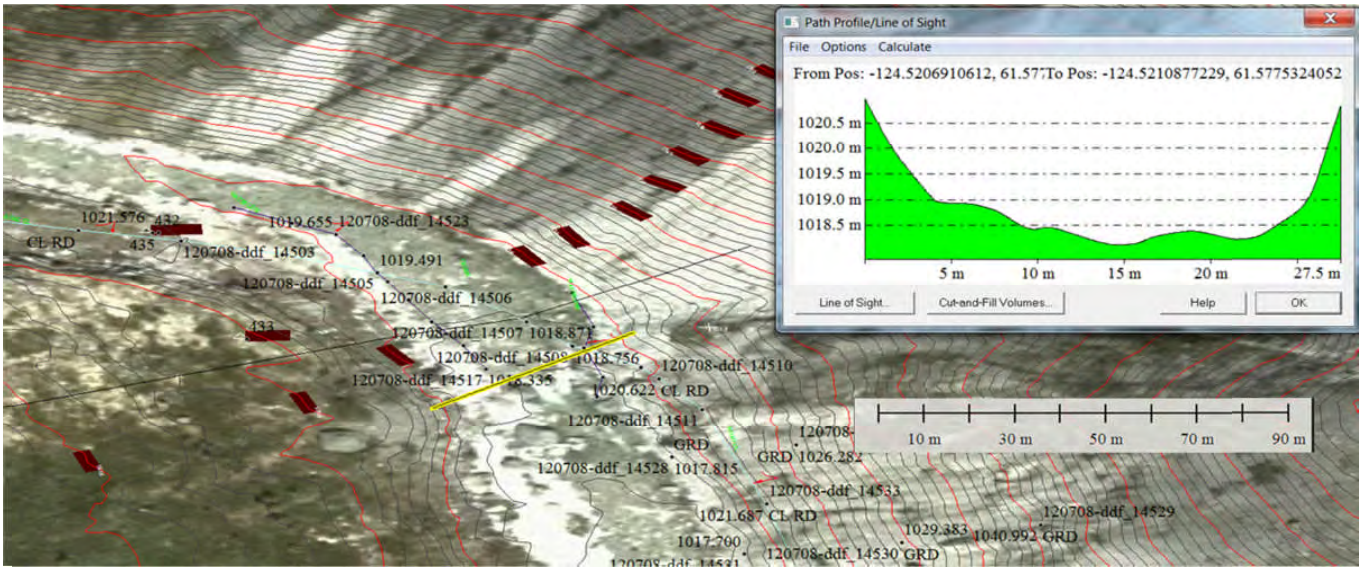


Figure 4: Sundog Creek at KM 26.8. Flow is from left to image bottom. Section plot is viewing downstream

The channel slope at and below the crossing reach was 0.040. A relatively high Manning's n value of 0.080 was assumed due to the boulder obstructions to the flow.

The computed water level at Sundog Creek Temporary Crossing 3 is 1019.13 m for the 100-year discharge of 29.4 m^3/s. The flow velocity in the main channel is 2.20 m/s and the maximum depth of flow is approximately 1.0 m.

3.5 KM 28.7, Sundog Creek Temporary Crossing 4

The fourth temporary span bridge crossing is proposed over Sundog Creek at Road KM 28.7. Figure 5 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was used "as-is" without adjustment for bathymetry.

The crossing is located in the middle of a short (15 m) relatively flat reach between upstream and downstream rapids with very large boulders in the channel. Due to difficulty in assessing the local channel slope, the hydraulic analysis for this site considered three LiDAR-derived sections, all applied without any adjustment for bathymetry. The two additional sections were located downstream of the crossing, first at the start of the white water section, and second about midway down though the rapids where the channel slope is approximately 10%. A Manning's n value of 0.080 was assumed for all sections.

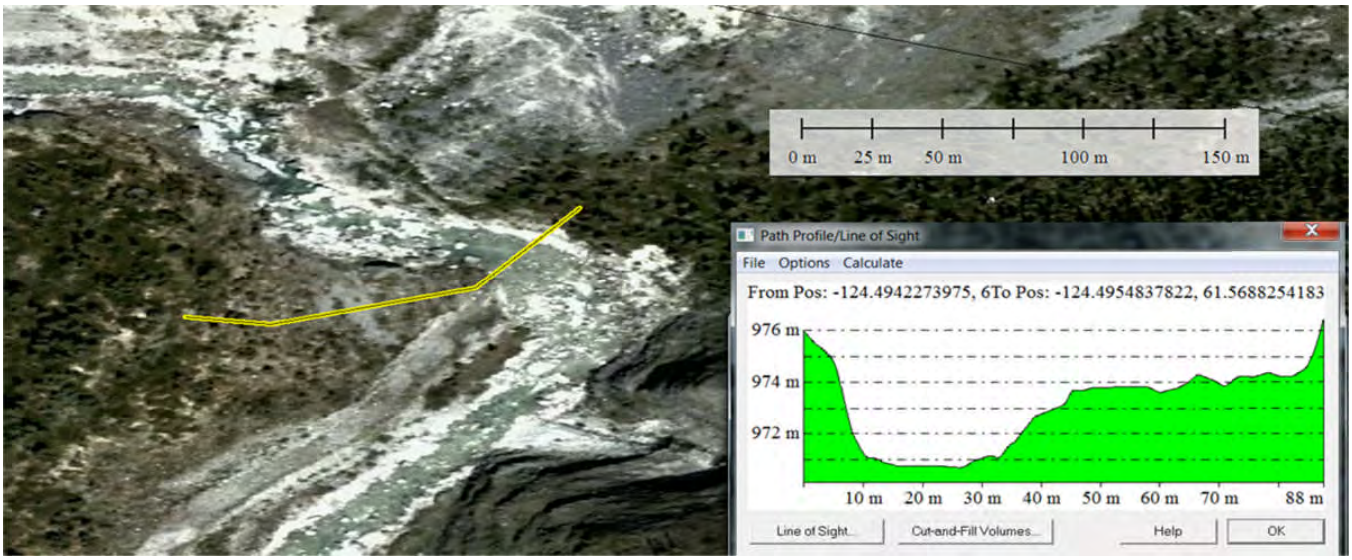


Figure 5: Sundog Creek at KM 28.7. Flow is from left to bottom left. Section plot is viewing downstream

The computed water level at Sundog Creek Temporary Crossing 4 is 971.52 m for the 100-year discharge of 33.0 m^3/s. The flow velocity in the main channel is 2.48 m/s and the maximum depth of flow is approximately 0.8 m.

3.6 KM 43, Unnamed Creek Temporary Crossing 5

A fifth temporary span bridge crossing is proposed over an unnamed creek at Road KM 43. Figure 6 shows the LiDAR-derived cross section used to determine the high water level at this location. The LiDAR section was modified by adding a ground survey bed elevation point which had been measured at the channel

centreline. The resulting channel minimum bed elevation is approximately 0.1 m below the LiDAR elevation which represents the water surface.

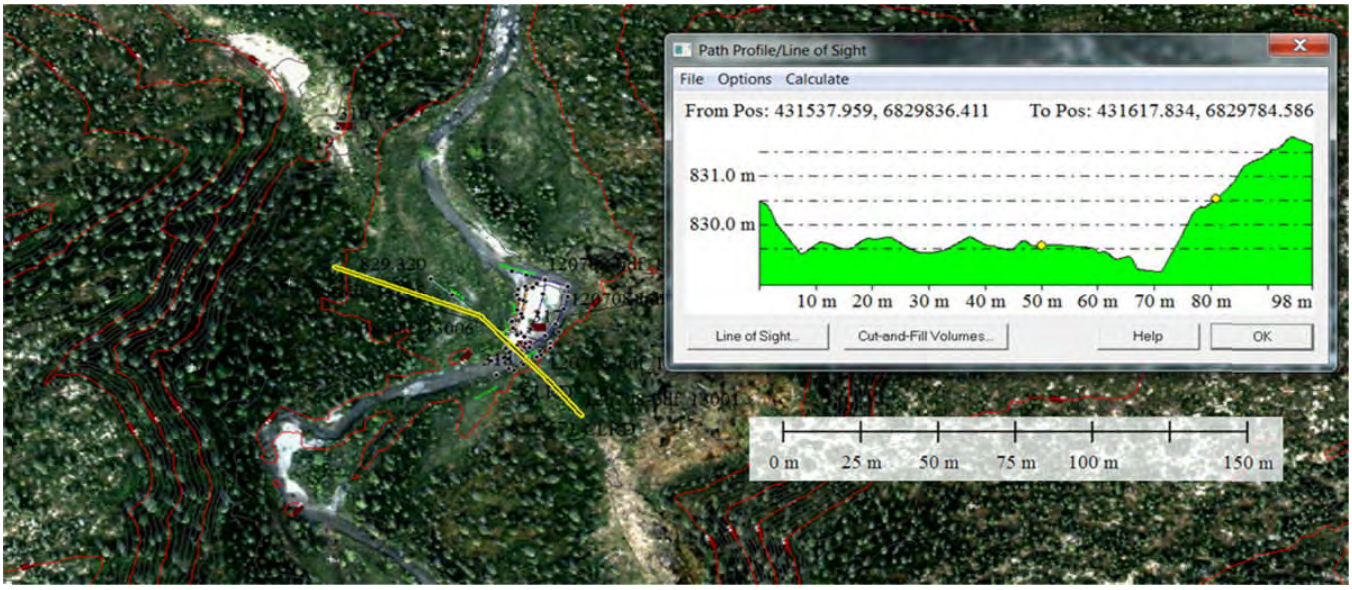


Figure 6: Unnamed Creek at KM 43. Flow is from bottom to top. Section plot is viewing downstream

The unnamed creek is about five metres wide and has a meandering plan form within a floodplain that is approximately 70 m wide at the crossing location. The channel slope through the crossing reach was assumed to be 0.01, considering a surveyed water edge slope of 0.008 and slightly higher LiDAR-derived slopes which will result when channel side bars are overtopped. Manning's n values of 0.024 and 0.080 were assumed for the main channel and overbank floodplain areas, respectively

The computed water level at the unnamed creek Temporary Crossing 5 is 829.86 m for the 100-year discharge of 16.5 m^3/s. The flow velocity in the main channel is 1.90 m/s and the maximum depth of flow is approximately 1.0 m. At the design flow, the entire floodplain will be inundated as shown in Figure 7 below. Any obstruction of the floodplain area due to road fill or bridge abutments will result in increased water levels on the upstream side of the crossing.

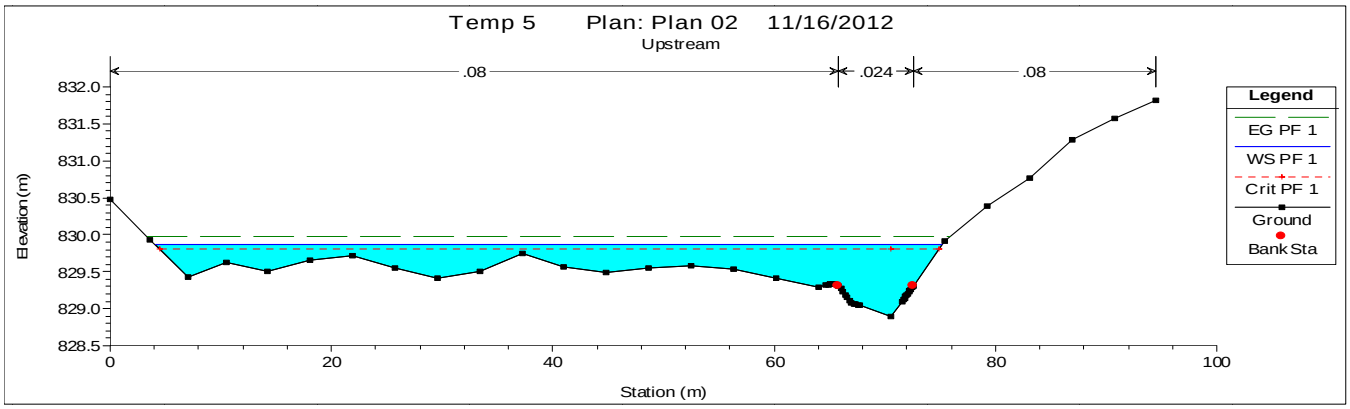


Figure 7: Unnamed Creek at KM 43. Depth and extent of inundation at design flow

3.7 KM 53, Polje Creek Permanent Crossing

A second permanent span bridge crossing is proposed over Polje Creek at Road KM 53. Figure 8 shows the channel configuration and the locations of three sections which were field surveyed and used for hydraulic modelling. The proposed crossing is at the middle section shown in yellow. The section plot included in Figure 8 is derived from LiDAR for consistency with previous figures.

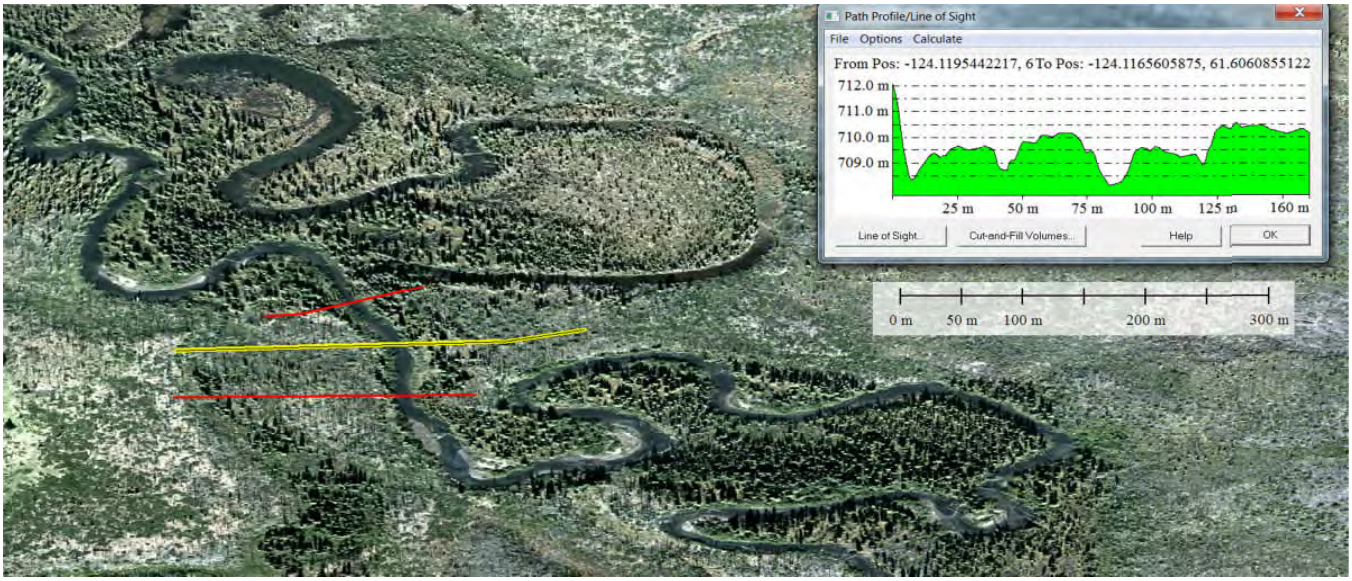


Figure 8: Polje Creek at KM 53. Flow is from bottom to top left. Section plot is viewing downstream

The Polje Creek channel is about eight metres wide and has a meandering plan form within a floodplain that is over 250 m wide in places. The channel slope through the crossing reach is 0.002. Manning's n values of 0.024 and 0.10 were assumed for the main channel and overbank floodplain areas, respectively.

The computed water level at the Polje Creek crossing is 710.40 m for the 100-year discharge of 59.7 m^3/s. The flow velocity in the main channel is 1.73 m/s and the maximum depth of flow is approximately 2.5 m. At the design flow, the entire floodplain will be inundated as shown in Figure 9 below. Any obstruction of the floodplain area due to road fill or bridge abutments will result in increased water levels on the upstream side of the crossing.

The computed design water level is believed to be conservatively high by as much as 0.3 m because it does not account for bypass floodplain flow past the right (east) end of the modelled section. The bypass water would overtop the main channel about 350 m upstream from the crossing, flow north over the right (east) floodplain, and drain into the oxbow channel section that is east from the main active channel.

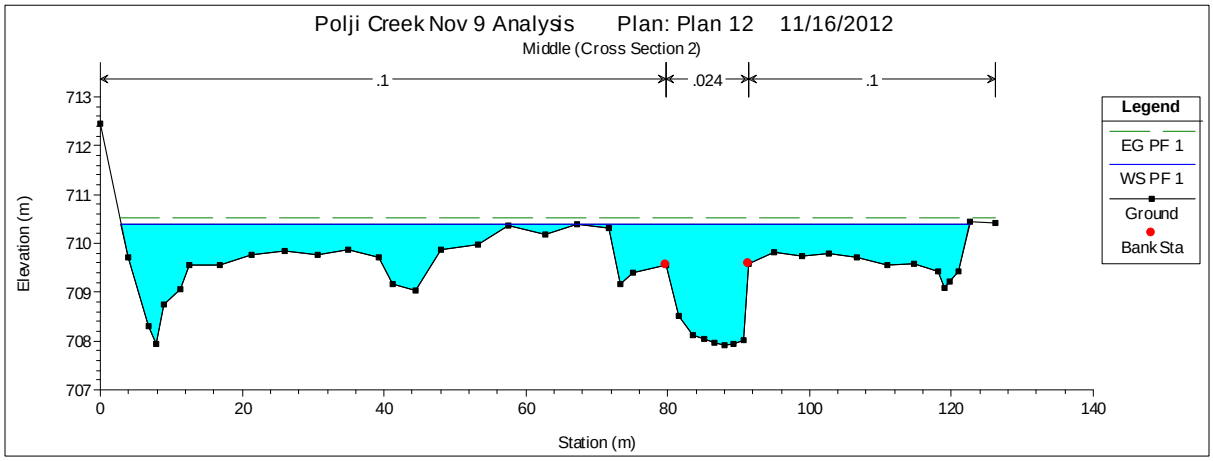
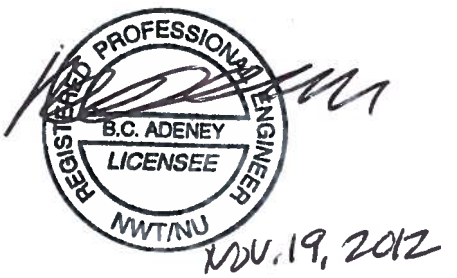


Figure 9: Polje Creek at KM 53. Depth and extent of inundation at design flow.

4.0 CLOSURE

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

Sincerely,
EBA Engineering Consultants Ltd.



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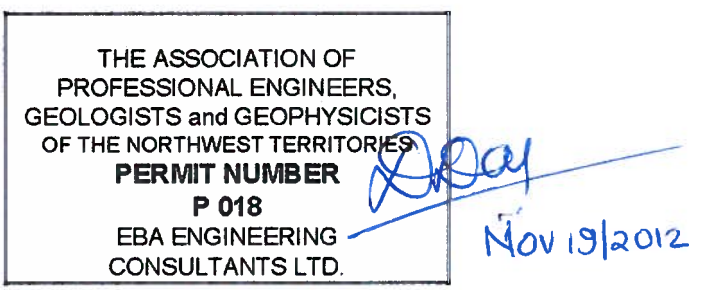

Attachments: Photos (12)

Photo 1: Sundog Creek Permanent Crossing, Road KM 23. Viewing upstream.

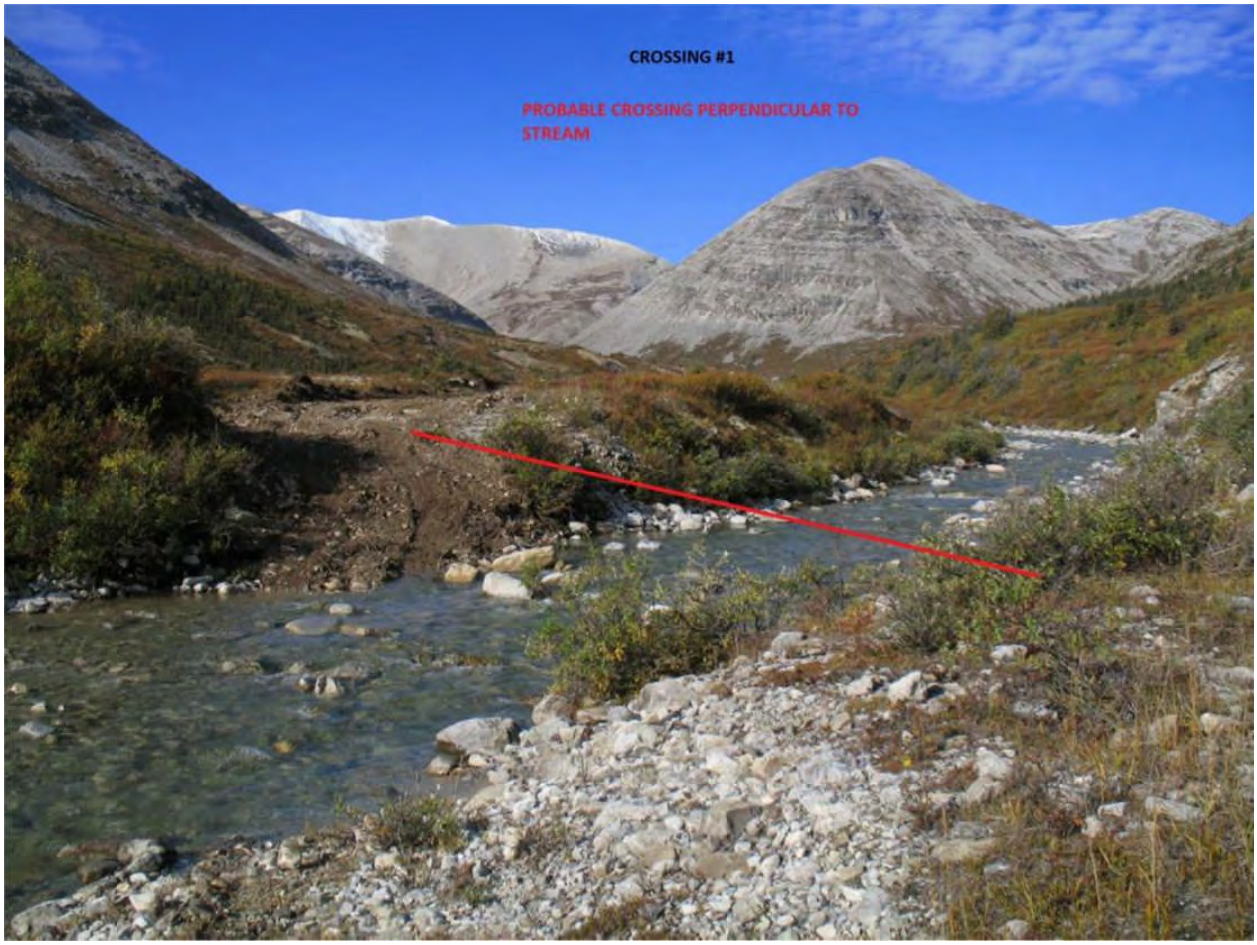

Photo 2: Sundog Creek Temporary Crossing 1, Road KM 24. Viewing upstream.

Photo 3: Sundog Temporary Crossing 2, Road KM 26.4. Viewing downstream.

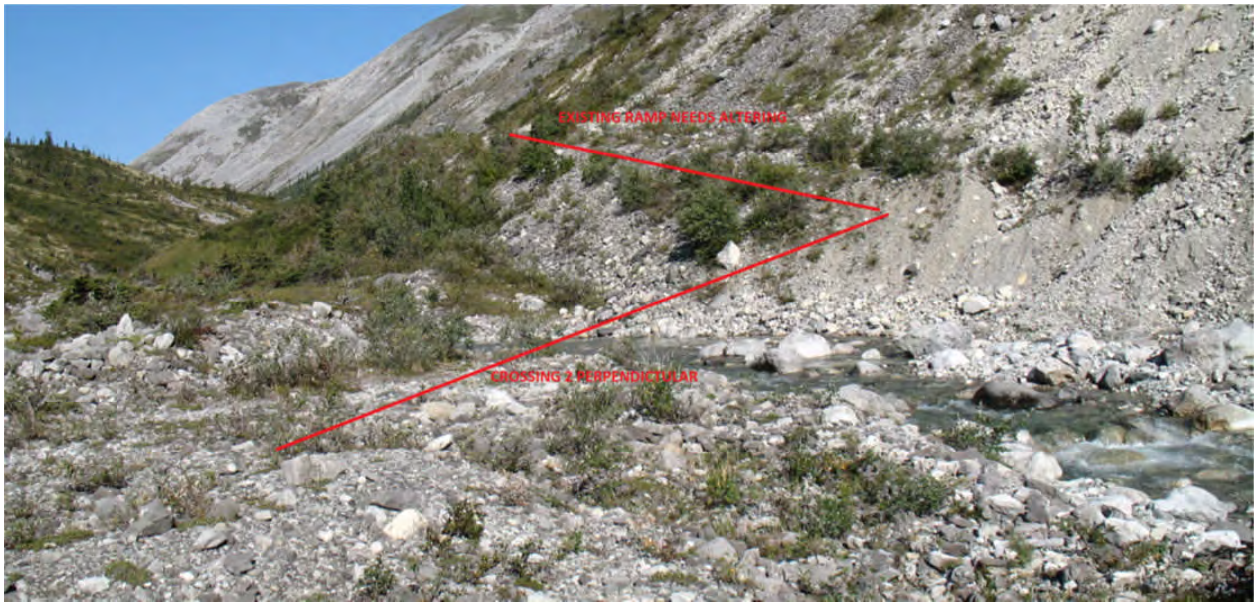

Photo 4: Sundog Temporary Crossing 2, Road KM 26.4. Viewing upstream.

Photo 5: Sundog Temporary Crossing 3, Road KM 26.8. Flow is left to right.

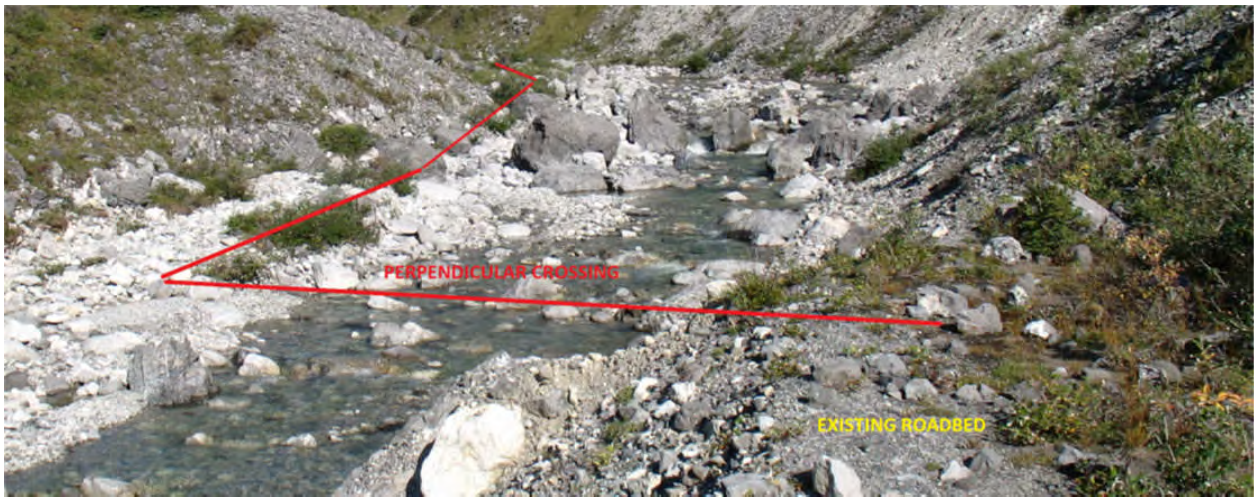

Photo 6: Sundog Temporary Crossing 3, Road KM 26.8. Viewing upstream.

Photo 7: Sundog Temporary Crossing 3, Road KM 26.8. Viewing downstream.

Photo 8: Sundog Temporary Crossing 4, Road KM 28.7. Viewing downstream.

Photo 9: Sundog Temporary Crossing 4, Road KM 28.7. Viewing downstream.

Photo 10: Unnamed Creek Temporary Crossing 5, Road KM 43. Flow is right to left.

Photo 11: Polje Creek Permanent Crossing, Road KM 53. Flow is right to left.

Photo 12: Polje Creek Permanent Crossing, Road KM 53. Flow is left to right.

APPENDIX 4

TETRA TECH EBA

December 18, 2014

ISSUED FOR USE
FILE: ENVMIN03009-01
Via Email: david@canadianzinc.com

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

Attention: Mr. David Harpley

Subject: Stream Crossing Design Water Levels for Prairie Creek Mine Access Road
Northwest Territories

1.0 INTRODUCTION

Tetra Tech EBA Inc, (Tetra Tech) was retained by Canadian Zinc Corporation (CZN) in November 2014 to determine design open water levels for 18 stream crossings along the access road from the CZN Prairie Creek Mine to the Liard Highway #7 east of Nahanni Butte, NWT. This work generally follows the methods used for a similar study conducted by Tetra Tech in 2012 for seven initial crossings for the same road. The study was performed under the direction of Mr. Bill Rozeboom who has provided water resources engineering support for the Prairie Creek Mine Project since 2008, and has participated in aerial and ground inspections of the access road in the mine vicinity and along Sundog Creek.

The majority of the crossings that are evaluated in the present work correspond to streams with potential fisheries habitat usage, based on prior analyses and aquatic surveys in 2014 by Hatfield Consultants. The aquatic surveys were generally made at the proposed crossing location, but in some cases, alignment adjustments also made in 2014 have moved the road to be either just upstream or downstream of the survey locations.

The road alignment revisions have altered the locations of the road Kilometer Post (KP) markers which measure distance from the mine site at KP 0. The KP markers used for aquatic surveys in 2014 and prior years are based on the original alignment. To minimize confusion, this report identifies stream crossings according to the KP markers that correspond to the 2014 alignment, and also presents the Hatfield KP markers for each stream (for which aquatic surveys were done in 2014). A summary of the 18 stream crossings is given below, with KPs for both the 2014 alignment and the Hatfield surveys, where applicable.

1. KP 6.1 Casket Creek
2. KP 13.4 Funeral Creek
3. KP 25.3 Sundog Trib.
4. KP 28.4 Sundog Creek (Hatfield KP 28.4)
5. KP 39.4 Sundog Trib. (Hatfield KP 39.8)
6. KP 46.2 Polje Trib. (Hatfield KP 47.0)
7. KP 49.6 Polje Trib. (Hatfield KP 50.2)
8. KP 53.5 Polje Trib. (Hatfield KP 54.3)
9. KP 87.2 Old Road at Tetcela Trib.

Tetra Tech EBA Inc.
14940 - 123 Avenue
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10. KP 89.7 Old Road at Tetcela Mainstem
11. KP 112.4 Grainger Trib. (Hatfield KP 122.8)
12. KP 123.4 Grainger River (Hatfield KP 123.7)
13. KP 124.8 Grainger River (Hatfield KP 125.1)
14. KP 131.2 Grainger Trib. (Hatfield KP 131.3)
15. KP 133.2 Grainger Trib. (Hatfield KP 133.7)
16. KP 134.9 Grainger Trib. (Hatfield KP 135.6)
17. KP 136.5 Grainger Trib. (Hatfield KP 136.7)
18. KP 154.9 Liard Trib. (Hatfield KP 154.4)

2.0 DESIGN APPROACH

Design water levels were determined on the basis of HEC-RAS modelling of open water 100-year peak flows, based on normal flow for a single cross section at the approximate crossing centreline location. Flows were estimated using the same regional analysis approach developed for the 2012 study. The design water levels are preliminary results for existing conditions, without hydraulic effects of road embankments, abutments, or piers which may be proposed at a future stage of design.

For most crossings, channel geometry and gradient were determined from high-resolution LiDAR elevation data obtained (flown) in June 2012 with 15 cm vertical accuracy and horizontal point density at around one point per square metre. Because of alignment changes, LiDAR data were not available for the last three crossings at KPs 134.9, 136.5, and 154.9. Unless otherwise stated, the LiDAR-derived section for each crossing was used as is, without adjustment for bathymetry (depth below the LiDAR surface elevation), which is a conservative approach for estimation of high water levels.

At the final three crossings, hydraulic analyses for each stream were made at a downstream location for which LiDAR data were available, generally within 400 m of the road crossing. Channel gradients and channel location in the road crossing vicinity were estimated on the basis of 1:50:000 scale NTS mapping and digital elevation models, and supplemented by Google Earth imagery. The water surface elevations computed for the downstream sections cannot be applied directly to the road crossing location, but the computed flow depths and velocities should be similar.

Estimates of Manning “n” hydraulic roughness values for the channel and floodplain areas were made on the basis of photographs provided by CZN, which showed the site conditions. These included aerial reconnaissance images taken on various dates and ground photographs taken by Hatfield Consultants during site surveys in late September 2014.

As indicated, the water levels provided herein are for open water flow conditions. There is a possibility of ice-influenced high water levels that could be higher than occur for open water conditions. Canadian Zinc has reported that the 2014 field survey program had specifically looked for, but did not find, out-of-channel high water marks such as debris or damaged vegetation at the crossing locations. Although there is no evidence at this time that ice conditions will govern the design high water levels, the potential for ice effects should be considered further at the time of final design.

3.0 100-YEAR DESIGN DISCHARGES

Tributary basin areas for each of the crossing locations were determined from digital analysis of GeoBase 1:50,000 scale Canadian Digital Elevation Data derived from the National Topographic Data Base. The watershed analysis was done using Global Mapper software, with a visual inspection of the delineation results against 1:50,000 scale Toporama mapping to confirm that the results were reasonable and to make adjustments as necessary. The watersheds for two streams with very small basin areas (less than 1.5 km^2) were adjusted on the basis of drainage patterns which could be inferred from Google Earth imagery.

Design discharges were estimated on the basis of a regional hydrology analysis completed for the 2012 design assessment using Water Survey of Canada peak flow data for Prairie Creek at Cadillac Mine (495 km^2), Flat River near the Mouth (8560 km^2), and South Nahanni River above Virginia Falls (14500 km^2). A best fit trend line of drainage area to 100-year discharge was determined on the basis of these three stations and used to estimate 100-year discharges at the crossing locations. The trend line equation is given below, with discharge (Q) in m^3/s and basin area (A) in km^2.

$$Q_{100} = 1.888\ A^{0.751}$$

Further analysis of the peak flow records for the same three streams was performed to determine equations with multiplier coefficients which can be used to convert the 100-year flows (proposed for the design of the road crossings) to 10-year and 250-year flows identified in the Mackenzie Valley Review Board's September 2014 Terms of Reference for the Prairie Creek All Season Road and Airstrip. The equations are given below, e.g., the 10-year flow is estimated as 0.7 times the 100-year flow, together with the range of original coefficients to indicate the accuracy of the estimate.

$Q_{10} = 0.70 \times Q_{100}$ (individual coefficients ranged from 0.57 to 0.81)

$Q_{250} = 1.15 \times Q_{100}$ (individual coefficients ranged from 1.05 to 1.21)

Figure 1 shows the 2014 access road alignment together with the extents of the watersheds that drain to each of the crossings being assessed, and the locations of corresponding aquatic survey sites. Basin area sizes and design flows for each of the crossings are presented in Table 1 together with computed design water level and flow velocity information.

The crossings have watersheds which range in size from less than 1.2 km^2 to a maximum of 727 km^2. In contrast, the regional equation being used to estimate 100-year design flows is based on frequency analyses of relatively large basins for which suitable long-term flow records are available, the smallest of which is the 495 km^2 Prairie Creek basin. The accuracy of the regional analysis equation is uncertain for the very small drainages which make up about one-half of the streams being assessed. The hydrology and hydraulics of these small streams should be re-assessed on a site-by-site basis if the crossing designs for these locations are sensitive to the estimated design flows and water levels.

The watershed for Polje Tributary at Road KP 53.5 (Hatfield KP 54.3) originates from the floodplain area of the Polje Creek main channel. Flood flows and water levels in this tributary channel will therefore be associated with Polje Creek main channel watershed, rather than an independent watershed. Design flows and water levels for the Polje Creek main channel, including the tributary, were assessed in the 2012 study and are carried forward into the present report.

4.0 DESIGN 100-YEAR FLOWS AND WATER LEVELS

The results of the hydrologic and hydraulic analyses for each of the 18 road crossings are summarized and presented in the Table and Figures sections at the end of this report. Site photographs are included for reference in an additional section. In each of the summary sections — Table, Figures, Photographs — results are presented in ascending order based on the 2014 road alignment KP at each crossing.

Table 1 presents a summary of the basin areas, design flows, and hydraulic characteristics for each stream at or near the crossing vicinity.

Two figures are presented for each crossing to show (1) its location and (2) the HEC-RAS model output plot with the design flood water level, energy grade line, and extent of inundation. The plan view location figures are based on CZN 2012 LiDAR imagery where available, and Google Earth imagery otherwise. The figures show the 2014 access road alignment, are annotated to show the direction of flow, and show the location where a single channel cross section to assess channel hydraulic parameters was “cut” from the LiDAR-derived elevation model. All cross sections are presented with a downstream orientation, i.e., looking downstream. At the few sites where the Hatfield 2014 aquatic surveys were offset from the 2014 road alignment, the survey site locations are explicitly labelled. Labels are not provided for the majority of sites for which the aquatic surveys were at the 2014 road crossing location.

The figures for each crossing are presented with expanded captions to identify any unique or complicating features for each site. The combination of Table 1 and figures with expanded captioning is presented in lieu of separate report sections for each crossing which would duplicate or otherwise present the same information.

As stated above, the design water levels presented in this report are preliminary values for open water flow conditions only, using a simplified model approach. Further consideration of ice effects which may affect hydraulic performance is recommended, as is additional modelling to assess effects of road embankments, abutments, or piers which may be proposed at a future stage of design.

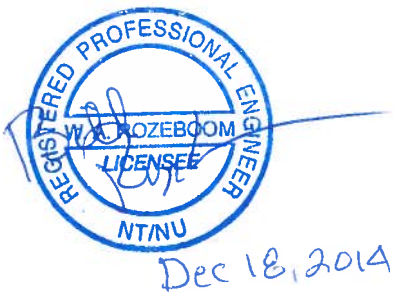
5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Canadian Zinc Corporation and their agents. Tetra Tech EBA Inc. (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.

6.0 CLOSURE

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

Sincerely,
Tetra Tech EBA Inc.



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PERMIT TO PRACTICE
TETRA TECH EBA INC.
Signature _____
Date Dec 18/2014
PERMIT NUMBER: P 018
NT/NU Association of Professional Engineers and Geoscientists

/cgc

TABLE

Table 1 - Summary of Design Flows and Water Levels

									100-year flow computed hydraulic parameters						
2014	Stream Name	Type	Basin	100-yr Q	Slope	Manning "n"		Min xsec	Water Surface			Energy Grade		Velocity	Notes
Road KP			Area, km^2	m^3/s	m/m	channel	overbank	elev, m	width, m	elev, m	depth, m	elev, m	depth m	m/s	
6.1	Casket Creek	alluvial fan	15.2	14.6	0.027	0.055	0.055	922.24	11	923.17	0.93	923.42	1.18	2.2	Analysis assumes water confined to left flowpath at existing bridge
13.4	Funeral Creek	incised alluvial	1.5	2.6	0.113	0.055	0.07	1241.39	6 to 8	1241.78	0.39	1242.04	0.65	2.4	Top width from outer bank to outer bank is 8 m.
25.3	Sundog Trib.	incised bedrock	5.8	7.1	0.090	0.055	0.07	1076.78	8	1077.3	0.52	1077.66	0.88	2.7	--
28.4	Sundog Creek	split flow	40.2	30.2	0.023	0.055	0.055	985.32	36	986.3	0.98	986.48	1.16	2.0	Top width is the sum of two channels over approx 50 m total width
39.4	Sundog Trib.	trib @ confluence	91.7	56.2	0.008	0.055	0.055	788.75	65	789.95	1.2	790.05	1.3	1.5	There may be additional flow from main channel if main and trib floods are coincident
	Sundog Main	main @ confluence	270.5	126.6	0.013	0.055	0.055	-	-	789.53	-	-	-	1.4	Main channel hydraulics give lower water level, so design should use tributary values
46.2	Polje Trib.	small incised	2.5	3.7	0.039	0.05	0.1	806.01	24	806.52	0.51	806.6	0.59	2.2	Small gravel-bed channel, 0.5 m wide and 0.5 m deep, with vegetated floodplain
49.6	Polje Trib.	small incised	2.3	3.6	0.038	0.05	0.1	754.8	11	755.51	0.71	755.57	0.77	1.1	Small gravel-bed channel, less than 0.5 m wide and 1 m deep, with vegetated floodplain
53.6	Polje Trib.	floodplain channel	n/a	n/a	0.002	-	0.1	707.8	-	710.4	2.6	-	-	< 1.7	Trib and main channels are hydraulically connected; WLs from 2012 main channel analysis
87.4	Tetcela Trib.	gravel channel	89.0	55.0	0.018	0.04	0.1	292.54	60	293.83	1.29	294.27	1.73	3.5	Single Xsec approach does not address rapidly varying channel width (35m u/s to 15 m d/s)
89.7	Tetcela Mainstem	gravel channel	727.0	266.1	0.003	0.03	0.1	267.93	329	270.34	2.41	270.7	2.77	3.1	main channel is about 25 m wide
122.4	Grainger Trib.	bouldery channel	11.1	11.5	0.021	0.04	0.1	547.68	32	548.44	0.76	548.63	0.95	2.9	main channel is about 2 m wide
123.4	Grainger River	cobble chanel	40.0	30.1	0.009	0.03	0.1	538.47	20	539.49	1.02	539.81	1.34	2.5	main channel is about 10 m wide
124.8	Grainger River	cobble chanel	41.5	31.0	0.020	0.03	0.1	511.85	41	512.61	0.76	513.09	1.24	3.2	top width given for main channel only
131.2	Grainger Trib.	small incised	2.2	3.4	0.066	0.06	0.1	612.25	7	612.87	0.62	613.13	0.88	3.0	--
133.2	Grainger Trib.	small incised	3.7	5.0	0.042	0.06	0.1	622.2	29	622.8	0.6	622.87	0.67	1.5	--
134.9	Grainger Trib.	small incised	3.4	4.8	0.074	0.06	0.1	-	-	-	0.49	-	0.64	2.8	Road crossing is out of LIDAR range; cross section taken about 300 m downstream
136.5	Grainger Trib.	small incised	1.2	2.1	0.082	0.06	0.1	-	-	-	0.47	-	0.71	2.7	Road crossing is out of LIDAR range; cross section taken about 400 m downstream
154.9	Liard Trib.	small incised	1.1	2.1	0.097	0.06	0.1	-	-	-	0.43	-	0.7	2.9	Road crossing out of LIDAR range; cross section taken about 300 m downstream

Notes: 100-year discharges estimated by regional regression equation, Q100 = 1.888 A^0.751
Energy elevations and depths refer to the energy grade line; water elevaton plus velocity head
Velocity refers to main channel velocity.

FIGURES

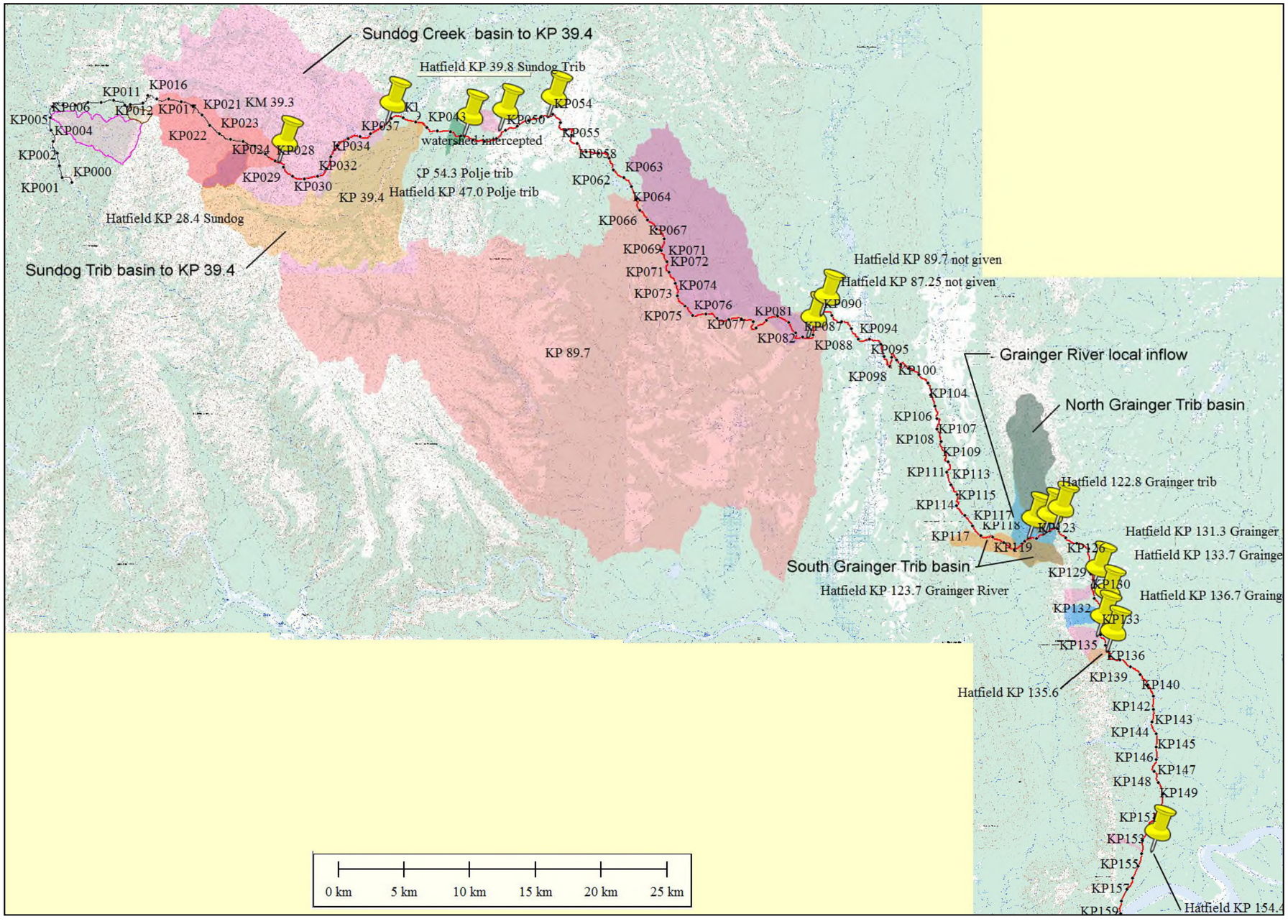


Figure 1: Prairie Creek Mine Access Road. 2014 Alignment with Kilometer Post (KP) markers, Hatfield 2014 Aquatic Survey Sites, and Watersheds to Road Crossings.

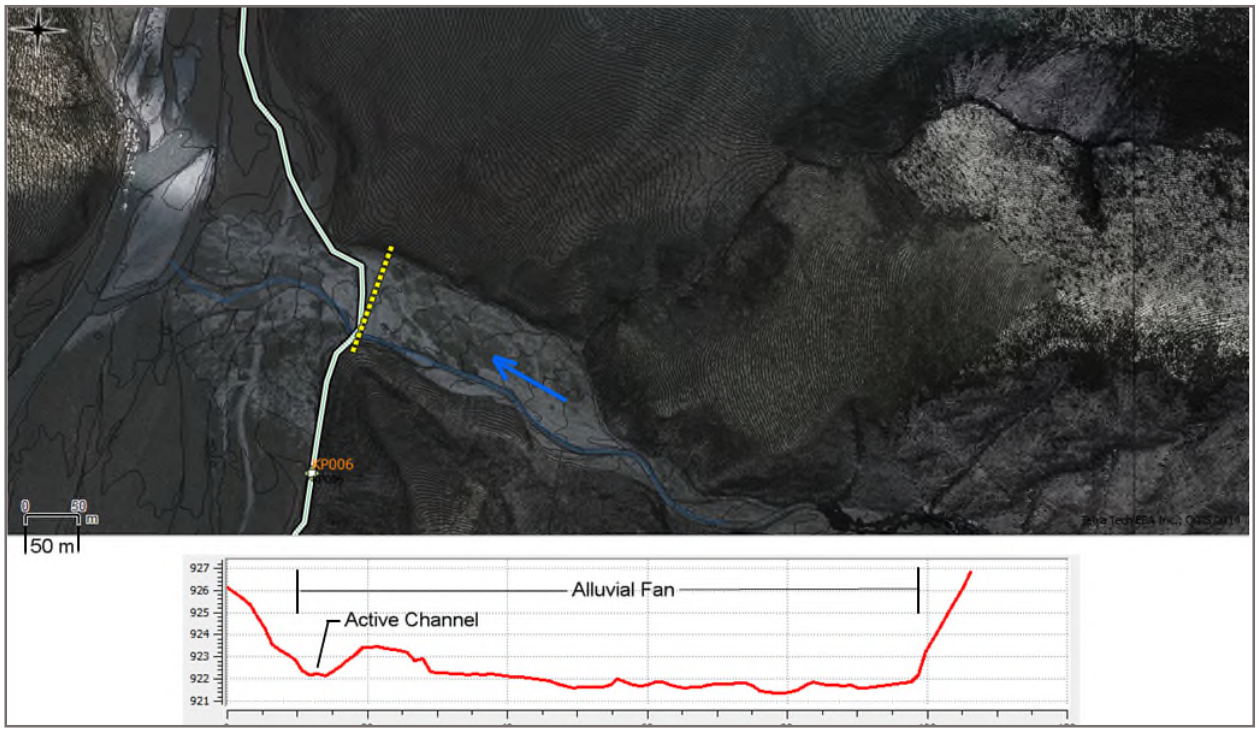


Figure 2: KP 6.1, Casket Creek, 2014 road alignment shown on 2012 orthophoto image. Channel cross section view taken at yellow dashed line showing full extent of alluvial fan, viewing downstream.

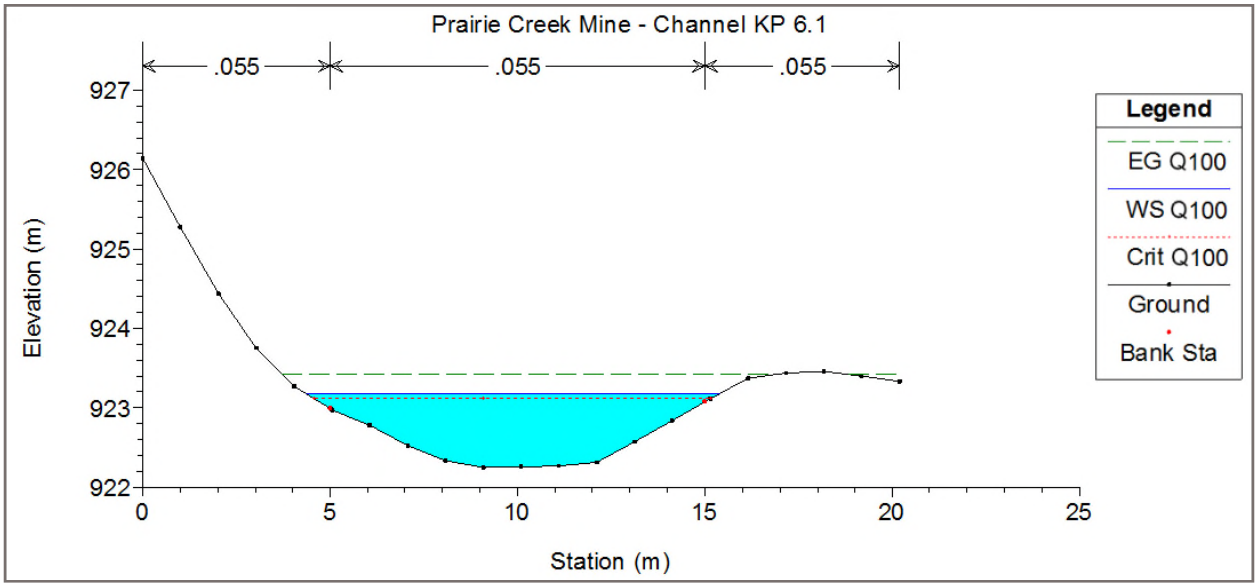


Figure 3: KP 6.1, Casket Creek, HEC-RAS model result for 100-year flood. Results shown are for scenario in which flow is confined to the presently active main channel on the left side of the alluvial fan where a bridge presently exists.

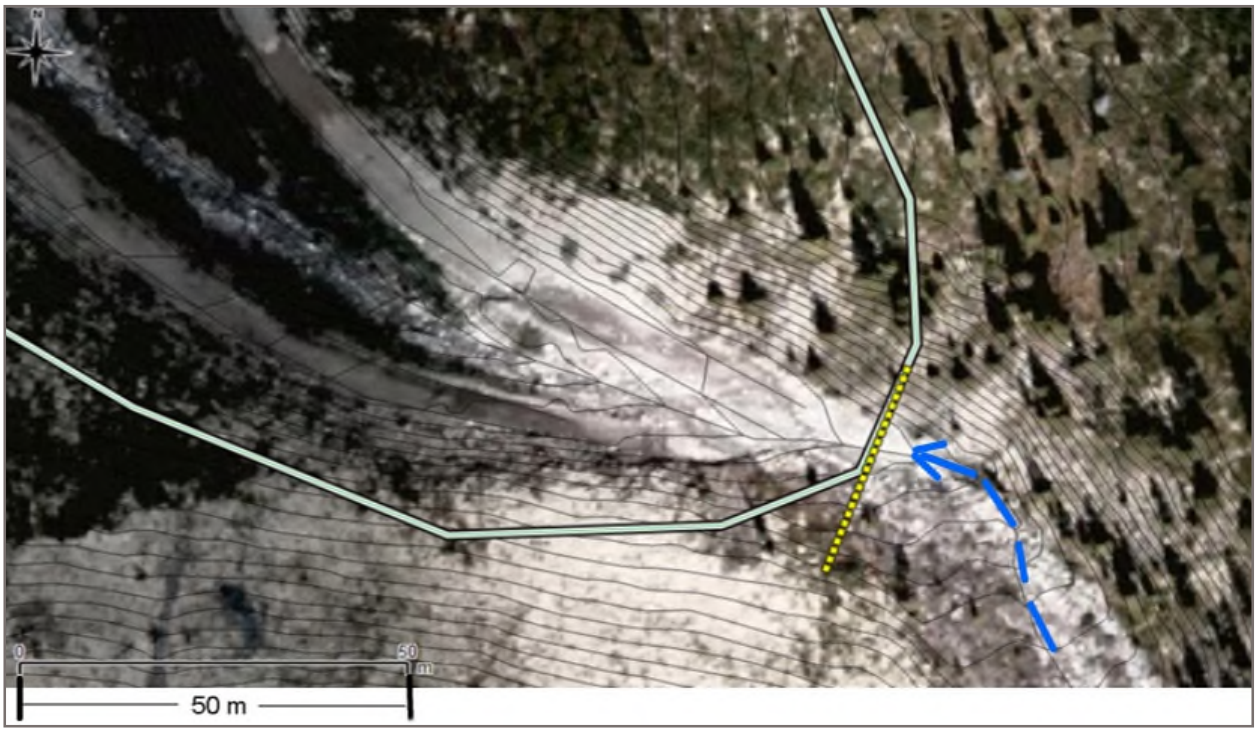


Figure 4: KP 13.4, Funeral Creek. 2014 road alignment shown on 2012 orthophoto image. Flow is right to left. Channel cross section view taken at yellow dashed line viewing downstream.

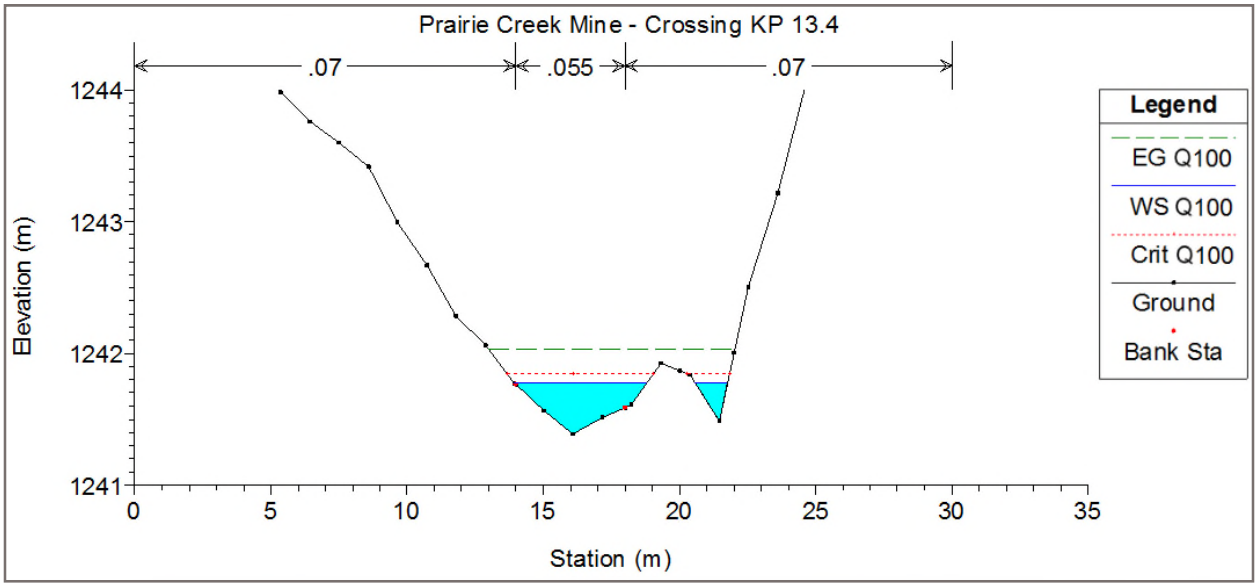


Figure 5: KP 6.1, Funeral Creek, HEC-RAS model result for 100-year flood.

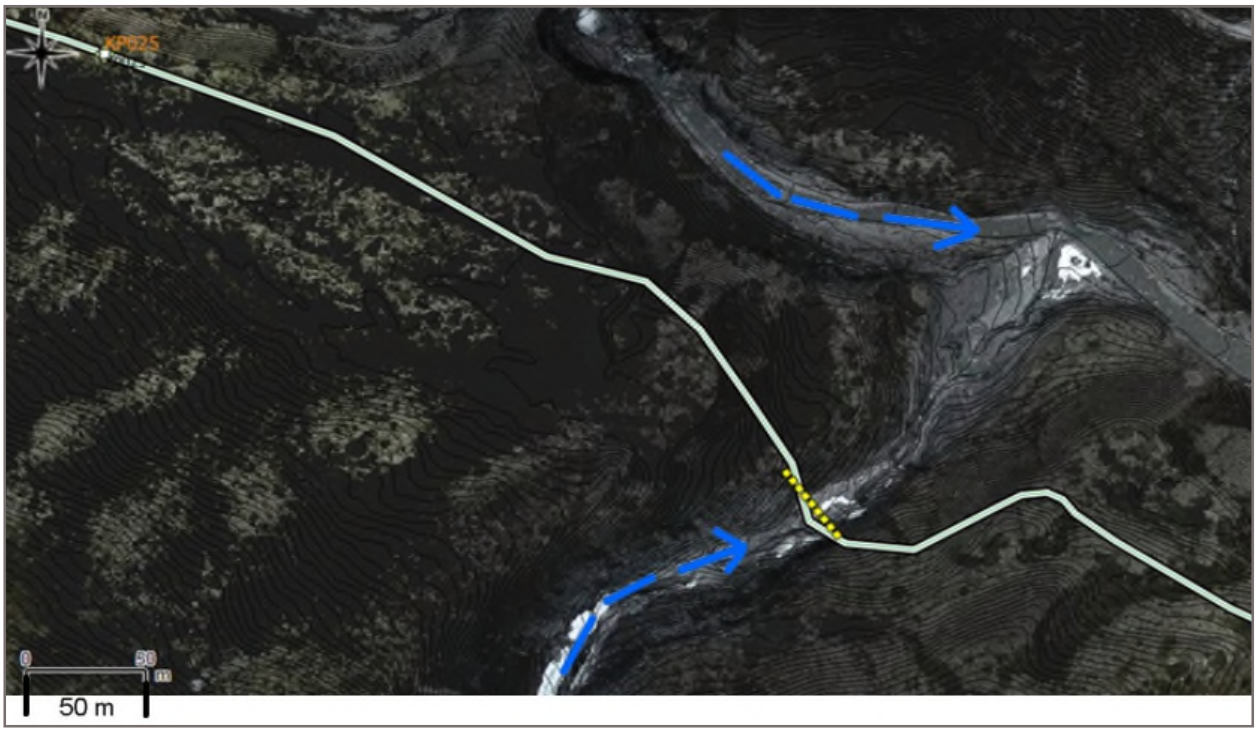


Figure 6: KP 25.3, Sundog Tributary. 2014 road alignment shown on 2012 orthophoto image. Flow is left to right. Channel cross section view taken at yellow dashed line viewing downstream.

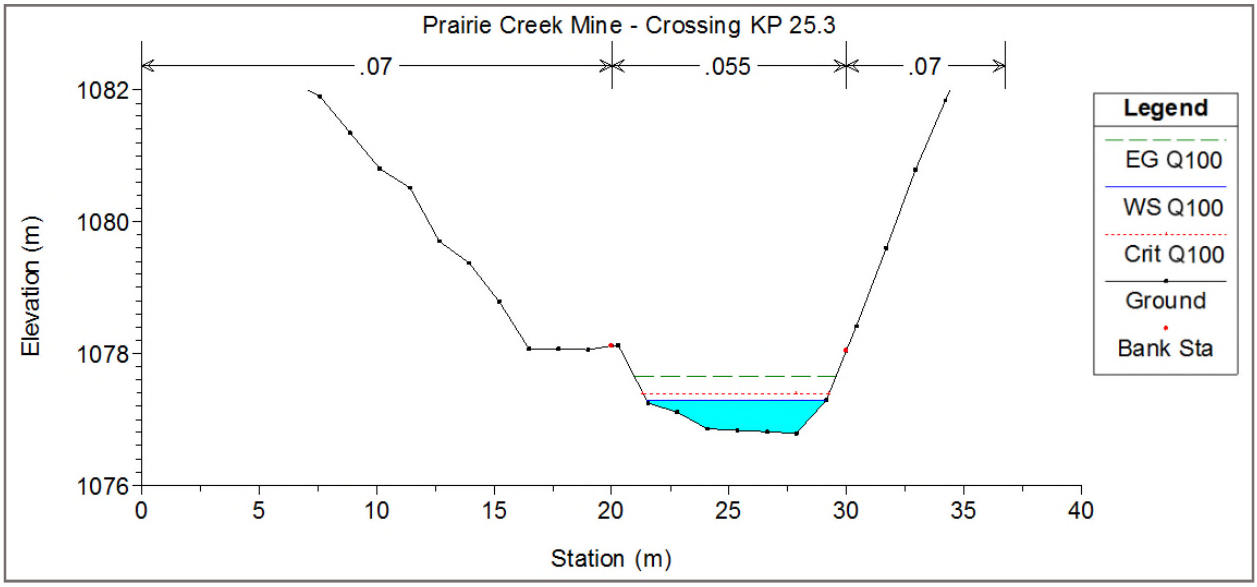


Figure 7: KP 25.3, Sundog Tributary, HEC-RAS model result for 100-year flood.

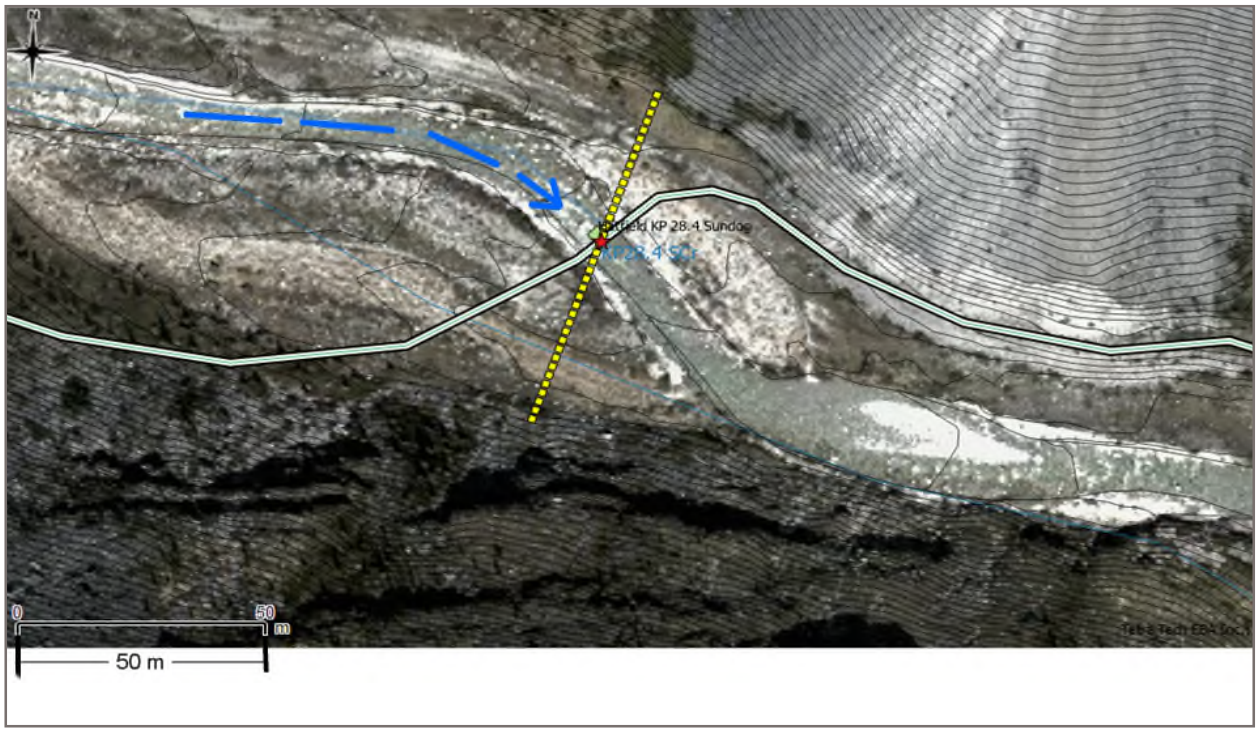


Figure 8: KP 28.4 Sundog Creek (Hatfield KP 28.4). 2014 road alignment shown on 2012 orthophoto image. Flow is left to right. Channel cross section view taken at yellow dashed line viewing downstream.

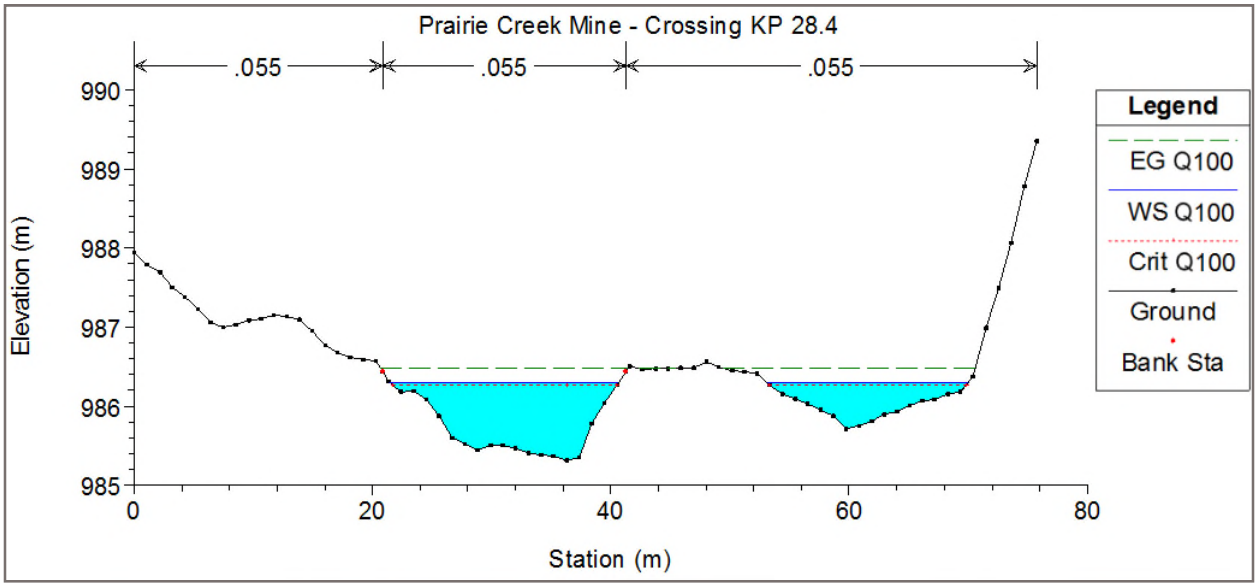


Figure 9: KP 28.4 Sundog Creek (Hatfield KP 28.4). HEC-RAS model result for 100-year flood. Note that split flow is expected under flood conditions.

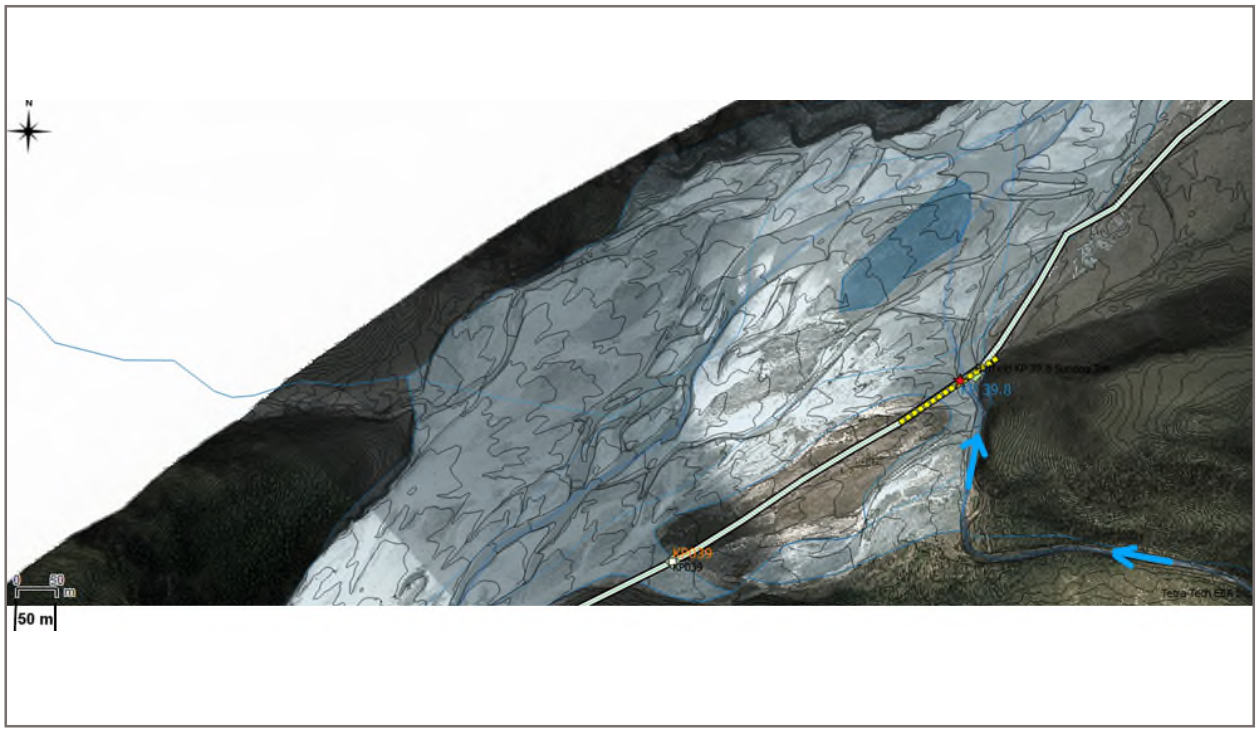


Figure 10: KP 39.4 Sundog Trib. (Hatfield KP 39.8). 2014 road alignment shown on 2012 orthophoto image. Flow is bottom to top. Channel cross section view taken at yellow dashed line viewing downstream. Note that crossing location may also receive split flow from Sundog Creek main channel.

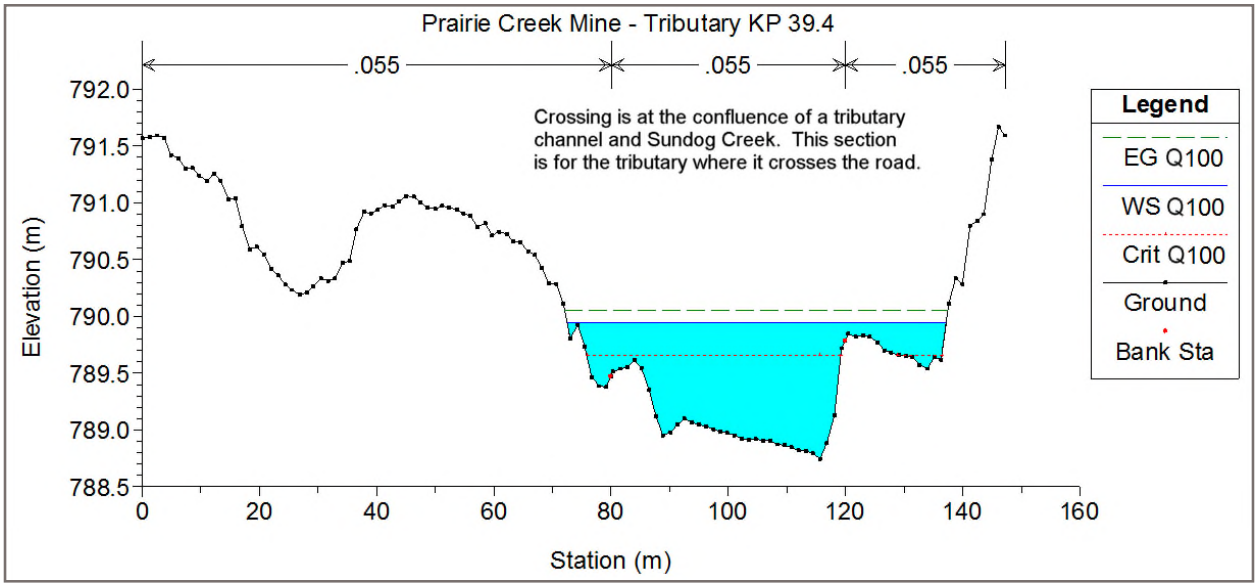


Figure 11: KP 39.4 Sundog Trib. (Hatfield KP 39.8). HEC-RAS model result for 100-year flood. See Figures 12 and 13 for water level determined for Sundog Creek main channel at this same location.

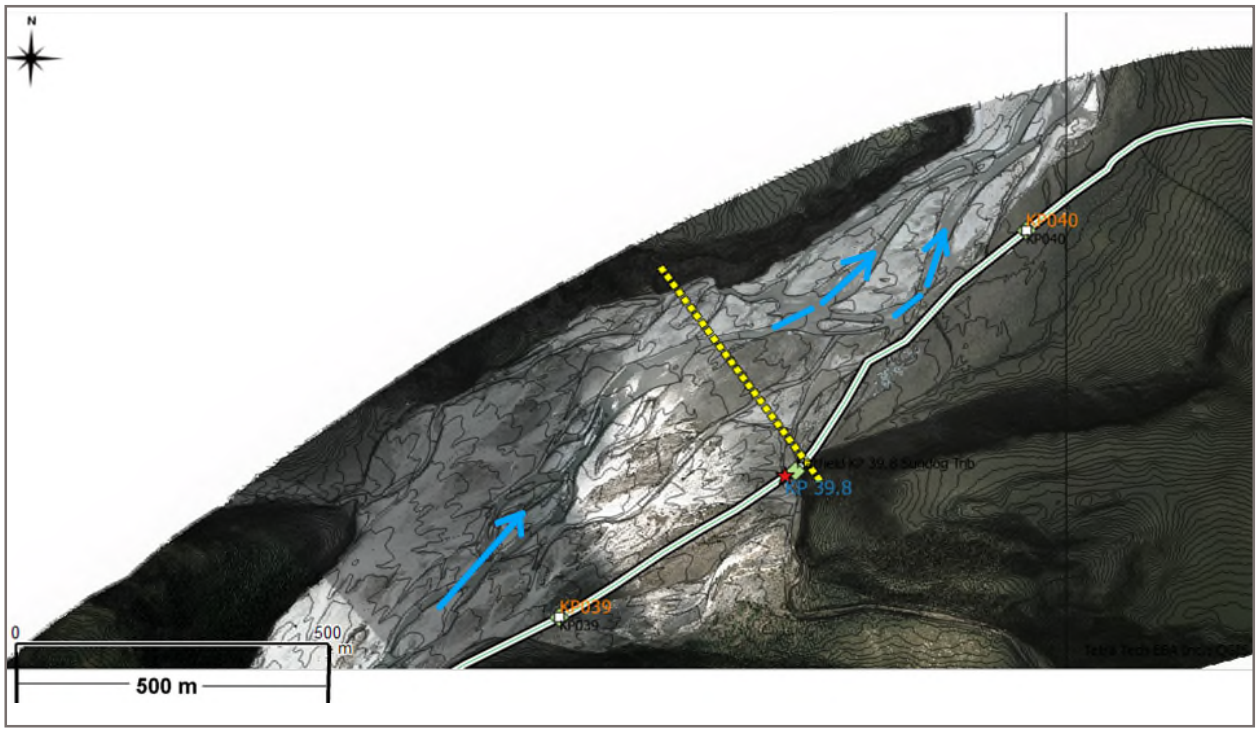


Figure 12: KP 39.4 Sundog Creek main channel at confluence with tributary (Hatfield KP 39.8). 2014 road alignment shown on 2012 orthophoto image. Flow is left to right. Channel cross section view taken at yellow dashed line viewing downstream.

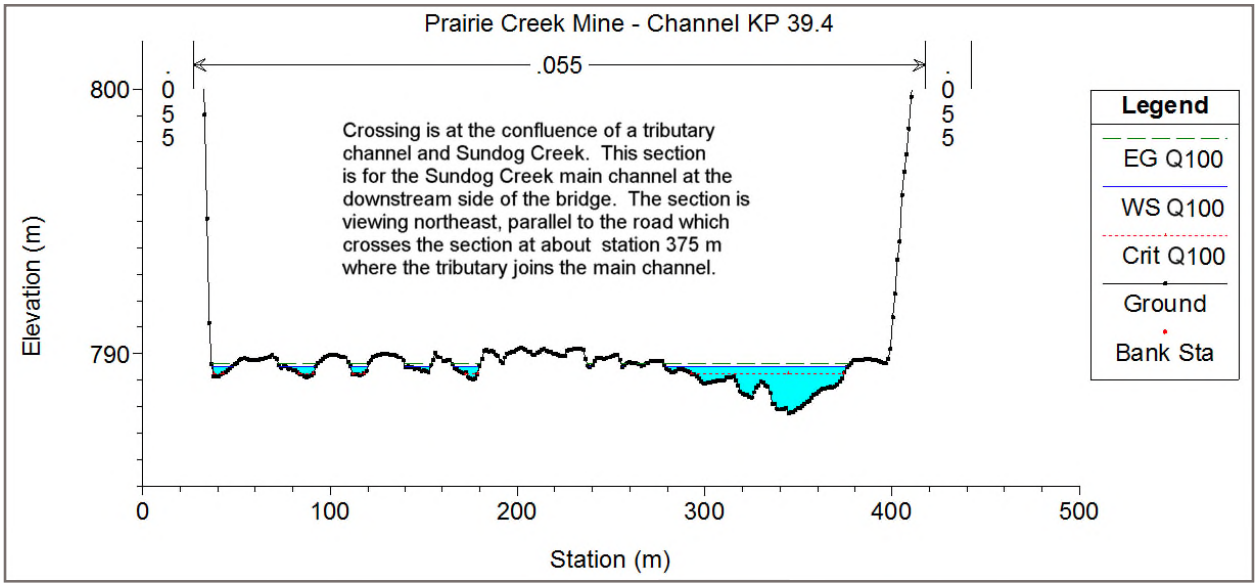


Figure 13: KP 39.4 Sundog Creek main channel at confluence with tributary (Hatfield KP 39.8). HEC-RAS model result for 100-year flood.

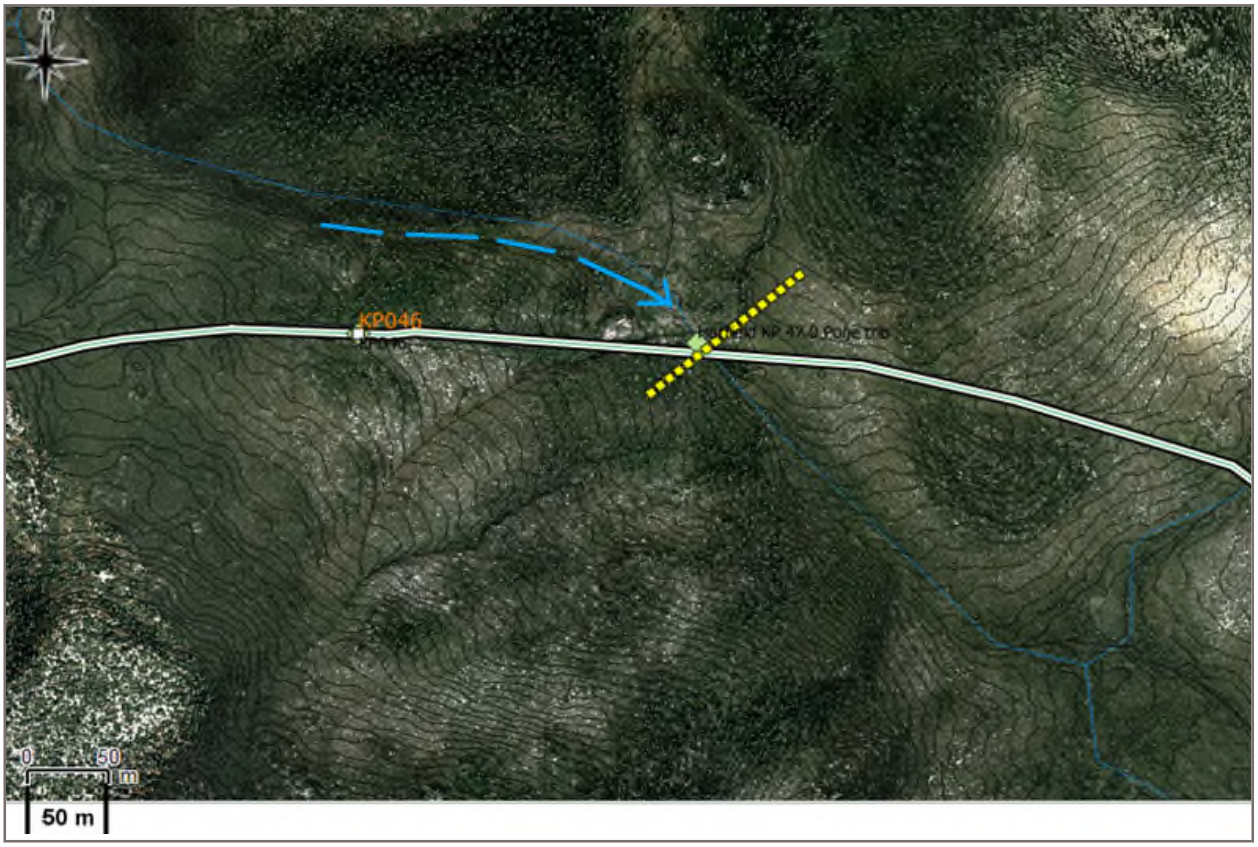


Figure 14: KP 46.2 Polje Trib. (Hatfield KP 47.0). 2014 road alignment shown on 2012 orthophoto image. Flow is left to right. Channel cross section view taken at yellow dashed line viewing downstream.

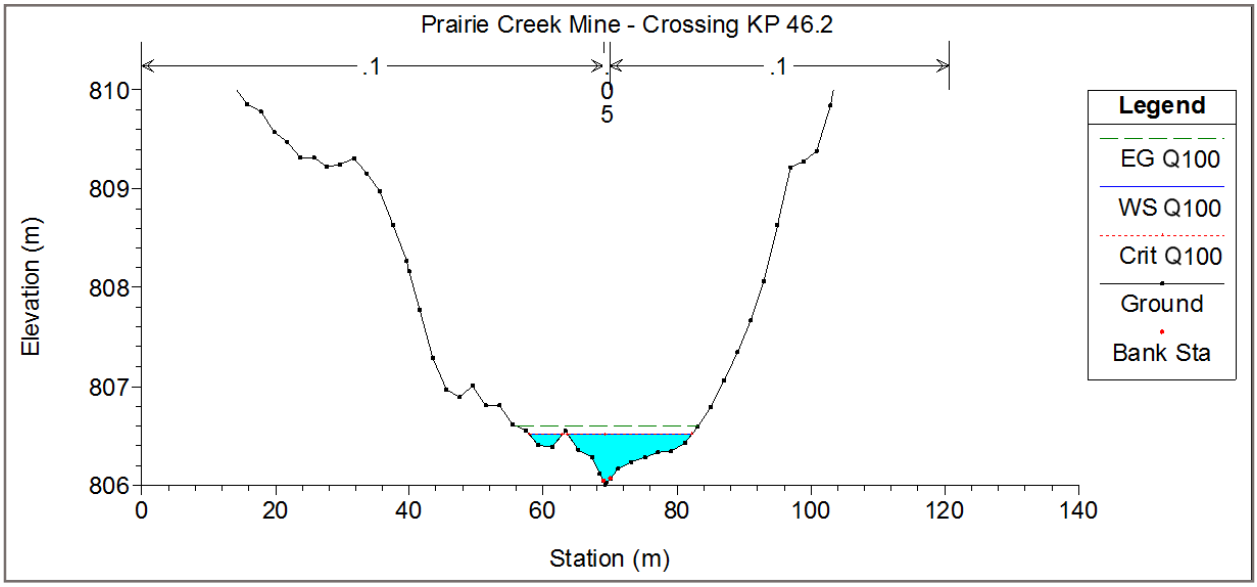


Figure 15: KP 46.2 Polje Trib. (Hatfield KP 47.0). HEC-RAS model result for 100-year flood.

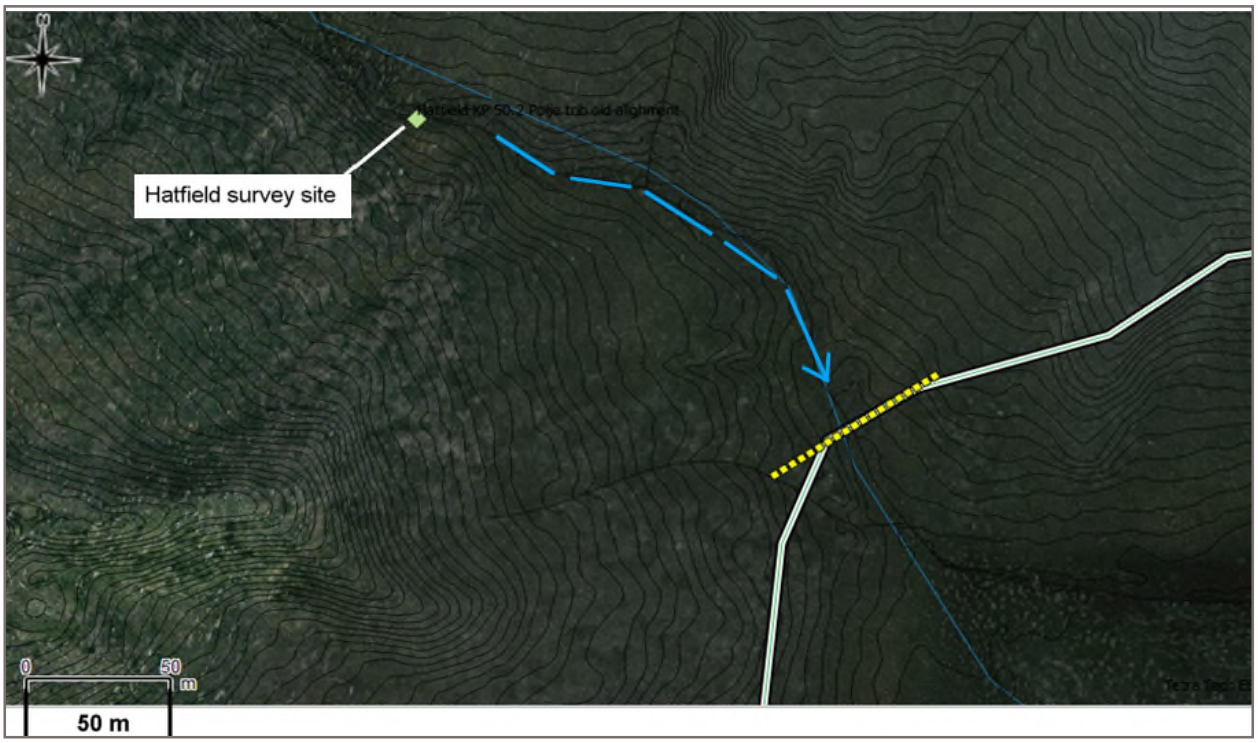


Figure 16: KP 49.6 Polje Trib. (Hatfield KP 50.2). 2014 road alignment shown on 2012 orthophoto image. Flow is top to bottom. Channel cross section view taken at yellow dashed line viewing downstream. Hatfield aquatic survey on this stream is at location shown, upstream from the 2014 road alignment.

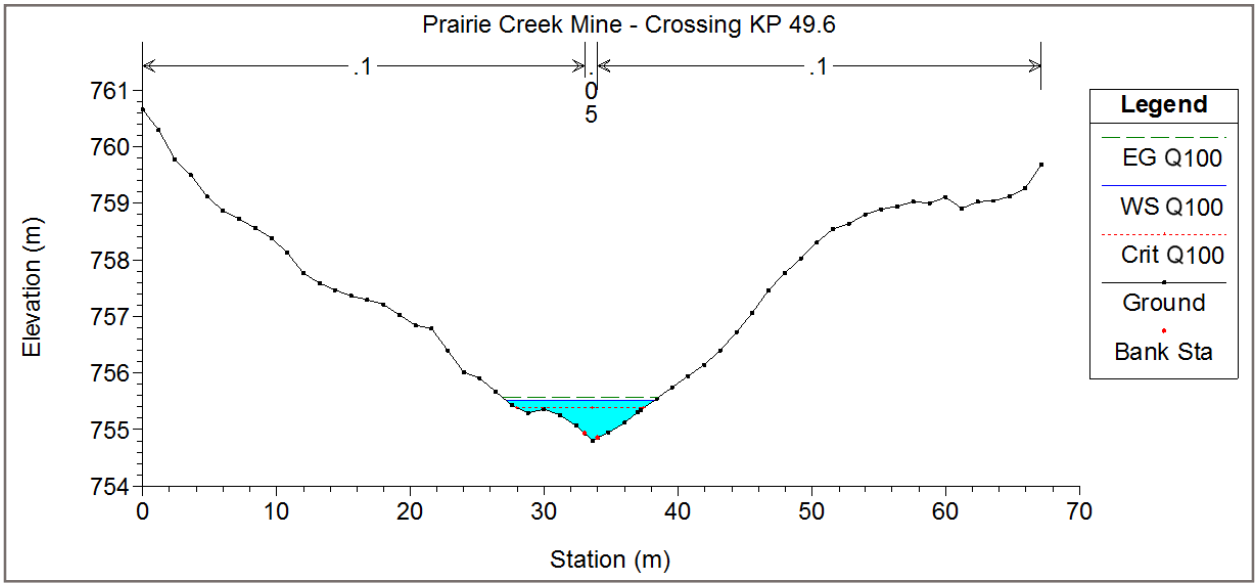


Figure 17: KP 49.6 Polje Trib. (Hatfield KP 50.2). HEC-RAS model result for 100-year flood.

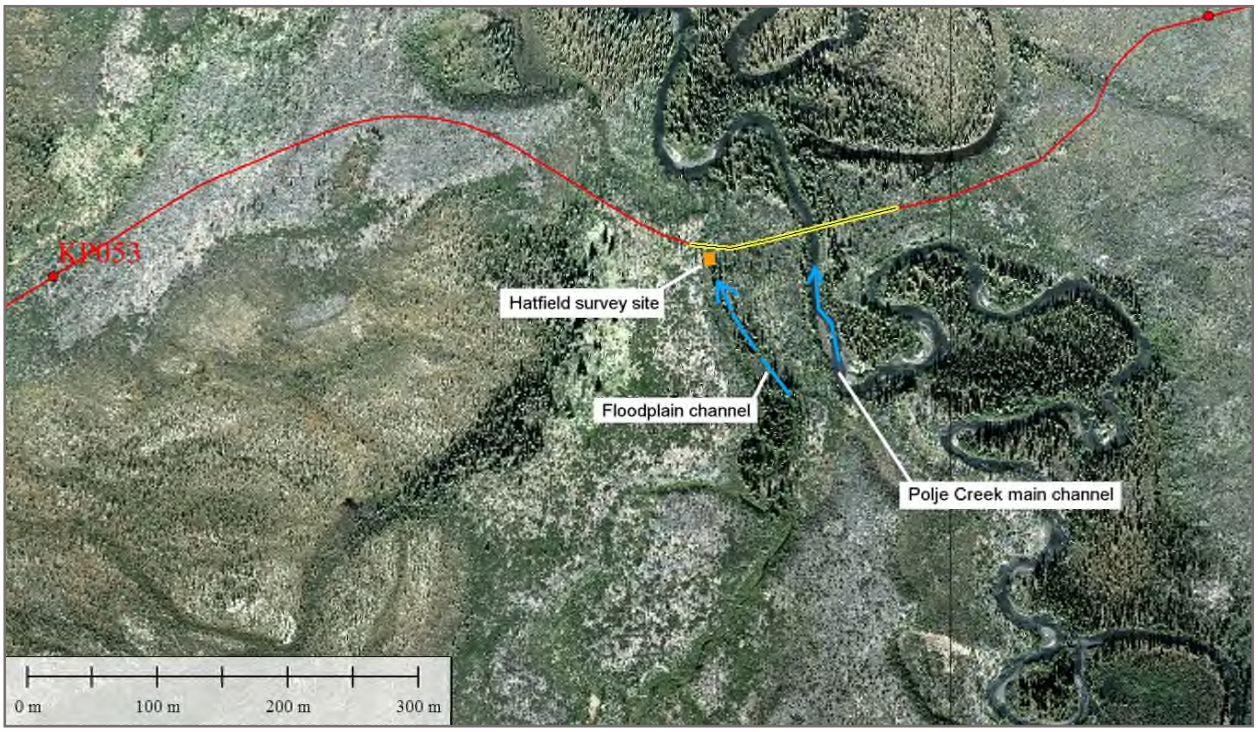


Figure 18: KP 53.6 Polje Trib. (Hatfield KP 54.3). 2014 road alignment shown on 2012 orthophoto image. Flow is bottom to top. Channel cross section view taken at yellow line viewing downstream.

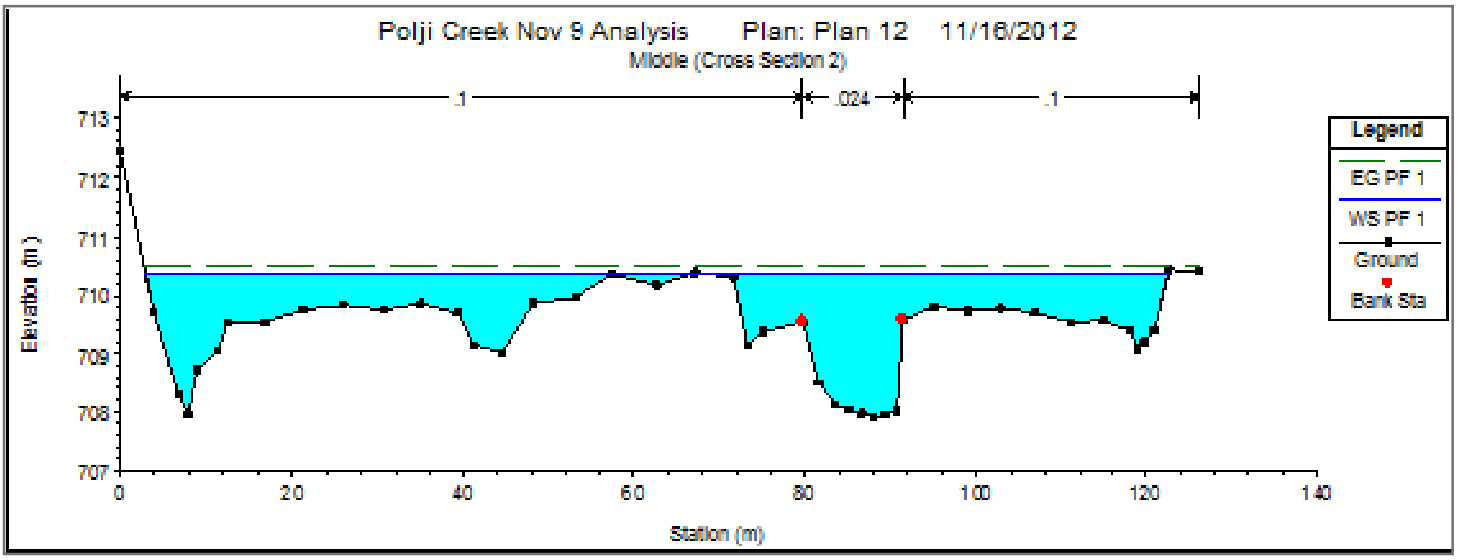


Figure 19: KP 53.6 Polje Trib. (Hatfield KP 54.3). HEC-RAS model results copied from analysis done in 2012 for 100-year flood on Polje Creek. The channel identified in Hatfield 2014 records as Polje Trib at KP 54.3 is located between about Stations 5 m and 10 m in the above figure. The main Polje Creek channel is located between about Stations 80 and 90 m.

Figure 20: KP 87.4 Tetcela Trib at Old Road. 2014 road alignment shown on 2012 orthophoto image. Flow is top to bottom. Channel cross section view taken at yellow dashed line viewing downstream.

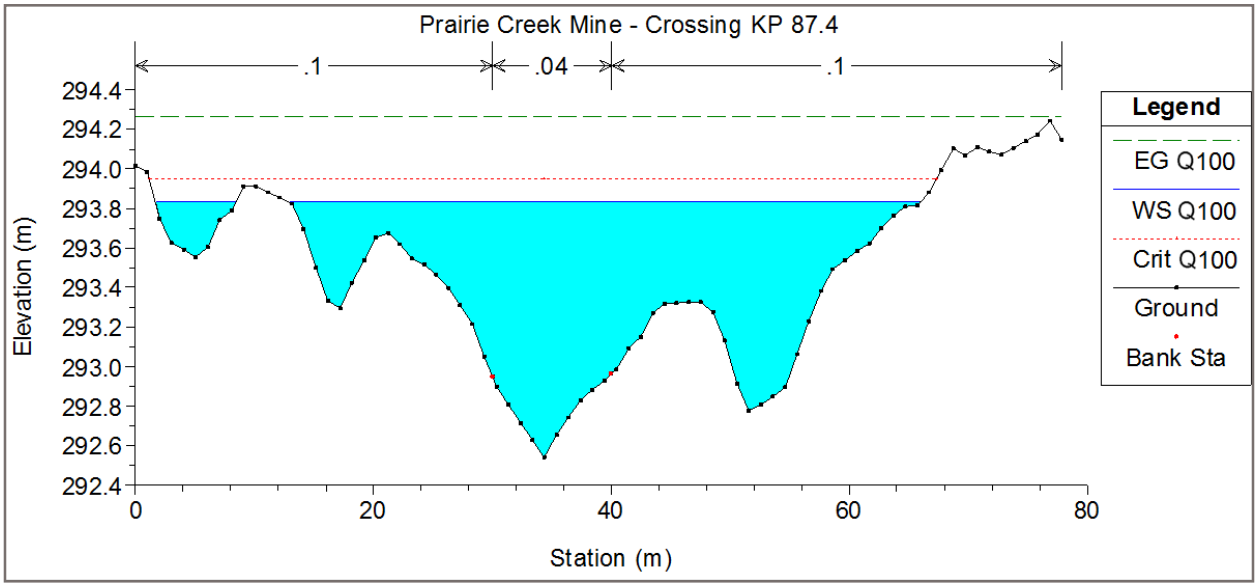


Figure 21: KP 87.4 Tetcela Trib at Old Road. HEC-RAS model result for 100-year flood. Single section methodology used for preliminary calculations may not accurately characterize flows though this reach due to rapidly-varying channel width which narrows to less than 20 m at a constriction immediately downstream from the crossing.

Figure 22: KP 89.7 Tetcela Mainstem at Old Road. 2014 road alignment shown on 2012 orthophoto image. Flow is bottom to top. Channel cross section view taken at yellow dashed line viewing downstream.

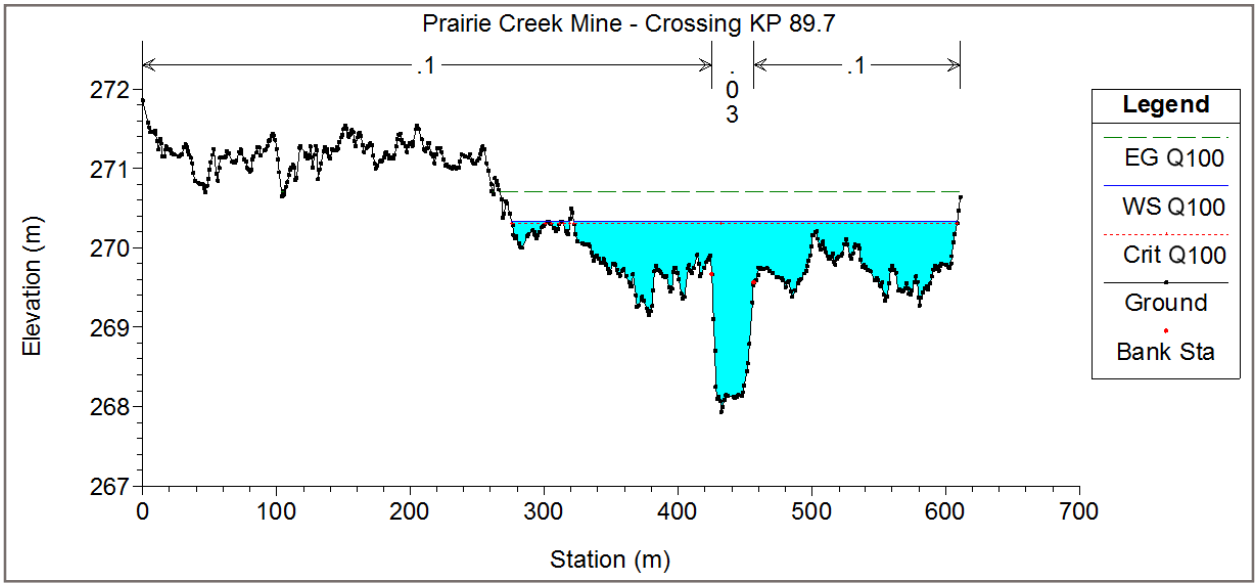


Figure 23: KP 89.7 Tetcela Mainstem at Old Road. HEC-RAS model result for 100-year flood.

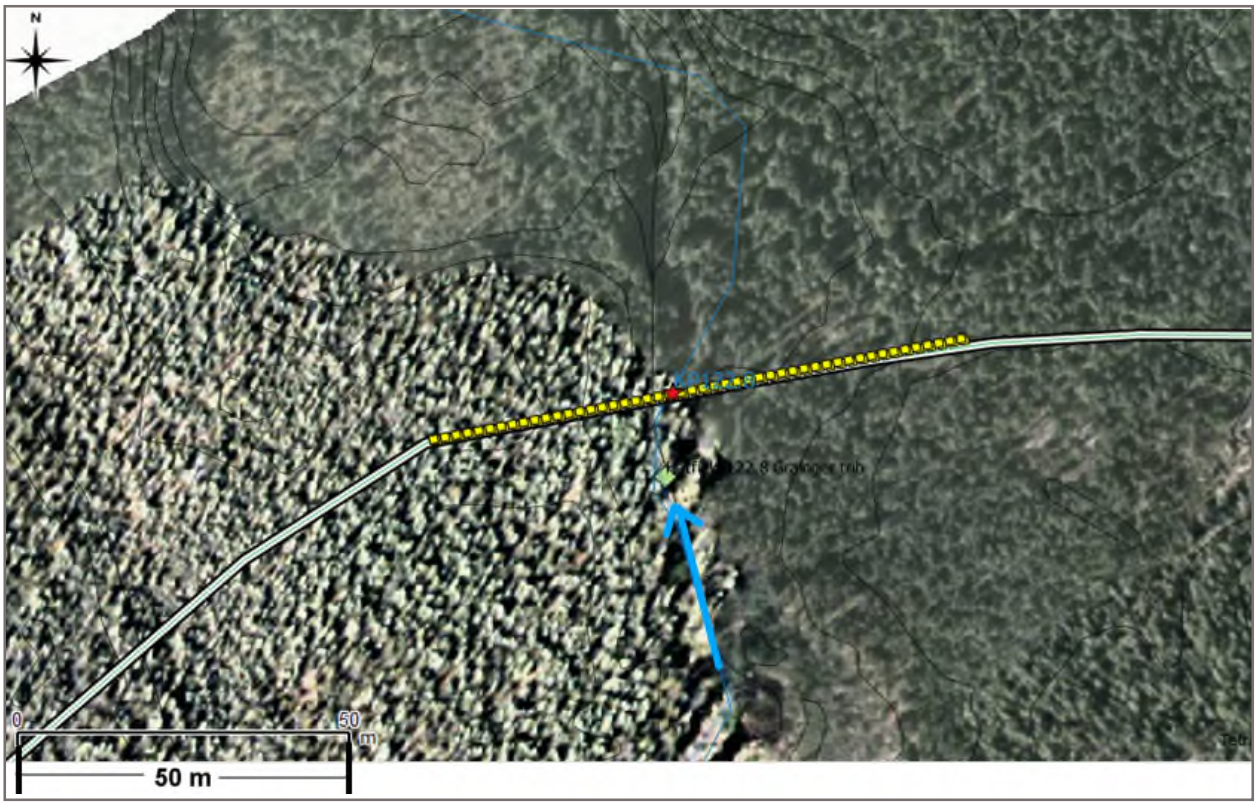


Figure 24: KP 122.4 Grainger Trib. (Hatfield KP 122.8). 2014 road alignment shown on 2012 orthophoto image. Flow is bottom to top. Channel cross section view taken at yellow dashed line viewing downstream.

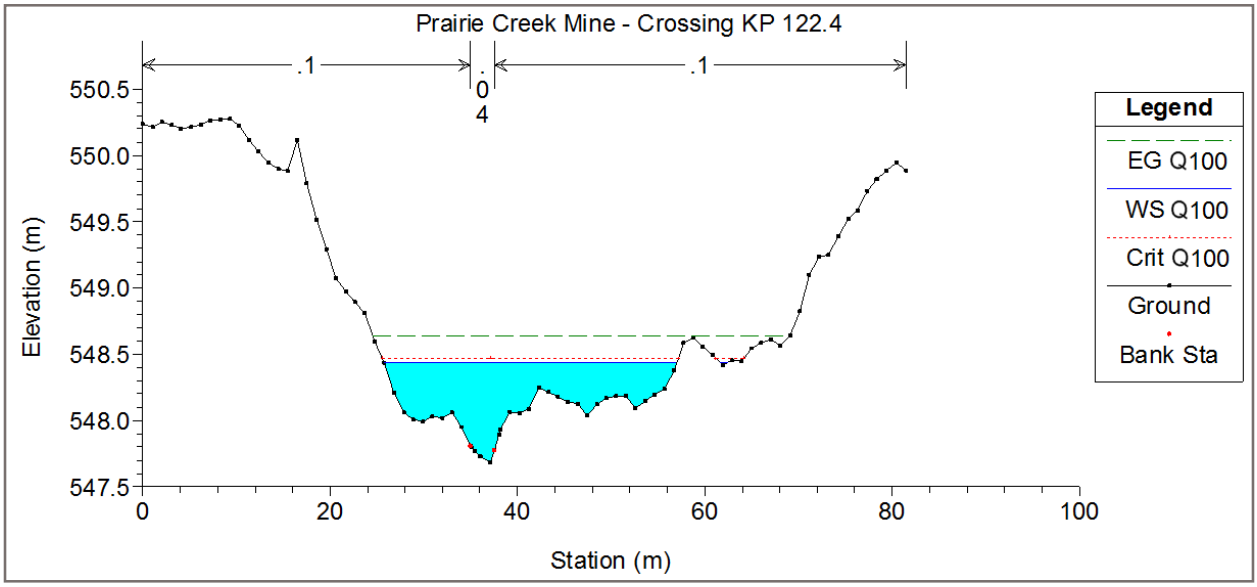


Figure 25: KP 122.4 Grainger Trib. (Hatfield KP 122.8). HEC-RAS model result for 100-year flood.

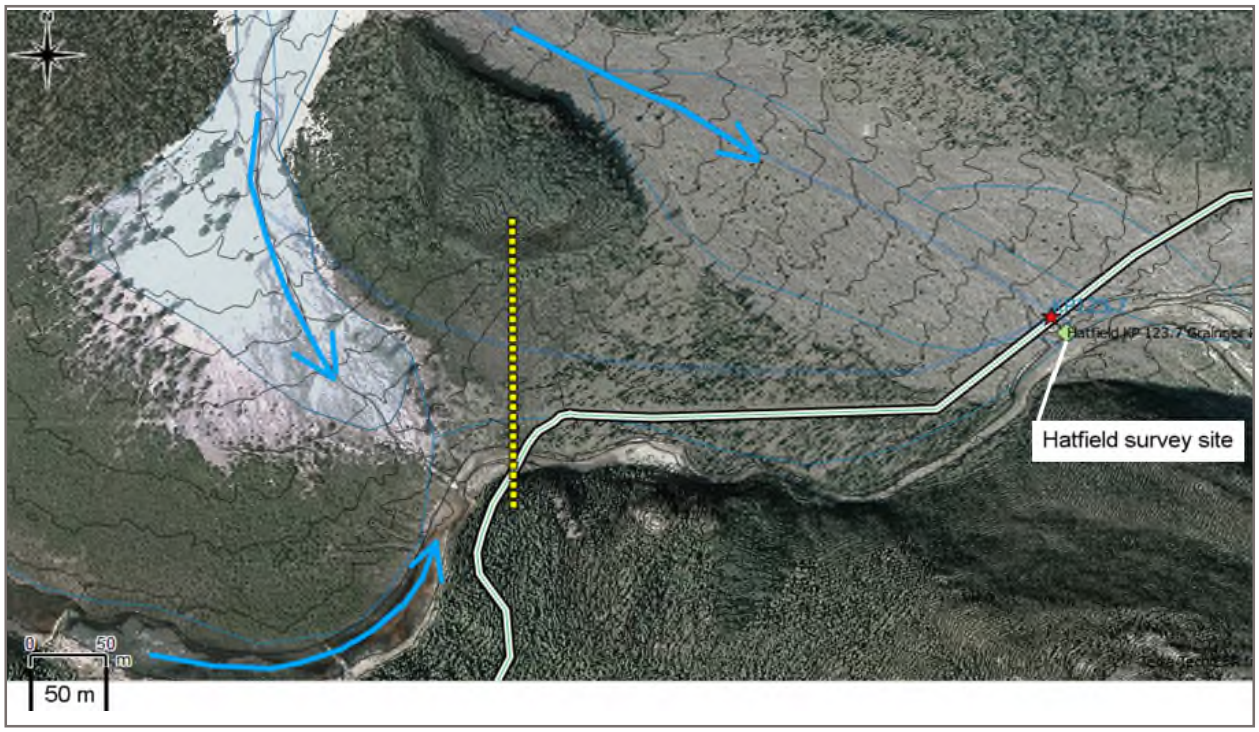


Figure 26: KP 123.4 Grainger River (Hatfield KP 123.7). 2014 road alignment shown on 2012 orthophoto image. Flow is generally left to right. Channel cross section view taken at yellow dashed line viewing downstream. The major watershed above the road crossing is from the north, and flood condition split flows are possible as indicated by the upper flow arrows. The scenario assumed for hydraulic modelling

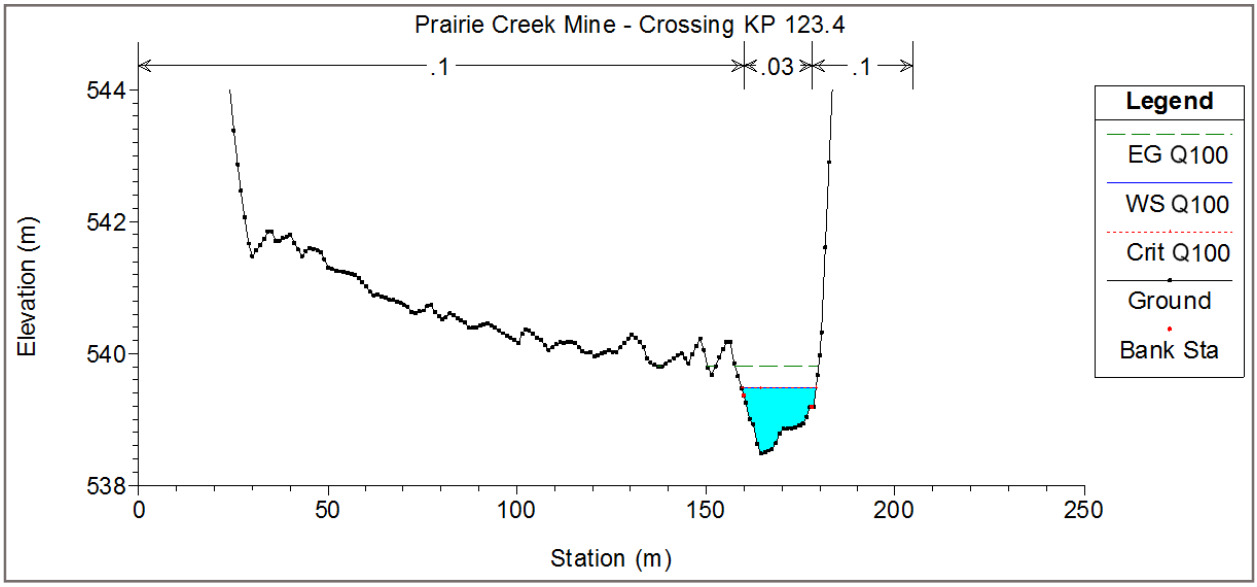


Figure 27: KP 123.4 Grainger River (Hatfield KP 123.7). HEC-RAS model result for 100-year flood.

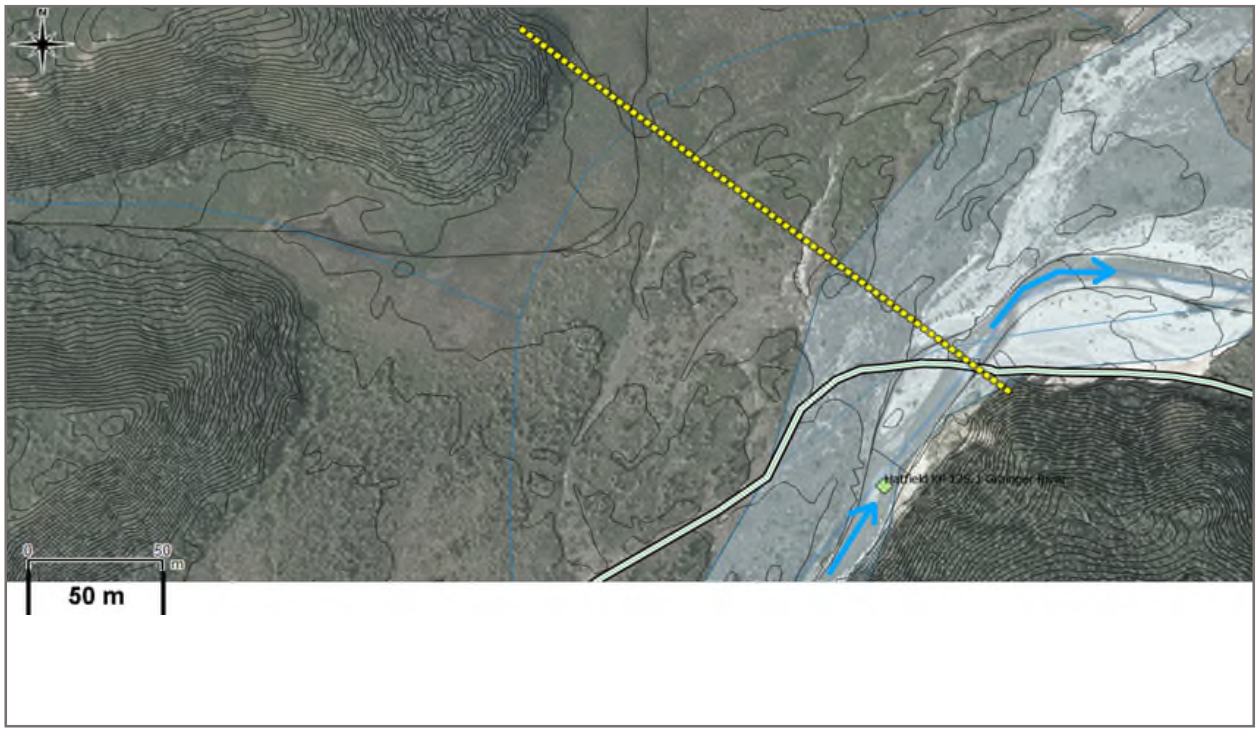


Figure 28: KP 124.8 Grainger River (Hatfield KP 125.1). 2014 road alignment shown on 2012 orthophoto image. Flow is generally left to right. Channel cross section view taken at yellow dashed line viewing downstream.

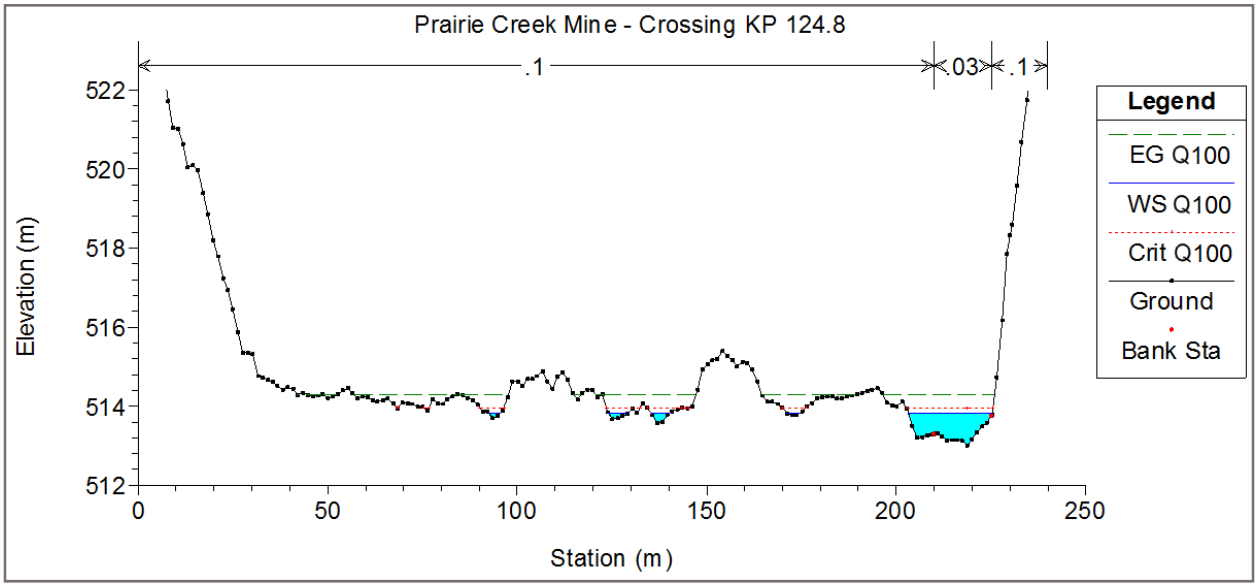


Figure 29: KP 124.8 Grainger River (Hatfield KP 125.1). HEC-RAS model result for 100-year flood.

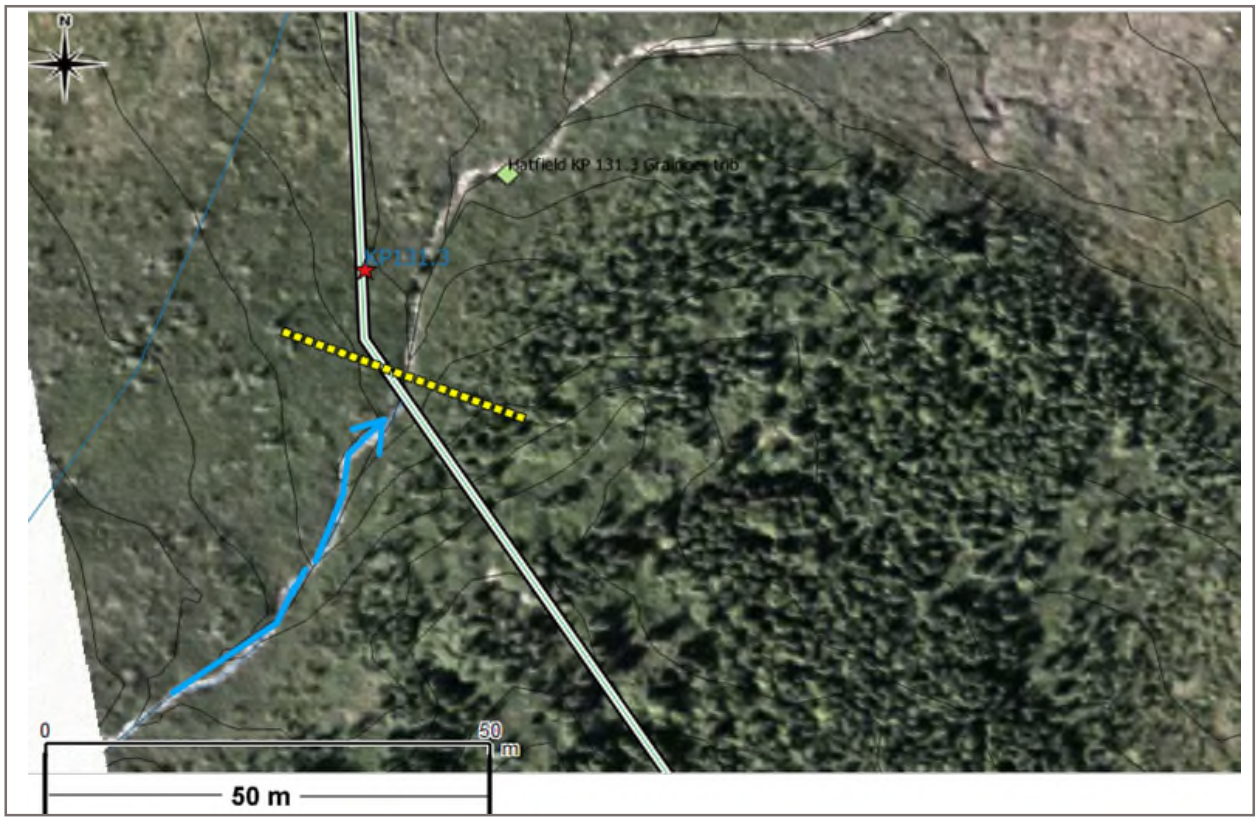


Figure 30: KP 131.2 Grainger Trib. (Hatfield KP 131.3). 2014 road alignment shown on 2012 orthophoto image. Flow is generally left to right. Channel cross section view taken at yellow dashed line viewing

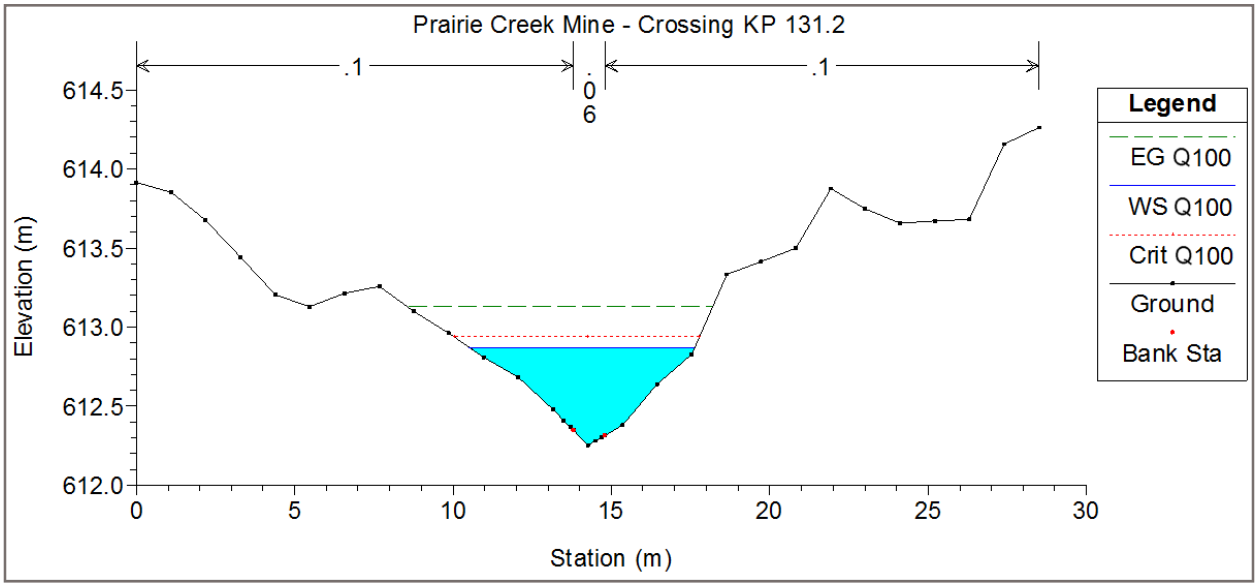


Figure 31: KP 131.2 Grainger Trib. (Hatfield KP 131.3). HEC-RAS model result for 100-year flood.

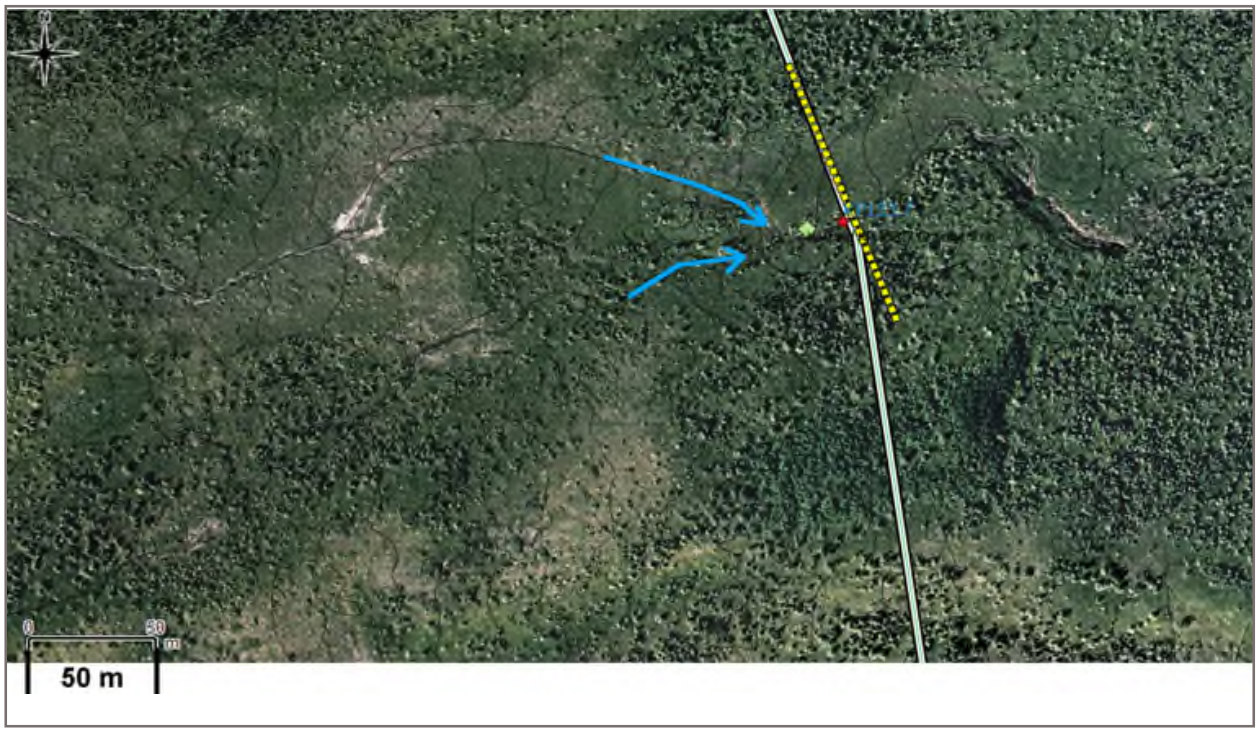


Figure 32: KP 133.2 Grainger Trib. (Hatfield KP 133.7). 2014 road alignment shown on 2012 orthophoto image. Flow is left to right. Channel cross section view taken at yellow dashed line viewing downstream.

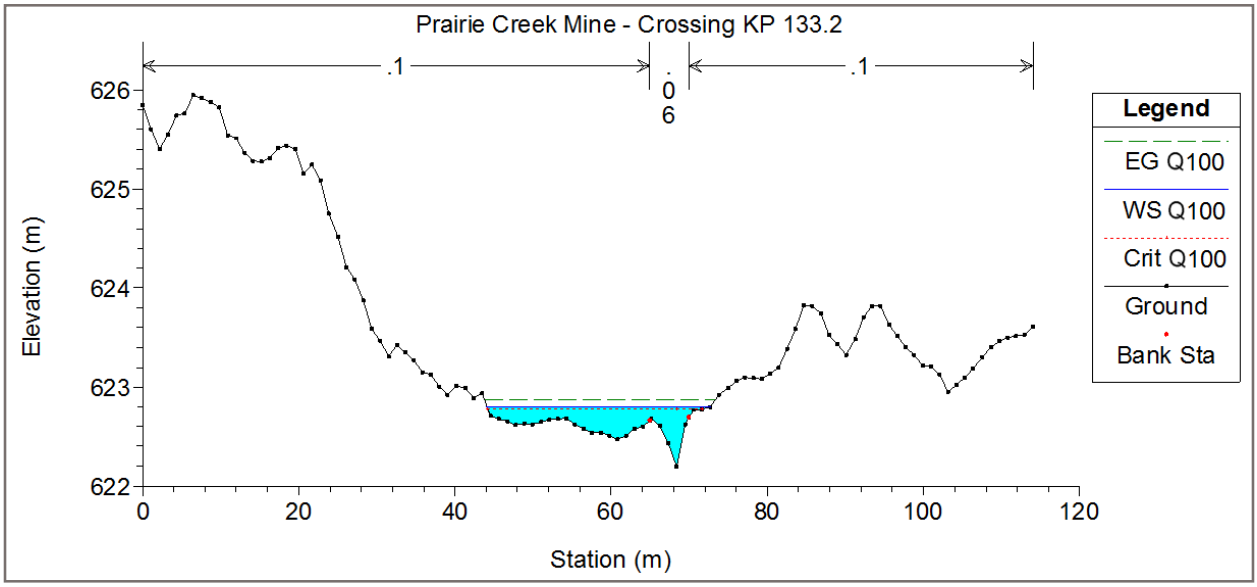


Figure 33: KP 133.2 Grainger Trib. (Hatfield KP 133.7). HEC-RAS model result for 100-year flood.

Figure 34: KP 134.9 Grainger Trib. (Hatfield KP 135.6). 2014 road alignment shown on Google Earth image. Flow is left to right. 2012 LiDAR data and orthophoto imagery not available for the 2014 crossing location due to alignment change. Channel cross section view taken at yellow dashed line viewing downstream, and located downstream from road crossing in reach with available LiDAR data.

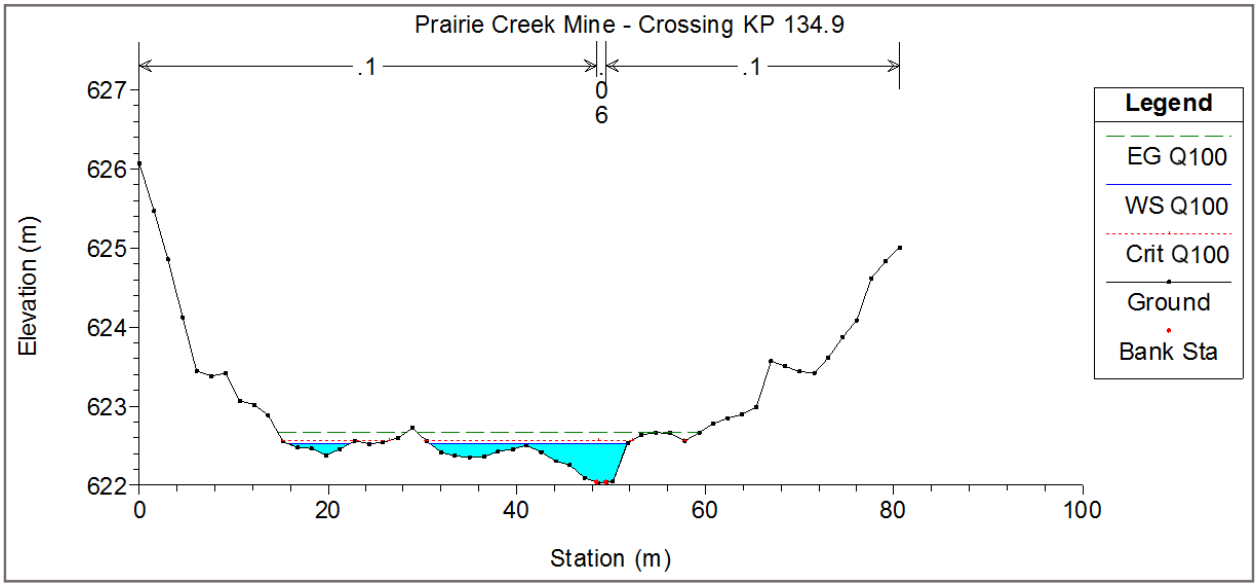


Figure 35: KP 134.9 Grainger Trib. (Hatfield KP 135.6). HEC-RAS model result for 100-year flood at section located about 300 m downstream of road crossing where LiDAR elevation data are available. Modelled flow depths and widths (but not elevations) should be similar to those that will occur at the road crossing.

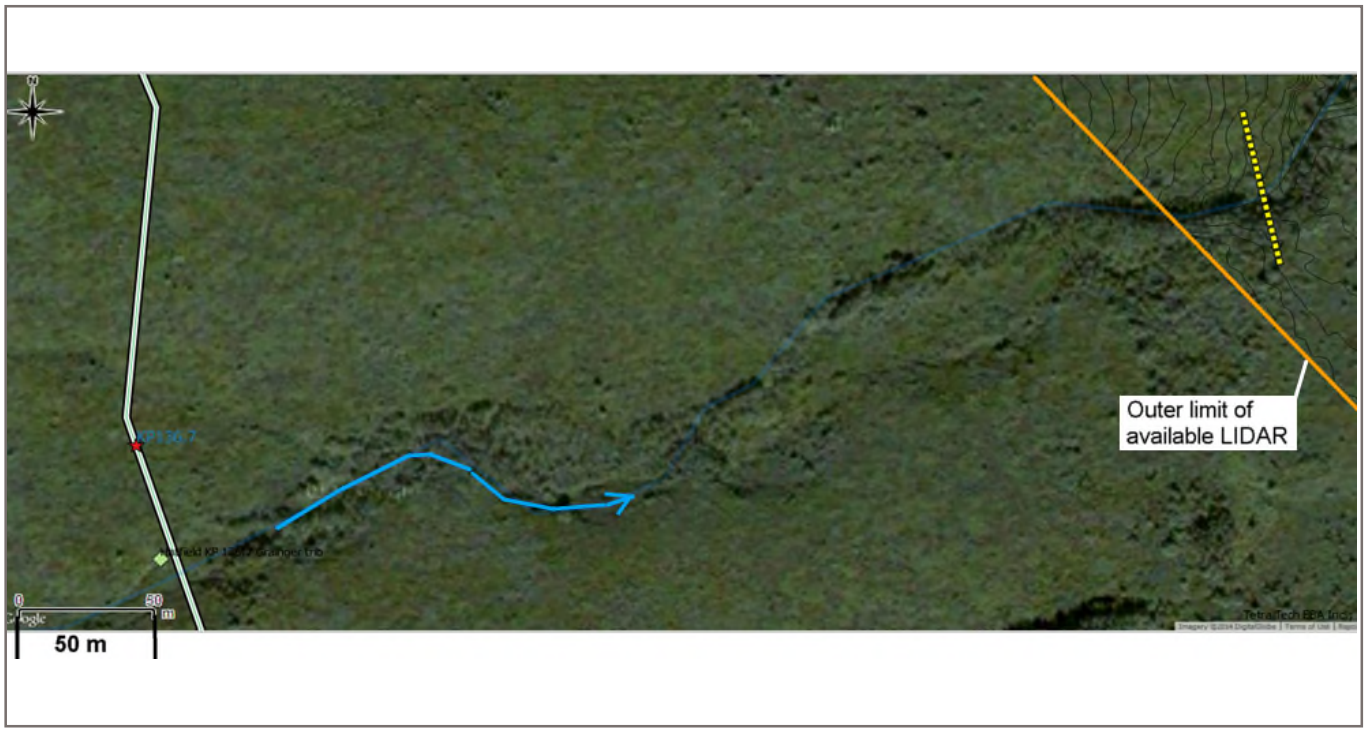


Figure 36: KP 136.5 Grainger Trib. (Hatfield KP 136.7). 2014 road alignment shown on Google Earth image. Flow is left to right. 2012 LiDAR data and orthophoto imagery not available for the 2014 crossing location due to alignment change. Channel cross section view taken at yellow dashed line viewing downstream, and located downstream from road crossing in reach with available LiDAR data.

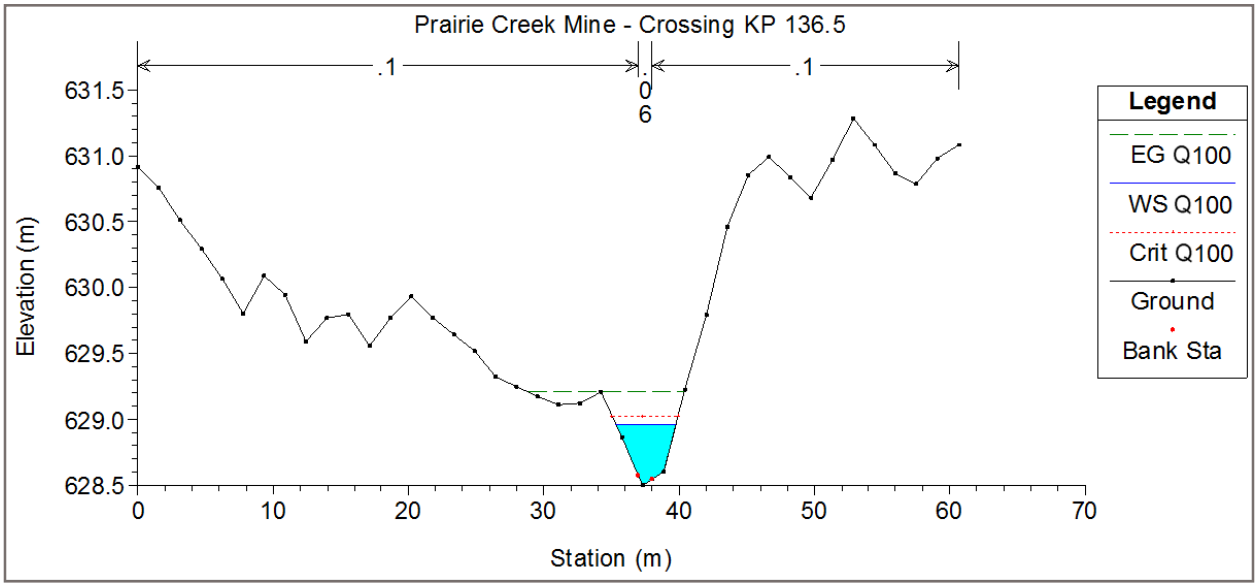


Figure 37: KP 136.5 Grainger Trib. (Hatfield KP 136.7). HEC-RAS model result for 100-year flood at section located about 400 m downstream of road crossing where LiDAR elevation data are available. Modelled flow depths and widths (but not elevations) should be similar to those that will occur at the road crossing.

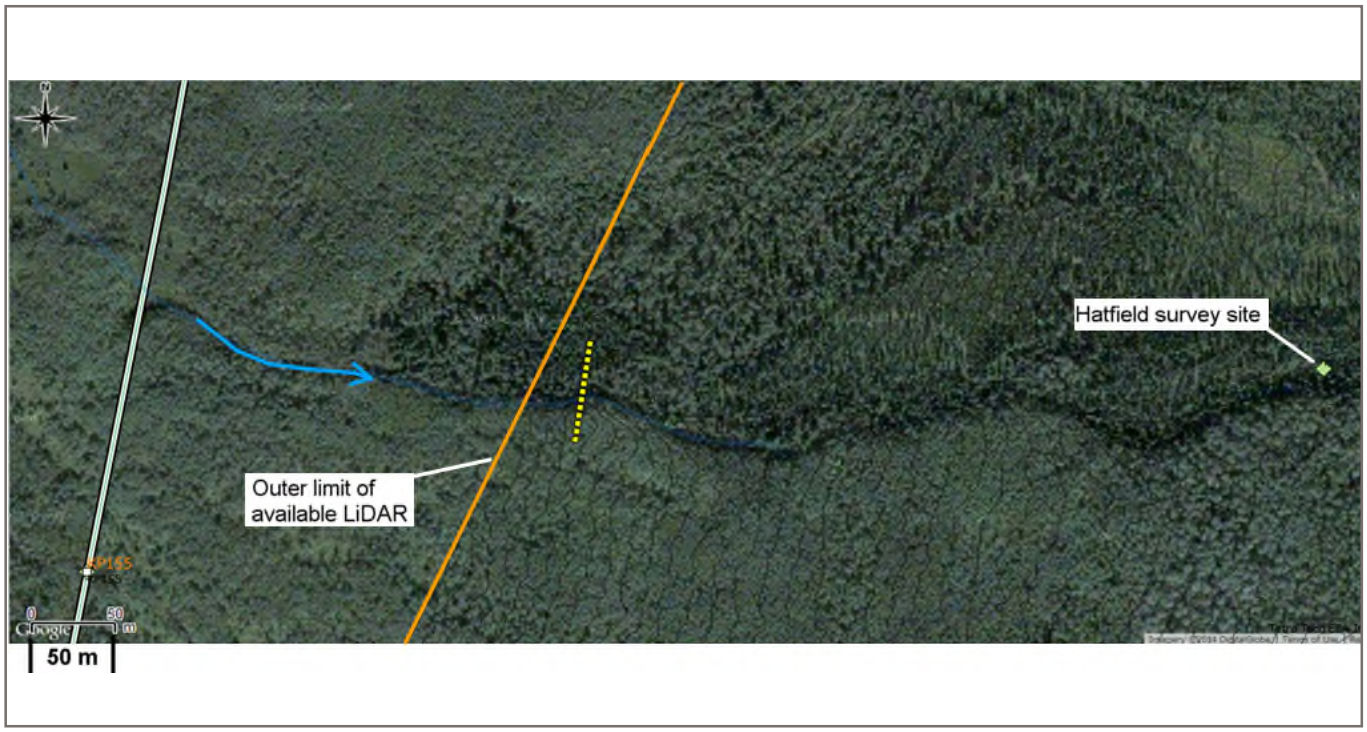


Figure 38: KP 154.9 Liard Trib. (Hatfield KP 154.4). 2014 road alignment shown on Google Earth image. Flow is left to right. 2012 LiDAR data and orthophoto imagery not available for the 2014 crossing location due to alignment change. Channel cross section view taken at yellow dashed line viewing downstream, and located downstream from road crossing in reach with available LiDAR data.

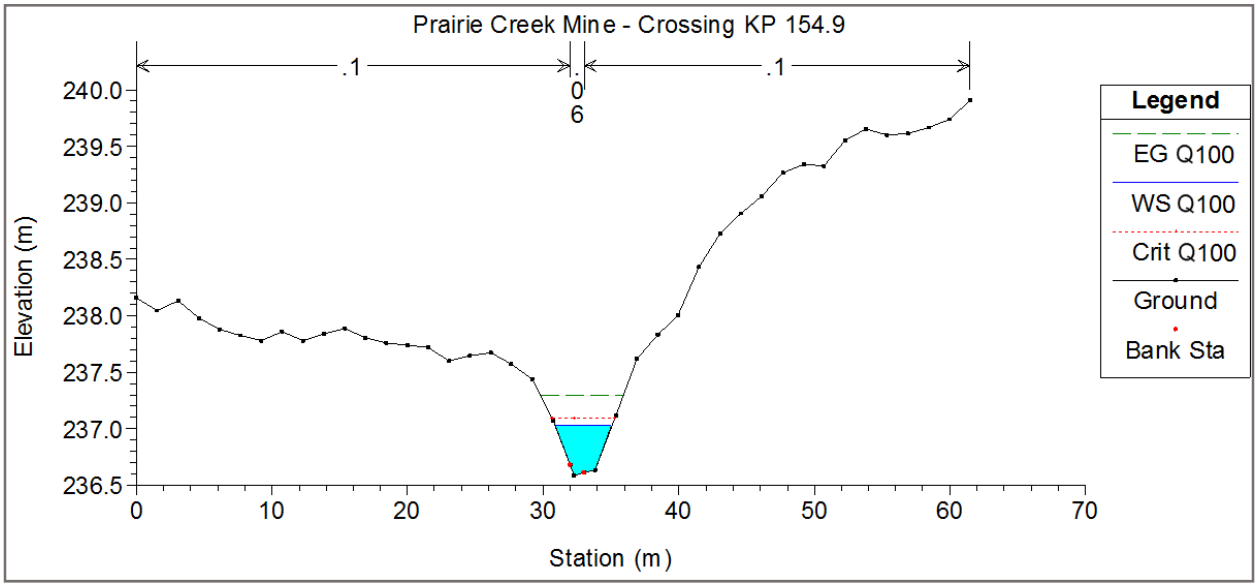


Figure 39: KP 154.9 Liard Trib. (Hatfield KP 154.4). HEC-RAS model result for 100-year flood at section located about 300 m downstream of road crossing where LiDAR elevation data are available. Modelled flow depths and widths (but not elevations) should be similar to those that will occur at the road crossing.

PHOTOGRAPHS

Photo 1: KP 6.1, Casket Creek. Aerial image viewing upstream, 2008. Active alluvial fan area with split flows and shifting of the main channel being likely during major flood events.

Photo 2: KP 6.1, Casket Creek. Ground image viewing upstream to bridge, 2008.

Photo 3: KP 6.1, Funeral Creek. View upstream to incised channel at original hairpin crossing. New crossing will be about 50 m upstream from original crossing.

Photo 4: KP 6.1, Funeral Creek. View downstream at original hairpin crossing.

Photo 5: KP 25.3 Sundog Tributary. Incised channel with bedrock control.

Photo 6: KP 25.3 Sundog Tributary. Incised channel with bedrock control.

Photo 7: KP 28.4 Sundog Creek (Hatfield KP 28.4), viewing upstream.

Photo 8: KP 28.4 Sundog Creek (Hatfield KP 28.4), viewing downstream. Photo taken September 2014.

Photo 9: KP 39.4 Sundog Trib. (Hatfield KP 39.8), viewing downstream. Crossing is at confluence with main channel Sundog Creek at top of image.

Photo 10: KP 39.4 Sundog Trib. (Hatfield KP 39.8), viewing downstream along dry tributary channel. Crossing is at confluence with main channel Sundog Creek at top of image. Photo taken September 2014.

Photo 11: KP 46.2 Polje Trib. (Hatfield KP 47.0). Viewing upstream.
Photo taken September 2014.

Photo 12: KP 46.2 Polje Trib. (Hatfield KP 47.0).
Photo taken September 2014.

Photo 13: KP 49.6 Polje Trib. (Hatfield KP 50.2). Viewing upstream. Photo taken September 2014.

Photo 14: KP 53.6 Polje Trib. (Hatfield KP 54.3). Viewing upstream. Photo taken September 2014.

Photo 15: KP 53.6 Polje Trib. (Hatfield KP 54.3). Survey tape is visible, stretched across channel.

Photo 16: KP 87.4 Tetcela Trib at Old Road.

Photo 17: KP 87.4 Tetcela Trib at Old Road. Viewing downstream. Photo taken September 2014.

Photo 18: KP 89.7 Tetcela Mainstem at Old Road.

Photo 19: KP 89.7 Tetcela Mainstem at Old Road. Viewing upstream. Photo taken September 2014.

Photo 20: KP 122.4 Grainger Trib. (Hatfield KP 122.8). Viewing upstream. Photo taken September 2014.

Photo 21: KP 122.4 Grainger Trib. (Hatfield KP 122.8). Photo taken September 2014.

Photo 22: KP 123.4 Grainger River (Hatfield KP 123.7). Viewing upstream. Photo taken September 2014.

Photo 23: KP 123.4 Grainger River (Hatfield KP 123.7). Viewing downstream. Photo taken September 2014.

Photo 24: KP 124.8 Grainger River (Hatfield KP 125.1). Viewing downstream. Photo taken September 2014.

Photo 25: KP 124.8 Grainger River (Hatfield KP 125.1). Photo taken September 2014.

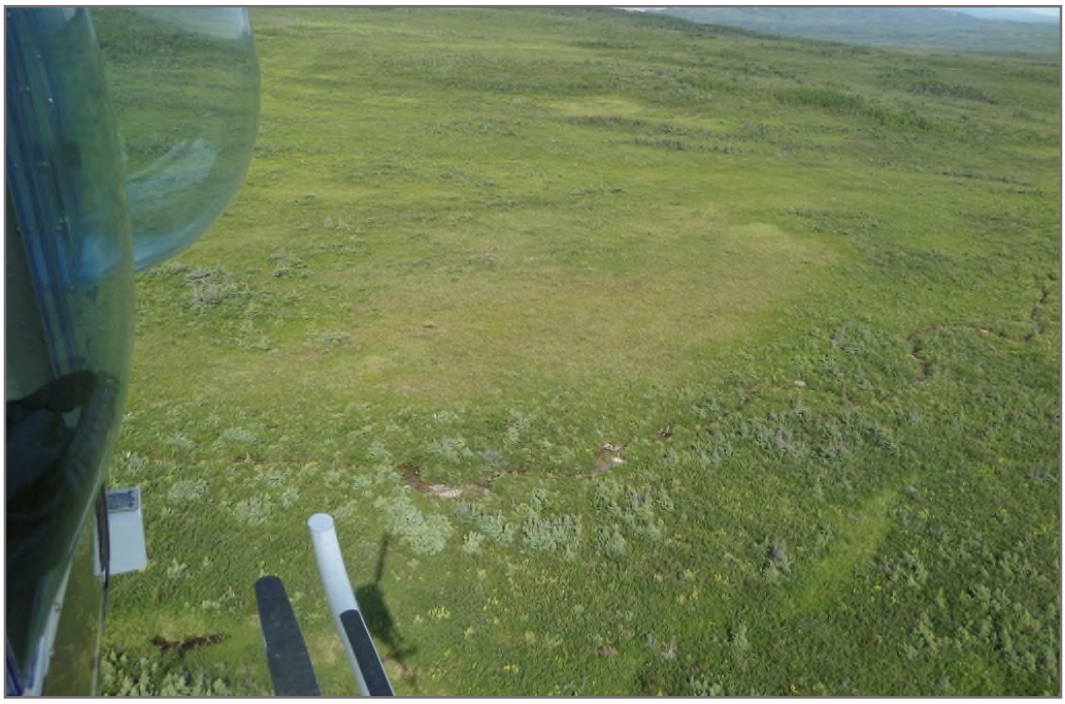


Photo 26: KP 131.2 Grainger Trib. (Hatfield KP 131.3).

Photo 27: KP 131.2 Grainger Trib. (Hatfield KP 131.3). Viewing upstream. Photo taken September 2014.

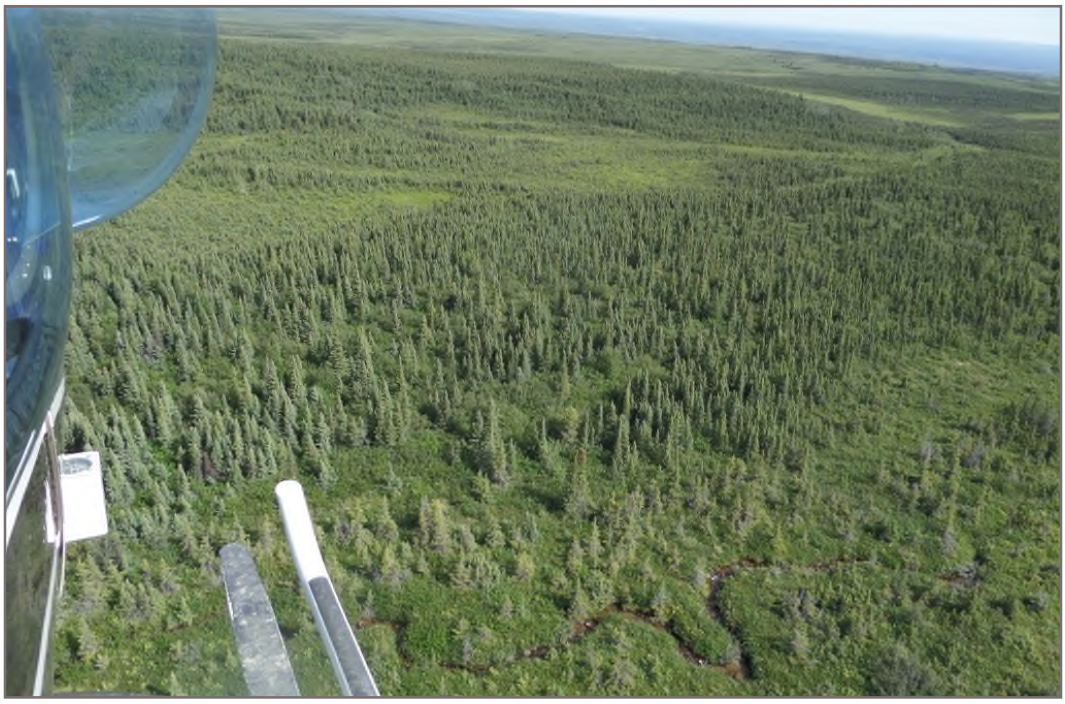


Photo 28: KP 133.2 Grainger Trib. (Hatfield KP 133.7).

Photo 29: KP 133.2 Grainger Trib. (Hatfield KP 133.7). Viewing upstream. Photo taken September 2014.

Photo 30: KP 134.9 Grainger Trib. (Hatfield KP 135.6) Viewing downstream. Photo taken September 2014.

Photo 31: KP 136.5 Grainger Trib. (Hatfield KP 136.7). Viewing downstream. Photo taken September 2014.

Photo 32: KP 154.9 Liard Trib. (Hatfield KP 154.4). Flow left to right.
Photo taken September 2014

APPENDIX 5

9819 – 12 Avenue SW | Edmonton, AB T6X 0E3 | 780.436.5868 | www.nhcweb.com

nhc
northwest hydraulic consultants

Ref. No. 16987

October 25, 2010

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

Attention: David Harpley

Via email: david@canadianzinc.com

Re: Regional Streamflow Time Series Trend Analysis

Dear Mr. Harpley:

This letter has been prepared to document a time series trend analysis of long-term streamflow records in the Prairie Creek mine vicinity. A trend analysis of the flow data had been requested by Natural Resources Canada (NRC) staff during technical meetings organized by the Mackenzie Valley Review Board for the Prairie Creek Mine Environmental Assessment.

The objectives of the trend analysis were twofold: (1) to assess if there are any obvious long-term trends in annual peak or mean flows in the region, and (2) to assess the representativeness of flows during the 1975 to 1990 period when the Prairie Creek at Cadillac Mine stream gauge was operated by the Water Survey of Canada (WSC).

A time series trend analysis on annual average flows and annual daily maximum flows was made using WSC flow data for the four gauges listed below. Most of the gauges have short periods of missing record within the period indicated above as having continuous record. For the Liard River gauge, missing flows during the winters of 1981 and 1982 were estimated on the basis of typical winter values to complete the period of record that is coincident with the Prairie Creek gauge.

Name	Gauge #	Basin Area, km^2	Record start	Notes
Prairie Creek at Cadillac Mine	10EC002	495	Oct 1974	Record ends after Dec 1990
Flat River near the Mouth	10EA003	8560	Oct 1960	Continuous records start 1973
South Nahanni River above Virginia Falls	10EB001	14500	Oct 1962	Continuous records start 1972
Liard River at Fort Liard	10ED001	222000	Oct 1943	Continuous records start 1965

To facilitate the assessment of the regional data and also the representativeness of the 1975 to 1990 period, the flow data were normalized using 1975 to 1990 average values. For each gauge, mean annual flows were normalized by dividing by the average of the 1975 to 1990 mean flows. Peak annual flows were normalized by dividing by the average of the 1975 to 1990 peak flow values.

Figure 1 shows a time series plot of normalized annual runoff for each station together with 10-year running average runoff amounts for the Liard and South Nahanni River stations. The ten year running

average is the average over the prior period, for example the 2009 value reflects the mean runoff for years 2000 through 2009. Normalized flows above 1.0 are greater than the average 1975-1990 value; normalized flows less than 1.0 are less than the average 1975-1990 value.

There is no obvious long term trend in the annual mean flows. The 10-year mean values show oscillations that are commonly found in hydrologic records and which are sometimes associated with cyclic variability in the Pacific Decadal Oscillation and other indices.

Figure 1: Normalized Annual Mean Flow

Annual mean flow divided by average flow for 1975-1990 (Prairie Creek period of record)
Liard River missing data for winters 1981 and 1982 estimated to extend continuous record

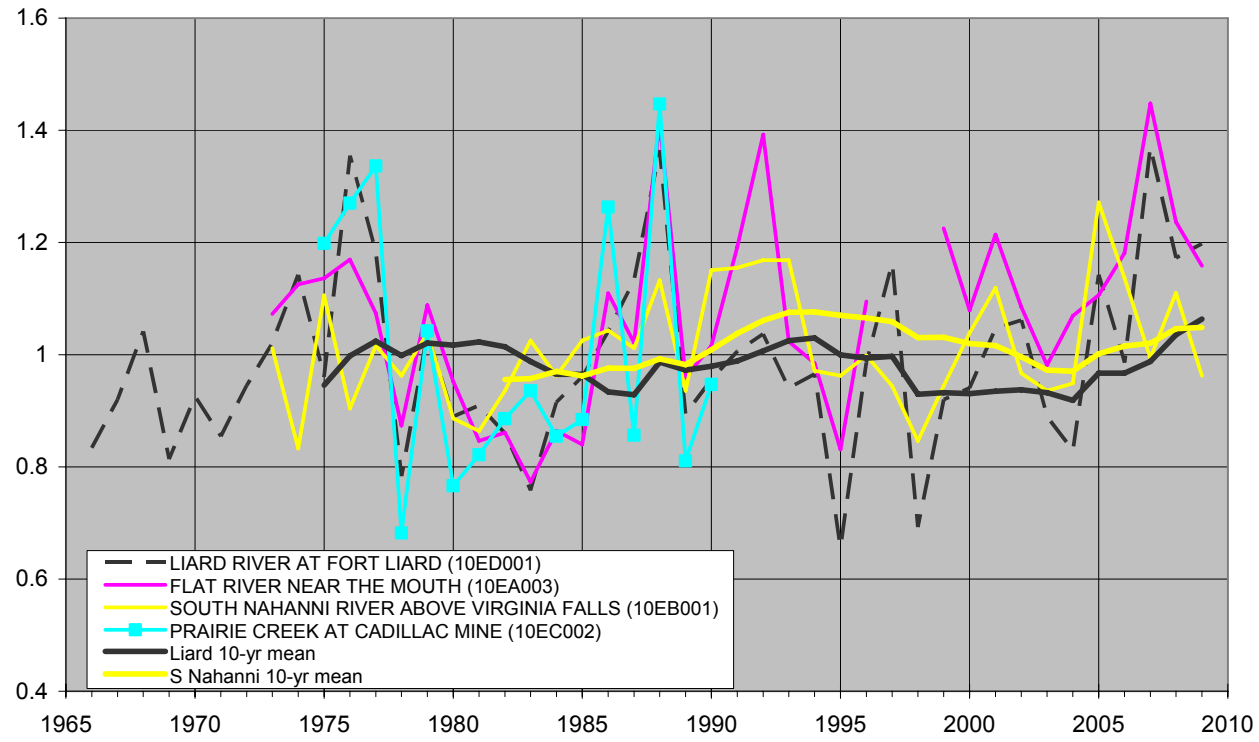
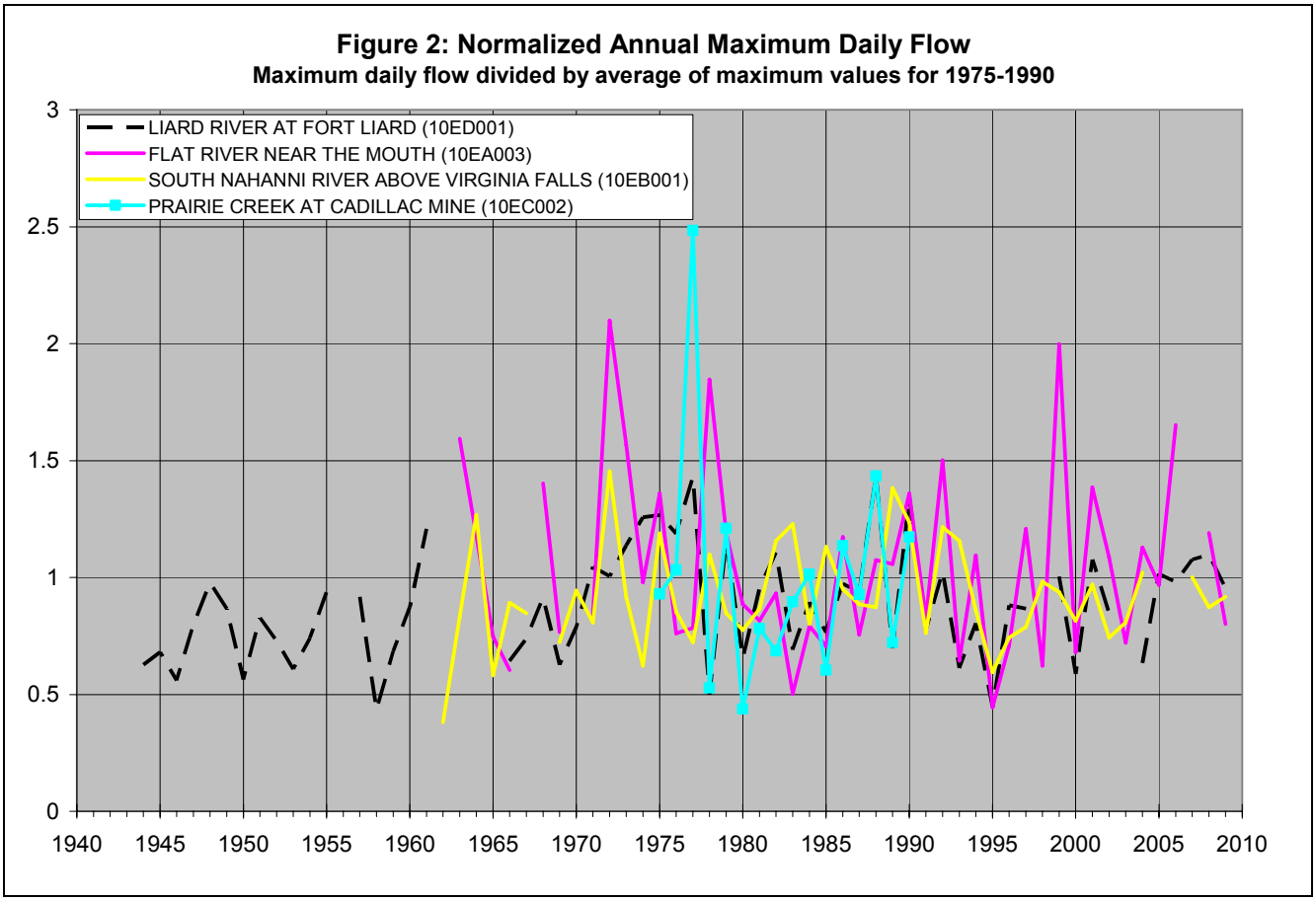


Figure 2 shows a time series plot of normalized annual maximum daily flow for each station. Normalized flows above 1.0 are greater than the average 1975-1990 value; normalized flows less than 1.0 are less than the average 1975-1990 value. The plot does not include 10 year running mean values because of gaps in the post-1997 peak flow records at all of the gauges.

There is no obvious long term trend in the annual peak flows. The normalized Prairie Creek peak flow for 1977 is the highest of all stations for all years of record, but this may be due in part to the relatively small size of the Prairie Creek basin. It is noted that the same year (1977) had the highest flow in the Liard River record but below-average peak flows in the Flat and South Nahanni Rivers.



In conclusion, there are no obvious trends in either the annual mean or annual peak flows at gauged streams in the Prairie Creek region. The 1975 -1990 record for Prairie Creek appears to be reasonably representative of average conditions considering the longer-term flow records at the regional stations. Also, the Prairie Creek record appears to include wet and dry years with runoff near both the upper and lower bounds of the range of variability seen in the other stations.

Respectfully submitted,

northwest hydraulic consultants

PROFESSIONAL ENGINEER ALBERTA
WILLIAM A. ROZEBOOM

W.A. (Bill) Rozeboom, M.B.A., P.Eng.
Senior Hydrologist

APPENDIX 6

Maxxam

Success Through Science®

Your C.O.C. #: G091539

Attention:DAVID HARPLEY
CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/08/12
Report #: R1619874
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B466000
Received: 2014/08/01, 08:00

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	4	2014/08/02	2014/08/02	BBY6SOP-00026	SM 22 2320 B m
Chloride by Automated Colourimetry	4	N/A	2014/08/01	BBY6SOP-00011	SM 22 4500-Cl- G m
Conductance - water	4	N/A	2014/08/02	BBY6SOP-00026	SM 22 2510 B m
Hardness Total (calculated as CaCO3)	4	N/A	2014/08/08	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	1	N/A	2014/08/07	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	3	N/A	2014/08/11	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	1	N/A	2014/08/08	BBY7SOP-00015	BCMOE BCLM Jul2013 m
Mercury (Dissolved) by CVAF	3	N/A	2014/08/11	BBY7SOP-00015	BCMOE BCLM Jul2013 m
Mercury (Total) by CVAF	4	2014/08/11	2014/08/11	BBY7SOP-00015	BCMOE BCLM Jul2013 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	3	N/A	2014/08/11	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	1	N/A	2014/08/12	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	1	N/A	2014/08/07	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	3	N/A	2014/08/08	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	4	2014/08/01	2014/08/08	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	4	2014/08/07	2014/08/07	BBY7SOP-00002	EPA 6020A R1 m
Filter and HNO3 Preserve for Metals	1	N/A	2014/08/07	BBY6WI-00001	EPA 200.2
Filter and HNO3 Preserve for Metals	3	N/A	2014/08/08	BBY6WI-00001	EPA 200.2
pH Water (1)	4	N/A	2014/08/02	BBY6SOP-00026	SM 22 4500-H+ B m
Sulphate by Automated Colourimetry	4	N/A	2014/08/01	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	1	2014/08/02	2014/08/05	BBY6SOP-00033	SM 22 2540 C m
Total Dissolved Solids (Filt. Residue)	3	2014/08/05	2014/08/06	BBY6SOP-00033	SM 22 2540 C m
Total Suspended Solids	1	N/A	2014/08/05	BBY6SOP-00034	SM 22 2540 D
Total Suspended Solids	3	N/A	2014/08/06	BBY6SOP-00034	SM 22 2540 D

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Maxxam

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Your C.O.C. #: G091539

Attention:DAVID HARPLEY
CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/08/12
Report #: R1619874
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B466000
Received: 2014/08/01, 08:00

Encryption Key

Sydney Morgan Strelau
12 Aug 2014 13:55:12 -07:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Sydney Morgan Strelau, Customer Service Representative
Email: SMorganStrelau@maxxam.ca
Phone# (604) 734 7276

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B466000
Report Date: 2014/08/12

CANADIAN ZINC CORPORATION

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		KG0177		KG0178	KG0179	KG0180		
Sampling Date		2014/07/28		2014/07/28	2014/07/28	2014/07/28		
COC Number		G091539		G091539	G091539	G091539		
	Units	GR @ GG	QC Batch	TETCELA	SUNDOG @ CC	POLIECK CROSSING	RDL	QC Batch
Calculated Parameters								
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	FIELD	FIELD	N/A	ONSITE
Misc. Inorganics								
Alkalinity (Total as CaCO3)	mg/L	154	7588645	192	104	145	0.50	7588645
Alkalinity (PP as CaCO3)	mg/L	<0.50	7588645	<0.50	<0.50	<0.50	0.50	7588645
Bicarbonate (HCO3)	mg/L	188	7588645	234	127	177	0.50	7588645
Carbonate (CO3)	mg/L	<0.50	7588645	<0.50	<0.50	<0.50	0.50	7588645
Hydroxide (OH)	mg/L	<0.50	7588645	<0.50	<0.50	<0.50	0.50	7588645
Anions								
Dissolved Sulphate (SO4)	mg/L	11.1	7587052	87.3	13.5	16.5	0.50	7587052
Dissolved Chloride (Cl)	mg/L	<0.50	7587041	4.2	0.75	<0.50	0.50	7587041
Physical Properties								
Conductivity	uS/cm	316	7588651	547	236	319	1.0	7588651
pH	pH	8.23	7588647	8.12	8.14	8.17	N/A	7588647
Physical Properties								
Total Suspended Solids	mg/L	<4.0	7587197	8.0 (1)	<4.0 (1)	<4.0 (1)	4.0	7588692
Total Dissolved Solids	mg/L	170	7587195	374 (1)	138 (1)	182 (1)	10	7588705

RDL = Reportable Detection Limit
N/A = Not Applicable
(1) Sample analysed past recommended hold time.

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Maxxam Job #: B466000
Report Date: 2014/08/12

CANADIAN ZINC CORPORATION

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		KG0177		KG0178		KG0179		KG0180		
Sampling Date		2014/07/28		2014/07/28		2014/07/28		2014/07/28		
COC Number		G091539		G091539		G091539		G091539		
	Units	GR @ GG	QC Batch	TETCELA	QC Batch	SUNDOG @ CC	QC Batch	POLIECK CROSSING	RDL	QC Batch
Misc. Inorganics										
Dissolved Hardness (CaCO3)	mg/L	172	7585903	271	7585903	117	7585903	157	0.50	7585903
Elements										
Dissolved Mercury (Hg)	ug/L	<0.010	7595654	<0.010	7595654	<0.010	7593599	<0.010	0.010	7595654
Dissolved Metals by ICPMS										
Dissolved Aluminum (Al)	ug/L	4.2	7596250	9.0	7592551	28.0 (1)	7592551	<3.0	3.0	7592551
Dissolved Antimony (Sb)	ug/L	<0.50	7591016	<0.50	7592551	<0.50	7592551	<0.50	0.50	7592551
Dissolved Arsenic (As)	ug/L	<0.10	7591016	0.35	7592551	0.12	7592551	<0.10	0.10	7592551
Dissolved Barium (Ba)	ug/L	92.1	7591016	73.8	7592551	35.6	7592551	90.9	1.0	7592551
Dissolved Beryllium (Be)	ug/L	<0.10	7591016	<0.10	7592551	<0.10	7592551	<0.10	0.10	7592551
Dissolved Bismuth (Bi)	ug/L	<1.0	7591016	<1.0	7592551	<1.0	7592551	<1.0	1.0	7592551
Dissolved Boron (B)	ug/L	<50	7591016	<50	7592551	<50	7592551	<50	50	7592551
Dissolved Cadmium (Cd)	ug/L	0.016	7591016	0.025	7592551	0.012	7592551	0.077	0.010	7592551
Dissolved Chromium (Cr)	ug/L	<1.0	7591016	<1.0	7592551	<1.0	7592551	<1.0	1.0	7592551
Dissolved Cobalt (Co)	ug/L	<0.50	7591016	<0.50	7592551	<0.50	7592551	<0.50	0.50	7592551
Dissolved Copper (Cu)	ug/L	0.54	7591016	1.42	7592551	0.27	7592551	0.31	0.20	7592551
Dissolved Iron (Fe)	ug/L	26.5	7591016	25.3	7592551	<5.0	7592551	10.0	5.0	7592551
Dissolved Lead (Pb)	ug/L	<0.20	7591016	<0.20	7592551	<0.20	7592551	<0.20	0.20	7592551
Dissolved Lithium (Li)	ug/L	<5.0	7591016	8.7	7592551	<5.0	7592551	<5.0	5.0	7592551
Dissolved Manganese (Mn)	ug/L	1.3	7596250	21.7	7592551	<1.0	7592551	4.6	1.0	7592551
Dissolved Molybdenum (Mo)	ug/L	<1.0	7591016	3.4	7592551	<1.0	7592551	3.4	1.0	7592551
Dissolved Nickel (Ni)	ug/L	<1.0	7591016	1.8	7592551	<1.0	7592551	1.4	1.0	7592551
Dissolved Selenium (Se)	ug/L	0.18	7591016	0.47	7592551	0.19	7592551	1.26	0.10	7592551
Dissolved Silicon (Si)	ug/L	1680	7591016	2450	7592551	581	7592551	1450	100	7592551
Dissolved Silver (Ag)	ug/L	<0.020	7591016	<0.020	7592551	<0.020	7592551	<0.020	0.020	7592551
Dissolved Strontium (Sr)	ug/L	66.2	7591016	372	7592551	26.7	7592551	102	1.0	7592551
Dissolved Thallium (Tl)	ug/L	<0.050	7591016	<0.050	7592551	<0.050	7592551	<0.050	0.050	7592551
Dissolved Tin (Sn)	ug/L	<5.0	7591016	<5.0	7592551	<5.0	7592551	<5.0	5.0	7592551
Dissolved Titanium (Ti)	ug/L	<5.0	7591016	<5.0	7592551	<5.0	7592551	<5.0	5.0	7592551
Dissolved Uranium (U)	ug/L	1.23	7591016	3.30	7592551	1.61	7592551	1.75	0.10	7592551
Dissolved Vanadium (V)	ug/L	<5.0	7591016	<5.0	7592551	<5.0	7592551	<5.0	5.0	7592551
Dissolved Zinc (Zn)	ug/L	<5.0	7591016	<5.0	7592551	<5.0	7592551	5.0	5.0	7592551
Dissolved Zirconium (Zr)	ug/L	<0.50	7591016	<0.50	7592551	<0.50	7592551	<0.50	0.50	7592551
Dissolved Calcium (Ca)	mg/L	47.4	7595845	78.0	7585904	26.9	7585904	46.8	0.050	7585904
Dissolved Magnesium (Mg)	mg/L	13.1	7595845	18.5	7585904	12.1	7585904	9.68	0.050	7585904
Dissolved Potassium (K)	mg/L	0.436	7595845	0.994	7585904	0.120	7585904	0.309	0.050	7585904
Dissolved Sodium (Na)	mg/L	0.905	7595845	5.19	7585904	0.183	7585904	0.517	0.050	7585904

RDL = Reportable Detection Limit
(1) Dissolved greater than total. Reanalysis yields similar results.

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Maxxam Job #: B466000
Report Date: 2014/08/12

CANADIAN ZINC CORPORATION

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		KG0177		KG0178		KG0179		KG0180		
Sampling Date		2014/07/28		2014/07/28		2014/07/28		2014/07/28		
COC Number		G091539		G091539		G091539		G091539		
	Units	GR @ GG	QC Batch	TETCELA	QC Batch	SUNDOG @ CC	QC Batch	POLJECK CROSSING	RDL	QC Batch
Dissolved Sulphur (S)	mg/L	3.2	7595845	30.5	7585904	4.8	7585904	5.7	3.0	7585904
RDL = Reportable Detection Limit										

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Maxxam Job #: B466000
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CANADIAN ZINC CORPORATION

CCME TOTAL METALS IN WATER (WATER)

Maxxam ID		KG0177	KG0178	KG0179	KG0180		
Sampling Date		2014/07/28	2014/07/28	2014/07/28	2014/07/28		
COC Number		G091539	G091539	G091539	G091539		
	Units	GR @ GG	TETCELA	SUNDOG @ CC	POLIECK CROSSING	RDL	QC Batch
Calculated Parameters							
Total Hardness (CaCO3)	mg/L	182	325	130	186	0.50	7585902
Elements							
Total Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	<0.010	0.010	7595408
Total Metals by ICPMS							
Total Aluminum (Al)	ug/L	15.5	275	6.1	64.2	3.0	7591847
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	7591847
Total Arsenic (As)	ug/L	0.31	0.61	0.13	0.17	0.10	7591847
Total Barium (Ba)	ug/L	94.5	79.7	32.4	92.6	1.0	7591847
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	0.10	7591847
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	7591847
Total Boron (B)	ug/L	<50	<50	<50	<50	50	7591847
Total Cadmium (Cd)	ug/L	0.013	0.046	0.017	0.088	0.010	7591847
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	<1.0	1.0	7591847
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	7591847
Total Copper (Cu)	ug/L	<0.50	1.33	<0.50	<0.50	0.50	7591847
Total Iron (Fe)	ug/L	54	499	<10	103	10	7591847
Total Lead (Pb)	ug/L	<0.20	0.32	<0.20	<0.20	0.20	7591847
Total Lithium (Li)	ug/L	<5.0	8.8	<5.0	<5.0	5.0	7591847
Total Manganese (Mn)	ug/L	4.6	29.3	<1.0	9.6	1.0	7591847
Total Molybdenum (Mo)	ug/L	<1.0	3.4	<1.0	3.5	1.0	7591847
Total Nickel (Ni)	ug/L	<1.0	2.6	<1.0	2.0	1.0	7591847
Total Selenium (Se)	ug/L	0.17	0.49	0.17	1.13	0.10	7591847
Total Silicon (Si)	ug/L	1770	3690	720	1960	100	7591847
Total Silver (Ag)	ug/L	<0.020	<0.020	<0.020	<0.020	0.020	7591847
Total Strontium (Sr)	ug/L	70.2	380	24.3	104	1.0	7591847
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050	<0.050	0.050	7591847
Total Tin (Sn)	ug/L	<5.0	<5.0	<5.0	<5.0	5.0	7591847
Total Titanium (Ti)	ug/L	<5.0	9.8	<5.0	<5.0	5.0	7591847
Total Uranium (U)	ug/L	1.38	3.54	1.65	1.89	0.10	7591847
Total Vanadium (V)	ug/L	<5.0	<5.0	<5.0	<5.0	5.0	7591847
Total Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	6.0	5.0	7591847
Total Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	<0.50	0.50	7591847
Total Calcium (Ca)	mg/L	52.6	96.1	31.5	57.3	0.050	7585905
Total Magnesium (Mg)	mg/L	12.2	20.8	12.5	10.5	0.050	7585905
Total Potassium (K)	mg/L	0.434	1.16	0.129	0.360	0.050	7585905
Total Sodium (Na)	mg/L	0.952	5.12	0.160	0.478	0.050	7585905
Total Sulphur (S)	mg/L	6.3	38.0	4.3	5.8	3.0	7585905
RDL = Reportable Detection Limit							

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	1.3°C

Sample KG0177, Elements by CRC ICPMS (dissolved): Test repeated.

Results relate only to the items tested.

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Maxxam Job #: B466000
Report Date: 2014/08/12

CANADIAN ZINC CORPORATION

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units
7587041	Dissolved Chloride (Cl)	2014/08/01	NC	80 - 120	97	80 - 120	<0.50	mg/L
7587052	Dissolved Sulphate (SO4)	2014/08/01	NC	80 - 120	92	80 - 120	0.98 ,RDL=0.50	mg/L
7587195	Total Dissolved Solids	2014/08/05	101	80 - 120	86	80 - 120	<10	mg/L
7587197	Total Suspended Solids	2014/08/05	107	80 - 120	100	80 - 120	<4.0	mg/L
7588645	Alkalinity (PP as CaCO3)	2014/08/02					<0.50	mg/L
7588645	Alkalinity (Total as CaCO3)	2014/08/02	NC	80 - 120	91	80 - 120	0.53 ,RDL=0.50	mg/L
7588645	Bicarbonate (HCO3)	2014/08/02					0.65 ,RDL=0.50	mg/L
7588645	Carbonate (CO3)	2014/08/02					<0.50	mg/L
7588645	Hydroxide (OH)	2014/08/02					<0.50	mg/L
7588647	pH	2014/08/02			102	97 - 103		
7588651	Conductivity	2014/08/02			100	80 - 120	<1.0	uS/cm
7588692	Total Suspended Solids	2014/08/06	101	80 - 120	103	80 - 120	<4.0	mg/L
7588705	Total Dissolved Solids	2014/08/06	103	80 - 120	84	80 - 120	<10	mg/L
7591016	Dissolved Antimony (Sb)	2014/08/07	98	80 - 120	96	80 - 120	<0.50	ug/L
7591016	Dissolved Arsenic (As)	2014/08/07	107	80 - 120	99	80 - 120	<0.10	ug/L
7591016	Dissolved Barium (Ba)	2014/08/07	NC	80 - 120	97	80 - 120	<1.0	ug/L
7591016	Dissolved Beryllium (Be)	2014/08/07	87	80 - 120	93	80 - 120	<0.10	ug/L
7591016	Dissolved Bismuth (Bi)	2014/08/07	78 (1)	80 - 120	99	80 - 120	<1.0	ug/L
7591016	Dissolved Boron (B)	2014/08/07					<50	ug/L
7591016	Dissolved Cadmium (Cd)	2014/08/07	91	80 - 120	97	80 - 120	<0.010	ug/L
7591016	Dissolved Chromium (Cr)	2014/08/07	92	80 - 120	96	80 - 120	<1.0	ug/L
7591016	Dissolved Cobalt (Co)	2014/08/07	87	80 - 120	97	80 - 120	<0.50	ug/L
7591016	Dissolved Copper (Cu)	2014/08/07	NC	80 - 120	97	80 - 120	<0.20	ug/L
7591016	Dissolved Iron (Fe)	2014/08/07	NC	80 - 120	100	80 - 120	<5.0	ug/L
7591016	Dissolved Lead (Pb)	2014/08/07	82	80 - 120	98	80 - 120	<0.20	ug/L
7591016	Dissolved Lithium (Li)	2014/08/07	NC	80 - 120	93	80 - 120	<5.0	ug/L
7591016	Dissolved Molybdenum (Mo)	2014/08/07	NC	80 - 120	91	80 - 120	<1.0	ug/L
7591016	Dissolved Nickel (Ni)	2014/08/07	NC	80 - 120	99	80 - 120	<1.0	ug/L
7591016	Dissolved Selenium (Se)	2014/08/07	99	80 - 120	95	80 - 120	<0.10	ug/L
7591016	Dissolved Silicon (Si)	2014/08/07					<100	ug/L
7591016	Dissolved Silver (Ag)	2014/08/07	90	80 - 120	89	80 - 120	<0.020	ug/L
7591016	Dissolved Strontium (Sr)	2014/08/07	NC	80 - 120	93	80 - 120	<1.0	ug/L
7591016	Dissolved Thallium (Tl)	2014/08/07	81	80 - 120	90	80 - 120	<0.050	ug/L

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units
7591016	Dissolved Tin (Sn)	2014/08/07	108	80 - 120	97	80 - 120	<5.0	ug/L
7591016	Dissolved Titanium (Ti)	2014/08/07	112	80 - 120	101	80 - 120	<5.0	ug/L
7591016	Dissolved Uranium (U)	2014/08/07	NC	80 - 120	94	80 - 120	<0.10	ug/L
7591016	Dissolved Vanadium (V)	2014/08/07	105	80 - 120	99	80 - 120	<5.0	ug/L
7591016	Dissolved Zinc (Zn)	2014/08/07	NC	80 - 120	100	80 - 120	<5.0	ug/L
7591016	Dissolved Zirconium (Zr)	2014/08/07					<0.50	ug/L
7591847	Total Aluminum (Al)	2014/08/07	107	80 - 120	105	80 - 120	<3.0	ug/L
7591847	Total Antimony (Sb)	2014/08/07	102	80 - 120	103	80 - 120	<0.50	ug/L
7591847	Total Arsenic (As)	2014/08/07	103	80 - 120	101	80 - 120	<0.10	ug/L
7591847	Total Barium (Ba)	2014/08/07	96	80 - 120	97	80 - 120	<1.0	ug/L
7591847	Total Beryllium (Be)	2014/08/07	100	80 - 120	93	80 - 120	<0.10	ug/L
7591847	Total Bismuth (Bi)	2014/08/07	104	80 - 120	102	80 - 120	<1.0	ug/L
7591847	Total Boron (B)	2014/08/07					<50	ug/L
7591847	Total Cadmium (Cd)	2014/08/07	99	80 - 120	98	80 - 120	<0.010	ug/L
7591847	Total Chromium (Cr)	2014/08/07	104	80 - 120	101	80 - 120	<1.0	ug/L
7591847	Total Cobalt (Co)	2014/08/07	102	80 - 120	100	80 - 120	<0.50	ug/L
7591847	Total Copper (Cu)	2014/08/07	NC	80 - 120	95	80 - 120	<0.50	ug/L
7591847	Total Iron (Fe)	2014/08/07	NC	80 - 120	103	80 - 120	<10	ug/L
7591847	Total Lead (Pb)	2014/08/07	102	80 - 120	98	80 - 120	<0.20	ug/L
7591847	Total Lithium (Li)	2014/08/07	99	80 - 120	94	80 - 120	<5.0	ug/L
7591847	Total Manganese (Mn)	2014/08/07	NC	80 - 120	97	80 - 120	<1.0	ug/L
7591847	Total Molybdenum (Mo)	2014/08/07	108	80 - 120	88	80 - 120	<1.0	ug/L
7591847	Total Nickel (Ni)	2014/08/07	108	80 - 120	103	80 - 120	<1.0	ug/L
7591847	Total Selenium (Se)	2014/08/07	99	80 - 120	93	80 - 120	<0.10	ug/L
7591847	Total Silicon (Si)	2014/08/07					<100	ug/L
7591847	Total Silver (Ag)	2014/08/07	79 (1)	80 - 120	102	80 - 120	<0.020	ug/L
7591847	Total Strontium (Sr)	2014/08/07	NC	80 - 120	95	80 - 120	<1.0	ug/L
7591847	Total Thallium (Tl)	2014/08/07	101	80 - 120	96	80 - 120	<0.050	ug/L
7591847	Total Tin (Sn)	2014/08/07	99	80 - 120	102	80 - 120	<5.0	ug/L
7591847	Total Titanium (Ti)	2014/08/07	92	80 - 120	92	80 - 120	<5.0	ug/L
7591847	Total Uranium (U)	2014/08/07	99	80 - 120	95	80 - 120	<0.10	ug/L
7591847	Total Vanadium (V)	2014/08/07	100	80 - 120	99	80 - 120	<5.0	ug/L
7591847	Total Zinc (Zn)	2014/08/07	NC	80 - 120	105	80 - 120	<5.0	ug/L

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units
7591847	Total Zirconium (Zr)	2014/08/07					<0.50	ug/L
7592551	Dissolved Aluminum (Al)	2014/08/08	105	80 - 120	107	80 - 120	<3.0	ug/L
7592551	Dissolved Antimony (Sb)	2014/08/08	NC	80 - 120	100	80 - 120	<0.50	ug/L
7592551	Dissolved Arsenic (As)	2014/08/08	109	80 - 120	104	80 - 120	<0.10	ug/L
7592551	Dissolved Barium (Ba)	2014/08/08	NC	80 - 120	102	80 - 120	<1.0	ug/L
7592551	Dissolved Beryllium (Be)	2014/08/08	101	80 - 120	95	80 - 120	<0.10	ug/L
7592551	Dissolved Bismuth (Bi)	2014/08/08	96	80 - 120	102	80 - 120	<1.0	ug/L
7592551	Dissolved Boron (B)	2014/08/08					<50	ug/L
7592551	Dissolved Cadmium (Cd)	2014/08/08	98	80 - 120	101	80 - 120	<0.010	ug/L
7592551	Dissolved Chromium (Cr)	2014/08/08	100	80 - 120	101	80 - 120	<1.0	ug/L
7592551	Dissolved Cobalt (Co)	2014/08/08	NC	80 - 120	102	80 - 120	<0.50	ug/L
7592551	Dissolved Copper (Cu)	2014/08/08	91	80 - 120	103	80 - 120	<0.20	ug/L
7592551	Dissolved Iron (Fe)	2014/08/08	106	80 - 120	116	80 - 120	<5.0	ug/L
7592551	Dissolved Lead (Pb)	2014/08/08	97	80 - 120	101	80 - 120	<0.20	ug/L
7592551	Dissolved Lithium (Li)	2014/08/08	NC	80 - 120	96	80 - 120	<5.0	ug/L
7592551	Dissolved Manganese (Mn)	2014/08/08	NC	80 - 120	105	80 - 120	<1.0	ug/L
7592551	Dissolved Molybdenum (Mo)	2014/08/08	NC	80 - 120	102	80 - 120	<1.0	ug/L
7592551	Dissolved Nickel (Ni)	2014/08/08	NC	80 - 120	104	80 - 120	<1.0	ug/L
7592551	Dissolved Selenium (Se)	2014/08/08	105	80 - 120	108	80 - 120	<0.10	ug/L
7592551	Dissolved Silicon (Si)	2014/08/08					<100	ug/L
7592551	Dissolved Silver (Ag)	2014/08/08	99	80 - 120	90	80 - 120	<0.020	ug/L
7592551	Dissolved Strontium (Sr)	2014/08/08	NC	80 - 120	100	80 - 120	<1.0	ug/L
7592551	Dissolved Thallium (Tl)	2014/08/08	103	80 - 120	94	80 - 120	<0.050	ug/L
7592551	Dissolved Tin (Sn)	2014/08/08	NC	80 - 120	101	80 - 120	<5.0	ug/L
7592551	Dissolved Titanium (Ti)	2014/08/08	97	80 - 120	105	80 - 120	<5.0	ug/L
7592551	Dissolved Uranium (U)	2014/08/08	NC	80 - 120	98	80 - 120	<0.10	ug/L
7592551	Dissolved Vanadium (V)	2014/08/08	101	80 - 120	102	80 - 120	<5.0	ug/L
7592551	Dissolved Zinc (Zn)	2014/08/08	NC	80 - 120	101	80 - 120	<5.0	ug/L
7592551	Dissolved Zirconium (Zr)	2014/08/08					<0.50	ug/L
7593599	Dissolved Mercury (Hg)	2014/08/08	88	80 - 120	90	80 - 120	<0.010	ug/L
7595408	Total Mercury (Hg)	2014/08/11	87	80 - 120	94	80 - 120	<0.010	ug/L
7595654	Dissolved Mercury (Hg)	2014/08/11	93	80 - 120	90	80 - 120	<0.010	ug/L
7596250	Dissolved Aluminum (Al)	2014/08/11			115	80 - 120	<3.0	ug/L

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units
7596250	Dissolved Manganese (Mn)	2014/08/11			105	80 - 120	<1.0	ug/L

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

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Maxxam

4606 Canada Way, Burnaby, BC Canada V5G 1K5 Ph: 604 734 7276 Toll Free: 1 800 665 8566 Fax: 604 731 2386

CHAIN OF CUSTODY RECORD

Page: 1 of 1

G 091539

Maxxam Job#: B466000

Invoice To: Require Report? Yes ☐ No ☐

Company Name: Canadian Zinc
Contact Name: David Hanphy
Address:
PO:
Phone / Fax#: Ph: 604 594 3855
E-mail: david@canadianzinc.com

Report To:

Company Name: Canadian Zinc
Contact Name:
Address:
PO:
Ph: Fax:
Phone / Fax#:
E-mail

PO #:	
Quotation #:	
Project # :	
Proj. Name:	
Location:	
Sampled By:	

REGULATORY REQUIREMENTS SERVICE REQUESTED:

- ☐ CSR
- ☑ CCME
- ☐ BC Water Quality
- ☐ Other
- ☐ DRINKING WATER

- ☐ Regular Turn Around Time (TAT) (5 days for most tests)
- ☐ RUSH (Please contact the lab)
- ☐ 1 Day ☐ 2 Day ☐ 3 Day

Date Required:

Special Instructions:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

Sample GR@GG for diss metals & diss Hg NOT filtered or acidified.

ANALYSIS REQUESTED

	Sample Identification	Lab Identification	Sample Type	Date/Time Sampled
1	GR@GG	K60177	SW	July 28
2	Tetcela	K60178		
3	Sundog@CC	K60179		
4	PoljeCK Crossing	K60180	↓	↓
5				
6				
7				
8				
9				
10				
11				
12				

B466000

ARRIVED AT DEPOT:

JUL 31 2014

ILO 10:10

TEMP: 5/15/15 19/19/19

*Relinquished by:	Date (YY/MM/DD):	Time:	Received by:	Date (YY/MM/DD):	Time:
	July 29	17:30	REBECCA BANTON	2014/08/01	08:00

Laboratory Use Only

Time Sensitive	Temperature on Receipt (°C)	Custody Seal Intact on Cooler?
☐	1.1.2	Yes ☑ No ☐

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

COD-1028 (09/10)

Maxxam International Corporation o/a Maxxam Analytics

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your C.O.C. #: 08350173

Attention:DAVID HARPLEY
CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/12/31
Report #: R1769600
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B488344
Received: 2014/10/02, 07:40

Sample Matrix: Soil
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	5	2014/10/04	2014/10/06	BBY7SOP-00001	EPA 6020a R1 m
Moisture	5	N/A	2014/10/04	BBY8SOP-00017	OMOE E3139 3.1 m
pH (2:1 DI Water Extract)	5	2014/10/06	2014/10/06	BBY6SOP-00028	BCMOE BCLM Mar2005 m
Total Organic Carbon LECO Method (1)	5	2014/12/29	2014/12/30	CAL SOP-00243	LECO 203-821-170 m
BC Hydrocarbons in Soil by GC/FID	4	2014/10/03	2014/10/06	BBY8SOP-00029	BCMOE EPH s 07/99 m
BC Hydrocarbons in Soil by GC/FID	1	2014/10/03	2014/10/07	BBY8SOP-00029	BCMOE EPH s 07/99 m

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	6	2014/10/02	2014/10/03	BBY6SOP-00026	SM 22 2320 B m
Chloride by Automated Colourimetry	6	N/A	2014/10/03	BBY6SOP-00011	SM 22 4500-Cl- G m
Conductance - water	6	N/A	2014/10/03	BBY6SOP-00026	SM 22 2510 B m
Hardness Total (calculated as CaCO3)	4	N/A	2014/10/06	BBY7SOP-00002	EPA 6020a R1 m
Hardness Total (calculated as CaCO3)	2	N/A	2014/10/08	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	6	N/A	2014/10/07	BBY7SOP-00002	EPA 6020a R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	6	N/A	2014/10/07	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	6	N/A	2014/10/07	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	4	2014/10/02	2014/10/06	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	2	2014/10/02	2014/10/08	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	4	2014/10/02	2014/10/03	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	2	2014/10/07	2014/10/08	BBY7SOP-00002	EPA 6020A R1 m
Filter and HNO3 Preserve for Metals	6	N/A	2014/10/07	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	6	N/A	2014/10/03	BBY6SOP-00026	SM 22 4500-H+ B m
Sulphate by Automated Colourimetry	6	N/A	2014/10/03	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	6	2014/10/03	2014/10/07	BBY6SOP-00033	SM 22 2540 C m
Total Suspended Solids	6	N/A	2014/10/04	BBY6SOP-00034	SM 22 2540 D

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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Your C.O.C. #: 08350173

Attention:DAVID HARPLEY
CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/12/31
Report #: R1769600
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B488344
Received: 2014/10/02, 07:40

(1) This test was performed by Maxxam Calgary Environmental
(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Sydney Morgan Strelau
31 Dec 2014 08:19:53 -08:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Sydney Morgan Strelau, Customer Service Representative
Email: SMorganStrelau@maxxam.ca
Phone# (604) 734 7276

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

PHYSICAL TESTING (SOIL)

Maxxam ID		KT3782	KT3783	KT3784	KT3785		
Sampling Date		2014/09/26	2014/09/26	2014/09/26	2014/09/26		
COC Number		08350173	08350173	08350173	08350173		
	Units	OLD ROAD TETCELA TRIB	BLUEFISH	OLD ROAD TETCELA MAIN	SUNDOG 29.2	RDL	QC Batch
Physical Properties							
Moisture	%	15	8.3	8.1	11	0.30	7664406
RDL = Reportable Detection Limit							

Maxxam ID		KT3786		
Sampling Date		2014/09/26		
COC Number		08350173		
	Units	GRAINGER @GG	RDL	QC Batch
Physical Properties				
Moisture	%	10	0.30	7664406
RDL = Reportable Detection Limit				

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

TOTAL PETROLEUM HYDROCARBONS (SOIL)

Maxxam ID		KT3782		KT3783		KT3784		
Sampling Date		2014/09/26		2014/09/26		2014/09/26		
COC Number		08350173		08350173		08350173		
	Units	OLD ROAD TETCELA TRIB	QC Batch	BLUEFISH	QC Batch	OLD ROAD TETCELA MAIN	RDL	QC Batch
Hydrocarbons								
EPH (C10-C19)	mg/kg	<100	7668412	<100	7669227	<100	100	7668412
EPH (C19-C32)	mg/kg	<100	7668412	<100	7669227	<100	100	7668412
Surrogate Recovery (%)								
O-TERPHENYL (sur.)	%	93	7668412	97	7669227	83		7668412
RDL = Reportable Detection Limit								

Maxxam ID		KT3785	KT3786		
Sampling Date		2014/09/26	2014/09/26		
COC Number		08350173	08350173		
	Units	SUNDOG 29.2	GRAINGER @GG	RDL	QC Batch
Hydrocarbons					
EPH (C10-C19)	mg/kg	<100	<100	100	7668412
EPH (C19-C32)	mg/kg	<100	<100	100	7668412
Surrogate Recovery (%)					
O-TERPHENYL (sur.)	%	96	90		7668412
RDL = Reportable Detection Limit					

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

MISCELLANEOUS (SOIL)

Maxxam ID		KT3782	KT3783	KT3784		KT3785		
Sampling Date		2014/09/26	2014/09/26	2014/09/26		2014/09/26		
COC Number		08350173	08350173	08350173		08350173		
	Units	OLD ROAD TETCELA TRIB	BLUEFISH	OLD ROAD TETCELA MAIN	RDL	SUNDOG 29.2	RDL	QC Batch
Misc. Inorganics								
Total Organic Carbon (C)	%	0.68	0.31	0.41	0.020	2.6 (1)	0.040	7766585

RDL = Reportable Detection Limit
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam ID		KT3786		
Sampling Date		2014/09/26		
COC Number		08350173		
	Units	GRAINGER @GG	RDL	QC Batch
Misc. Inorganics				
Total Organic Carbon (C)	%	3.0	0.020	7766585

RDL = Reportable Detection Limit

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		KT3776	KT3777	KT3778	KT3779		
Sampling Date		2014/09/26	2014/09/26	2014/09/26	2014/09/26		
COC Number		08350173	08350173	08350173	08350173		
	Units	BLUEFISH	OLD ROAD TETCELA MAIN	FISHTRAP	GRAINGER @GG	RDL	QC Batch
Calculated Parameters							
Filter and HNO3 Preservation	N/A	FIELD	FIELD	FIELD	FIELD	N/A	ONSITE
Misc. Inorganics							
Alkalinity (Total as CaCO3)	mg/L	187	234	205	160	0.50	7663822
Alkalinity (PP as CaCO3)	mg/L	1.69	2.19	<0.50	<0.50	0.50	7663822
Bicarbonate (HCO3)	mg/L	224	280	250	195	0.50	7663822
Carbonate (CO3)	mg/L	2.03	2.63	<0.50	<0.50	0.50	7663822
Hydroxide (OH)	mg/L	<0.50	<0.50	<0.50	<0.50	0.50	7663822
Anions							
Dissolved Sulphate (SO4)	mg/L	38.7	128	175	16.4	0.50	7665397
Dissolved Chloride (Cl)	mg/L	1.4	4.8	3.7	0.53	0.50	7665392
Physical Properties							
Conductivity	uS/cm	415	656	713	326	1.0	7663824
pH	pH	8.35	8.34	8.29	8.23	N/A	7663823
Physical Properties							
Total Suspended Solids	mg/L	<4.0	<4.0	<4.0	<4.0	4.0	7664356
Total Dissolved Solids	mg/L	278	480	602	210	10	7664619

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		KT3780		KT3781		
Sampling Date		2014/09/26		2014/09/26		
COC Number		08350173		08350173		
	Units	SUNDOG 29.2	QC Batch	UN-NAMED	RDL	QC Batch
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Misc. Inorganics						
Alkalinity (Total as CaCO3)	mg/L	128	7663826	221	0.50	7663822
Alkalinity (PP as CaCO3)	mg/L	<0.50	7663826	<0.50	0.50	7663822
Bicarbonate (HCO3)	mg/L	156	7663826	270	0.50	7663822
Carbonate (CO3)	mg/L	<0.50	7663826	<0.50	0.50	7663822
Hydroxide (OH)	mg/L	<0.50	7663826	<0.50	0.50	7663822
Anions						
Dissolved Sulphate (SO4)	mg/L	73.5	7665397	30.0	0.50	7665397
Dissolved Chloride (Cl)	mg/L	0.64	7665392	0.91	0.50	7665392
Physical Properties						
Conductivity	uS/cm	375	7663830	462	1.0	7663824
pH	pH	8.01	7663829	8.25	N/A	7663823
Physical Properties						
Total Suspended Solids	mg/L	<4.0	7664356	<4.0	4.0	7664356
Total Dissolved Solids	mg/L	276	7664619	350	10	7664619

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		KT3782		KT3783		KT3784		
Sampling Date		2014/09/26		2014/09/26		2014/09/26		
COC Number		08350173		08350173		08350173		
	Units	OLD ROAD TETCELA TRIB	QC Batch	BLUEFISH	QC Batch	OLD ROAD TETCELA MAIN	RDL	QC Batch
Physical Properties								
Soluble (2:1) pH	pH	8.29	7666151	8.54	7666159	8.35	N/A	7666151
Total Metals by ICPMS								
Total Aluminum (Al)	mg/kg	2710	7666149	1890	7666157	2280	100	7666149
Total Antimony (Sb)	mg/kg	0.79	7666149	0.21	7666157	0.52	0.10	7666149
Total Arsenic (As)	mg/kg	7.06	7666149	5.33	7666157	5.42	0.50	7666149
Total Barium (Ba)	mg/kg	229	7666149	98.3	7666157	139	0.10	7666149
Total Beryllium (Be)	mg/kg	<0.40	7666149	<0.40	7666157	<0.40	0.40	7666149
Total Bismuth (Bi)	mg/kg	<0.10	7666149	<0.10	7666157	<0.10	0.10	7666149
Total Cadmium (Cd)	mg/kg	0.506	7666149	0.235	7666157	0.409	0.050	7666149
Total Calcium (Ca)	mg/kg	45300	7666149	117000	7666157	39100	100	7666149
Total Chromium (Cr)	mg/kg	7.9	7666149	5.5	7666157	5.7	1.0	7666149
Total Cobalt (Co)	mg/kg	6.94	7666149	2.78	7666157	4.27	0.30	7666149
Total Copper (Cu)	mg/kg	9.98	7666149	6.67	7666157	8.33	0.50	7666149
Total Iron (Fe)	mg/kg	10100	7666149	7020	7666157	8920	100	7666149
Total Lead (Pb)	mg/kg	6.05	7666149	3.95	7666157	4.63	0.10	7666149
Total Magnesium (Mg)	mg/kg	8710	7666149	38800	7666157	9020	100	7666149
Total Manganese (Mn)	mg/kg	540	7666149	251	7666157	293	0.20	7666149
Total Mercury (Hg)	mg/kg	<0.050	7666149	<0.050	7666157	<0.050	0.050	7666149
Total Molybdenum (Mo)	mg/kg	4.08	7666149	1.24	7666157	2.81	0.10	7666149
Total Nickel (Ni)	mg/kg	19.1	7666149	8.89	7666157	14.4	0.80	7666149
Total Phosphorus (P)	mg/kg	475	7666149	177	7666157	350	10	7666149
Total Potassium (K)	mg/kg	392	7666149	333	7666157	318	100	7666149
Total Selenium (Se)	mg/kg	0.51	7666149	<0.50	7666157	<0.50	0.50	7666149
Total Silver (Ag)	mg/kg	<0.050	7666149	<0.050	7666157	<0.050	0.050	7666149
Total Sodium (Na)	mg/kg	<100	7666149	<100	7666157	<100	100	7666149
Total Strontium (Sr)	mg/kg	79.8	7666149	83.2	7666157	63.5	0.10	7666149
Total Thallium (Tl)	mg/kg	0.148	7666149	0.169	7666157	0.129	0.050	7666149
Total Tin (Sn)	mg/kg	0.15	7666149	0.13	7666157	0.15	0.10	7666149
Total Titanium (Ti)	mg/kg	38.5	7666149	65.4	7666157	55.7	1.0	7666149
Total Vanadium (V)	mg/kg	26.9	7666149	12.0	7666157	17.1	2.0	7666149
Total Zinc (Zn)	mg/kg	53.2	7666149	22.9	7666157	51.8	1.0	7666149
Total Zirconium (Zr)	mg/kg	1.95	7666149	1.37	7666157	1.86	0.50	7666149

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		KT3785	KT3786		
Sampling Date		2014/09/26	2014/09/26		
COC Number		08350173	08350173		
	Units	SUNDOG 29.2	GRAINGER @GG	RDL	QC Batch
Physical Properties					
Soluble (2:1) pH	pH	8.47	8.66	N/A	7666151
Total Metals by ICPMS					
Total Aluminum (Al)	mg/kg	<1000	1150	1000	7666149
Total Antimony (Sb)	mg/kg	<1.0	<1.0	1.0	7666149
Total Arsenic (As)	mg/kg	7.3	7.7	5.0	7666149
Total Barium (Ba)	mg/kg	39.2	36.9	1.0	7666149
Total Beryllium (Be)	mg/kg	<4.0	<4.0	4.0	7666149
Total Bismuth (Bi)	mg/kg	<1.0	<1.0	1.0	7666149
Total Cadmium (Cd)	mg/kg	<0.50	<0.50	0.50	7666149
Total Calcium (Ca)	mg/kg	142000	98900	1000	7666149
Total Chromium (Cr)	mg/kg	<10	<10	10	7666149
Total Cobalt (Co)	mg/kg	<3.0	<3.0	3.0	7666149
Total Copper (Cu)	mg/kg	<5.0	<5.0	5.0	7666149
Total Iron (Fe)	mg/kg	4050	5310	1000	7666149
Total Lead (Pb)	mg/kg	8.5	4.0	1.0	7666149
Total Magnesium (Mg)	mg/kg	96100	47900	1000	7666149
Total Manganese (Mn)	mg/kg	93.2	204	2.0	7666149
Total Mercury (Hg)	mg/kg	<0.50	<0.50	0.50	7666149
Total Molybdenum (Mo)	mg/kg	1.7	1.2	1.0	7666149
Total Nickel (Ni)	mg/kg	<8.0	<8.0	8.0	7666149
Total Phosphorus (P)	mg/kg	128	143	100	7666149
Total Potassium (K)	mg/kg	<1000	<1000	1000	7666149
Total Selenium (Se)	mg/kg	<5.0	<5.0	5.0	7666149
Total Silver (Ag)	mg/kg	<0.50	<0.50	0.50	7666149
Total Sodium (Na)	mg/kg	<1000	<1000	1000	7666149
Total Strontium (Sr)	mg/kg	70.1	60.7	1.0	7666149
Total Thallium (Tl)	mg/kg	<0.50	<0.50	0.50	7666149
Total Tin (Sn)	mg/kg	<1.0	<1.0	1.0	7666149
Total Titanium (Ti)	mg/kg	<10	63	10	7666149
Total Vanadium (V)	mg/kg	<20	25	20	7666149
Total Zinc (Zn)	mg/kg	42	26	10	7666149
Total Zirconium (Zr)	mg/kg	<5.0	<5.0	5.0	7666149

RDL = Reportable Detection Limit
N/A = Not Applicable

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

CSR DISSOLVED METALS IN WATER (WATER)

Maxxam ID		KT3776	KT3777	KT3778	KT3779	KT3780		
Sampling Date		2014/09/26	2014/09/26	2014/09/26	2014/09/26	2014/09/26		
COC Number		08350173	08350173	08350173	08350173	08350173		
	Units	BLUEFISH	OLD ROAD TETCELA MAIN	FISHTRAP	GRAINGER @GG	SUNDOG 29.2	RDL	QC Batch
Misc. Inorganics								
Dissolved Hardness (CaCO3)	mg/L	219	343	314	174	200	0.50	7662640
Dissolved Metals by ICPMS								
Dissolved Aluminum (Al)	ug/L	8.5	<3.0	19.5	<3.0	4.0	3.0	7667932
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7667932
Dissolved Arsenic (As)	ug/L	0.27	0.34	0.47	0.22	0.11	0.10	7667932
Dissolved Barium (Ba)	ug/L	97.1	72.0	58.4	89.6	72.4	1.0	7667932
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7667932
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7667932
Dissolved Boron (B)	ug/L	<50	<50	68	<50	<50	50	7667932
Dissolved Cadmium (Cd)	ug/L	0.013	0.035	0.012	0.014	0.028	0.010	7667932
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7667932
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7667932
Dissolved Copper (Cu)	ug/L	0.42	0.61	0.57	0.28	0.31	0.20	7667932
Dissolved Iron (Fe)	ug/L	37.1	36.1	95.1	15.2	<5.0	5.0	7667932
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.20	7667932
Dissolved Lithium (Li)	ug/L	<5.0	11.2	<5.0	<5.0	<5.0	5.0	7667932
Dissolved Manganese (Mn)	ug/L	4.3	30.3	7.3	2.0	<1.0	1.0	7667932
Dissolved Mercury (Hg)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7667932
Dissolved Molybdenum (Mo)	ug/L	2.3	3.8	<1.0	1.1	1.4	1.0	7667932
Dissolved Nickel (Ni)	ug/L	<1.0	2.0	<1.0	<1.0	<1.0	1.0	7667932
Dissolved Selenium (Se)	ug/L	0.26	0.56	<0.10	0.24	0.20	0.10	7667932
Dissolved Silicon (Si)	ug/L	1850	2550	1370	1640	801	100	7667932
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	0.020	7667932
Dissolved Strontium (Sr)	ug/L	173	479	957	73.8	39.0	1.0	7667932
Dissolved Thallium (Tl)	ug/L	0.082	<0.050	<0.050	<0.050	<0.050	0.050	7667932
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	7667932
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	7667932
Dissolved Uranium (U)	ug/L	3.68	4.50	0.47	2.07	2.56	0.10	7667932
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	7667932
Dissolved Zinc (Zn)	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	5.0	7667932
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7667932
Dissolved Calcium (Ca)	mg/L	60.5	97.7	76.5	46.6	41.5	0.050	7662652
Dissolved Magnesium (Mg)	mg/L	16.6	24.0	30.0	14.1	23.4	0.050	7662652
Dissolved Potassium (K)	mg/L	0.555	1.16	1.34	0.505	0.218	0.050	7662652
Dissolved Sodium (Na)	mg/L	4.48	7.18	37.2	1.15	0.266	0.050	7662652
Dissolved Sulphur (S)	mg/L	12.8	42.3	62.0	4.8	23.5	3.0	7662652
RDL = Reportable Detection Limit								

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

CSR DISSOLVED METALS IN WATER (WATER)

Maxxam ID		KT3781		
Sampling Date		2014/09/26		
COC Number		08350173		
	Units	UN-NAMED	RDL	QC Batch
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	242	0.50	7662640
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	15.9	3.0	7667932
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	7667932
Dissolved Arsenic (As)	ug/L	0.40	0.10	7667932
Dissolved Barium (Ba)	ug/L	109	1.0	7667932
Dissolved Beryllium (Be)	ug/L	<0.10	0.10	7667932
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	7667932
Dissolved Boron (B)	ug/L	<50	50	7667932
Dissolved Cadmium (Cd)	ug/L	<0.010	0.010	7667932
Dissolved Chromium (Cr)	ug/L	<1.0	1.0	7667932
Dissolved Cobalt (Co)	ug/L	<0.50	0.50	7667932
Dissolved Copper (Cu)	ug/L	0.34	0.20	7667932
Dissolved Iron (Fe)	ug/L	363	5.0	7667932
Dissolved Lead (Pb)	ug/L	<0.20	0.20	7667932
Dissolved Lithium (Li)	ug/L	<5.0	5.0	7667932
Dissolved Manganese (Mn)	ug/L	11.0	1.0	7667932
Dissolved Mercury (Hg)	ug/L	<0.050	0.050	7667932
Dissolved Molybdenum (Mo)	ug/L	1.3	1.0	7667932
Dissolved Nickel (Ni)	ug/L	<1.0	1.0	7667932
Dissolved Selenium (Se)	ug/L	<0.10	0.10	7667932
Dissolved Silicon (Si)	ug/L	1970	100	7667932
Dissolved Silver (Ag)	ug/L	<0.020	0.020	7667932
Dissolved Strontium (Sr)	ug/L	258	1.0	7667932
Dissolved Thallium (Tl)	ug/L	<0.050	0.050	7667932
Dissolved Tin (Sn)	ug/L	<5.0	5.0	7667932
Dissolved Titanium (Ti)	ug/L	<5.0	5.0	7667932
Dissolved Uranium (U)	ug/L	0.83	0.10	7667932
Dissolved Vanadium (V)	ug/L	<5.0	5.0	7667932
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	7667932
Dissolved Zirconium (Zr)	ug/L	<0.50	0.50	7667932
Dissolved Calcium (Ca)	mg/L	68.8	0.050	7662652
Dissolved Magnesium (Mg)	mg/L	17.1	0.050	7662652
Dissolved Potassium (K)	mg/L	0.729	0.050	7662652
Dissolved Sodium (Na)	mg/L	8.72	0.050	7662652
Dissolved Sulphur (S)	mg/L	10.5	3.0	7662652
RDL = Reportable Detection Limit				

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

CSR TOTAL METALS IN WATER (WATER)

Maxxam ID		KT3776	KT3777	KT3778	KT3779		KT3780		
Sampling Date		2014/09/26	2014/09/26	2014/09/26	2014/09/26		2014/09/26		
COC Number		08350173	08350173	08350173	08350173		08350173		
	Units	BLUEFISH	OLD ROAD TETCELA MAIN	FISHTRAP	GRAINGER @GG	QC Batch	SUNDOG 29.2	RDL	QC Batch
Calculated Parameters									
Total Hardness (CaCO3)	mg/L	215	364	321	185	7662681	209	0.50	7662681
Total Metals by ICPMS									
Total Aluminum (Al)	ug/L	10.3	33.5	33.3	9.3	7663540	4.9	3.0	7669834
Total Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	7663540	<0.50	0.50	7669834
Total Arsenic (As)	ug/L	0.29	0.39	0.47	0.22	7663540	<0.10	0.10	7669834
Total Barium (Ba)	ug/L	95.7	73.7	58.0	92.2	7663540	74.3	1.0	7669834
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10	<0.10	7663540	<0.10	0.10	7669834
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	7663540	<1.0	1.0	7669834
Total Boron (B)	ug/L	<50	<50	81	<50	7663540	<50	50	7669834
Total Cadmium (Cd)	ug/L	0.012	0.032	<0.010	0.017	7663540	0.013	0.010	7669834
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	<1.0	7663540	<1.0	1.0	7669834
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50	<0.50	7663540	<0.50	0.50	7669834
Total Copper (Cu)	ug/L	<0.50	0.68	1.04	<0.50	7663540	<0.50	0.50	7669834
Total Iron (Fe)	ug/L	44	185	111	47	7663540	<10	10	7669834
Total Lead (Pb)	ug/L	<0.20	<0.20	<0.20	<0.20	7663540	<0.20	0.20	7669834
Total Lithium (Li)	ug/L	<5.0	11.8	<5.0	<5.0	7663540	<5.0	5.0	7669834
Total Manganese (Mn)	ug/L	4.6	32.9	5.9	2.9	7663540	<1.0	1.0	7669834
Total Mercury (Hg)	ug/L	<0.050	<0.050	<0.050	<0.050	7663540	<0.050	0.050	7669834
Total Molybdenum (Mo)	ug/L	2.2	4.0	<1.0	1.1	7663540	1.5	1.0	7669834
Total Nickel (Ni)	ug/L	<1.0	2.3	<1.0	<1.0	7663540	<1.0	1.0	7669834
Total Selenium (Se)	ug/L	0.21	0.50	<0.10	0.20	7663540	0.15	0.10	7669834
Total Silicon (Si)	ug/L	1800	2850	1390	1770	7663540	885	100	7669834
Total Silver (Ag)	ug/L	0.025	<0.020	<0.020	<0.020	7663540	<0.020	0.020	7669834
Total Strontium (Sr)	ug/L	171	473	951	78.5	7663540	40.5	1.0	7669834
Total Thallium (Tl)	ug/L	0.088	<0.050	<0.050	0.051	7663540	<0.050	0.050	7669834
Total Tin (Sn)	ug/L	<5.0	<5.0	<5.0	<5.0	7663540	<5.0	5.0	7669834
Total Titanium (Ti)	ug/L	<5.0	<5.0	<5.0	<5.0	7663540	<5.0	5.0	7669834
Total Uranium (U)	ug/L	3.82	4.79	0.54	2.14	7663540	2.79	0.10	7669834
Total Vanadium (V)	ug/L	<5.0	<5.0	<5.0	<5.0	7663540	<5.0	5.0	7669834
Total Zinc (Zn)	ug/L	<5.0	5.1	<5.0	<5.0	7663540	<5.0	5.0	7669834
Total Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50	<0.50	7663540	<0.50	0.50	7669834
Total Calcium (Ca)	mg/L	57.5	102	75.5	48.5	7662947	42.8	0.050	7662947
Total Magnesium (Mg)	mg/L	17.3	26.6	32.1	15.5	7662947	24.8	0.050	7662947
Total Potassium (K)	mg/L	0.549	1.18	1.17	0.567	7662947	0.171	0.050	7662947
Total Sodium (Na)	mg/L	4.55	7.02	37.9	1.27	7662947	0.221	0.050	7662947
Total Sulphur (S)	mg/L	12.8	45.4	64.7	6.6	7662947	22.3	3.0	7662947
RDL = Reportable Detection Limit									

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Maxxam Job #: B488344
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CANADIAN ZINC CORPORATION

CSR TOTAL METALS IN WATER (WATER)

Maxxam ID		KT3781		
Sampling Date		2014/09/26		
COC Number		08350173		
	Units	UN-NAMED	RDL	QC Batch
Calculated Parameters				
Total Hardness (CaCO3)	mg/L	252	0.50	7662681
Total Metals by ICPMS				
Total Aluminum (Al)	ug/L	50.5	3.0	7669834
Total Antimony (Sb)	ug/L	<0.50	0.50	7669834
Total Arsenic (As)	ug/L	0.42	0.10	7669834
Total Barium (Ba)	ug/L	110	1.0	7669834
Total Beryllium (Be)	ug/L	<0.10	0.10	7669834
Total Bismuth (Bi)	ug/L	<1.0	1.0	7669834
Total Boron (B)	ug/L	<50	50	7669834
Total Cadmium (Cd)	ug/L	<0.010	0.010	7669834
Total Chromium (Cr)	ug/L	<1.0	1.0	7669834
Total Cobalt (Co)	ug/L	<0.50	0.50	7669834
Total Copper (Cu)	ug/L	2.36	0.50	7669834
Total Iron (Fe)	ug/L	387	10	7669834
Total Lead (Pb)	ug/L	<0.20	0.20	7669834
Total Lithium (Li)	ug/L	<5.0	5.0	7669834
Total Manganese (Mn)	ug/L	11.3	1.0	7669834
Total Mercury (Hg)	ug/L	<0.050	0.050	7669834
Total Molybdenum (Mo)	ug/L	1.5	1.0	7669834
Total Nickel (Ni)	ug/L	<1.0	1.0	7669834
Total Selenium (Se)	ug/L	<0.10	0.10	7669834
Total Silicon (Si)	ug/L	2100	100	7669834
Total Silver (Ag)	ug/L	<0.020	0.020	7669834
Total Strontium (Sr)	ug/L	272	1.0	7669834
Total Thallium (Tl)	ug/L	<0.050	0.050	7669834
Total Tin (Sn)	ug/L	<5.0	5.0	7669834
Total Titanium (Ti)	ug/L	<5.0	5.0	7669834
Total Uranium (U)	ug/L	0.90	0.10	7669834
Total Vanadium (V)	ug/L	<5.0	5.0	7669834
Total Zinc (Zn)	ug/L	<5.0	5.0	7669834
Total Zirconium (Zr)	ug/L	<0.50	0.50	7669834
Total Calcium (Ca)	mg/L	72.1	0.050	7662947
Total Magnesium (Mg)	mg/L	17.5	0.050	7662947
Total Potassium (K)	mg/L	0.788	0.050	7662947
Total Sodium (Na)	mg/L	8.55	0.050	7662947
Total Sulphur (S)	mg/L	10.4	3.0	7662947
RDL = Reportable Detection Limit				

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	1.0°C

CSR/CCME METALS IN SOIL (SOIL) Comments

Sample KT3785-02 Elements by ICPMS (total): Detection Limits raised due to sample matrix interference.
Sample KT3786-02 Elements by ICPMS (total): Detection Limits raised due to sample matrix interference.

Results relate only to the items tested.

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Maxxam Job #: B488344
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CANADIAN ZINC CORPORATION

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7668412	O-TERPHENYL (sur.)	2014/10/06	101	50 - 130	101	50 - 130	101	%				
7669227	O-TERPHENYL (sur.)	2014/10/07	86	50 - 130	98	50 - 130	105	%				
7663540	Total Aluminum (Al)	2014/10/03	NC	80 - 120	109	80 - 120	<3.0	ug/L	18	20		
7663540	Total Antimony (Sb)	2014/10/03	100	80 - 120	100	80 - 120	<0.50	ug/L	NC	20		
7663540	Total Arsenic (As)	2014/10/03	105	80 - 120	103	80 - 120	<0.10	ug/L	13	20		
7663540	Total Barium (Ba)	2014/10/03	NC	80 - 120	102	80 - 120	<1.0	ug/L	11	20		
7663540	Total Beryllium (Be)	2014/10/03	105	80 - 120	101	80 - 120	<0.10	ug/L	NC	20		
7663540	Total Bismuth (Bi)	2014/10/03	103	80 - 120	93	80 - 120	<1.0	ug/L	NC	20		
7663540	Total Boron (B)	2014/10/03					<50	ug/L	NC	20		
7663540	Total Cadmium (Cd)	2014/10/03	103	80 - 120	101	80 - 120	<0.010	ug/L	NC	20		
7663540	Total Chromium (Cr)	2014/10/03	106	80 - 120	106	80 - 120	<1.0	ug/L	NC	20		
7663540	Total Cobalt (Co)	2014/10/03	106	80 - 120	104	80 - 120	<0.50	ug/L	NC	20		
7663540	Total Copper (Cu)	2014/10/03	108	80 - 120	105	80 - 120	<0.50	ug/L	NC	20		
7663540	Total Iron (Fe)	2014/10/03	NC	80 - 120	106	80 - 120	<10	ug/L	6.8	20		
7663540	Total Lead (Pb)	2014/10/03	103	80 - 120	98	80 - 120	<0.20	ug/L	NC	20		
7663540	Total Lithium (Li)	2014/10/03	120	80 - 120	109	80 - 120	<5.0	ug/L	NC	20		
7663540	Total Manganese (Mn)	2014/10/03	NC	80 - 120	99	80 - 120	<1.0	ug/L	9.0	20		
7663540	Total Mercury (Hg)	2014/10/03	105	80 - 120	91	80 - 120	<0.050	ug/L				
7663540	Total Molybdenum (Mo)	2014/10/03	NC	80 - 120	97	80 - 120	<1.0	ug/L	NC	20		
7663540	Total Nickel (Ni)	2014/10/03	109	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
7663540	Total Selenium (Se)	2014/10/03	110	80 - 120	97	80 - 120	<0.10	ug/L	NC	20		
7663540	Total Silicon (Si)	2014/10/03					<100	ug/L	3.2	20		
7663540	Total Silver (Ag)	2014/10/03	92	80 - 120	91	80 - 120	0.032, RDL=0.020	ug/L	NC	20		
7663540	Total Strontium (Sr)	2014/10/03	NC	80 - 120	102	80 - 120	<1.0	ug/L	3.3	20		
7663540	Total Thallium (Tl)	2014/10/03	98	80 - 120	92	80 - 120	<0.050	ug/L	NC	20		
7663540	Total Tin (Sn)	2014/10/03	103	80 - 120	100	80 - 120	<5.0	ug/L	NC	20		
7663540	Total Titanium (Ti)	2014/10/03	106	80 - 120	102	80 - 120	<5.0	ug/L	NC	20		
7663540	Total Uranium (U)	2014/10/03	106	80 - 120	101	80 - 120	<0.10	ug/L	NC	20		
7663540	Total Vanadium (V)	2014/10/03	100	80 - 120	113	80 - 120	<5.0	ug/L	NC	20		
7663540	Total Zinc (Zn)	2014/10/03	110	80 - 120	105	80 - 120	<5.0	ug/L	NC	20		
7663540	Total Zirconium (Zr)	2014/10/03					<0.50	ug/L	NC	20		
7663822	Alkalinity (PP as CaCO3)	2014/10/02					<0.50	mg/L				

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7663822	Alkalinity (Total as CaCO3)	2014/10/02			96	80 - 120	<0.50	mg/L				
7663822	Bicarbonate (HCO3)	2014/10/02					<0.50	mg/L				
7663822	Carbonate (CO3)	2014/10/02					<0.50	mg/L				
7663822	Hydroxide (OH)	2014/10/02					<0.50	mg/L				
7663823	pH	2014/10/03			101	97 - 103			2.8	N/A		
7663824	Conductivity	2014/10/02			100	80 - 120	1.2, RDL=1.0	uS/cm				
7663826	Alkalinity (PP as CaCO3)	2014/10/03					<0.50	mg/L	NC	20		
7663826	Alkalinity (Total as CaCO3)	2014/10/03	NC	80 - 120	98	80 - 120	<0.50	mg/L	0.67	20		
7663826	Bicarbonate (HCO3)	2014/10/03					<0.50	mg/L	0.67	20		
7663826	Carbonate (CO3)	2014/10/03					<0.50	mg/L	NC	20		
7663826	Hydroxide (OH)	2014/10/03					<0.50	mg/L	NC	20		
7663829	pH	2014/10/03			101	97 - 103			0.79	N/A		
7663830	Conductivity	2014/10/03			100	80 - 120	1.2, RDL=1.0	uS/cm	0.39	20		
7664356	Total Suspended Solids	2014/10/04	108	80 - 120	101	80 - 120	<4.0	mg/L	NC	20		
7664406	Moisture	2014/10/04					<0.30	%	16	20		
7664619	Total Dissolved Solids	2014/10/07	NC	80 - 120	96	80 - 120	<10	mg/L	3.1	20		
7665392	Dissolved Chloride (Cl)	2014/10/03	NC	80 - 120	105	80 - 120	<0.50	mg/L	3.6	20		
7665397	Dissolved Sulphate (SO4)	2014/10/03	NC	80 - 120	102	80 - 120	<0.50	mg/L				
7666149	Total Aluminum (Al)	2014/10/06					<100	mg/kg			95	70 - 130
7666149	Total Antimony (Sb)	2014/10/06	94	75 - 125	98	75 - 125	<0.10	mg/kg			120	70 - 130
7666149	Total Arsenic (As)	2014/10/06	NC	75 - 125	94	75 - 125	<0.50	mg/kg	0.60	30	94	70 - 130
7666149	Total Barium (Ba)	2014/10/06	NC	75 - 125	99	75 - 125	<0.10	mg/kg			101	70 - 130
7666149	Total Beryllium (Be)	2014/10/06	96	75 - 125	97	75 - 125	<0.40	mg/kg				
7666149	Total Bismuth (Bi)	2014/10/06					<0.10	mg/kg				
7666149	Total Cadmium (Cd)	2014/10/06	96	75 - 125	103	75 - 125	<0.050	mg/kg	3.7	30	106	70 - 130
7666149	Total Calcium (Ca)	2014/10/06					<100	mg/kg			91	70 - 130
7666149	Total Chromium (Cr)	2014/10/06	NC	75 - 125	99	75 - 125	<1.0	mg/kg	2.2	30	102	70 - 130
7666149	Total Cobalt (Co)	2014/10/06	87	75 - 125	105	75 - 125	<0.30	mg/kg			90	70 - 130
7666149	Total Copper (Cu)	2014/10/06	NC	75 - 125	103	75 - 125	<0.50	mg/kg	0.90	30	95	70 - 130
7666149	Total Iron (Fe)	2014/10/06					<100	mg/kg			92	70 - 130
7666149	Total Lead (Pb)	2014/10/06	NC	75 - 125	101	75 - 125	<0.10	mg/kg	1.4	35	100	70 - 130
7666149	Total Magnesium (Mg)	2014/10/06					<100	mg/kg			93	70 - 130
7666149	Total Manganese (Mn)	2014/10/06	NC	75 - 125	103	75 - 125	<0.20	mg/kg			96	70 - 130

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Maxxam Job #: B488344
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION

QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7666149	Total Mercury (Hg)	2014/10/06	92	75 - 125	96	75 - 125	<0.050	mg/kg	NC	35	100	70 - 130
7666149	Total Molybdenum (Mo)	2014/10/06	NC	75 - 125	103	75 - 125	<0.10	mg/kg			104	70 - 130
7666149	Total Nickel (Ni)	2014/10/06	NC	75 - 125	102	75 - 125	<0.80	mg/kg			96	70 - 130
7666149	Total Phosphorus (P)	2014/10/06					<10	mg/kg			90	70 - 130
7666149	Total Potassium (K)	2014/10/06					<100	mg/kg				
7666149	Total Selenium (Se)	2014/10/06	95	75 - 125	96	75 - 125	<0.50	mg/kg				
7666149	Total Silver (Ag)	2014/10/06	88	75 - 125	93	75 - 125	<0.050	mg/kg				
7666149	Total Sodium (Na)	2014/10/06					<100	mg/kg				
7666149	Total Strontium (Sr)	2014/10/06	NC	75 - 125	97	75 - 125	<0.10	mg/kg			103	70 - 130
7666149	Total Thallium (Tl)	2014/10/06	98	75 - 125	104	75 - 125	<0.050	mg/kg			92	70 - 130
7666149	Total Tin (Sn)	2014/10/06	95	75 - 125	97	75 - 125	<0.10	mg/kg				
7666149	Total Titanium (Ti)	2014/10/06	NC	75 - 125	95	75 - 125	<1.0	mg/kg			103	70 - 130
7666149	Total Vanadium (V)	2014/10/06	NC	75 - 125	98	75 - 125	<2.0	mg/kg			103	70 - 130
7666149	Total Zinc (Zn)	2014/10/06	NC	75 - 125	103	75 - 125	<1.0	mg/kg	0.78	30	91	70 - 130
7666149	Total Zirconium (Zr)	2014/10/06					<0.50	mg/kg				
7666151	Soluble (2:1) pH	2014/10/06			100	97 - 103			0.38	N/A		
7666157	Total Aluminum (Al)	2014/10/06					<100	mg/kg			91	70 - 130
7666157	Total Antimony (Sb)	2014/10/06	92	75 - 125	96	75 - 125	<0.10	mg/kg			105	70 - 130
7666157	Total Arsenic (As)	2014/10/06	91	75 - 125	92	75 - 125	<0.50	mg/kg	0.70	30	95	70 - 130
7666157	Total Barium (Ba)	2014/10/06	NC	75 - 125	95	75 - 125	<0.10	mg/kg	6.2	35	96	70 - 130
7666157	Total Beryllium (Be)	2014/10/06	99	75 - 125	95	75 - 125	<0.40	mg/kg				
7666157	Total Bismuth (Bi)	2014/10/06					<0.10	mg/kg				
7666157	Total Cadmium (Cd)	2014/10/06	100	75 - 125	101	75 - 125	<0.050	mg/kg			103	70 - 130
7666157	Total Calcium (Ca)	2014/10/06					<100	mg/kg			84	70 - 130
7666157	Total Chromium (Cr)	2014/10/06	100	75 - 125	95	75 - 125	<1.0	mg/kg	3.6	30	105	70 - 130
7666157	Total Cobalt (Co)	2014/10/06	91	75 - 125	93	75 - 125	<0.30	mg/kg			89	70 - 130
7666157	Total Copper (Cu)	2014/10/06	NC	75 - 125	103	75 - 125	<0.50	mg/kg	2.0	30	95	70 - 130
7666157	Total Iron (Fe)	2014/10/06					<100	mg/kg			89	70 - 130
7666157	Total Lead (Pb)	2014/10/06	95	75 - 125	96	75 - 125	<0.10	mg/kg	0.78	35	96	70 - 130
7666157	Total Magnesium (Mg)	2014/10/06					<100	mg/kg			92	70 - 130
7666157	Total Manganese (Mn)	2014/10/06	NC	75 - 125	96	75 - 125	<0.20	mg/kg			96	70 - 130
7666157	Total Mercury (Hg)	2014/10/06	97	75 - 125	95	75 - 125	<0.050	mg/kg			82	70 - 130
7666157	Total Molybdenum (Mo)	2014/10/06	105	75 - 125	101	75 - 125	<0.10	mg/kg			112	70 - 130

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7666157	Total Nickel (Ni)	2014/10/06	NC	75 - 125	101	75 - 125	<0.80	mg/kg			98	70 - 130
7666157	Total Phosphorus (P)	2014/10/06					<10	mg/kg			93	70 - 130
7666157	Total Potassium (K)	2014/10/06					<100	mg/kg				
7666157	Total Selenium (Se)	2014/10/06	92	75 - 125	94	75 - 125	<0.50	mg/kg				
7666157	Total Silver (Ag)	2014/10/06	95	75 - 125	91	75 - 125	<0.050	mg/kg				
7666157	Total Sodium (Na)	2014/10/06					<100	mg/kg				
7666157	Total Strontium (Sr)	2014/10/06	NC	75 - 125	94	75 - 125	<0.10	mg/kg			97	70 - 130
7666157	Total Thallium (Tl)	2014/10/06	91	75 - 125	93	75 - 125	<0.050	mg/kg			91	70 - 130
7666157	Total Tin (Sn)	2014/10/06	94	75 - 125	95	75 - 125	<0.10	mg/kg				
7666157	Total Titanium (Ti)	2014/10/06	NC	75 - 125	90	75 - 125	<1.0	mg/kg			109	70 - 130
7666157	Total Vanadium (V)	2014/10/06	NC	75 - 125	90	75 - 125	<2.0	mg/kg			105	70 - 130
7666157	Total Zinc (Zn)	2014/10/06	NC	75 - 125	100	75 - 125	<1.0	mg/kg	0.38	30	93	70 - 130
7666157	Total Zirconium (Zr)	2014/10/06					<0.50	mg/kg				
7666159	Soluble (2:1) pH	2014/10/06			99	97 - 103			1.1	N/A		
7667932	Dissolved Aluminum (Al)	2014/10/07	102	80 - 120	104	80 - 120	<3.0	ug/L				
7667932	Dissolved Antimony (Sb)	2014/10/07	102	80 - 120	100	80 - 120	<0.50	ug/L				
7667932	Dissolved Arsenic (As)	2014/10/07	103	80 - 120	102	80 - 120	<0.10	ug/L				
7667932	Dissolved Barium (Ba)	2014/10/07	NC	80 - 120	103	80 - 120	<1.0	ug/L				
7667932	Dissolved Beryllium (Be)	2014/10/07	100	80 - 120	100	80 - 120	<0.10	ug/L				
7667932	Dissolved Bismuth (Bi)	2014/10/07	97	80 - 120	100	80 - 120	<1.0	ug/L				
7667932	Dissolved Boron (B)	2014/10/07					<50	ug/L				
7667932	Dissolved Cadmium (Cd)	2014/10/07	101	80 - 120	101	80 - 120	<0.010	ug/L				
7667932	Dissolved Chromium (Cr)	2014/10/07	104	80 - 120	105	80 - 120	<1.0	ug/L				
7667932	Dissolved Cobalt (Co)	2014/10/07	105	80 - 120	108	80 - 120	<0.50	ug/L				
7667932	Dissolved Copper (Cu)	2014/10/07	103	80 - 120	106	80 - 120	<0.20	ug/L				
7667932	Dissolved Iron (Fe)	2014/10/07	107	80 - 120	111	80 - 120	<5.0	ug/L				
7667932	Dissolved Lead (Pb)	2014/10/07	97	80 - 120	100	80 - 120	<0.20	ug/L				
7667932	Dissolved Lithium (Li)	2014/10/07	101	80 - 120	101	80 - 120	<5.0	ug/L				
7667932	Dissolved Manganese (Mn)	2014/10/07	104	80 - 120	106	80 - 120	<1.0	ug/L				
7667932	Dissolved Mercury (Hg)	2014/10/07	96	80 - 120	102	80 - 120	<0.050	ug/L				
7667932	Dissolved Molybdenum (Mo)	2014/10/07	NC	80 - 120	96	80 - 120	<1.0	ug/L				
7667932	Dissolved Nickel (Ni)	2014/10/07	106	80 - 120	109	80 - 120	<1.0	ug/L				
7667932	Dissolved Selenium (Se)	2014/10/07	103	80 - 120	105	80 - 120	<0.10	ug/L				

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7667932	Dissolved Silicon (Si)	2014/10/07					<100	ug/L				
7667932	Dissolved Silver (Ag)	2014/10/07	104	80 - 120	95	80 - 120	<0.020	ug/L				
7667932	Dissolved Strontium (Sr)	2014/10/07	NC	80 - 120	102	80 - 120	<1.0	ug/L				
7667932	Dissolved Thallium (Tl)	2014/10/07	100	80 - 120	103	80 - 120	<0.050	ug/L				
7667932	Dissolved Tin (Sn)	2014/10/07	98	80 - 120	99	80 - 120	<5.0	ug/L				
7667932	Dissolved Titanium (Ti)	2014/10/07	105	80 - 120	103	80 - 120	<5.0	ug/L				
7667932	Dissolved Uranium (U)	2014/10/07	101	80 - 120	102	80 - 120	<0.10	ug/L				
7667932	Dissolved Vanadium (V)	2014/10/07	103	80 - 120	107	80 - 120	<5.0	ug/L				
7667932	Dissolved Zinc (Zn)	2014/10/07	104	80 - 120	108	80 - 120	<5.0	ug/L				
7667932	Dissolved Zirconium (Zr)	2014/10/07					<0.50	ug/L				
7668412	EPH (C10-C19)	2014/10/06	NC	50 - 130	75	50 - 130	<100	mg/kg	8.5	40		
7668412	EPH (C19-C32)	2014/10/06	NC	50 - 130	86	50 - 130	<100	mg/kg	NC	40		
7669227	EPH (C10-C19)	2014/10/07	NC	50 - 130	83	50 - 130	<100	mg/kg	NC	40		
7669227	EPH (C19-C32)	2014/10/07	91	50 - 130	87	50 - 130	<100	mg/kg	NC	40		
7669834	Total Aluminum (Al)	2014/10/08	103	80 - 120	104	80 - 120	4.9, RDL=3.0	ug/L	NC	20		
7669834	Total Antimony (Sb)	2014/10/08	103	80 - 120	101	80 - 120	<0.50	ug/L	NC	20		
7669834	Total Arsenic (As)	2014/10/08	101	80 - 120	100	80 - 120	<0.10	ug/L	NC	20		
7669834	Total Barium (Ba)	2014/10/08	101	80 - 120	105	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Beryllium (Be)	2014/10/08	98	80 - 120	98	80 - 120	<0.10	ug/L	NC	20		
7669834	Total Bismuth (Bi)	2014/10/08	101	80 - 120	103	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Boron (B)	2014/10/08					<50	ug/L	NC	20		
7669834	Total Cadmium (Cd)	2014/10/08	100	80 - 120	102	80 - 120	<0.010	ug/L	NC	20		
7669834	Total Chromium (Cr)	2014/10/08	101	80 - 120	107	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Cobalt (Co)	2014/10/08	102	80 - 120	105	80 - 120	<0.50	ug/L	NC	20		
7669834	Total Copper (Cu)	2014/10/08	104	80 - 120	107	80 - 120	<0.50	ug/L	NC	20		
7669834	Total Iron (Fe)	2014/10/08	110	80 - 120	114	80 - 120	<10	ug/L	NC	20		
7669834	Total Lead (Pb)	2014/10/08	102	80 - 120	104	80 - 120	<0.20	ug/L	NC	20		
7669834	Total Lithium (Li)	2014/10/08	98	80 - 120	102	80 - 120	<5.0	ug/L	NC	20		
7669834	Total Manganese (Mn)	2014/10/08	102	80 - 120	106	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Mercury (Hg)	2014/10/08	103	80 - 120	106	80 - 120	<0.050	ug/L				
7669834	Total Molybdenum (Mo)	2014/10/08	97	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Nickel (Ni)	2014/10/08	101	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Selenium (Se)	2014/10/08	95	80 - 120	100	80 - 120	<0.10	ug/L	NC	20		

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7669834	Total Silicon (Si)	2014/10/08					<100	ug/L	NC	20		
7669834	Total Silver (Ag)	2014/10/08	86	80 - 120	105	80 - 120	<0.020	ug/L	NC	20		
7669834	Total Strontium (Sr)	2014/10/08	101	80 - 120	103	80 - 120	<1.0	ug/L	NC	20		
7669834	Total Thallium (Tl)	2014/10/08	103	80 - 120	102	80 - 120	<0.050	ug/L	NC	20		
7669834	Total Tin (Sn)	2014/10/08	100	80 - 120	100	80 - 120	<5.0	ug/L	NC	20		
7669834	Total Titanium (Ti)	2014/10/08	96	80 - 120	115	80 - 120	<5.0	ug/L	NC	20		
7669834	Total Uranium (U)	2014/10/08	104	80 - 120	105	80 - 120	<0.10	ug/L	NC	20		
7669834	Total Vanadium (V)	2014/10/08	97	80 - 120	104	80 - 120	<5.0	ug/L	NC	20		
7669834	Total Zinc (Zn)	2014/10/08	103	80 - 120	110	80 - 120	<5.0	ug/L	NC	20		
7669834	Total Zirconium (Zr)	2014/10/08					<0.50	ug/L	NC	20		
7766585	Total Organic Carbon (C)	2014/12/30			98	75 - 125	0.020, RDL=0.020	%	49 (1)	35	107	75 - 125

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

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Maxxam Analytics Inc

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5 Ph: (604) 734-7276 Fax: (604) 731-2386, Toll Free: (800) 685-6566

CHAIN OF CUSTODY RECORD

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Maxxam Job #: B488344 COC #: 08350173 Page: ___ of ___

Invoice To: Require Report? Yes ☐ No ☐

Company Name:	Canadian Zinc
Contact Name:	Claudia Martinez
Address:	1700-650 West Georgia St
PC:	
Phone / Fax#:	Ph: 604 688 2001 Fax:
E-mail	claudia@canadianzinc.com

Report To:

Company Name:	Canadian Zinc
Contact Name:	David Harpley
Address:	
PC:	
Phone / Fax#:	Ph: 604 594 3855 Fax:
E-mail	david@canadianzinc.com

PO #:	
Quotation #:	
Project #:	
Proj. Name:	
Location:	
Sampled by:	

REGULATORY REQUIREMENTS:

- ☐ CSR
- ☑ CCME
- ☐ BC Water Quality
- ☐ Other
- ☐ DRINKING WATER

SERVICE REQUESTED:

- ◉ Regular Turn Around Time (TAT) (5 days for most tests)
- RUSH (Please contact the lab) ○ 1 Day ○ 2 Day ○ 3 Day
- Date Required:

SPECIAL INSTRUCTIONS:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

Bluefish, Un-named and Fishtrap diss. samples are not filtered or acidified.
Other diss. samples are filtered and acidified.

ANALYSIS REQUESTED

	Sample Identification	Lab Identification (Lab Use Only)	Sample Type	Date/Time(24hr) Sampled	Dissolved Metals (DM)	Total Metals	pH, Cond, alk	SO_4, Cl	TSS, TDS	EPH	Field Filtered? Y/N	Field Acidified? Y/N	Field Acidified? Y/N	Number of Containers
1	Bluefish	KT3776	Surface W	Sep 26 2014		X	X	X	X					3
2	Old Road Tetcela Main	KT3777	Surface W	Sep 26 2014		X	X	X	X					3
3	Fishtrap	KT3778	Surface W	Sep 26 2014		X	X	X	X					3
4	Grainger @ GG	KT3779	Surface W	Sep 26 2014		X	X	X	X					3
5	Sundog 29.2	KT3780	Surface W	Sep 26 2014		X	X	X	X					3
6	Un-named	KT3781	Surface W	Sep 26 2014		X	X	X	X					3
7	Fishtrap		Surface W	Sep 26 2014		X	X	X	X					3
8	Old Road Tetcela Trib	KT3782	Sediment	Sep 26 2014		X				X				2
9	Bluefish	KT3783	Sediment	Sep 26 2014		X				X				2
10	Old Road Tetcela Main	KT3784	Sediment	Sep 26 2014		X				X				2
11	Sundog 29.2	KT3785	Sediment	Sep 26 2014		X				X				2
12	Grainger @ GG	KT3786	Sediment	Sep 26 2014		X				X				2

ARRIVED AT DEPOT: OCT 01 2014 TIME: 12:13

B488344

Laboratory Use Only

*Relinquished By: (Print name and sign)	Date (yy/mm/dd):	Time (24hr):	Received by: (Print name and sign)	Date (yy/mm/dd):	Time (24 hr):	Time Sensitive
			JOHN GREGG	2014/10/02	07:40	☐

Temperature on Receipt (°C)				Custody Seal	Yes	No
A) 1	B) 1	C)		Present?	☑	☐
Just sampled & rec'd on ice: ☐				Intact?	☑	☐

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

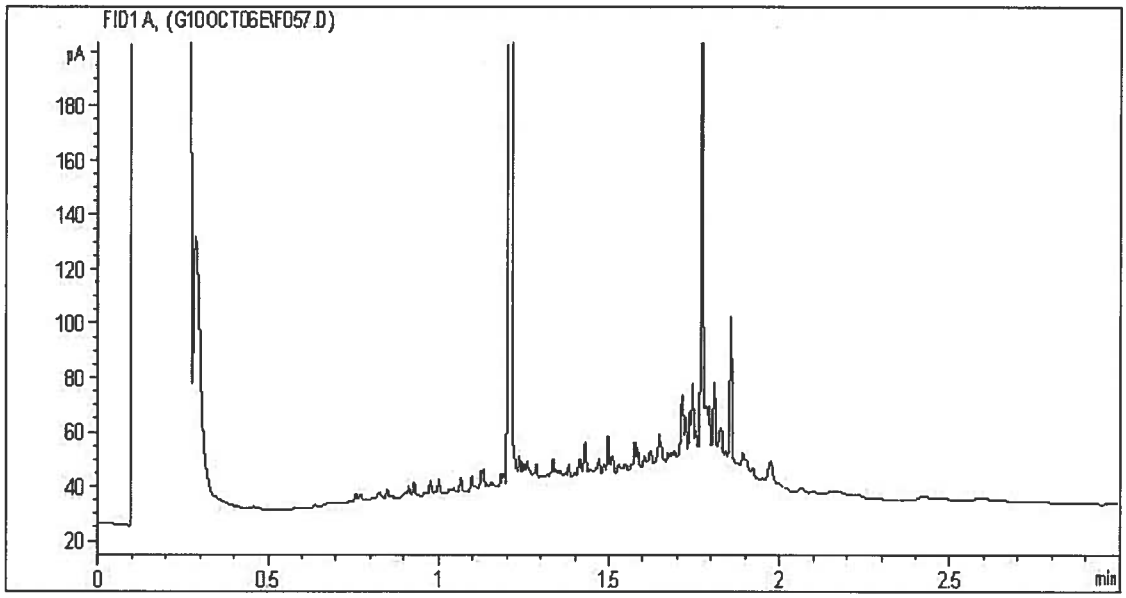
BBY FOD-00077R1_C

Maxxam Analytics Success Through Science ®

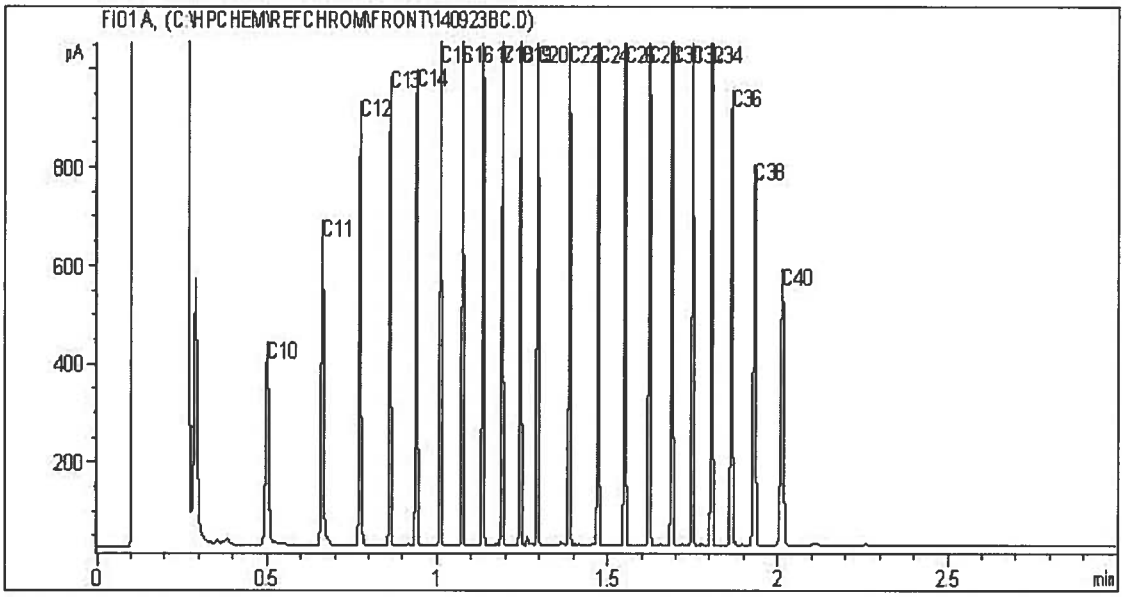
Maxxam Job #: B488344
Report Date: 2014/12/31
Maxxam Sample: KT3782

CANADIAN ZINC CORPORATION
Client ID: OLD ROAD TETCELA TRIB

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

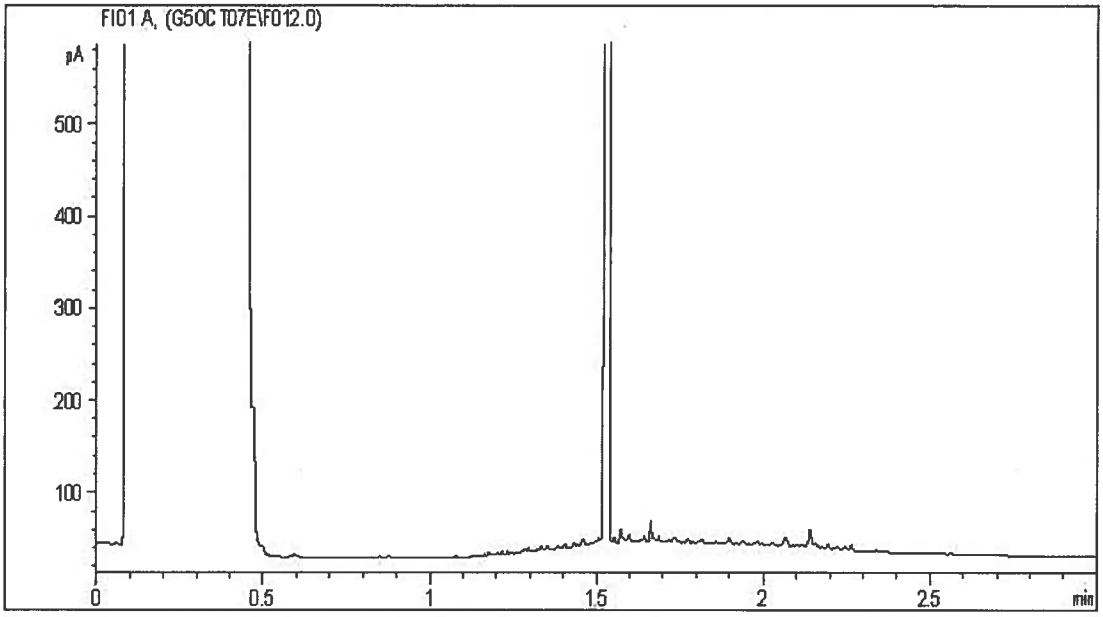
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

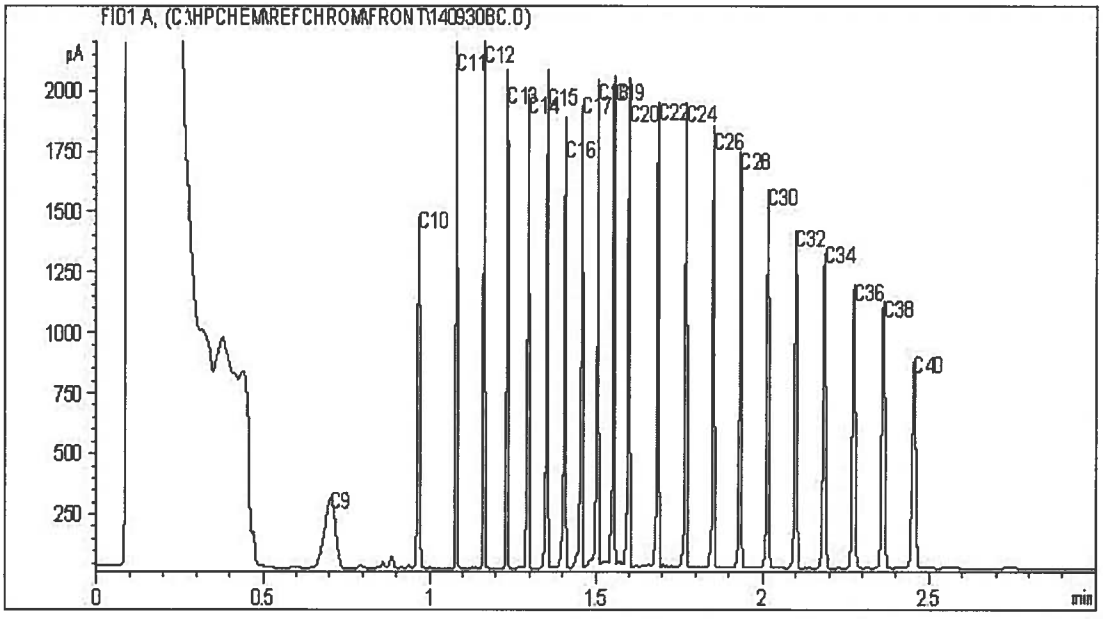
Maxxam Job #: B488344
Report Date: 2014/12/31
Maxxam Sample: KT3783

CANADIAN ZINC CORPORATION
Client ID: BLUEFISH

BC Hydrocarbons in Soil by GC/FID Chromatogram



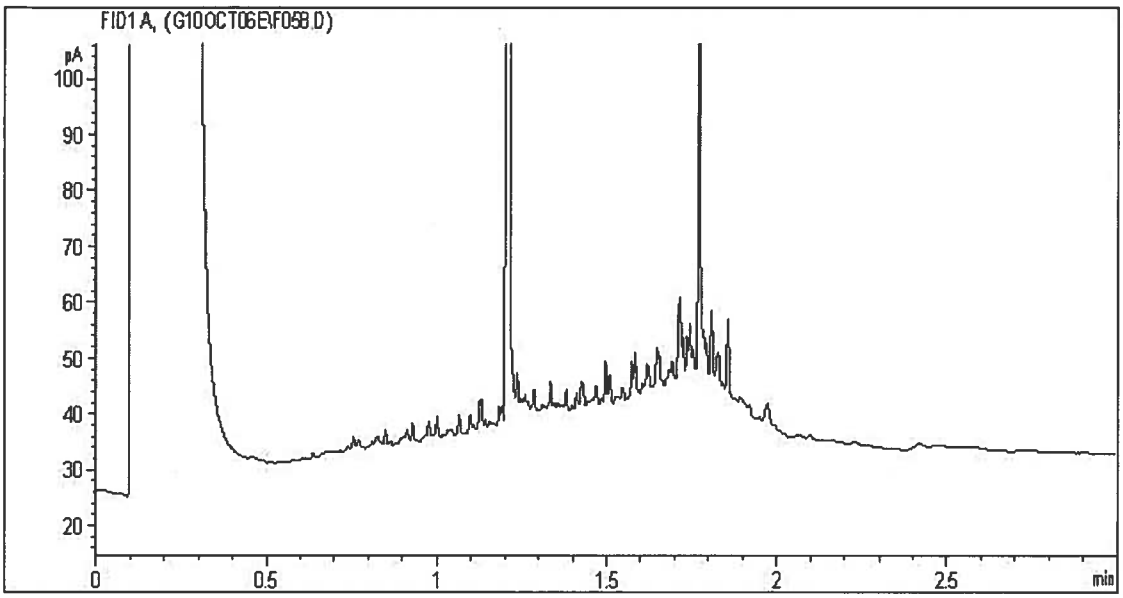
Carbon Range Distribution - Reference Chromatogram



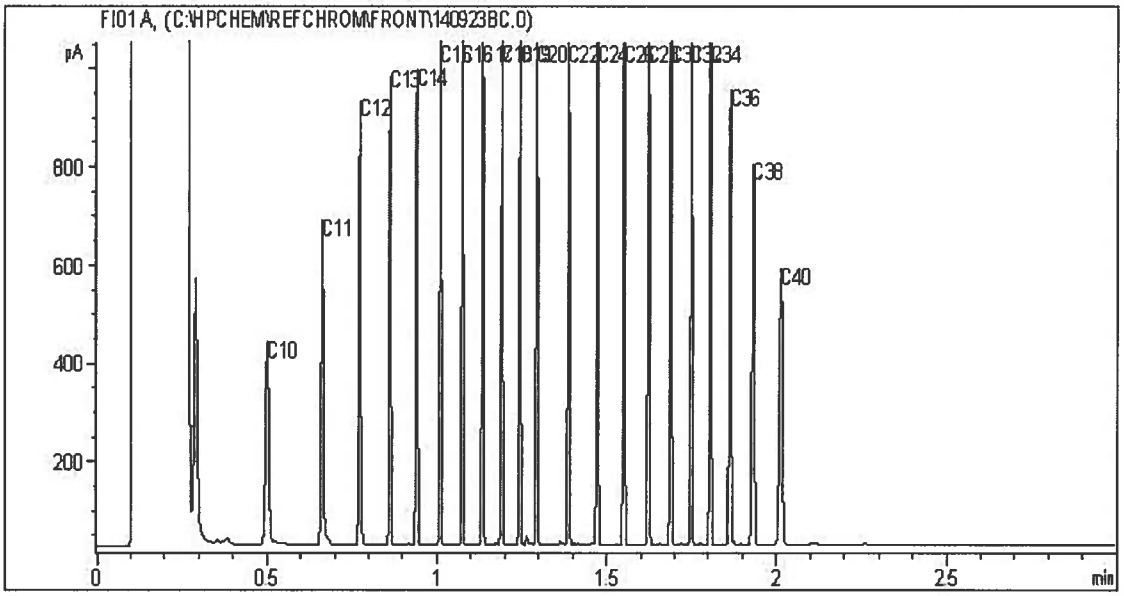
TYPICAL PRODUCT CARBON NUMBER RANGES

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

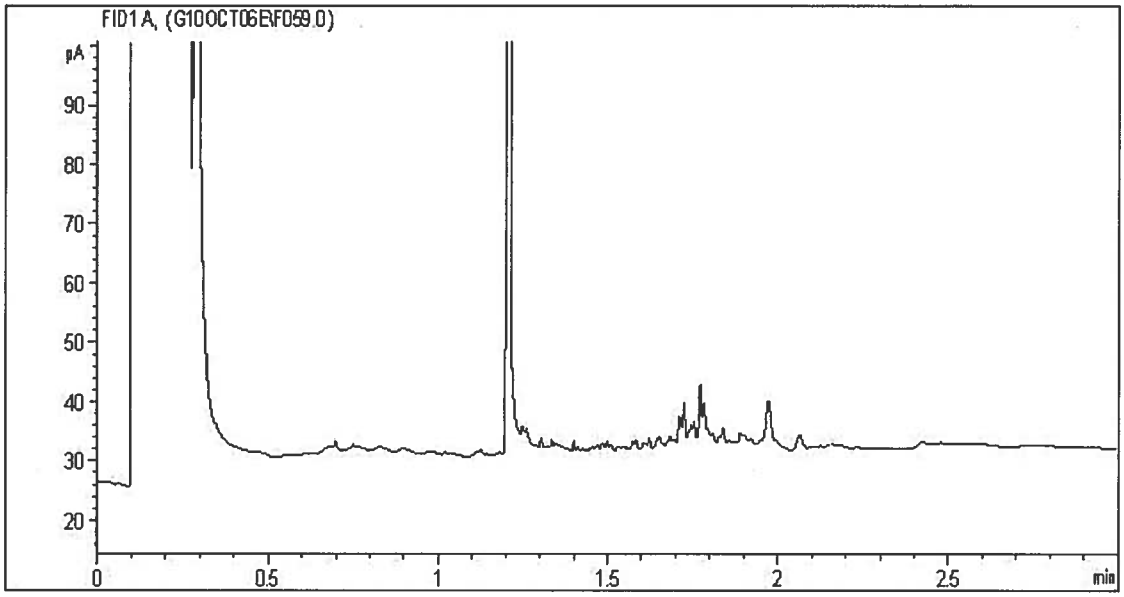
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

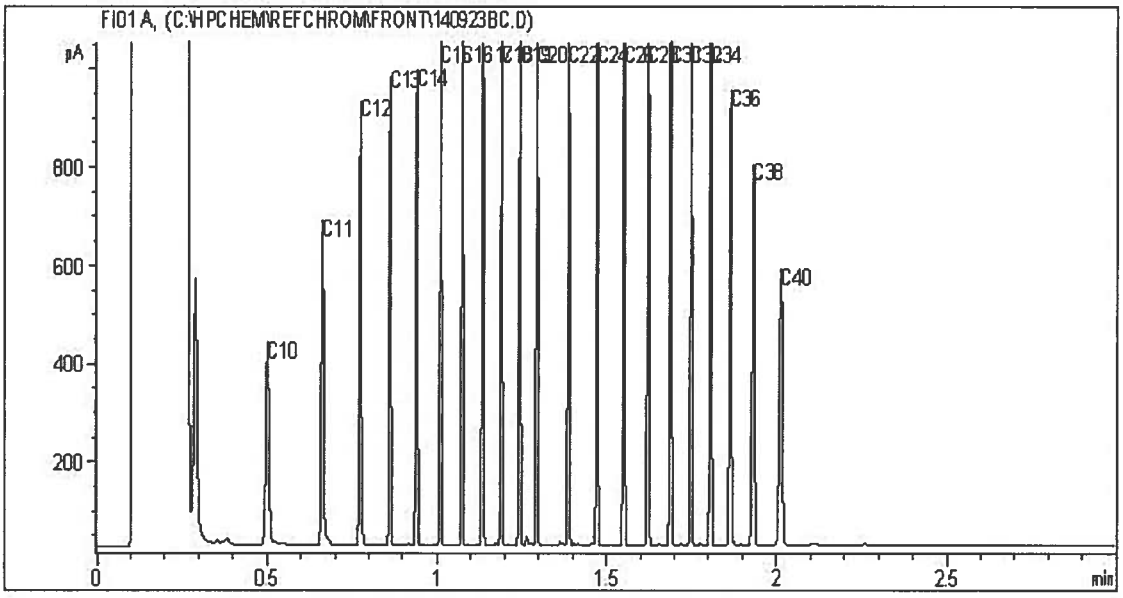
Maxxam Job #: B488344
Report Date: 2014/12/31
Maxxam Sample: KT3785

CANADIAN ZINC CORPORATION
Client ID: SUNDOG 29.2

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

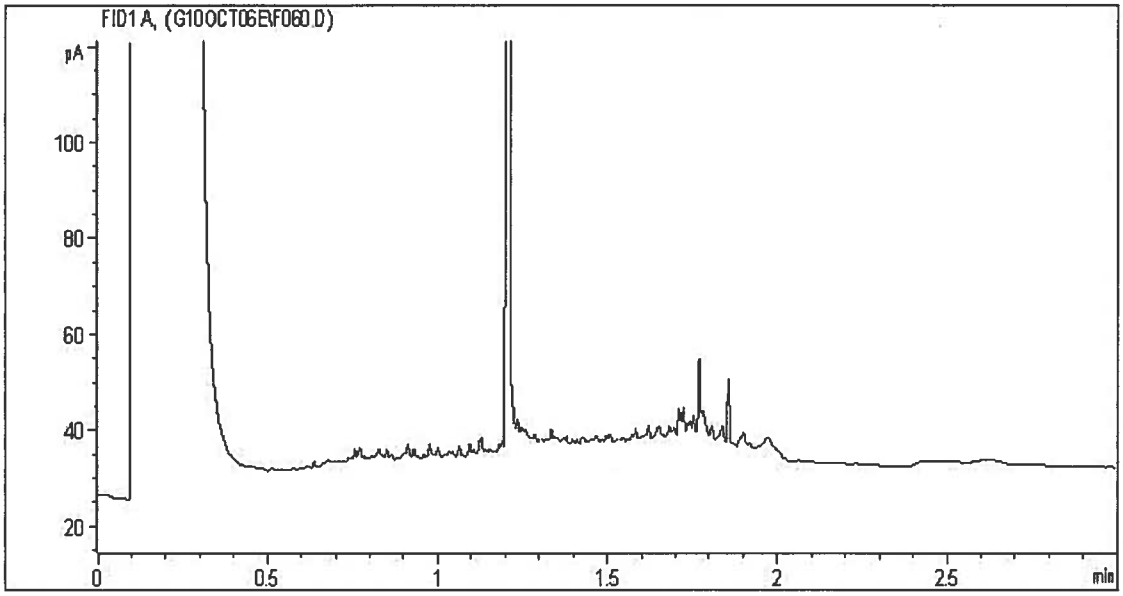
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

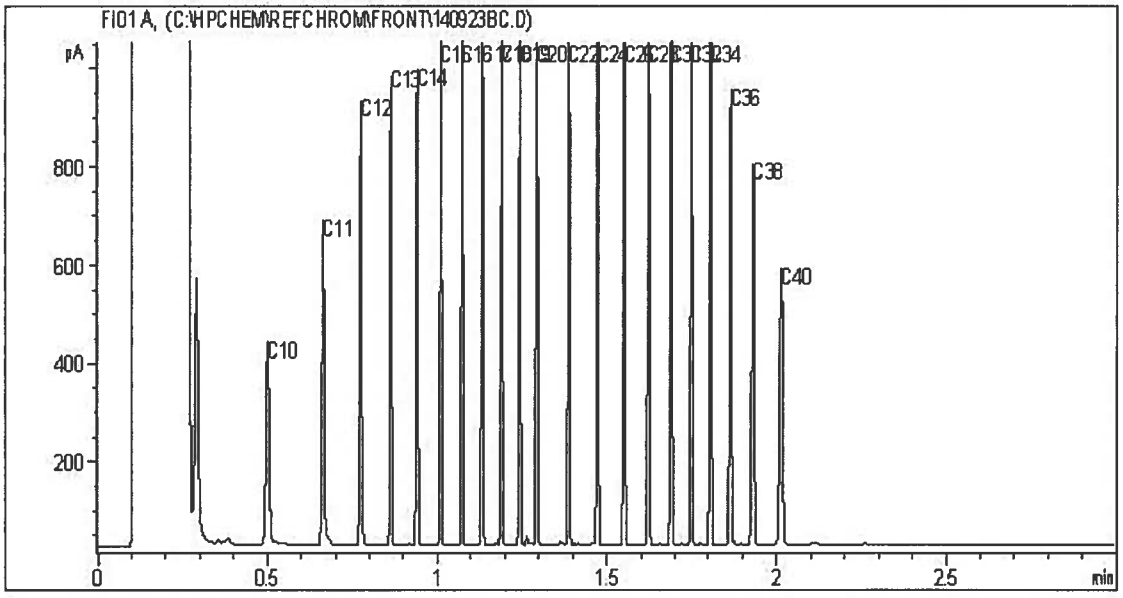
Maxxam Job #: B488344
Report Date: 2014/12/31
Maxxam Sample: KT3786

CANADIAN ZINC CORPORATION
Client ID: GRAINGER @GG

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



TYPICAL PRODUCT CARBON NUMBER RANGES

Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

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Your Project #: PRAIRIE CREEK MINE, NORTHWEST
Your C.O.C. #: 08350188

Attention:DAVID HARPLEY

CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/12/31
Report #: R1769632
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B4A0466
Received: 2014/11/04, 14:45

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	4	2014/11/06	2014/11/06	BBY7SOP-00001	EPA 6020a R1 m
Moisture	3	N/A	2014/11/08	BBY8SOP-00017	OMOE E3139 3.1 m
Moisture	1	N/A	2014/11/09	BBY8SOP-00017	OMOE E3139 3.1 m
pH (2:1 DI Water Extract)	4	2014/11/06	2014/11/07	BBY6SOP-00028	BCMOE BCLM Mar2005 m
Total Organic Carbon LECO Method (1)	4	2014/12/29	2014/12/30	CAL SOP-00243	LECO 203-821-170 m
BC Hydrocarbons in Soil by GC/FID	3	2014/11/07	2014/11/10	BBY8SOP-00029	BCMOE EPH s 07/99 m
BC Hydrocarbons in Soil by GC/FID	1	2014/11/08	2014/11/10	BBY8SOP-00029	BCMOE EPH s 07/99 m

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	1	2014/11/05	2014/11/06	BBY6SOP-00026	SM 22 2320 B m
Alkalinity - Water	1	2014/11/06	2014/11/06	BBY6SOP-00026	SM 22 2320 B m
Chloride by Automated Colourimetry	2	N/A	2014/11/06	BBY6SOP-00011	SM 22 4500-Cl- G m
Conductance - water	2	N/A	2014/11/06	BBY6SOP-00026	SM 22 2510 B m
Hardness Total (calculated as CaCO3)	2	N/A	2014/11/06	BBY7SOP-00002	EPA 6020a R1 m
Hardness (calculated as CaCO3)	2	N/A	2014/11/08	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Dissolved) by CVAF	2	N/A	2014/11/15	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CVAF	1	2014/11/14	2014/11/14	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Mercury (Total) by CVAF	1	2014/11/14	2014/11/15	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	2	N/A	2014/11/08	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (dissolved)	2	N/A	2014/11/08	BBY7SOP-00002	EPA 6020A R1 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	2	2014/11/05	2014/11/06	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	2	2014/11/05	2014/11/06	BBY7SOP-00002	EPA 6020A R1 m
Filter and HNO3 Preserve for Metals	2	N/A	2014/11/08	BBY7 WI-00004	BCMOE Reqs 08/14
pH Water (2)	2	N/A	2014/11/06	BBY6SOP-00026	SM 22 4500-H+ B m
Sulphate by Automated Colourimetry	2	N/A	2014/11/06	BBY6SOP-00017	SM 22 4500-SO42- E m
Total Dissolved Solids (Filt. Residue)	2	2014/11/06	2014/11/07	BBY6SOP-00033	SM 22 2540 C m
Total Suspended Solids	2	N/A	2014/11/07	BBY6SOP-00034	SM 22 2540 D

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Your Project #: PRAIRIE CREEK MINE, NORTHWEST
Your C.O.C. #: 08350188

Attention:DAVID HARPLEY

CANADIAN ZINC CORPORATION
650 West Georgia Street
Suite 1710
Vancouver, BC
CANADA V6B 4N9

Report Date: 2014/12/31
Report #: R1769632
Version: 2 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

MAXXAM JOB #: B4A0466
Received: 2014/11/04, 14:45

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Calgary Environmental
(2) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Encryption Key

Sydney Morgan Strelau
31 Dec 2014 08:21:07 -08:00

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Sydney Morgan Strelau, Customer Service Representative
Email: SMorganStrelau@maxxam.ca
Phone# (604) 734 7276

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

PHYSICAL TESTING (SOIL)

Maxxam ID		LB2024		LB2025		LB2026		LB2027		
Sampling Date		2014/09/19		2014/09/19		2014/09/19		2014/09/19		
COC Number		08350188		08350188		08350188		08350188		
	Units	FUNERAL	QC Batch	SUNDOG @CAT	QC Batch	POLIJIE	QC Batch	PRAIRIE	RDL	QC Batch
Physical Properties										
Moisture	%	6.6	7711373	21	7711132	17	7711358	5.9	0.30	7711903
RDL = Reportable Detection Limit										

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Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

TOTAL PETROLEUM HYDROCARBONS (SOIL)

Maxxam ID		LB2024	LB2025	LB2026		LB2027		
Sampling Date		2014/09/19	2014/09/19	2014/09/19		2014/09/19		
COC Number		08350188	08350188	08350188		08350188		
	Units	FUNERAL	SUNDOG @CAT	POLIJIE	QC Batch	PRAIRIE	RDL	QC Batch
Hydrocarbons								
EPH (C10-C19)	mg/kg	<100	<100	<100	7713375	<100	100	7714253
EPH (C19-C32)	mg/kg	<100	<100	<100	7713375	<100	100	7714253
Surrogate Recovery (%)								
O-TERPHENYL (sur.)	%	97	93	94	7713375	102		7714253
RDL = Reportable Detection Limit								

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Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

MISCELLANEOUS (SOIL)

Maxxam ID		LB2024		LB2025		LB2026		LB2027		
Sampling Date		2014/09/19		2014/09/19		2014/09/19		2014/09/19		
COC Number		08350188		08350188		08350188		08350188		
	Units	FUNERAL	RDL	SUNDOG @CAT	RDL	POLIJIE	RDL	PRAIRIE	RDL	QC Batch
Misc. Inorganics										
Total Organic Carbon (C)	%	5.2 (1)	0.040	<0.20 (2)	0.20	0.039	0.020	3.3 (2)	0.040	7766585

RDL = Reportable Detection Limit

(1) Detection limits raised due to dilution to bring analyte within the calibrated range.
Duplicate exceeds acceptance criteria due to sample non homogeneity. Reanalysis yields similar results.

(2) Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		LB2022		LB2023		
Sampling Date		2014/09/19		2014/09/19		
COC Number		08350188		08350188		
	Units	POLIJIE CREEK	QC Batch	FUNERAL CREEK	RDL	QC Batch
Calculated Parameters						
Filter and HNO3 Preservation	N/A	FIELD	ONSITE	FIELD	N/A	ONSITE
Misc. Inorganics						
Alkalinity (Total as CaCO3)	mg/L	193	7708244	172	0.50	7709354
Alkalinity (PP as CaCO3)	mg/L	2.49	7708244	<0.50	0.50	7709354
Bicarbonate (HCO3)	mg/L	229	7708244	210	0.50	7709354
Carbonate (CO3)	mg/L	2.99	7708244	<0.50	0.50	7709354
Hydroxide (OH)	mg/L	<0.50	7708244	<0.50	0.50	7709354
Anions						
Dissolved Sulphate (SO4)	mg/L	30.0	7709993	87.5	0.50	7709993
Dissolved Chloride (Cl)	mg/L	1.2	7709991	0.75	0.50	7709991
Physical Properties						
Conductivity	uS/cm	421	7708249	465	1.0	7709371
pH	pH	8.38	7708248	8.21	N/A	7709370
Physical Properties						
Total Suspended Solids	mg/L	<4.0	7708892	<4.0	4.0	7708892
Total Dissolved Solids	mg/L	228	7708888	264	10	7708888

RDL = Reportable Detection Limit
N/A = Not Applicable

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		LB2022	LB2023		
Sampling Date		2014/09/19	2014/09/19		
COC Number		08350188	08350188		
	Units	POLIJIE CREEK	FUNERAL CREEK	RDL	QC Batch
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	243	265	0.50	7707077
Elements					
Dissolved Mercury (Hg)	ug/L	<0.010	<0.010	0.010	7720177
Dissolved Metals by ICPMS					
Dissolved Aluminum (Al)	ug/L	<3.0	<3.0	3.0	7709558
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	7709558
Dissolved Arsenic (As)	ug/L	0.13	0.50	0.10	7709558
Dissolved Barium (Ba)	ug/L	131	66.1	1.0	7709558
Dissolved Beryllium (Be)	ug/L	<0.10	<0.10	0.10	7709558
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	7709558
Dissolved Boron (B)	ug/L	<50	<50	50	7709558
Dissolved Cadmium (Cd)	ug/L	0.092	0.054	0.010	7709558
Dissolved Chromium (Cr)	ug/L	<1.0	<1.0	1.0	7709558
Dissolved Cobalt (Co)	ug/L	<0.50	<0.50	0.50	7709558
Dissolved Copper (Cu)	ug/L	0.37	0.37	0.20	7709558
Dissolved Iron (Fe)	ug/L	14.1	5.7	5.0	7709558
Dissolved Lead (Pb)	ug/L	<0.20	<0.20	0.20	7709558
Dissolved Lithium (Li)	ug/L	<5.0	5.1	5.0	7709558
Dissolved Manganese (Mn)	ug/L	17.6	<1.0	1.0	7709558
Dissolved Molybdenum (Mo)	ug/L	4.8	3.6	1.0	7709558
Dissolved Nickel (Ni)	ug/L	2.0	2.7	1.0	7709558
Dissolved Selenium (Se)	ug/L	2.05	1.62	0.10	7709558
Dissolved Silicon (Si)	ug/L	2480	1560	100	7709558
Dissolved Silver (Ag)	ug/L	<0.020	<0.020	0.020	7709558
Dissolved Strontium (Sr)	ug/L	146	390	1.0	7709558
Dissolved Thallium (Tl)	ug/L	<0.050	<0.050	0.050	7709558
Dissolved Tin (Sn)	ug/L	<5.0	<5.0	5.0	7709558
Dissolved Titanium (Ti)	ug/L	<5.0	<5.0	5.0	7709558
Dissolved Uranium (U)	ug/L	2.80	5.30	0.10	7709558
Dissolved Vanadium (V)	ug/L	<5.0	<5.0	5.0	7709558
Dissolved Zinc (Zn)	ug/L	6.4	33.7	5.0	7709558
Dissolved Zirconium (Zr)	ug/L	<0.50	<0.50	0.50	7709558
Dissolved Calcium (Ca)	mg/L	73.1	59.1	0.050	7707169
Dissolved Magnesium (Mg)	mg/L	14.6	28.5	0.050	7707169
Dissolved Potassium (K)	mg/L	0.559	0.415	0.050	7707169
Dissolved Sodium (Na)	mg/L	0.929	1.58	0.050	7707169
RDL = Reportable Detection Limit					

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		LB2022	LB2023		
Sampling Date		2014/09/19	2014/09/19		
COC Number		08350188	08350188		
	Units	POLIJIE CREEK	FUNERAL CREEK	RDL	QC Batch
Dissolved Sulphur (S)	mg/L	12.1	27.9	3.0	7707169
RDL = Reportable Detection Limit					

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Maxxam Job #: B4A0466
Report Date: 2014/12/31

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

CCME TOTAL METALS IN WATER (WATER)

Maxxam ID		LB2022		LB2023		
Sampling Date		2014/09/19		2014/09/19		
COC Number		08350188		08350188		
	Units	POLIJIE CREEK	QC Batch	FUNERAL CREEK	RDL	QC Batch
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	223	7706996	251	0.50	7706996
Elements						
Total Mercury (Hg)	ug/L	<0.010	7719366	<0.010	0.010	7719978
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	5.2	7708728	<3.0	3.0	7708728
Total Antimony (Sb)	ug/L	<0.50	7708728	<0.50	0.50	7708728
Total Arsenic (As)	ug/L	0.12	7708728	0.52	0.10	7708728
Total Barium (Ba)	ug/L	131	7708728	64.8	1.0	7708728
Total Beryllium (Be)	ug/L	<0.10	7708728	<0.10	0.10	7708728
Total Bismuth (Bi)	ug/L	<1.0	7708728	<1.0	1.0	7708728
Total Boron (B)	ug/L	<50	7708728	<50	50	7708728
Total Cadmium (Cd)	ug/L	0.093	7708728	0.051	0.010	7708728
Total Chromium (Cr)	ug/L	<1.0	7708728	<1.0	1.0	7708728
Total Cobalt (Co)	ug/L	<0.50	7708728	<0.50	0.50	7708728
Total Copper (Cu)	ug/L	<0.50	7708728	<0.50	0.50	7708728
Total Iron (Fe)	ug/L	49	7708728	<10	10	7708728
Total Lead (Pb)	ug/L	<0.20	7708728	<0.20	0.20	7708728
Total Lithium (Li)	ug/L	<5.0	7708728	<5.0	5.0	7708728
Total Manganese (Mn)	ug/L	17.6	7708728	<1.0	1.0	7708728
Total Molybdenum (Mo)	ug/L	4.6	7708728	3.4	1.0	7708728
Total Nickel (Ni)	ug/L	1.9	7708728	2.7	1.0	7708728
Total Selenium (Se)	ug/L	2.04	7708728	1.49	0.10	7708728
Total Silicon (Si)	ug/L	2280	7708728	1450	100	7708728
Total Silver (Ag)	ug/L	<0.020	7708728	<0.020	0.020	7708728
Total Strontium (Sr)	ug/L	137	7708728	368	1.0	7708728
Total Thallium (Tl)	ug/L	<0.050	7708728	<0.050	0.050	7708728
Total Tin (Sn)	ug/L	<5.0	7708728	<5.0	5.0	7708728
Total Titanium (Ti)	ug/L	<5.0	7708728	<5.0	5.0	7708728
Total Uranium (U)	ug/L	2.66	7708728	5.20	0.10	7708728
Total Vanadium (V)	ug/L	<5.0	7708728	<5.0	5.0	7708728
Total Zinc (Zn)	ug/L	5.8	7708728	32.8	5.0	7708728
Total Zirconium (Zr)	ug/L	<0.50	7708728	<0.50	0.50	7708728
Total Calcium (Ca)	mg/L	67.7	7707170	55.1	0.050	7707170
Total Magnesium (Mg)	mg/L	13.2	7707170	27.6	0.050	7707170
Total Potassium (K)	mg/L	0.517	7707170	0.358	0.050	7707170
Total Sodium (Na)	mg/L	0.822	7707170	1.53	0.050	7707170
RDL = Reportable Detection Limit						

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CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

CCME TOTAL METALS IN WATER (WATER)

Maxxam ID		LB2022		LB2023		
Sampling Date		2014/09/19		2014/09/19		
COC Number		08350188		08350188		
	Units	POLIJIE CREEK	QC Batch	FUNERAL CREEK	RDL	QC Batch
Total Sulphur (S)	mg/L	10.8	7707170	29.1	3.0	7707170
RDL = Reportable Detection Limit						

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CANADIAN ZINC CORPORATION
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Sampler Initials: DH

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		LB2024	LB2025	LB2026	LB2027		
Sampling Date		2014/09/19	2014/09/19	2014/09/19	2014/09/19		
COC Number		08350188	08350188	08350188	08350188		
	Units	FUNERAL	SUNDOG @CAT	POLIJIE	PRAIRIE	RDL	QC Batch
Physical Properties							
Soluble (2:1) pH	pH	8.83	8.54	8.30	8.77	N/A	7708909
Total Metals by ICPMS							
Total Aluminum (Al)	mg/kg	4350	662	3350	3240	100	7708907
Total Antimony (Sb)	mg/kg	0.49	0.11	0.60	1.19	0.10	7708907
Total Arsenic (As)	mg/kg	6.38	0.86	5.60	5.35	0.50	7708907
Total Barium (Ba)	mg/kg	31.1	16.0	196	70.2	0.10	7708907
Total Beryllium (Be)	mg/kg	<0.40	<0.40	<0.40	<0.40	0.40	7708907
Total Bismuth (Bi)	mg/kg	<0.10	<0.10	<0.10	<0.10	0.10	7708907
Total Cadmium (Cd)	mg/kg	2.15	0.247	0.542	1.63	0.050	7708907
Total Calcium (Ca)	mg/kg	207000	216000	21500	196000	100	7708907
Total Chromium (Cr)	mg/kg	8.1	2.1	7.7	6.6	1.0	7708907
Total Cobalt (Co)	mg/kg	3.60	0.47	4.24	3.93	0.30	7708907
Total Copper (Cu)	mg/kg	6.85	1.19	9.74	9.10	0.50	7708907
Total Iron (Fe)	mg/kg	16000	2460	13100	11000	100	7708907
Total Lead (Pb)	mg/kg	49.0	3.84	5.39	21.8	0.10	7708907
Total Lithium (Li)	mg/kg	9.4	<5.0	5.2	5.4	5.0	7708907
Total Magnesium (Mg)	mg/kg	54100	106000	5140	32900	100	7708907
Total Manganese (Mn)	mg/kg	225	121	255	185	0.20	7708907
Total Mercury (Hg)	mg/kg	<0.050	<0.050	<0.050	0.187	0.050	7708907
Total Molybdenum (Mo)	mg/kg	3.31	0.87	3.31	4.04	0.10	7708907
Total Nickel (Ni)	mg/kg	20.5	2.34	17.0	20.4	0.80	7708907
Total Phosphorus (P)	mg/kg	276	155	484	463	10	7708907
Total Potassium (K)	mg/kg	591	149	413	432	100	7708907
Total Selenium (Se)	mg/kg	<0.50	<0.50	<0.50	<0.50	0.50	7708907
Total Silver (Ag)	mg/kg	0.053	<0.050	<0.050	0.087	0.050	7708907
Total Sodium (Na)	mg/kg	146	138	<100	113	100	7708907
Total Strontium (Sr)	mg/kg	480	84.0	30.1	463	0.10	7708907
Total Thallium (Tl)	mg/kg	0.248	<0.050	0.140	0.094	0.050	7708907
Total Tin (Sn)	mg/kg	0.18	<0.10	0.15	0.14	0.10	7708907
Total Titanium (Ti)	mg/kg	15.5	10.1	67.9	9.2	1.0	7708907
Total Uranium (U)	mg/kg	0.930	1.29	0.833	1.16	0.050	7708907
Total Vanadium (V)	mg/kg	25.0	5.2	23.8	23.2	2.0	7708907
Total Zinc (Zn)	mg/kg	319	29.2	69.1	204	1.0	7708907
Total Zirconium (Zr)	mg/kg	2.15	0.51	1.67	2.72	0.50	7708907

RDL = Reportable Detection Limit
N/A = Not Applicable

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CANADIAN ZINC CORPORATION
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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.3°C

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7713375	O-TERPHENYL (sur.)	2014/11/10	85	50 - 130	96	50 - 130	90	%				
7714253	O-TERPHENYL (sur.)	2014/11/10	101	50 - 130	96	50 - 130	105	%				
7708244	Alkalinity (PP as CaCO3)	2014/11/06					<0.50	mg/L	NC	20		
7708244	Alkalinity (Total as CaCO3)	2014/11/06	NC	80 - 120	94	80 - 120	<0.50	mg/L	1.3	20		
7708244	Bicarbonate (HCO3)	2014/11/06					<0.50	mg/L	1.3	20		
7708244	Carbonate (CO3)	2014/11/06					<0.50	mg/L	NC	20		
7708244	Hydroxide (OH)	2014/11/06					<0.50	mg/L	NC	20		
7708248	pH	2014/11/06			101	97 - 103			0.25	N/A		
7708249	Conductivity	2014/11/06			101	80 - 120	1.5, RDL=1.0	uS/cm	0.78	20		
7708728	Total Aluminum (Al)	2014/11/06	103	80 - 120	105	80 - 120	<3.0	ug/L	NC	20		
7708728	Total Antimony (Sb)	2014/11/06	103	80 - 120	103	80 - 120	<0.50	ug/L	NC	20		
7708728	Total Arsenic (As)	2014/11/06	105	80 - 120	103	80 - 120	<0.10	ug/L	NC	20		
7708728	Total Barium (Ba)	2014/11/06	NC	80 - 120	101	80 - 120	<1.0	ug/L	0.085	20		
7708728	Total Beryllium (Be)	2014/11/06	103	80 - 120	106	80 - 120	<0.10	ug/L	NC	20		
7708728	Total Bismuth (Bi)	2014/11/06	95	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
7708728	Total Boron (B)	2014/11/06					<50	ug/L	NC	20		
7708728	Total Cadmium (Cd)	2014/11/06	99	80 - 120	100	80 - 120	<0.010	ug/L	0	20		
7708728	Total Chromium (Cr)	2014/11/06	101	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
7708728	Total Cobalt (Co)	2014/11/06	100	80 - 120	100	80 - 120	<0.50	ug/L	NC	20		
7708728	Total Copper (Cu)	2014/11/06	95	80 - 120	101	80 - 120	<0.50	ug/L	NC	20		
7708728	Total Iron (Fe)	2014/11/06	101	80 - 120	105	80 - 120	<10	ug/L	NC	20		
7708728	Total Lead (Pb)	2014/11/06	96	80 - 120	97	80 - 120	<0.20	ug/L	NC	20		
7708728	Total Lithium (Li)	2014/11/06	94	80 - 120	99	80 - 120	<5.0	ug/L	NC	20		
7708728	Total Manganese (Mn)	2014/11/06	NC	80 - 120	99	80 - 120	<1.0	ug/L	1.9	20		
7708728	Total Molybdenum (Mo)	2014/11/06	NC	80 - 120	95	80 - 120	<1.0	ug/L	NC	20		
7708728	Total Nickel (Ni)	2014/11/06	96	80 - 120	103	80 - 120	<1.0	ug/L	NC	20		
7708728	Total Selenium (Se)	2014/11/06	99	80 - 120	98	80 - 120	<0.10	ug/L	1.1	20		
7708728	Total Silicon (Si)	2014/11/06					<100	ug/L	2.1	20		
7708728	Total Silver (Ag)	2014/11/06	103	80 - 120	92	80 - 120	<0.020	ug/L	NC	20		
7708728	Total Strontium (Sr)	2014/11/06	NC	80 - 120	99	80 - 120	<1.0	ug/L	1.9	20		
7708728	Total Thallium (Tl)	2014/11/06	86	80 - 120	82	80 - 120	<0.050	ug/L	NC	20		
7708728	Total Tin (Sn)	2014/11/06	99	80 - 120	101	80 - 120	<5.0	ug/L	NC	20		

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QUALITY ASSURANCE REPORT(CONT'D)

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7708728	Total Titanium (Ti)	2014/11/06	106	80 - 120	102	80 - 120	<5.0	ug/L	NC	20		
7708728	Total Uranium (U)	2014/11/06	104	80 - 120	102	80 - 120	<0.10	ug/L	0.86	20		
7708728	Total Vanadium (V)	2014/11/06	101	80 - 120	103	80 - 120	<5.0	ug/L	NC	20		
7708728	Total Zinc (Zn)	2014/11/06	NC	80 - 120	102	80 - 120	<5.0	ug/L	NC	20		
7708728	Total Zirconium (Zr)	2014/11/06					<0.50	ug/L	NC	20		
7708888	Total Dissolved Solids	2014/11/07	NC	80 - 120	88	80 - 120	<10	mg/L	3.1	20		
7708892	Total Suspended Solids	2014/11/07	85	80 - 120	101	80 - 120	<4.0	mg/L	NC	20		
7708907	Total Aluminum (Al)	2014/11/06					<100	mg/kg	0.91	35	107	70 - 130
7708907	Total Antimony (Sb)	2014/11/06	NC	75 - 125	102	75 - 125	<0.10	mg/kg	11	30	122	70 - 130
7708907	Total Arsenic (As)	2014/11/06	NC	75 - 125	99	75 - 125	<0.50	mg/kg	13	30	99	70 - 130
7708907	Total Barium (Ba)	2014/11/06	NC	75 - 125	100	75 - 125	<0.10	mg/kg	17	35	100	70 - 130
7708907	Total Beryllium (Be)	2014/11/06	98	75 - 125	100	75 - 125	<0.40	mg/kg	NC	30		
7708907	Total Bismuth (Bi)	2014/11/06					<0.10	mg/kg	NC	30		
7708907	Total Cadmium (Cd)	2014/11/06	100	75 - 125	106	75 - 125	<0.050	mg/kg	5.3	30	100	70 - 130
7708907	Total Calcium (Ca)	2014/11/06					<100	mg/kg	3.4	30	95	70 - 130
7708907	Total Chromium (Cr)	2014/11/06	96	75 - 125	103	75 - 125	<1.0	mg/kg	5.7	30	110	70 - 130
7708907	Total Cobalt (Co)	2014/11/06	97	75 - 125	103	75 - 125	<0.30	mg/kg	3.7	30	95	70 - 130
7708907	Total Copper (Cu)	2014/11/06	NC	75 - 125	106	75 - 125	<0.50	mg/kg	11	30	91	70 - 130
7708907	Total Iron (Fe)	2014/11/06					<100	mg/kg	5.3	30	99	70 - 130
7708907	Total Lead (Pb)	2014/11/06	NC	75 - 125	102	75 - 125	<0.10	mg/kg	12	35	101	70 - 130
7708907	Total Lithium (Li)	2014/11/06	94	75 - 125	98	75 - 125	<5.0	mg/kg	NC	30		
7708907	Total Magnesium (Mg)	2014/11/06					<100	mg/kg	2.2	30	98	70 - 130
7708907	Total Manganese (Mn)	2014/11/06	NC	75 - 125	105	75 - 125	<0.20	mg/kg	0.62	30	100	70 - 130
7708907	Total Mercury (Hg)	2014/11/06	98	75 - 125	102	75 - 125	<0.050	mg/kg	NC	35	103	70 - 130
7708907	Total Molybdenum (Mo)	2014/11/06	NC	75 - 125	105	75 - 125	<0.10	mg/kg	19	35	117	70 - 130
7708907	Total Nickel (Ni)	2014/11/06	100	75 - 125	103	75 - 125	<0.80	mg/kg	2.9	30	97	70 - 130
7708907	Total Phosphorus (P)	2014/11/06					<10	mg/kg	8.5	30	93	70 - 130
7708907	Total Potassium (K)	2014/11/06					<100	mg/kg	NC	35		
7708907	Total Selenium (Se)	2014/11/06	103	75 - 125	106	75 - 125	<0.50	mg/kg	NC	30		
7708907	Total Silver (Ag)	2014/11/06	91	75 - 125	102	75 - 125	<0.050	mg/kg	NC	35		
7708907	Total Sodium (Na)	2014/11/06					<100	mg/kg				
7708907	Total Strontium (Sr)	2014/11/06	NC	75 - 125	98	75 - 125	<0.10	mg/kg	11	35	103	70 - 130

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QUALITY ASSURANCE REPORT(CONT'D)

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7708907	Total Thallium (Tl)	2014/11/06	97	75 - 125	105	75 - 125	<0.050	mg/kg	NC	30	97	70 - 130
7708907	Total Tin (Sn)	2014/11/06	NC	75 - 125	96	75 - 125	<0.10	mg/kg	12	35		
7708907	Total Titanium (Ti)	2014/11/06	NC	75 - 125	96	75 - 125	<1.0	mg/kg	4.2	35	108	70 - 130
7708907	Total Uranium (U)	2014/11/06	99	75 - 125	100	75 - 125	<0.050	mg/kg	3.4	30	97	70 - 130
7708907	Total Vanadium (V)	2014/11/06	NC	75 - 125	97	75 - 125	<2.0	mg/kg	3.4	30	109	70 - 130
7708907	Total Zinc (Zn)	2014/11/06	NC	75 - 125	108	75 - 125	<1.0	mg/kg	7.8	30	93	70 - 130
7708907	Total Zirconium (Zr)	2014/11/06					<0.50	mg/kg	NC	30		
7708909	Soluble (2:1) pH	2014/11/07			101	97 - 103			0.28	N/A		
7709354	Alkalinity (PP as CaCO3)	2014/11/06					<0.50	mg/L				
7709354	Alkalinity (Total as CaCO3)	2014/11/06			97	80 - 120	<0.50	mg/L				
7709354	Bicarbonate (HCO3)	2014/11/06					<0.50	mg/L				
7709354	Carbonate (CO3)	2014/11/06					<0.50	mg/L				
7709354	Hydroxide (OH)	2014/11/06					<0.50	mg/L				
7709370	pH	2014/11/06			101	97 - 103			0.28	N/A		
7709371	Conductivity	2014/11/06			99	80 - 120	<1.0	uS/cm	1.3	20		
7709558	Dissolved Aluminum (Al)	2014/11/08	104	80 - 120	100	80 - 120	<3.0	ug/L	NC	20		
7709558	Dissolved Antimony (Sb)	2014/11/08	105	80 - 120	96	80 - 120	<0.50	ug/L	NC	20		
7709558	Dissolved Arsenic (As)	2014/11/08	108	80 - 120	104	80 - 120	<0.10	ug/L	NC	20		
7709558	Dissolved Barium (Ba)	2014/11/08	NC	80 - 120	98	80 - 120	<1.0	ug/L	0.070	20		
7709558	Dissolved Beryllium (Be)	2014/11/08	107	80 - 120	101	80 - 120	<0.10	ug/L	NC	20		
7709558	Dissolved Bismuth (Bi)	2014/11/08	102	80 - 120	98	80 - 120	<1.0	ug/L	NC	20		
7709558	Dissolved Boron (B)	2014/11/08					<50	ug/L	NC	20		
7709558	Dissolved Cadmium (Cd)	2014/11/08	103	80 - 120	96	80 - 120	<0.010	ug/L	NC	20		
7709558	Dissolved Chromium (Cr)	2014/11/08	106	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
7709558	Dissolved Cobalt (Co)	2014/11/08	105	80 - 120	102	80 - 120	<0.50	ug/L	NC	20		
7709558	Dissolved Copper (Cu)	2014/11/08	102	80 - 120	103	80 - 120	<0.20	ug/L	NC	20		
7709558	Dissolved Iron (Fe)	2014/11/08	NC	80 - 120	110	80 - 120	<5.0	ug/L	9.4	20		
7709558	Dissolved Lead (Pb)	2014/11/08	103	80 - 120	100	80 - 120	<0.20	ug/L	NC	20		
7709558	Dissolved Lithium (Li)	2014/11/08	104	80 - 120	99	80 - 120	<5.0	ug/L	NC	20		
7709558	Dissolved Manganese (Mn)	2014/11/08	NC	80 - 120	102	80 - 120	<1.0	ug/L	4.6	20		
7709558	Dissolved Molybdenum (Mo)	2014/11/08	NC	80 - 120	98	80 - 120	<1.0	ug/L	NC	20		
7709558	Dissolved Nickel (Ni)	2014/11/08	99	80 - 120	102	80 - 120	<1.0	ug/L	NC	20		

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QUALITY ASSURANCE REPORT(CONT'D)

CANADIAN ZINC CORPORATION
Client Project #: PRAIRIE CREEK MINE, NORTHWEST
Sampler Initials: DH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7709558	Dissolved Selenium (Se)	2014/11/08	105	80 - 120	96	80 - 120	<0.10	ug/L	NC	20		
7709558	Dissolved Silicon (Si)	2014/11/08					<100	ug/L	6.6	20		
7709558	Dissolved Silver (Ag)	2014/11/08	94	80 - 120	89	80 - 120	<0.020	ug/L	NC	20		
7709558	Dissolved Strontium (Sr)	2014/11/08	NC	80 - 120	96	80 - 120	<1.0	ug/L	1.3	20		
7709558	Dissolved Thallium (Tl)	2014/11/08	100	80 - 120	93	80 - 120	<0.050	ug/L	NC	20		
7709558	Dissolved Tin (Sn)	2014/11/08	NC	80 - 120	93	80 - 120	<5.0	ug/L	NC	20		
7709558	Dissolved Titanium (Ti)	2014/11/08	114	80 - 120	107	80 - 120	<5.0	ug/L	NC	20		
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7709558	Dissolved Vanadium (V)	2014/11/08	112	80 - 120	101	80 - 120	<5.0	ug/L	NC	20		
7709558	Dissolved Zinc (Zn)	2014/11/08	107	80 - 120	106	80 - 120	<5.0	ug/L	NC	20		
7709558	Dissolved Zirconium (Zr)	2014/11/08					<0.50	ug/L	NC	20		
7709991	Dissolved Chloride (Cl)	2014/11/06	NC	80 - 120	99	80 - 120	<0.50	mg/L	0.20	20		
7709993	Dissolved Sulphate (SO4)	2014/11/06	NC	80 - 120	91	80 - 120	<0.50	mg/L	1.4	20		
7711132	Moisture	2014/11/08					<0.30	%	0.47	20		
7711358	Moisture	2014/11/08					<0.30	%	2.9	20		
7711373	Moisture	2014/11/08					<0.30	%	4.3	20		
7711903	Moisture	2014/11/09					<0.30	%	1.2	20		
7713375	EPH (C10-C19)	2014/11/10	83	50 - 130	86	50 - 130	<100	mg/kg	NC	40		
7713375	EPH (C19-C32)	2014/11/10	92	50 - 130	94	50 - 130	<100	mg/kg	NC	40		
7714253	EPH (C10-C19)	2014/11/10	88	50 - 130	83	50 - 130	<100	mg/kg	NC	40		
7714253	EPH (C19-C32)	2014/11/10	98	50 - 130	92	50 - 130	<100	mg/kg	NC	40		
7719366	Total Mercury (Hg)	2014/11/14	94	80 - 120	91	80 - 120	<0.010	ug/L	NC	20		
7719978	Total Mercury (Hg)	2014/11/15	91	80 - 120	96	80 - 120	<0.010	ug/L	NC	20		
7720177	Dissolved Mercury (Hg)	2014/11/15	112	80 - 120	118	80 - 120	<0.010	ug/L	NC	20		

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QUALITY ASSURANCE REPORT(CONT'D)

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
7766585	Total Organic Carbon (C)	2014/12/30			98	75 - 125	0.020, RDL=0.020	%	49 (1)	35	107	75 - 125

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

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Maxxam Analytics Inc

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5 Ph: (604) 734-7276 Fax: (604) 731-2386, Toll Free: (800) 665-8566

CHAIN OF CUSTODY RECORD

Click here to get the COC number

Maxxam Job #: B4A0466 COC #: _____ Page: 1 of 1

Invoice To: Require Report? Yes ☑ No ☐	Report To:
Company Name: #99030 Canadian Zinc Corporation	Company Name: Same as invoice
Contact Name: David Harpley, VP of Environment & Permit	Contact Name:
Address: Suite 1710 - 650 West Georgia Street, Vancouver, PC: V6B 4N9	Address: PC:
Phone / Fax#: Ph: 604-688-2001 Fax: 604-688-2043	Phone / Fax#: Ph: Fax:
E-mail: david@canadianzinc.com	E-mail:

PO #:
Quotation #: 800711
Project #:
Proj. Name: Prairie Creek Mine, Northwest Territories
Location:
Sampled by: D Harpley

REGULATORY REQUIREMENTS:
☐ CSR
☑ CCME
☐ BC Water Quality
☐ Other _____
☐ DRINKING WATER

SERVICE REQUESTED:
☑ Regular Turn Around Time (TAT) (5 days for most tests)
☐ RUSH (Please contact the lab) ☐ 1 Day ☐ 2 Day ☐ 3 Day
Date Required: _____

SPECIAL INSTRUCTIONS:
Return Cooler ☑ Ship Sample Bottles (please specify) ☐
To Villers Air Service Ltd - 170 Bell Road, Fort Nelson, BC V0C 1R0
Tel: 250-774-2072, Fax: 250-774-6182

ANALYSIS REQUESTED

	Sample Identification	Lab Identification	Sample Type	Date/Time(24hr) Sampled	BTEX/VPH ☐ MTBE	VOC/VPH ☐	EPH ☐ TEH	PAH ☐ LEPH/HEPH	CCME-PHC (Fractions 1-4 Plus BTEX) ☐	CCME-PHC (Fractions 2-4) ☐	CCME-PHC (Fraction 1 Plus BTEX) ☐	PCB ☐	Phenols by 4AAP ☐ Phenols by GC/MS	TOG ☐ MOG ☐ SMOG	Dissolved Metals (Dis) Y/N	Field Filtered? Y/N	Field Acidified? Y/N	Total Metals Y/N	Nitrate ☐ Nitrite ☐ Ammonia	Chloride ☐ Fluoride ☐ Sulphate	Total suspended solids (TSS) ☐ TDS ☐	pH ☐ Conductivity ☐ Alkalinity	BOD ☐ COD ☐	Coliform: Total & E.coli ☐ Fecal	Asbestos ☐	HOLD ☐	Number of Containers	Samples are from a Drinking Water Source? ☐ NO ☑ YES	Does source supply multiple households? ☐ NO ☐ YES
1	Polje Creek	LB2022	Surface W	14/09/19											X	X	X			X	X	X					3		
2	Funeral Creek	LB2023	Surface W	14/09/19											X	X	X			X	X	X					3		
3																													
4																													
5																													
6																													
7	Funeral	LB2024	Soil	14/09/19			X											X									2		
8	Sundog@Cat	LB2025	Soil	14/09/19			X											X									2		
9	Polje	LB2026	Soil	14/09/19			X											X									2		
10	Prairie	LB2027	Soil	14/09/19			X											X									2		
11																													
12																													
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B4A0466

Print name and sign

*Relinquished By:	Date (yy/mm/dd):	Time (24 hr):	Received by:	Date:	Time:	Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
Ted Boychuk	2014/10/28	12:00	SARANBIR TAKHAR	2014/11/04	09:45	☐	A: 2 B: 3 C: 3	Present	☑	☐
								Intact	☐	☐

IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THIS CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

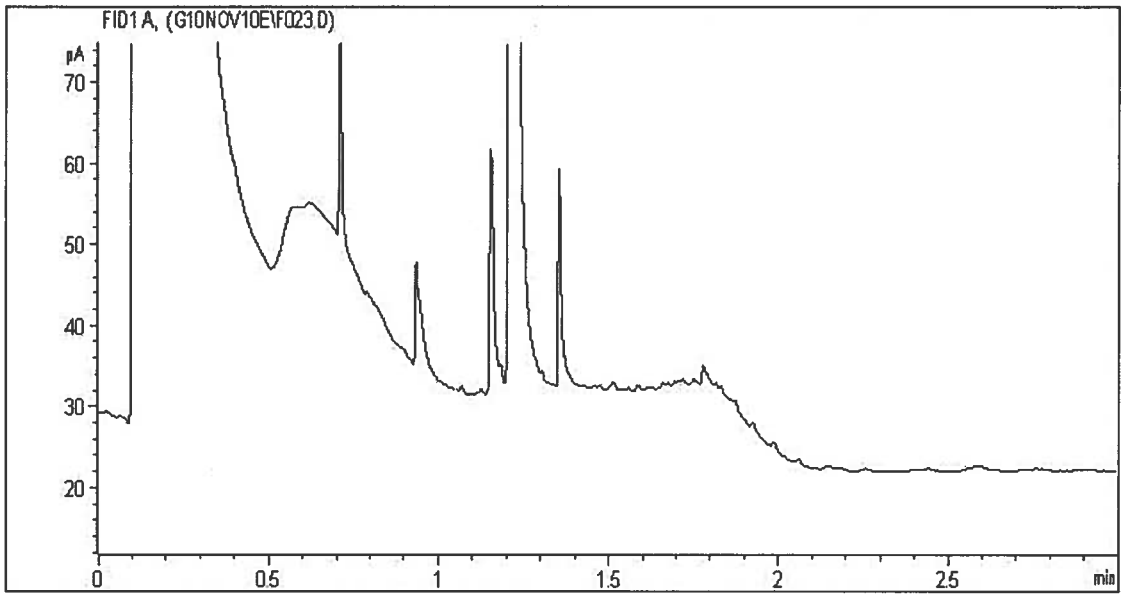
SBY PCD-00077R1_B

Maxxam Analytics Success Through Science ®

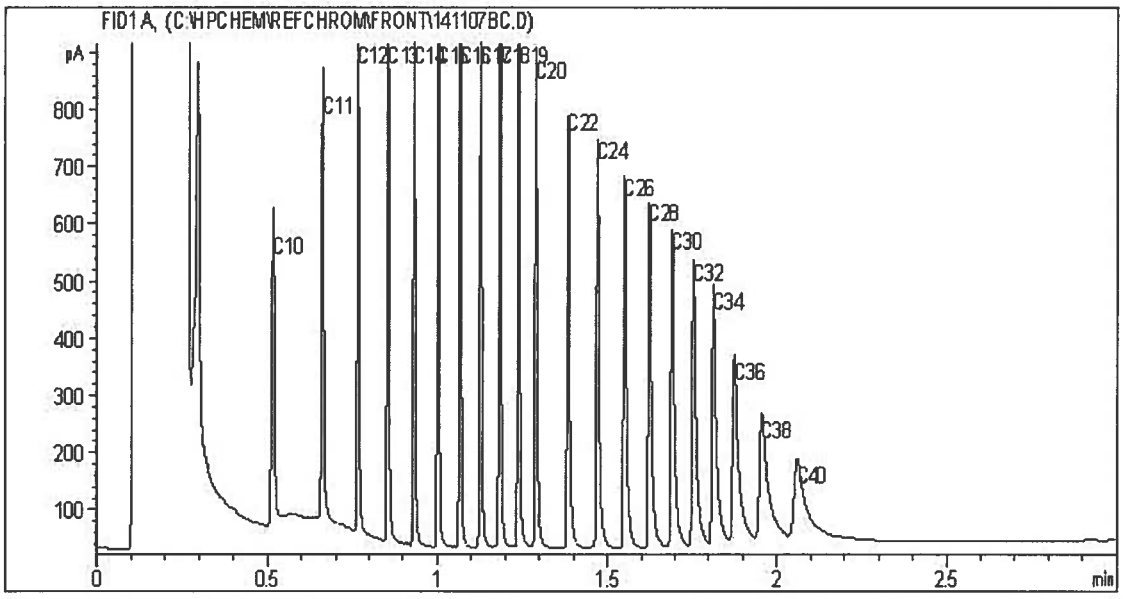
ARRIVED AT DEPOT:
OCT 30 2014
TEMP: 1/2/21
10:00
ILO

2 SARANBIR TAKHAR 2014/11/04 6.5.8 C: N/A
14:45

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram

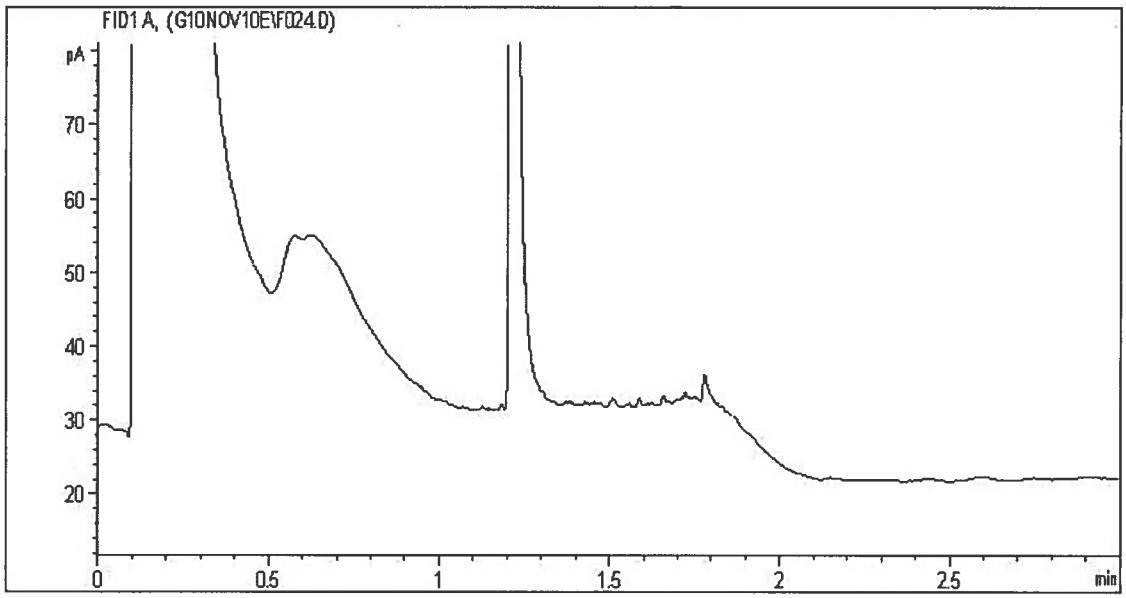


TYPICAL PRODUCT CARBON NUMBER RANGES

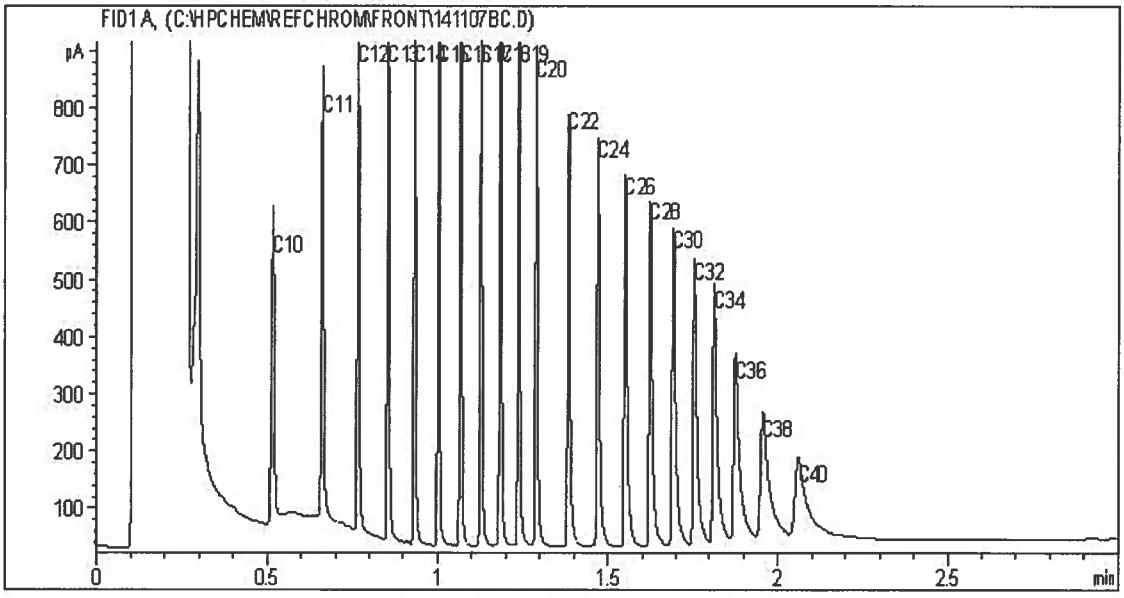
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram

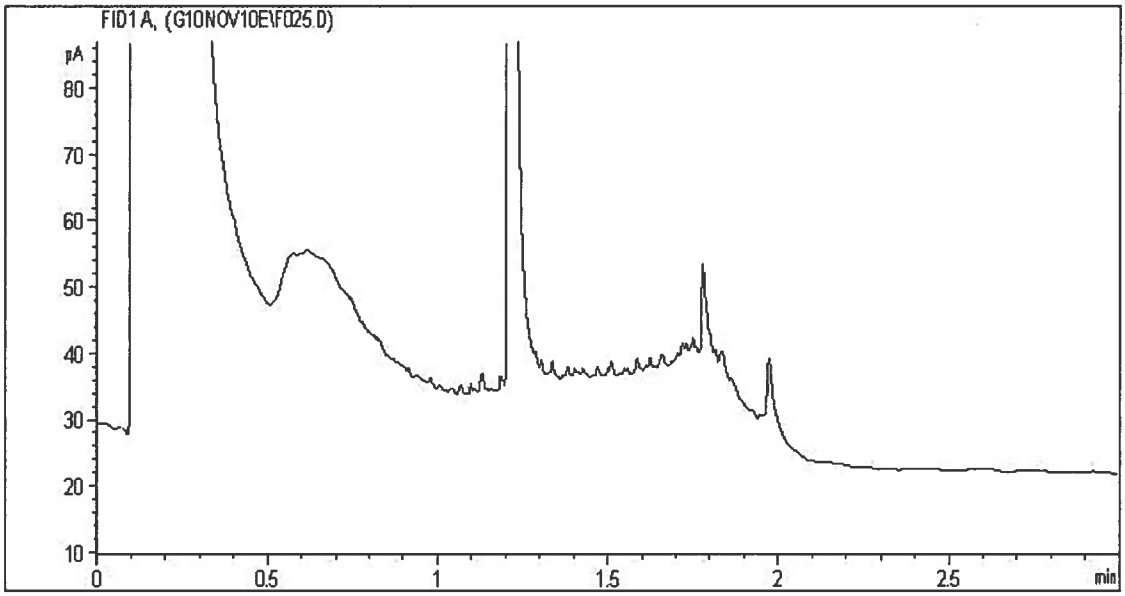


TYPICAL PRODUCT CARBON NUMBER RANGES

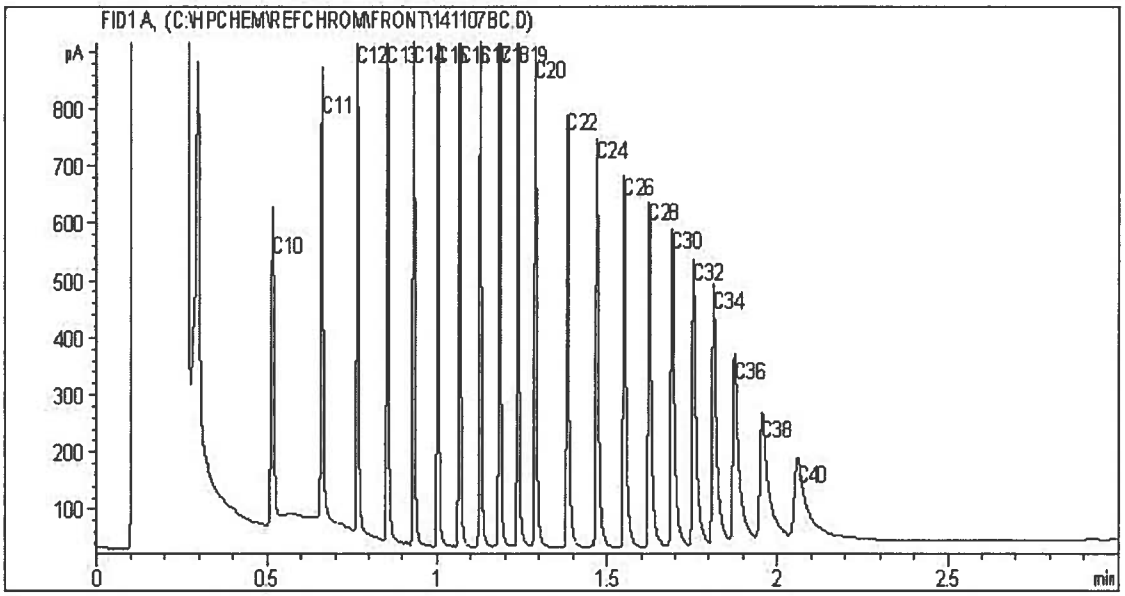
Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



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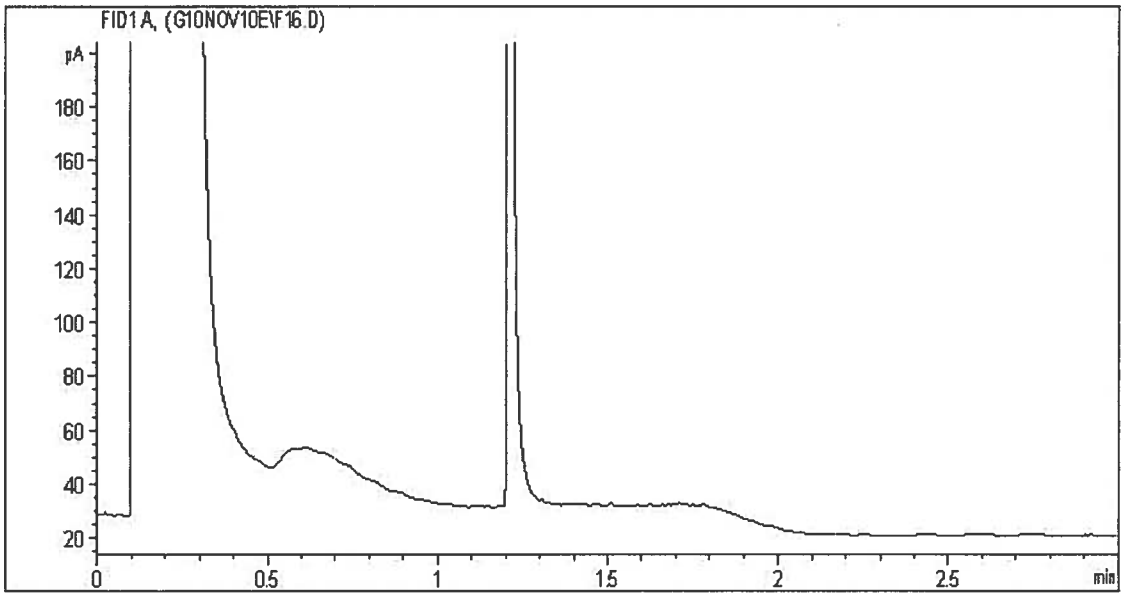
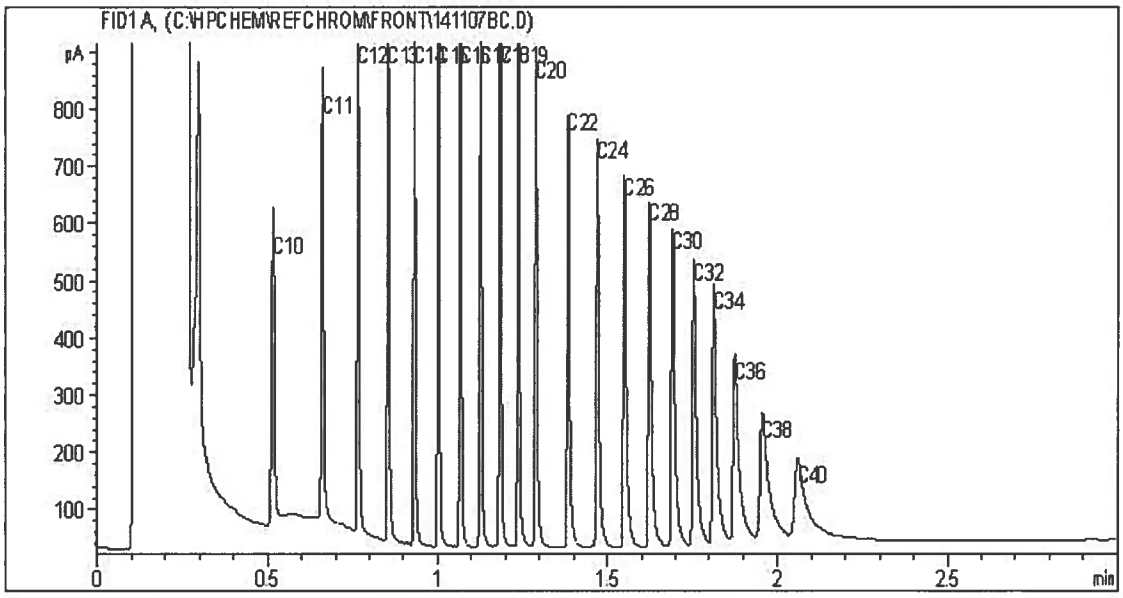
BC Hydrocarbons in Soil by GC/FID Chromatogram



Carbon Range Distribution - Reference Chromatogram



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Gasoline:	C4 - C12	Diesel:	C8 - C22
Varsol:	C8 - C12	Lubricating Oils:	C20 - C40

Note: This information is provided for reference purposes only. Should detailed chemist interpretation or fingerprinting be required, please contact the laboratory.

APPENDIX 7

CANADIAN ZINC CORPORATION

VEGETATION AND WILDLIFE & WILDLIFE HABITAT – DEVELOPERS ASSESSMENT REPORT SECTIONS

Prairie Creek Mine – All Season Road and Airstrip, Northwest Territories

FEBRUARY 2015

TETRA TECH EBA

ISSUED FOR USE
FILE: ENVMIN03058-01

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APPENDIX SECTIONS

Appendix A Tetra Tech EBA's General Conditions

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. (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. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

1.1 General

Canadian Zinc Corporation (CZN), is proposing to operate the Prairie Creek Mine. The Mine is located at approximately 61º 33' north latitude and 124º 48' west longitude adjacent to Prairie Creek, a tributary of the South Nahanni River, NWT. Prairie Creek flows into the South Nahanni River approximately 43 km downstream of the Prairie Creek Mine.

Applications for operating permits were referred to the Mackenzie Valley Environmental Review Board (MVEIRB) for environmental assessment (EA0809-002) and on December 8, 2011 the MVEIRB issued their Report of Environmental Assessment (REA). The MVEIRB concluded that the proposed development, as described in the REA and including CZN's commitments, is not likely to have any significant adverse impacts on the environment or to be a cause for significant public concern.

The file was returned to the Mackenzie Valley Land and Water Board (MVLWB) for the permitting phase, and mine operations permits were subsequently issued, including Water Licence MV2008L2-0002 issued on September 24, 2013. As changes were made to the access road alignment during the EA, CZN applied for and received new access road Land Use Permits (LUPs) and Water Licences from both the MVLWB and Parks Canada.

In the previous environmental assessment (EA0809-002), CZN received approval for winter road access (and its associated facilities and temporary camps and work support infrastructure) to the Mine. CZN is now proposing to upgrade the winter road to an all season road and develop an airstrip outside the Mackenzie Mountains (the Project) (Figure 1). The length of the access road from the Mine to the existing Nahanni Access Road, located on the south side of the Liard River, is 174.5 km. Approximately 83 km of the proposed all season road crosses Nahanni National Park Reserve (NNPR) land. The proposed all season road generally follows the winter road alignment assessed and approved during the MVEIRB EA0809-02 review process. CZN has proposed to complete the access road upgrade in two phases. Descriptions of these two phases as they have been described to date are presented in Section 2.0 of this report.

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by CZN to conduct an assessment of the potential effects of upgrading part or all of the existing approved winter access road to an all season road and an airstrip on the vegetation and wildlife of the project area. This assessment of potential impacts is intended to be incorporated by CZN into its Developer's Assessment Report (DAR) for the proposed Project.

1.2 Use of This Report

This report was prepared by Tetra Tech EBA using existing available information and baseline surveys. The material in this report reflects Tetra Tech EBA's best professional judgment in light of information available to it at the time of preparation. It is understood that portions of this report will be incorporated into the body of the DAR, but that the report in its entirety will be included as an appendix to the DAR.

Any use which a third party makes of this report or any reliance on or decisions to be made based on it, are the responsibility of such third party. Tetra Tech EBA accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based on this report.

1.3 Report Organization

This report has been organized in separate sections reflecting the organization of the DAR. Specifically, the following sections of the DAR are addressed:

- Existing Environment and Baseline sections for species at risk, wildlife and vegetation (Sections 5.1.4, 5,1.6 and 5.1.7 of the TOR); which correspond to Sections 4.4, 4.6 and 4.7 of the DAR Table of Contents;
- Impacts to traditional harvesting and traditionally harvested species (Section 7.2.1 of the TOR; which corresponds to Section 8.0 of the DAR Table of Contents;
- Impact assessment for species at risk, wildlife and vegetation (Sections 7.3.6, 7.3.8 and 7.3.9 of the TOR); which correspond to Sections 11.6, 11.8 and 11.9 of the DAR Table of Contents); and
- Cumulative effects assessment as it relates to traditional harvesting, species at risk, wildlife and vegetation (Section 10 of the TOR); which corresponds to Section 14 of the DAR Table of Contents.

The various report sections, in aggregate, constitute the assessment of the potential effects of the Project on species at risk, wildlife and vegetation along the proposed all season access road and airstrip.

2.0 PROJECT DESCRIPTION

Canadian Zinc intends to complete construction of the all season road and airstrip and operate the Mine using the winter road for the first few years of operation. The majority of the road right-of-way is proposed to be cleared during winter road construction in the first years of operations. The all season access road effects assessment is consistent with the approach previously employed by CZN (2010) and Golder (2010) for the winter road approval and licenses, with differentiation between two all season road project development phases (Table 2-1).

CZN proposes to develop the all season road in two phases: 1) Phase 1 from the Mine to the Tetcela Transfer Facility (TTF); and 2) Phase 2 from the TTF to the Liard Transfer Facility (LTF). Once in operation, full scale concentrate hauling is restricted to approximately 250 calendar days per year due to seasonal constraints at the Liard River crossing (e.g., barge operation from mid-May to early November and winter ice bridge open to full 60 tonne capacity from mid-January to late March).

Table 2-1: Project Development Phases at a Glance

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All Season Access Road Assessment
PHASE 1 ALL SEASON ROAD			
Clearing the 20 m wide winter road alignment from the Mine to Kilometre Post (KP) 86, currently approved under existing Land Use and Water Licences	KP 0-86	September to January, year 1 of mine construction	*No.* *Currently approved.*
Clearing a 4 km long, approx. 20 m wide (5 m running surface) road alignment different from the approved winter road	KP 24.5-28.5	Winter clearing year 2 or 3 of mine operation	Yes

Table 2-1: Project Development Phases at a Glance

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All Season Access Road Assessment
Construction of a 86 km long all season road with a 5 m wide running surface from the Prairie Creek Mine to the Tetcela Transfer Facility following the approved winter road route (note, an all season road bed already exists from the Mine to approx. KP 33)	KP 0-86	Summer/fall/winter construction, year 2 or 3 of mine construction	Yes
Clearing and excavation of 31 borrow pits (total area approximately 13.31 ha) and their access roads (total area approximately 0.80 ha)	Locations as identified in this DAR	Clearing September to January. Combination of summer/fall and winter construction and excavation commencing in year 2 or 3 of mine operation and tentatively extending to year 5 of mine operation	Yes
Construction of the Tetcela Transfer Facility (TTF) beyond that approved with the winter road (2 ha additional)	KP 86	Summer/fall/winter construction, year 2 or 3 of mine construction	Yes
Operation and maintenance of the road and facilities	KP 0-86	~14 year mine life, plus 6 year closure	Yes
Construction and operation of temporary construction support infrastructure and workspaces including camps, laydown, staging areas, and bulk fuel storage. To be located within borrow pits and existing disturbances, as much as possible (total area approximately 3.69 ha)	Locations as identified in this DAR	Combination of summer/fall and winter construction commencing in year 2 or 3 of mine operation and tentatively extending to year 5 of mine operation for temporary camps and life of mine for permanent camps	*No.* *Currently approved.*
PHASE 2 ALL SEASON ROAD			
Clearing the 20 m wide winter road alignment from KP 86 to the Nahanni Access Road, currently approved under existing Land Use and Water Licences	KP 86-174.5	September to January, year 1 of mine construction	*No.* *Currently approved.*
Clearing a 4 km long, approx. 20 m wide (5 m wide running surface) road alignment different from the approved winter road	KP 90.5-94.5	Winter clearing, tentatively year 5 of mine operation	Yes
Clearing a 1 km long, approx. 20 m wide (5 m wide running surface) road alignment different from the approved winter road	KP 122.5-123.5	Winter clearing, tentatively year 5 of mine operation	Yes
Construction of a 90 km long, 5 m wide running surface all season road from the Tetcela Transfer Facility to the Nahanni Access Road	KP 86-174.5	Combination of summer/fall and winter construction, tentatively year 5 of mine operation	Yes

Table 2-1: Project Development Phases at a Glance

Project Scope	Geographic Scope	Temporal Scope	Included as Part of All Season Access Road Assessment
Clearing and excavation of 18 borrow pits (total area approximately 27.37 ha) and their access roads (total area approximately 3.86 ha)	Locations as identified in this DAR	Clearing September to January. Combination of summer/fall and winter construction and excavation commencing in year 2 or 3 of mine operation and tentatively extending to year 5 of mine operation	Yes
Construction and operation of temporary construction support infrastructure and workspaces including camps, laydown, staging areas, and bulk fuel storage. To be located within borrow pits and existing disturbances, as much as possible (total area approximately 3.69 ha)	Locations as identified in this DAR	Combination of summer/fall and winter construction commencing in year 2 or 3 of mine operation and tentatively extending to year 5 of mine operation for temporary camps and life of mine for permanent camps	*No.* *Currently approved.*
Construction of landing areas and operation of a barge crossing at the Liard River	KP 160	~14 year mine life, plus 6 year closure	Yes
Operation and maintenance of the road and facilities, annually	KP 86-184.5	~14 year mine life, plus 6 year closure	Yes
Construction and operation of the Liard River winter crossing, annually	KP 160	~14 year mine life, plus 6 year closure	*No.* *Currently approved.*
AIRSTRIP			
Clearing to accommodate approx.1 km long, 50 m wide airstrip to support road construction & maintenance, and secondarily as an alternate to the existing airstrip at the Prairie Creek Mine (total area approximately 7.62 ha)	KP 55	Winter clearing, ~14 year mine life, plus 6 year closure	Yes
Construction, operation, and maintenance of the airstrip	KP 55	~14 year mine life, plus 6 year closure	Yes
COMBINED DEVELOPMENTS			
Closure and reclamation	KP 0-174.5 and airstrip	~ 6 years after mine closure (2029-2036)	Yes

2.1 Road Alignment

The original winter access road to the Prairie Creek Mine was constructed in the early 1980's and operated for two winter seasons carrying over 800 loads into the Mine site. During EA0809-002, the route was optimized to reduce environmental and logistical risks. Four re-alignments were included in the revised route:

- Polje By-Pass, within the expanded Nahanni National Park Reserve (NNPR);

- Silent Hills re-alignment, within the expanded NNPR;
- Wolverine-Grainger Gap re-alignment; and,
- Nahanni Front Range re-alignment.

In accordance with the MVLWB and Parks Canada Land Use Permits and Water Licences, CZN is authorized to construct and operate a winter road that mostly follows the same route as the historical winter road constructed in 1981 and 1982. These authorizations permit the clearing of the winter access road, which will occur prior to the construction of this proposed all season road. As part of these authorizations, CZN concluded Impact Benefits Agreement negotiations with the NDDB and LKFN, and potential impacts on harvesting was one of the issues discussed. The all season road will generally follow the cleared winter access route, except in three locations that traverse wet areas that are conducive for winter road operations and an area of steep talus scree (Figure 1):

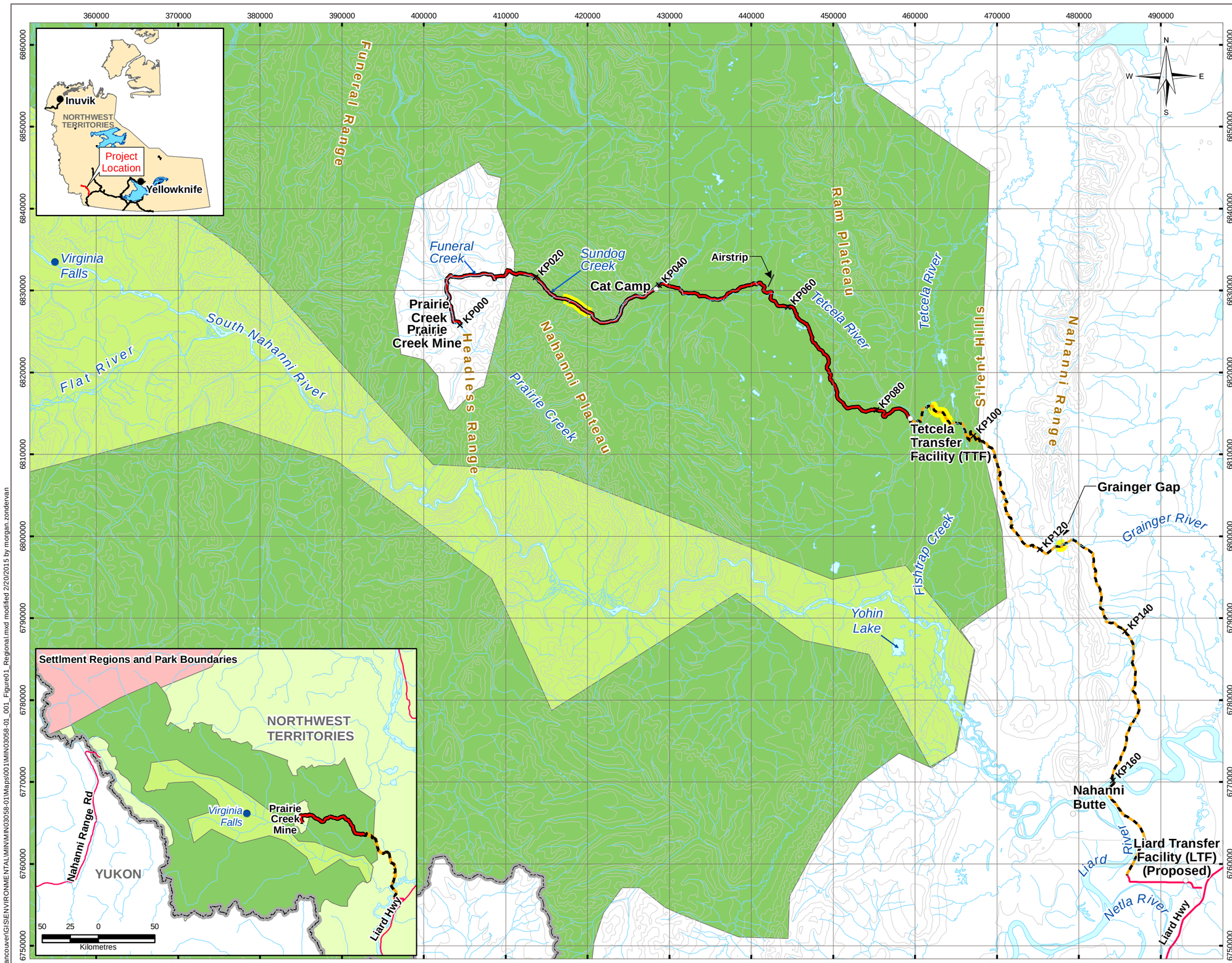
- 4 km section in Phase 1 (approximately from KP 24.5-28.5) (rerouted to avoid steep talus scree);
- 4 km section in Phase 2 (approximately from KP 90.5-94.5) (rerouted to avoid wet area); and
- 1 km section in Phase 2 (approximately from KP 122.5-123.5) (rerouted to avoid wet area).

A detailed field program is required to locate the precise road location, and therefore, the proposed road alignment provided herein has been defined to within a 100 m corridor, plus or minus 50 m on either side.

From an economic perspective, seasonal road access only would penalize the operation because significant working capital is required to finance annual operating activities before any revenue from the concentrates produced in that year is available. Seasonal road access only also presents logistical challenges for the effective and efficient operation of the Prairie Creek Mine.

All season access would remove the economic and logistical penalties, but is counter-balanced by the anticipated significant cost to upgrade the access road. However, all season access could promote other activities, such as increased tourism, and greater involvement of local aboriginal groups may occur. Also, with all season access, CZN could consider alternate, lower cost and more environmentally-friendly fuels to power the operation, such as propane or liquefied natural gas (LNG).

Therefore, in addition to applying for all season road use from the Mine to the TTF (Phase 1), CZN has also applied for all season road use from the TTF to the Nahanni Butte Access Road (Phase 2), which when combined represents the entire road to the Liard Highway. This will enable the year-round transport of concentrates and consumables.



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LEGEND

Proposed All Season Road

- Phase 1
- Phase 2
- Existing Road
- Proposed All Season Road Realignment
- All Season Road Kilometre Marker
- Proposed Airstrip
- Contour (200 m)
- Watercourse
- Waterbody
- Previous Nahanni National Park Reserve Boundary
- Current Nahanni National Park Reserve Boundary
- Deh Cho Settlement Region
- Sahtu Settlment Region
- Yukon / NWT Border

NOTES
Base data source:
NTS 1:250,000
Road alignment provided by AllNorth (Jan 22, 2015)

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Project Location

PROJECTION UTM Zone 10		**DATUM** NAD83			**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:450,000 (5 2.5 0 5 Kilometres)					TETRA TECH EBA
FILE NO. MIN03058-01_001_Figure01_Regional.mxd					
PROJECT NO. ENVMIN03058-01	**DWN** MEZ	**CKD** SL	**APVD** KL	**REV** 0	**Figure 1**
OFFICE Tt EBA-VANC	**DATE** February 20, 2015				

The road bed from the Mine (KP 0) to KP 39 (Cat Camp) is already of all season quality. In addition, Cadillac's road LUP provided for all season use of that section. The majority of the remainder of the road to the TTF location (Phase 1 KP 86) is on solid ground with very little muskeg terrain. Although initial road use for early mine operations would be winter only using existing permits, CZN wishes to obtain new permits to allow phased all season use of the road.

Phase 1 would see the western portion of the road upgraded for all season use to allow the mineral concentrates to be transported to the TTF. Subject to future economic justification and funding, Phase 2 would see the eastern portion of the road from the TTF to the Liard River crossing upgraded. This phase would also provide an opportunity for multi-party collaboration and use.

2.2 Road Bed Design and Construction

The average cleared right-of-way is understood to be 20 m wide, with sections of up to 35 m wide in locations with significant side slopes. The proposed width of the all season road surface will be a 5 m running surface (or 10 m including shoulders) for a single lane. There will be approximately 3 turnouts per kilometre for passing, making for an 8 m wide running surface in these locations. Turnouts will be approximately 30 m long.

The additional limited clearing required for the all season road will be undertaken outside the migratory bird nesting period, as birds and nests are protected under the *Migratory Birds Convention Act* (Government of Canada 1994) under Section 12(1h). All season road construction will preferentially be completed in the summer, but will also occur through the fall and winter.

The road bed will preferably be built with free-draining gravel fill and with a slight camber. Side slopes will be a minimum two horizontal to one vertical units. For crossing soft ground, the bed thickness will be increased, and/or a geotextile will be laid first.

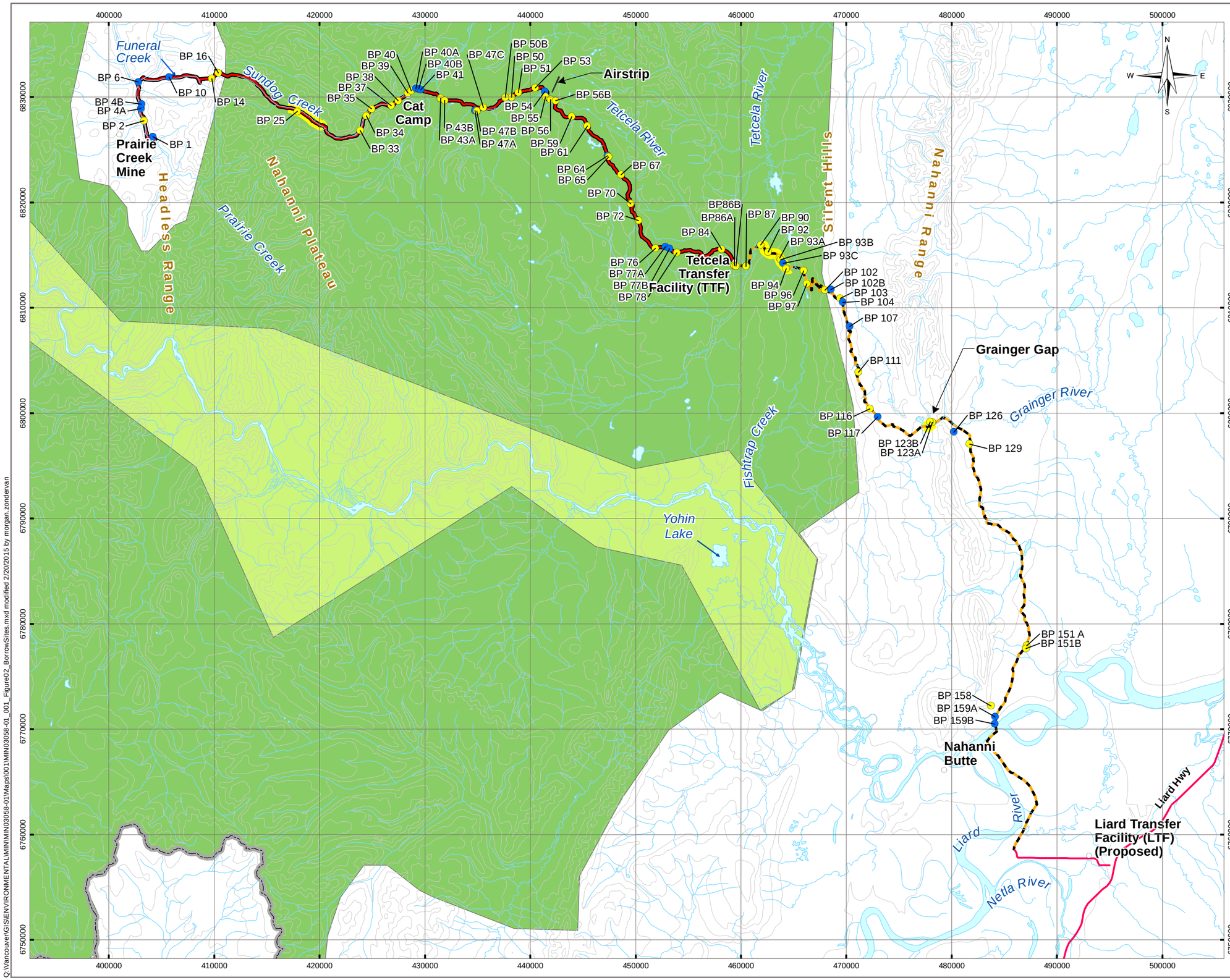
To facilitate road construction and minimize travel, a temporary camp will be established near the location of construction. As construction progresses, the camp would be moved closer. The camp would likely consist of a number of accommodation trailers, a kitchen/diner, a diesel-fed generator with a storage tank up to a capacity of 4,500 litres, a double-chamber garbage incinerator plus an ash bin, and a sewage lagoon or pit. Some of the possible locations for such camps include Cat Camp, the TTF, the eastern lower slope of the Silent Hills, and the eastern side of the Front Range near Grainger Gap.

Larger watercourses will be crossed by span-crossing structures. Some of these have already been approved for the winter road. Smaller watercourses, and areas where runoff would pond upslope of the road, would be addressed by closed or open-bottom culverts on a case-by-case basis, as required.

There are two possible construction approaches: 1) a large crew or crews working day and night shifts to complete construction in a relatively short period of time; or 2) a smaller crew working a single shift on a multi-year basis. Either possible construction approach is being considered; however, the smaller crew working over multiple years may prove most suitable to the overall development plan and is most likely to be adopted.

2.3 Borrow Sources

Aggregate materials for road construction will be obtained from multiple local sources located within or in close proximity to the all season road right-of way. Forty nine (49) preferred borrow sources (Figure 2) have been identified for use during the construction phase, and 25 additional borrow sources have be identified as possible backup sources. The borrow sites have been categorized by the type of material and its' construction application. The borrow sites will be utilized for three construction applications; Subgrade Borrow Supply, Surfacing Aggregate Supply, and Rock Quarry Supply. Possible sources for winter sand are also noted.



LEGEND

Proposed All Season Road

- Phase 1
- Phase 2
- Existing Road
- Proposed All Season Road Realignment

Borrow Site

- Preferred
- Potential Alternative Source
- Proposed Airstrip
- Contour (200 m)
- Watercourse
- Waterbody
- Previous Nahanni National Park Reserve Boundary
- Current Nahanni National Park Reserve Boundary
- Yukon / NWT Border

NOTES
Base data source:
NTS 1:250,000
Road alignment provided by AllNorth (Jan 22, 2015)

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Proposed All Season Road and Airstrip Locations

PROJECTION UTM Zone 10	**DATUM** NAD83		**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:350,000 (5 2.5 0 5 Kilometres)			TETRA TECH EBA
FILE NO. MIN03058-01_001_Figure02_BorrowSites.mxd			
PROJECT NO. ENVMIN03058-01	**DWN** MEZ / **CKD** SL / **APVD** RH / **REV** 0		**Figure 2**
OFFICE Tt EBA-VANC	**DATE** February 20, 2015		

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All borrow source development needed for construction of the all season road and airstrip will conform with INAC's Northern Land Use Guidelines – Pits and Quarries (2010). The majority of the all season road right-of-way is underlain with rock that originated from shallow Paleozoic ocean margins, and as such consists primarily of carbonate materials which are non-acid generating. In some areas of the route there are additional interspersed and separate sedimentary layers consisting of siltstones, mudstones, and shale, as noted in outcrops inspected by Allnorth (2015). Many of these outcrops were sampled and the parent material is considered to be calcareous as well and they constitute acid absorbing materials, not acid generating materials.

2.4 Phase 1 Development (KP 0 to KP 86, TTF)

2.4.1 All Season Road

The road from the Mine (KP 0) to the TTF (KP 86) would be upgraded for all season use (Figure 1). The section from KP 0 to Cat Camp (KP 39) was previously permitted for all season use in 1980. However, there are potentially fish-bearing creek crossings from KP 26.5 to KP 39 that would require crossing structures in order to be crossed outside of the winter period.

Upgrading the road will require little to no work from KP 0 to KP 23 over and above the work that will already have been completed for winter use. From KP 23 to KP 28.5, an all season road bed exists, although a re-alignment is proposed between KP 24.5 and 28.5 to avoid talus slopes and reduce the number of creek crossings. If bridges have not already been installed at these locations for winter use, they will need to be.

From KP 28.5 to Cat Camp (KP39), the road traverses the Sundog Creek alluvial floodplain. The old winter road alignment currently crosses the creek channel approximately six times. However, the future road alignment can be shifted slightly south in some places to avoid these crossings. In two locations (approximately KP 35 and 38), the creek channel needs to be moved to the north. Because of the braided nature of the channel, and the fact that the channel changes location significantly from year to year, no net loss in habitat value is expected to occur from the realignment.

A significant tributary to Sundog Creek at KP 39 will require a crossing structure. A gravel road bed will need to be placed between KP 40 and at least KP 55 because the underlying soils are too soft to support vehicles.

There are significant gravel sources in the Cat Camp area in the form of talus slopes immediately adjacent to the road alignment. Additional borrow sources are also present from KP 49 to 54. A bridge crossing of Polje Creek at KP 54 is already planned. From KP 55 to the TTF (KP 86), the road traverses mostly upland karst terrain with thin soil cover.

Gravel fill requirements are expected to be much less, except in a few locations, such as at KP 62 and KP 64 where the road crosses drainage in proximity to Mosquito Lake, and from KP 83 to the TTF, where there is muskeg.

2.4.2 Tetcela Transfer Facility

The approved TTF at KP 86 would be enlarged to accommodate storage of all of the concentrates between the annual closure of the winter road to the Highway and the opening of the next winter road. Additional storage sheds would be added to the existing infrastructure, or the existing sheds would be enlarged. The TTF would become the main concentrate storage location, as opposed to the Mine. Therefore, the concentrate storage shed at the Mine could be moved to the TTF.

A dry storage shed may also be provided to store incoming materials. These would be brought in during the winter and mostly hauled directly into the Mine, however there might be a need to have some storage at the TTF

to allow hauling to the Mine over the course of the following spring and summer. During the winter period, fuel will be back-hauled into the Mine directly and there will be no need for temporary storage at the TTF. However, a truck fueling station with a 10,000 litre storage tank in a bermed and lined enclosure may be provided so that the mine fleet can fuel up at the TTF instead of at the Mine, thus avoiding the haul of that fuel into the Mine. Because the facility would be in operation all season, fire-fighting equipment and protocols would be put in place.

2.4.3 Concentrate/Supplies Haul

The Mine will produce ~120,000 tonnes of concentrate per year when the Mine is producing at maximum capacity. Therefore, approximately 330 tonnes will be produced daily and will need to be transported to the TTF. For a truck capacity of 30 tonnes, this means 11 trips. Travel time to the TTF and back averaging 30 kms per hour (km/hr) would be approximately 7 hours, with 1 hour added for unloading, rest, and turnaround. As a result, it is likely that there would be a mine fleet of approximately 6 trucks which would make 2 trips per day in convoys, with a day shift and a night shift. The trucks would return empty, unless they carry some supplies that were left in storage at the TTF.

When the winter road is open to the Highway, all of the annual Mine fuel requirement and most of the annual supplies required will be brought in to the Mine directly on the back-haul of taking concentrates out. This will be accomplished by using 10,000 litre fuel tanks incorporated into the trailers used for the concentrate haul, the same approach that will be used when the entire road is used in winter only. Traffic over the winter period on the western portion of the road will be much less than before, but the same as before on the eastern portion of the road. Special deliveries will be required as before, for consumables such as explosives and mine reagents.

2.5 Phase 2 Development (KP 86 to KP 183, LTF)

2.5.1 All Season Road

Subject to future economic justification and funding, Phase 2, the eastern portion of the road from the TTF (KP 86) to the Liard River crossing would be constructed. The road from the TTF to approximately KP 96 at the toe of the Silent Hills crosses some of the softest ground on the whole route. There are two crossings of the Tetcela River, each of which would require a bridge, followed by a muskeg area and then the short Fishtrap Creek wetland section. The current alignment will be moved slightly to the south onto firmer ground between KP 90.5 and 94.5. There may be borrow sources in intervening areas, and at the lower slopes of the Silent Hills.

The road then ascends the Silent Hills to Wolverine Pass via switch-backs, and after the Pass heads south along the eastern slope of the range before turning east towards Grainger Gap at KP 121. This section of the road should not require significant fill because the upland terrain is well drained. From KP 121 to KP 126, the road crosses the headwaters of the Grainger River. A re-alignment between KP 122.5 and 123.5 will avoid some very boggy ground. The Grainger Gap area is next to KP 125 and the road is on the northern bank of the Grainger River on an old floodplain terrace where the ground is firmer. There are significant gravel sources in the Gap area.

The road section from KP 125 to the Liard River (KP 160) has varied ground conditions. The first 15 km is well drained, but the remainder has increasing muskeg as the road crosses the historical Liard floodplain. There is significant borrow material available along the toe of the Front Range. East of the Liard River, the road continues across the Liard floodplain to the Nahanni Butte Access Road at KP 174.5.

A private barge would operate on the Liard River crossing during the ice-free period, with an ice bridge in the winter. As the preferred barge landing locations may not coincide exactly with the ice bridge, there may be two

road approaches on each side of the river. Small staging areas will be required adjacent to the barge landing sites on both sides of the river. Equipment will likely be stationed at these sites to maintain the barge landing areas.

2.5.2 Concentrate/Supplies Haul

Concentrates would be hauled out of the Mine daily to travel the 184 km to the Liard Transfer Facility (LTF) near the Liard Highway. Travel will not occur during periods when crossings of the Liard River are not possible. At the Liard River crossing near Fort Simpson, the 10 year average (1998-2008) dates for ferry operation are May 13 to November 4, and for ice bridge operation November 28 to April 21. However, 60 tonne ice bridge crossings are only possible from January 15, and likely have to end sooner than April 21. Therefore, it is assumed that approximately 250 days would be available for hauling in an average year. Thus, to move 120,000 tonnes of concentrate using trucks with 30 tonne loads, 16 trips per day would be required.

Travel time to the LTF averaging 30 km/hr with a brief stop would be approximately 8 hours in winter. In summer, the trip would be approximately 9 hours to allow for the barge crossing of the Liard River, which could be a bottle-neck. In winter, sixteen trucks might transport concentrates to the LTF during the day shift, with the trucks returned with supplies during the night shift. There are two possible summer transportation scenarios, as follows:

- Sixteen trucks will leave the Mine, equally spaced throughout the 24 hour day to the west bank of the Liard River. Trailers loaded with supplies for the Mine will be delivered to the west bank for shipment to the Mine. When the trucks arrive, the rigs will unhitch from the concentrate trailers and hitch the supplies trailers. A second truck crew will then take the supplies trailers into the Mine. This avoids a bottle-neck at the ferry crossing as there would be nearly a full day to transfer the concentrate trailers to the LTF, unload and load, and return them to the north bank. However, this option will require a trailer transfer area on the west bank of the river; and,

- Sixteen trucks leave the Mine in one hour intervals and travel all the way to the LTF. After unloading and loading, a second crew driver immediately returns the truck to the Mine. Ferry crossings are synchronized so that few crossings are made without a loaded truck aboard.

The most efficient transportation plan will need to be determined. As for the Phase 1 road, there will be special delivery trips in addition to the concentrate trips.

2.6 Airstrip

CZN proposes to build an airstrip in the Sundog-Ram Plateau area to support road construction, maintenance and restoration/closure, and secondarily to facilitate air access to the Mine when the existing Mine airstrip is inaccessible due to poor weather. This new airstrip, with proposed dimensions approximately 1,000 x 50 m, would also be available to Parks Canada to support NNPR activities, and to all aircraft for emergency landings.

A number of potential locations were studied previously by BGC Engineering in 2001 and more recently by Allnorth (2015). The current preferred new airstrip location is in the Poljie Creek area (Figure 2). This site offers a good alignment with the apparent prevailing winds, ample runway length, clear approaches on both ends, and suitable runway constructability (Allnorth 2015).

The soil overburden of this area has been typically characterized by Allnorth (2015) as consisting of a thin veneer ranging from approximately 0.3 to 0.6 m deep, with the surface soils ranging between sandy and silty materials over distance. It was also noted that the entire investigation area had been burned by forest fires within the last few decades and has regenerated to pine.

As the new airstrip will also serve as a backup to the existing Prairie Creek Mine airstrip, during times when that airstrip is inaccessible, the air traffic (3-4 aircraft/week) will be diverted to the new airstrip to bring in both supplies and people. Aircraft that have used the existing airstrip include the DHC-5 Buffalo, the DHC-6 Twin Otter, Dash 7-100, and Hawker Siddeley 748. Many smaller aircraft have also accessed the strip, including Caravan, Beaver, Islander and Beechcraft.

3.0 ASSESSMENT METHODOLOGY

The assessment methodology employed to assess potential impacts on the valued components — species at risk, wildlife and vegetation conforms with the impact assessment steps summarized in Section 4.1 of the MVEIRB TOR for the Prairie Creek Mine All Season Road. Consistent with the MVEIRB TOR, the assessment methodology employed includes:

- identify any valued components used and how they were determined;
- identify the natural range of background conditions (where historic data are available), and current baseline conditions, and analyze for discernible trends over time in each valued component, where appropriate, in light of the natural or existing variability for each;
- identify any potential direct and indirect impacts on the valued components that may occur as a result of the proposed development, identifying all analytical assumptions;
- identify and evaluate any proposed mitigation measures as to their technical and economic feasibility to reduce the predicted impacts and discuss constraints, uncertainties and implementation challenges to the effective use of the proposed measures and clearly identify all mitigation commitments;
- predict the likelihood of each impact occurring after the committed to mitigation measures are implemented, providing a rationale for the confidence held in the prediction. The developer will also present the predictions in a manner that facilitates the formulation of testable questions for future follow-up programs, as well as textually and schematically indicate the pathways of predicted impacts;
- compare the predicted impacts to pre-development conditions or to conditions without the Project as appropriate. Include a description of any plans, strategies or commitments to avoid, reduce or otherwise manage and mitigate the identified potential adverse impacts, with consideration of best management practices in relation to the valued component or development component in question;
- describe techniques such as models utilized in impact prediction including techniques used where any uncertainty in impact prediction was identified;
- identify, and provide an opinion on the significance of any residual adverse impacts predicted to remain after any mitigation measures and indicate the methodologies for reaching such conclusions; and
- identify any monitoring, evaluation, and adaptive management plans required to:

  i. detect potential unexpected changes;

  ii. ensure that predictions are accurate; and

  iii. proactively manage against developing adverse impacts when they (or unexpected changes) are encountered.

The developer will describe how the predicted impacts are expected to arise from the proposed development, as well as its views on impact significance. This will include describing the mechanisms for cause and effect and providing supporting references (including where Traditional Knowledge was used). Where professional judgment has been used in determining impacts, this must be made clear. The developer will also provide a discussion on the uncertainty involved with each prediction. For each predicted impact, the developer will describe:

- the nature or type of the impact;
- the geographical range of the impact;
- the timing of the impact (including duration, frequency and extent);
- the magnitude of the impact (what degree of change is expected);
- the reversibility of the impact; and
- the likelihood and certainty of the impact.

The criteria described above will be used by the developer as a basis for its opinions on the significance of impacts on the biophysical and human environment.

This assessment of potential effects related to the upgrading of the current approved winter access road to an all season road addresses the wildlife and vegetation valued components discussed in this supporting report to the DAR for the Prairie Creek Mine All Season Road. The assessment of effects considers direction/magnitude, geographic extent, duration, frequency of occurrence, reversibility and certainty of predicted effects, and is consistent with the approach previously employed by Golder (2010).

The following criteria have been used for the significance determination with respect to wildlife and vegetation, as summarized in Table 3-1:

- Direction and Magnitude – The degree, extensiveness, or scale to which an activity may affect a valued component. Effects can be negative (adverse) or positive (beneficial) while magnitude may be defined as low, moderate or high, depending on how the particular valued component or group of valued components are affected;
- Geographic Extent – The geographic location or area where the effect is predicted to occur. The geographic extent may be identified as local (confined to the area of the access road), regional (with respect to the Dehcho), or territorial in scale;
- Duration – The length of time that an effect is expected to occur as a result of an activity. Short-term duration is defined as the construction phase (in this case one year for each phase), medium-term duration (up to the end of mine life, 14 years), or long-term duration (extending beyond end of mine life);
- Frequency – The predicted rate of occurrence over which an effect may take place. Frequency is defined as low if it occurs once, medium if it occurs intermittently or periodically, or high if it occurs often or continuously;
- Reversibility – Whether the predicted effect(s) can be reversed, or the capacity of the valued component to be restored to pre-development conditions with mine and road closure and reclamation; and
- Certainty – the likelihood and certainty of an effect.

Table 3-1: Assessment of Effects Criteria Associated with the Project

Criterion (of effect)	Low	Moderate	High
Direction and magnitude (severity of adverse environmental effects)	Change is above baseline conditions but within thresholds and within likely range of natural variability	Change is substantially above baseline conditions but within thresholds and within likely range of natural variability	Change exceeds baseline conditions and causes changes beyond the range of natural variability
Geographic extent	Area of effect does not extend past the footprint of the project	Area of effect extends beyond the project footprint but not of regional or territorial consequence	Area of effect is likely to extend into the region or be of territorial consequence
Duration	Effect is only evident during the construction or startup phase	Effect is evident during operation phase	Effect extends beyond the operational life of the road
Frequency	Factors causing the effect occur infrequently	Factors causing the effect occur at regular intervals but infrequently	Factors causing the effects occur regularly and frequently
Reversibility	Effect is readily reversible over a short period of time (i.e., one season)	Effect is reversible over the life of the road	Effect is not reversible even after road closure and reclamation
Certainty	Unlikely to occur	Could reasonably be expected to occur	Will occur, or is likely to occur

An explanation of the significance of environmental effects based on the criteria outlined in Table 3-1 is provided in Table 3-2.

Table 3-2: Significance Criteria for Environmental Effects Assessment

Overall Significance	**Low**	The effect is expected to be of low significance and further assessment and/or specific management are likely not required.
	Moderate	The effect is expected to be of moderate significance and specific management measures or plans are necessary.
	High	The effect is expected to be of high significance and further study or monitoring is necessary to supplement the baseline data, and to be used for refining a management strategy and planning.

4.0 EXISTING ENVIRONMENT AND BASELINE CONDITIONS

4.1 Environmental Setting

The Prairie Creek Mine site is located within the Alpine Forest-Tundra section of the Boreal Forest, characterized by stunted fir with limited undergrowth and open areas dominated by lichen.

The Mine is connected to the Liard Highway via an access road (Figure 1), most of which already exists from the old alignment used in 1981-82. The road leaves the Mine site heading north along the Prairie Creek valley for about 7 km before turning east to cross the Mackenzie Mountains. As the Access Road climbs out of the Prairie Creek valley it enters Sub-Alpine Shrub and Alpine Tundra from an elevation of approximately 1000 m AMSL at KP 10.

The road continues to climb through the Alpine to the summit of 1530 m at KP 17, then dropping down and leaving the Sub-Alpine again at the 1000 m elevation around KP 25. As the road drops from the 1000 m elevation to the 900 m elevation, it passes through a spruce-lichen Alpine forest zone similar to that found at the Mine site and then into Riparian Alluvial habitat in the Sundog tributary valley bottom.

As the road crosses the Ram Plateau, it passes through an open forest Black Spruce/Pine Parkland setting between the 830 to 930 m elevations, before dropping down into the Tetcela River valley. The valley consists of a mixed coniferous/deciduous closed forest. The road then passes through a short distance of muskeg open shrub/sedge wetland at the headwaters of Fishtrap Creek, and climbs up and over the Silent Hills, again a closed mixed coniferous/deciduous forest. The road then crosses an area of black spruce muskeg and wetlands of the Grainger River headwaters before passing through mixed coniferous deciduous pine parkland at Grainger Gap (Second Gap).

Once through the Grainger Gap, the road heads south along the foothills of the Front Range through mixed deciduous coniferous forest towards Nahanni Butte, thus avoiding the Grainger Till plain. The road crosses the Liard River near the community and continues through forest to the Liard Highway.

Vegetation and/or wildlife field studies specific to the Prairie Creek Mine and its access road have included:

Table 4-1: Summary of the Prairie Creek Mine and Access Road Field Surveys

Survey Month	Beak (1980; 1981)	RES (1994)	CZN (2006)	Chillborne (2007)	EBA (2009; 2010)	Golder (2010; 2014a; 2014b)
January	X					X
February						X
March	X					
April	X			X		
May						
June	X		X			
July	X				X	
August						
September		X				X
October						
November						
December						X

4.2 Wildlife Species at Risk

The focus of this assessment is the biological status of species at a territorial level, and includes consideration of those species potentially present along the all season access road that are:

- Listed on the *Species at Risk (NWT) Act*;
- Listed on Schedule 1 of the *Species at Risk Act* (SARA) public registry; or
- Ranked by the General Status Ranks of Wild Species in the NWT as May Be At Risk and At Risk.

The all season access road also lies at the distributional limit of other species that have special conservation status, but the occurrence of these species in the region of the road route and NNPR have not been reported or reported only once. The known range of the Canada Warbler (*Wilsonia canadensis*; listed as Threatened under the SARA and At Risk in the NWT) extends as far north as the very southern border of the expanded NNPR, approximately 20 km south of the all season access road junction with the Liard Highway. Since the Prairie Creek all season access road route predominantly follows the permitted winter route (thereby reducing any potential habitat loss) and is slightly outside the northern extent of this species distribution, the Canada Warbler was not evaluated for this effects assessment. Nonetheless, mitigation to alleviate potential adverse effects to the Canada Warbler will be similar to species included in the effects assessment.

Where available, detailed species descriptions presented in the baseline Vegetation and Wildlife Assessment Report for the Prairie Creek Mine (Golder 2010) and the Occupancy Pattern of Caribou in the Prairie Creek Mine Road and Surrounding Area (Golder 2014a) were directly applied.

The Mackenzie Valley Review Board (MVEIRB) Terms of Reference (TOR) (dated September 12, 2014) identified the following key objectives to describe species at risk (including birds) baseline conditions relating to the Prairie Creek All Season Road (EA1415-01):

- Wildlife species presence, distribution, and abundance;
- Seasonal movements, habitat requirements (e.g., breeding, calving, feeding) and sensitive time periods;
- Population status and trends, limits and size, sensitivity, including species use and timing;
- Habitat types including local and regional distribution and abundance;
- Migratory patterns, routes and timing in relation to all season road route alternatives, construction activities, and operation;
- Harvest pressures (subsistence, resident and non-resident harvesting) by species, season, and geographic area;
- Current and historical levels of natural and human-caused fragmentation and connectivity;
- Baseline contaminant concentrations in harvested species that may change as a result of the all season road using existing data;
- Any known issues with respect to the health (e.g., parasites, diseases, condition) using existing data;
- Location of raptor nesting sites within 1 km of the proposed project footprint; and
- Use of the project area by resident and migratory birds.

4.2.1 Collared Pika (*Ochotona collaris*)

Table 4-2: Collared Pika at a Glance

Collared Pika	
NWT Population Summary	
Conservation Status	Assessed as Special Concern by COSEWIC (2011) and ranked as May Be At Risk in the NWT
Trend	Population trend unknown
Size	Population size unknown in the NWT, Dehcho, or the Prairie Creek Mine area
Sensitivities and Threats	Climate-driven changes to habitat
Health, Parasites, and Contaminants	Known infections from a number of internal parasites and fleas, but their impact to overall health unknown
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 within the Mackenzie Mountains (approximately KP 0-36), but not all suitable habitat is occupied
Seasons of Use	All seasons, but most sensitive to road disturbances in the spring, summer, and fall
Key Habitats	Above the treeline (between 700 to 1,800 m elevation) in talus slopes (i.e., boulder fields with medium to large sized rocks), alpine meadows within 10 m from talus, and predominantly on south-facing slopes (COSEWIC 2011)
Existing Harvest Pressure	None
Traditional Knowledge	
No known reports	

Collared Pikas are poorly surveyed across the NWT, and known observations are recorded mainly as incidental observations. Although the presence of Collared Pikas is generally based on their sighting, distinct vocal calls, and observed haypiles, their presence is under-reported due to the general remoteness of their distribution. Nonetheless, collared pikas were assessed by COSEWIC as Special Concern (2011) and ranked as May Be At Risk in the NWT. Their population size and trend is currently unknown in the NWT, but they are considered particularly sensitive to climate-related changes in habitat and habitat availability such as tree and shrub encroachment.

Collared Pikas are a small member of the rabbit and hare group of species. They live in boulder fields (or talus slopes) in alpine areas, above the treeline, and commonly 700 to 1,800 m above sea level (COSEWIC 2011). These boulder fields occur in small isolated patches across the region. Within the talus slope, they defend small territories year round ranging in size from a 15-25 m radius area (COSEWIC 2011). Within talus, medium to large sized boulders are preferred and the availability of nearby alpine meadows are essential for suitable habitat (COSEWIC 2011). While foraging in the meadows, Collared Pikas commonly remain within 10 m of the protective cover of the talus (COSEWIC 2011).

In the meadows, Collared Pikas forage on a variety of grasses and herbs, some of which they immediately eat while others are harvested and laid out to dry in haypiles located within the talus. These haypiles are an important component of the pikas winter survival. Since pikas do not hibernate, they rely on their stored haypiles deep within the talus matrix to overwinter; however, they may continue to forage in meadows and within the talus matrix under the snow (COSEWIC 2011). Collared Pikas are most sensitive to potential road-related disturbances in the spring, summer, and fall when they are actively foraging and haying, and in July when juveniles are dispersing.

They also use the talus for protective cover from weather (including warm temperatures) and predators (e.g., weasels, foxes, and raptors). In June, the young are born in a nest within the talus. Once weaned, juvenile pikas disperse in July in search of their own territory, a time in which they may be particularly exposed to predation.

Juveniles rarely disperse far from their natal boulder field; however, evidence of dispersal greater than 2 km has been documented (COSEWIC 2011).

Pika abundance within suitable talus patches vary considerably both temporally and spatially (COSEWIC 2011). South facing talus slopes are generally the most productive habitat, and therefore, densities of Collared Pikas are generally higher (COSEWIC 2011). Population fluctuations are known to occur, likely as a result of harsh winters and early springs (COSEWIC 2011). Within a talus slope, collared pikas may be locally abundant. However, talus naturally occurs in isolated pockets across the alpine, and not all suitable habitat may be occupied. COSEWIC (2011) reports that in 2009, no pikas were observed in suitable habitat in the Ram Plateau despite an abundance of suitable talus slope habitat. Likewise, in 2010 only 56% of suitable talus patches were occupied by Collared Pikas in Tombstone Territorial Park, Yukon (COSEWIC 2011).

Collared Pikas may be present along the first 36 kilometres of the all season access road from the mine site where suitable talus slopes may occur. An additional two kilometres of the all season access road within the Nahanni Range, is proposed in the forested valley bottom (less than 600 m elevation) and likely outside suitable Collared Pika habitat. Collared Pikas were unreported during the Prairie Creek Mine and access road studies and camp observation logs. However in July 2012, 12 Collared Pikas were recorded incidentally immediately near the all season access road and reported in Environment and Natural Resources' (ENR's) Wildlife Management Information System (WMIS) (ENR 2014a). Pikas were observed and/or heard in talus between Phase 1 KP 15 to 22.

4.2.2 Boreal Woodland Caribou (*Rangifer tarandus caribou*)

Table 4-3: Boreal Woodland Caribou at a Glance

Boreal Woodland Caribou	
NWT Population Summary	
Conservation Status	Listed as Threatened under the NWT (2014) and federal (2003) SARAs
Trend	Declining in the Dehcho
Size	Estimated 2,318 caribou in the Dehcho North and Southwest portions (Species at Risk Committee 2012)
Sensitivities and Threats	Habitat loss and changes resulting from forest fires and human developments that may increase access and hunting success of predators and hunters, and sensory disturbances
Health, Parasites, and Contaminants	A number of parasites known to occur (Johnson et al. 2010). Contaminant levels typical for large mammals and representative of natural background conditions (Deh Cho First Nations ND)
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 2 (approximately from KP 125 to the Liard Highway; total of 25 km before joining with the Nahanni Access Road) (Species at Risk Committee 2012)
Seasons of Use	All seasons
Key Habitats	Strongly associated with upland and lowlands with black spruce and lichens (Species at Risk Committee 2012)
Existing Harvest Pressure	Low. Hunted opportunistically for subsistence use, particularly in the winter (Species at Risk Committee 2012)
Traditional Knowledge	
▪ The population west of the Liard River to the mountains considered low abundance but stable (i.e., generally west of the Nahanni Range) (Species at Risk Committee 2012). Whereas the population east of the Liard River to Trout Lake is considered high abundance and stable (i.e., generally east of the Nahanni Range) (Species at Risk Committee 2012). ▪ Animals generally healthy, and disease and parasites not considered a major threat to the population (Species at Risk Committee 2012). ▪ Very sensitive to human noises and disturbances, but are thought to adapt a certain extent to only some disturbance types (Species at Risk Committee 2012).	

Habitat fragmentation and degradation of the boreal forests across Canada have led to declining Boreal Woodland Caribou populations. In the NWT, their overall range has remained relatively intact; however, their populations are protected as a Threatened species under both the territorial and federal SARAs because of their small population size and the expected threat to their habitat (e.g., forest fires and human development).

The Boreal Woodland Caribou population estimated in the Dehcho was reportedly in decline from 2005 to 2010, with the adult female annual survival rate ranging from 62 to 93% (Larter and Allaire 2010). Current population estimates are unknown; however, the Species at Risk Committee (2012) estimated caribou densities in the Dehcho north and southwest were approximately 2 caribou per 100 km^2, and therefore, deriving a population of 2,318 caribou across the 115,888 km^2 area.

The Status of Boreal Caribou in the NWT (Species at Risk Committee 2012) suggests that the all season access road extends through Boreal Caribou range from approximately KP 125 to 173 (east of the Nahanni Range), along the existing Nahanni Butte road, and Liard Highway (Species at Risk Committee 2012). Golder (2010) also reported that Boreal Woodland Caribou may also occupy the Tetcela River and Fishtrap Creek areas (west of the Nahanni Range), which they access via the Grainger Gap. However, uncertainty exists whether the caribou reported occupying the Tetcela River and Fishtrap Creek areas may instead be Northern Mountain Woodland Caribou ecotype (Section 4.2.3). Traditional knowledge may help to clarify this uncertainty, and indicates that Boreal Woodland and Northern Mountain caribou are known to interact particularly west of the Liard River near Nahanni National Park Reserve (Species at Risk Committee 2012). For the purposes of this report, it is assumed that Boreal Woodland Caribou primarily occur east of the Nahanni Range, but may infrequently occur to the west in the Tetcela River and Fishtrap Creek areas.

Group size and daily movements change seasonally. Boreal Caribou live in small groups during much of the year, though group size increases leading up to the rut (rut occurring mid-September to mid-October) and is the highest in March and April (Larter and Allaire 2010). Pregnant females become solitary and disperse from the group to calve; possibly only rejoining another female during post-calving (Larter and Allaire 2010) to minimize predation risk to their calf. Boreal Woodland Caribou are non-migratory, but they do make seasonal movements to exploit best available habitats in response to plant phenology and weather. Movement is most reduced the week or two after calving and in mid-winter (February) (Larter and Allaire 2010), but increases in late summer and fall. Routes of travel include areas with hard ground and adequate cover. These may include high ridges, large river drainages, seismic lines, and snowmobile tracks (Species at Risk Committee 2012).

Individual caribou occupy their home range year round, with the location and size of home ranges being dependent on the distribution and relative availability of high quality habitat, primarily upland and lowland black spruce and lichen dominated habitats (Gunn et al. 2004).

In the Dehcho, collared female Boreal Woodland Caribou occupy home ranges averaging 2,824 km^2 (Larter and Allaire 2010). At individual and population levels, Boreal Woodland Caribou require large expanses of suitable habitat with specific habitat features to support key life requirements (e.g., calving, predator avoidance).

To determine the integrity of existing Boreal Woodland Caribou habitat, the Deh Cho Land Use Planning Committee (ND) completed a minimum patch size analysis, and indicated habitat along the proposed all season road meets the species minimum habitat patch size requirements (>515 ha) and represents core Boreal Woodland Caribou habitat. The density of linear corridors (including the existing Prairie Creek winter road) surrounding the proposed all season road is low, ranging from <0.6 km/km^2 along the Phase 1 section and majority of the Phase 2 section, and a high of 0.6-1.0 km/km^2 in isolated locations along Phase 2, primarily as a result of seismic activity (Deh Cho Land Use Planning Committee ND).

This linear corridor density is below the Dehcho Land Use Planning Committee's (ND) Cautionary Threshold (1.0 km/km^2), which represents the lowest threshold at which development, upon reaching the Cautionary Threshold, should be required to monitor impacts. The majority of lands within the Dehcho also fall below this Cautionary Threshold with a few exceptions including the Cameron Hills and Fort Liard areas (Deh Cho Land Use Planning Committee ND).

Across the larger Dehcho region, the Species at Risk Committee (2012) analyzed the degree of habitat fragmentation using known forest fires (1965-2010) and development activity (e.g., seismic lines, existing roads including the Prairie Creek winter road). Results indicate that 13.8% of Boreal Woodland Caribou range across the Dehcho-South study area remains as unburned habitat patches greater than 500 km^2 in size and beyond 500 m from human disturbances (i.e., the most valuable Boreal Caribou habitat) (Species at Risk Committee 2012). This large undisturbed area (500 km^2), is considered the minimum size required for Boreal Caribou to effectively reduce risk of predation (Species at Risk Committee 2012).

Caribou are particularly sensitive to disturbance during calving, post-calving, and winter periods. On average, female caribou in the Dehcho calve on or around May 15 (but may range from April 30 to June 6) (Larter and Allaire 2010; Species at Risk Committee 2012). During the calving season, females seek secluded habitats that are difficult for predators to access, and include large wetlands and marshes, islands in lakes, high ridges, and burn areas (Species at Risk Committee 2012). In all seasons, Boreal Woodland Caribou are often associated with lichen-rich mature or old growth black and white spruce forests (greater than 100 years old) present within bogs and along lakes and rivers (Gunn et al. 2004; Species at Risk Committee 2012).

In winter, Boreal Woodland Caribou tend to favour uplands of forested rolling hills, bogs, and south facing slopes where the snow is not too deep. Their winter diet consists of up to 80% ground and tree lichens. In summer, they may also occupy forest edges, marshes, burn areas, and meadows on higher ground that provide the fresh green growth of flowering plants and grasses (Species at Risk Committee 2012). In the fall, caribou tend to also occupy higher elevations.

Field observations of caribou (ecotype not classified) occurring throughout the Mackenzie Mountains and east along the proposed all season road have been summarized and reported in Golder 2010 and 2014 (Appendix B). During these studies, few caribou were documented east of the Nahanni Range in the winter and summer (assumed to represent Boreal Woodland Caribou's primary range, as reported by the Species at Risk Committee [2012]); however, caribou tracks and some visual sightings of caribou were also recorded in the Tetcela River and Sundog Creek valleys in the winter (Golder 2010; 2014).

Golder (2014) estimated the area of caribou occupancy during the 2010-2011 and 2014 winters along the all season access road. During the 2010-2011 winter studies, caribou occupancy was estimated to be lowest (less than 20%) from the TTF to the Liard Highway (approximately 100 km to the Liard Highway or 54% of the entire road length) and the highest (80-100%) occupancy from the mine site to KP 18 as well as near the Ram Plateau and Sundog Creek (total 52 km). The remaining sections of the all season access road (Phase 1 sections within the Mackenzie Mountains) were estimated to have moderately-low to moderately-high caribou winter occupancy (21-79%) (Golder 2014b). In contrast, during the 2014 winter, the area of caribou occupancy was estimated to be low (less than 20%) from approximately KP 8 to the Liard Highway, representing 96% of the entire all season access road (Golder 2014b). These results may indicate annual variation in overwintering caribou along the access road.

During the field surveys, caribou were most commonly observed in the Mackenzie Mountains (e.g., Prairie and Vera creek valleys), and likely represent Northern Mountain Woodland Caribou (Section 4.2.3). Caribou observed in the Tetcela River and Sundog Creek valleys may have been boreal woodland and/or northern mountain woodland caribou.

To date, little is known about the occurrence and frequency of disease and parasites within Boreal Caribou. Johnson et al. (2010) have begun testing boreal caribou occurring in the Dehcho and reported all 104 adult female caribou

appeared healthy when examined in the field. Based on the analysis of blood and fecal samples, evidence of ten disease agents were detected, including *Trypanosoma* species, Trichostrongyle-type ova, and *Bovine herpesvirus* 1 at a prevalence of approximately 72, 62, and 38% respectively, of the samples tested. Evidence of these disease agents have also been previously reported in woodland caribou and/or other wild ungulates in Canada and Alaska.

Heavy metals, organochlorines (OC's), and polycyclic aromatic hydrocarbons (PAH's) were measured in key traditional foods across the North. The Deh Cho First Nations (ND) report that caribou kidney and livers collected from the Yukon have the highest levels of naturally occurring cadmium; however, these levels remain safe for human consumption.

Across the Dehcho, some harvests are believed to be unreported, but with this in mind, boreal woodland caribou harvest levels are estimated to range from 100–150 a year (Species at Risk Committee 2012). In the study area, incidental resident harvest for subsistence predominates, with the majority of all harvests occurring in the winter (Species at Risk Committee 2012). A total of 1070 Boreal Caribou harvest sites within living memory (spanning approximately 60 years) from residents of Nahanni Butte and other Dehcho communities were identified and mapped (Gunn et al. 2004).

Based on fixed kernel analysis of these lifetime harvest sites, the larger proportion of Boreal Caribou harvesting occurs around Trout Lake, Kakisa and Tathlina lakes, and Fort Simpson, with a small harvesting area north of Liard River near Nahanni Butte and the southern portion of the proposed all season access road (Gunn et al. 2004).

Currently NWT residents and non-residents are permitted to harvest one caribou annually from the Dehcho and the Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitter zones.

4.2.3 Northern Mountain Woodland Caribou (*Rangifer tarandus caribou*)

Table 4-4: Northern Mountain Woodland Caribou at a Glance

Northern Mountain Woodland Caribou	
NWT Population Summary	
Conservation Status	Listed as Special Concern under SARA (2005), but assessed as Secure under the NWT General Status Rank
Trend	The Nahanni Complex and Redstone herds believed to be stable throughout their range (ENR 2014b)
Size	Nahanni complex estimated at 3,000 animals, and Redstone herd estimated at 10,000 (ENR 2014b)
Sensitivities and Threats	Hunting and industrial disturbances. Increased access resulting in increased hunting pressure and predation risk.
Health, Parasites, and Contaminants	Contaminant levels below human and animal health concern (Larter et al. ND). Most of the metals analyzed were found in concentrations similar or lower than Barren-ground Caribou, Reindeer, and/or other mountain ungulates (Larter et al. ND).
Relationship with the Prairie Creek All Season Road	
Expected Presence	Entire Prairie Creek Mine and the all season access road outside the defined species range; however, Northern Mountain woodland caribou may occasionally occur between the Mackenzie Mountains and the Nahanni Range
Seasons of Use	Possibly year round, but infrequent
Key Habitats	Alpine and subalpine plateaus, and open conifer forests found in valley bottoms, lower slopes, and boreal forest zone
Existing Harvest Pressure	Moderate
Traditional Knowledge	
▪ First Nations have reported declining caribou numbers in the mountains (Parks Canada et al. 2009)	

The Northern Mountain Woodland Caribou range has remained relatively intact due to its innate remoteness. Although, threats of habitat modifications and loss from human developments are increasing. As a result, the Northern Mountain Caribou is listed as Special Concern under SARA and assessed as Secure in the NWT.

The Prairie Creek Mine and the all season access road are located outside of the defined range of Northern Mountain Caribou (ENR 2014c); however, a few caribou have been observed near the Mine and access road route in the spring, summer, and winter (CZN 2010; Golder 2010). ENR (2014) explained that “trace occurrences” of Northern Mountain Caribou are known in the area east of the Mine site to the Nahanni Range. However, it is not clear which mountain herd(s) occupy this zone.

The Nahanni Complex (consisting of the Lower Nahanni, La Biche, and Coal River herd) and Redstone herds are closest to the Prairie Creek mine and all season access road route (CZN 2010). Based on the Management Plan for Northern Mountain Caribou (Environment Canada 2012b), the Coal River and possibly the La Biche herds overwinter primarily within NNPR, with the Prairie Creek Mine located at the most north easterly edge of their annual ranges; however, the Redstone herd may be the most likely caribou herd occurring near the Prairie Creek Mine.

The Nahanni Complex group are estimated to total 3,000 animals (ENR 2014c). Of the three herds, the Coal River herd occupies the largest annual range, covering approximately 30,000 km^2 (with just over half of their range extending into the Yukon) (Weaver 2008; Gullickson and Manseau 2000). In general, the annual range of collared females from the Nahanni Complex extend primarily south of the Prairie Creek Mine and south and west into the Yukon; however, a few individuals may winter near the Prairie Creek Mine site (Weaver 2008). They are known to spend their calving, summer, and fall periods in the south-east corner of Yukon, and after rut, migrate north and east into the Northwest Territories to spend the winter primarily within the original boundaries of the NNPR and further south into the expanded park zone (Weaver 2008).

The Redstone herd is one of the largest Northern Mountain Caribou herds in the NWT, estimated at 10,000 animals, and covers an annual range of nearly 90,000 km^2 (includes the Dehcho, Sahtu, and Gwich’in regions) (Weaver 2006; ENR 2014c). Recent evidence seems to suggest the Redstone herd is divided into two sub-herds, the Moose Horn River sub-herd ranging the furthest south and likely occurring near the all season access road (Creighton 2006). The Redstone herd occupies range further north and west of the Prairie Creek Mine and all season access road in the Dehcho and Sahtu regions. Their calving and summer periods are spent in the Mackenzie Mountains near the NWT and Yukon border at the headwaters of the South Nahanni watershed, and move down into the boreal forest of the Sahtu regions in the winter. With exceptions, in the fall and winter, some move further south into the Dehcho region and overwinter in the South Nahanni River watershed (north of Virginia Falls) (Weaver 2006).

These caribou herds have an annual range that straddles the Northwest Territories and Yukon, and are migratory; moving in elevation and between summer and winter ranges seasonally. They summer primarily in alpine and subalpine areas, exploiting alpine plateaus for forage and insect avoidance (1,200-1,600 m elevations) (Weaver 2006; Creighton 2006). Calving primarily occurs in the Yukon or near the Yukon/NWT border, where between the last week of May and the first week of June (May 26-June 5), gravid cows disperse to known plateaus and upland sites to calve (Weaver 2008). In particular, the Moose Horn River sub-herd primarily calves near Moose Ponds, in the headwaters of the South Nahanni, Caribou Cry, and Keel rivers (Creighton 2006).

In the winter, the Nahanni Complex herd move to lower elevations in the subalpine (400-900 m elevations) and the Redstone herd (Moose Horn River sub-herd) moves further into river valleys in the boreal forest zone (600-1,700 m elevations) where snow depths are lower and snow is softer (Weaver 2008; Creighton 2006). However, in years with low snowfall, caribou may remain in upper subalpine and alpine areas (1,250 – 1,400 m elevation) (Weaver 2008). On the spring migration to calving ranges, the Moose Horn River sub-herd follow major river

valleys, such as the Ravens Throat, Silverberry, and Keel rivers (Creighton 2006), but this varies depending on winter distribution and in some years, may include the Tetcela River valley.

Weaver (2008) identified preferred seasonal habitat based on collared caribou locations. These include:

- Winter (early and late): subalpine and montane open conifer forests found in valley bottoms and lower slopes;
- calving: open and closed conifer habitats near the timberline adjacent to and also within rock outcrops and alpine meadows;
- summer: rock outcrops and snowfields, low shrub, and herb dominated alpine tundra habitats;
- rut: montane plateaus near low shrub and open conifer habitats (often on or near their summer range); and
- migration: major river valleys either following the river courses or along the higher elevation valleys.

Between these elevation and seasonal range migrations, Weaver (2008) found a strong pattern of fidelity to spring migration routes, calving sites, and summer ranges; moderate fidelity to rutting areas; and weaker fidelity to winter ranges and fall migration routes. Calving and the late winter seasons are the most sensitive periods of time when caribou may be occasionally interact with the all season road.

Winter Mine site and access road surveys in January and March 1981 found only one group of 5 caribou to the west of the Mine site (CZN 2010). This is a relatively small number, suggesting the area is not part of the “core” winter range (CZN 2010; Beak 1981). By June 9 and 10, 1981, 19 groups of 74 caribou (including calves) were observed in high elevation habitats (ranging from 1,112 to 1,585 m), and by mid-July, two caribou were observed at 1,370 and 1,555 m; all June and July observations were within 16 km of the Prairie Creek Mine and/or its access road (Beak 1981). Similarly, a few caribou (total of 14 observations of 28 adult females, bulls, and calves, plus a single observation of large group consisting of 25-35 animals) have been reported infrequently in the camp wildlife logs (2001-2008) in June, July, and August (Golder 2010). June 1 was the earliest report of a calf observed within the camp log (Golder 2010). The June observations of females with calves confirm that calving may infrequently occur in the area; however, based on the timing of known calving season (May 26-June 5), the calves observed may have already been a week or two old.

Forty-three caribou were also observed within the first 26 km of the all season access road and documented in ENR’s WMIS (ENR 2014a). These observations consisted of eleven separate groups detected in June and July. The group size ranged from 1 to 12 (ENR 2014a).

Caribou occupancy modeling was completed in 2014 to determine the distribution of caribou along the access road route during the non-winter period (Golder 2014b). Using a ground-based caribou sign survey and occupancy model, caribou were predicted to most likely occur in elevated terrain within the Mackenzie Mountains near the Mine site, the lower Sundog Creek drainage, west of the Ram Plateau, and the Silent Hills (Golder 2014b). The remaining sections of the access road displayed a low probability (0.00 – 0.20) of caribou occurrence (Golder 2014b).

A few Northern Mountain Caribou may be expected to occasionally occur near the all season access road year round; however, are uncommon in the winter. Caribou at and near the Prairie Creek Mine site (including near the access road from KP 0-36) may be part of the Nahanni Complex (particularly the Coal River herd), and/or the Redstone herd (i.e., Moose Horn River sub-herd), and/or a local population (Golder 2010). Caribou observed east of the Mackenzie Mountains to the Nahanni Range, along the access road from KP 36-125, are likely from the Redstone herd or are Boreal Woodland caribou.

NWT residents and non-residents are permitted to harvest one caribou annually from the Dehcho and the Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitter zones. ENR (2014) report that an average of 159 Northern Mountain Caribou are harvested by non-resident hunters per year throughout the entire Mackenzie Mountains (total of eight outfitter zones). Since 1965, the average annual harvest of mountain caribou by non-resident harvesters has risen from 44 (from 1965 to1968) to 171 (from 1991 to 1997) (Veitch et al. 2000). After Dall's Sheep, Mountain Woodland Caribou are the second-most sought after species in the Mackenzie Mountains by non-resident harvesters (Veitch et al. 2000). The number of Northern Mountain Caribou harvested each year by residents of Nahanni Butte or the Dehcho region are unknown.

Northern Mountain Caribou harvested from the Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitter zones were found to have metal and radionuclide contaminant levels below human and animal health concern (Larter et al. ND). Although metal and radionuclide concentrations were found in caribou kidney and/or muscle tissue, the levels were similar or lower than Barren-ground Caribou, Reindeer, and/or other mountain ungulates (e.g., sheep, goats) except for cadmium and mercury (Larter et al. ND). Cadmium levels found in caribou kidney tissue was significantly lower than compared to moose inhabiting the southern Mackenzie Mountains.

4.2.4 Mountain Goat (*Oreamnos americanus*)

Table 4-5: Mountain Goat at a Glance

Mountain Goat	
NWT Population Summary	
Conservation Status	Not Assessed by COSEWIC, but ranked as May Be At Risk in the NWT
Trend	Stable
Size	Estimated 351-424 within the Nahanni Butte (D/OT/02) outfitter zone and 70-80 inside NNPR (Veitch et al. 2002)
Sensitivities and Threats	Availability of winter forage, human disturbance
Health, Parasites, and Contaminants	Generally healthy, some metal concentrations in muscles and kidneys, and *Trichinella* species not found in tests (Larter and McDonald 2014)
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 12 to 42 and Phase 2 KP 123 to 160
Seasons of Use	All seasons
Key Habitats	High alpine precipice cliffs
Existing Harvest Pressure	Low
Traditional Knowledge	
▪ No known reports	

In the NWT, Mountain Goats are ranked as May Be At Risk since they exist as a disjunct population, which amplifies their sensitivity to natural and human disturbances. In the Nahanni Butte (D/OT/02) outfitter zone, which includes the all season access road route, the Mountain Goat population is estimated at 351-424 (ENR 2014b). Similarly, in the Flat River area within the NNPR, the Mountain Goat population was estimated at 429 in 2004 (Larter 2004). In 1981, an estimated 70-80 goats occurred within the original boundaries of NNPR (Veitch et al. 2002).

The Ragged Range near the Yukon border is considered core Mountain Goat range; however, smaller discontinuous, occupied areas exist along the South Nahanni River (Wilson and Haas 2012). Near the Prairie Creek Mine and its access road, Mountain Goat range exists primarily along the Nahanni Range, as well as further north onto the Ram Plateau and south onto the Headless Range. Along the all season access road,

Mountain Goats may be expected to occur from approximately Phase 1 KP 12 to 42 and Phase 2 KP 123 to the Liard River crossing. Mountain Goats were not observed during any Prairie Creek Mine and access road surveys, including on the Nahanni Range (Beak 1981; RES 1994; CNZ 2006; Chillborne 2007; EBA 2009; EBA 2010; Golder 2010; Golder 2014).

Mountain goats prefer areas above timberline in subalpine and alpine zones with exposed rock faces comprising of cliffs, ledges, pinnacles, and talus slopes. Mountain goats do not migrate; they maintain the same ranges throughout the year but undertake seasonal movements in elevation (Banfield 1974). In the winter, they move to lower elevations to less steep terrain that provides both available forage and rock faces, which they use as escape terrain to avoid predation (Rideout and Hoffman 1975). Highest wind exposed ridges may also be favoured seasonally, as wind action exposes their winter forage items. In the spring and summer, they gradually move to higher elevations to areas with steep cliff faces and available forage that includes grasses, sedges, rushes, conifers, and forbs (Yukon Government 2014).

Proximity to escape terrain remains important during all seasons, especially in May and June when kids are born. Landscape features such as caves and large rock overhangs are particularly important during the kidding season (Yukon Government 2014) to provide shelter and additional protection from predators. Although little is known about dispersal, it is thought to occur infrequently in late summer by juvenile males (and even fewer females), which have been reported to travel up to 93 km to occupy new range; sometimes even traveling through coniferous forest away from escape terrain (Mountain Goat Management Team 2010).

Adult males disperse across their range, often observed alone or in pairs in the spring and summer. Females occur in small groups of two to four individuals (Rideout and Hoffman 1975). Goats begin to congregate for the rut (November and December), and may be seen in larger groups throughout the winter (Government of Yukon 2014; Rideout and Hoffman 1975). Although the size of annual home ranges are unknown in the NWT, in Montana the average home range was 21.5 km^2, 24.0 km^2, and 48.3 km^2 for adult males, females, and yearlings, respectively (Rideout and Hoffman 1975).

Goats may be seen in larger groups at salt licks, an important habitat for which they may travel several kilometres in the spring and summer to reach (Rideout and Hoffman 1975). Several known mineral licks occur within approximately 10 km of Mountain Goat range near the Prairie Creek Mine and its access road. These licks occur near the Liard River at the southern tip of the Nahanni Range, surrounding Nahanni Butte, the community's access road, and along the Liard Highway (nearest to approximately Phase 2 KP 151 south) (Wilson and Haas 2012; ENR 2014a).

There are no known records of subsistence harvesting of Mountain Goats in the Dehcho, Sahtu, or Gwich'in regions (including within the NNPR) (Veitch et al. 2002); hunting is being conducted solely by a few resident and non-resident harvesters (Veitch et al. 2002; Larter 2012).

Of the five outfitting zones known to include Mountain Goats, only two, the Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitter zones account for 74% of the total harvest (Veitch et al. 2002). Over a period of 20 years (1981-2001), residents harvested 25 goats (Veitch et al. 2002). Most current harvest data from 2002-2010 indicates an average annual harvest increased to 13 adults (range of 5 to 21 goats a year) (Larter 2012). In 2004, Larter (2004) indicated the existing levels of harvesting (1-4 adults a year) likely do not affect the current population.

Kidney and muscle tissues from 17 Mountain Goat harvested from the Nahanni Butte and South Nahanni outfitting zones have been analyzed for metals. Concentrations of select metals, including cadmium were elevated, but cadmium concentrations were substantially lower than found in Moose, which has resulted in a

health advisory (Larter and McDonald 2014). No evidence of *Trichinella* spp. was found (Larter and McDonald 2014).

4.2.5 Wood Bison (*Bison bison athabascae*)

Table 4-6: Wood Bison at a Glance

Wood Bison	
NWT Population Summary	
Conservation Status	Listed as Threatened under the SARA (2003) and ranked At Risk in the NWT
Trend	Slowly increasing (ENR 2010)
Size	In 2004, the Nahanni herd estimated at 400 animals (ENR 2010)
Sensitivities and Threats	Disease, collisions with motor vehicles, and drowning
Health, Parasites, and Contaminants	Believed to be free of bovine tuberculosis and bovine brucellosis, and no anthrax outbreak has been recorded (ENR 2010)
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 2 from approximately KP 140 to along the Liard Highway
Seasons of Use	All seasons
Key Habitats	Liard River and its tributaries, meadows, and oxbows with sedges and horsetails
Existing Harvest Pressure	Negligible to low
Traditional Knowledge	
▪ Some communities no longer recognize bison as part of their heritage, due to the long ago absence of wood bison in the NWT (ENR 2010). Re-introduced herds allow for cultural and spiritual reconnection (ENR 2010).	

Historically, Wood Bison ranged throughout most of the boreal regions of western Canada, including the Dehcho and specifically the Nahanni Butte areas. Due to overharvesting and a period of severe winters, Wood Bison were thought to be extinct until a residual population of approximately 200 Wood Bison (believed to have not hybridized with Plains Bison) were discovered remaining in Wood Buffalo National Park, NWT in 1957 (Parks Canada 1984). Today, Wood Bison are listed as Threatened under SARA (2003) and ranked as At Risk in the NWT.

Wood Bison present along the all season access road route are part of the Nahanni herd, which were re-introduced near Nahanni Butte over a span of 18 years (1980, 1989, and 1998) as part of a re-introduction program into their former range. During this time, approximately 100 Wood Bison were re-introduced. By 2004, the Nahanni herd was last estimated at 400 animals, and their population is considered to be slowing increasing (ENR 2010; Larter and Allaire 2007).

Wood Bison undertake seasonal movements to best utilize differing habitats and food resources. However, their annual distribution largely remains within the Liard River valley, and are seldom observed in the Nahanni National Park Reserve (Parks Canada et al. 2009). Their range extends on both sides of the Liard River, from the Blackstone River (approximately 25 km east of Nahanni Butte) south into northern British Columbia (Golder 2010). Project-related activities may encounter Wood Bison year round in the Phase 2 development from approximately KP 140 to the Nahanni Butte access road (total of approximately 35 km) and beyond along the Liard Highway to Fort Liard.

Golder (2010; 2014) summarized bison observations reported during the Prairie Creek Mine and access road surveys. Bison were yet to be introduced to the area by the time of Beak's early 1980 surveys; however, since then, four bison were observed at the airstrip in Nahanni Butte in June 2006, 13 bison were seen in December

2010, and three bison were seen in February 2011. Bison visual observations and tracks have been reported within 2 km of the Liard and South Nahanni rivers and their oxbows (Golder 2010; 2014).

Wood Bison observations from the Dehcho Nahanni Bison Classification Surveys (1999 to present) and incidental observations have also been reported in ENR's WMIS (ENR 2014a). A total of 440 bison (including calves) documented in the WMIS were concentrated along the Liard River, at the community of Nahanni Butte, and the oxbows and tributaries towards the Liard Highway (ENR 2014a) (Phase 1 KP 156 to 184.5).

Wood Bison are grazers, and rely heavily on sedges and horsetail that grow in meadow openings, particularly in the winter. In summer, bison can be found in small willow pastures, wetlands, and uplands where they feed on sedges, grasses, forbs, and willow leaves and twigs. In the fall, they can be found in forests and in winter, bison move to graminoid fens and lakeshores where they feed on sedges.

Larter and Allaire (2007) indicate that the Nahanni herd is known to commonly swim across the Liard River to access important habitat on either side of the river. Although animals may cross the Liard River anywhere within the herds range, crossings are known at Swan Point (approximately 6 km downstream from the proposed access road barge crossing) and Muskeg and Kotaneelee rivers (at least 130 km upstream from the access road barge crossing). While crossing, a few bison are known to drown annually during spring break up and peak discharge from the mountains (Larter and Allaire 2007).

The Government of the Northwest Territories maintains an extensive program to prevent bison from diseased herds interacting with those considered disease-free. The Nahanni herd is thought to be healthy, and free of bovine tuberculosis (*Mycobacterium bovis*), brucellosis (*Brucella abortis*), and Johne's disease (*Mycobacterium avium paratuberculosis*) (Larter and Allaire 2007). Similarly, no anthrax (*Bacillus anthracis*) outbreak has been reported within this herd (EBR 2010).

Wood Bison are known to be attracted to and become habituated to roadways, traffic, and human activities. The all season access road may provide bison with palatable forage along the roadway side slopes, easier travel with long sightlines to see approaching predators, and suitable habitat to avoid biting insects. Bison are known to occupy habitats on and near the Liard Highway, which places them at risk of vehicle-collisions. Bison-vehicle collisions have been reported on the Liard Highway, particularly where known bison trails converge onto the Highway between Flett Crossing and Muskeg River (highway section between Nahanni Butte and Fort Liard) (Wildlife Collision Prevention Program 2014). Since 2000, a total of 12 bison from the Nahanni herd have been reportedly involved in vehicle collisions, with most collisions occurring from August to October (associated with the rut season) (Larter and Allaire 2007; Wildlife Collision Prevention Program 2014). Of these 12 reported collisions, local residents were most commonly involved than compared to commercial and tourist traffic (Wildlife Collision Prevention Program 2014).

Residents of Nahanni Butte and Fort Liard have each been allowed a single Wood Bison harvest per year since 1998. Since this time, Larter and Allaire (2007) have reported only two bison being harvested. This seems to indicate bison harvest has not been an important component of today's subsistence harvest from these two communities. However, the current NWT Hunting Guide now permits NWT residents to harvest Wood Bison from this herd via a tag quota for one male bison to be hunted from July 1 to June 30.

4.2.6 Grizzly Bear (*Ursus arctos*)

Table 4-7: Grizzly Bear at a Glance

Grizzly Bear	
NWT Population Summary	
Conservation Status	Assessed as Special Concern by COSEWIC (2012) and ranked as Sensitive in the NWT
Trend	Stable within the NNPR (Parks Canada et al. 2009)
Size	Estimated 665 Grizzly Bears in NNPR (Parks Canada et al. 2009), and 10 individual Grizzly Bears in the Prairie Creek drainage and adjacent Mackenzie Mountains (Weaver 2006)
Sensitivities and Threats	Human developments and activities, hunting
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Predominantly in Phase 1 from KP 0-70, with low expected presence the remainder of the road
Seasons of Use	Year round, as denning habitat may exist in the Prairie Creek drainage (Golder 2010)
Key Habitats	High elevation valleys associated with subalpine and alpine habitat types
Existing Harvest Pressure	Low to negligible
Traditional Knowledge	
▪ There used to be more Grizzly Bears at the eastern portion of the South Nahanni Watershed and near Nahanni Butte (Parks Canada et al. 2009).	

The current distributions of Grizzly Bears have significantly contracted from their historical range in southern and western Canada; however, they are reportedly expanding in the NWT, Nunavut, Saskatchewan, and Manitoba (COSEWIC 2012a). They are considered highly sensitive to human disturbances, and risk higher rates of mortality near roads and human developments. Consequently, Grizzly Bears were assessed by COSEWIC as Special Concern (2012) and ranked as Sensitive in the NWT.

The majority of the Grizzly Bears occupying the NWT occur in the Mackenzie Mountains (ENR 2014b). Within Nahanni National Park, their population is considered stable and, in 2009, estimated at 665 individuals (Parks Canada et al. 2009). Weaver (2006) suggested 500 Grizzly Bears in this population is needed to maintain a viable population. Within the Greater Nahanni Ecosystem, Grizzly Bear occurrence was reportedly higher in mountainous habitats, such as Prairie Creek, than compared to the boreal forested zone (Weaver 2006). Those individual bears detected within the boreal forest zone were usually associated with mountainous terrain (Weaver 2006), possibly indicating that the boreal forest zone may represent the periphery of individual home ranges that are less frequently occupied. Home range sizes are negatively correlated to habitat quality. Weaver (2006) estimated the average male Grizzly Bear range may encompass as much as 2,147 km^2, a home range much larger than estimated Grizzly Bear range sizes in the Yukon (COSEWIC 2012a).

In the Mackenzie Mountains, Grizzly Bears are active from approximately mid-April to late October. Grizzly Bear habitat use outside of the denning season is complex and a function of many factors including plant phenology (as plants make up about 90% of their diet), prey availability and distribution, and human presence (ENR 2014d). Miller et al. (1982) reported Grizzly Bears in the Mackenzie Mountains select for alpine habitats in June and July (likely in response to availability of food sources), subalpine habitats in August, both alpine and subalpine habitats equally in September, and higher elevation habitat types as winter approached. Similarly, Weaver (2006) documented Grizzly Bears in the Greater Nahanni Watershed most commonly occur in high elevation valleys associated with subalpine and alpine habitat types in June. Less commonly, Grizzly Bears occupy spruce-lichen woodland or pine-aspen habitat types at the lower elevation boreal forests (Weaver 2006).

Dens are located predominantly on southeast facing slopes in alpine habitat between 1,400 to 1,800 m in elevation; however, a few dens are reported in subalpine habitat, and even fewer in white spruce forest habitat (Miller et al. 1982). Golder (2010) indicated potential denning areas may occur on the eastern slope of the Mackenzie Mountains. Pregnant females give birth to cubs in February while hibernating.

Grizzly Bear densities were predicted by Weaver (2006) across the Greater Nahanni Ecosystem, including the entirety of Phase 1 of the all season access road. These modeling results indicate that Grizzly Bear densities are predicted to be high to very high (22 to 28 bears per 1,000 km^2) at the Mine to approximately KP 39, moderate to low (17 to 10 bears per 1,000 km^2) from approximately KP 39 to 70, and consistently low for the remainder of their study area through the boreal forest zone (Weaver 2006). The areas of high to moderate densities reported by Weaver (2006) also correlate with the Important Wildlife Area designated for Grizzly Bears in the Greater Nahanni Ecosystem (Wilson and Haas 2012). Of particular importance, the area north and northwest of the original NNPR boundaries (and north of the Prairie Creek Mine and proposed all season road) has the largest expanse of high to very high predicted Grizzly Bear densities, and Weaver (2006) concluded this area is particularly important for a viable grizzly population. Based on Weaver's (2006) predicted bear density map, the all season access road from KP 0 to 39 bisects a potential bear movement corridor from the South Nahanni River to this more northern area.

Grizzly Bears can be expected to occur throughout the length of the all season access road; however, are most common in Phase 1 from KP 0 to 70. Considering known den site elevation preferences, denning may occur near KP 0 to 40. Grizzly Bears are considered infrequent visitors to the remainder of the road, including the entire Phase 2 development. However, a single Grizzly Bear has been documented in the Nahanni Range, near the Grainger Gap (Phase 2 KP 125) (ENR 2014a).

As reported by Golder (2010), Grizzly Bears have been infrequently observed during the wildlife surveys, with observations restricted to five visual observations (including a sow with two cubs) and sign including bear diggings, feeding logs, tracks, and scat. Anecdotal information from the camp observation logs suggest that a number of lone Grizzly Bears move through the Prairie Creek valley each spring and summer (May to August), along with occasional family groups (sow and cubs) (CZN 2010). Observations were mostly in the immediate Mine site area, the airstrip, and the road in between (CZN 2010). Information from Canadian Zinc is that Grizzly Bears numbering up to 5-6 per annum are commonly seen moving up the Prairie Creek valley in the spring, and down the valley in the summer. Groups are usually a single male or a sow with one or two cubs. The same groups have been seen infrequently in the Sundog Creek drainage as far east as Cat Camp.

In the Mackenzie Mountains, non-resident hunting of Grizzly Bears has been prohibited since 1982; however, NWT residents may harvest one adult Grizzly Bear (not accompanied by a cub or in a den) from August 15 to October 31. First Nations subsistence hunts are permitted year round. The reported Grizzly Bear harvests from the Mackenzie Mountains occur primarily in the Gwich'in and Inuvialuit Settlement areas (COSEWIC 2012a). From 2001 to 2010, an average of 42.4 Grizzly Bears are killed in the NWT annually, of which, 69% are hunted (49.6% subsistence hunts), 30% are killed for defense of life or property, and less than 1% are killed because of an accident, vehicle-collision, or research-related (COSEWIC 2012a).

4.2.7 Wolverine (*Gulo gulo*)

Table 4-8: Wolverine at a Glance

Wolverine	
NWT Population Summary	
Conservation Status	Assessed as Special Concern by COSEWIC (2003) and ranked as Sensitive in the NWT
Trend	Stable in the NWT
Size	Approximately 3,500-7,300 across the NWT; no data for the Dehcho
Sensitivities and Threats	Overharvesting, habitat loss and fragmentation, and a decline in prey populations
Health, Parasites, and Contaminants	No baseline conditions known for the Dehcho; however, parasitic trematodes, cestodes, and nematodes documented in the NWT
Relationship with the Prairie Creek All Season Road	
Expected Presence	All of Phases 1 and 2
Seasons of Use	All seasons
Key Habitats	Wherever existing prey species exist
Existing Harvest Pressure	Low
Traditional Knowledge	
▪ Wolverine populations vary in space and time (COSEWIC 2014)	

Wolverines are assessed as Special Concern by COSEWIC (2003) and ranked as Sensitive in the NWT, due to their low resiliency to human-caused effects, their innate low reproductive rates, and requirement for expansive home ranges. The Wolverine population size in the NWT is estimated approximately 3,500-7,300 (COSEWIC 2014). Although the population size is relatively unknown, their population is considered stable (COSEWIC 2014).

Wolverines remain solitary and require an expansive home range; living at low population densities even under optimal conditions (Banci 1994). Across North America, northern mountain populations, such as Kluane Wildlife Sanctuary in the Yukon, have the highest densities (maximum of 10 Wolverines per 1,000 km2) (COSEWIC 2014). It has been suggested an area as large as 20,000 km2 may be required to maintain a stable Wolverine population (to appreciate the size, the expanded boundary of the NNPR now covers 30,000 km2) (COSEWIC 2014).

Wolverines occupy a variety of habitats within the boreal forest and Mackenzie Mountains year-round. Home ranges and habitat selection varies between sexes. In northern British Columbia, home ranges were up to 405 km^2 for females, 1,366 km^2 for males, and 4,600 km^2 for sub-adults (Hatler et al. 2008 in Golder 2010). With male home ranges generally overlapping with several females. Based on these large home ranges, the all season access road may directly interact with approximately 16 females, 8 males, and 5 sub-adults from the Mine site to the Nahanni Access road (KP 0-174.5).

Habitat selection is directly associated with food abundance, predation risk (especially for females with kits), and level of human disturbances (COSEWIC 2014). In mountainous regions, females appear to select higher elevations and steeper terrain, whereas, males and sub-adults more commonly occupy lower elevation forests, particularly in the winter (COSEWIC 2014). Wolverine habitat is present throughout the geographic scope of the all season road (entirety of Phases 1 and 2) wherever abundant food resources exist.

Wolverines are generalists; they scavenge on carrion and prey on birds and small and large mammals and forage on plant materials. The presence of large prey, such as ungulates, at least at some time during the year, appears to be important for the persistence of Wolverine populations. On the tundra, Wolverine densities reportedly decline in direct association with caribou populations (COSEWIC 214).

During the Prairie Creek Mine and access road surveys, Wolverine observations were uncommon (Golder 2010). A single Wolverine was reported in July 1980 in alpine tundra habitat and tracks were seen in December 2010 and February 2011 near the Tetcela River (approximately 25 km north of the all season access road) (Golder 2010; 2014). Mine site personnel reported seeing Wolverines infrequently from 1968 to 1980 (Golder 2010).

Although active year round, Wolverines construct snow dens to escape predators, cache food, and raise their young. Natal dens are generally associated with large boulders in talus slopes, downed logs in avalanche chutes, and/or persistent snow banks that remain into late spring (e.g., ravines and leeward slopes, COSEWIC 2014). Kits (young) are born in February or March within this natal den. Within the boreal zone, natal dens have also been documented in abandoned beaver lodges and bear dens, in upturned roots and fallen logs, or rock crevices (Banci 1994). Fidelity to den sites or denning areas is observed in some females (COSEWIC 2014). An accumulation of persistent snow may also be important for food caching to protect against other scavengers, insects, and decomposition (COSEWIC 2014). Food caching is considered important for continued persistence during low prey densities. Natal denning and food caches are more likely within the mountainous regions of the Phase 1 all season access road from KP 0-40.

Although considered healthy, Wolverines in the NWT are known to host several parasites including trematodes, cestodes, and nematodes (COSEWIC 2014).

Besides being a species with special conservation status, Wolverines are also an important furbearer for local communities throughout the NWT. The majority of Wolverines, approximately 70%, in the territories are hunted from snowmobiles during winter (Mulders 1999). Harvests are typically centred near the communities and where road access is available.

4.2.8 Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Western Long-eared Myotis (*Myotis evotis*)

Table 4-9: Little Brown Myotis, Northern Myotis, and Western Long-eared Myotis at a Glance

Little Brown Myotis, Northern Myotis, and Western Long-eared Myotis	
NWT Population Summary	
Conservation Status	Little Brown Myotis and Northern Myotis listed as Endangered by SARA (2014) and ranked as May Be At Risk in the NWT. Western Long-eared Myotis is Not Assessed by COSEWIC, but ranked as May Be At Risk in the NWT
Trend	Population trend unknown in the NWT
Size	Population size unknown in the NWT
Sensitivities and Threats	Habitat loss, white-nose syndrome fungus, over-wintering habitat
Health, Parasites, and Contaminants	White-nose syndrome fungus unreported in the NWT
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 40-86 and the entire Phase 2 (KP 86 to the Liard Highway)
Seasons of Use	All seasons
Key Habitats	Karst terrain for overwintering
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

After unprecedented rates of population decline due to white-nose syndrome (*Pseudogymnoascus destructans*, a fungal disease which arrived in the United States in 2006 and Canada in 2010) across eastern Canada and the United States, Little Brown Myotis (*Myotis lucifugus*) and Northern Myotis (*Myotis septentrionalis*) are listed as Endangered by SARA (2014) and ranked as May Be At Risk in the NWT. To date, COSEWIC has yet to assess the Western Long-eared Myotis (*Myotis evotis*), but it is ranked as May Be At Risk in the NWT. Although white-nose syndrome has yet to be reported west of Ontario in Canada it is estimated to be spreading 200 to 400 km a year, and has the potential to reach the NWT in 12 to 18 years (ENR 2014b; COSEWIC 2013a)

COSEWIC (2013) identified limiting bat habitat includes foraging areas, maternity roosts, and overwintering hibernacula. Foraging areas are common within the Dehcho and along the all season access road. Northern Myotis and Western Long-eared Myotis are reliant on forested habitats and forest clearings, including trails, and the Little Brown Myotis favours open habitats, particularly aquatic environments. Both species will forage across a variety of habitat types, wherever an abundance of insects exist.

During the day, bats roost in trees, tree cavities, rock crevices, buildings, and bridges; at night they feed on insects. Between night feeding bouts, bats return to temporary night roosts. Wildlife trees, specifically those with rot damage, cavities, or loose bark, are important roosting habitat. Bats are known to use these wildlife trees for maternity colonies, as well as day and night roosts. These wildlife trees are most commonly present in mature forest stands likely occurring in the dense mixedwood habitats. Summer foraging habitat is common throughout their NWT range.

In the spring, females occupy maternity roosts, sometimes in large colonies, under bridges, in buildings, rock crevices, tree cavities in large-diameter trees, or even in large clumps of tree lichens (COSEWIC 2013a). These maternity roosts are reused each year.

The Little Brown Myotis and the Northern Myotis are likely year round residents and overwinter in colonies where suitable habitat exists. There is no current evidence to suggest the Western Long-eared Myotis overwinters in the NWT. Bats across Canada may begin their state of hibernation (more specifically torpor) in late September to October, and arouse in late April to early June (COSEWIC 2013a). Although specific periods of hibernation are unknown in the NWT, it is anticipated that it extends from late September to early June, in direct association with insect availability.

Suitable hibernacula in the NWT may be limited, restricting their northern distribution; however, may be common in the NNPR. Hibernacula are critical habitats, and are reused annually (COSEWIC 2013a). In the area of the all season access road, caves and rock crevices have the most potential as hibernacula, possibly occurring in the karst terrain between KP 60-64. The all season access road (following the permitted winter road (EA0809-002)) has been re-routed from the original 1980s winter road route to avoid potential disturbances to these sinkholes and poljes and fragmentation of habitats in between. However, not all potential hibernacula habitat (e.g., caves, rock crevices) are suitable for over-wintering bats (COSEWIC 2013a). Overwintering occupancy is influenced by site-specific conditions including the temperature and temperature stability, humidity, running water, cave and opening sizes, and length and angle of tunnels (COSEWIC 2013a).

To date, only a single hibernaculum is known in the South Slave Region of the NWT (COSEWIC 2013a; ENR 2014b). The location is confidential and not publically available.

Lausen (2006) completed mist-net and ultrasound detector system surveys from July 16-31 and August 3-5, 2006 in the South Nahanni River watershed, which included surveys in the karst terrain near the all season access road (near Phase 1 KP 56 to 59). During these surveys, both the Little Brown Myotis and Northern Myotis were detected; however, there were fewer bat captures in the karst area near the access road than compared to lower elevations in the NNPR. Lausen (2006) concluded that the karst terrain near the access road did not appear to

provide highly favourable summer roosting habitat (at least for females) due to its higher elevation and cooler night temperatures, but more suitable habitat was present along the South Nahanni River. Little Brown Myotis and Northern Myotis were most common, and a single Western Long-eared Myotis was detected within the NNPR during these surveys (Lausen 2006).

Although this survey provided confirmation of these three bat species occurring in the karst area (near KP 56 to 59) and/or in the NNPR during the summer, it remains unknown whether these bat species overwinter (Lausen 2006). There are no observation records of bats during the Prairie Creek Mine and access road studies and from the camp observation logs.

While overwintering, bats are not sensitive to disturbances except if occurring directly at or within the hibernacula (COSEWIC 2013a).

4.2.9 Harlequin Duck (*Histrionicus histrionicus*)

Table 4-10: Harlequin Duck at a Glance

Harlequin Duck	
NWT Population Summary	
Conservation Status	Ranked as May Be At Risk in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Human disturbance and habitat loss
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 37-41
Seasons of Use	Late spring to early fall
Key Habitats	Fast-flowing turbulent rivers and streams in the forested zone
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Harlequin Duck populations show signs of recovery across their range; however, their populations May Be At Risk in the NWT with an estimated population size in the low 100s. Human-related disturbances and habitat loss are potential threats to their population. Harlequin Ducks are sensitive to human-related effects. Alteration of habitat, nest site disturbances, and contamination altering aquatic invertebrate abundance potentially threaten breeding populations (Kneteman et al. 2010; COSEWIC 2013b).

In the forested zone, swift-flowing streams, particularly those with braided channels provide nesting habitat. Harlequin Ducks nest on or near the ground, preferring stream channel islands or stream banks (generally within 5 m) with suitable protective cover (e.g., shrubs, fallen logs). Nest site fidelity is expected (Robertson and Goudie 1999). They may also occupy lakes downstream from the nest site, and moult in large groups away from the nesting site (Robertson and Goudie 1999).

In Alberta, Harlequin Ducks arrive in late April or early May and depart by mid-September (Kneteman et al. 2010). Inside NNPR, Harlequin Ducks have been recorded along the South Nahanni River, its southern tributaries, and nearby lakes. Based on these records, Harlequin Ducks are present from at least early May to the end of August

(Sullivan et al. 2009). Harlequin Ducks observed at Rabbitkettle Lake is the nearest known observation to the Prairie Creek Mine, approximately 135 km (Sullivan et al. 2009).

The fast-flowing Sundog Creek tributary along the proposed all season access road from Phase 1 KP 37 to 41 may provide suitable Harlequin Duck habitat, although Canadian Zinc report no sightings of ducks of any kind in Sundog Creek, and note that KP 37 to 41 is often dry in the summer and fall, apart from a few ribbons and deep pools.

4.2.10 Horned Grebe (*Podiceps auritus*)

Table 4-11: Horned Grebe at a Glance

Horned Grebe	
NWT Population Summary	
Conservation Status	Assessed as Special Concern by COSEWIC (2009) and ranked as Sensitive in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Habitat loss and alteration
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 40-86 and Phase 2 KP 86 to the Liard Highway
Seasons of Use	Late spring, summer, and early fall
Key Habitats	Small sized waterbodies with high cover of emergent and submergent vegetation
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Horned Grebes have been assessed by COSEWIC as Special Concern (2009), and ranked as Sensitive in the NWT. The Horned Grebe population is stable in the Yellowknife area, and is presumed to be stable throughout its range in the NWT (Fournier and Hines 1999; ENR 2014b). In the Yellowknife area, Horned Grebes were found in higher densities along Highway 3 as a direct result of the large number of small man-made (borrow pits) and natural ponds in the area (Fournier and Hines 1999).

Horned Grebes arrive in the NWT in May and depart by mid-August to early September (Environment Canada 2014). Within their breeding range, Horned Grebes occupy small ponds, wetlands, shallow lakeshores, and other natural or human-made permanent or semi-permanent waterbodies, wherever their main foods (aquatic insects, fish, frogs, and crustaceans) are abundant. Favourable breeding ponds include areas of open water for feeding and sufficient cover of emergent (e.g., cattails and sedge) and submergent vegetation to provide nesting substrate (Fournier and Hines 1999). Horned Grebes are most sensitive during nesting.

In late July and August, adults leave their pre-fledged young at the breeding ponds and reside at larger waterbodies (waterbodies greater than 15 ha in size and depths greater than 1 m) to molt immediately prior to fall migration. During molt, Horned Grebes experience a flightless period and may form large post-breeding aggregations during this sensitive time (Fournier and Hines 1999; Stout and Cook 2003).

Grebes have the potential to occur wherever suitable habitat exists along the all season access road in Phase 1 from KP 40-86 and in Phase 2 from KP 86 to the Liard Highway. Horned Grebe's were not observed during any of the wildlife and wetland surveys completed for Prairie Creek mine and its winter road; however, an unidentified

grebe was recorded at an identified wetland along the access road route in 1980 (KPA 1980 in Golder 2010). Parks Canada (1984) reported Horned Grebes were uncommon breeders in the NNPR; however, observation records exist along the South Nahanni and Liard rivers; none known along or within many kilometres from the all season access road (Sullivan et al. 2009).

4.2.11 Peregrine Falcon (*Falco peregrinus anatum*)

Table 4-12: Peregrine Falcon at a Glance

Peregrine Falcon	
NWT Population Summary	
Conservation Status	Listed as Special Concern under the SARA (2012) and ranked Sensitive in the NWT
Trend	Stable
Size	Greater than 1000 known breeders in the NWT; population in the Dehcho or near the Prairie Creek mine unknown
Sensitivities and Threats	Limited threats within the NWT
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Potential nesting habitat within 1.5 km from Phase 1 KP 56-59 and Phase 2 KP 125-127, 129-130, 136-137, and 157-159; but entire all season access road for hunting
Seasons of Use	Late spring, summer, early fall
Key Habitats	Nesting cliffs near water and preferably 50 to 200 m in height
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

The Peregrine Falcon population has nearly recovered following the ban of organochlorine pesticide use and re-introduction programs across Canada. However, they remain listed as Special Concern under the SARA, and are ranked as Sensitive in the NWT.

In the NWT, the *anatum* subspecies range extends along the South Nahanni River (and area) within the NNPR boundaries and along the Mackenzie River valley (Environment Canada et al. 2014), and may be expected to occur along the all season access road. Peregrine Falcons may occur along the all season access road from mid-May to late August.

Peregrine Falcons require suitable nesting habitat and a larger hunting home range from which they return to in successive years. Peregrine Falcons nest on ledges of cliffs, preferably 50 to 200 m in height and commonly near water. Not only is a nest site reused by a territorial pair in successive years, but the same nest site may be reused through successive generations (COSEWIC 2007a). The all season access road route does not meet the necessary habitat requirements for nesting Peregrine Falcons throughout most of its length; however, potential cliff habitat may be provided by the karst features located near KP 56-59 and along Phase 2 of the Nahanni Range.

Their home range from which they hunt can extend up to 27 km from their nest (ENR 2014e). Hunting occurs in open habitats, such as alpine and subalpine tundra, meadows, riparian areas, lakes, and may also include roadways and other man-made disturbance areas. Suitable hunting habitat exists along the length of the access road.

Surveys in 1980, 1981, 1994, 2006, 2007 and 2009 did not result in any observations of Peregrine Falcons (CZN 2010). Parks Canada (1984) reported Peregrine Falcons were rare breeders in the NNPR, and a single nest site was is known along the South Nahanni River (ENR 2014a). A territorial pair, which may be nesting along the lower South Nahanni River, may hunt along the all season access road where suitable habitat exists, as the majority of the road route is within the probable home range.

The sensitivity of Peregrine Falcons to human disturbances and equipment/vehicles is relatively unknown. Overtime, they may show a degree of tolerance to human activities.

4.2.12 Yellow Rail (*Coturnicops noveboracensis*)

Table 4-13: Yellow Rail at a Glance

Yellow Rail	
NWT Population Summary	
Conservation Status	Listed as Special Concern under SARA (2003) and ranked as May Be At Risk in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Habitat loss and alteration
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 2 KP 126 to the Nahanni Access Road (total approximately 49 km) and further to the Liard Highway
Seasons of Use	Late spring, summer, and early fall
Key Habitats	Sedge dominated wetlands and marshes
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Across Canada, much of the Yellow Rail habitat has been altered and lost. Although population estimates are unknown across the majority of their Canadian range, this significant loss of habitat is believed to have affected their population size. Therefore, the Yellow Rail is listed as Special Concern under SARA (2003) and ranked as May Be At Risk in the NWT. The all season access road is located at the extreme northern limit of their range. Based on their known distribution in the NWT (Environment Canada et al. 2014) and their preferred habitat requirements, the potential to occur along the all season access road is restricted primarily east of Nahanni Range and along the Liard Highway, wherever site specific habitat conditions exists. The Phase 1 portion of the all season access road is located outside its known range. However, Environment Canada et al. (2014) report that the presence of Yellow Rails has not been confirmed at other suitable habitats outside existing range boundaries.

Yellow Rails arrive in the NWT in early May to breed and, during this time, are sensitive to disturbances particularly from human activities and changes in water levels. Nests are constructed on the ground, concealed with sedge and grasses. Yellow Rails may return to the same breeding site for several years; however, fluctuating water levels are thought to influence annual nest site selection (Bazin and Baldwin 2007). Yellow Rails begin their southern migration in late September to early October.

Preferred feeding and nesting habitats are sedge and rush dominated wetlands with low tree/shrub cover and shallow water depths (ranging from moist substrate to 12 cm water). In shallow water and along muddy

shorelines, they feed on freshwater snails, aquatic and terrestrial insects, and seeds. Suitable habitat is restricted to small isolated shrub and herb wetland land cover types present along the all season access road from approximately KP 126 to the Liard Highway. Although outside the known Yellow Rail range, sedge meadows also form inside the poljes nearest to Phase 1 KP 56 to 59 during low water years, and have the potential to irregularly provide Yellow Rail habitat.

There are no known records of Yellow Rail observations at the Prairie Creek Mine or its access road. Parks Canada (1984) reported Yellow Rails as not occurring inside the NNPR (Parks Canada 1984). Similarly, there are no reported Yellow Rails on eBird Canada within the NNPR or the entire Dehcho region (Sullivan et al. 2009).

4.2.13 Short-eared Owl (*Asio flammeus*)

Table 4-14: Short-eared Owl at a Glance

Short-eared Owl	
NWT Population Summary	
Conservation Status	Listed as Special Concern under SARA (2012) and ranked as Sensitive in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Limited threats in the NWT. Sensitive to disturbance during nesting
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 (approximately KP 0-70) and Phase 2 (approximately KP 125-130)
Seasons of Use	Spring, summer, and fall
Key Habitats	Large open areas of alpine tundra, low shrub and herb bogs, marshes, and other non-forested areas
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Short-eared Owls are listed as Special Concern under SARA and ranked as Sensitive in the NWT, due to habitat loss and degradation on its wintering grounds (primarily in the United States) and a progressive decline in habitat on its breeding range (within Canada).

Little is known about Short-eared Owls in the NWT. Much like elsewhere in the species range, their populations in the NWT fluctuate annually in size and distribution in direct association with small mammal populations (e.g., lemmings, mice, shrews). Short-eared Owls are nomadic, and arrive in the NWT to breed in April or May and depart by late October (CWS et al. 2014). While here, Short-eared Owls are associated with large open habitats wherever an abundance of small mammals are present, particularly in alpine tundra, bogs, marshes, and other non-forested areas (CWS et al. 2014). Preferred nesting habitat includes expansive areas of open grasslands or low-structured open shrublands that are dominated by grasses or sedges typically less than 50 cm in height.

Based on the existing land cover types, expansive open areas dominated by grasses or sedges occur along the all season access road potentially in low shrub, wetland herb, wetland shrub, and herb land cover classes in isolated patches along Phase 1 from KP 0-40 (approximately) and along Phase 2 from KP 125-130. Short-eared Owls also hunt in open areas such as along roadside ditches, beaver ponds, lakeshores, riparian areas, and

graminoid fens primarily at dawn and dusk. Suitable hunting areas are available throughout the length of the all season access road.

Nests are located on the ground in dry open habitats dominated by grasses or sedges typically less than 50 cm in height, or of sufficient height to conceal an incubating female (Wiggins et al. 2006). Nests may be re-used in consecutive years (Wiggins et al. 2006). Egg laying is initiated by mid-June, and owlets fledge by mid-August. Short-eared Owls are sensitive to disturbance during nesting, and may abandon nests as a result. However, they are known to successfully nest in close proximity to active agricultural activities (COSEWIC 2008).

Short-eared Owls have been observed near Rabbitkettle Lake, inside the original boundaries of NNPR, in early to mid-May and are expected breeding residents (Sullivan et al. 2009; Parks Canada 1984). This owl has not been observed in the Prairie Creek Mine site or along the access road during the field studies (CZN 2010); however, a single observation along the Liard River near Nahanni Butte was listed by Sullivan et al. (2009).

4.2.14 Common Nighthawk (*Chordeiles minor*)

Table 4-15: Common Nighthawk at a Glance

Common Nighthawk	
NWT Population Summary	
Conservation Status	Listed as Threatened under SARA (2010) and ranked as At Risk in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Vehicle collisions, reductions in insect abundance, human activities that increase predator abundance
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 0-8 and 37-86 and entire Phase 2
Seasons of Use	Summer and early fall
Key Habitats	Open forests, forest clearings, recent burns, rock outcrops, and peat bogs
Existing Harvest Pressure	None
Traditional Knowledge	
▪ Trout Lake residents (approximately 125 km southeast of Nahanni Butte) have reported Common Nighthawk numbers have been decreasing in recent years (Parks Canada et al. 2009).	

Across Canada Common Nighthawk populations are declining due to habitat loss and reductions in insect abundance. In the NWT, Common Nighthawks occur at the northern extent of their range. As a result, they have been listed as Threatened under SARA and ranked At Risk in the NWT.

Population estimates within the NWT or in the Dehcho are unknown; however, they are expected summer residents along the all season access road wherever suitable habitat exists. They arrive in the NWT in mid-May to early June, and depart by mid-August to mid-September (CWS et al. 2014). Common Nighthawks nest directly on the ground in a variety of substrates, including sand, gravel, or bare rock, and are sensitive to disturbances while nesting (CWS et al. 2014; COSEWIC 2007b). However, the level of sensitivity to human disturbances is unknown.

They maintain territories, which vary in size depending on habitat suitability and nest site availability (COSEWIC 2007b). Preferred nesting habitat includes: open forests, forest clearings, recent burn areas, rock outcrops, lakeshores,

gravel areas (including gravel quarries, airstrips, and roads), and exposed land (CWS et al. 2014; COSEWIC 2007a). Although Common Nighthawks are known to nest on human developed sites, they tend to prefer natural sites (COSEWIC 2007b). Appropriate nesting habitat is likely common throughout the all season access road route.

Common Nighthawks are aerial insectivores, feeding on flying ants and beetles, and other flying insects primarily at dawn and dusk. Their preferred feeding habitat includes areas with an abundance of insects, including habitats preferred for nesting, as well as wetlands and marshes and open water (including lakes, rivers, and streams). Common Nighthawks will also forage near artificial lights that have attracted insects (CWS et al. 2014).

Suitable nesting and foraging habitat exists primarily within the boreal forest zone and possibly within large montane valleys such as Prairie Creek. Within Phase 1 of the all season access road development, Common Nighthawks may occur from KP 0-8 and KP 37-86. Within Phase 2, they may be expected to occur along its entire length from KP 86 to the Liard Highway.

There is no record of Common Nighthawks being observed in the Prairie Creek Mine area, but there were several observations near ponds along the access road in wetland surveys during the July 1980 studies (CZN 2010). The sightings near ponds along the access road route suggest that Common Nighthawk is a breeding resident (CZN 2010). Suitable habitat occurs in the Prairie Creek valley (open gravel areas, airstrip) and in the open terrain lying between the east slope of the Mackenzie Mountains and the Nahanni Range. As such, habitat for Common Nighthawk is in proximity to the Mine site and portions of the access road. Within the NNPR, Lausen (2006) captured a Common Nighthawk while mist-netting bats, and Parks Canada (1984) reports Common Nighthawks are a common summer breeder in the area.

4.2.15 Olive-sided Flycatcher (*Contopus cooperi*)

Table 4-16: Olive-sided Flycatcher at a Glance

Olive-sided Flycatcher	
NWT Population Summary	
Conservation Status	Listed as Threatened under SARA (2010) and ranked as At Risk in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Limited threats in the NWT
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 0-8 and 37-86 and entire Phase 2
Seasons of Use	Summer
Key Habitats	Open and semi-open habitats and habitat edges
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Olive-sided Flycatcher populations are declining across Canada; however, there is no clear cause for this decline. For this reason, the Olive-sided Flycatcher is legally listed as Threatened under SARA, and ranked At Risk in the NWT. Population estimates within the NWT or in the Dehcho are unknown; however, they are an expected summer resident along the all season access road wherever suitable habitat exists.

Similar to other insectivores, the Olive-sided Flycatcher arrives in the NWT late (late May and early June) and departs early (late July and early August) in response to insect availability (CWS et al. 2014).

Feeding Olive-sided Flycatchers are closely associated with waterbodies that have a high density of insects (e.g., beaver ponds, lake edges, streams), but they also feed in open and semi-open habitats such as natural and man-made habitat edges, open forests, regenerating forests, and wetland edges. Preferred feeding areas include tall prominent trees or snags for perching and from which they pursue flying insects.

Typical Olive-sided Flycatcher nesting habitat includes forest edges with large trees and standing snags (COSEWIC 2007). Nests are typically built in coniferous trees (COSEWIC 2007c). Along the all season access road, Olive-sided Flycatchers may occupy open and sparse coniferous and mixedwood forests, wetlands, shrublands, and habitat edges such as along the road, transfer facility stations, airstrips, and the mine. Olive-sided Flycatchers may be expected to occur in the Phase 1 development from KP 0-8 and 37-86 and the entire Phase 2 portion.

Parks Canada (1984) reported Olive-sided Flycatchers were possible breeders in NNPR, and they have been reported multiple times within the NNPR and along the Liard Highway (Sullivan et al. 2009). No Olive-sided Flycatchers have been reported at the Prairie Creek Mine or along its access road (CZN 2010). Nonetheless, they are expected to occur throughout much of the all season access road route, primarily within the boreal forest zone.

4.2.16 Bank Swallow (*Riparia riparia*) and Barn Swallow (*Hirundo rustica*)

Table 4-17: Bank and Barn Swallow at a Glance

Bank Swallow and Barn Swallow	
NWT Population Summary	
Conservation Status	Bank and Barn swallows assessed as Threatened by COSEWIC (2013 and 2011, respectively) and ranked as Secure and Sensitive in the NWT, respectively
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	None known in the NWT (ENR 2014b)
Health, Parasites, and Contaminants	Nest and body parasites
Relationship with the Prairie Creek All Season Road	
Expected Presence	Entire Phase 1 and 2
Seasons of Use	Spring to Fall
Key Habitats	Open habitats, sheltered vertical substrates and steep banks near water
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

There has been an evident decline in both the Barn and Bank swallow populations across Canada; in the NWT, the Barn Swallow population may be declining even though there are no known threats (ENR 2014b). Consequently, Barn and Bank swallows were assessed by COSEWIC as Threatened and ranked as Sensitive and Secure in the NWT, respectively.

Barn and Bank swallows may migrate together in mixed-flocks. Both are insectivores, and are expected to arrive by mid-May with the abundance of flying insects and depart late summer to early fall (Garrison 1999; Bromley and Trauger ND).

Throughout its Canadian range, Barn Swallows are most associated with human settlements. Barn Swallow preferred habitat includes fields and open meadows, wetlands, and lakes for feeding, buildings and man-made structures (including bridges and buildings) for nesting, and a waterbody near the nest site to supply the required mud for nest building (Brown and Bomberger Brown 1999). Natural nest sites, such as cliffs and caves may also be used, and old nests may be reused the following year. Nest re-use leads to common infections with body parasites such as fleas and blowflies (COSEWIC 2011b). Favoured nesting habitat for the Barn Swallow exists at the Prairie Creek Mine site and outbuildings, possibly within Nahanni Butte and from the park buildings inside the NNPR.

Unlike the Barn Swallow, the Bank Swallow excavates its nest by burrowing in exposed soil banks along eroded watercourses and lakeshores; however, they may also nest in sand and gravel pits/quarries, and road embankments that are situated near feeding habitat (COSEWIC 2013c). They nest primarily in colonies, which can reach as many as thousands of individuals (Garrison 1999). Nests are re-occupied each year, and several flea and blowfly species are known to occur inside the burrows (COSEWIC 2013c). Wetlands, open water, meadows, riparian, and shrublands are preferred feeding habitats (Garrison 1999), and exist throughout the all season access road. Suitable nesting habitat may exist wherever exposed soil banks occur along the creeks and Tetecla River drainages and the east slopes of the Nahanni Range.

Although the all season access road is located within the species' known ranges and suitable nesting habitat exists, only a few Barn Swallows and multiple Bank Swallow observations have been reported along the South Nahanni and Liard rivers (Sullivan et al. 2009). In NNPR, Bank Swallows were considered common breeders (Parks Canada 1984). There have been no recorded observations of swallows during the Prairie Creek Mine and access road studies and from the camp observation logs.

4.2.17 Rusty Blackbird (*Euphagus carolinus*)

Table 4-18: Rusty Blackbird at a Glance

Rusty Blackbird	
NWT Population Summary	
Conservation Status	Listed as Special Concern under SARA (2009) and ranked as Sensitive in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Removal and destruction of nests from buildings, bridges, and quarries, exposure to uncharacteristically cold weather
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Expected Presence	Phase 1 KP 40-86 and all of Phase 2
Seasons of Use	Spring, summer, and fall
Key Habitats	Treed wetlands with open water
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Significant declines in Rusty Blackbird populations have been reported across North America; however, their population size in the NWT is generally unknown. Rusty Blackbirds are listed as Special Concern under SARA (2009) and ranked as Sensitive in the NWT. In the NWT, there is little threat to Rusty Blackbird populations to date, as there is little development and an abundance of suitable habitat.

Rusty Blackbirds can be expected to occur in the Dehcho and along the all season access road from early May to late September. Their occurrence along the all season access road is in direct association with boreal forest wetlands, which are located in low elevations east from the Mackenzie Mountains to the Liard River. Occurrence in habitats at high elevations, such as Phase 1 KP 0-39, is considered uncommon (Environment Canada 2014).

Rusty Blackbirds are most commonly associated with forest edges along natural waterbodies (COSEWIC 2006). They forage on the ground along the edges of these waterbodies (e.g., fens, bogs, beaver ponds, streams, and swampy lake shores) in search for aquatic and terrestrial insects and plant materials (e.g., seeds and fruits). Nests are constructed primarily in conifer and deciduous trees in suitable feeding habitat. Research indicates Rusty Blackbird populations are associated with beaver lodge densities in an area (Avery 1995). The Traditional Knowledge Assessment Report indicated beaver was once commonly harvested along Fishtrap Creek and Tetcela River, therefore, it is assumed these areas also support Rusty Blackbird. Areas with a low beaver lodge density are thought to have a low Rusty Blackbird abundance.

In the NNPR, Parks Canada (1984) reports Rusty Blackbirds are uncommon summer breeders; however, multiple reports of sightings within the Park and a single report in Nahanni Butte have since been reported (Sullivan et al. 2009). Previous field surveys for the Prairie Creek Mine site did not identify Rusty Blackbird as occurring there (CZN 2010). Appropriate Rusty Blackbird habitat along the all season access road occurs primarily in the low elevation boreal forest zone from Phase 1 KP 56-86 and all of Phase 2, wherever suitable habitat exists. Rusty Blackbird habitat is likely common throughout the Dehcho.

4.2.18 Western Toad (*Anaxyrus boreas*)

Table 4-19: Western Toad at a Glance

Western Toad	
NWT Population Summary	
Conservation Status	Assessed as Special Concern by COSEWIC (2012) and ranked as May Be At Risk in the NWT
Trend	Unknown
Size	Unknown. Unconfirmed sighting in NNPR (Parks Canada et al. 2009)
Sensitivities and Threats	Climate variability, disease, and vehicle-collisions
Health, Parasites, and Contaminants	No baseline conditions known to date
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	Phase 2 approximately KP 156 to Nahanni Access Road (total 19 km) and along the Liard Highway
Seasons of Use near the Access Road	All seasons
Key Habitats	Shallow ponds, springs, lake shores, oxbows, road ditches, and wetlands
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

The Western Toad, non-calling population, has declined or is projected to decline across much of its known range (COSEWIC 2012b). In Canada, the Western Toad has been assessed as Special Concern by COSEWIC (2012) and is ranked as May Be At Risk in the NWT. The Western Toad is at its northern most range in the Dehcho region, and its population is considered to be small; however, precise population sizes are unknown as few

surveys have been undertaken in the NWT. Western Toads are inconspicuous most of the year, since they are most active at night (i.e., nocturnal) and, in the NWT, do not call.

Western Toads undertake a spring migration to congregate at communal breeding ponds to reproduce within a 1 to 2 week period. Breeding ponds are used in successive years (COSEWIC 2012b). Only a few suitable breeding habitat sites available may be occupied, due to site fidelity and a communal breeding strategy (COSEWIC 2012b). In August, the newly emerged toadlets migrate away from the breeding pond *en masse.* During this time, they are especially vulnerable to predation and human disturbances such as vehicle traffic (COSEWIC 2012b).

Western Toads use a variety of aquatic and terrestrial habitat types throughout their life history stages including wetlands, shallow sandy margins of ponds, slow moving rivers and backwaters, beaver ponds, borrow pits and road ditches, and springs during breeding. The predominant characteristic of the breeding sites include silty and/or sandy bottom substrates and high water temperatures (COSEWIC 2012b). Western Toads are sensitive to disturbance at breeding, spring migration, and in the egg and tadpole stages. Both the egg masses and tadpoles are particularly vulnerable to predation and habitat changes such as altered water levels and water chemistry.

Wetlands, riparian areas, and upland sites are occupied in summer, sometimes several kilometres from the breeding pond. Throughout the summer, Western Toads may range up to approximately 1.2 km from a waterbody; however, their abundance is greatest in forests less than 100 m from water (COSEWIC 2012b). In the summer, they seek open warm foraging grounds with an abundance of prey such as closed deciduous forests, clearcuts and recent burns, subalpine and alpine meadows, and areas with sufficient overhead cover (e.g., coarse woody debris, boulders, shrubs).

Western Toads hibernate underground below the frost line in small mammal dens, abandoned beaver lodges, muskrat tunnels, red squirrel middens, or burrows dug themselves in or near springs and other waterbodies, and in areas that accumulate snow (COSEWIC 2012b). The use of communal hibernacula are common, particularly those within 2 km of the breeding sites.

Based on the presumed range of Western Toads, suitable year-round habitat may exists at and near the Liard River (Phase 2 KP 156 to the Nahanni Access Road, approximately) and along the Liard Highway. Western Toads have been unreported along the all season access road. However, a single unconfirmed report (considered questionable by Parks Canada (1984)) of toads near the Liard River, approximately 4 km upstream from the proposed barge crossing is acknowledged (ENR 2014a).

4.3 Other Wildlife and Wildlife Habitat Traditionally Harvested

Additional species with Secure and Sensitive populations in the NWT have known distributions along or near the all season access road. The focus of this assessment is the biological status of species or species groups traditionally harvested and those that are of ecological significance.

White-tailed Deer (*Odocoileus virginianus*), Mule Deer (*O. hemionus*), and Elk (*Cervus elaphus*) have been expanding their range north, but are rarely observed in or around NNPR and Nahanni Butte. These species are not discussed further in this document.

The MVEIRB Terms of Reference (TOR) (dated September 12, 2014) identified key objectives to describe wildlife and wildlife habitat baseline conditions relating to the Prairie Creek All season road (EA1415-01):

- Wildlife species presence, distribution, and abundance;
- Seasonal movements, habitat requirements (e.g., breeding, calving, feeding) and sensitive time periods;

- Habitat types including local and regional distribution and abundance;
- Species of importance to subsistence harvesters;
- Habitat or sites of special value or sensitivity, include species use and timing;
- Migratory patterns, routes, and timing in relation to the all season road route alternatives, construction activities;
- Harvest pressures (subsistence, resident, and non-resident harvesting) by species, season, and geographical area;
- Listing and location(s) of existing invasive species;
- Current and historic levels of natural and human-caused fragmentation and connectivity;
- Existing baseline contaminant concentrations in harvested species that may change as a result of the all season road;
- Any known issues with respect to the health of harvested species (e.g., parasites, diseases, condition);
- Use of the project area by resident and migratory birds; and
- Location of known raptor nesting sites or potential raptor nesting habitat within 1 km of the proposed project footprint.

4.3.1 Dall's Sheep (*Ovis dalli dalli*)

Table 4-20: Dall's Sheep at a Glance

Dall's Sheep	
NWT Population Summary	
Conservation Status	Not assessed by COSEWIC, and ranked as Secure in the NWT
Trend	Not Rated within NNPR, but status considered good (Parks Canada et al. 2009). In the NWT, populations likely stable
Size	Estimated at 800-1,200 within the Greater Nahanni Ecosystem (Weaver 2006) and 14,000-26,000 in the Mackenzie Mountains (Veitch 2014)
Sensitivities and Threats	Overharvesting, human disturbances, disease
Health, Parasites, and Contaminants	Generally healthy, but known to host sheep lungworm (*Protostrongylus stilesi*) and the ecthyma virus
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	Phase 1 within the Nahanni Plateau from KP 0-39 and Phase 2 along the Nahanni Range from KP 124-160
Seasons of Use near the Access Road	All seasons
Key Habitats	Alpine and subalpine plateaus, ridges, and mineral licks
Existing Harvest Pressure	Moderate
Traditional Knowledge	
▪ No known reports	

Dall's Sheep populations are ranked as Secure in the NWT. Their populations have been estimated at 14,500 to 26,500 of which 14,000 to 26,000 occur in the Mackenzie Mountains (Veitch 2014). Depending on the quality of habitat, Dall's Sheep densities may range from 20 to 55 sheep per 100 km^2, but are uncommonly over 55 per 100 km^2 (Barichello et al. 1987). Weaver (2006) reported that Dall's Sheep densities within the Greater Nahanni Ecosystem averaged 37 sheep per 100 km^2.

Important Dall's Sheep concentration areas within the Mackenzie Mountains are known to occur along and near the all season access road include the Nahanni Plateau (along Phase 1 KP 0-39), Ram Plateau (Phase 1 KP 61 is the closest point (approximately 4 km) to the Ram Plateau), and the Nahanni Range (Phase 2 KP 124-160). Dall's Sheep commonly spend their entire lives within a single well-defined mountain block or range (Simmons 1982), remaining primarily within the subalpine and alpine zones. Therefore, little dispersal is expected to occur between those potentially occupying the Nahanni Plateau, Ram Plateau, and Nahanni Range. Although infrequent, dispersal to new ranges has been reported, particularly involving young rams, although adult ewes have also been documented dispersing (Simmons 1982).

Outside the rutting period, adult males are often observed alone or in small groups of other males, whereas, ewe groups (including young rams, yearlings, and lambs) commonly occur in larger groups (ENR 2014f). Movements between annual ranges, as well as to mineral licks, are commonly confined to this specific mountain block. Annual movements between these ranges commonly follow the same route. In general, good winter habitat is also good summer habitat, with the winter range simply a contraction of the summer range (Simmons 1982; Beak 1981).

In the summer, Dall's Sheep commonly occupy high alpine meadows, and slowly begin moving to their winter ranges at lower elevations as snow accumulates. Sheep are particularly sensitive on their winter ranges, when suitable food resources are restricted and winter weather influences snow deposition and hardness. Optimum winter habitat includes low plateaus and ridges with shallow or wind swept snow, near timberline where snow crusting is limited, and in areas where forage is most accessible (Simmons 1982). A winter range is commonly utilized each year; however, shifts in winter range are known to occur (Simmons 1982).

Mineral licks are also an important habitat feature, particularly for ewe groups in the spring and early summer, but are regularly visited throughout the snow-free period (Parks Canada 1984). Parks Canada (1984) report Dall's Sheep visits to mineral licks "begin in early June, peaks in July, and ends by October". A high fidelity to mineral licks has been reported, with ewe groups travelling 5 to 20 km from their summer feeding areas to a mineral lick (Simmons 1982; Parks Canada 1984). Particularly, the location of mineral licks are believed to strongly influence the summer distribution of ewes, lambs, and juvenile groups (Parks Canada 1984).

At the Prairie Creek Mine, Beak (1981) reported the presence of a mineral lick below Adit #3 and explained the attraction to possibly rock salt used for melting ice. Near the all season access road, known mineral licks occur primarily along the South Nahanni and Liard rivers, including near the confluence with Prairie Creek (at least 25 km from the all season access road) (Wilson and Haas 2012; Parks Canada 1984). Known mineral licks near the confluence of Prairie Creek and the South Nahanni River are known to be visited by both Dall's sheep and Moose, and are subsequently considered important points of interest for Park visitors (Parks Canada 1984). Dall's Sheep travelling to this Prairie Creek/South Nahanni River mineral lick may move along Prairie Creek.

Another mineral lick is known approximately 11 km north of the all season access road nearest to Phase 1 KP 10, and multiple licks are known near the Liard River crossing and the community of Nahanni Butte (Wilson and Haas 2012; ENR 2014a). Dall's Sheep occurring on the Nahanni Range may occupy mineral licks on the north side of the Liard River, including a moderate and high density mineral lick area approximately 10 km west (nearest point) of the Phase 2 access road, and smaller mineral lick areas near KPs 156-157 (Wilson and Haas, ENR 2014a).

Sheep are grazers and require food supplies that are adjacent to suitable terrain to escape predators. Grasses and sedges compose the majority of their diet, with leaves and stems of some shrubs, forbs, mosses, and lichens selected seasonally. Typically, rugged terrain is occupied to escape from predators, and females will seek isolated high cliffs and ridges to lamb. Lambing occurs in late May to early June, with lambing completed by June 9-10 (Beak 1982 in Golder 2010). Beak (1981) indicated Dall's Sheep observations suggest three possible lambing areas: 1) Folded Mountain within a kilometre from Phase 1 KP 7 of the all season access road; and 2 and 3) peaks immediately east and west of the Mine site airstrip (both within a kilometre of Phase 1 KP 2 and 3). Similarly, the Nahanni Range would provide suitable lambing areas.

As indicated by CZN (2010), Dall's Sheep inhabit the Prairie Creek Mine site area and are regularly observed during the spring and summer around the mine, moving to fall range (including rutting) and winter range to the east of Prairie Creek on the Nahanni Plateau. Sheep, primarily ewes, yearlings and lambs, are common on the east side of the valley above the Mine and Mill site in the spring. Rams appear to be more widely dispersed, including the west side of the Prairie Creek valley. This draw to the Mine site by ewe, lamb, and juvenile groups in the summer may be attributable to possible soda ash near Adit #3, as described by Beak (1981), and to human presence which deters predators.

Surveys indicate sheep occur along the access road from the Mine site throughout the Nahanni Plateau, along Funeral Creek and the pass to Sundog Creek, primarily in the winter, spring, and early summer. On the Nahanni Range, March surveys indicated sheep occurred primarily north of the all season access road at elevations greater than 1,000 m, compared to the road elevation at 500 m (Beak 1981). In June 2006, the largest group of Dall's Sheep were immediately adjacent to the Mine site (Golder 2010).

Based on the camp log records, Dall's Sheep (primarily ewes with lambs, yearlings) are commonly at and near the Mine and Mine site airstrip in June and July, with sheep observations declining into August, September, and October (Golder 2010). Golder (2010) suggests the ewes, yearlings, and lambs may undertake a late-summer dispersal away from areas immediately around the Mine site. Overall, rams appear more widely dispersed away from the Mine site; the nearest known observation location being on the west side of the Prairie Creek valley (Golder 2010).

Threats to Dall's Sheep in the NWT include disease, human disturbance, inability to quickly colonize new areas, and potential over harvest (Barichello et al. 1987; ENR 2014b). Dall's Sheep are moderately resilient to human disturbances if within a continuous population (i.e., the Mackenzie Mountain population); however, they show a low resilience to disturbances if the population is fragmented or isolated from others. Dall's sheep are known to habituate to harmless human activity in routine space and time (Weaver 2006).

Although Dall's Sheep are considered healthy in the NWT, they are known to host sheep lungworm (*Protostrongylus stilesi*), which has been linked to fatal pneumonia outbreaks (ENR 2014f). Similarly, the ecthyma virus, a contagious virus to people and other ungulates including Moose and caribou, have also been reported in the NWT (ENR 2014f).

In the Mackenzie Mountains, non-resident harvesters preferentially seek trophy Dall's Sheep during their hunts from July 15 to October 31. During the 2012 hunting season, a total of 207 rams were harvested by non-resident harvesters; up from the average annual harvest of 197 calculated over the past 22 years (Larter and Allaire 2013). The meat is later distributed to the local communities, including Nahanni Butte. Resident and general hunting licence holders (e.g., First Nations groups) also harvest for subsistence in the Mackenzie Mountains. In the Mackenzie Mountains, resident hunters reportedly harvested 7 rams (Larter and Allaire 2013), and general hunting licence holders are known to harvest approximately 20-30 Dall's Sheep a year.

4.3.2 Moose (*Alces alces*)

Table 4-21: Moose at a Glance

Moose	
NWT Population Summary	
Conservation Status	Secure in the NWT
Trend	Assumed to be Stable (Parks Canada et al. 2009; RWED 2005)
Size	Density estimates range from 0.02-0.07 moose/km^2 around Nahanni Butte and southeast portion of the NNPR (Parks Canada et al. 2009). Also, 0.049 moose/km^2 in the Liard River valley (RWED 2005).
Sensitivities and Threats	Over harvesting, predation, vehicle collisions
Health, Parasites, and Contaminants	Cadmium levels relatively high in Moose kidney and liver tissues taken from the southern Mackenzie Mountains and Liard/Mackenzie river valleys (Larter and Kandola 2010). Ticks are rare. Moose warts (papillomas) and hydatid tapeworm cysts common (RWED 2005).
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	The entire Phase 1 and 2 portions
Seasons of Use near the Access Road	All seasons
Key Habitats	Valleys and riparian areas, mineral licks, semi-open forests, early successional habitats, lakeshores
Existing Harvest Pressure	Moderate
Traditional Knowledge	
▪ Moose are an important game animal in the NNPR (Parks Canada et al. 2009) ▪ Local accounts from the Dehcho region indicate the Moose population has been decreasing in some areas and stable in others (ENR 2014b)	

Moose commonly occur throughout the boreal forest, and their populations are listed as Secure in the Northwest Territories. Based on traditional harvesting areas identified during local consultations, an aerial Moose survey was conducted along the Liard River and uplands in 2004 (RWED 2005) (including Nahanni Butte and the Phase 2 portion of the all season access road east of Nahanni Range). Based on these results, the Moose density was estimated at 0.049 Moose/km² and the population was believed to be stable (RWED 2005). Similarly, the density of Moose around Nahanni Butte and the southeast portion of the NNPR ranged from 0.02-0.07 Moose/km^2 (Parks Canada 2009).

Moose habitat is not considered limiting within the geographic scope of the Prairie Creek all season road. Low elevation habitats such as semi-open forests and habitats with an abundance of willow and other deciduous shrubs close to lakes, inside river valleys and riparian areas, and along lakeshores are favoured by Moose, and common east of Nahanni Plateau. Suitable habitat types include tall and low shrub, wetlands (treed, shrub, and herb), coniferous open, broadleaf open, and mixedwoods. NNPR wardens also observed Moose occupying high elevation subalpine shrublands (a narrow band of shrubs in the transition between subalpine forests to alpine tundra) in the late fall and early winter, and with increasing snow deposition, moved to lower elevations later in the winter (Parks Canada 1984).

Moose are primarily browsers, and browse on willow, young aspen and balsam poplar, Saskatoon, Canada buffalo-berry, rose, and red-osier dogwood. These preferred browse species commonly occur in abundance in semi-open early successional habitats such as floodplains, oxbows, wetlands, regenerating burns, and previously

disturbed areas. Habitats with a high cover of willow and other browse material support Moose throughout the year, especially in the winter, and occur throughout the All season access road route east of Nahanni Plateau (beginning at approximately Phase 1 KP 37) to the Liard Highway.

The use of browse material declines in the spring and summer when forbs, grasses, and aquatic plants are available. Wet and aquatic habitats are common feeding areas during all non-winter months, but tend to peak during late June to early August when plant nutrition and digestibility are highest. In addition, Moose may seek aquatic habitats in the summer to avoid heat stress.

Moose also seek distinct habitats to minimize detection from predators and avoid insect harassment. Dense coniferous forests and tall shrub stands are used to conceal from predators, and open wind exposed ridgelines and aquatic habitats are used to avoid insects. They may also use lake shorelines and islands to reduce encounters with predators, especially during calving.

Gill (1978) recognized mineral licks as critical Moose habitat that are utilized year round, but especially in the winter. Along the Prairie Creek all season access road, known mineral licks occur primarily near the South Nahanni and Liard rivers (Wilson and Haas 2012). Based on known mineral lick locations and/or density map (Wilson and Haas 2012; ENR 2014a), the Phase 1 and 2 road developments may pass as close as:

- 11 km (approximately) south of a single known mineral lick (nearest to Phase 1 KP 10);
- 10 km (approximately) west of moderate and high density mineral lick areas located north of the Liard River (nearest to Phase 2 KP 151);
- 2 km (approximately) of a high density mineral lick area located near the Nahanni Butte airport (nearest to Phase 2 KP 162-164) and a single mineral lick near Phase 2 KP 156); and
- Within a few 100 m from three mineral licks near Phase 2 KP 157, the junction with the Nahanni Access road, and along the Liard Highway (nearest to Phase 2 KP 178-184.5).

Another area of mineral licks occur near the confluence with Prairie Creek and the South Nahanni River, at least 25 km from the all season access road (Parks Canada 1984). These known mineral licks are known to be visited by Moose (Parks Canada 1984), which may access the mineral lick along the South Nahanni River and the Prairie Creek valleys.

Previous field surveys for the Prairie Creek Mine and its access road observed Moose and Moose sign at the Mine site and along most of the length of the access road, albeit more commonly east of the Nahanni Plateau (Golder 2010; 2014b). Presumed Moose high and moderate winter and summer ranges included the area north of Liard River to the Grainger River, the Tetcela River and Fishtrap Creek valleys, and Silent Hills (Beak 1981). However, Moose were occasionally observed in the Mackenzie Mountains, along Prairie Creek and at the Mine site in the spring and summer. Over a seven year period (2001-2007), a total of three adult Moose were reported in the camp observation logs near the Mine and Mine site airstrip (Golder 2010). Movement corridors likely occur along low valleys in the Mackenzie Mountains, along the existing access road, and along major rivers and their larger tributaries.

Moose are assumed to be the preferred subsistence species in the area. Metal concentration analyses were conducted from Moose occurring in the Liard and Mackenzie River valleys and the southern Mackenzie Mountains due to concern of metal contaminants in country foods. The level of cadmium, mercury, and zinc were higher in Moose from the southern Mackenzie Mountains than compared to the Liard/Mackenzie river valleys (Larter and Kandola 2010). However, only cadmium levels in Moose kidney and liver tissue were above levels reported elsewhere and were considered a public health concern (Larter and Kandola 2010). As a result, a public health

advisory is in effect for cadmium levels reported in Moose liver and kidney tissues taken from the southern Mackenzie Mountains and Liard/Mackenzie river valleys (including all portions of the all season road) (Larter and Kandola 2010). Moose have also been found to commonly host Moose warts (papillomas) and hydatid tapeworm cysts, but ticks are rare (RWED 2005).

Traditional harvesting of Moose within the original boundaries of NNPR concentrated along the eastern boundary and into Yohin Lake, and totalled approximately 2 to 12 Moose annually (Parks Canada 1984). No other harvest locations and harvest numbers are known; however, assumed to frequently occur along the Liard River valley and the Liard Highway. NWT residents and non-residents are permitted to harvest one Moose annually from the Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitter zones. Across the Mackenzie Mountains, non-residents harvested a record number (85 Bull Moose) in 2012, the largest known harvest since records began in 1991 (Larter and Allaire 2013). This increased harvest was attributed to outfitter zone (D/OT/01) ownership changes, which prior to 2005, the majority of this outfitter's clientele targeted Dall's sheep, consequently only harvesting 24 Moose a year (Larter and Allaire 2013).

4.3.3 Furbearers

Furbearers are an important economic and cultural resource for many hunters and trappers in the north. Based on available species range maps and previous wildlife field surveys conducted in the Prairie Creek project area, three furbearing species were chosen to represent all furbearers potentially occurring in the area of the all season access road. These include: Grey Wolf (*Canis lupus*), Beaver (*Castor canadensis*), and Marten (*Martes americana*). Wolverines, another important furbearer, also occur along the all season access road and was described in Section 4.2.7.

The habitat requirements and potential distributions of these selected species along the all season access road are considered representative of other furbearers also occurring in the area (e.g., Red Fox *Vulpes vulpes*, Snowshoe Hare *Lepus americanus*, Muskrat *Ondatra zibethicus*, River Otter *Lontra canadensis*, American Mink *Neovison vison*, Canada Lynx *Canadensis*, and weasel species). Although these additional species were not selected for a focused effects assessment, the potential for Project-related effects and applicable Project mitigation to reduce adverse effects are addressed by the selected representative species.

Furbearer distribution and population abundance have not been formally surveyed for the Prairie Creek Mine and its access road; however, they are expected to occur throughout the all season access road route wherever suitable habitat exists.

Table 4-22: Furbearers at a Glance

Furbearers	
NWT Population Summary	
Conservation Status	Grey Wolf, Beaver, and Marten – All Secure in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Over harvesting, habitat loss, human activities
Health, Parasites, and Contaminants	No baseline conditions known for most species. Cadmium levels elevated in Beaver, but at levels suitable for consumption. Beavers in the Dehcho are considered a healthy food (Deh Cho First Nations ND)

Table 4-22: Furbearers at a Glance

Furbearers	
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	Entire Phase 1 and 2
Seasons of Use near the Access Road	Year round
Key Habitats	Various, wherever suitable habitat exists
Existing Harvest Pressure	Low
Traditional Knowledge	
▪ No known reports	

Grey Wolves are hunted and trapped for their fur and are important to the local and regional economies in the north. The Grey Wolf is a habitat generalist, occupying habitats with an abundance of prey. Wolf densities in the Dehcho, particularly areas near Trout and Celebita lakes, are considered to be relatively high (Larter 2004b). Across the boreal forest zone of the NWT, estimates reach as high as one wolf per 101 km^2 (Van Zyll de Jong and Carbyn 2000). An estimated 30 to 75 Grey Wolves were expected to occur in and around NNPR, and were considered widely occurring (Parks Canada 1984). A pack, ranging in size generally from two to sixteen individuals (ENR 2014b), maintains a home territory, which varies in size depending on prey densities. Within this territory, wolves construct dens to raise their pups; the denning period typically beginning by early May. Inside the original boundaries of NNPR, Grey Wolf dens were associated with waterbodies, and an occupied wolf den was once reported near the Prairie Creek-South Nahanni River confluence (Parks Canada 1984). Grey Wolf dens are reused in consecutive years, and wolves at the den site are sensitive to human disturbances.

There have not been any formal Grey Wolf studies conducted for the Prairie Creek Mine and its access road; however, several wolves have been observed incidentally during aerial surveys and in the camp observation logs (Golder 2010). Wolves have been reported at the Prairie Creek Mine and Harrison Creek, near the Mine site airstrip, and along the access road (Golder 2010). During this time, the number of Grey Wolves detected ranged from one to a pack of five (Golder 2010). Grey Wolves are expected to occur throughout the entire Prairie Creek all season access road.

Beavers are a common harvest species in the NWT; they are traditionally harvested for their pelt, hide, and meat. Beavers occur primarily at low elevations, where wetlands, slow moving streams, ponds, and lakes are present. Their distribution and abundance are dependent on habitat quality, and they are sensitive to water level changes, especially in the fall and winter. Based on available habitat along the all season access road, Beaver are assumed to range primarily from Phase 1 KP 64-86 and the entire length of Phase 2. However, their abundance is expected to be higher along the Tetcela River and Fishtrap Creek valleys, and east and west of the Nahanni Range where there are more wetlands, then compared to the mountainous regions.

Low concentrations of cadmium have been documented in the kidney and livers of Beaver collected from the Slave River and Mackenzie deltas (INAC 2004). Cadmium is naturally present across the NWT, and finds its way into the food web from the weathering of rocks and subsequent plant uptake (INAC 2004). Cadmium may also be released into the environment from burning fuels and refuse. Concentrations are low and are not considered harmful to Beavers or to the people eating them.

Marten are expected to occur throughout the forested areas traversed by the all season access road east of the Mackenzie Mountains (Phase 1 KP 64-86 and entire length of Phase 2). They favour mature coniferous forest stands with complex downed and overhead structures; however, all habitats may be occupied if abundant prey and cover exist. Marten were considered common inside the original boundaries of NNPR (Parks Canada 1984).

Marten prefer forests with a high canopy cover, and in general, do not travel across open areas that are 200 m wide or greater (Salmo Consulting Inc. et al. 2004). Marten populations are generally cyclic in response to their dominant prey populations. Like many furbearers, Marten are particularly sensitive to disturbance during their denning period (March or April), when litters are born in dens within rock piles, tree roots, deadfall, or peat banks. Marten are considered to be relatively tolerant to human disturbances and activities, but are vulnerable to overharvest (Salmo Consulting Inc. et al. 2004).

In the NWT, Wolves are classified as both big game and furbearers. All NWT residents are permitted to harvest as many Grey Wolves as they have tags for, and non-residents may hunt within an outfitting zone (ENR 2014b). All residents require a licence to trap.

Non-residents hunting within the Mackenzie Mountains harvest, on average, approximately 15 Grey Wolves a year; however, 24 were harvested in 2012 (the highest recorded harvest since records began in 1991 (Larter and Allaire 2013). Harvesters within these outfitter zones did not harvest Wolverine (Larter and Allaire 2013).

4.3.4 Waterfowl and Trumpeter Swan (*Cygnus buccinators*)

Table 4-23: Waterfowl at a Glance

Waterfowl	
NWT Population Summary	
Conservation Status	All ranked as Secure or Sensitive in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Over harvesting, habitat loss
Health, Parasites, and Contaminants	Contaminant levels depend on the species and migration habits; however, waterfowl in the Dehcho are considered healthy and nutritious (Deh Cho First Nations ND)
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	Entire Phase 1 and 2 with higher densities assumed to occur from Phase 1 KP 62-86 and the entire length of Phase 2 (KP 86 to the Liard Highway)
Seasons of Use near the Access Road	Spring, summer, and fall
Key Habitats	Lakes, ponds, wetlands, rivers, streams, and oxbows
Existing Harvest Pressure	Low
Traditional Knowledge	
▪ No known reports	

In the NWT, flocks of various waterfowl species are frequently observed migrating each spring and summer. Many waterfowl species remain in the Dehcho region and likely along the all season access road route for the purposes of breeding. Some species may only use this area for spring and/or fall staging for a short period of time, before continuing on with their migration, and others may migrate through the area without staging.

Waterfowl select habitats that provide secure nest sites, and safe areas for rearing young and molting adults. Specific nesting habitat requirements vary with species, and can range from tree cavities, mats of vegetation in the water or at the water's edge, and the ground in wooded uplands. Waterfowl have a high fidelity to breeding sites, returning to the same nest site each year in the spring. Within the NWT and the Dehcho, waterfowl generally breed throughout the boreal forest at higher densities than mountain valleys. However, waterfowl can be expected to occur and breed wherever their habitat requirements are met. Consequently, they are expected throughout much of the low lying habitats along all season access road including productive shallow waters of

lakes, ponds, wetlands, rivers, and streams. Although low densities of waterfowl may be expected along Prairie, Sundog, and Funeral creeks (as well as other mountain streams), the Tetcela River and Fishtrap creek valleys (from Phase 1 KP 62-86 and Phase 2 KP 86-97), the wetlands west of the Nahanni Range (Phase 2 KP 103-123), the wetlands east of the Nahanni Range (Phase 2 KP 142-147), and the oxbows and streams from the Liard River to the Liard Highway (Phase 2 KP 156-158 and 161-184) are expected to support higher densities.

During spring and fall migration, waterfowl may occur in higher densities along the all season access road, where suitable habitat exists. The timing of the spring migration for the all season access road is unknown; however, it is assumed to begin by mid to late April and continue until the last week of May (EBA 2003; Latour 2003). Fall migration is more prolonged (ranging from late August and into October) as migrants gradually travel south and peak migration, as seen in the spring, is more relaxed.

Suitable staging habitat is likely restricted to the low elevation habitats along the Tetcela River valley, east of Nahanni Range, and near the Nahanni Access Road and Liard Highway since ice cover likely remains at the Prairie Creek Mine and Nahanni Plateau during spring migration.

Within the NNPR, Yohin and Rabbitkettle lakes are considered important waterfowl breeding habitats (Parks Canada et al. 2009). Yohin Lake, approximately 20 km southwest from the all season access road, supports a small nesting population of Trumpeter Swans (*Cygnus buccinators*). Rabbitkettle Lake, in the Ragged Range near the western edge of NNPR, supports several species of loons and grebes (Parks Canada et al. 2009).

Trumpeter Swans are considered Not At Risk (1996) in Canada and are ranked as Sensitive in the NWT. There are no known threats to their population in the NWT. Favorable habitat for both nesting and foraging includes freshwater marshes and large boreal ponds and lakes. Requirements for nesting habitat include approximately 100 m for take-off from the water, accessible forage, and low human disturbance (Mitchell and Michael 2010). Trumpeter swans that breed in the Greater Nahanni Ecosystem are part of the Rocky Mountain Population known to overwinter in the northwestern USA (Montana, Wyoming, and Idaho). Like many waterfowl species, swans are territorial on their breeding grounds.

In 2005, Trumpeter Swan surveys were conducted across the NNPR and Dehcho Region. In total 415 Trumpeter Swans were detected, including 37 broods (Beyersbergen 2007). During these surveys, Trumpeter Swans were observed throughout the survey area, with the highest concentrations being in the Tetcela River valley and at Yohin Lake (Beyersbergen 2007). During the June 2006 aerial survey along the all season access road, a “few swans” (not recorded to species, but assumed to be a Trumpeter Swan) were observed on ponds nearest to Phase 1 KP 64 (Mosquito Lake) and 75 (Golder 2010).

Threats to waterfowl include potential overhunting and habitat loss.

4.3.5 Raptors

Table 4-24: Raptors at a Glance

Raptors	
NWT Population Summary	
Conservation Status	All ranked as Secure or Sensitive in the NWT
Trend	Population trend unknown in NWT or Dehcho
Size	Population size unknown in NWT or Dehcho
Sensitivities and Threats	Disturbances during the breeding season
Health, Parasites, and Contaminants	No baseline conditions known

Table 4-24: Raptors at a Glance

Raptors	
Relationship with the Prairie Creek All Season Road	
Presence along the All Season Road	Entire Phase 1 and 2
Seasons of Use near the Access Road	All seasons
Key Habitats	All habitat types
Existing Harvest Pressure	None
Traditional Knowledge	
▪ No known reports	

Raptors are a diverse group of species with varying distributions, population densities, habitat requirements, and life histories. As predators, raptors can be expected to occur wherever their prey species occur, including birds, small mammals, young ungulates, and carrion. In a given area, raptor abundances may fluctuate in direct response to their primary prey's distribution and abundance.

Raptors have species-specific habitat requirements. Some raptors are breeding residents to the Prairie Creek Mine and its access road, whereas others may be present as a migrant or a year-round resident (e.g., Gyrfalcon [*Falco rusticolus*]). The distribution and abundance of overwintering raptors, such as Gyrfalcons, are dependent on locally abundant prey such as ptarmigan, grouse, and snowshoe hare.

Raptors can be expected to occur and nest near the entire all season access road route, wherever their habitat requirements are met. Suitable nest sites and food resources are the main factors that naturally limit breeding raptors in an area. Raptors exhibit nest site fidelity, returning to the same nest site each year whether this includes a nest in a tree, on a cliff, on the ground, or a nest previously constructed by another species. It is during the mating and incubation stages that raptors are most susceptible to human disturbances, and may desert a nest as a direct result of human activity.

A single known raptor nest, occupied by a Golden Eagle (*Aquila chrysaetos*) in 2010, was documented approximately 5 km southeast of the Prairie Creek Mine (ENR 2014a). Raptor nests within 1 km of the Prairie Creek Mine and its associated Project footprint are unknown.

Data within ENR's WIMS presents six raptor species nest within the region. Within the original boundaries of NNPR, three Bald Eagle (*Haliaeetus leucocephalus*) nests are known near Yohin Lake, and one Peregrine Falcon, four American Kestrel (*Falco sparverius*), one Red-tailed Hawk (*Buteo jamaicensis*), and one Northern Harrier (*Circus cyaneus*) nests have been documented along or near the South Nahanni River (ENR 2014a). A single Golden Eagle nest was also reported at the western portion of the NNPR (Parks Canada 1984). Peregrine Falcon is discussed in Section 4.2.10.

During the Prairie Creek Mine and access road field surveys, a single Gyrfalcon and several Golden Eagles were reported (Golder 2010). The only observation of a Gyrfalcon was in January near Funeral Creek, and five Golden Eagles were observed in March and July west of the Prairie Creek Mine, near the eastern most edge of the Nahanni Plateau, north of the Grainger Gap, and along the Silent Hills (Beak 1981). An eagle, not identified to species, was also observed in June 2006 (Golder 2010).

4.4 Vegetation

4.4.1 Objectives from the TOR

Consistent with the MVEIRB ToR for the all season road and associated infrastructure, this section serves to provide a description of the existing vegetation resources within the study area (within 50 m of the proposed development – as defined by the MVEIRB), including:

1. vegetation and vegetation assemblages;
2. any classification system followed, as appropriate ;
3. identification of species or assemblages that are rare, valued, protected or designated (e.g., vulnerable, threatened, endangered);
4. location and abundance of rare plants;
5. historic and current human use of vegetation, including subsistence and commercial harvesting, (e.g., berry picking, forestry);
6. existing baseline contaminant concentrations in harvested species or vegetation (e.g., berries) that may change as a result of the all season road and as available;
7. locations and quantities of merchantable timber;
8. listing and location(s) of existing invasive species; and
9. frequency of forest fires and post-fire vegetation succession.

4.4.2 Background Information Sources

The description of vegetation conditions in this report is based primarily on the most currently available Earth Observation for Sustainable Development of Forests (EOSD) vegetation classification descriptions and data, correlated to the extent feasible with the information reported in Golder (2010) and previous studies carried out for the Prairie Creek Mine site area and for the access road. These previous studies include the following:

- Preliminary Environmental Evaluation for Mine, Mill and Camp. May 1980. Report prepared for Cadillac Explorations Limited, Prairie Creek Project, NWT by Ker, Priestman & Associates Ltd., Victoria, BC.
- Preliminary Environmental Evaluation for Winter Access Road. May 1980. Report prepared for Cadillac Explorations Limited, Prairie Creek Project, NWT by Ker, Priestman & Associates Ltd., Victoria, BC.
- Environmental Evaluation for Cadillac Explorations Ltd. Prairie Creek Project, NWT. October 1980. Report prepared for Cadillac Explorations Limited by Ker, Priestman & Associates Ltd. Victoria, BC.
- Prairie Creek Project Vegetation & Wildlife Studies, 1981. Report prepared for Cadillac Explorations Ltd. September 198 by Beak Consultants Limited, Richmond, BC.
- Prairie Creek Project Vegetation and Wildlife Initial Evaluation. December 1994. Report prepared for Rescan Environmental Services Ltd. by Robertson Environmental Services.
- Rare Plant and Wildlife Survey, Prairie Creek Mine Area and Winter Road, NT. Report prepared for Canadian Zinc Corporation by EBA Engineering Consultants Ltd. (EBA). 2010.

- Vegetation and Wildlife Assessment Report, Prairie Creek Mine, Northwest Territories. Report prepared for Canadian Zinc Corporation by Golder Associates Ltd. (Golder). 2010.
- Reclamation assessment, invasive and rare plant survey 2010 Prairie Creek Mine access road, NT. Report prepared for Canadian Zinc Corporation by EBA Engineering Consultants Ltd. (EBA). 2011.
- EOSD Vegetation Classification (25m) data for the NWT. Accessed in November 2014 from http://www.enr.gov.nt.ca/programs/forest-resources/inventory-and-analysis.

4.4.3 Conditions Prior to Site Development

The study area is located primarily within the Taiga Cordillera and Taiga Plains Ecozones of the Northwest Territories and is characterized by several significant topographic features (e.g., Mackenzie Mountains, the Nahanni Ranges and the Liard floodplain) resulting in an array of growing conditions, and consequently, numerous vegetation species assemblages (Ecosystem Classification Group 2007). Wild fires occasionally occur in the region and have influenced forested ecosystems throughout much of the landscape. However, the Prairie Creek watershed had not been influenced by any form of human activity, apart from possible First Nations use such as trapping or hunting parties, prior to mineral exploration (Golder 2010).

Mineral exploration and associated infrastructure, including the existing winter access road has affected a small area of the land base of the Prairie Creek watershed and overall Project area, and apart from local influences, has not affected the physical nature or biological composition of natural plant associations or communities in this watershed or ecosystems adjacent to the existing winter access road.

4.4.4 Vegetation Cover Description

The vegetation units described and summarized below, represent vegetation cover types, based on predominant physical conditions and species composition (also referred to as vegetation or habitat “units”). As previously indicated, Tetra Tech EBA has used the most currently available EOSD vegetation classification descriptions and data and correlated these descriptions to the extent feasible with the information reported in Golder (2010), which was based on Robertson Environmental Service’s (RES) (1994) summary of the earliest studies conducted by Beak (1981, 1982). Relevant information on wildlife use of these habitat units is also provided, as noted during previous investigations of the project area (primarily from Beak [1981]).

4.4.4.1 Previously Mapped Vegetation Cover Units

Detailed vegetation cover mapping prepared as part of vegetation and wildlife studies conducted by Beak for the original 181 km winter access road in 1981 included the delineation of dominant vegetation associations through aerial photograph review and aerial surveys. Vegetation associations identified as part of these surveys were characterized in terms of dominant vegetation species during a field reconnaissance during the same time period. As mapping for the original winter access road was presented at a scale of 1:250,000, the naming convention used by Beak for each map unit reflects the dominant vegetation associations recorded for each unit; however, each map unit generally contains several associated sub-dominant community types, as described by Beak in the 1981 vegetation and wildlife report. Beak community classifications, and an additional community classification described by RES (1994) are described below, as presented in the vegetation and wildlife report prepared for the current winter access road (Golder 2010; pg 6-10).

Spruce/Lichen

This vegetation unit is distributed entirely within the Mackenzie Mountains, extending from the valley floor to the upper slope extensions of relatively stable colluvial slopes. This unit’s approximate elevation range is

975-1280 m above sea level (ASL). Its most conspicuous feature is the cream-coloured ground cover provided by a thick layer of lichen, primarily reindeer lichen (*Cladina stellaris*). Forest cover is variable, depending on aspect and topography, with the greatest tree densities in draws and on south, southwest, and west-facing slopes.

In the Funeral-Sundog Pass area, the spruce/lichen vegetation unit is more sparsely stocked in its tree cover than where it occurs in the Prairie Creek area; this is explained in part by the steep, narrow valley of the Funeral-Sundog Pass area, which influences thermal conditions, plus its greater extent of talus, and hence less total plant cover.

Subalpine Shrub

In the Mackenzie Mountains, this vegetation unit occupies a mid-elevation zone lying between the spruce lichen and alpine tundra vegetation units. Vegetation was sampled from two sites, one in the Prairie Creek drainage and the other in the Funeral-Sundog Pass drainages by Beak (1981). Both sites were characterized by a thin organic layer, a variable shrub cover (10 to 100%) dominated by dwarf birch (*Betula nana*), Labrador tea (*Ledum groenlandicum*), and willow (*Salix glauca*). Herb cover was limited (5-30%), but the ground cover was 60 to 100% and dominated by reindeer lichen at one site, and *Cetraria* and *Alectoria* lichens at the other site (Funeral-Sundog Pass area).

Alpine Tundra

This vegetation unit comprises a substantial area, and provides much of the characteristic features of the Mackenzie Mountains. It comprises all land above tree line, and thus was found to be highly variable in plant cover and type (Beak 1981). Characteristic vegetation, based on greatest coverage, was lichen (*Cetraria nivalis*), mountain-avens (*Dryas integrifolia*), heather (*Cassiope tetregona*), and creeping willow (*Salix nivalis*).

Pine Parkland

A small component of the pine parkland vegetation unit occurs within the Mackenzie Mountain portion of the Prairie Creek Mine site study area (Beak 1981). This unit occurs in a low elevation valley immediately north of the Second Canyon between 425 m and 750 m ASL. Pine parkland was characterized by low tree layer cover (8 to 15%) consisting of jack pine (*Pinus banksiana*), black spruce (*Picea mariana*), white spruce (*Picea glauca*), and willow (*Salix arbusculoides*). The shrub layer (coverage 5 to 45%) was dominated by dwarf birch and Scouler's willow (*Salix scouleriana*) while the herb layer (coverage 15 to 65%) was dominated by bunchberry (*Cornus canadensis*), lingonberry (*Vaccinium vitus-idaea*), and twinflower (*Linnaea borealis*). The ground cover almost complete (100%) with primarily red-stemmed feathermoss (*Pleurozium schreberi*) and *Cladonia* lichens. No vegetation sampling was conducted in this area (Beak 1981).

Black Spruce Parkland

This unit extends from the eastern base of the Mackenzie Mountain ramparts eastward to the eastern edge of the Ram Plateau. In terms of the access road, it starts at KP 32 and extends more or less continuously to KP 64. The elevation range of this vegetation unit is 793 to 915 m ASL (Beak 1981).

Tree cover varies from 5% to 30% and is comprised mostly of black spruce, with patches of white spruce on well drained south aspects. Trees support a rich corticous lichen cover of *Alectoria* and *Pannelia* species. The shrub layer (20 to 45% cover) is primarily composed of dwarf birch and willow (*Salix glauca*). Cover of the herb layer is also moderate (10 to 45%); major species are kinnikinnik (*Arctostaphylos uva-ursi*) along with Labrador tea and blueberry (*Vaccinium* spp.). Ground cover is 100%, and is composed primarily of reindeer lichen and red-stemmed feathermoss (Beak 1981).

Riparian Alluvial

The riparian alluvial unit is essentially sparsely vegetated alluvial streams and rivers of the Ram River system. The braided streams in this unit are relatively wide in places, and on some of the in-stream islands which survive for several years, there may be colonization by willow, mountain avens, and various grasses and sedges.

Mixed Coniferous/Deciduous

The mixed coniferous deciduous vegetation unit covers the low elevations of the Tetcela and Fishtrap Creek drainages from KP 64 to 110 where the access approaches Grainger Pass. This is a post-fire successional forest, estimated to have resulted from a burn occurring between 1940 and 1950. Two subtypes were identified:

- the Tetcela Valley; and
- the Silent Hills (Beak 1981).

The western slopes of the Silent Hills are well drained, and the tree cover estimated at 78%. Of this, 80% was deciduous, primarily trembling aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*), with the remainder (20%) white spruce (Beak 1981).

The Tetcela Valley transect was variable and included elements of black spruce parkland mixed with a dense mixed coniferous-deciduous forest. The vegetation succession appeared to be returning to black spruce parkland. In 1981, tree cover varied from 60 to 100%, and comprised birch, alder (*Alnus crispa*), and Scouler's willow with lesser amounts of black spruce and jack pine. Cover in the lower strata (shrub, herb, and moss layers) was considerably less than the tree cover (Beak 1981). The forest included a significant portion of black spruce snags.

Black Spruce Muskeg

This vegetation unit is distributed in lowland, waterlogged drainages which grade into open wetlands. It occurs in three areas:

- Fishtrap Creek, west of the Silent Hills within an elevation range of 244 to 305 m ASL;
- an eastern tributary of the Tetcela/Ram River system in the valley between the Silent Hills and the Nahanni Range at an elevation of approximately 490 m ASL, and;
- a lowland area west of the Grainger River near its mouth.

A representative habitat sampling site in 1981 was located in the Tetcela drainage and had predominantly shrubs (cover of 35 to 60%), comprised of black spruce and blueberry willow (*Salix myrtillifolia*), Labrador tea and dwarf birch (Beak 1981). Cover in the herb layer was 25 to 50% and comprised mostly of red bearberry (*Arctostaphylos rubra*), grass and Labrador tea. *Dicranum* moss and lichens provided a thick ground cover.

Burn

RES (1994) reported that since the Beak vegetation studies of 1981 and 1982, there had been two burns along the access road. The earliest was situated within black spruce parkland near KP 66, and appeared to be 5 to 10 years old (since 1981/82). No examination of regenerating vegetation was made at that time. The second burn took place in July and August of 1994 and is located immediately east of the Nahanni Range.

Grainger Tillplain

The Grainger tillplain unit is a rolling, drumlinized tillplain with little elevation range (approximately 460 to 670 m ASL) and an absence of forest cover (Beak 1981). The basic site types include depressions and drier meadows. The former are wet sedge meadows dominated by beaked sedge (*Carex rostrata)*. The drier meadows are composed of a shrub layer (80% cover) of dwarf birch, cinquefoil (*Potentilla fruticosa*), Labrador tea and sweet gale (*Myrica gale).* The herb layer is mostly comprised of sedges (*Carex* spp.), red bearberry, and horsetail (*Equisetum* spp.), and the ground cover is *Dicranum* moss. In other areas, there is a taller shrub community of alder, dwarf birch, and willow (*Salix planifolia*), or coniferous thickets of black spruce. RES reported that as of 1994, over 40% of this habitat type occurring along the access road had recently burned.

Floodplain/Tillplain

This is a heterogeneous unit comprising the following subunits: Grainger tillplain, lowland marsh, shrub, and mixed forest in three cover categories: <30%, 30 to 50%, and >50% (Beak 1982). Major tree species in this mosaic include trembling aspen, white spruce, black spruce, paper birch, jack pine and alder. The densest of the mixed forest communities, comprising more than 50% cover, is distributed along parts of the Grainger River (Beak 1982).

Aspen Liard Floodplain

This vegetation type borders the Liard River from KP 151 to 164.5, excluding the Liard River crossing itself. The climax tree species is white spruce, but frequent fires have led to a dis-climax of trembling aspen (Beak 1981). Within the aspen subunit, the canopy was estimated to reach a height of 20 m, with other understory trees between 12 m and 16 m. The shrub layer was predominantly alder and prickly rose (*Rosa acicularis*). There was limited ground cover (5%) owing to a thick layer of deciduous litter.

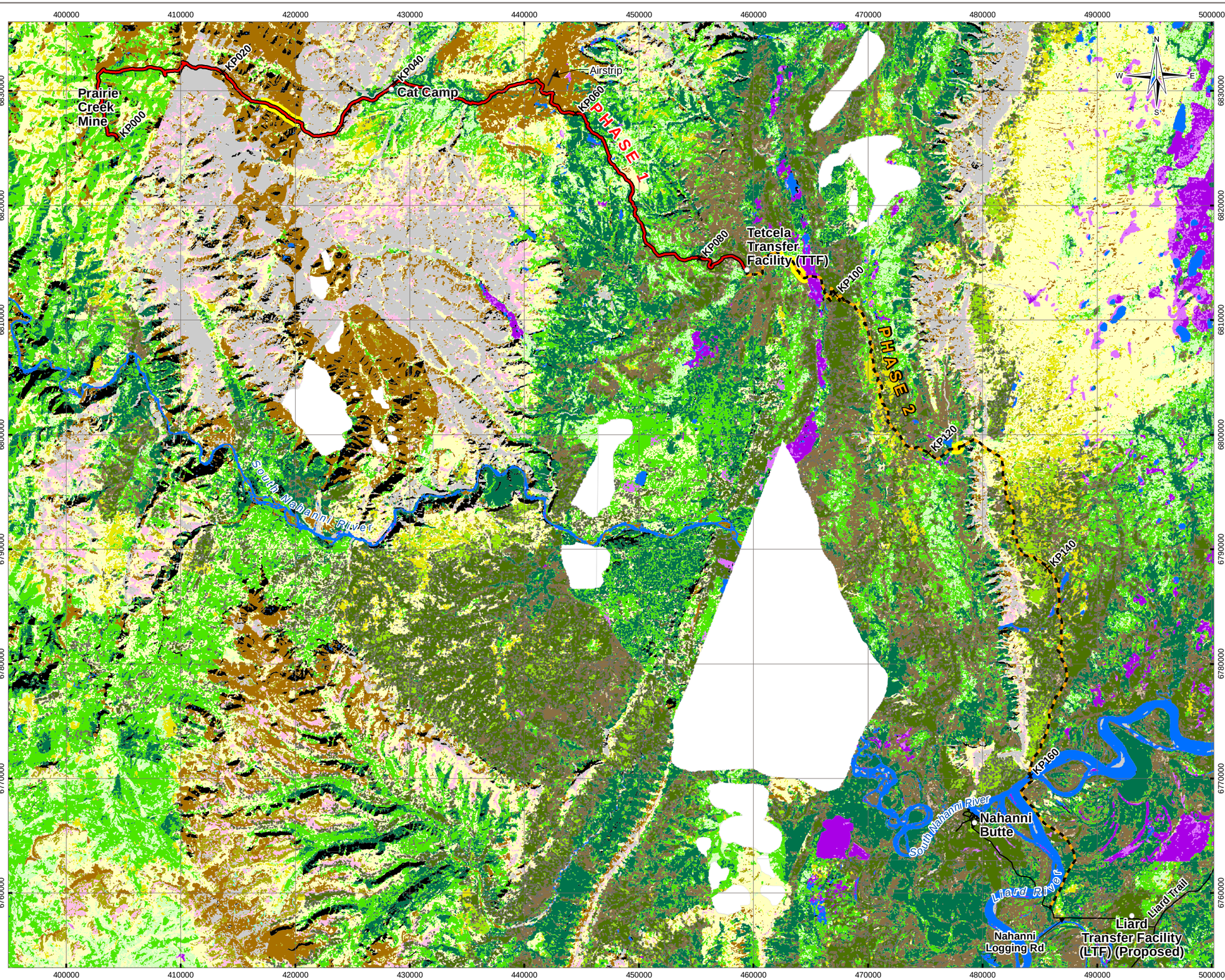
4.4.4.2 Current Earth Observation for Sustainable Development of Forests (EOSD) Cover Units

EOSD is land cover inventory for approximately 80% of the total land area in Canada, derived from Landsat satellite data and represents the highest spatial resolution satellite-derived map for land cover in Canada (25 metre resolution) (Government of Canada 2014). EOSD map units are represented by land cover classes which are categorized based on spectral differentiation of the land surface, including differentiation of vegetation community types based on dominant vegetation structural classes and density.

EOSD mapping of the study area is presented in Figure 2, and includes 20 potential EOSD land cover classes. Descriptions of EOSD land cover (Nelson and Wulder 2003; pg 14-15) classes are presented in Table 4-25.

Table 4-25: EOSD Land Cover Class Descriptions

Cover	Description
No Data	—
Shadow	—
Cloud	—
Snow/Ice Glacier/snow	—
Rock/Rubble	Bedrock, rubble, talus, blockfield, rubbley mine spoils, or lava beds.
Exposed Land	<5% vegetation. River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces.
Water	Lakes, reservoirs, rivers, streams, or salt water.
Shrub – Tall	At least 20% ground cover which is at least one-third shrub. Average shrub height > = to 2 m.
Shrub – Low	At least 20% ground cover which is at least one-third shrub. Average shrub height < 2 m.
Herb	Vascular plant without woody stem (grasses, crops, forbs, gramminoids). Minimum of 20% ground cover **or** one-third of total vegetation must be herb.
Bryoids	Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose, not crustose). Minimum of 20% ground cover **or** one-third of total vegetation must be a bryophyte or lichen
Wetland – Treed	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is trees.
Wetland – Shrub	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is low shrub.
Wetland – Herb	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is herb.
Coniferous – Dense	> 60% crown closure. Coniferous trees are 75% or more of total basal area.
Coniferous – Open	26-60% crown closure. Coniferous trees are 75% or more of total basal area.
Coniferous – Sparse	10-25% crown closure. Coniferous trees are 75% or more of total basal area.
Broadleaf – Dense	> 60% crown closure. Broadleaf trees are 75% or more of total basal area.
Broadleaf – Open	26-60% crown closure. Broadleaf trees are 75% or more of total basal area.
Broadleaf – Sparse	10-25% crown closure. Broadleaf trees are 75% or more of total basal area.
Mixed Wood – Dense	> 60% crown closure. Neither coniferous nor broadleaf trees account for 75% or more of total basal area.
Mixed Wood – Open	26-60% crown closure. Neither coniferous nor broadleaf trees account for 75% or more of total basal area.
Mixed Wood – Sparse	10-25% crown closure. Neither coniferous nor broadleaf trees account for 75% or more of total basal area.



LEGEND

Proposed All Season Road

- Phase 1
- Phase 2
- Existing Road
- Proposed All Season Road Realignment
- × All Season Road Kilometre Marker
- Proposed Airstrip

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 (Natural Resources Canada, accessed through geobase.ca)
Existing roads from CanVec (1:50,000)

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Land Cover Classification

PROJECTION UTM Zone 10	**DATUM** NAD83		**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:325,000 (5 2.5 0 5 Kilometres)			TETRA TECH EBA
FILE NO. MIN03058-01_002_Figure03_LC.mxd			
PROJECT NO. ENVMIN03058-01.002	**DWN** MEZ / **CKD** SL / **APVD** RH / **REV** 0		**Figure 3**
OFFICE Tt EBA-VANC	**DATE** February 20, 2015		

Q:\Vancouver\GIS\ENVIRONMENTAL\MIN\MIN03058-01\Maps\002\MIN03058-01_002_Figure03_LC.mxd modified 2/20/2015 by morgan.zondervan

4.4.4.3 Concordance of the Beak (1981) and EOSD Map Units

As the majority of the Beak (1981) map units were field verified, this dataset contains the most accurate characterization of vegetation community composition currently available for the proposed all season road study area. However, as a portion of the proposed all season road varies from the original (1981) winter road route, a portion of the proposed all season road is not encompassed by the Beak (1981) vegetation community mapping. Therefore, it is considered prudent to characterize vegetation communities for this portion of the proposed all season road using available data sets (EOSD) while maintaining the level of detail (with respect to floristic composition) provided by historic data sets (i.e., Beak 1981) to allow for an accurate assessment of potential project related effects to vegetation and other resources.

Concordance of the Beak (1981) and EOSD map units was determined (to the greatest extent feasible) by comparing the Beak community descriptions (Section 4.4.4.1) with the EOSD land cover class descriptions (Section 4.4.4.2) and identifying similarities between the two based primarily on the presence and relative percent cover of dominant structural layers. Available mapping of the two classification systems within the proposed development area were then cross-referenced to confirm agreement between the two classification systems.

As previously discussed, the naming convention used by Beak for each map unit reflects the dominant vegetation associations recorded for each unit; however, each map unit generally contains several associated sub-dominant community types. Therefore, multiple EOSD land cover classes may be applicable for a given map unit as described by Beak. Table 4-26 presents the applicable EOSD land cover classes that correspond to given Beak community descriptions. It should be noted that the map unit (Burn) described by RES (1994) is not included in this table as a detailed description of dominant structural layers is not available.

Table 4-26: Concordance of the Beak 1981 Community Mapping and EOSD Map Units

Map Unit	Dominant Vegetation Association(s) (Beak 1981)	Sub-dominant Vegetation Association(s) (Beak 1981)	Corresponding EOSD Classification(s)
Spruce – Lichen	Low density (7-8%) coniferous stands; lichen communities and exposed talus slopes	Low shrub communities	Exposed land; coniferous-open; bryoid
Subalpine Shrub	Low shrub communities	Exposed rock (talus and bolder); herbaceous communities; and bryophyte communities	Shrub-low; coniferous-open; exposed land; bryoid; rock/rubble
Alpine Tundra	Low shrub and herbaceous communities		Exposed land; rock/rubble; bryoid; shrub-low; herb
Pine Parkland	Low density jack pine stands (8-15% cover)	Depressional black spruce forest	Coniferous-sparse; coniferous-open; coniferous-dense; mixedwood-dense
Black Spruce Parkland	Low to medium density black spruce stands (5-30% cover)		Coniferous-sparse; coniferous-open; coniferous-dense
Riparian Alluvial	Shrub communities and deciduous stands (balsam poplar *Populus balsamifera*)		Shrub-low; shrub-tall; herb; broadleaf-open; broadleaf-dense

Table 4-26: Concordance of the Beak 1981 Community Mapping and EOSD Map Units

Map Unit	Dominant Vegetation Association(s) (Beak 1981)	Sub-dominant Vegetation Association(s) (Beak 1981)	Corresponding EOSD Classification(s)
Mixed Coniferous/Deciduous	Mixedwood stands of aspen, paper birch and white spruce	Low and high density coniferous forest (primarily black spruce with some pure jack pine stands); and tall shrub	Mixedwood-dense; mixedwood-open; coniferous-dense; coniferous-open; coniferous-sparse; shrub-tall
Black Spruce Muskeg	Black Spruce Bog		Wetland-treed; wetland-shrub
Grainger Tillplain	Sedge wetlands and low shrub communities	Tall shrub communities; deciduous stands (primarily balsam poplar); and low density coniferous stands	Wetland shrub; wetland herb; shrub-low; shrub-tall; broadleaf-open; broadleaf-dense; coniferous-open; coniferous-sparse
Floodplain/Tillplain	Co-dominant mixedwood stands of aspen and white spruce	Deciduous forest (aspen and paper birch; jack pine stands; black spruce muskeg; and shrub communities	Mixedwood-open; mixedwood-dense; broadleaf-open; broadleaf-dense; coniferous-open; coniferous-dense; wetland-treed; wetland-shrub; wetland-herb; shrub-low; shrub-tall
Aspen Liard Floodplain	Climax white spruce and early succession aspen stands	Low shrub communities (including waterlogged soils and bogs)	Coniferous-open; coniferous-dense; broadleaf-open; broadleaf-dense; shrub-low; shrub-tall; wetland-treed; wetland-shrub; herb

4.4.4.4 Mapped EOSD Vegetation Communities and Associated Vegetation Conditions

Available EOSD mapping was compared to the proposed route for the all season road to determine the expected vegetation communities present within the study area (i.e., 50 m buffer to both sides of the alignment), and the relative proportion of these communities within the study area. A total of 17 EOSD land class types were identified within the proposed all season road study area (all footprint components combined) (Table 4-27). Additional commentary describing existing vegetation conditions relative to the MVEIRB ToR is provided below.

Table 4-27: EOSD Land Class Types Present Within the All Season Access Road Study Area

EOSD Land Cover Class	EOSD Land Class Within the Phase I Study Area (ha) *	Percentage of the Phase I Study Area Encompassed by Cover Class (%)*	EOSD Land Class Within the Phase II Study Area (ha)*	Percentage of the Phase II Study Area Encompassed by Cover Class (%)*
Broadleaf-dense	34.4	4.0	315.6	35.4
Broadleaf-open	10.9	1.3	98.8	11.1
Bryoids	5.7	0.7	0.9	0.1
Coniferous-dense	86.2	10.1	96.6	10.8
Coniferous-open	193.1	22.6	57.0	6.4
Coniferous-sparse	31.1	3.6	7.0	0.8
Exposed land	210.2	24.6	0.0	0.0
Herb	0.3	0.0	3.2	0.4

Table 4-27: EOSD Land Class Types Present Within the All Season Access Road Study Area

EOSD Land Cover Class	EOSD Land Class Within the Phase I Study Area (ha) *	Percentage of the Phase I Study Area Encompassed by Cover Class (%)*	EOSD Land Class Within the Phase II Study Area (ha)*	Percentage of the Phase II Study Area Encompassed by Cover Class (%)*
Mixedwood-dense	50.2	5.9	156.9	17.6
Mixedwood-open	5.7	0.7	9.8	1.1
Rock/rubble	70.4	8.2	0.1	0.0
Shadow	14.2	1.7	0.1	0.0
Shrub-low	115.7	13.6	53.0	5.9
Shrub-tall	14.7	1.7	68.4	7.7
Water	9.8	1.1	6.4	0.7
Wetland-shrub	0.7	0.1	0.4	0.0
Wetland-treed	0.4	0.0	17.9	2.0
Total	**853.5**	**100.0**	**892.0**	**100.0**

*- Values rounded for reporting purposes

EOSD mapping of the study area indicates the presence of a variety of vegetation communities, which, based on the review of the corresponding Beak (1981) community descriptions, vary significantly in terms of vegetation species diversity and structural diversity. This variability can be attributed to the influence of numerous factors including elevation, topography, climatic variability, soil substrate, nutrient/moisture availability, and fire regime (amongst others).

Fire activity is strongly influenced by characteristics of the surrounding landscape including topography and fuel availability. Based on a study conducted by Bothwell et al. (2004), forest fuels in the regional context of the study area are predominantly described as low-density coniferous forests and non-fuel (wetlands, shrub lands and rock) forest cover types. This description is generally consistent with the EOSD mapping results tabulated above. Results of the Bothwell et al. (2004) study suggest that the fire behaviour in the region (e.g., Nahanni National Park Reserve) is influenced by fuel continuity, associated with mountainous terrain, and may explain a lower proportion of large (>200 ha) fires, relative to other areas examined as part of the study. The mean fire return interval calculated for the region was 28 years, while a fire cycle of 1,142 years was determined for fires greater than 200 hectares.

Given the differences in structural diversity and community composition associated with the vegetation community types determined through analysis of EOSD data and concordance with the Beak (1981) community descriptions, it is anticipated that vegetation community types present within the study area will vary substantially with respect to the availability and abundance of materials utilized by the local human community. Two of these potential uses, specified for assessment by the MVEIRB, include the potential use of the landscape for timber harvest activities and the potential use of the landscape for berry harvesting activities.

The Deh Cho Land Use Planning Committee commissioned a study of logging potential of commercially viable forests in the Deh Cho territory (PACTeam Canada 2003), which encompasses the all season road study area. The study was conducted using various metrics to assess logging potential, including the assessment of forest cover mapping to identify suitable stands for logging and the economic viability of conducting logging operations (e.g., access constraints). Based on the results of the study, the majority of the land encompassing Phase 1 of the all season access road study area is currently considered to have low to no potential for commercially viable forestry operations, while the area encompassing Phase 2 of the all season access road is considered to have high to very high potential for commercially viable forestry operations. A portion of this area, from Nahanni Butte to Nahanni National Park Reserve, was identified as being one of the most productive sites in the territory relative to the production of white spruce saw timber.

Based on the review of applicable literature (Cambell and Luckert 2012) it is recognized that berry harvesting represents an important food source for local First Nation communities and offers a substantial economic offset. Based on 1997 values, a per capita replacement cost of $201.14 was calculated for blueberries harvested by the Nahanni Butte community. The results of the Beak (1981) vegetation assessment for the original winter road alignment identified blueberry species (*Vaccinium* spp.), at varying levels of abundance, within several vegetation communities; generally characterized as forested. Based on lower productivity associated with higher elevation sites (e.g., reduced growing season, nutrient availability) it can be assumed that forested sites at lower elevations with the study area will generally provide the most productive sites with respect to blueberry production within the proposed all season road study area.

4.4.5 Plant Species At Risk

The Northwest Territories General Status Ranking Program is an evaluation of species status within the NWT. Species ranked as 'May be at Risk' or 'At Risk' are considered the highest priority for further assessment [Environment and Natural Resources (ENR) 2014a]. As part of the background research conducted to assess the presence of plant species at risk in proximity to the proposed all season access road, Tetra Tech requested occurrence data for vascular plant, bryophyte and lichen species (currently ranked as a species at risk in the NWT) which have been historically observed within a 50 km radius of the study area; recorded as part of the NWT ENR virtual herbarium database (ENR 2014g).

The results of the database search indicate that 16 vascular plants species, one lichen species and 13 bryophyte species currently ranked as 'may be at risk'; one vascular plant species ranked as 'sensitive' and one vascular plant species ranked as 'undetermined' by the NWT General Status Ranking Program have been historically identified within a 50 km radius of the CZN study area. A summary of the database search results, including the NWT General Status Rank, NatureServe global status rank (if applicable) (NatureServe 2014) and approximate recorded distance from the CZN study area boundary is provided in Table 4-28.

Table 4-28: Plant Species at Risk Historically Observed in Proximity to the Study Area

Common Name	Scientific Name	NWT Status[1]	Global Status[2]	Recorded Distance from CZN Study Area
Vascular Plants				
snow fleabane	*Erigeron nivalis*	May be at Risk		2 occurrences – greater than 42.6 km
Porsild's whitlow-grass	*Draba porsildii*	May be at Risk	G3G4	40.2 km
Beringian hairy potentilla	*Potentilla villosula*	May be at Risk	G4	23.4 km
Raup's willow	*Salix raupii*	May be at Risk	G2	24.9 km
velvetleaf blueberry	*Vaccinium myrtilloides*	Sensitive	G5	5.0 km
Canada violet	*Viola canadensis*	Undetermined	G5	6 occurrences – greater than 24.1 km
Nahanni aster	*Symphyotrichum nahanniense*	May be at Risk	G2	19.8 km
Mackenzie sedge	*Carex mackenziei*	May be at Risk	G4G5	20.0 km
Peck's sedge	*Carex peckii*	May be at Risk	G5	24.1 km
Smooth cliff-brake	*Pellaea glabella*	May be at Risk	G5	2 occurrences – greater than 34.8 km
Alaska parsley-fern	*Cryptogramma sitchensis*	May be at Risk	G4	26.2 km
Mingan moonwort	*Botrychium minganense*	May be at Risk	G4G5	29.6 km

Table 4-28: Plant Species at Risk Historically Observed in Proximity to the Study Area

Common Name	Scientific Name	NWT Status[1]	Global Status[2]	Recorded Distance from CZN Study Area
green spleenwort	*Asplenium trichomanes-ramosum*	May be at Risk	G5	48.0 km
Yukon fleabane	*Erigeron yukonensis*	May be at Risk	G2G4	34.8 km
white-flowered hawkweed	*Hieracium albiflorum*	May be at Risk	G4G5	28.4 km
seaside angelica	*Angelica lucida*	May be at Risk	G5	49.0 km
Loesel's twayblade	*Liparis loeselii*	May be at Risk	G5	2 occurrences – greater than 18.8 km
choke cherry	*Prunus virginiana*	May be at Risk	G5	4 occurrences – greater than 24.0 km
Lichens				
aboreal bottle-collection lichen	*Tholurna dissimilis*	May be at Risk	G4G5	48.1 km
Bryophytes				
bigspore arctic granite moss	*Andreaeobryum macrosporum*	May be at Risk	G2G3	5 occurrences – 18.5 km
twinkle mountain-moss	*Arctoa fulvella*	May be at Risk	G3G5	24.9 km
long-necked candlesnuffer	*Encalypta longicolla*	May be at Risk	G3	3 occurrences – greater than 17.0 km
blunt candlesnuffer	*Encalypta mutica*	May be at Risk	G3	3 occurrences – greater than 17.0 km
trim silk moss	*Entodon concinnus*	May be at Risk	G4G5	18.5 km
torque rock moss	*Grimmia torquata*	May be at Risk	G3G5	38.0 km
Mueller feather-moss	*Isopterygiopsis muelleriana*	May be at Risk	G5	38.0 km
alpine plagiobryum moss	*Plagiobryum demissum*	May be at Risk	G3G5	18.5 km
Zier's plagiobryum moss	*Plagiobryum zierii*	May be at Risk	G4G5	38.0 km
six-ranked haircap moss	*Polytrichum sexangulare*	May be at Risk	G4	2 occurrences – greater than 38.0 km
crisp rhabdoweisia moss	*Rhabdoweisia crispata*	May be at Risk	G5	38.0 km
polar limestone moss	*Seligeria polaris*	May be at Risk	G3G5	18.5 km
Velenovsky's hilpertia moss	*Tortula scotteri*	May be at Risk	G1	49.6 km

[1] NWT General Status Ranking (ENR 2014b)
[2] NatureServe global status ranking (NatureServe 2014)

Results of the ENR virtual herbarium search indicate that no vegetation species at risk occurrences have been historically recorded within five kilometres of the CZN study area (ENR 2014g). It should be noted that these results do not necessarily negate the potential presence of vegetation species at risk within the study area, but they do provide valuable insight with respect to the types of vegetation species which may require further consideration given their presence in the regional context of the study area. Of the species listed above, two species (Nahanni aster and Raup's willow) are currently considered globally imperiled (G2 global status ranking – NatureServe 2014) and one species (Velenovsky's hilpertia moss) is considered critically imperiled (G1 global

status ranking – NatureServe 2014). As such, further commentary with respect to these species has been provided in Sections 4.4.6, 4.4.7 and 4.4.8.

Rare plant surveys related to the Prairie Creek Mine Project and associated winter access road were initiated by EBA on behalf of CZN in July 2009 and further surveys were completed in August 2010 (EBA 2010; 2011).

In July 2009, rare plant surveys were conducted along the Prairie Creek Mine winter road; the proposed waste rock storage facility; and the area around camp and the beaver pond to the south.

A total of 340 plant observations, representing 193 species and 44 families of vascular plants, were documented during the 2009 field survey. No plants listed within the federal SARA were observed in the surveyed areas. However, one plant species, few flower meadow rue (*Thalictrum sparsiflorum*), listed as 'May Be At Risk' (ENR 2014b) was documented along the Prairie Creek winter road and an adjacent wetland.

Two additional plant species ranked as 'May Be At Risk' by the ENR were identified along the existing winter access road [Hornemann willowherb (*Epilobium hornemanni*) and linear-leaved willowherb (*Epilobium leptophyllum*)] have restricted distribution in the NWT with limited known occurrences, but are globally secure (Golder 2010). Six plant species ranked as 'Sensitive' by the ENR [alpine anemone (*Anemone drummondii*), bog birch (*Betula pumila*), lesser black-scaled sedge (*Carex atrosquama*), one-glume spike rush (*Eleocharis uniglumis*), alpine groundsel (*Packera pauciflora*) and yellow mountain heather (*Phyllodoce glanduliflora*)] identified adjacent to the Prairie Creek winter road have small regional distributions in the NWT with a small number of known occurrences, but are globally secure. It was concluded that impacts to these local occurrences (and potential additional occurrences near the access road) can be avoided or reduced by limiting the amount of additional land disturbance for upgrades and operation of the all access road.

In August 2010, the proposed Polje By-Pass re-alignment was surveyed for unique or important vegetation communities and rare plants. The habitat in which the proposed Polje By-Pass re-alignment traverses was burned by a forest fire in 1996. The vegetation community now comprises a jack pine regeneration stand approximately 14 years old. No rare plants or sensitive habitats were documented within the jack pine regeneration along the proposed Polje By-Pass alignment. It was concluded that this proposed re-alignment would not threaten rare plants or sensitive vegetation communities (EBA 2011).

4.4.6 Nahanni Aster (*Symphotrichum nahanniense*)

Nahanni aster is a perennial wildflower endemic to Canada and found only in the southern Mackenzie Mountains in the Nahanni National Park Reserve (COSEWIC 2014b). This species relies on specific habitat requirements and, as a result, the entire population of Nahanni aster is confined to six known sites, all of which are hot and warm springs with tufa (calcium carbonate deposits). The closest known site to the proposed CZN all season road occurs approximately 20 km from the proposed CZN all season road study area boundary.

Given the very small range, habitat specificity and population size of this species, it is considered susceptible to losses resulting from alterations to geothermal processes or landslide events. Nahanni aster is currently ranked as globally imperiled (G2) by NatureServe, special concern by COSEWIC and 'May Be At Risk' by ENR.

4.4.7 Raup's Willow (*Salix raupii*)

Raup's willow is currently considered globally imperiled (G2) by NatureServe and 'May Be At Risk' by ENR. This species has a very restricted range and is known from two sites in NWT, two sites in the Yukon, two sites in Alberta and three sites in British Columbia (ENR 2014h). The closest known occurrence of this species to the proposed CZN all season road occurs approximately 25 km from the proposed CZN all season road study area boundary.

This species is associated with a variety of habitats, including white spruce woodlands, trembling aspen woodlands, gravel floodplains, and black spruce treed bogs. Potential threats to the known occurrences of this species are not currently well understood; however, potential threats from development (specifically logging) have been identified as a potential concern to known populations of this species in Alberta (NatureServe 2014).

4.4.8 Velenovsky's Hilpertia Moss (*Tortula scotteri*)

Velenovsky's hilpertia moss is currently considered critically imperiled (G1) by NatureServe and 'May Be At Risk' by ENR. This species is known from two localities in NWT and British Columbia (ENR 2014h). The closest known occurrence of this species to the proposed CZN all season road occurs approximately 50 km from the proposed CZN all season road study area boundary.

Preferred habitat for this species includes exposed soil on high elevation slopes (NatureServe 2014).

5.0 EFFECTS ASSESSMENT – TRADITIONAL HARVESTING

This assessment of potential effects related to the upgrading of the current approved winter access road to an all season road addresses the traditionally harvested wildlife valued components for the Prairie Creek all season road construction, operation, and closure (activities summarized in Table 2-1). In accordance with the MVLWB and Parks Canada Land Use Permits and Water Licences, CZN is authorized to construct and operate a winter road that mostly follows the same route as the historical winter road constructed in 1981 and 1982. These authorizations permit the clearing of the winter access road, which will occur prior to the construction of this proposed all season road. As part of these authorizations, CZN concluded Impact Benefits Agreement negotiations with the NDDB and LKFN, and potential impacts on harvesting was one of the issues discussed. The all season road will generally follow the cleared winter access route, except in three locations that traverse wet areas that are conducive for winter road operations and an area of steep talus scree (Figure 2):

- 4 km section in Phase 1 (approximately from KP 24.5-28.5) (rerouted to avoid steep talus scree);
- 4 km section in Phase 2 (approximately from KP 90.5-94.5) (rerouted to avoid wet area); and
- 1 km section in Phase 2 (approximately from KP 122.5-123.5) (rerouted to avoid wet area).

Additional Project-related clearing, construction, and operations are required for the proposed airstrip and associated access road infrastructure, including 49 proposed borrow sources and their access roads.

The Project effects assessment focuses on important harvestable species. In this regard, information was drawn from the results of CZN's discussion with Leon Konisenta, an elder from the Nahanni Dehe Dene Band (NDDB) on January 27, 2010. Information on historical traditional harvesting and harvesting areas is contained in the confidential section of the Traditional Knowledge Assessment Report Addendum by Crosscurrent Associates Ltd. (August 2009).

For the purposes of this report, two sources of information were available from which to determine the important harvest species and harvest areas that were reviewed and are summarized in Section 5.1:

1. Mr. Konisenta provided information that is considered representative of important harvest areas and harvestable species; and
2. CZN DAR (CZN 2010), with the approval of the NDDB, provided suitable non-confidential information selected from the Traditional Knowledge Assessment Report Addendum.

The TOR outlines the geographical scope of any potential effects to harvesting at a 50 km minimum along the all season access road; however, a broader spatial scope was considered for select species.

The temporal scope of the effects assessment includes activities during the construction, operation, and closure phases, and those potentially posing the greatest adverse effects. Times when selected harvested species are most sensitive to human disturbances and the duration of potential effects with relation to the operational life of the access road are also considered. Table 5-1 summarizes the selected species for the assessment of traditional harvesting, the geographical and temporal scopes, and the rationale for selection.

Table 5-1: Summary of Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Inclusion into the Assessment and Geographic and Temporal Scopes
Boreal Caribou	Dehcho-South region*	Winter project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ Although potentially occurring near the all season road year round, Boreal Caribou are hunted opportunistically, mostly in the winter. Across the entire Dehcho region, an estimated 100-150 Boreal Caribou are harvested a year, thereby contributing to a very low component of the subsistence needs. ▪ Listed as Threatened under the NWT (2014) and federal (2003) SARAs. ▪ Total of 25 km of Phase 2 (KP 125-Nahanni Access Road) occurs along the edge of known range. Uncertainty exists whether Boreal Caribou also infrequently occur in the Tetecla River and Fishtrap Creek area. ▪ The winter season is a sensitive period of time for Boreal Caribou. Winter construction and operation of the access road previously assessed in Golder (2010).
Northern Mountain Caribou	Nahanni Complex summer range Moose Horn River subherd winter range	Summer Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ Based on their remoteness, they are currently harvested opportunistically by members of the Naha Dehe Dene Band (harvest records unknown). ▪ On average, 159 harvested a year by non-residents in the Mackenzie Mountain outfitter zones, and harvest levels are slowly increasing. ▪ Listed as Special Concern under SARA (2005) but assessed as Secure under the NWT. ▪ All season access road and airstrip are located outside known herd ranges; however, a few caribou have been observed in the Mackenzie Mountains mainly in the summer (late May-early September). ▪ Caribou predicted to most likely occur in elevated terrain within the Mackenzie Mountains near the Mine site, the lower Sundog Creek drainage, west of the Ram Plateau near the proposed airstrip, and the Silent Hills during the non-winter period. ▪ The all season access road is located outside their calving ranges.

Table 5-1: Summary of Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Inclusion into the Assessment and Geographic and Temporal Scopes
Moose	Outfitter zones	Fall and winter Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ Main harvested species by members of the Naha Dehe Dene Band. ▪ Second most popular harvest species targeted by non-residents hunting inside the Mackenzie Mountain outfitter zones, and harvest levels increasing. Known harvest levels from Mackenzie Mountain outfitters. ▪ Predominantly occur in the eastern half of Phase 1 (and airstrip) and all of Phase 2 access road development. ▪ Individual Moose remain year round within their relatively small home ranges ▪ Most sensitive to disturbances in the winter. ▪ Subsistence harvests occur predominantly in the fall.
Dall's Sheep	Outfitter zones	Project components, year round Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ Once harvested by members of the Naha Dehe Dene Band. General license holders harvest 20-30 Dall's Sheep a year from the entire Mackenzie Mountains, thereby contributing to a very low component of the subsistence needs. ▪ The most favoured target species for non-resident harvesters in the Mackenzie Mountain outfitter zones. Average annual harvest of 197 rams, and harvest levels increasing. Known harvest levels from Mackenzie Mountain outfitters. ▪ Trophy Dall's Sheep hunts from July 15 to October 31. ▪ Potential lambing areas located within 1 km of Phase 1 KP 2, 3, and 7. Similarly, the Nahanni Range and Ram Plateau provide suitable lambing areas. ▪ Most sensitive to disturbances on their winter ranges, in the eastern fringe of Nahanni Plateau and Nahanni Range north of the access road.
Wolverine	Within 50 km of the Project	Winter and early spring Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ An important furbearer for members of the Naha Dehe Dene Band, and may be trapped from late October to May. ▪ None harvested by non-resident hunters in the Mackenzie Mountain outfitter zones since 1991. ▪ Assessed as Special Concern by COSEWIC (2003) and ranked as Sensitive in the NWT. ▪ Present along the entire (all of Phase 1 and Phase 2) access road and airstrip year round. ▪ Most sensitive to disturbances in the winter when access to food resources are restricted and females with kits are occupying natal dens.

Table 5-1: Summary of Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Inclusion into the Assessment and Geographic and Temporal Scopes
Grey Wolf	Within 50 km of the project	Winter and spring Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ An important furbearer for members of the Naha Dehe Dene Band, and may be trapped from late October to May. ▪ Occasionally hunted by non-residents in the Mackenzie Mountain outfitter zones. Average annual harvest of 15, and harvest levels increasing. ▪ Present along the entire (all of Phase 1 and Phase 2) access road year round. ▪ Generally tolerant of human land-use developments and their activities, but most sensitive in the winter when access to food resources are restricted, and in the spring (May) when denning.
Beaver	Within 50 km of the Project	Late fall, winter, and spring Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ An important furbearer for members of the Naha Dehe Dene Band, and may be trapped during early winter and late spring seasons. ▪ Present year round from Phase 1 KP 64-86 and Phase 2 KP 86-Liard Highway. ▪ Most sensitive to water level changes, particularly in the fall and winter.
Marten	Within 50 km of the Project	Winter and spring Project components Entire life of the access road (road closure beings 6 years after Mine closure (approx. 2036), after which time access will be eliminated)	▪ An important furbearer for members of the Naha Dehe Dene Band, and may be trapped from late October to May. ▪ Present year round from approximately Phase 1 KP 64-86 and Phase 2 KP 86-Liard Highway. ▪ Generally tolerant of human land-use developments and their activities, but most sensitive if the den is disturbed when denning (March or April).

* As described in the Boreal Caribou Species Status Report (Species At Risk Committee 2012) the Dehcho-South Boreal Caribou study area extends south from the Mackenzie River and into British Columbia. This study area does not represent a separate population, but rather an achievable area to effectively study a species occurring at low densities across much of the boreal forest zone of the NWT.

Species not included in this effects assessment, but harvested for subsistence or economics, are generally not susceptible to human disturbances, unlikely to interact with the all season access road in sufficient numbers, are largely covered by the assessment of the selected species, or their populations are considered regionally abundant.

The Mackenzie Valley Review Board (MVEIRB) Terms of Reference (TOR) (dated September 12, 2014) identified the following key objectives to describe and evaluate potential effects of the all season access road on caribou, moose, sheep, furbearers, and fish[1] and other traditional harvesting (EA1415-01):

- Sensitive or important harvesting areas of habitat both inside and outside the Nahanni National Park Reserve;
- Direct and indirect alteration of habitat including all season road footprint impact;
- Sensory disturbance and predicted changes in behaviour (including habitat avoidance and effective habitat loss in relation to all season road facilities or activities), energetics, health, and condition;
- Wildlife movement patterns, home ranges, distribution, and abundance;
- Wildlife mortality due to harvesting and vehicle collisions;
- Disruption of sensitive life stages or habitat (e.g., migration, calving, denning, overwintering);
- Effect to population cycles;
- Effects to predator-prey relationships;
- Increased human-wildlife interactions;
- Contaminant levels in harvested species that could be impacted by the all season road;
- Changes in access, including increased access to the land and surrounding waters, as well as increased access to environmentally and culturally sensitive areas;
- Changes in hunting and fishing pressures from people who do not reside in the region, and how road-related changes in harvest pressures could impact the resource;
- Changes in the abundance and distribution of harvested resources, including caribou, moose, sheep, and other wildlife (e.g., furbearers, waterfowl) that would adversely affect harvesting;
- Distribution of harvest patterns, or loss or alteration of high-value harvest areas including:
  - Changes to harvest effort as perceived by harvesters;
  - Changes in harvester travel patterns;
  - Changes in harvest levels;
  - Changes in harvesters' costs; and
  - Changes in seasonal harvesting patterns.

[1] A fish assessment was not part of Tetra Tech EBA's scope of work.

- Competition among harvesters within and between communities as a result of increased access and loss or alteration to the land resulting from the project;
- Changes in the quality of harvested species (including contamination) that would adversely affect their consumption;
- Measures to avoid or minimize changes in the abundance, distribution, or quality of harvested species, or mitigate the consequences of such changes;
- Mechanisms to control project workforce-related hunting, fishing, or disturbance of wildlife;
- Other traditional harvesting activities such as for berries or medicinal plants; and
- Mechanisms of resource management agencies and other parties to manage hunting and fishing by:
  - Resident hunters and fishers;
  - Non-resident hunters and fishers; and
  - Aboriginal harvesters.

5.1 Current Knowledge on Harvested Wildlife and Harvesting Areas

The following is an excerpt from the DAR (CZN 2010) outlining the information from the Traditional Knowledge Assessment Report Addendum and Mr. Konisenta regarding harvested wildlife and important harvesting areas:

Mr. Konisenta information:

- Caribou: Traditional harvesting used to include caribou, particularly in the early 1960s. Some animals were harvested in the Second Gap area. However, no caribou have been harvested for approximately 20 years;
- Moose: Harvesting of moose used to be common. Harvesting occurred near Nahanni Butte, around the Swan Point area (along the Liard River, approximately 6 km downstream from the proposed Liard River crossing) and along the Liard Highway. In the fall, members would also travel up the South Nahanni River to the 'flats' to hunt moose. Harvested numbers were plentiful, numbering 25-30 animals in some years. Members did not need to travel too far to find moose, and could use the available access routes. Moose numbers have dwindled, and Moose are now rarely found along the easy access routes. Mr. Konisenta attributes this partly to the introduction of bison to the area;
- Dall's Sheep: Members used to harvest a few Dall's sheep annually from the Nahanni Range in proximity to the village. None are harvested now; and
- Furbearers: Trapping used to be very common in the Liard River lowlands, and west of the Nahanni Range to the Wolverine Pass area. Animals trapped included Lynx, Mink, Marten, Wolverine, Fox, Beaver, and River Otter. In 1978, about 600 Marten were caught. However, there has been no trapping for six years because of a combination of fewer animals, lower pelt prices, and rising costs (fuel for skidoos). Trapping was also common in the Yohin Lake, lower Fishtrap Creek and Netla River areas. Trapped animals were mainly Marten, Beaver, and Muskrat. Between 30 and 50 animals were trapped in good years. This trapping has also dwindled, but still occurs periodically because of the easier access.

Traditional Knowledge Assessment Report Addendum:

- Lower portion of the South Nahanni River valley: is a rich ecological area, well utilized for harvesting, and an area of high traditional occupancy. River travel allowed access from late spring, after break-up, through to the fall.

- Deadman Valley: located at the confluence with Prairie Creek and the South Nahanni River (at least 25 km from the all season access road). High traditional use area for hunting Moose and Dall's Sheep. The sheep licks (mineral licks), near the confluence, are hunted, particularly in the fall. From here, people also travelled up Prairie Creek to set trap lines.

- First Canyon: located approximately 14 km downstream from the Prairie Creek-South Nahanni River confluence. Most hunting is carried out while travelling up the river, keeping an eye on the lower edges of the valley for sheep.

- Lower South Nahanni River and surrounding wetlands (referred to as the Splits): High quantity of traditional place names indicating high use within living and recent generations. There is an abundance of harvested species (e.g., Moose, Beaver, and Dall's Sheep) here, as well as tributaries providing access to additional critical harvesting areas to the north and south, including Yohin Lake and Fishtrap Creek.

- Tetcela River, Fishtrap Creek, and Bluefish Creek valleys: Although documented use of traditional harvesting and traditional trails throughout the region, and likely along the entire all season access road (as overland travel was common), these wetland valleys received the heaviest traditional use. A settlement was once located at Fishtrap Creek, and harvesting occurred throughout the area including winter trapping for Beaver, Cross-fox, Lynx, Marten, Mink, Wolverine, Grey Wolf, Woodchuck, Squirrel, Weasel, and Ermine, and spring harvesting of migratory birds as well as Beaver. Moose were also harvested, as they were known to overwinter in this valley area. The plateau areas were specifically used during the winter months as key travel corridors to the north towards the North Nahanni River, Cli Lake, and the pass through the Nahanni Range to Little Doctor Lake, and as a trap line for Beaver, Lynx, Marten, Muskrat, Grey Wolf, Wolverine, Cross-fox (i.e., Red Fox), and Mink.

- Nahanni Range: prime harvesting area for Dall's Sheep, likely due to the presence in the area of a sheep lick. Sheep are seen all along the high country and at Second Gap, particularly in the summer. In the spring, they calve in the area. The sheep stay on top of the mountains during the winter where snow is absent.

- Grainger River watershed from Nahanni Range Second Gap to the Liard River (lower portion of the all season access road): the area is relatively flat and dominated by wetlands and mixed forest cover. A known mineral lick occurs here (Moose lick hill). This area is particularly good habitat for beaver and for woodland caribou, which are known to be in the area at different times of the year, particularly along the lower levels of the Nahanni Range in the spring time. It appears that the caribou move down into the lowlands for the winter, where moose are also found. This area is known for extensive traditional use of the lowland area between the Nahanni Range and Liard River, particularly for trapping and big game harvesting purposes, most of which would occur during the winter. Along with Woodland Caribou, Moose, and Dall's Sheep, the furbearers traditionally harvested in this area include Beaver, Lynx, Marten, Muskrat, Grey Wolf, Wolverine, Cross-fox, Mink, and Weasel. Spring hunting expeditions also occurred into the area.

At present, little harvesting, including hunting and trapping activities, occur proximal to the all season access road due to restricted access. Harvesting areas near the all season access road are assumed to be principally associated with the Liard and South Nahanni rivers, as well as the Liard Highway that provide access to immediately adjacent lands.

Based on fixed kernel analysis of these lifetime harvest sites, Boreal Caribou are harvested primarily near the communities including a small harvesting area north of the Liard River near Nahanni Butte and the southern portion of the proposed all season access road (Gunn et al. 2004).

In 1984, Parks Canada reported hunting across the southern Mackenzie Mountains have been minimal to non-existent, and concluded that the hunting pressure inside the NNPR boundaries was very low and did not pose any adverse effects to wildlife populations. Harvesting inside the original boundaries of the NNPR were reportedly "minimal to non-existent", with hunters accessing the park along the South Nahanni River (Parks Canada 1984). Inside the NNPR boundary, year round hunting and trapping activities were concentrated along the eastern most boundary closest to Nahanni Butte and into Yohin Lake, seldom occurring beyond the entrance to the First Canyon (approximately 14 km downstream from the Prairie Creek-South Nahanni River confluence) (Parks Canada 1984). However, Parks Canada wardens reported occasional summer hunting and trapping excursions further into NNPR as far as Virginia Falls, and Dall's Sheep were occasionally harvested from the Prairie Creek mineral licks (at the confluence with the South Nahanni River) (Parks Canada 1984).

There are historical trap lines near the all season access road at Grainger Gap. A NDDB member (R. Vital) has a cabin on the west side of the Gap. The next nearest trap line is to the south of the Liard Highway in the Arrowhead Hills (pers. comm. Steve Gooderham November 24, 2014). Local area trapping and subsistence harvest data are unknown.

5.2 Effects to Harvesting and Harvesting Areas

The alignment of the Prairie Creek all season road will generally follow the winter access road alignment, which was modified to address concerns from the Naha Dehe Dene Band about wildlife issues and from Parks Canada regarding re-routing around the unique polje karst features. The permitted winter road (and likewise this proposed all season access road), was re-routed from the original 1980's winter access road to avoid environmentally and culturally sensitive areas identified through consultations.

Current harvesting is restricted in the area of the proposed all season access road, with the winter access road allowing for winter access only. During the EA for the new winter road, the Naha Dehe Dene Band considered the potential impacts on their harvesting activities in the areas in and around the seasonal access road. They are of the opinion that the winter road has the potential to improve their harvesting activities because of the improved access. This is the greatest impediment to their harvesting at present. Although traditionally important, little harvesting, including hunting and trapping activities, is assumed to occur at present any distance beyond the Liard and South Nahanni rivers. Harvested species and general harvest levels are assumed based on information provided by Mr. Konisenta and the Traditional Knowledge Assessment Report Addendum.

Boreal Caribou subsistence hunts and furbearer trapping occur primarily in the winter. The existing winter access road provides access to suitable furbearer and Boreal Caribou range; therefore, the all season access road is considered to provide little additional benefit to winter harvest and trapping activities in terms of facilitation of traditional harvesting. With the development of the proposed all season access road, year round access will allow harvesting of other species that have previously been limited (e.g., Northern Mountain Caribou, Moose, Dall's Sheep). However, this must be counter-balanced by the concern that improved access will encourage hunting by non-residents, considered in the next section.

With the addition of the proposed all season access road, harvesters could access the surrounding area on a year round basis, providing an economic and cultural value to the members of the Naha Dehe Dene Band until closure of the access road (Table 5-2). The Naha Dehe Dene Band were also directly involved in the re-alignment of the road to avoid areas they consider sensitive to wildlife. Therefore, mitigation has effectively been applied to limit impacts to specific sensitive and existing harvesting areas. No further mitigation is recommended.

Table 5-2: Project Effects on Predicted Harvesting and Harvesting Areas

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Positive	Low	Moderate	Moderate	Moderate	Moderate	High
Northern Mountain Caribou	Both	Positive	High	Moderate	Moderate	Moderate	Moderate	Moderate
Moose	Both	Positive	High	Moderate	Moderate	Moderate	Moderate	High
Dall's Sheep	Both	Positive	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Wolverine	Both	Positive	Low	Moderate	Moderate	Moderate	Moderate	High
Grey Wolf	Both	Positive	Low	Moderate	Moderate	Moderate	Moderate	High
Beaver	Both	Positive	Low	Moderate	Moderate	Moderate	Moderate	High
Marten	Both	Positive	Low	Moderate	Moderate	Moderate	Moderate	High
Overall Significance								
Moderate								

Confidence in this assessment is moderate since local harvesting areas, harvesting and trapping levels, and propensity to harvest "less preferred" species (e.g., Dall's Sheep) are assumed and the winter road will provide better winter hunting and trapping access. The measurable parameter for effects to harvesting and harvesting areas is qualitative based on the belief of members of the Naha Dehe Dene Band that the road supports local harvesting and access to harvesting areas.

Based on the predicted overall positive effects predicted, the all season access road is not predicted to impede the harvest or change sensitive and existing harvesting areas. Positive residual effects are anticipated.

5.3 Effects on Wildlife from Harvesting Pressure

Current levels of harvesting (includes both trapping and hunting) along the all season access road is very low, as access restricts use. Areas adjacent to the Liard and South Nahanni rivers that are accessible by boat in the summer and snowmobile in the winter are likely utilized. Although the South Nahanni River allows access into the NNPR, the reported harvest levels inside the park are low. The permitted winter road currently permits winter access from the Nahanni Access Road to the Prairie Creek Mine.

Within the original boundaries of the NNPR, non-resident hunters are not permitted to hunt; only those holding a NWT General Hunting Licence (primarily Aboriginal subsistence harvesters) are allowed (Larter and Allaire 2013). The expanded park boundary now encompasses 80% of Phase 1 and 42% of Phase 2 of all season access road, as well as portions of two outfitting zones (the Nahanni Butte D/OT/02 and South Nahanni D/OT/01) that are in operation for non-resident hunters.

The Nahanni Butte D/OT/02 and South Nahanni D/OT/01 outfitting zones cover much of the Mackenzie Mountains found within the Dehcho, and the proposed all season access road is located within both. Portions of the all season access road including the majority of Phase 1 and Phase 2 KP 86-142 (extending 40 km outside of the NNPR boundary) are within an outfitting zone. Although now mostly part of the NNPR, non-resident hunters continue to be allowed to hunt within these outfitting zones until their current outfitting permits with Parks Canada terminate in 2019. With the termination of the outfitting zones in 2019, no wildlife harvesting by non-resident hunters will be allowed across the entire NNPR. Outside the NNPR boundary, non-resident hunter harvests will continue to be permitted along a 40 km section of the all season access road (Phase 2 KP 102-142) that lies inside outfitting zone D/OT/02.

Hunter harvest reports from all Mackenzie Mountain outfitting zones (total of six other outfitting zones besides the Nahanni Butte and South Nahanni) have been reported from 1991 to 2012. During this time, an average of 366 outfitter non-resident hunting licenses have been sold for the Mackenzie Mountains per year (Larter and Allaire 2013). These non-residents have reported harvesting six species: Dall's Sheep, Northern Mountain Caribou, Moose, Mountain Goat, Grey Wolf, and Black Bear. Of these species, Dall's Sheep and Northern Mountain Caribou were most commonly harvested (averaging 197 and 159, respectively per year), followed by Moose (averaging 56 per year), Grey Wolf (averaging 15 per year), and Mountain Goat (averaging 9 per year, primarily from the Nahanni Butte and South Nahanni zones), and Black Bear (averaging less than 1 per year) (Larter and Allaire 2013).

With outfitting permits with Parks Canada terminating in 2019, non-resident harvests along approximately 100 km of the all season access road and at the proposed airstrip will be completely eliminated. Non-resident harvests will be constrained within a 40 km section of the all season road, where the D/OT/02 outfitting zone extends outside the NNPR boundary. Mountain Goat, Dall's Sheep and Moose would be likely targets by non-resident guided hunters, and to a much lesser extent Grey Wolf and Wolverine. NDDB elders (R. Vital, J.M. Konisenta) say Mountain Goats have not been seen north of the village and Dall's sheep are scarce also. Of the target species by non-residents, currently Moose are the only important subsistence harvest species.

Non-residents are permitted to harvest Dall's Sheep from 15 July to 31 October and Moose from 1 September to 31 October. These harvest periods coincide with those of the subsistence harvests.

In combination with subsistence harvests, non-resident hunter harvesting within this 40 km section of all season access road places moderate to high levels of harvesting pressure on Moose and Dall's Sheep. Moose are considered the primary subsistence harvest species, and non-resident hunter harvests of Moose are increasing. Dall's Sheep and Mountain Goat are less favoured subsistence species (assumption based on the reported 20-30 Dall's Sheep harvested annually from the entire Mackenzie Mountains and no reported Mountain Goat harvests). Dall's Sheep and Mountain Goats along this section of access road (Nahanni Range) may be particularly sensitive to overharvest due to their isolation from larger populations; however, subsistence harvest of Dall's Sheep and Mountain Goats are considered negligible.

CZN is in the process of engaging with the Naha Dehe Dene Band and government regarding control of the use of the access road. CZN commits to use means available to control road use with the assistance of the Naha Dehe Dene Band and to monitor un-authorized use of the road as primary mitigation. A Controlled Road Use Plan was approved for use of the winter access road; however, this will need to be upgraded for Mine operations and all season access to incorporate safety and security, communications, road use monitoring, and wildlife response and reporting. CZN believes this is important for safety reasons, and to minimize the potential for harvesting pressures on wildlife.

CZN's intent is to work with the Naha Dehe Dene Band to discourage use of the full access road by non-residents. When the road is open, the un-authorized road use will pose safety risks. CZN will be able to impose rules for its employees and contractors (e.g., no hunting or straying off the access road alignment) but does not have jurisdiction to impose rules on others. Parks Canada regulations for NNPR stipulate that "existing roads in NNPR are restricted access only and are not open to the public for motorized use", with exceptions for Aboriginal people pursuing their traditional harvesting rights (Parks Canada 2013), resulting in the exclusion of non-Project related and non-Aboriginal travel along approximately 51% of the all season access road.

Direct engagement with the proprietors of the Nahanni Butte D/OT/02 outfitting zone regarding access to the Nahanni Range portion of their outfitting zone (outside the NNPR boundary) and hunting agreements along and near the access road may be required. This includes total harvests from this portion of their outfitting zone.

The key issue is control of access by non-resident hunters. CZN previously committed to the operation of a security check-point where the winter road leaves the Nahanni Access Road. CZN will commit to the operation of the check-point year–round for the all season road. CZN will also engage with the NDDB regarding the most efficient location of the check-point outside of the winter period. The concern is that hunters could access the road via the Liard River, thus avoiding the check-point if it is located at the Nahanni Access Road. It may be more effective to locate the check-point on the north-west side of the Liard River and some distance from the river. The check-point would deter access, but access could not be legally denied.

CZN would operate a barge on the river for truck traffic, and this barge would be private, so would not be available to non-residents. However, this would not prevent non-residents from using their own boats. As a benefit to NDDB members, CZN could consider barge use by NDDB members, and even consider barge transits to the village from the crossing location which would facilitate road use by residents and/or access to the Liard Highway.

Besides the elimination of non-resident guided hunts inside NNPR boundaries, Parks Canada regulations restricting public use of roads (except Aboriginal people pursing traditional harvesting) inside the park, and CZN's security check-point and barge control near the beginning of the road, there are two other possibilities that may deter use of the road by non-residents:

- a no shooting corridor similar to that operating on the Ingraham Trail which prevents shooting within 1 km off the road alignment. The corridor is primarily for safety, but should be equally effective in deterring non-resident hunters who would have to travel more than 1 km off-road to hunt. CZN is exploring the adoption of a corridor with the GNWT, and has had initial engagement with the NDDB and LKFN on the matter. The NDDB have not yet taken a position, while the LKFN are supportive.

- Dehcho land claims discussions are on-going. A conclusion of these discussions could enable the area of the road to be designated private, which would allow the road to be gated and un-authorized access could be legally denied. This is the situation for the access road to Fortune Mineral's Nico Mine in the Tlicho Region. This would be the best outcome for the Prairie Creek road in terms of controlling non-resident hunting, but the timetable of land claims discussions is uncertain.

CZN is continuing to investigate the above two possibilities because they would provide additional mitigation. Therefore, the predicted effect on harvesting pressure with operation of the proposed all season access road is dependent on the magnitude of mitigation applied. As a base, we can assume that: 1) non-resident harvests will cease in the NNPR by 2019; 2) resident harvests outside the expanded boundaries of NNPR will increase; 3) non-resident harvests outside the NNPR will occur without either of the two additional mitigation possibilities noted above; and 4) subsistence harvest levels of Moose will increase and somewhat increase for Dall's Sheep from current levels, but the overall harvest in the region will decrease after 2019. The predicted effects of this base case are summarized in Table 5.3. If the two additional mitigation possibilities are also adopted, the predicted effects on Dall's sheep for Phase 2 and on Moose reduces to low, and the overall significance is low.

Table 5-3: Project Effects on Predicted Harvesting Pressure

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Moderate	High	Low	Moderate	High
Northern Mountain Caribou	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Moose	Both	Adverse	Moderate	Moderate	High	High	Moderate	Moderate
Dall's Sheep	Phase 1	Positive	Moderate	Moderate	High	Moderate	High	Moderate
Dall's Sheep	Phase 2	Adverse	Moderate	Moderate	High	Moderate	Moderate	Moderate
Wolverine	Both	Adverse	Low	Moderate	High	Low	Moderate	High
Grey Wolf	Both	Adverse	Low	Moderate	High	Low	Moderate	High
Beaver	Both	Adverse	Low	Moderate	High	Low	Moderate	High
Marten	Both	Adverse	Low	Moderate	High	Low	Moderate	High
Overall Significance								
Low								

Confidence in this assessment is moderate since the existing and future subsistence harvest levels of Moose and Dall's Sheep by members of the Naha Dehe Dene Band are unknown. In addition, the effects assessment assumes non-resident harvests will cease in the NNPR in 2019, thereby, eliminating all existing non-resident harvests throughout much of the all season road.

The measurable parameters for harvesting pressure are the total number of hunters and trappers reported accessing the all season road (at the control gate as part of the Access Control Plan or otherwise) a year, and the belief of the Naha Dehe Dene Band members whether the all season access road supports unacceptable hunting pressure on harvest species.

Based on the predicted adverse effects from harvest pressure and the current distribution of harvesting, without additional mitigation (e.g., 1 km no-shooting corridor, private road through the Dehcho Land Claim process), the all season access road is likely to result in a low level of residual effects to Moose and Dall's Sheep. These road-related changes in harvest pressures could affect subsistence and economic wildlife resources. With the application of either additional mitigation steps discussed, no residual effects are predicted.

5.4 Effects of Direct Habitat Loss on Harvested Wildlife

The approved winter road will be used during the Mine start-up phase and early operations, at least 2 years prior to the construction of an all season road. With the alignment of the all season access road essentially the same as the winter road alignment, only an additional 9 km (approximately 18 ha) of road will be been cleared to allow for the all season road, as well as 45.34 ha for the borrow sources and their access roads, and 7.62 ha for the proposed airstrip (total 70.96 ha). A total of 9 km of new alignments from the winter road route are required to bypass boggy or wet areas that are conducive for winter road operations, but need to be avoided, to the extent possible, by the proposed all season road alignment, and to avoid most of the steep talus in upper Sundog Creek.

Effects associated with clearing the road route and winter operations of the access road (including temporary camps and bulk fuel areas) have been permitted for the life of the Prairie Creek Mine. Therefore, the remaining Project-related effects are assessed for clearing 70.96 ha of total harvested wildlife habitat for the construction of the all season access road and airstrip (Table 5-4).

The alignment of the Prairie Creek winter access road was modified from the early 1980's alignment to address concerns from the Naha Dehe Dene Band about wetland/wildlife issues, and from Parks Canada regarding re-routing around the unique polje karst features. In addition, the approved winter road was re-aligned to upland habitat on the east side the Nahanni Range to avoid bisecting Woodland Caribou and Moose habitat.

The additional footprint for the all season access road and airstrip consist of direct loss of habitat potentially occupied occasionally by the assessed species. This direct loss of habitat will occur during construction and is reversible after closure.

Although a few Northern Mountain Caribou have been observed near the all season access road, primarily in the summer, the proposed access road and airstrip lie outside their defined annual range and are not considered important habitat for the local herds. Of the additional footprints proposed within Northern Mountain Caribou habitat (e.g., Nahanni Plateau), beyond the approved winter road, an additional 4 km of road (realigned to avoid steep talus scree) and six preferred borrow sources are proposed; totalling approximately 10 ha.

Similar to Northern Mountain Caribou, direct habitat loss within Dall's Sheep range is limited to the Phase 1 development phase KP 0-32, where 4 km of the access road is realigned to avoid steep talus scree and four borrow sources are proposed. In addition, a 1 km road section and two preferred borrows through the Nahanni Range (Phase 2 KP 122.5-123.5) are proposed; however, the Nahanni Range portions of the Project traverse through lower habitat at least 500 m in elevation below the Dall's Sheep habitat. Dall's Sheep habitat in the Ram Plateau is not part of the proposed all season access road route or airstrip (nearest approximately 4 km distance).

The airstrip, a 4 km road realignment (Phase 2 KP 90.5-94.5), and the majority of the preferred borrow sources proposed are located within the boreal forest zone east of the Mackenzie Mountains to the west of the Nahanni Range. This habitat is potentially suitable for Moose, Wolverine, Grey Wolf, and Marten.

No additional clearing is required within Boreal Caribou habitat east of the Nahanni Range, except for four preferred borrow sources and a 1.5 km borrow source road (total 15.41 ha) located in upland habitat at the edge of Boreal Caribou range.

The proposed all season access road and airstrip also avoid wetlands and ponds, as much as possible, thus inherently minimizing direct effects to Beaver habitat. However, water resources may be required during the construction and operation phases of the all season access road (e.g., dust suppression), but the water sources approved for winter road construction are lakes, and the volumes approved for extraction are less than 10% of lake volume. The same sources would be used for the all season road. Beavers are sensitive to water level changes, especially in the fall and winter when they are storing and using cached food, and overwintering in lodges. Significant changes to water levels in Beaver-occupied ponds may cause abandonment.

In the design of the approved winter road, the NBDB were directly involved in plans to re-align the road to avoid areas they consider sensitive to wildlife, such as wetlands. Similarly, borrow source locations for construction of the all season road were deliberately selected inside or immediately neighbouring the road right-of-way, as much as possible. Temporary camps and transfer facilities will be located inside borrow disturbance areas, whenever possible. Therefore, mitigation has effectively been applied in the design stages to limit impacts, including direct and indirect habitat loss, disturbance to wildlife, and mortality. No further mitigation is recommended due to the re-vegetation potential upon closure.

Table 5-4: Project Effects on Predicted Harvest Species Habitat Loss

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Low	High	Low	Moderate	Moderate
Northern Mountain Caribou	Both	Adverse	Low	Low	Moderate	Low	Moderate	Moderate
Moose	Both	Adverse	Low	Low	Moderate	Low	Moderate	High
Dall's Sheep	Both	Adverse	Low	Low	Moderate	Low	Moderate	High
Wolverine	Both	Adverse	Low	Low	Moderate	Low	Moderate	High
Grey Wolf	Both	Adverse	Low	Low	Moderate	Low	Moderate	High
Marten	Both	Adverse	Low	Low	Moderate	Low	Moderate	High
Beaver	Both	Adverse	Low	Low	Moderate	Low	Moderate	Moderate
Overall Significance								
Low								

Confidence in this assessment is high since the amount of habitat directly lost is relatively low compared to the winter road, and the proportion of habitat types (or land cover class) disturbed by the Project will not exceed 20% of their total area within 100 m of the road corridor (Section 7.3.1). The measurable parameter for direct habitat loss is total footprint of the all season access road and its facilities that deviate from the approved winter road and associated facilities.

Project related effects to wildlife habitat loss is reversible following decommissioning and reclamation of disturbances. No residual effects are anticipated from the direct habitat loss.

5.5 Effects from Project-Related Wildlife Disturbances

Indirect consequences of Project-related disturbances can occur as a result of road, airstrip, and borrow source construction, operation/extraction, and closure. These indirect consequences may be in the form of avoidance of the disturbance area and surrounding habitat (i.e., functional habitat loss due to the road itself, traffic, dust), as well as altered movements (e.g., habituation and attraction), and energetics when interacting with the road, borrow source, and/or airstrip.

Avoidance

Scientific evidence suggests avoidance behaviour of land use developments is dependent on the frequency and type of human activity, visual and noise disturbances, and season. Site infrastructure (e.g., storage sheds, forklift, small crew at the TTF, electrical power generator) required for the operation of the proposed Phase 1 all season access road and the TTF remains similar to that already permitted for use of the Prairie Creek Mine winter road, except for the season of use. With the arrival of concentrate trucks, forklifts will be used to load and unload concentrate bags inside the storage sheds. Similarly, noise levels will remain the same as winter operations; estimated at approximately 99 decibels (dBA), which is similar to a highway transport truck (Golder 2010). At 0.5 km from the road, this noise level (99 dBA) is expected to reduce to 35 dBA (Golder 2010) (the level between normal speech and a whisper). Noise disturbances from the operation of the all season road differ from the winter road in temporal extent, not noise level.

With the proposed all season road, there will be a reduction in daily traffic volumes during winter operations and general site activity compared to the winter road. The Prairie Creek winter road daily traffic volume (from late November to early April) will be approximately 37 vehicles, round trip, per day.

To compare, during winter operations, the proposed all season access road Phase 1 development will include approximately six trucks making two round trips per day (total 12 vehicles, round trip, per day) (as well as year round). Therefore, the Phase 1 all season road development will significantly reduce the number of daily vehicle-wildlife interactions over the winter as a direct result of minimizing the number of trips. This is particularly important considering the winter period is a time when many wildlife species are most sensitive to disturbances.

With the development of Phase 2, 16 trucks will make a single return trip daily (total of 16 vehicles, round trip, per day or approximately 1 concentrate truck every 0.75 hours), winter and summer. This traffic volume is still considerably less than the existing Prairie Creek Mine daily winter road volumes; however, traffic volumes proposed are extended throughout the year.

Studies have indicated traffic volumes at 15 vehicles per hour (equivalent to 90 trucks, round trip, per day) affected Boreal Caribou behaviour in Newfoundland and Alaska (Anderson et. al 2002). Although there has been no studies regarding Boreal Caribou responses to low traffic roads in the NWT, the proposed traffic volumes for the Phase 1 and 2 developments (including both scenarios) are below traffic volumes that have been known to induce adverse behavioral responses in Boreal Caribou elsewhere. In contrast, studies indicate Grizzly Bears cross low traffic volume roads and do not avoid high quality habitats nearby (COSEWIC 2012a; Chruszcz et al. 2003). However, because Grizzly Bears are more likely to cross low volume roads, mortality as a result of vehicle collisions may be greater (Chruszcz et al. 2003). This is mitigated to some degree by maintaining slow traffic speeds.

Northern Mountain Caribou were found to avoid habitat within 2 km of high use roads (defined as paved or winter plowed roads) and within 1 km of low use roads (defined as dirt or gravel roads) in northern British Columbia; however, the associated traffic volumes weren't considered (Polfus et al. 2011).

The use of the Prairie Creek Mine access road by non-mine related traffic (e.g., snowmobiles, all-terrain vehicles) will be controlled to the extent possible using a check-point. As such, the potential for disturbance associated with this use can be minimized. As well, speed limits will be enforced for safety and to minimize dust. Dust accumulation along gravel roads may reduce habitat quality. The majority of the large dust particles released from the construction, operation, and closure phases of the all season road are anticipated to settle out about 10 m from its source. However, dust deposition may extend up to 100 m away from the all season access road, potentially along the alpine tundra portions of Phase 1, depending on site conditions (e.g., wind) and particle size characteristics.

The construction phase of the all season access road and airstrip is expected to generate the greatest degree of disruption, at least temporarily; however this disruption will be localized to the sites of construction and will decline into the operations phase. Overall, the daily level of visual and noise disturbances from the proposed all season access road is likely reduced from levels predicted during winter road use.

Altered Movements

Wildlife may change their movement patterns and behaviour in association with the all season access road, its associated facilities, and the airstrip, as well as its traffic, embankment characteristics, and/or plowed snow banks. Any changes in their movements are related to their sensitivity to disturbances and human-activities, as well as the level of disturbance. However, wildlife sensitivity to human-related disturbances and activities vary depending on a number of factors including the species, individual, season, and past experiences. Some species

may be wary of the all season access road (and its activities or snow banks) and hurriedly cross or deflect from crossing at that particular location. Other species may utilize the roadway as a travel corridor and habituate to human activities. For example, Boreal Woodland caribou cross low traffic roads (and other linear features, such as the existing winter road and cutlines) year round; however, cows are less likely to cross with young calves. Therefore, the all season access road itself may alter the movements of Boreal Caribou cows with calves until the route is suitably re-vegetated.

Other species, such as Red Fox, Moose, Black Bear, and Grey Wolf are likely to travel along the access road corridor. Marten are also relatively tolerant to human disturbances and activities; but tend not to cross open areas (natural or man-made) that are 200 m wide or more (Salmo Consulting Inc. et al. 2004) (wider than the proposed access road and its facilities, and airstrip).

Moose are also considered relatively tolerant to human disturbances (Salmo Consulting Inc. et al. 2004), although they may still be affected by the visual and noise disturbances from vehicle traffic and unacceptably high snow banks. Available evidence suggests moose may avoid linear features and other land use developments by 100 to 500 m depending on the season, sex, surrounding habitat, especially if hunted (Salmo Consulting Inc. et al. 2004). Moose encountering vehicles travelling on the all season road or air traffic may show minor displacement behaviour and temporarily avoid the immediate area.

In contrast, Dall's Sheep are commonly observed at and near the Prairie Creek Mine and its associated activity sites in the summer. Dall's Sheep near Phase 1 of the all season access road may be habituated to Project-related disturbances.

Traffic on the all season access road may also encounter harvest species at or travelling to mineral licks known to occur within 11 kilometres of the Mine site, Phase 1 KP 10, Phase 2 KP 151, 156, 157, the Nahanni Access Road, and along the Liard Highway. Moose (and their predators) are main users of the mineral licks along Phase 2, Nahanni Access Road, and Liard Highway. Dall's Sheep (and their predators) on the Nahanni Range may use the known mineral licks nearest to Phase 2 KP 151-157, as well as near the Mine site and Phase 1 KP 10. Dall's Sheep, particularly ewe groups (with lambs and yearlings) commonly utilize mineral licks from June to early October; during this time, they are known to habituate to human activities (e.g., consistently observed at the Prairie Creek Mine site).

Several harvest species may also become attracted to the all season access road and its facilities. Attraction to foods and other materials stored at the facilities could occur if proper handling and storage procedures are not followed. Of the selected harvest species, Wolverine, Grey Wolf, and Marten have the potential to become attracted to the access road and its facilities to gain access to food, shelter, and security (e.g., from predators, insects).

Project-related disturbances leading to avoidance and altered movements during construction, operation, and closure may have energetic consequences and, if severe in magnitude and frequency (species dependent) (Anderson et al. 2002), may lead to individual health declines and possibly population declines. Anderson et al. (2002) summarized the results of studies completed on caribou near moderate and low traffic roads. Barren-ground Caribou responded to moderate traffic volumes (defined as 15 vehicles per hour) in northern Alaska by moving faster and for a farther distance than their responses to low traffic volumes (defined as less than 1 vehicle per hour; similar to the proposed all season access road traffic volume) (Anderson et al. 2002).

Based on the available information, a small number of individual harvest animals may be expected to be present in the vicinity of the all season access road and associated infrastructure year round, and may potentially directly encounter or be disturbed by localized road and airstrip-related noise or activities. Considering the existing

indirect habitat potentially lost as a result of the existing Prairie Creek Mine winter road and its activities, the proposed all season access road is not believed to noticeably amplify these adverse effects.

To mitigate project-related wildlife disturbances, measures in effect for the winter road will be maintained throughout construction, operation, and closure of the all season road, including:

- Strict use of CZN's Controlled Road Use Plan and Waste Management Plan to minimize traffic and other disturbances, maintain low speed limits, as well as to limit wildlife attractants;
- Reporting and evaluating wildlife sightings along the access road, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered;
- Snow removal practices along the access road and airstrip to manage high snow banks, so that wildlife can readily move off as vehicles approach and aircraft flyover; and
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so, particularly when in convoy) for all wildlife seen on or immediately adjacent to the road, giving wildlife the opportunity to move off.

All general mitigation measures proposed are summarized in Section 5.10.

The predicted effect of Project-related disturbances on harvestable wildlife, after mitigation is applied, is summarized in Table 5-5.

Table 5-5: Project Effects on Predicted Project-Related Disturbances

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Moderate	High	High	Moderate	High
Northern Mountain Caribou	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Moose	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Dall's Sheep	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Wolverine	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Grey Wolf	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Marten	Both	Adverse	Low	Moderate	Moderate	High	Moderate	High
Beaver	Both	Adverse	Low	Moderate	Moderate	High	Moderate	Moderate
Overall Significance								
Low								

Confidence in this assessment is moderate since traffic volumes along the all season access road are considered low (and below sensitive species known thresholds), but the sensitivity of harvested species to development-related activities differs with a number of factors (e.g., species, season, individual, project activity). The measurable parameter for Project-related disturbances is the number of direct human encounters with dangerous wildlife, number of reports of possible wildlife attraction and habituation to the Project, and overall Project and non-Project related traffic.

Based on the predicted overall low adverse effects predicted and the current distribution of harvesting, indirect habitat loss as a result of the all season access road and airstrip are not anticipated to adversely affect current

harvesting areas and effort. With adherence to mitigation, there are no residual effects anticipated that will adversely alter current harvesting.

5.6 Risks to Harvested Wildlife from Non-Harvest Mortality

The assessment of non-traditional mortality includes vehicle collisions, increased human interactions, and defense of life/property kills. It does not include mortality as a direct result of traditional subsistence harvest and non-resident hunter harvests.

Although the risk of collisions are low, all assessed wildlife species have the potential to encounter vehicle and air traffic as well as equipment operating at the TTF during Phase 1, year round throughout the entire length of the Project. The risk to each species differs depending on their inherent behaviours, abundance along the access road and airstrip, and seasonal use of the surrounding area. During winter operations, bears will be hibernating and Northern Mountain Caribou will have primarily migrated out of the area; therefore, they are not likely to interact with the Project during this time.

Throughout the year, some species may be more reluctant to remain on the roadway and airstrip for any length of time, rather opting to quickly cross (e.g., Boreal Caribou cow with calf) and other species may selectively occupy the roadway/airstrip for travel and securing food. For example, Black Bears may be attracted to the low traffic access road, particularly in the spring when plant emergence may be earlier than in the forest, thereby increasing their risk of vehicle collisions. Similarly, bears and Wolves may use the access road to travel, putting themselves at greater risk of mortality.

Wildlife can also be reluctant to move off the roadway/airstrip or become trapped in the winter if snow banks are built up too high, although year round, the all season access road and airstrip will have low traffic volumes. Traffic during construction, operation, and closure phases pose a low risk to wildlife. Across the NWT, vehicle collisions do not pose a major threat to Boreal Caribou (Species at Risk Committee 2012). Only “very small numbers” of accidental mortality from vehicle collisions have been reported across NWT to date (Species at Risk Committee 2012). The risk of wildlife-vehicle collisions is low due to suitably slow speed limits and low traffic volumes on the road.

Wood Bison are commonly a problem along the NWT highways, often causing significant damage to vehicles and risk to human and bison themselves. Wood Bison may be encountered along the southern portion of Phase 2 of the all season access road near the Liard River, along the Nahanni Access Road, and along the Liard Highway.

Potential attraction and habituation of bears, Grey Wolf, and Wolverine to food waste, human garbage, and sewage sludge is of particular concern since this can lead to an increase of human-wildlife encounters, risk to people, and associated wildlife relocation or mortality. As outlined in the CZN (2010) DAR, individuals that are attracted to the Project and become habituated can become highly problematic for industrial camps; the mortality risk for these individuals is higher. Across the north, existing mines and camps have successfully managed wildlife attractants with monitoring and modifications as required.

Mortality of furbearers may occur during clearing activities that occur in the winter denning and natal seasons. Accidental mortality at the den sites (hibernation and natal dens) is associated with clearing activities (construction phase only); however, an encounter with dens (hibernation and natal dens) while constructing the 9 km of all season road, borrow sources, and airstrip is considered rare. Since the all season access road and borrow sources are proposed to follow or closely follow the winter road route, few animals are believed to be denning in the area.

Once the roadway is cleared, the construction of the roadbed and operation of the access road may also affect Beavers. The construction of the roadbed has the potential to alter surface water drainage, thereby altering

downstream Beaver habitat. In addition, pumping from local water sources may be required periodically during the construction and operation phases for compaction and dust suppression. Beavers are sensitive to water level changes, especially in the fall and winter. Significant changes to water levels in Beaver-occupied ponds may lead to higher risk of predation if Beavers are forced to abandon the pond or direct mortality if significant water volumes are removed in the winter.

To mitigate to risk of mortality, measures that were previously proposed for the winter access road (and TTF) will be followed (CZN 2010; Golder 2010), including, but not limited to:

- Food and food wastes and other putrescible matter will be incinerated on a daily basis and always stored in a manner inaccessible to furbearers to reduce the risk of attraction and habituation to the access road, its facilities, and the airstrip;
- Strict use of CZN's Controlled Road Use Plan and Waste Management Plan to minimize non-Project related traffic and other disturbances, as well as to limit wildlife attractants;
- Reporting and evaluating wildlife sightings along the access road, airstrip, and at the TTF (especially Black Bear, Grey Wolf, and Wolverine), and if an attractant is identified, corrective management options for waste management will be considered;
- Snow removal practices along the access road and airstrip to manage high snow banks, so that wildlife can readily move off as vehicles/air traffic approach;
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so, particularly when in convoy) for all wildlife seen on or immediately adjacent to the road, to give them time to move away.
- Develop standard aircraft procedures for flying into and departing from the proposed airstrip to accommodate wildlife, if present on or near the airstrip;
- Maintain a minimum flight altitude of 600 m during all times, except during take-off and landings;
- Bear awareness (and other dangerous species) program to ensure employees and contractors are aware and informed of the risk level on Project entry for the first time and on a regular basis;
- Similar to the Prairie Creek Mine site, a structure for reporting human-dangerous wildlife encounters at the TTF and resulting incidents to inform Mine management and ENR staff;
- A protocol for dealing with problem wildlife, with a designated chain of responsibilities for ensuring worker safety and efficient and speedy resolution of incidents;
- Annual reporting of bear observations, movements, incidents, and how incidents were resolved;
- No significant changes in water levels permitted and/or adhering to the DFO Water Withdrawal Protocol if pumping water from a known Beaver pond in the fall and winter periods; and,
- Design and construct the all season access road with suitable culvert placement and sizes to maintain natural drainage patterns.

All general mitigation measures proposed are summarized in Section 5.10.

The predicted effect of Project-related mortality on harvestable wildlife, after mitigation is applied, is summarized in Table 5-6.

Table 5-6: Project Effects on Predicted Non-Harvest Mortality

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Low	Moderate	Low	Low	High
Northern Mountain Caribou	Both	Adverse	Low	Low	Moderate	Low	Low	High
Moose	Both	Adverse	Low	Low	Moderate	Low	Low	High
Dall's Sheep	Both	Adverse	Low	Low	Moderate	High	Low	High
Wolverine	Both	Adverse	Low	Low	Moderate	Low	Low	High
Grey Wolf	Both	Adverse	Low	Low	Moderate	Low	Low	High
Marten	Both	Adverse	Low	Low	Moderate	Low	Low	High
Beaver	Both	Adverse	Low	Low	Moderate	Low	Low	High
Overall Significance								
Low								

Confidence in this assessment is high since Project-related traffic volumes are low and below sensitive species known thresholds throughout the life of the all season road, the access control plan is expected to minimize non-Project related traffic, and applicable policies and plans will manage wildlife attractants and travel across the road. The measurable parameter for Project-related mortality is the total number of wildlife-vehicle collisions and defense of life and property kills a year.

Based on the predicted overall low mortality effects predicted and the current distribution of harvesting, mortality from non-harvesting related access road effects is not anticipated to adversely affect current harvesting areas and harvest species abundance. With adherence to mitigation, there are no residual effects anticipated that will adversely alter current harvesting.

5.7 Effects on Contaminant Levels in Harvested Wildlife

For the effects assessment of the construction, operations, and closure of the Prairie Creek Mine winter access road, CZN (2010) identified mineral concentrates and diesel fuel as the primary sources of potential wildlife effects in the event of a release. Special deliveries will also be required for consumables such as explosives and mill reagents. In the event of a release to the environment, a few resident animals may be affected if they ingest plants, soils, or water potentially affected with these products. While being transported along the access road from the Mine, concentrates will be bagged securely and handled carefully to minimize the risk of rupture or spillage. Given the high value of the concentrate, great care will be taken in transport, handling, and storage procedures as necessary.

In the previous EA, CZN advised that their intention is to ensure the bags of concentrate are clean on the outside after filling and during storage and transport. Transport trucks will similarly be clean by not entering the storage shed directly, and driving through a wheel-wash before leaving site. Truck boxes will have sides and a tail-gate, and the tops will be covered by tarpaulin for secondary containment of any dust. As part of the draft Contaminant Loading Management Plan, CZN also committed to sampling the soils of the road bed in a number of locations, both before and during haul operations. The intent is to confirm that no significant concentrate dust is being emitted. Since these measures would be continued for all season road operations, we believe they represent a suitably high level of mitigation to avoid effects due to contaminant levels. CZN may also use a bulk concentrate

transport method, consisting of a container with a sealed lid. This containerized approach is expected to be no worse than bags in terms of potential concentrate releases.

In the proposed Phase 1 development, the TTF will become the main concentrate storage location. The existing concentrate storage shed at the Mine may be moved to the TTF, and additional storage sheds are proposed to add to the existing infrastructure at the TTF (or existing sheds will be removed and replaced with a larger structure). Concentrates will be stored at the TTF inside these dry storage sheds until the following winter road operation window or until Phase 2 (all season access road from the TTF to the Nahanni Access Road) is constructed the following year.

During the winter operation period, fuel will be back-hauled into the Mine directly and there will be no need for temporary storage at the TTF. Diesel fuel, other hydrocarbons, mill process chemicals, and other potential mine-related and other supplies will be delivered to the Mine in industry standard tanks, containers or consumer packages. However, a truck fueling station with a 10,000 litre storage tank in a bermed and lined enclosure may be provided so that the Mine fleet can fuel up at the TTF instead of at the Mine, thus avoiding the haul of that additional fuel into the Mine.

With the construction and operation of the proposed Phase 2 development, the concentrates stored at the TTF from the previous year and those processed at the Mine in subsequent years will be transported year round along the entire all season road, with back hauls transporting fuel and other Mine-related supplies.

Wildlife that are most at risk of adverse effects from potential contaminant inputs to the environment due to the construction and operation of the all season access road are those with smaller home ranges, year round presence (particularly overwintering), and have a large proportion of their territory within 100 m (largest predicted dust deposition zone) of the all season road. Since the risk of accidental rollover is greatest during winter driving conditions, species overwintering in the immediate area of the access road are of most concern. Based on this criteria, two of the selected harvestable species, Beaver and Marten, are most at risk as they have relatively small winter ranges and a few individuals likely occur year round near the all season access road. Larger mammals that have larger home ranges and are present on an infrequent or seasonal basis (e.g., caribou, Moose, Dall's Sheep) are less likely to be exposed to potential road-related materials.

Potential effects on vegetation and soil chemistry, and subsequently on wildlife that forage on them, may occur during construction, operation, and closure of the access road and TTF. If a spill occurs, the effects would be localized and of short duration until the spilled material is recovered. Effects on waterbodies and the wildlife they support are a primary concern in the event of accidental spills and leakage of materials, as well from dust deposition during snow-free periods.

The majority of the large dust particles dispersed from the construction, operation, and closure phases of the all season road are anticipated to settle out about 10 m from source. However, dust deposition may extend up to 100 m away from the all season access road potentially along the alpine tundra portions of Phase 1, depending in part, on site conditions (e.g., wind) and particle size characteristics. Naturally occurring heavy metals, such as cadmium are found across the NWT and have found their way into the food chain to ultimately affect the consumption of wild foods.

A current public health advisory is in effect for cadmium levels found in Moose (kidney and liver tissue only) that occur in the southern Mackenzie Mountains and the Liard/Mackenzie river valleys. Similarly, caribou kidney and livers collected from the Southern Mackenzie Mountains also have high levels of naturally occurring cadmium; however, these levels remain safe for human consumption. Dall's Sheep metal levels are also high, but at levels suitable for consumption. Low but reportable concentrations of cadmium are also found in the kidney and livers of Beaver collected from the Slave River and Mackenzie deltas (INAC 2004).

Cadmium is naturally present across the NWT, and finds its way into the food web from the weathering of rocks and subsequent plant uptake (INAC 2004). Cadmium may be released further into the environment from dust deposition from the all season access road in the spring, summer, and fall. Existing concentrations of cadmium and other heavy metals are still considered low and are not considered harmful to wildlife or to the people eating them (with the exception of the Moose kidney and liver tissue public health advisory).

The GNWT (1998) dust suppression guidelines will be implemented at the TTF and along portions of the road and airstrip, as appropriate, to reduce dust generation during the snow free months. This will generally involve watering dust-prone areas as and when required, as well as adhering to speed limits on roads, which helps limit the re-suspension of particulate material.

Similarly, the Phase 1 road development within the Mackenzie Mountains include portions of steep terrain, as does the Phase 2 road development over the Silent Hills. Accidental rollover, particularly during winter months, poses the greatest risk for accidental release. An all season road will mean much less traffic in winter.

Appropriate materials management systems, spill contingency procedures (including truck driver training in spill response), dust management procedures, and transport safety procedures will be in place to minimize the risk of dust deposition, accidental spills or leakage, including rollovers, and subsequent cleanup of spills, should they occur. The existing spill management plan will be reviewed and improved, as necessary, prior to road and airstrip operation.

To mitigate to risk of possible contamination of harvest resources, measures that were previously proposed at the Prairie Creek Mine and winter access road (and its facilities) will be followed (CZN 2010; Golder 2010), including, but not limited to:

- Implement appropriate materials management systems to minimize the risk of accidental spills or leakage of concentrate, diesel fuel, other hydrocarbons, and other hazardous materials being shipped to the Mine site;
- Diligent management of dust along the access road, airstrip, and transfer facilities following the dust management plan;
- Follow the existing draft Contaminant Loading Management Plan and soil sampling along the road bed both before and during haul operations;
- Implement a winter driving policy requiring tire chains to be used on haul trucks in the mountains (KP 0-29) to increase traction; and
- Finalize and train staff on the existing spill management plan and procedures to quickly respond to an accidental spill. This plan will include provision for rapid deployment of cleanup crews and for contaminant and clean-up of spilled material and contaminated surfaces.

All general mitigation measures proposed are summarized in Section 5.10.

The predicted effect of Project-related effect on contaminant levels in harvestable wildlife, after mitigation is applied, is summarized in Table 5-7.

Table 5-7: Project Effects on Predicted Harvest Species Contaminant Levels

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Low	High	Low	High	High
Northern Mountain Caribou	Both	Adverse	Low	Low	High	Low	High	High
Moose	Both	Adverse	Low	Low	High	Low	High	High
Dall's Sheep	Both	Adverse	Low	Low	High	Low	High	High
Wolverine	Both	Adverse	Low	Low	High	Low	High	High
Grey Wolf	Both	Adverse	Low	Low	High	Low	High	High
Marten	Both	Adverse	Low	Low	High	Low	High	High
Beaver	Both	Adverse	Low	Low	High	Low	High	High
Overall Significance								
Low								

Confidence in this assessment is moderate since the risk of Project-related effects on contaminant levels in wildlife are predicted to be low with adherence to mitigation; however, existing contaminant levels in many harvest species remains unknown. No residual effects resulting from Project-related wildlife contamination are anticipated. Since no residual effects are anticipated, and the natural levels of heavy metals are known to occur in harvestable species at varying concentrations across the north, no measurable parameter for Project-related effects to the consumption quality of harvest species is proposed.

Based on the predicted overall low risk of contaminant related effects, the proposed all season access road is not anticipated to contribute to the consumption quality of harvest species.

5.8 Effects to Predator-Prey Relationships of Harvested Wildlife

Although not the only predator in the region, Grey Wolves are considered the primary predator of adult ungulates in the Dehcho. A number of other predators (e.g., Grizzly Bear, Golden Eagle), prey on ungulate calves and Beavers. Densities of predators in the Dehcho are generally unknown. Grey Wolf densities are considered relatively high near Trout Lake; however, they are unknown near the all season access road. Aerial surveys conducted for the Prairie Creek Mine and access road infrequently detected Grizzly Bear, Wolverine, and Golden Eagle in the area.

Predation can be a significant factor in determining prey abundance and distribution. To minimize the risk of encountering a predator, prey species have evolved several strategies such as remaining solitary or in small groups, occupying habitats where alternate prey densities are low, and birthing in isolation near protective cover. Human developments, such as roads, may challenge prey strategies and alter predator behavior. Some predators (e.g., bears, wolves) use roads for travel, a strategy that increases prey encounter rates (Anderson et al. 2002) and, therefore, predation risk to harvested species. For example, the Species At Risk Committee (2012) identified that Boreal Caribou are at greater risk of predation and harvesting if they occur within 400 m or of a road or seismic line. With the approved winter road development, the proposed all season road and airstrip will not significantly alter predator travel.

Predation can also be a major source of ungulate calf mortality, which can have a direct effect on the populations (Anderson et al. 2002). Possible Dall's Sheep lambing areas exist within approximately 1 km from Phase 1 KP 2, 3, and 7. These sections of the all season access road currently exist as all season quality from past construction and access road approvals. Therefore, the proposed all season access road is not anticipated to alter existing predation that may possibly occur on Dall's Sheep lambs. Similarly, the access road has been re-aligned

specifically to avoid sensitive wildlife areas (identified by the Naha Dehe Dene Band members) and wetlands. The proposed airstrip and all season access road includes approximately 10 km of new vegetation clearing west of the Nahanni Range, outside designated Boreal Caribou range.

Predator-prey dynamics may be altered after a forest fire or human disturbance (e.g., the all season access road). In particular, Moose favour these early regenerating habitats and respond with increasing populations, thereby, correspondingly increasing their predators' populations. Large blocks of forests at the proposed airstrip location and along the all season access road are in various stages of regeneration after fires in the 1940s, 1970s and 1990s. In the north, Boreal Caribou prefer forests at least 100 years old and, in comparison, Moose are thought to benefit from young forests less than 30 years of age. Therefore, based on the fire history of the local area, regenerating habitats are aging beyond Moose preferences (youngest known burn area is approximately 25 years old). As the regenerating habitats age, this level of predator-prey dynamic should eventually be restored to pre-existing disturbance levels.

Similarly, human disturbances may attract predators seeking food and shelter, thereby increasing encounter rates with prey near areas of human activity. Predators, such as Red Fox, Wolverine, Grey Wolf, and bears have been known to source food from litter, people purposely feeding, and unsecure containments.

Mitigation for possible adverse effects to the predator-prey relationships have been incorporated into the design of the airstrip and all season road by locating the proposed infrastructure on or near existing disturbances, and re-aligning the all season road around important wetlands and wildlife areas. Additional mitigation includes:

- Managing the small portion of the winter road not used for the all season access to prevent predator and non-Project related travel of the corridor, if necessary; and,
- Implementing a waste management plan that prohibits littering, purposely feeding wildlife, and storing attractants accessible to wildlife.

All general mitigation measures proposed are summarized in Section 5.10.

The predicted effect of clearing an additional approximately 10 km of airstrip and access road on the predator-prey dynamics, after mitigation is applied, is summarized in Table 5-8.

Table 5-8: Project Effects on Predicted Harvest Species Predator-Prey Relationships

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Boreal Caribou	Phase 2	Adverse	Low	Moderate	High	High	Moderate	High
Northern Mountain Caribou	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Moose	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Dall's Sheep	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Wolverine	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Grey Wolf	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Marten	Both	Adverse	Low	Moderate	High	High	Moderate	Moderate
Beaver	Both	Adverse	Low	Moderate	High	High	Moderate	Low
Overall Significance								
Low								

Confidence in this assessment is high since the amount of clearing for the realignment of the all season road (three road sections, each less than 4 km in length) is negligible compared to the approved winter road and outside sensitive Boreal Caribou defined range. It is not plausible to measure effects to predator-prey dynamics as a direct result of the all season access road and airstrip considering its direct association with the existing winter road corridor.

With adherence to mitigation, no residual effects resulting from Project-related effects to predator-prey dynamics is anticipated.

5.9 Effects to Traditionally Harvested Plants

5.9.1 Berries and Medicinal Plants

Given the differences in structural diversity and community composition associated with the vegetation community types present within the study area, it is anticipated that these vegetation community types will vary substantially with respect to the availability and abundance of materials utilized by the local human community. Such uses are assumed to include the harvest of plants for traditional medicinal use and the harvest of berries for human consumption.

Based on the review of applicable literature (Cambell and Luckert 2012) it is understood that berry harvesting represents an important food source for local Aboriginal communities and offers a substantial economic offset. Based on 1997 values, a per capita replacement cost of $201.14 was calculated for blueberries harvested by the Nahanni Butte community. It can be assumed that such replacement costs have increased when considering inflation and the likelihood of an increasing human population.

Given that the full range of traditional uses of local vegetation species for medicinal and consumption purposes, and preferred areas for harvesting such species cannot be appropriately quantified as part of this assessment, Tetra Tech's approach for assessing potential project related impacts to traditionally important plant species was conducted by examining potential effects to the landscape supporting such species, rather than a detailed account of potential effects to a specific plant or group of plants. This approach allows for a quantifiable determination of habitat loss relative to the CZN study area. This approach assumes that all vegetation communities within the study area are of equal importance with regards to traditionally important plant species; however, as previously discussed, vegetation community types within the CZN study area likely vary in their relative importance with respect to the harvest of traditionally important plants given differences in species diversity and site productivity.

Negative, direct project related effects to habitat potentially capable of supporting traditionally important plants will occur as a result of project development which will require the removal of surface vegetation; however, these effects will be partially mitigated by limiting the amount of new disturbance required for construction by constructing the majority of the all season road within the confines of the approved winter road route. The approved winter road will be fully cleared of woody vegetation prior to construction of the all season road, with the exception of 9 km of additional clearing located outside of the approved winter road route.

The extent of direct effects will be confined to the constructed road right of way (maximum 20 m wide) and the footprint of borrow areas and the airstrip, which will be limited in frequency to once during project construction. For Phase 1 of the all season road, surface area encompassed by the road surface will be 85.6 ha, while Phase 2 will encompass 89.4 ha. The footprint area for both phases of the project, including the road footprint, borrow areas, borrow access roads, camps and the airstrip is 236.5 ha. Based on the calculated areas for EOSD land cover classes present within the 100 m wide study area, the proportion of land cover classes disturbed by each phase of the project will not exceed 20 % of the respective land cover class area.

It is expected that project related effects to traditionally important plants will be reversible following decommissioning and reclamation of proposed disturbances. Based on the rating criteria used for this assessment, the significance of direct project related effects to vegetation communities capable of supporting traditionally important plants is anticipated to be low. Following reclamation, no residual effects to traditionally important plant species are anticipated.

Negative, indirect effects to habitats potentially capable of supporting traditionally important plants would be anticipated to occur primarily during the operations phase of the project. During this time period, vehicle operation along the roadway has the potential to generate road dust which, based on the review of applicable literature (summarized in Section 7.3.5), has the potential to alter physical and chemical properties present in off-site vegetation communities, and therefore, potentially altering the health and vegetation composition of such sites. Similarly, the potential for spills of deleterious substances associated with vehicle use of the roadway during operation (and construction) may affect vegetation communities in a similar manner, as well as resulting consequences to the suitability of traditionally important plants for human consumption. The extent, magnitude and duration of such effects are considered moderate given the potential for off-site effects to traditionally important plants during the operational phase of the project. Frequency of effects would be considered moderate as potential effects will occur at regular intervals throughout the operational phase of the project; however, a low volume of traffic is anticipated during operation of the roadway. Any such indirect effects are considered reversible assuming adherence to appropriate mitigation standards.

A third potential indirect consequence of road construction may include the introduction of invasive plant species. Such species have the potential to alter the community composition of off-site vegetation communities and out-compete desirable native vegetation species. The extent, magnitude and duration of such effects are considered moderate given the potential for off-site effects to traditionally important plants during the operational phase of the project. Frequency of effects would be considered moderate as potential effects may occur at regular intervals throughout the operational phase of the project. Any such indirect effects are considered reversible assuming adherence to appropriate mitigation standards.

A positive consequence of road construction would be the improved access to areas of plant harvesting proximal to the road.

The following mitigation measures are recommended to reduce or eliminate potential indirect project related effects to traditionally important plants:

- Dust suppression strategies (e.g., water or approved dust suppressant products) in accordance with the GNWT dust suppression guidelines;
- Preparation of an Emergency Response Plan for spill containment and management along the access road;
- Fuel storage facilities that meet industry standards for tank construction, location and spill containment;
- Hydrocarbon and chemicals that are hauled along the access road or stored at the TTF are in industry standard containers with appropriate spill containment and management measures in place; and
- Development and implementation of an invasive species management plan to ideally prevent, or if necessary, control the establishment of invasive species in off-site vegetation communities adjacent to the roadway.

With adherence to the mitigation measures described above, the significance of indirect project related effects to traditionally important plants is anticipated to be low. No residual effects to traditionally important plant species are anticipated as a result of the project.

5.10 Traditional Harvesting Mitigation and Best Management Practices

The general mitigation and best management practices considered for the proposed all season access road include previous commitments for the approved winter access road (CZN 2010; Golder 2010), together with specific measures for the proposed all season access road. Proposed mitigation and best management practices include the development and/or implementation of the following:

- A no hunting policy for all Project employees and contractors while working and/or at the Mine site;
- CZN's Controlled Road Use Plan;
- Suitable speed limits on the Prairie Creek All Season Road;
- Discourage use of engine retarder breaks;
- A winter driving policy requiring tire chains to be used on haul trucks in the mountains (Phase 1 KP 0-29) to increase traction;
- A wildlife and wildlife habitat mitigation and monitoring plan that includes annual engagement with members of the Naha Dehe Dene Band to monitor measureable parameters of effects;
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so, particularly when in convoy) for all wildlife seen on or immediately adjacent to the road, to allow them to move away;
- Policy that all Project-related transportation activities are to give the right-of-way to any wildlife that such activity may encounter;
- Develop standard aircraft procedures for flying into and departing from the proposed airstrip to accommodate wildlife, if present on or near the airstrip;
- Maintain a minimum flight altitude of 600 m during all times, except during take-off and landings;
- Dust suppression strategies (e.g., water or approved dust suppressant products) in accordance with the GNWT dust suppression guidelines;
- Follow the existing draft Contaminant Loading Management Plan and soil sampling along the road bed both before and during haul operations;
- An education program of wildlife related policies and mitigation to all Project employees and contractors, including a bear awareness program to ensure employees and contractors are informed of bears and other potentially dangerous wildlife and the level of risk;
- Policy for all Project employees and contractors to avoid all known or suspected den and nest sites;
- An alert system to warn personnel of Woodland Caribou and other sensitive wildlife in the local area by relaying sighting information to vehicles/aircraft and equipment operators and on-site personnel;
- Wildlife record logs to be completed by all Project employees and contractors for all wildlife sightings (e.g., Dall's Sheep, caribou, Wood Bison, and carnivores) with respect to species, location along the access road and airstrip, numbers observed, and reaction to Project activity. If a problem area is identified, corrective measures will be considered.

- ENR's Woodland Caribou Best Management Practices for Industrial and Commercial Activities (once developed) to be incorporated into the wildlife monitoring program, where feasible, to manage or mitigate habitat impacts and sensory disturbances on Woodland Caribou;
- Snow removal practices along the access road and airstrip to manage high snow banks, so that wildlife can readily move off as vehicles/aircraft approach;
- A structure for reporting human-dangerous wildlife encounters at the TTF and resulting incidents to inform Mine management and ENR staff;
- A protocol for dealing with problem bears, with a designated chain of responsibilities for ensuring worker safety and efficient and speedy resolution of incidents;
- A Waste Management Plan that prohibits littering, purposely feeding wildlife, and storing attractants accessible to wildlife. Incinerate all waste foods and human garbage consistent with current industry good management practices to minimize wildlife attraction to the local area. Adaptive management will be applied to waste management practices. If wildlife are found to be attracted to the site (i.e., problem wildlife) additional management practices, if required, will be adopted;
- An Emergency Response Plan for spill containment and management along the access road;
- Fuel storage facilities that meet industry standards for tank construction, location and spill containment;
- Appropriate materials management systems to minimize the risk of accidental spills or leakage of concentrate, diesel fuel, other hydrocarbons, and other hazardous materials being shipped to the mine site. This includes ensuring hydrocarbon and chemicals that are hauled along the access road or stored at the TTF are in industry standard containers with appropriate spill containment and management measures in place;
- Staff training on the existing spill management plan and procedures to quickly respond to an accidental spill. This plan to include provision for rapid deployment of cleanup crews and for contaminant and cleanup of spilled material and contaminated surfaces;
- Managing the small portion of the winter road not used for all season access to prevent predator and non-Project related travel of the corridor, if necessary;
- Preservation of natural drainage patterns along the haul road to maintain the natural function and processes of peatland habitats adjacent to the haul road;
- A policy to avoid significant changes to water levels while pumping water from a known Beaver pond in the fall and winter periods;
- Maintain sufficient buffer distances between development activities (e.g., re-fuelling and material storage) and waterbodies, where possible;
- Non-mine vehicles, including all-terrain vehicles (ATVs) and snowmobiles will be prohibited on site;
- Pets will be prohibited along the all season access road; and
- Development and implementation of an invasive species management plan to ideally prevent, or if necessary, control the establishment of invasive plant species in off-site vegetation communities adjacent to the roadway.

6.0 EFFECTS ASSESSMENT – NAHANNI NATIONAL PARK RESERVE

The NNPR is Canada's third largest national park, encompassing over 30,000 km^2 and approximately 85 km of the proposed all season access road route. This assessment of potential effects related to upgrading of the current approved winter access road to an all season road addresses wildlife and vegetation valued components present inside the NNPR (activities summarized in Table 2-1). In accordance with their MVLWB and Parks Canada Land Use Permits and Water Licences, CZN is authorized to construct and operate a winter road that generally follows the same route as the historical winter road access constructed in 1981/82. These authorizations permit the clearing of the winter access road, which will occur at least 2 years prior to the construction of this proposed all season road.

The alignment of the Prairie Creek winter access road has already been modified to address concerns from the Naha Dehe Dene Band about wetland/wildlife issues, and from Parks Canada regarding re-routing around the unique polje karst features. Effects associated with clearing the road route and winter operations of the access road have been permitted for the life of the Prairie Creek Mine. All but 9 km (or 18 ha) of clearing along the all season access road is required beyond that approved under the winter road; 8 km (or 16 ha) will be within the NNPR boundary, along with the airstrip (7.62 ha), borrow sites (18.18 ha) and their access roads (0.80 ha), and the 2 ha expansion of the TTF. Therefore, the remaining Project-related effects are assessed for the removal of 42.60 ha of harvested wildlife habitat along the access road and airstrip within the NNPR during winter clearing activities.

The goals of the Park Management Plan are to maintain the quality of the land, water, air, and wildlife, while expanding visitor experience and encouraging the discovery of NNPR to visitors and respecting traditions and cultural values. To do so, Parks Canada has developed species monitoring measures (e.g., population density, composition, occupancy) that provide a general assessment of the parks ecological integrity. Of these, Parks Canada monitors Species at Risk, forest bird communities, Grizzly and Black bears, Moose, Northern Mountain Caribou, Dall's Sheep, and Trumpeter Swan (Parks Canada et al. 2009).

Diverse and abundant wildlife populations, especially Parks Canada's ecological indicators, are also symbols of Canadian wilderness and of a healthy ecosystem, and are important for visitors. The Project effects assessment focuses on selected wildlife species currently monitored inside NNRP. In the assessment, the geographical scope of any potential effects to wildlife within the NNPR must be sufficient to assess potential impacts at a local population level, with due consideration to seasonal and migratory movements, and lifecycle requirements of each species.

The temporal scope of the effects assessment includes activities during the construction, operation, and closure phases considered to potentially pose the greatest adverse effects, as well as times when selected wildlife species are most sensitive to human disturbances and the duration of potential effects with relation to the operational life of the access road. Table 6-1 summarizes the selected species for the assessment of potential Project-related effects to NNPR, the geographical and temporal scopes, and the rationale for our selection.

The all season access road and airstrip are located outside the defined annual ranges of the Boreal and Northern Mountain caribou occurring within the NNPR; however based on modeling and aerial and ground-based surveys along the proposed road, the Nahanni Complex and Redstone Northern Mountain caribou occur in low numbers, primarily in the summer in the Nahanni Plateau, the lower Sundog Creek drainage, west of the Ram Plateau, and the Silent Hills. Therefore, Boreal Caribou are not part of this effects assessment to NNPR.

Table 6-1: Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Selection
Northern Mountain Caribou	Nahanni Complex summer range	Winter Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Listed as Special Concern under SARA (2005), but assessed as Secure under the NWT ▪ Requires substantially large home range, mostly outside the zone of influence of the all season access road and airstrip ▪ Sufficient population information is known on the Nahanni Complex herd within NNPR upon which to base the effects assessment ▪ Sensitive to human disturbances ▪ Monitored by Parks Canada in the NNPR to assess the general ecological integrity of the park. Caribou herds considered in decline
Moose	NNPR	Winter Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Secure in the NWT ▪ Population density estimates known around Nahanni Butte and southeast portion of the NNPR ▪ Monitored by Parks Canada in the NNPR to assess the general ecological integrity of the park
Dall's Sheep	NNPR	Project components, year round Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Secure in the NWT ▪ Potential lambing areas located within 1 km of Phase 1 KP 2, 3, and 7. Similarly the Nahanni Range and Ram Plateau provide suitable lambing areas. ▪ Those with ranges isolated from the larger Mackenzie Mountain population considered most sensitive to disturbance ▪ Most sensitive to disturbances on their winter ranges, in the eastern fringe of Nahanni Plateau and Nahanni Range north of the access road. ▪ Mineral licks visited from early June to October. ▪ Monitored by Parks Canada in the NNPR to assess the general ecological integrity of the park.
Mountain Goat	NNPR	Winter Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ May Be At Risk in the NWT, and not assessed by COSEWIC ▪ Their Nahanni Range distribution is isolated from the core Mackenzie Mountain range ▪ Generally sensitive to human disturbances, particularly while on their winter range

Table 6-1: Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Selection
Grizzly Bear	NNPR	Spring, summer, and fall Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Assessed as Special Concern by COSEWIC and ranked as Sensitive in the NWT ▪ Requires substantially large home range ▪ Sufficient population information is known within NNPR to assess effects ▪ Generally sensitive to human disturbances during the non-denning periods ▪ Monitored by Parks Canada in the NNPR to assess the general ecological integrity of the park. Population considered stable in NNPR
Trumpeter Swan	NNPR	Spring, summer, and fall Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Not At Risk in Canada and ranked as Sensitive in the NWT ▪ Small localized population found only inside NNPR within the NWT ▪ Summer breeder representative of other waterfowl species ▪ Monitored by Parks Canada in the NNPR to assess the general ecological integrity of the park
Harlequin Duck	NNPR	Spring, summer, and fall Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Ranked as May Be At Risk in the NWT ▪ Small localized population known inside NNPR approximately 135 km northwest of the Prairie Creek Mine ▪ No population information known in the NWT ▪ Sensitive to human disturbances in the summer
Common Nighthawk	5 km from Project	Summer and fall Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Listed as Threatened under SARA and ranked as At Risk in the NWT ▪ No population information known in the NWT ▪ Maintains small territories that vary in size depending on habitat quality and nest site availability ▪ Late spring arrival and early fall departure from the NWT

Table 6-1: Selected Assessment Species and Geographical and Temporal Scopes

Species	Geographic Scope	Temporal Scope	Rationale(s) for Selection
Olive-sided Flycatcher	1 km from Project	Summer Project components Entire life of the access road (road closure 6 years after Mine closure (approx. 2036)	▪ Listed as Threatened under SARA and ranked as At Risk in the NWT ▪ Maintains small territories ▪ Only present in the NWT from late May to early August ▪ No population information known in the NWT

Species not included in the NNPR effects assessment are unlikely to interact with the Project in substantial numbers due to their low densities across the region (e.g., Short-eared Owl), are generally numerous (e.g., Marten) and their habitats common across the Dehcho (e.g., Rusty Blackbird), not considerably susceptible to Project-related disturbances (e.g., Collared Pika, Bank and Barn swallows), and effects may be addressed by the assessment of another species (e.g., Wolverine effects largely covered through the Grizzly Bear effects assessment). Table 6-2 summarizes the rationale. A concentrated determination of effects to species not selected for the NNPR effects assessment is provided in Section 7.0.

Table 6-2: Rationale for Species Not Selected for Assessment

Species	Rationale(s) for Exclusion from the NNPR Effects Assessment
Collared Pika	▪ Little information is known about their distribution and abundance within NNPR to develop the effects assessment ▪ Not considerably susceptible to Project-related disturbances, except at small localized areas
Boreal Caribou	▪ NNPR lies outside the defined range of Boreal Caribou, although they may rarely occur west of Nahanni Range into the NNPR
Wood Bison	▪ Generally numerous and their population is increasing, and not found in the NNPR along the road alignment ▪ Relatively tolerant to road related disturbances
Wolverine	▪ Effects and mitigation largely inferred through the Grizzly Bear effects assessment ▪ Naturally occur in low densities and over large home ranges depending on prey abundance
Myotis species	▪ All three species Ranked as May Be At Risk in the NWT and Little Brown Myotis and Northern Myotis assessed as Endangered by COSEWIC ▪ Not considerably susceptible to Project-related disturbances since the all season access road avoids karst topography, which may support important bat overwinter hibernacula ▪ No population information known in the NWT to develop the effects assessment
Horned Grebe	▪ Not considerably susceptible to Project-related disturbances since the all season access road avoids wetlands as much as possible
Peregrine Falcon	▪ Not considerably susceptible to Project-related disturbances since 95% of the all season access road routes at least 1.5 km from potential cliff nesting habitat ▪ Relatively tolerant to road related disturbances
Yellow Rail	▪ No known observations of Yellow Rails occurring within or the NNPR or Dehcho region ▪ Not considerably susceptible to Project-related disturbances since the all season access

	road avoids wetlands as much as possible ▪ Fluctuating annual breeding distribution based on water levels, therefore difficult to assess for effects
Short-eared Owl	▪ Irruptive distribution and fluctuating density which is difficult to assess for direct Project-related effects
Bank and Barn Swallow	▪ Not considerably susceptible to Project-related disturbances. Project-related effects may be positive, as both species occupy human-made nesting substrates
Rusty Blackbird	▪ Habitat considered common across the Dehcho ▪ Not considerably susceptible to Project-related disturbances since the all season access road avoids wetlands as much as possible
Western Toad	▪ Little information is known about their distribution and abundance within NNPR to develop the effects assessment

Based on the scope of this report, the NNPR effects assessment is restricted to wildlife and vegetation related effects outlined in the TOR, including:

- Ecosystem and habitat loss;
- Wildlife habitat fragmentation and barriers to movement and gene flow;
- Ability of habitat or species to recover;
- Changes to wildlife and vegetation species distribution and abundance;
- Invasive species; and,
- Ecosystem functioning.

6.1 Ecosystem and Habitat Loss

As part of proposed project activities, habitat loss within the NNPR will occur as a direct result of vegetation clearing to accommodate the proposed all season road access route and other associated infrastructure (e.g., borrows and camp locations). It is anticipated that such effects will be mitigated by constructing the proposed all season access road within the ROW of the approved winter access road, which will limit the amount of additional clearing required for construction of the project.

Effects to the relative abundance of habitat types within the NNPR as a result of project development were quantified by comparing the mapped vegetation community types (EOSD Cover Units) present within the study area to the proposed project disturbance footprint. Table 6-3 presents the anticipated habitat loss within the NNPR as a result of proposed project construction. For comparative purposes, Table 6-3 also presents the area of each respective EOSD cover type within the project study area, which for the purpose of this assessment encompasses a 50 m buffer surrounding proposed project related disturbances.

Table 6-3: Summary of Terrestrial Ecosystems Potentially Disturbed by Project Construction within the NNPR

EOSD Land Cover Class	Phase I Road Area (ha) *	Phase II Road Area (ha) *	Airstrip Area (ha)*	Borrow Site Area (ha)*	Borrow Site Access Road Area (ha)*	Tectela Transfer Facility (ha)*	Cleared Area Outside of Winter Road Route (Phase I) (ha)*	Cleared Area Outside of Winter Road Route (Phase II) (ha)*
Broadleaf-dense	3.43	5.82	0.00	1.63	0.00	0.00	0.00	0.45
Broadleaf-open	0.11	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Bryoids	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coniferous-dense	6.38	1.96	0.00	1.01	0.06	0.35	0.00	1.19
Coniferous-open	17.30	1.43	0.00	2.93	0.36	0.00	2.01	0.92
Coniferous-sparse	2.77	0.10	0.00	0.90	0.07	0.00	0.09	0.13
Exposed land	11.38	0.00	7.62	3.39	0.00	0.00	0.52	0.00
Herb	0.05	0.00	0.00	0.00	0.00	0.00	0.00	
Mixedwood-dense	5.14	5.15	0.00	2.81	0.00	1.65	0.00	2.05
Mixedwood-open	0.51	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Rock/rubble	5.77	0.00	0.00	1.93	0.00	0.00	0.00	0.00
Shadow	1.58	0.00	0.00	0.78	0.00	0.00	0.00	0.00
Shrub-low	11.42	0.00	0.00	2.57	0.31	0.00	1.34	0.00
Shrub-tall	1.68	0.05	0.00	0.10	0.00	0.00	0.00	0.00
Water	0.29	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Wetland-shrub	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Wetland-treed	0.00	1.79	0.00	0.04	0.00	0.00	0.00	0.00
Total	**68.49**	**16.36**	**7.62**	**18.18**	**0.80**	**2.00**	**3.96**	**4.78**

*- Values rounded for reporting purposes

The proposed disturbance area encompassed by the road surface (Phase I and Phase II combined) and other proposed disturbances within the NNPR will be 117.5 ha. Based on the calculated areas for EOSD land cover classes present within the 100 m wide study area, the proportion of land cover classes disturbed by the project will not exceed 20% of the respective land cover class area.

Given the low proportion of habitat loss relative to available habitat within the study area and the mitigation of project related effects by reducing clearing requirements by constructing within the approved winter road route, the extent, magnitude, duration and frequency of potential project related effects are considered low, and reversible following decommissioning and reclamation of project related disturbances. The overall significance of effects with respect to habitat loss within the NNPR is considered low and no residual effects are anticipated as a result of project construction.

6.2 Effects on Wildlife Habitat Fragmentation and Movement

The NNPR encompasses the majority of the South Nahanni River watershed, a large naturally diverse area that allows for natural ecological processes. The current level of habitat fragmentation inside the NNPR is very low

and limited to the 1980's Prairie Creek Mine winter road that has naturally re-vegetated, the approved winter access road, and the visitor trails, campgrounds, and park stations, as well as natural forest fires.

The approved winter access road will be constructed at least 2 years prior to the proposed all season road. Once the winter access is constructed, an additional 8 km of right-of-way is proposed to be cleared inside the NNPR (an additional 1 km outside the park boundary), plus an airstrip (7.62 ha) and preferred borrow sources (18.98 ha, including a borrow source access road). The preferred borrow sources are proposed directly within the road right-of-way, as much as possible, and require limited access. Of the preferred borrow sources proposed within the NNPR, only one (1) requires an access road. This borrow pit access road (400 m in length) is proposed as a temporary winter access route near Phase 1 KP 47.

Habitat fragmentation may occur as a direct result of realigning 8 km of the all season access road, developing a single borrow source located off the existing road right-of-way, and the airstrip. Little habitat fragmentation will occur as a result of the proposed borrow sources since all but one borrow is directly connected to the approved winter road. Therefore, the all season access road, one borrow and its access road, and airstrip modestly increases habitat fragmentation beyond the existing winter access.

As fragmentation increases, the integrity of the habitat is reduced leading to changes in species diversity and localized movements; however, some species are considered more sensitive to habitat fragmentation than others. For instance, Salmo Consulting Inc. et al. (2004) report Moose populations appear to be more sensitive to overharvesting and other sources of mortality than compared to habitat loss and fragmentation. In contrast, Boreal Caribou (ranges outside the NNPR) are considered one of the most sensitive to linear disturbances.

As a measure of habitat integrity, linear corridor densities were estimated across the Dehcho in the Dehcho Cumulative Effects Assessment. Mapped linear corridor densities (e.g., seismic line and roads) along the all season access road within NNPR was <0.6 km/km^2 (Phase 1 and portions of Phase 2), with isolated patches consisting of older cutlines near the southern terminus of the access road outside the NNPR boundary at a density of 0.6-1.0 km/km^2.The mapped linear corridor density in the NNPR is the lowest density mapped, and is well below the Dehcho Land Use Planning Committee's (ND) cautionary threshold (1.0 km/km^2), which represents the lowest threshold at which development, upon reaching it, should be required to monitor impacts. The proposed all season access road, borrow sources, and airstrip will not significantly increase habitat fragmentation beyond the existing winter access road.

Habitat fragmentation outside the boundaries of NNPR is equally low, with several proposed NWT Protected Areas Strategy areas of interest and Draft Interim Dehcho Land Use conservation zones that permit regional wildlife movements.

Forest fires inside NNPR also lead to habitat fragmentation, and influence habitat availability and effectiveness for species. Within the area of the all season access road and airstrip, several large scale forest fires have occurred since the 1940's that have encompassed areas east of Nahanni Range, the Tetcela River and Fishtrap Creek valleys, and along the polje by-pass re-alignment. Accidental Project-related ignition of forest fires has the potential to occur along the length of the all season access road and at the airstrip. However, the access road clearing can also act as a fire break, as was the case on the Ram Plateau near Mosquito Lake.

For boreal forest birds (e.g., Olive-sided Flycatcher and Common Nighthawk) the effects of habitat fragmentation are generally unknown; however, habitat models suggest that the effects of habitat loss are far greater than increasing fragmentation (AXYS 2001). Along the all season access road and airstrip, available habitat for Olive-sided Flycatcher and Common Nighthawk (as well as other boreal forest birds) is not limiting, and movements across the proposed developments are not likely to be adversely altered.

Wildlife may change their local movement patterns and behaviour once disturbed by the all season access road, its facilities, and airstrip, as well as its traffic, embankment characteristics, and/or plowed snow banks. Any changes to their movements are directly related to their sensitivity to disturbance levels and human-activities. Wildlife sensitivity to human-related disturbances and activities vary depending on a number of factors including the species, individual, season, and past experiences. Some species may be wary of the all season access road (and its activities or snow banks) and hurriedly cross or deflect from crossing at that particular location. Northern Mountain Caribou, Moose, Dall's Sheep, and Grizzly Bear may alter their movements in response to the proposed road, airstrip, and their traffic; however, Grizzly Bear may be the most sensitive to the proposed all season access road and may show a higher degree of reluctance to cross. Although, the degree of reluctance varies, and CZN has observed grizzlies walking along the existing all season road several times in the Prairie Creek and Sundog Creek valleys. In the mountainous section (approximately Phase 1 KP 0-33) within Grizzly Bear, Northern Mountain Caribou, and Dall's Sheep range the road currently exists as all season quality.

The sensitivity of Grizzly Bears to roads is dependent on the existing degree of fragmentation, traffic volumes, season, gender, and surrounding habitat quality. Salmo Consulting Inc. et al. (2004) suggested traffic volume was the most important predictor of Grizzly Bear movements across roads. Therefore, it is important to maintain low traffic volumes (such as 16 concentrate trucks, per day (equivalent to 1 concentrate truck approximately every 0.75 hours), which is proposed along the all season access road) throughout the life of the Project.

Weaver (2006) indicated a large area in the Mackenzie Mountains, approximately 25 km north of the all season road, as having the largest expanse of high to very high predicted Grizzly Bear densities. Based on Weaver's (2006) predicted bear density map, the all season access road from KP 0 to 39 crosses perpendicular with potential bear movements while travelling to this predicted high use area. Low traffic volumes proposed are not expected to inhibit Grizzly Bear population recovery, since studies indicate Grizzly Bears (both sexes) cross low traffic volume roads (COSEWIC 2012a; Chruszcz et al. 2003; Salmo Consulting Inc. et al. 2004).

Harlequin Ducks are also sensitive to human-related disturbances. Within the forested zone, the approved winter road, and therefore, the all season access road travels parallel with and crosses 4 km of the Sundog Creek tributary, which is possible Harlequin Duck habitat (Phase 1 KP 37-41). Although traffic along the all season access road will parallel possible Harlequin Duck habitat, it will not substantially alter Harlequin Duck movements.

In contrast, Dall's Sheep are commonly observed at and near the Prairie Creek Mine and its associated activity sites in the summer. Dall's Sheep near Phase 1 of the all season access road may be habituated to Project-related disturbances. In addition, the all season access road is located at least 500 m below possible Mountain Goat habitat along the Nahanni Range and outside the defined range of Northern Mountain Caribou, and is not anticipated to significantly affect goats and caribou.

The all season access road (estimated at 20 m wide right-of-way) and the airstrip are not considered a full barrier to wildlife movement. They are permeable, year round, to all species assessed since the proposed developments remain narrow and Project-related traffic volumes are low. With only the proposed Phase 1 development, a total of approximately six trucks, averaging 30 km/hr, will make two return trips daily from the Mine to the TTF. With the development of Phase 2, 16 Project-related trucks averaging 30 km/hr, will make a single return trip daily from the Mine to the Liard Transfer Facility (LTF).

Northern Mountain Caribou, Moose, Dall's Sheep, and Mountain Goats travel several kilometres to reach mineral licks. During this time, they may encounter the proposed all season access road, as mineral licks are known within 11 km of the Mine site, Phase 1 KP 10, Phase 2 KP 151-157, the Nahanni Access Road, and along the Liard Highway. No mineral licks are known near the proposed airstrip. Dall's Sheep, particularly ewe groups (with lambs and yearlings) commonly utilize mineral licks from June to early October; however, they are also known to

habituate to human activities since they are consistently observed at the Prairie Creek Mine site. Since the traffic volumes are low, the all season access road is not considered a barrier to movements.

Forest clearing (resulting in a small level of habitat fragmentation) will occur during winter construction of Phases 1 and 2 and the airstrip, and is reversible after closure. Besides designing the all season access road and borrow source locations to follow the already permitted winter road corridor and right-of-way, no further mitigation associated with habitat fragmentation is recommended. Potential effects to wildlife movements will occur principally during construction and operation.

The use of the Prairie Creek Mine access road by non-mine related traffic (e.g., snowmobiles, all-terrain vehicles) will be controlled to the extent possible using a check-point. As such, the potential for disturbance associated with this additional use can be minimized or avoided. As well, suitable speed limits will be enforced to minimize disturbances.

To mitigate project-related wildlife disturbances, measures recommended to minimize effects from the winter road will be continued from construction to closure of the proposed all season road and airstrip, as well as additional measures specific for all-weather use. These include:

- Strict use of CZN's Controlled Road Use Plan to minimize traffic and other disturbances and maintain low speed limits;
- Reporting and evaluating wildlife sightings along the access road, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered;
- Snow removal practices along the access road and airstrip to manage high snow banks, so that wildlife can readily move off the roadway as vehicles approach;
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road to allow them to move away.
- Discuss main issues and considerations regarding wildlife populations and effects during the Technical Advisory Committee meetings proposed by CZN in EA0809-002; and
- Report annual updates and results of the Wildlife Mitigation and Monitoring Plan, Controlled Road usage, and inspections and enforcements.

All general mitigation measures proposed are summarized in Section 6.10.

With adherence to the mitigation, the predicted effects to habitat fragmentation and barriers to movements is summarized in Table 6-4.

Table 6-4: Project Effects on Predicted Habitat Fragmentation and Movement

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Northern Mountain Caribou	Both	Adverse	Moderate	Moderate	Moderate	Low	Moderate	High
Moose	Both	Adverse	Low	Moderate	High	Moderate	Moderate	Moderate
Dall's Sheep	Both	Adverse	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Mountain Goat	Both	Adverse	Low	Moderate	Moderate	Low	Moderate	High
Grizzly Bear	Phase 1	Adverse	Moderate	Moderate	Moderate	Low	Moderate	Moderate
Trumpeter Swan	Both	Adverse	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Harlequin Duck	Phase 1	Adverse	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Common Nighthawk	Both	Positive	Low	Moderate	High	Moderate	Moderate	High
Olive-sided Flycatcher	Both	Positive	Low	Moderate	High	Moderate	Moderate	High
Overall Significance								
Low								

Confidence in this assessment is moderate since the amount of habitat fragmentation within the area of the proposed clearing is low (considering the majority of clearing has been approved for the winter road) and select species are expected to infrequently encounter the access road and airstrip (e.g., naturally low species densities, large home ranges, seasonal distribution). However, species' sensitivity to disturbances vary depending on a number of biotic and abiotic factors including season, gender, and harvesting pressure. The measurable parameter for Project-related disturbances is the number of Project-related encounters with wildlife and overall Project and non-Project related vehicle traffic recorded at the check-point annually.

Overall, the predicted adverse effects are moderate, but reversible after the Mine's life. With adherence to mitigation, there are low residual effects of low significance anticipated that will adversely alter local wildlife movements in NNPR

6.3 Effects on Wildlife Species Distribution and Abundance

Species avoidance and abundance effects from Project-related disturbances can occur as a direct result of road and airstrip construction, operation, and closure activities, as well as indirectly by providing hunting access. These consequences may range from minor to strong avoidance. In areas without hunting, avoidance to roads is either non-existent or very temporal in nature (Jalkotzy et al. 1997).

The use of the Prairie Creek Mine access road by non-mine related traffic will be controlled to the extent possible using a check-point and a private Liard River barge crossing. With these controls, potential effects can be minimized. However, subsistence harvesting activities along the road may directly change wildlife abundance along the access road, and if significant, may cause wildlife to avoid the road. These potential effects may also occur during the period of winter road operation before the all season road.

A few Northern Mountain Caribou may occasionally occur near the proposed all season access road and airstrip on an annual basis; however, these proposed developments are located outside their defined range. Northern Mountain caribou may occur on the Nahanni Plateau, the lower Sundog Creek drainage, west of the Ram Plateau, and the Silent Hills primarily during the non-winter period. Disturbance related effects on Northern

Mountain Caribou are considered low since the all season access road is not part of their core range (including their calving and primary winter range), and consequently, they may occur infrequently in the area. If present, Northern Mountain Caribou are likely to avoid the proposed access road and airstrip. Traditional knowledge and the Species at Risk Committee 2012 indicate that roads may affect Boreal Caribou as far as 1 km away (Species at Risk Committee 2012). Northern Mountain Caribou are assumed to be as sensitive to roads as Boreal Caribou. However, their exposures to Project-related disturbances are expected to be limited and sporadic, and traffic levels are low, infrequent, and predictable, particularly during operation, thereby minimizing potential disturbances.

The proposed all season access road and airstrip are located primarily in low elevation habitats, approximately 500 m below possible Mountain Goat habitat on the Nahanni Range. Further, on the Ram Plateau, possible Mountain Goat habitat is located at least 4 km from the proposed access road route and airstrip, and therefore, goats are not likely to be disturbed. Roads are thought to affect Mountain Goats within a 400 m zone of influence and aircrafts within 1 km (AXYS 2001). Subsistence harvests of Mountain Goats are negligible and are not expected to alter Mountain Goat distribution and abundance. In addition, non-resident harvests are expected to be terminated inside NNPR by 2019. Mountain Goats are generally reluctant to move from their mountain blocks and, therefore, their distribution and abundance across the landscape is expected to change little over time as a result of the access road, airstrip, and negligible hunting pressure.

In Kluane National Park, Moose are relatively tolerant of roads, aircraft, and related disturbances, and the predicted zone of influence to which Moose were adversely affected by roads and aircraft was approximately 100 and 200 m, respectively (AXYS 2001). Other available evidence suggests moose may avoid linear features and other land use developments by 100 to 500 m depending on the season, sex, surrounding habitat, and hunting pressure (Salmo Consulting Inc. et al. 2004). Linear features, such as the approved winter road, may disturb Moose that have home ranges along its length.

Since subsistence Moose harvesting is permitted inside NNPR (non-resident harvests to terminate by 2019), Moose may avoid the proposed all season access road and airstrip by 500 m or more, depending on the level of hunting pressure (less avoidance distance if negligible to low hunting pressure). This has the potential to directly affect Moose abundance in a localized area. Mr. Konisenta indicated to CZN (2010) that Moose harvesting was common along easily accessible corridors; however, Moose numbers have dwindled, and are now rarely found along these same easy access routes. Mr. Konisenta attributes this partly to the introduction of bison to the area; however, hunting pressure is also a likely root cause.

By managing hunting pressure, Moose avoidance and abundance affects along the proposed all season access road may be minimized. For example, a Boreal Caribou study modelled potential habitat use (including buffer distances from roads and cutlines) and compared this with known lifetime harvest kill sites and aerial survey sightings across the Dehcho. This study indicated that Boreal Caribou distribution has remained stable at the regional level within living memory (approximately 60 years) even with hunting (Gunn et al. 2004).

Dall's Sheep sensitivity to roads and aircraft in Kluane National Park was determined to be low, with the predicted zone of influence reaching as far as 200 and 500 m, respectively (AXYS 2001). Like Mountain Goats, Dall's Sheep are generally reluctant to move from their mountain block, and therefore, their distribution across the landscape changes little over time as a result of land use developments. A few Dall's Sheep have traditionally been harvested annually from the Nahanni Range in proximity to Nahanni Butte (outside NNPR). Although none are apparently harvested now, the proposed all season access road allows access for Dall's Sheep subsistence harvesting inside the NNPR in the Mackenzie mountains which has the potential to reduce the resident population. However, boat access to Dall's Sheep inside the NNPR via the South Nahanni River exists, with low hunting pressure to date.

In Kluane National Park, Grizzly Bears were found to be the least tolerant of road-related disturbances (AXYS 2001). It was suggested Grizzly Bears are adversely affected 3 km from roads in the fall and 500 m in the spring

and summer (AXYS 2001). Even on a seasonally closed road (such as a winter only road) the zone of influence was approximately 600 m, and when the road re-opened, the zone of influence increased to 1,200 m (AXYS 2001). Therefore, the proposed all season access road has the potential to affect Grizzly Bear distribution, particularly for those bears with home ranges within the Mackenzie Mountains, as the boreal forest zone generally represents the periphery of individual home ranges that are less frequently occupied. CZN's recorded anecdotal sightings suggest the numbers of grizzlies in the immediate area is low (as expected for species with large home ranges), and those present are currently not perturbed by the road. This may change with the all season traffic, but note that the road from KP 0-33 is of all season quality already and is likely to be utilized in non-winter seasons for maintenance related to the winter road permits, thus any impacts to grizzly distribution may have occurred prior to the all season road. As such, Grizzly Bear distribution is not likely to be significantly affected by the all season road.

Trumpeter Swans are also highly sensitive to human activities and developments while at their breeding ponds (ESRD 2013). Intense or sustained levels of disturbances near active breeding ponds during the breeding season may result in nest loss, clutch failure, increased predation to young, and abandonment of the entire pond (ESRD 2013). Even low level repeated disturbances over time may result in reduced use or abandonment (ESRD 2013). As a result of their sensitivity, ESRD recommends all permanent or long-term developments (including roads) avoid habitat occupied by Trumpeter Swans by 500 m (ESRD ND). Breeding Trumpeter Swans have been observed primarily in the wetlands and ponds in the Tetcela River valley and at Yohin Lake, as well as near Phase 1 KP 64 (Mosquito Lake) and 75. Known or suspected Trumpeter Swan ponds and wetlands along the proposed all season access road are outside the recommended 500 m buffer, except at Phase 1 KP 64 (Mosquito Lake) and 75. Additional wetlands occupied by Trumpeter Swans may also occur within this 500 m buffer, particularly at Phase 1 KP 65.5 and Phase 2 KP 86 and 98. Although the proposed all season access road has been re-aligned to avoid wetlands and ponds, as much as possible, potential adverse effects to a few territorial Trumpeter Swans is of moderate magnitude and moderate likelihood of effect. However, their willingness to relocate will depend on the timing of disturbances. Upon spring arrival, Trumpeter Swans may select available territorial ponds further from the access road due to the low but regular traffic volumes, thereby, avoiding road-related disturbances during the sensitive nesting and rearing periods.

Harlequin Ducks and their habitat may be sensitive to traffic related disturbances and susceptible to dust-related changes to water pH and invertebrate abundance and diversity. Considerable disturbances at the nest site may lead to site abandonment. However, potential nesting habitat is limited near the proposed all season access road and the probability of occupation is low.

The proposed all season access road is not likely to affect Common Nighthawk and Olive-sided Flycatcher distribution and abundance. Both species may occupy the proposed roadway while feeding, and prefer forest clearings and habitat edges found along the access road and airstrip. Common Nighthawks have been known to nest and forage in and near human developments, and may eventually show some degree of tolerance.

Predation can also be a significant factor in determining prey abundance and distribution. Prey species have evolved several strategies such as remaining solitary or in small groups, occupying habitats where alternate prey densities are low, and birthing in isolation near protective cover to minimize the risk of encountering a predator. The integrity of prey species habitat plays a critical role in their strategies to avoid predation risk. Roads and other human developments decrease the integrity of habitats and increase predation risk to ungulates since predators may use roads to travel faster and access new habitats. However, in the subalpine and alpine zones where Northern Mountain Caribou and Dall's Sheep occur, access roads provide less advantage to predator travel. Similarly, in the boreal forest zone, the approved winter access road currently supports predator travel.

CZN's intent is to work with the Naha Dehe Dene Band to discourage use of the full access road by non-residents. CZN will be able to impose rules for its employees and contractors, but does not have jurisdiction to impose rules on others. Although, Parks Canada regulations for NNPR stipulate that "existing roads in NNPR are

restricted access only and are not open to the public for motorized use", with exception for Aboriginal people pursuing their traditional harvesting rights (Parks Canada 2013), thereby resulting in the exclusion of non-Project related and non-Aboriginal travel along approximately 51% of the all season access road. CZN also proposes to operate a private barge on the Liard River, which will not be available for non-resident use.

These potential effects can be mitigated by implementing the following:

- Strict use of CZN's Controlled Road Use Plan to minimize traffic and other disturbances and maintain low speed limits;
- Follow dust suppression strategies (e.g., water or approved dust suppressant products) in accordance with the GNWT dust suppression guidelines;
- Prohibit pumping water from ponds occupied by Trumpeter Swans during the nesting period;
- Educate staff and contractors on CZN's wildlife policies;
- Reporting and evaluating wildlife sightings along the access road and airstrip, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered;
- Report annual updates and results of the Wildlife Mitigation and Monitoring Plan, Controlled Road usage, and inspections and enforcements; and
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road, to allow them to move away.

All general mitigation measures proposed are summarized in Section 6.10.

The predicted effects on wildlife distribution and abundance in NNPR is summarized in Table 6-5.

Table 6-5: Project Effects on Predicted Species Distribution and Abundance

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Northern Mountain Caribou	Both	Adverse	Low	Moderate	Moderate	Low	Moderate	Moderate
Moose	Both	Adverse	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Dall's Sheep	Both	Adverse	Low	Moderate	Moderate	Moderate	Moderate	Moderate
Mountain Goat	Both	Adverse	Low	Moderate	Moderate	Low	Moderate	High
Grizzly Bear	Phase 1	Adverse	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Trumpeter Swan	Both	Adverse	Moderate	Moderate	High	Moderate	Moderate	Moderate
Harlequin Duck	Phase 1	Adverse	Moderate	Low	Moderate	Low	Moderate	High
Common Nighthawk	Both	Positive	Low	Low	Moderate	Moderate	Moderate	Moderate
Olive-sided Flycatcher	Both	Positive	Low	Low	Moderate	Moderate	Moderate	Moderate
Overall Significance								
Moderate								

Measureable parameters are the number of key species (e.g., Grizzly Bear, Dall's Sheep, Moose, Trumpeter Swan) recorded along the all season access road and airstrip (similar to the camp logs) to assess the percent occupancy of species. Parks Canada (2009) uses a similar approach to monitoring Grizzly Bears observed by park visitors. This approach does not provide a measure of relative abundance, but it does provide a relative index of distribution and the number of human-wildlife encounters. In addition, the annual traffic volume reported at the check-point provides a relative measure of disturbance levels.

Confidence in this assessment is moderate since the level of non-Project related traffic is unknown but assumed to be restricted to a few local subsistence harvesters. Overall, low residual effects are anticipated.

6.4 Effects on Vegetation Species Distribution and Abundance

As significant effects to the relative abundance of terrestrial ecosystems within the NNPR are not anticipated as a result of the project, it can be reasonably assumed that the distribution and abundance of characteristic or 'common' vegetation species associated with these habitats are not likely to be significantly affected by project activities. However, populations of rare plants, which can be characterized by limited spatial distribution, limited size and/or limited densities, can be particularly vulnerable to disturbance.

Based on the results of an NWT ENR virtual herbarium database search, 16 vascular plants species, one lichen species and 13 bryophyte species currently ranked as 'may be at risk'; one vascular plant species ranked as 'sensitive' and one vascular plant species ranked as 'undetermined' by the NWT General Status Ranking Program have been historically identified within a 50 km radius of the CZN study area, the closest occurrence being located 5 km from the CZN study area.

Of the species identified as part of the ENR database search, two species (Nahanni aster and Raup's willow) are currently considered globally imperiled (G2 global status ranking – NatureServe 2014) and one species (Velenovsky's hilpertia moss) is considered critically imperiled (G1 global status ranking – NatureServe 2014), the closest occurrence of these species being located approximately 20 km from the CZN study area.

Rare plant surveys related to the Prairie Creek Mine Project and associated winter access road were initiated by EBA on behalf of CZN in July 2009, and further surveys were completed in August 2010 (EBA 2010; 2011).

In July 2009, rare plant surveys were conducted along the Prairie Creek Mine winter road; the proposed waste rock storage facility; and the area around camp and the beaver pond to the south.

A total of 340 plant observations, representing 193 species and 44 families of vascular plants, were documented during the 2009 field survey. No plant species listed within the federal SARA were observed in the surveyed areas. However, one plant species, few flower meadow rue (*Thalictrum sparsiflorum*), listed as 'May Be At Risk' (ENR 2014b), was documented along the Prairie Creek winter road and an adjacent wetland. As the species appears locally abundant within the study area, conversion of the winter road to an all season access is unlikely to threaten the viability of this species locally, considering confirmed observations were identified outside of the proposed development footprint.

Two additional plant species ranked as 'May Be At Risk' by the ENR were identified along the existing winter access road (Hornemann willowherb *Epilobium hornemanni* and linear-leaved willowherb *Epilobium leptophyllum*), have restricted distribution in the NWT with limited known occurrences, but are globally secure (Golder 2010). Six plant species ranked as 'Sensitive' by the ENR—alpine anemone (*Anemone drummondii*), bog birch (*Betula pumila*), lesser black-scaled sedge (*Carex atrosquama*), one-glume spike rush (*Eleocharis uniglumis*) alpine groundsel (*Packera pauciflora*) and yellow mountain heather (*Phyllodoce glanduliflora*) — identified adjacent to the Prairie Creek winter road have small regional distributions in the NWT with a small number of known occurrences, but are globally secure. It was concluded that impacts to these local occurrences

(and potential additional occurrences near the access road) can be avoided or reduced by limiting the amount of additional land disturbance for upgrades and operation of the all season access road.

In August 2010, the proposed Polje By-Pass re-alignment was surveyed for unique or important vegetation communities and rare plants. The habitat in which the proposed Polje By-Pass re-alignment traverses was burned by a forest fire in 1996. The vegetation community now comprises a jack pine regeneration stand approximately 14 years old. No rare plants or sensitive habitats were documented within the jack pine regeneration along the proposed Polje By-Pass alignment. It was concluded that this proposed re-alignment would not threaten rare plants or sensitive vegetation communities (EBA 2011).

Based on the findings of the ENR database search and results of the rare plant surveys conducted, the extent, magnitude, duration and frequency of potential project related effects to rare plant species resulting from conversion of the approved winter access road to an all season road are characterized as low and reversible. The overall significance of effects to rare plants within the NNPR is considered low. No residual effects to rare plants are anticipated assuming appropriate application of mitigation strategies related to indirect project effects resulting from dust generation, spills and the introduction of invasive species.

6.5 Effects from Invasive Wildlife Species

Invasive wildlife species are non-native species introduced into areas beyond their natural range by humans and are capable of causing harm to the environment and outcompeting native species. To date, there are no known invasive wildlife species present in the NWT.

However, alien wildlife species, are native species that have been introduced beyond their natural ranges due to their natural dispersal from surrounding provinces or territories. Example alien wildlife species to the NWT include the House Sparrow (*Passer domesticus*) and European Starling (*Sturnus vulgaris*).

Alien wildlife species, such as the House Sparrow and European Starling, expand their distributions into new ranges and out-compete desirable native wildlife. Preferred House Sparrow habitat includes human settlements in which it remains year round. House Sparrows are reported in the communities of Fort Simpson and Fort Liard; however, there are no known reports in Nahanni Butte and the NNPR (Sullivan et al. 2009). House Sparrows are known to outcompete native bird species from suitable nest sites. Similarly, the European Starling, preferring to remain year round, occurs in and near human settlements with a component of open, grassy areas. They are relatively aggressive birds and outcompete for nesting cavities. One European Starling was observed near Rabbitkettle Lake inside the NNPR, and there have also been a few observations near the communities of Fort Liard and Fort Simpson (Sullivan et al. 2009).

Construction of the approved winter access road may already increase the range extension of invasive wildlife species such as the House Sparrow and European Starling into areas not currently occupied (or assumed to not be occupied). The winter access road will be cleared at least 2 years prior to the construction of the all season access road; therefore, the all season access road will not pose any additional adverse effects to native species from the expanded distribution of alien wildlife.

Potential effects from invasive wildlife species as a result of the all season access road and its associated infrastructure and activities will remain similar to baseline winter road conditions. Mitigation measures are not considered necessary, beyond the general mitigation and best management practices (refer to Section 6.10).

Confidence in this assessment is high since the all season access road route will be cleared and alien wildlife (e.g., European Starling) has already been recorded inside the NNPR. Overall, predicted effects from alien wildlife species expansion into the NNPR on boreal forest birds is negligible to low. No residual effects are anticipated.

6.6 Effects from Invasive Vegetation Species

Invasive plants have the ability to aggressively establish and quickly spread in new environments. These adaptations coupled with their ability to out compete native species can affect plant species richness, diversity, and the composition and function of affected natural ecosystems (Haber 1997). The successful introduction and colonization of an area by invasive plant species relies, in part, on the presence of suitable habitat, access to a source of invasive plant material, and a means of dispersal.

The disturbances associated with development projects can unintentionally create growing conditions that facilitate the successful establishment of invasive plants. Exposed soil resulting from the removal of plant cover is particularly susceptible to colonization. Dirty equipment transported to site from other areas can act as a dispersal mechanism for invasive plant propagules that may have become lodged in tires and mud.

The most effective management of invasive plants is preventing their establishment into an area (Carlson and Shephard 2007; Schrader and Hennon 2005; USDA 2006; Polster 2005; Clark 2003). Removal once established is more costly and can be particularly challenging logistically in more remote northern areas.

In August 2010 EBA completed an invasive plant survey and reclamation assessment along the existing Prairie Creek Mine access road, and a rare plant survey along the proposed and now approved road re-alignments (EBA 2011). Surveys were conducted from August 9 to 13, 2010. The study area for these surveys included that section of the access road occurring within the boundaries of the expanded Nahanni National Park Reserve.

No invasive alien plant species were documented along the portions of the access road surveyed; consequently, they are not believed to be an issue at this time.

The Prairie Creek Mine site and existing winter access road have been in place since 1982, and Mine-related heavy equipment is already on site. In the future, any new equipment would be brought in along the access road on trucks or tractor trailer units. Similarly, Mine supplies and fuel will be brought in along the access road. Invasive plants are usually brought into a site (or along an access road) through dirty vehicles or heavy equipment operating during the non-winter period, when seeds of invasive plants can more readily be mixed with mud or dirt on vehicles or equipment, and then fall off along a road way or at a work site.

The risk of invasive species introduction during the construction and operation of Phase 1 (which occurs within the NNPR) of the all season access road will be minimal, as all equipment and vehicle traffic associated with this phase of the project will be brought into the site during the winter months. Operations during the summer construction season would be within a closed system, which is the time period that is most conducive to the spread and establishment of invasive species. The risk of invasive species introduction will increase upon completion of Phase 2 of the project which would allow for the transport of vehicles and equipment during the summer months, and thereby increase the potential for transport of invasive species into the study area. It is recommended that an invasive species management plan be developed prior to project construction to determine appropriate best management practices with respect to the prevention of invasive species establishment and invasive species control. The invasive species management plan should be developed in consultation with applicable stakeholders to ensure proposed mitigation efforts comply with existing regulations which may potentially limit the application of specific invasive species control measures (e.g. use of herbicides in National Parks).

The use of seed mixes for re-vegetation of disturbance areas may also introduce invasive species. Given this risk, CZN's approach (as defined in EA0809-002) for re-vegetation of disturbed areas will rely primarily on encroachment of native species from surrounding vegetation communities.

Given the low anticipated traffic volumes anticipated for the all season road and the application of additional mitigation strategies (which should include an invasive species management plan) the extent, magnitude, duration and frequency of potential effects from invasive species introduction are considered low and reversible.

Overall, the significance of effects from invasive plants is expected to be low. No residual effects are anticipated assuming the appropriate application of mitigation strategies

6.7 Effects on the Ability of Wildlife Species to Recover

Effects at individual and wildlife population levels are known to incur with increasing human developments and activities. Habitat loss and fragmentation, changes to movements and behaviour, and mortality are key examples of development-related effects that, if significant, have the potential to adversely affect the condition of species.

Minimizing habitat loss and fragmentation and avoiding sensitive wildlife areas and unique landscapes identified by the Naha Dehe Dene Band and Parks Canada were fundamental in the routing design of the winter road, and thus the all season access road. Similarly, limiting Project-related disturbances and traffic-wildlife encounters are inherent in the Project operations design. Wildlife-Project encounters, which have the potential to alter wildlife movements and increase mortality, are anticipated to occur most intensely during the construction and operation phases. At Project closure (approximately six years after Mine closure), Project-related wildlife encounters will be significantly reduced and habitats will be recovering, permitting the recovery of species populations.

Species, such as Grizzly Bear and Northern Mountain Caribou that have large annual ranges, low reproductive rates, and/or have specialized needs are often considered to have low ecological resilience and are less likely to recover from unacceptable effects (Salmo Consulting Inc. et al. 2004). A certain level of available habitat is required to maintain viable populations in a given land base. Grizzly Bears are believed to require at least 1,000 ha of available habitat (minimum patch size) (Salmo Consulting Inc. et al. 2004).

Grizzly Bears are known to have relatively low resilience (COSEWIC 2012). In NNPR, an expansive area that is predicted to support high to very high Grizzly Bear densities occurs approximately 25 km north of the all season access road (Weaver 2006). This area was suggested to be particularly important to support a viable grizzly population. Parks Canada estimated that 665 Grizzly Bears are currently present in the NNPR, and suggest 500 bears are required to maintain a viable population (Parks Canada et al. 2009; Weaver 2006).

Northern Mountain caribou have relatively low reproductive rates, are forage specialists, and have relatively high calf mortality. The proposed all season access road and airstrip are located outside the defined range of the caribou herds occupying NNPR. ENR (2014) explained that “trace occurrences” of Northern Mountain caribou are known in the area east of the Mine site to the Nahanni Range. Consequently, the all season access road is not located within a core caribou area. The proposed Project will not affect the ability of Northern Mountain caribou herds to recover as only a small portion of the herd is expected to be infrequently exposed to the proposed Project.

Species such as Moose respond quickly during habitat recovery, as twin births are common after forest fires or human disturbances (e.g., clear-cuts). Forest renewal after habitat disturbance and natural fire cycles will promote Moose recovery.

Other species, such as small mammals, have the highest ecological resilience as they mature early, have high reproductive rates, and are habitat and/or food generalists (Salmo Consulting Inc. et al. 2004).

The proposed all season access road will include a 4 km re-alignment within the boreal forest zone and an additional 4 km re-alignment in the Nahanni Plateau subalpine tundra (plus an additional 1 km outside park boundaries). Although the proposed all season access road may directly affect 4 km of boreal forest bird habitat within the NNPR, only a fraction of the regional populations will be exposed to the Project-related habitat loss and activities, and adverse

Project-related encounters as a result of traffic are considered inconsequential at the population level. Therefore, the Project is not anticipated to change the ability of boreal forest bird species present within NNPR to recover.

Trumpeter Swans have a relatively low resilience since they will not re-nest if a clutch is lost, have specific breeding and staging habitat requirements, and delayed maturity (ESRD 2013). The proposed all season access road mainly avoids wetlands and ponds, particularly those in the Tetcela River valley where breeding Trumpeter Swans concentrate. However, the access road alignment runs adjacent to the shoreline of Mosquito Lake, where "a few swans" (assumed to be Trumpeter Swans) were observed during the June 2006 aerial survey. Any Trumpeter Swan potentially breeding at this lake, and any other large pond within approximately 500 m of the all season access road, may be adversely disturbed by Project activity. Since Trumpeter Swans are territorial during the nesting season, it is likely that a single pair will occupy a breeding lake (ESRD 2013); therefore, minimizing the number of individuals affected for a given wetland disturbance. Although the proposed all season access road may affect a few Trumpeter Swans, it is not expected to adversely alter their ability to recover since the proposed road routes at least 500 m away from most core breeding ponds.

Potential Harlequin Duck nesting habitat is extremely limited near the proposed all season access road. Although Harlequin Ducks and their habitat are particularly sensitive to human-related disturbances, the likelihood of their occurrence near Project-related activities is low.

At a landscape level, species that occur in isolation from other larger populations are less resilient, have less ability to recover, and are less likely to persist over time. The long term maintenance and viability of a population is a balance between individuals removed from a population (e.g., dispersal, mortality) and those introduced (e.g., immigration and birth) (AXYS 2001).

Although infrequent, Dall's Sheep dispersal to new ranges has been reported, particularly involving young rams, although adult ewes have also been documented dispersing (Simmons 1982). Dall's Sheep occupying the Nahanni Range and Ram Plateau are spatially isolated from larger populations on the Nahanni Plateau and Mackenzie Mountains; however, infrequent dispersal is anticipated.

Similarly, The Ragged Range near the Yukon border was identified as core Mountain Goat range; however, smaller discontinuous, occupied areas exist along the South Nahanni River (Wilson and Haas 2012). Although Mountain Goats were not observed during the Prairie Creek Mine and access road aerial surveys, defined Mountain Goat range near the all season access road occurs along the Nahanni Range as well as further north onto the Ram Plateau and south onto the Headless Range. Mountain Goats, primarily juvenile males have been reported dispersing up to 93 km. Mountain Goats possibly occurring on the Nahanni Range and Ram Plateau are not completely isolated from the other populations along the South Nahanni River, and dispersal likely occurs.

Possible dispersal corridors for Dall's Sheep and Mountain Goats are unknown; however, preferred routes of travel may include the South Nahanni River and creeks with suitable canyons and steep topography. Nonetheless, the all season access road mainly travels parallel to potential dispersal corridors, and is not expected to impede dispersing individuals. In addition, low traffic volumes will be maintained which should minimize wildlife-vehicle encounters during operations.

Mitigation to possible changes in species ability to recover have been incorporated into the design of the all season road and its operations by routing it in direct association with the winter road, re-aligning around important wetlands and wildlife areas (where possible), and maintaining low traffic volumes. The following additional mitigation is proposed:

- Strict use of CZN's Controlled Road Use Plan to minimize traffic and other disturbances and maintain low speed limits;

- Prohibit pumping water from ponds occupied by Trumpeter Swans during the nesting period;
- Educate staff and contractors on CZN's wildlife policies; and
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so, particularly when in convoy) for all wildlife seen on or immediately adjacent to the road, to allow them to move away.
- Discuss main issues and considerations regarding wildlife populations and effects during the Technical Advisory Committee meetings proposed by CZN in EA0809-002; and
- Report annual updates and results of the Wildlife Mitigation and Monitoring Plan, Controlled Road usage, and inspections and enforcements.

All general mitigation measures proposed are summarized in Section 6.10.

The predicted effect from the proposed all season access road on wildlife species' ability to recover, after mitigation is applied, is summarized in Table 6-6.

Table 6-6: Project Effects on Predicted Ability of Wildlife Species to Recover

Species	Road Phase(s)	Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Certainty
Northern Mountain Caribou	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Moose	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Dall's Sheep	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Mountain Goat	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Grizzly Bear	Phase 1	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Trumpeter Swan	Both	Adverse	Moderate	Moderate	High	Low	Moderate	Moderate
Harlequin Duck	Phase 1	Adverse	Moderate	Low	High	Low	Moderate	High
Common Nighthawk	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Olive-sided Flycatcher	Both	Adverse	Low	Moderate	High	Low	Moderate	Moderate
Overall Significance								
Low								

Confidence in this assessment is high since the proposed all season access road is not located in core habitat, traffic volumes are low, and access control will be implemented. A measurable parameter is the number of key species (e.g., Grizzly Bear, Dall's Sheep, Moose, Trumpeter Swan) recorded along the all season access road to assess the percent occupancy of species. This approach does not provide a measure of relative abundance, but it does provide a relative index of distribution and the number of human-wildlife encounters. In addition, the annual traffic volume reported at the check-point provides a relative measure of avoidance.

With adherence to mitigation, there are no residual effects restricting the recovery of species.

6.8 Effects on the Ability of Habitat to Recover

It is understood that the all season access road will be reclaimed within six years of the closure of the Prairie Creek Mine site. As part of the reclamation objectives for the project, it is anticipated that re-vegetation of the roadway, borrow sources and other disturbances associated with the development of the all season access road will occur primarily through encroachment of native species from surrounding vegetation communities.

A reclamation assessment of the original winter road was conducted by EBA (EBA 2011) to assess the progress of natural reclamation (re-vegetation) of the roadway. Based on the findings of the assessment, it was determined that natural re-vegetation of the roadway was occurring and species composition on the roadway was reflective of species present in adjacent undisturbed habitats. Given the similarity of habitats between the original winter access road and the proposed all season access road, it can be reasonably assumed that reclamation of disturbances along the proposed all season access would progress along a similar trajectory as the original winter road, assuming efforts are made to re-establish and/or maintain conditions on disturbed sites that are conducive to the re-establishment of native vegetation species.

As part of the DAR prepared for the approved winter road access, CZN has committed to constructing road infrastructure in accordance with standard industry best practice, including guidelines described in the *Northern Land Use Guidelines: Access Roads and Trails* (INAC 2008). It is anticipated that adherence to such practices will assist natural re-vegetation and re-establishment of disturbed habitats within the project area. All best management practices, including the salvage of topsoil, erosion control measures, and the maintenance of the existing hydrological regimes (using appropriately placed culverts or other methods) should be determined prior to construction.

Assuming adherence to standard industry best practices during construction, the extent, duration and frequency of potential project related effects to the ability of disturbed habitats to recover are considered low and reversible.

Overall, the significance of effects is expected to be low. No residual effects are anticipated assuming the appropriate application of mitigation strategies.

6.9 Ecosystem Functioning – Wildlife and Vegetation

Tetra Tech's scope of work for this assignment was limited to the assessment of potential project related effects to wildlife and vegetation resources, including potential effects to these resources within the confines of the NNPR. As such, discussion of potential effects to ecosystem functioning within the NNPR as part of this report is limited specifically to wildlife and vegetation considerations.

The preceding sections detail the assessment of potential project related effects to specific facets of ecosystems within the NNPR as they relate to wildlife and vegetation, including potential ecosystem effects pertaining to habitat loss, habitat fragmentation, species distribution and abundance, invasive species and the ability of habitats/species to recover from potential project related effects. The significance of effects for all for these ecosystem considerations was determined to be low to moderate, while residual effects were not anticipated or could be managed with appropriate mitigation strategies.

Given the low significance of project related effects to individual wildlife/vegetation considerations examined as part of the NNPR effects assessment and the high probability of successful management of residual effects associated with proposed project development, the significance of effects to the overall function of ecosystems as they pertain to wildlife and vegetation within the NNPR is considered low, assuming adherence to applicable mitigation strategies.

6.10 Nahanni National Park Reserve Mitigation and Best Management Practices

During EA0809-002, the original winter access route was optimized to reduce environmental and logistical risks. With direct consultation with the Naha Dehe Dene Band and Parks Canada, four re-alignments were included in the revised and approved winter road route to avoid unique karst terrain and areas considered sensitive to wildlife. Therefore, mitigation has effectively been applied to limit impacts, including direct and indirect habitat loss, disturbance to wildlife, and mortality within NNPR at the design stage.

The Nahanni National Park Management Plan (Parks Canada 2010) seeks opportunities to maintain the quality of the land, water, air, and wildlife, while expanding visitor experience and encouraging the discovery of NNPR by visitors and respecting traditions and cultural values. This park plan recognizes the Prairie Creek Mine and its access road within the NNPR expansion area, and provides mitigation to minimize potential effects to wildlife from the road (e.g., access control) as well as park-related activities involving potential visitor disturbances, trail development, and aircraft disturbances.

Besides the general mitigation and best management practices outlined in Sections 5.0-7.0, mitigation specifically outlined to avoid and/or minimize effects to the Nahanni National Park Reserve from Project-related construction, operation, and closure is provided:

- Adherence to standard industry best practices during construction;
- Strict use of CZN's Controlled Road Use Plan to minimize traffic and other disturbances and maintain low speed limits;
- Prohibit pumping water from ponds occupied by Trumpeter Swans during the nesting period;
- Snow removal practices along the access road to manage high snow banks, so that wildlife can readily move off the roadway as vehicles approach;
- Educate staff and contractors on CZN's wildlife policies;
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so, particularly when in convoy) for all wildlife seen on or immediately adjacent to the road, to allow them to move away;
- Discuss main issues and considerations regarding wildlife populations and effects during the Technical Advisory Committee meetings proposed by CZN in EA0809-002;
- Report annual updates and results of the Wildlife Management Plan, Controlled Road usage, and inspections and enforcements;
- Reporting and evaluating wildlife sightings along the access road and airstrip, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered;
- Hunting, trapping, harvesting, and fishing by site employees and contractors will be prohibited;
- Managing the small portion of the winter road not used for the all season access to prevent predator and non-Project related travel of the corridor, if necessary;
- Pets will be prohibited along the access road; and
- The appropriate regulatory agencies (i.e., GNWT ENR and Parks Canada) will be contacted to receive additional direction regarding new issues that arise.

7.0 EFFECTS ASSESSMENT – OTHER WILDLIFE AND WILDLIFE HABITAT, VEGETATION

7.1 Other Wildlife and Wildlife Habitat

In CZN's application for an all season road, two phases of development are proposed: Phase 1 all season road use from the Mine to the TTF; and Phase 2 all season road use from the TTF to the Liard Highway. The two phases combined represent the entire road application. However, the road bed from the Mine (KP 0) to KP 39 (Cat Camp) is already of all season quality. In addition, Cadillac's road LUP provided for all season use of that section.

An effects assessment has been prepared for the Prairie Creek Mine and new winter road route (Golder 2010; CZN 2010), that is highly relevant as a basis for consideration of any possible changes to predicted effects resulting from converting the existing winter access road to an all season road. Therefore, this all season access road effects assessment is consistent with the approach previously employed by CZN (2010) and Golder (2010), with the assessment of wildlife and wildlife habitat, and vegetation, including species at risk valued components.

This section of the effects assessment focuses on species that have not already been evaluated in the effects to traditional harvesting and traditionally harvested species, and to Nahanni National Park Reserve. These include:

- Collared Pika
- Wood Bison
- Little Brown, Northern, and Western Long-eared Myotis
- Horned Grebe
- Yellow Rail
- Short-eared Owl
- Peregrine Falcon
- Barn and Bank Swallows
- Rusty Blackbird
- Western Toad

Based on the TOR, the assessment of environmental impacts and cumulative effects are to focus on impacts to traditional harvesting and traditionally harvested species, effects of potential accidents and malfunctions, and impacts to Nahanni National Park Reserve. The TOR indicates these key lines of inquiries are considered topics of greatest concern. Outside of these key lines of inquiry, the following subjects of note (*Effects Assessment – Other*) may be assessed at a moderate level.

The TOR identified the following key objectives to describe and evaluate potential effects of the all season access road on other wildlife and wildlife habitat, including species at risk (EA1415-01):

- Methods to minimize Project effects on species including the strategies for mitigation and monitoring;
- Direct and indirect alteration of habitat including direct road footprint impact;

- Visual or auditory disturbance, including habitat avoidance and effective habitat loss in relation to all season road facilities or activities;
- Effect of construction and pre-construction activities;
- Wildlife mortality due to increased harvesting and vehicle collisions;
- Disruption of sensitive life stages or habitat (e.g., migration, breeding, calving, denning, overwintering);
- Wildlife movement patterns and corridors, home ranges, distribution and abundance;
- Effects to sensitive or important areas or habitat;
- Habitat fragmentation;
- Effects to population cycles;
- Effects to predator-prey relationships;
- Attraction of predators to birds and bird eggs;
- Increased human-wildlife conflicts (e.g., bear encounters);
- Mortality from collisions with temporary or permanent structures and wires;
- Potential disturbance to raptors nesting within 1 km of the proposed project footprint;
- Use of the project area by resident and migratory birds protected by the *Migratory Birds Convention Act,* 1994;
- How road-related changes in harvest pressures could impact the resource;
- Ability of habitat or species to recover;
- Response to edge effects; and
- Invasive species (vegetation and wildlife).

The following section follows the effects assessment steps summarized in Sections 4.1, 7.3.6, and 7.3.8 of the MVEIRB TOR for the Prairie Creek All season road.

7.1.1 Effects from Direct and Indirect Habitat Loss and Alteration on Other Wildlife

The proposed upgrades from the approved winter road to the all season access road and alternate airstrip require an additional footprint of approximately 70.96 ha (includes an additional 18 ha for the access road realignments, 45.34 ha for borrow sources and their access roads, and 7.62 ha for the airstrip). This is considered a relatively small area in the context of the existing winter road and the common habitats that occur in the region (Golder 2010). The additional clearing for the proposed all season road will include 4 km in Phase 1 and 5 km in Phase 2.

The proposed all season road has been re-aligned to avoid sensitive karst terrain, lowlands, wetlands, and ponds, as much as possible, which have the potential to support several species at risk. Consequently, direct impacts to Little Brown Myotis, Northern Myotis, Western Long-eared Myotis, Horned Grebe, Yellow Rail, Rusty Blackbird,

and Western Toad habitat have already been considered and avoided to the extent possible. Bats may overwinter, in hibernaculas in the karst terrain. Hibernacula are critical habitats, and are reused annually.

Bats are most sensitive to disturbance while overwintering. Traffic along the all season access road will continue through the winter, during bat overwintering periods; however, their disturbance from noise, vibration, and visual disturbances during this time will be negligible. COSEWIC (2013) indicates that noise from road disturbances deter foraging bats; however, the severity and disturbance distances are unknown. In both Manitoba and Newfoundland, a 200 m buffer between developments and known hibernacula have been recommended (COSEWIC 2013). Although no bat hibernacula are known near the all season access road, potential habitat such as the karst terrain, are a minimum of 350 m from the already permitted winter road route and airstrip. Not all karst terrain (including caves) provide suitable overwintering bat habitat, nor are all suitable overwintering habitat occupied by overwintering bats.

Indirect impacts to birds and bats from road dust and noise are relatively unknown. However, effects attributed to road dust are typically less than 10 – 20 m from the road, but may extend into habitats 100 m downwind depending on the adjacent landscape and habitat types (e.g., open wetland or pond). Similarly, airborne dust from the access road has the potential to alter Western Toad habitat. Introduced fine sediment into roadside ditches and nearby ponds has the potential to increase water turbidity and possibly degrade the habitat by inhibiting aquatic plant growth and macro-invertebrates, and altering water pH (Forman and Alexander 1998). Habitat alteration effects are considered low in magnitude and local in extent.

The sensitivity of boreal forest birds to noise, human presence and activities is relatively unknown, but some songbird species are thought to be negatively affected by noise. Human-induced noise may mask communication calls; consequently, some species may avoid nearby habitats. Some species remain in these habitats in lower densities, and may have lower nest success or productivity as a result (AMEC 2005).

Collared Pika habitat is naturally fragmented, with selective preference for boulder fields edged by alpine meadows. Suitable Collared Pika habitat exists in small isolated patches within the first 36 kilometres from the Mine site of Phase 1 of the all season access road. Much of this entire 36 km length of the all season access road exists as all-season quality from former construction and directly follows the new winter road route, which was already approved in EA0809-002. To upgrade the proposed all season road, a new 4 km length section is proposed. This road section and seven preferred borrow sources have the potential to affect Collared Pika habitat, particularly since Collared Pikas were observed and/or heard in talus between Phase 1 KP 15 to 22.

Since a relatively small length of access road will be constructed and Collared Pikas do not occupy all suitable talus habitat within their known range and remain within 10 m of the talus (except during dispersal in July), few Collared Pikas are expected to directly interact with the all season access road and possibly two borrow sources. The new section of access road is to avoid a stretch of boulder fields, but Collared Pikas habitat may occur at the proposed borrow sources (BP 14 and 16).

Although pikas do not hibernate, they remain under the protective and insulating cover of snow during winter. During the snow-free period (e.g., late spring, summer, and fall), a small number of collared pikas may be exposed to and disturbed by localized noise or traffic along the road. Similarly, collared pikas may be expected to forage along the road edge. Pika attempts to cross the road would be uncommon as pikas primarily remain within 10 m of protective cover (the road width itself is less than 10 m wide); however in July, juveniles dispersing from their natal territory may be infrequently exposed to vehicle traffic. The Phase 1 portion of the all season access road has the potential to directly and indirectly affect a few collared pikas that might occur near the road throughout construction, operation, closure, and reclamation phases.

The main way that the all season access road and associated infrastructure and activities may directly and indirectly effect Collared Pika habitat is through direct habitat loss at two borrow sources (BP 14 and 16), widening of the existing road, and changes in the late spring, summer, and fall daily movements including habitat avoidance and disturbance during operations. Direct and indirect habitat loss effects are considered moderate in magnitude and low in geographical extent and duration, as not all Collared Pika habitat remains occupied. The number and frequency of such exposures would be expected to be moderate and periodic. Overall significance is moderate. Confidence in this assessment is moderate due to the existing access road present within Collared Pika range, previous records of Collared Pikas near the road, and the inherent behaviour of pikas to remain within 10 m of the talus for protective cover.

Wood Bison may be sensitive to disturbance, particularly during the calving and post calving season (approximately April to August), and may be wary of human activities particularly the harvested herds. Nevertheless, Wood Bison are known to become habituated to traffic and human activities, and are known to enter Nahanni Butte. While in communities and other development areas, Wood Bison come into conflict with people and may damage property and become a safety hazard to people.

Wood Bison encountering the proposed all season access road may show minor displacement behaviour and move away from the immediate area. The construction phase, in particular, is expected to generate some degree of disruption, at least temporarily. The duration of exposures during construction are expected to be low, perhaps lasting a few minutes to a few months, and are reversible upon cessation of the activity or by moving away from the activity. Visual and noise disturbances from the access road and associated facilities are considered to be low in magnitude, local in extent, and reversible upon cessation of the activity or by moving away from the activity. The number and frequency of such exposures would be expected to be moderate and periodic. Confidence in this assessment is high since Wood Bison are considered very tolerant of traffic and land use working zones.

No direct loss of preferred Peregrine Falcon and Short-eared Owl nesting habitat is expected as a result of the 8 km of the proposed clearing activities. Peregrine Falcons are known to tolerate a moderate level of human-disturbances; however, breeding individuals not habituated to human activity may be affected by disturbances near the nest site. The nearest potential cliff nesting habitat to the proposed all season access road is in the karst terrain in Phase 1. Short-eared Owls may infrequently occur in the all season access road to feed during the construction, operation, and closure phases, and may conceivably be disturbed by localized vehicle traffic or aircraft noise and activity. Short-eared Owls are sensitive to disturbance during nesting, and may abandon nests as a result. However, they are irruptive breeders to the area and not anticipated to occur every year.

Golder (2010) considered mitigation for clearing the restricted access road and transfer facility footprint unnecessary. Similarly, reducing traffic volumes to the extent possible reduces the potential for Project-related indirect habitat loss effects. To mitigate project-related wildlife disturbances, measures in effect for the winter road will be maintained throughout construction, operation, and closure. Of those mitigation measures, those most noteworthy and specific to reducing Project-related disturbances to wildlife include:

- Strict use of CZN's Controlled Road Use Plan and Waste Management Plan to minimize traffic and other disturbances, maintain low speed limits, as well as to limit wildlife attractants;
- Surveying for and reporting the presence/absence of Collared Pikas (ranked as May Be At Risk in the NWT) at borrow sources BP 14 and 16 prior to Project-related disturbances, and consider additional mitigation should pikas be present;
- Reporting and evaluating wildlife sightings along the access road, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered;

- Snow removal practices along the access road to manage high snow banks, so that wildlife can readily move off the roadway as vehicles approach; and
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road to allow them to move away.

All general mitigation measures proposed are summarized in Section 7.1.7.

Overall, direct habitat effects as a result of the all season access road and its associated infrastructure are expected to be negligible to low in magnitude, local in geographic extent, reversible upon closure, and of low significance. Construction of the all season road, in particular, is expected to generate the greatest degree of disruption, at least temporarily, and infrequent disruption is expected during operations and closure. The disturbance from or avoidance of the all season road and associated activities may disturb wildlife since species sensitivities to roads and traffic are not well documented, and not clearly known. However, daily traffic volumes are predicted to be low and below sensitive species known thresholds. The duration of exposures, including during construction, are expected to be low, perhaps lasting a few minutes to a few months, and are reversible upon cessation of the activity and at road closure. The number and frequency of such exposures would be expected to be low and infrequent.

Confidence in this assessment is high since the access road is proposed along the existing winter road, as much as possible, avoids sensitive habitats for several species at risk, and operations will remain similar to baseline winter road conditions. With adherence to mitigation, no adverse residual effects are anticipated.

7.1.2 Effects on Wildlife Movement, Distribution, and Abundance

Indirect consequences of Project-related disturbances can occur as a result of road/airstrip construction, operation, and closure. The proposed Project limits the intensity of any potential disturbance by minimizing habitat loss and fragmentation, manages low traffic volumes and speeds, and reduces the proximity to important habitats. For example, 5 km of the 9 km of additional clearing for the proposed all season access road avoids wetland habitat, which directly avoids disturbances to Horned Grebe, Yellow Rail, Barn and Bank swallows, Rusty Blackbird, and Western Toad, should they be present. The proposed all season access road and airstrip will not affect wildlife movement, distribution, and abundance at these locations since there is no direct habitat loss and species have relatively small home ranges.

Consequences of Project-related disturbances can occur as a result of road construction, operation, and closure, and can vary in frequency, magnitude, and severity depending on several factors including the species involved, individual animal, season, and gender.

Some species maintain the same territories year after year (e.g., Peregrine Falcon); however, their tendency to move their territory as a direct result of habitat modification and disturbances for most species are unknown. Conservative action to reduce the Project footprint and Project-wildlife encounters helps to counter these unknowns.

Road and airstrip construction can lead to the creation of habitat edges through otherwise continuous forest. It is these edges, that result from the approved winter road, that provide a conduit for Brown-headed Cowbirds (*Molothrus ater*), a brood parasite that lays its eggs in another species' nest to the detriment of the other species reproductive potential, to penetrate (at least 200 m from the edge) into forests. Similarly, bird predators (e.g., Short-eared Owls, Common Ravens) concentrate their scavenging and hunting activities at habitat edges. While hunting along the access road, Short-eared Owls may infrequently encounter traffic; however, Short-eared Owl populations fluctuate annually in size and distribution and are not expected to occupy much of the access road route.

Wood Bison may become indifferent to the traffic and human activities associated with the all season access road and the transfer facilities. Wood Bison form small herds throughout the year and occupy open habitats, such as roadways to detect approaching predators. The Prairie Creek Mine access road and transfer facilities likely support Wood Bison security habitat. Consequently, Wood Bison may select and gather near the proposed Project infrastructure.

General mitigation measures that are proposed include:

- CZN's Controlled Road Use Plan;
- Speed limits on the Prairie Creek All Season Road;
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road, to allow them to move away;
- An education program of wildlife related policies and mitigation to all Project employees and contractors, including a bear awareness program to ensure employees and contractors are informed of bears and other potentially dangerous wildlife and the level of risk;
- An alert system to warn personnel of Woodland Caribou and other sensitive wildlife in the local area by relaying sighting information to vehicles and equipment operators and on-site personnel;
- Wildlife record logs to be completed by all Project employees and contractors for all wildlife sightings (e.g., Dall's Sheep, caribou, Wood Bison, and carnivores) with respect to species, location along the access road, numbers observed, and reaction to road activity. If a problem area is identified, corrective measures will be considered.

With adherence to mitigation, effects to wildlife movement, distribution, and abundance as a result of the all season access road and its associated activities is considered negligible to low in magnitude, reversible upon cessation of the activity or by moving away from the activity, and a low likelihood of occurrence. No residual effects are anticipated. Confidence in this assessment is high since direct loss of available habitat as a result of the proposed all season access road is low (9 km), many species occur infrequently or in small territories away from road activities, and traffic levels and speeds will be low.

7.1.3 Effects on Predator-Prey Relationships

Effects on predator-prey relationships including but not limited to Grey Wolf, Boreal Caribou, Moose, and Dall's Sheep are discussed in Section 5.2.7. This section focuses on other wildlife species not already addressed in the key lines of inquiry effects assessments.

Wolves are the primary predator of adult Wood Bison; Grey Wolf and Black Bears target calves and juveniles. Although Wood Bison are preyed upon, Moose are considered wolves' preferred prey species considering they are a smaller and more manageable size than bison. By supporting higher predator densities, an increasing Wood Bison population may indirectly influence predation rates on Moose. Mr. Konisenta suggests that Moose numbers have declined partly due to the introduction of bison to the area.

Similarly, predator-prey dynamics may be altered after a forest fire or human disturbance (e.g., the all season access road). In particular, Wood Bison favour these early regenerating grass and forb habitats and respond with increasing populations, thereby, correspondingly increasing their predators' populations.

Predators may incidentally take Collared Pikas, the assessed birds (e.g., Horned Grebe), and Western Toads. Predators, such as Red Fox, Wolverine, Wolves, and bears have been known to source food from litter, people purposely feeding, and unsecured containments. As predators are attracted to human disturbances, their encounter rates with prey occupying nearby habitats also increase.

General mitigation measures proposed in Section 7.1.7 will lessen any potential predator-prey effects, although no specific measures are recommended. Effects predator-prey relationships for the species assessed in this section are considered negligible to low in magnitude, moderate in geographical extent, expanding beyond the operational life of the access road, but occurring infrequently. Confidence in this assessment is high since the all season access road route will be already cleared (except for 9 km). No residual effects are predicted as a result of the all season access road affecting predator-prey relationships.

7.1.4 Effects from Invasive Species

Invasive wildlife species are non-native species introduced into areas beyond their natural range by humans and are capable of causing harm to the environment and outcompeting native species. To date, there are no known invasive wildlife species present in the NWT.

However, alien wildlife species, are native species that have been introduced beyond their natural ranges due to their natural dispersal from surrounding provinces or territories. Example alien wildlife species to the NWT include the House Sparrow and European Starling.

Alien wildlife species, such as the House Sparrow and European Starling, expand their distributions into new ranges and out-compete desirable native wildlife. The preferred habitat of the House Sparrow includes human settlements, in which it remains year round. House Sparrows are reported in the communities of Fort Simpson and Fort Liard; however, there are no known reports within Nahanni Butte and the NNPR (Sullivan et al. 2009). House Sparrows are known to outcompete native bird species from suitable nest sites. Similarly, the European Starling occurs in and near human settlements that have a component of open, grassy areas, preferring to remain year round. They are aggressive birds and outcompete native species for nesting cavities. One European Starling was observed near Rabbitkettle Lake inside the NNPR, as well as a few observations near the communities of Fort Liard and Fort Simpson (Sullivan et al. 2009).

A potential effect of constructing the approved winter access road may be to increase the range of invasive wildlife species such as the House Sparrow and European Starling into areas not currently occupied (or assumed to not be occupied). The winter access road will be cleared prior to the construction of the all season access road (except for 9 km); therefore, the all season access road will not pose any significant additional adverse effects to native species from the expanded distribution of alien wildlife.

Potential effects from invasive wildlife species as a result of the all season access road and its associated infrastructure and activities will remain similar to baseline conditions since the winter road route will be cleared prior to construction of the all season road. Mitigation measures are not considered necessary, beyond the general mitigation and best management practices.

Beyond designing the all season access road to follow the already permitted winter road corridor, no further mitigation associated with habitat fragmentation and associated invasive species advancement is recommended.

The predicted effects to invasive wildlife is considered low in magnitude, moderate in geographical extent, expending beyond the operational life of the access road, but occurring infrequently. Confidence in this assessment is high since the winter road will already be cleared and alien wildlife (e.g., European Starling) has already been recorded in the region. No residual effects are predicted as a result of the all season access road affecting invasive wildlife species.

7.1.5 Effects on the Ability of Wildlife to Recover

Habitat loss and fragmentation, changes to movements and behaviour, and mortality are key examples of development-related effects that, if significant, have the potential to adversely affect the condition of the species. A species' ability to recover from significant decline depends on a variety of factors including the species:

- Inherent biological traits, such as home range size, reproductive potential, habitat specialist or generalist;
- Balance between population growth (e.g., immigration and birth) and decline (e.g., emigration and mortality); and
- Occurrence in isolation of core populations.

For instance, Wood Bison have a relatively high resilience to many forms of disturbance; however, they are threatened by disease and overharvesting.

Several of these assessed species occur in the area of the proposed all season access road at the northern extent of their range. Although available habitat exists and human-made threats to these species in the NWT are limited, their populations are ranked from Secure (e.g., Bank Swallow) to May Be At Risk (e.g., Yellow Rail). Recovery of these species populations are largely dependent upon threats faced across their annual range, outside the NWT. Therefore, their population recovery is critically dependent upon conditions outside the all season access road zone of influence.

Minimizing habitat loss and fragmentation and avoiding sensitive wildlife areas and unique landscapes identified by the Naha Dehe Dene Band and Parks Canada were fundamental in the routing design of the all season access road. Similarly, limiting Project-related disturbances and traffic-wildlife encounters are inherent in the Project operations design.

No Project-related effects are expected to significantly cause the assessed species populations to decline, and the Project is not anticipated to affect the ability of these species to recover.

Further descriptions on the ability of wildlife in the NNPR to recover are discussed in Section 6.1.4.

7.1.6 Risks of Wildlife to Direct and Indirect Mortality

Species discussed in this section are not traditionally harvested in the area of the all season access road. Refer to Sections 5.2.1 and 5.2.2 for mortality effects associated with harvesting and harvesting pressure.

The predominant risk to wildlife mortality is direct animal-vehicle/aircraft collisions, although the risk is low considering the low traffic speeds (average 30 km/hr) and/or traffic volume. However, species that occupy or are attracted to the Project, and those that occur in highest abundance along the road and airstrip are at greater risk of Project-related mortality. Species, such as Collared Pika, Horned Grebe, Yellow Rail, and Rusty Blackbird that maintain small territories, occur in low densities, or do not venture far from their protective cover have a low risk of Project-related mortality.

Pika abundance within suitable talus patches vary considerably both temporally and spatially (COSEWIC 2011). In 2012, Collared Pikas were reported near the all season access road, and may be present at proposed borrow sources BP 14 and 16. Construction-related disturbances at these proposed borrow sources and other talus fields along the all season access road may result in direct mortality. Potential mortality as a result of construction activities is considered moderate in magnitude, low in duration and geographical extent, and a moderate likelihood of occurrence without mitigation.

Traffic along the access road poses the greatest risk of mortality to Wood Bison, Short-eared Owl, and Western Toad. Since traffic volumes and TTF activities can be a disturbance, are predictable, but have no negative

stimulus associated with them, Wood Bison may become indifferent to the traffic resulting in an increased risk of mortality. The Wildlife Collision Prevention Program (2014) reports the highest risk of bison-vehicle collisions in the NWT occurs from August to November and from sunset to sunrise. Mortality of Wood Bison a result of the Prairie Creek Mine access road traffic is considered moderate in magnitude and duration, low in geographical extent, moderate in frequency, and a low likelihood of occurrence since traffic volumes and speed limits will be low.

Larter and Allaire (2007) indicated that the Nahanni Wood Bison herd is known to commonly swim across the Liard River to access important habitat on either side of the river, particularly at Swan Point (approximately 6 km downstream from the proposed all season access road barge crossing) and Muskeg and Kotaneelee rivers (at least 130 km upstream from the all season access road barge crossing). A few bison are known to drown annually during spring break up and peak discharge from the mountains (Larter and Allaire 2007). Known Liard River crossing locations are well up and down-stream from the all season access road barge crossing. Effects to bison mortality and/or avoidance/disturbance from wave action and/or human disturbances is not anticipated. In addition, the barge crossing location is situated on the Liard River approximately 1 km up-stream from a 90 degree bend, which would act to dissipate wave action from barge crossings during summer months.

Short-eared Owls may hunt along the all season road, particularly since low traffic levels are proposed. This increases their encounter rate with vehicles and therefore, risk of collision. However, since Short-eared Owls irregularly occur in an area (a single known observation was recorded near Nahanni Butte), their risk of mortality as a result of the proposed Project is considered negligible.

Similarly, bats may forage along the all season access road during the summer. The risk of bat mortality as a result of vehicle collisions from low traffic volumes and low speeds is low.

Western Toads are particularly susceptible to mortality from high traffic roads due to migration to breeding ponds and dispersal post-breeding. Western Toads are not known to strongly avoid roads or traffic, consequently increasing their risk to road mortality, particularly in the spring and fall near breeding ponds. Bouchard et al. (2009) reported a 6% mortality rate for Northern Leopard Frogs while crossing roads with very low traffic volumes (11 mean vehicles per hour) and a 28% mortality rate at higher traffic volumes (58 mean vehicles per hour). Traffic volumes along the proposed access road are anticipated to be low, below the thresholds identified for Northern Leopard Frogs.

Additional ways the all season access road and associated infrastructure and activities may affect wildlife are through increased predation risk, direct nest loss, and drowning from wave action caused by the proposed barge across the Liard River. Predators, such as Red Foxes, eagles, gulls, and Common Ravens may be attracted to litter along the road or by deliberate feeding by employees. Once in the area, these predators will prey upon resident species. This attraction of predators may lead to the indirect death of several species, including Collared Pikas, Wood Bison, Horned Grebe, and Short-eared Owl.

Barn and Bank swallows have the potential to be directly affected by nest loss. Besides using natural nesting substrates (e.g., soil banks along rivers and streams), these species favour nesting in buildings, bridges, and sand and gravel pits, and are at risk of accidental nest mortality. Both species are known to occur in the area, principally along the South Nahanni and Liard rivers; however, their risk to road-related mortality is relatively low.

Maintaining low traffic volumes, low speeds (average 30 km/hr), and having re-aligned the access road route away from sensitive wildlife areas, will minimize Project-related mortality effects. Additional mitigation proposed includes:

- Strict use of CZN's Controlled Road Use Plan and Waste Management Plan to minimize traffic and other disturbances, maintain low speed limits, as well as to limit wildlife attractants;

- Surveying for and reporting the presence/absence of Collared Pikas (ranked as May Be At Risk in the NWT) at borrow sources BP 14 and 16 prior to Project-related disturbances, and consider additional mitigation should pikas be present;
- Cease barging activities if Wood Bison are observed crossing the river near the barge location;
- Educate employees and contractors to avoid disturbance to nests;
- Reporting and evaluating wildlife sightings along the access road, and if a problem area is identified, corrective management options for traffic and Project-related activities will be considered; and
- Policy giving wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road, to allow them to move away.

All general mitigation measures proposed are summarized in Section 7.1.7.

With adherence to mitigation, direct and indirect mortality effects as a result of the all season access road and its associated infrastructure are expected to be negligible in magnitude, local in geographic extent, infrequent, reversible upon closure, and of low significance.

Confidence in this assessment is high since the access road is proposed as a low traffic-low speed road, avoids sensitive habitats for several species at risk, and species abundances are likely low in the immediate vicinity of the road. Project-related activities that potentially lead to mortality will be reversible following closure of the proposed road, and as such, no residual effects are anticipated as a result of project related activities.

7.1.7 Other Wildlife and Wildlife Habitat Mitigation and Best Management Practices

Mitigation to limit effects to wildlife has effectively been applied at the design stage by engaging with the Naha Dehe Dene Band and Parks Canada to avoid sensitive wildlife and unique karst terrain areas, reducing traffic volumes from the approved winter road levels, and maintaining low speed limits.

Additional general mitigation and best management practices considered for the proposed all season access road incorporate previous commitments for the approved winter access road (CZN 2010; Golder 2010, 2012). Mitigation measures to further avoid or reduce effects on wildlife along the proposed access road include:

- Provide the Dehcho Land Use Planning Committee (and others as requested) the post-construction digital footprint of the all season access road and associated facilities to incorporate into ongoing cumulative effects monitoring across the Dehcho.
- Surveying for and reporting the presence/absence of Collared Pikas (ranked as May Be At Risk in the NWT) at borrow sources BP 14 and 16 prior to Project-related disturbances, and consider additional mitigation should pikas be present;
- Implement a no hunting policy for all Project employees and contractors while working on or off-site for CZN;
- Strict use of CZN's Controlled Road Use Plan;
- Implement and enforce speed limits on the Prairie Creek All Season Road;
- Discourage use of engine retarder breaks;

- Develop a winter driving policy requiring tire chains to be used on haul trucks on the KP 0-29 and KP 96-102 sections to increase traction;
- Amend the existing draft Wildlife Mitigation and Monitoring Plan, as necessary, to include the monitoring of measureable parameters of effects;
- Implement a policy and train employees and contractors to give wildlife the right-of-way, which obligates drivers to stop (when safe to do so) for all wildlife seen on or immediately adjacent to the road, to allow them to move away;
- Develop standard aircraft procedures for flying into and departing from the proposed airstrip to accommodate wildlife, if present on or near the airstrip;
- Maintain a minimum flight altitude of 600 m during all times, except during take-off and landings;
- Follow dust suppression strategies (e.g., water or approved dust suppressant products) in accordance with the GNWT dust suppression guidelines;
- Follow the existing draft Contaminant Loading Management Plan and soil sampling along the road bed both before and during haul operations;
- Provide an education program for wildlife related policies and mitigation to all Project employees and contractors, including a bear awareness program to ensure employees and contractors are informed of bears and other potentially dangerous wildlife, avoiding all known or suspected den and nest sites, and no littering or feeding wildlife;
- Employ an alert system to warn personnel of wildlife in the local area by relaying sighting information to vehicles and equipment operators and on-site personnel;
- Train all Project employees and contractors to record wildlife sightings (e.g., Dall's Sheep, caribou, Wood Bison, and carnivores) in the wildlife record logs with respect to species, location along the access road, numbers observed, and reaction to road activity. If a problem area is identified, corrective measures will be considered.
- Incorporate ENR's Woodland Caribou Best Management Practices for Industrial and Commercial Activities (once developed) to be incorporated into the wildlife monitoring program, where feasible, to manage or mitigate habitat impacts and sensory disturbances on Woodland Caribou;
- Strict snow removal practices along the access road and airstrip to manage high snow banks, so that wildlife can readily move off as vehicles/aircraft approach;
- Provide a structure for reporting human-dangerous wildlife encounters at the TTF and resulting incidents to inform Mine management and ENR staff;
- Managing the small portion of the winter road not used for the all season access to prevent predator and non-Project related travel of the corridor, if necessary;
- Implement a protocol for dealing with problem bears, with a designated chain of responsibilities for ensuring worker safety and efficient and speedy resolution of incidents;
- Preserve natural drainage patterns along the haul road to maintain the natural function and processes of peatland habitats adjacent to the haul road;

- Develop and implement a Waste Management Plan that prohibits littering, purposely feeding wildlife, and storing attractants accessible to wildlife. Incinerate all waste foods and human garbage consistent with current industry good management practices to minimize wildlife attraction to the local area. Adaptive management will be applied to waste management practices. If wildlife are found to be attracted to the site (i.e., problem wildlife) additional management practices, if required, will be adapted;
- Employ appropriate materials management systems to minimize the risk of accidental spills or leakage of concentrate, diesel fuel, other hydrocarbons, and other hazardous materials being shipped to the Mine site;
- Train staff on the existing Spill Management Plan and procedures to quickly respond to an accidental spill. This plan to include provision for rapid deployment of cleanup crews and for contaminant and cleanup of spilled material and contaminated surfaces;
- Strict adherence to policies to avoid significant changes to water levels while pumping water from a known Beaver pond in the fall and winter periods;
- Maintain sufficient buffer distances between development activities (e.g., re-fuelling and material storage) and waterbodies, where possible;
- Non-mine vehicles, including all-terrain vehicles (ATVs) and snowmobiles will be prohibited on site;
- Pets will be prohibited along the all season access road; and
- The appropriate regulatory agencies (*i.e.,* GNWT ENR and Parks Canada) will be contacted to receive additional direction regarding new issues that arise.

7.2 Vegetation

7.2.1 Effects of Land Clearing on Terrestrial Ecosystems

Effects to terrestrial ecosystems resulting from construction of the future all season road will be reduced as most of the proposed all season alignment will already have been cleared for the current approved winter access road (20 m right-of-way). The only exception is about 9 km of the proposed all season road that varies from the winter road alignment (see Figure 3). CZN is currently authorized to construct their new winter access road in accordance with existing LUP's and Water Licences from both the MVLWB and Parks Canada. The MVLWB issued LUP MV2012F0007and Water Licence MV2012L1-0005 on January 10, 2013 and Parks Canada issued LUP Parks2012-L001 and Water Licence Parks2012_W001 on August 26, 2013.

Under these authorizations, approximately 63 km of new alignment will be cleared for the upgrading of the existing winter access road. This will consist of a re alignment to avoid karst features and bisecting the poljes west of Mosquito Lake, a realignment between Fishtrap Creek and Grainger Gap, and a realignment of the road east of Grainger Gap, wherein the new alignment will be located closer to the eastern foot of the Nahanni Range (providing for an ice bridge crossing of the Liard River just east of the community of Nahanni Butte).

The proposed realignment of the access road will result in a shorter road (174.5 km compared to a previous 181.1 km) and a revised footprint. The resulting footprint is summarized by vegetation units in Table 7-1 and is based on a total length of 174.5 km and an assumed average road footprint width of 10 m. The 63 km of old access road footprint that will not be used has naturally re-vegetated since it was initially constructed in 1981. The overall significance of impacts to vegetation from the access road is expected to be low.

Table 7-1: Summary of Terrestrial Ecosystems Potentially Affected by Project Construction

EOSD Land Cover Class	Phase I Road Area (ha) *	Phase II Road Area (ha) *	Airstrip Area (ha)*	Borrow Site Area (ha)*	Borrow Site Access Road Area (ha)*	Tectela Transfer Facility (ha)*	Cleared Area Outside of Winter Road Route (Phase I) (ha)*	Cleared Area Outside of Winter Road Route (Phase II) (ha)*
Broadleaf-dense	3.4	32.0	0.0	4.2	1.1	0.0	0.0	0.4
Broadleaf-open	1.0	9.6	0.0	2.5	1.0	0.0	0.0	0.0
Bryoids	0.7	0.1	0.0	0.5	0.0	0.0	0.0	0.0
Coniferous-dense	6.4	9.6	0.0	1.1	0.1	0.4	0.0	1.9
Coniferous-open	20.7	5.6	0.0	3.6	0.6	0.0	2.0	1.0
Coniferous-sparse	2.8	0.5	0.0	0.9	0.1	0.0	0.1	0.1
Exposed land	21.8	0.0	7.6	3.7	0.0	0.0	0.5	0.0
Herb	0.0	0.3	0.0	0.0	0.0	0.0	0.0	
Mixedwood-dense	5.1	16.2	0.0	6.1	0.0	1.7	0.0	2.6
Mixedwood-open	0.5	1.0	0.0	0.3	0.0	0.0	0.0	0.0
Rock/rubble	6.4	0.0	0.0	3.5	0.0	0.0	0.0	0.0
Shadow	1.7	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Shrub-low	12.1	5.2	0.0	12.6	1.4	0.0	1.3	0.1
Shrub-tall	1.7	6.7	0.0	0.7	0.5	0.0	0.0	0.0
Water	1.2	0.6	0.0	0.3	0.0	0.0	0.0	0.0
Wetland-shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wetland-treed	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0
Total	**85.6**	**89.4**	**7.6**	40.**7**	**4.7**	**2.0**	**4.0**	**6.2**

*- Values rounded for reporting purposes

The extent of direct effects will be primarily confined to the constructed road footprint (~10 m wide) and the footprint of borrow areas and the airstrip, which will be limited in frequency to once during project construction.

For Phase 1 of the all season road, the surface area encompassed by the road surface will be 85.6 ha, while Phase 2 will encompass 89.4 ha. The footprint area for both phases of the project, including the road footprint, borrow areas, borrow access roads, camps and the airstrip is 237.9 ha. Based on the calculated areas for EOSD land cover classes present within the 100 m wide study area, the proportion of land cover classes disturbed by each phase of the project will not exceed 20 % of the respective land cover class area. It is expected that project related effects to terrestrial ecosystems within the CZN study area will be reversible following decommissioning and reclamation of disturbances, and as such, no significant residual effects are anticipated as a result of project related activities.

7.2.2 Effects to Merchantable Timber Resources

The Deh Cho Land Use Planning Committee commissioned a study of logging potential of commercially viable forests in the Deh Cho territory (PACTeam Canada 2003), which encompasses the all season road study area. The study was conducted using various metrics to assess logging potential, including the assessment of forest cover mapping to identify suitable stands for logging and the economic viability of conducting logging operations (e.g. access constraints). Based on the results of the study, the majority of the land encompassing Phase 1 of the

all season access road study area is currently considered to have low to no potential for commercially viable forestry operations, while the area encompassing Phase 2 of the all season access road is considered to have high to very high potential for commercially viable forestry operations. A portion of this area, from Nahanni Butte to Nahanni National Park Reserve, was identified as being one of the most productive sites in the territory relative to the production of white spruce saw timber.

As a large proportion of Phase 1 and Phase 2 of the proposed all season access road will be constructed using the approved winter road route, the clearing of potential merchantable timber resources will be conducted prior to the all season access road construction, and as such, potential effects to merchantable timber resources in the study area will be minimized. Given the existing clearing requirements for construction of both Phase 1 and Phase 2 of the all season road, it is anticipated that a low volume of merchantable and/or waste timber will ultimately be available for use by the local community.

As clearing for the majority of Phase 1 and Phase 2 of the proposed all season access road will be confined to the proposed project ROW, which will generally follow the approved winter road route, the extent, magnitude, duration and frequency of potential project related effects are considered low and reversible following reclamation. The overall significance of effects to merchantable timber resources are considered low and no residual effects are anticipated as a result of project construction.

7.2.3 Effects from Fire

Based on a study conducted by Bothwell et al. (2004), forest fuels in the regional context of the study area are predominantly described as low-density coniferous forests and non-fuel (wetlands, shrub lands and rock) forest cover types. Results of the Bothwell et al. (2004) study suggest that the fire behaviour in the region (e.g., Nahanni National Park Reserve) is influenced by fuel continuity, associated with mountainous terrain, and may explain a lower proportion of large (>200 ha) fires, relative to other areas examined as part of the study. The mean fire return interval calculated for the region was 28 years, while a fire cycle of 1,142 years was determined for fires greater than 200 hectares.

It can be reasonably assumed that the risk of human caused fire in direct proximity to the proposed all season access road will increase given the potential for fire risks associated with vehicle malfunction and other human induced fire risks (e.g., smoking). These risks would be considered most pertinent during periods of low precipitation and associated decreases in fine fuel moisture content; typically associated with the summer months. Although fire is a natural disturbance within the boreal forest ecosystem, the alteration of natural forest fire cycles has the potential to disrupt long-range ecosystem management objectives (particularly associated with the Nahanni National Park Reserve), along with the potential dangers to local residents and interests of stakeholders in the region (including CZN).

Along with the potential risks posed by development of the all season access road, several positive benefits related to fire management practices in the region can be anticipated as a result of project development. These would likely include increased access to more remote areas of the region should fire control activities be warranted and the potential use of the road as a fire break in certain circumstances.

It is anticipated that potential fire risks associated with construction and operation of the all season access road can generally be avoided through the application of mitigation measures related to fire prevention and emergency response. It is recommended that all staff be trained in appropriate fire prevention techniques, and appropriate emergency response procedures.

Assuming application of appropriate mitigation measures, and the low anticipated volume of traffic utilizing the proposed all season access, the extent, magnitude, duration and frequency of potential fire related effects are

characterized as low and reversible. The overall significance of effects is considered low and no residual effects are anticipated.

7.2.4 Effects of Access Road-Related Emissions on Vegetation

The air quality assessment presented in the DAR for the CZN Prairie Creek Mine (CZN 2010) indicated that construction and operation of the winter access road would result in the release of exhaust emissions from equipment, transport trucks, other trucks, and electrical power generation emissions (at the transfer facilities and Cat Camp). Emissions from equipment and trucks are primarily particulates (as carbon soot) and exhaust gases (SO_2, NO_x and SO_2) from burning diesel fuel. These emissions will be of low intensity compared to Mine-site emissions. With snow melt in the spring, the limited amount of particulates will settle onto ground cover vegetation and be absorbed into the organic substrate (CZN DAR 2010; Golder 2010).

During the snow free months, when the all season road will continue to operate at a low intensity, the emissions from trucks, other vehicles and stationary emission sources at the transfer facilities will be of a similar low intensity. As a result, these limited emissions are not expected to have a measurable effect on vegetation adjacent to the all season access road, Cat Camp or the transfer facilities. Overall, the significance of access road related air emissions on vegetation is expected to be low. No residual effects to vegetation are anticipated from road related air emissions.

7.2.5 Effects of Dust Generation on Vegetation

Road construction and use of the access road during the summer months, will generate dust. The potential effects of dust deposition on plant species varies with the deposition frequency, load and duration, as well as the physical and chemical properties of the dust and the plant species involved.

A variety of factors can influence dust deposition patterns, such as particle size, wind direction and velocity, terrain, vegetation density and structure (e.g., tall vs. short), vehicle size, speed, and traffic volumes. Several studies of the effects of road dust on vegetation have highlighted the variability in particle transport, with effects being detected 100 m away (Auerbach et al. 1997), 200 m away (Santelmann and Gorham 1988; Angold 1997), and up to 400 m away (Lamprecht and Graber 1996). Walker and Everett (1987) discovered that up to 75% of the total dust load can generally be deposited within the first 10 m of the road, irrespective of site conditions.

Studies carried out by the United States Environmental Protection Agency (US EPA 1995) also highlight the influence of particle size on dust deposition patterns. Larger particles (e.g., those with an aerodynamic diameter >100 µm) tended to settle within 10 m of the source, while particles with moderate sizes (e.g., with diameters between 30 – 100 µm) settled out within 100 m. Particulates with aerodynamic diameters <15 µm were transported over much greater distances because they were less influenced by gravitational settling

Dust particles that settle directly onto plants can have both a physical and physiological effect. Dust can block stomata, smother leaf surfaces, and increase leaf surface temperature, all of which can reduce the overall photosynthetic efficiency in the plant (Thompson et al. 1984; Pyatt and Haywood 1989; Farmer 1993).

The surrounding environment can also be modified by an increase in dust deposition. Studies have reported changes in substrate properties such as soil pH, soil nutrient regime, earlier snowmelt due to changes in surface albedo, and depth of permafrost thaw (Walker and Everett 1991; Auerbach et al. 1997; Gunn 1998). Longer-term studies have shown that these substrate changes can influence subsequent changes in plant community composition, most notably, a decline in Sphagnum and lichen species abundance and vigour and an increase in graminoids nearer the dust source (Myers-Smith et al. 2006; Auerbach et al. 1997).

Plant groups such as lichens and Sphagnum moss species tend to have a higher sensitivity to disturbance and are often used as indicators of environmental conditions (Myers-Smith et al. 2006; Markert 1993; Tyler 1989; Spatt and Miller 1981). Documented declines in lichen abundance in studies of road dust deposition have been attributed primarily to the sensitivity of lichens to the physical and chemical properties of the dust, as well as being out-competed by other species that are responding more favourably to the changes in local growing conditions (Myers-Smith et al. 2006; Auerbach et al. 1997). Declines in Sphagnum abundance were largely attributed to changes in soil pH, from acidic to more neutral conditions (Myers-Smith et al. 2006; Auerbach et al. 1997).

The primary dust-related effects resulting from the year round use of the all season road are anticipated to occur within about 10 m of the main development footprint, as this is where the majority of the large dust particles are expected to settle out. However, dust-related effects may occur at greater distances from the roadway depending, in part, on site conditions and particle size characteristics.

Plant species expected to be affected by dust settling along the all season road are generally common and will be "washed" during annual snow melt and summer rainfall events. The GNWT (1998) dust suppression guidelines will be implemented at the TTF and along portions of the road located in environments which are more prone to adverse effects from road dust accumulation (e.g., wetlands), as appropriate, to limit dust generation during the snow free months. Dust management will generally involve watering dust-prone areas as and when required, as well as adhering to speed limits on roads, which helps limit the re-suspension of particulate material.

With the diligent application of these mitigation measures, the significance of dust generation from the construction and operation of the all season road and associated traffic on adjacent vegetation is expected to be low. No residual effects resulting from project related dust generation are anticipated.

7.2.6 Effects on Harvested Plants

There is no direct information with which to assess the potential for impacts related to cultural uses of plant species in the Prairie Creek Mine site area or along the access road. However, CZN was informed by an elder of the Nahanni Butte Dene Band that plants are primarily harvested in proximity to the settlement of Nahanni Butte (David Harpley, pers. comm. in CZN DAR 2010; Golder 2010).

As previously discussed in Section 5.6, effects to habitats capable of supporting traditionally important plants within the CZN study area may potentially occur as a direct result of habitat clearing during construction and indirectly from the generation of road dust, potential spills of deleterious substances and introduction of invasive species. All criteria used for assessing potential effects to traditionally important plants were generally rated as low and not significant, considering the use of an existing disturbance (winter access road) for construction of the majority of the all season road and the low anticipated volume of traffic associated with use of the all season road. Assuming the appropriate application of mitigation measures during the life of the project, no residual effects to traditionally important plant species are anticipated from the project.

7.2.7 Effects on Rare Plants

As previously reported, results of the ENR virtual herbarium search indicate that no vegetation species at risk occurrences have been historically recorded within five kilometres of the CZN study area. Of the species identified during the search, two species (Nahanni aster and Raup's willow) are currently considered globally imperiled (G2 global status ranking – NatureServe 2014) and one species (Velenovsky's hilpertia moss) is considered critically imperiled (G1 global status ranking – NatureServe 2014). The nearest known occurrences of these species to the CZN study area are 20 km, 25 km, and 50 km respectively. Potential project-related effects to these species are considered unlikely given the spatial isolation of known populations from the proposed project.

Rare plant surveys related to the Prairie Creek Mine Project and associated winter access road were initiated by EBA on behalf of CZN in July 2009 and further surveys were completed in August 2010 (EBA 2010; 2011).

In July 2009, rare plant surveys were conducted along the Prairie Creek Mine winter road; the proposed waste rock storage facility; and the area around camp and the beaver pond to the south.

A total of 340 plant observations, representing 193 species and 44 families of vascular plants, were documented during the 2009 field survey. No plant species listed within the federal SARA were observed in the surveyed areas. However, one plant species, few flower meadow rue (*Thalictrum sparsiflorum*), listed as 'May Be At Risk' (ENR 2014b), was documented along the Prairie Creek winter road and an adjacent wetland. As the species appears locally abundant within the study area, conversion of the winter road to an all season access is unlikely to threaten the viability of this species locally, considering confirmed observations were identified outside of the proposed development footprint.

Two additional plant species ranked as 'May Be At Risk' by the ENR were identified along the existing winter access road (Hornemann willowherb *Epilobium hornemanni* and linear-leaved willowherb *Epilobium leptophyllum*), have restricted distribution in the NWT with limited known occurrences, but are globally secure (Golder 2010). Six plant species ranked as 'Sensitive' by the ENR—alpine anemone (*Anemone drummondii*), bog birch (*Betula pumila*), lesser black-scaled sedge (*Carex atrosquama*), one-glume spike rush (*Eleocharis uniglumis*) alpine groundsel (*Packera pauciflora*) and yellow mountain heather (*Phyllodoce glanduliflora*) - identified adjacent to the Prairie Creek winter road have small regional distributions in the NWT with a small number of known occurrences, but are globally secure. It was concluded that impacts to these local occurrences (and potential additional occurrences near the access road) can be avoided or reduced by limiting the amount of additional land disturbance for upgrades and operation of the all season access road.

In August 2010, the proposed Polje By-Pass re-alignment was surveyed for unique or important vegetation communities and rare plants. The habitat in which the proposed Polje By-Pass re-alignment traverses was burned by a forest fire in 1996. The vegetation community now comprises a jack pine regeneration stand approximately 14 years old. No rare plants or sensitive habitats were documented within the jack pine regeneration along the proposed Polje By-Pass alignment. It was concluded that this proposed re-alignment would not threaten rare plants or sensitive vegetation communities (EBA 2011).

Based on the results of the rare plant surveys conducted, the extent, magnitude, duration and frequency of potential project related effects to rare plant species resulting from conversion of the existing winter access road to an all season road are characterized as low and reversible. The overall significance of effects is considered low. No residual effects to rare plants are anticipated assuming appropriate application of mitigation strategies related to dust generation, spill prevention and the introduction of invasive species.

7.2.8 Introduction of Invasive Plants

Trends in invasive alien plant species presence and establishment in the north are being monitored with increasing interest by scientists and regulatory agencies alike. Invasive alien plant species are those that have been introduced into areas beyond their natural range by humans and are capable of causing significant harm to the environment, economy, or society (GNWT and NWT Biodiversity Team 2010). Though the incidence of invasive plant species in the north is still much lower compared to areas further south, the prospect of climate change and increased development could lead to more frequent, unintentional introductions.

Recent studies in northern climates have shown that invasive plants are becoming more prevalent; however, it is unclear whether this is due in part or in combination to a true increase in plant species, the conduct of more

surveys specifically targeting invasive species, or increased development in remote areas (Shrader and Hennon 2005; Carlson and Shephard 2007).

Invasive plants have the ability to aggressively establish and quickly spread in new environments. These adaptations coupled with their ability to out compete native species can affect plant species richness, diversity, and the composition and function of affected natural ecosystems (Haber 1997). The successful introduction and colonization of an area by invasive plant species relies, in part, on the presence of suitable habitat, access to a source of invasive plant material, and a means of dispersal.

The disturbances associated with development projects can unintentionally create growing conditions that facilitate the successful establishment of invasive plants. Exposed soil resulting from the removal of plant cover is particularly susceptible to colonization. Dirty equipment transported to site from other areas can act as a dispersal mechanism for invasive plant propagules that may have become lodged in tires and mud.

The most effective management of invasive plants is preventing their establishment into an area (Carlson and Shephard 2007; Schrader and Hennon 2005; USDA 2006; Polster 2005; Clark 2003). Removal once established is more costly and can be particularly challenging logistically in more remote northern areas.

In August 2010 EBA completed an invasive plant survey and reclamation assessment along the existing Prairie Creek Mine access road, and a rare plant survey along the proposed and now approved road re-alignments (EBA 2011). Surveys were conducted from August 9 to 13, 2010. The study area for these surveys included that section of the access road occurring within the boundaries of the expanded Nahanni National Park Reserve.

No invasive alien plant species were documented along the portions of the access road surveyed; consequently, they are not believed to be an issue at this time.

The Prairie Creek Mine site and existing winter access road have been in place since 1982, and Mine-related heavy equipment is already on site. In the future, any new equipment would be brought in along the access road on trucks or tractor trailer units. Similarly, Mine supplies and fuel will be brought in along the access road. Invasive plants are usually brought into a site (or along an access road) through dirty vehicles or heavy equipment operating during the non-winter period, when seeds of invasive plants can more readily be mixed with mud or dirt on vehicles or equipment, and then fall off along a road way or at a work site.

The risk of invasive species introduction during the construction and operation of Phase 1 of the all season access road will be minimal, as all equipment and vehicle traffic associated with this phase of the project will be brought into the site during the winter months. Operations during the summer construction season will be within a closed system, which is the time period that is most conducive to the spread and establishment of invasive species. The risk of invasive species introduction will increase upon completion of Phase 2 of the project which would allow for the transport of vehicles and equipment during the summer months, and thereby increase the potential for transport of invasive species into the study area. It is recommended that an invasive species management plan be developed prior to project construction to determine appropriate best management practices with respect to the prevention of invasive species establishment and invasive species control. The invasive species management plan should be developed in consultation with applicable stakeholders to ensure proposed mitigation efforts comply with existing regulations which may potentially limit the application of specific invasive species control measures (e.g. use of herbicides in National Parks).

The use of seed mixes for re-vegetation of disturbance areas may also introduce invasive species. Given this risk, CZN's approach (as defined in EA0809-002) for re-vegetation of disturbed areas will rely primarily on encroachment of native species from surrounding vegetation communities.

Given the low anticipated traffic volumes anticipated for the all season road and the application of additional mitigation strategies (which should include an invasive species management plan) the extent, magnitude, duration and frequency of potential effects from invasive species introduction are considered low and reversible.

Overall, the significance of effects from invasive plants is expected to be low. No residual effects are anticipated assuming the appropriate application of mitigation strategies.

7.2.9 Effects to Soil, Hydrological and Permafrost Regimes

The study area is characterized by a variety of vegetation cover types ranging from alpine tundra areas with little to no soil development, to lowland areas dominated by wetland communities and organic soils (Beak 1981). Based on the review of the winter access road DAR (CZN 2010), the study area also contains areas with 'ice-rich ground' or discontinuous permafrost. Road construction in these environments presents challenges, both from the perspective of maintaining a viable, safe road surface and from the perspective of maintaining biological integrity in potentially sensitive environments.

Challenges associated with road engineering in permafrost areas are well documented, and generally result from removal of insulating vegetation (active thaw layer) overlying permafrost soils and disruption of the thermal equilibrium (Ferrians et al. 1970). Once vegetation is removed, the active thaw layer increases and collects greater quantities of moisture leading to greater heaving of the ground during the winter and a greater incidence of sediment flow, landslides and subsidence during the summer. All of these resulting consequences can have detrimental effects to the stability of road surfaces.

Thawing of permafrost can potentially result in direct and indirect negative effects to terrestrial and aquatic vegetation communities (ENR 2014i). Thawing of permafrost resulting in slumping and landslides can physically alter the landscape, and can potentially alter drainage patterns, moisture regimes, and nutrient regimes resulting in changes to community composition. Sediment releases caused by thawing permafrost can also alter suspended sediment levels in waterbodies, altering chemical and nutrient concentrations which may also result in changes to aquatic vegetation community composition.

Road construction can negatively affect physical and chemical properties of soil including changes to structure, porosity, permeability, organic matter content and chemical conditions; resulting from soil disturbance, compaction and mixing of soil layers (Johnston and Johnston 2004).

Road construction in wetland areas also has the potential to alter hydrology and cause changes to such communities. Jeglum (1975) and Hillman (1987) reported increases in tree growth and the development of a drier treed bog on one side of a road following construction in an open peatland. Similar studies conducted by Lieffers and Rothwell (1987) and Lieffers (1988) found that water drawdown on peatland soils increased growth of shrubs and hardwoods. Prevost et al. (1999) observed that changes in water levels, nutrient levels, and pH generally results in changes to species composition and species growth rates.

The use of existing disturbance areas (winter access road) for construction of a proportion of the all season access road will reduce potential project related effects to soil resources in the study area and avoid wetland areas to the greatest extent feasible. As part of the DAR prepared for the approved winter road access, CZN has committed to constructing road infrastructure in accordance with standard industry best practice, including guidelines described in the *Northern Land Use Guidelines: Access Roads and Trails* (INAC 2008). All best management practices, including the salvage of topsoil, erosion control measures, and the maintenance of the existing hydrological regimes (using appropriately placed culverts or other methods) should be determined prior to construction.

Assuming adherence to standard industry best practices during construction, the extent, duration and frequency of potential project related effects to soils, hydrology and permafrost regimes are considered low and reversible.

Overall, the significance of effects are expected to be low. No residual effects are anticipated assuming the appropriate application of mitigation strategies.

7.2.10 Mitigation and Best Management Practices

7.2.10.1 General Best Management Practices

Currently authorized changes in the alignment of the winter access road are related to the avoidance of karst features west of Mosquito Lake, avoidance of wetlands between Fishtrap Creek and Grainger Pass, and extensive areas of muskeg between Granger Pass and the Liard Highway. The latter two realignments are favoured by residents of Nahanni Butte. Other realignment changes are to avoid bisecting karst features (poljes) and sharp bends (CZN DAR 2010; Golder 2010).

General best management practices (BMPs) related to mitigating further potential effects on vegetation (including ecosystems and rare plants) along the current winter road corridor and future access road include:

- Confine all season road development activities to the approved winter road corridor to the greatest extent feasible;
- Preparation of an Emergency Response Plan for spill containment and management along the access road;
- Fuel storage facilities that meet industry standards for tank construction, location and spill containment;
- Staff training with respect to fire prevention protocols and emergency response procedures;
- Construction in accordance with best standard industry practices in relation to soil disturbance, hydrology maintenance and construction in permafrost areas;
- Hydrocarbon and chemicals that are hauled along the access road or stored at the TTF meet industry standard containers with appropriate spill containment and management measures in place;
- Refuelling of trucks and equipment away from any stream, lake, wetland or other water body, per industry standards;
- Diligent application of the GNWT (1998) dust suppression guidelines at the TTF and along portions of the road as appropriate; and
- Development and implementation of an invasive species management plan to ideally prevent, or if necessary, control the establishment of invasive species in off-site vegetation communities adjacent to the roadway.

7.2.10.2 Re-vegetation During Reclamation

It is anticipated that re-vegetation of borrow sources and other disturbances associated with the development of the all season access road will occur primarily through encroachment of native species from surrounding vegetation communities.

7.2.10.3 Vegetation Control

During operation of the all season access road, it is anticipated that vegetation control may be required to control shrub and tree growth within the road ROW to maintain safe driving conditions. Additional vegetation control may be required in the event that invasive species are identified within proximity to the proposed development.

Control of tree and shrub growth within the proposed ROW should be conducted using mechanical methods (such as a brush mower). The use of herbicides and/or other chemical means of vegetation control are not recommended.

If required, control of invasive species should be conducted in accordance with an invasive species management plan that should be developed prior to project construction. The plan should detail appropriate best management practices with respect to invasive species control. The invasive species management plan should be developed in consultation with applicable stakeholders to ensure proposed mitigation efforts comply with existing regulations which may potentially limit the application of specific invasive species control measures (e.g., use of herbicides in National Parks).

8.0 CUMULATIVE EFFECTS

A cumulative effects assessment was performed on residual wildlife effects from the proposed all season access road (construction, operation, and closure) and airstrip interacting with residual effects predicted from other existing and future human-related projects and activities in the immediate vicinity or broader geographic region (i.e., Northern Mountain Caribou herd annual range).

8.1 Residual Effects of the All Season Access Road

With the application of the proposed mitigation measures, there are three residual effects identified for the proposed all season access road and airstrip, including:

- Positive residual effects on subsistence harvest and harvesting areas of Moose and Dall's Sheep;
- Adverse residual effects to Moose harvest pressure; and
- Adverse residual effects to Grizzly Bear movements in NNPR.

8.2 Existing Projects Considered in the Cumulative Effects Assessment

The potential cumulative effects of the Prairie Creek Mine and associated Project infrastructure, including the entire winter access road, were most recently discussed in the CZN DAR (2010). The Project had been referred to the Mackenzie Valley Environmental Review Board (MVEIRB) for environmental assessment (EA0809-002) and on December 8, 2011 the MVEIRB issued their Report of EA (REA).The MVEIRB concluded that the proposed development, as described in the REA and including CZN's commitments, is not likely to have any significant adverse impacts on the environment or to be a cause for significant public concern.

Golder had been retained by CZN to undertake the cumulative effects assessment (CEA) for the Project, which was provided as Appendix 17 to the DAR (Golder 2010). This previous CEA for wildlife was performed in the context of residual effects from the Prairie Creek Mine and associated winter access road operation, and how the potential residual effects could be additive to residual effects from other resource development projects in the immediate vicinity or broader geographic region (i.e., southern Mackenzie Mountains).

In accordance with the previous EA0809-002 environmental assessment process, three mining projects were identified for consideration in the CEA (Figure 4): the Howard's Pass district (Selwyn Project), the existing Cantung Mine and, the Mactung development proposal in the MacMillan Pass area. Increased road access related to these three mining projects was also to be considered in that CEA.

For purposes of the current all season road CEA, it is highly relevant to revisit the CZN DAR (2010) and Golder (2010) CEA, as a basis for consideration of any possible changes to predicted cumulative effects resulting from converting the existing winter access road, to an all season road, most likely in two phases.

Given the spatial separation between the Prairie Creek Mine and winter access road, and the three mine projects in the Mackenzie Mountains to the north, the potential for the identified residual effects from the Prairie Creek Mine and winter access road to result in a cumulative effect on the species discussed was determined to be unlikely (CZN DAR 2010).

Over the larger geographic region, there are a small number of human developments and activities that may interact to cumulatively affect wildlife in NNPR:

- Highway 7 (a gravel road considered to be a low traffic highway by the Department of Transportation) and the Nahanni Butte access. The average annual daily traffic volumes on Highway 7 collected from 2002 – 2011 ranged from 30-50 vehicles, with peak summer (June, July, August) daily traffic volumes reaching 40-70 vehicles (DOT 2012); and
- Active and inactive mines, their access roads, and airstrips including:
  - The Selwyn Project includes a 22 km approved access road (the Howard's Pass Access Road) at the headwaters of Flat River that is located inside the expanded NNPR boundary. This access road has been granted a 30 year licence of occupation. This mine and access road is located within the annual ranges of the Nahanni Complex and Finlayson caribou herds. The Prairie Creek Mine and access road are located at the extreme limit of the Nahanni Complex herds' winter range.
  - The Cantung mine includes a low traffic gravel road constructed in the early 1960's (referred to as the Nahanni Range Road). This road is located in the upper reaches of the Coal and La Biche river watersheds, immediately outside the expanded NNPR border. This road is managed by controlled gated access, with an apparent high level of success (Anderson et al. 2002). The Coal River Northern Mountain Caribou herd (part of the Nahanni Complex) occupies this area in the spring, summer, and fall, and crosses this road on their annual migrations (Weaver 2008). The Prairie Creek Mine and access road are located outside their defined annual range; however, a few caribou may occur near the all season access road in the winter.
  - The existing DAR (CZN 2010) considered the Mactung Mine, 339 km to the northwest, too far from the Prairie Creek Mine and its access road and was not likely to act cumulatively with the Prairie Creek Mine and activities. Species with large home ranges, such as Grizzly Bears and Northern Mountain caribou, were assessed. Management measures, including a Bear Management Plan for the Prairie Creek Mine and its access road, can go a long way to reduce the risk of cumulative impacts to regional grizzly populations. Similarly, the Mactung mining project predicts that there will be no effects on the overall health and migration of the Redstone caribou population. The Redstone herd may also occur in the area of the Prairie Creek mine; however, it is thought to be subdivided into two subherds, with only the Moose Horn River subherd potentially occupying the area of the Prairie Creek Mine, but does not encompass the Mactung project area.

– Prairie Creek Mine is at KP 0 of the proposed all season access road. Three residual effects were identified for the Prairie Mine and winter access road, these included (Golder 2010):

1) Potential for air traffic effects to Dall's sheep lambing activity in the spring (May-June) on the slopes above the airstrip and on Folded Mountain.

2) Potential for mortality of Dall's Sheep, Woodland Caribou (no distinction between Northern Mountain and Boreal woodland caribou), Moose, and Wood Bison from operation of the access road (November to mid-April) when populations are present in proximity to the access road alignment.

3) Potential for movements of Woodland Caribou and Grizzly Bear to be affected by sensory disturbance related to Mine site activity and human presence.

Overall in the wildlife cumulative effects assessment for the Prairie Creek Mine and the winter access road, Golder (2010) predicted the Selwyn, Cantung, and Mactung projects (proposed and active) were too far from the Prairie Creek Mine and its access road to likely interact adversely. The Prairie Creek Mine site is 186 km air distance from the existing Cantung mine site, 242 km from the Selwyn Project, and 339 km from the propose Mactung Mine development area (Golder 2010).

8.2.1.1 Foreseeable Future Projects Considered in the Cumulative Effects Assessment

There has been low industrial interest in the local area, which has been driven by land withdrawals over the past decade as the Dehcho Land Claim Process has been on-going (Senes 2011). Reportedly very few industrial interests were within or close to the Sambaa K'e candidate protected area given its remote location, climate, and small population base which limit economic growth potential (Senes 2011). Similar limits to industrial interest are anticipated in the region of the NNPR.

Over the foreseeable future, there are a few anthropogenic activities that may interact to cumulatively effect wildlife, these include:

- Exclusion of non-resident harvesting in the Nahanni Butte and South Nahanni outfitting zones inside the expanded NNPR boundary; and
- Protection from anthropogenic development through the Draft Interim Dehcho Land Use Plan conservation zones and other parks in the region.

Besides human developments, there are other conservation programs occurring over the larger geographic region that have the potential to moderate adverse effects from these human developments. Connecting to the NNPR, large corridors surrounding major rivers (e.g., the Mackenzie, Root rivers to the north) are defined as conservation zones in the Draft Interim Dehcho Land Use Plan, as well as large areas further away encompassing Sibbeston Lake to the North Nahanni River and Arrowhead Hills (NWT PAS 2014). Trout Lake (Sambaa K'e), approximately 100 km southeast of NNPR, is a proposed National Wildlife Area (NWT Protected Areas Strategy candidate protected area). Inherent in the values of conservation zones and national parks/wildlife areas, any new industrial developments will be prohibited. Therefore, little additional land use developments are anticipated in the immediate future surrounding NNPR to adversely interact with residual effects potentially occurring as a result from the proposed all season access road.

8.2.1.2 Cumulative Effects of All Season Access Road

Moose, Dall's Sheep, and Grizzly Bear adverse effects potentially persist as a result of the proposed all season access road and airstrip after mitigation is applied. In contrast, positive affects remain for members of the Naha Dehe Dene Band by providing additional access to Moose and Dall's Sheep harvesting areas.

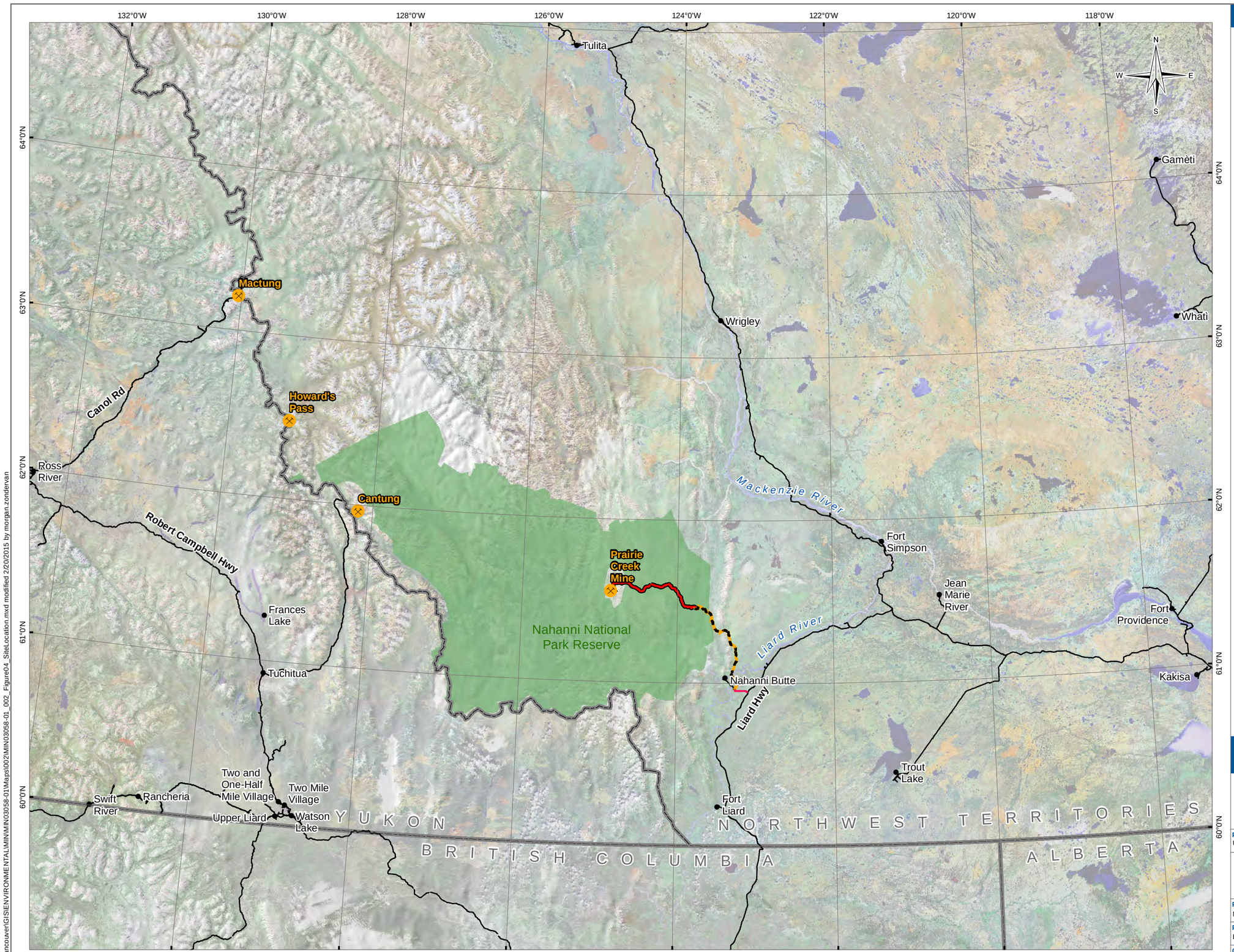
Residual wildlife effects from the proposed all season access road has the potential to interact adversely primarily with the Prairie Creek Mine and its airstrip. These could affect Grizzly Bear and Dall's Sheep.

The proposed all season access road effects assessment includes associated effects during winter operations, and therefore, essentially negates the predicted winter operation effects.

Moose: The environmental assessment for the Prairie Creek Mine and winter road predicted a low likelihood of vehicle collisions with moose along the Prairie Creek winter access road, but was not expected to be a cumulative effect for regional moose populations in the NWT (Golder 2010). The proposed all season access road reduces traffic volumes from the approved winter road levels and, therefore, essentially negates this potential cumulative effect. However, the cumulative harvest pressure anticipated because of the proposed all season access road may act cumulatively with Moose-vehicle mortality assumed to occur along Highway 7. Strict access control measures are required to monitor and manage non-Project related travel and hunting pressure along the all season access road.

Dall's Sheep: The environmental assessment for the Prairie Creek Mine and winter road predicted it was unlikely that cumulative effects on Dall's sheep habitat or populations would occur with full operation of the Prairie Creek Mine and its winter access road with other mines across the region (Golder 2010). However, potential residual effects in harvest pressure as a result of the proposed all season access road may act cumulatively with the predicted residual effects to Dall's Sheep lambing activity in the spring (May to June) near the airstrip and Folded Mountain. However, this is counter-balanced by the end of outfitter hunting for sheep in the NNPR by 2019. Strict access control measures and flight management (during lambing season) into the Prairie Creek Mine are required to monitor and manage non-Project related travel, hunting pressure, and disturbances to lambing areas near the Mine site and Phase 1 of the all season access road.

Grizzly Bear: The environmental assessment for the Prairie Creek Mine and winter road predicted a low but manageable risk to the regional Grizzly Bear population associated with bear-human encounters and mortality (Golder 2010). Golder (2010) suggested this risk to regional grizzly populations could be managed with a Bear Management Plan for the Prairie Creek Mine. Potential residual effects to Grizzly Bear movements through NNPR were predicted from the proposed all season access road. However, since traffic volumes and speed limits remain low, and the few resident bears using the Prairie Creek corridor are low, no further mitigation is considered necessary beyond the Bear Management Plan.



LEGEND

- Community
- Exploration Activity Location
- Provincial Boundary
- National Park
- Existing Road

Proposed All Season Road

- Phase 1
- Phase 2
- Existing Road

NOTES
Base data source:
ESRI Base Data and Maps
Road alignment provided by AllNorth (Jan 22, 2015)

STATUS
ISSUED FOR USE

PRAIRIE CREEK ALL SEASON ROAD DEVELOPER'S ASSESSMENT REPORT

Regional Location Map

PROJECTION UTM Zone 10		**DATUM** NAD83		**CLIENT** CANADIAN ZINC CORPORATION
Scale: 1:2,500,000 — 50 25 0 50 Kilometres				TETRA TECH EBA
FILE NO. MIN03058-01_002_Figure04_SiteLocation.mxd				
PROJECT NO. ENVMIN03058-01.002	**DWN** MEZ	**CKD** SL	**APVD** RH	**REV** 0
OFFICE Tt EBA-VANC	**DATE** February 20, 2015			**Figure 3**

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9.0 FOLLOW-UP AND MONITORING

Golder (2012) prepared a Draft Wildlife Mitigation and Monitoring Plan (WMMP) for the Prairie Creek Mine and winter access road operation that outlines approaches to reduce potential human-wildlife conflicts and to measure the effectiveness of the mitigation measures implemented. This plan was developed to be dynamic to allow further evaluation through engagement with appropriate stakeholders and development based on the principles of adaptive management.

The draft WMMP considers:

- On-site education consisting of detailed site orientation session for all site personnel and visitors regarding general wildlife education and site-specific wildlife policies and rules, including bear awareness and response programs, wildlife-human conflict management, waste management, and prevention and treatment of problem wildlife;
- Regular surveillance by a wildlife monitor to ensure appropriate policies are being followed (e.g., waste management plan);
- Management of toxic substances, waste, and employee safety on the Mine site;
- Management of sensory disturbances at the mine, airstrip, and access road;
- Dall's Sheep and caribou monitoring program to ensure Project-related effects are minimized;
- Traffic management including but not limited to checking and deterring wildlife from the airstrip prior to take-off and landing, vehicle speed limits, yielding the right-of-way to wildlife, appropriate signage to warn drivers of wildlife "caution zones" (including moveable signs), reporting system of wildlife on the road, and wildlife sweeps prior to avalanche control and management;
- Access road control including signage at the south-eastern terminus of the access road to deter non-mine related use (including ATVs and snowmobiles), manning a check-point and screening station, and reporting of public use of the access road and evidence of land use (e.g., hunting, firewood harvesting);
- Wildlife monitoring by qualified wildlife monitors to conduct ground surveillance at Mine start up and production periods at the Mine and along the access road, responding to and reporting on wildlife incidents and bear encounters, and reporting wildlife-Project interactions (including the wildlife observation logs);
- Ground-based caribou monitoring (caribou numbers, frequency and location of occurrence, and response to aircrafts), during year-round Mine operations and winter access road use by qualified wildlife monitor surveillance at the Mine and airstrip and through reported observation logs by winter road users and pilots at the airstrip;
- Aerial and ground-based reconnaissance surveys to determine Dall's Sheep sensitive lambing areas within 5 km of the Mine site, airstrip, and airstrip approach and their distribution, movements, and behaviour during the parturition period in relation to the Mine and airstrip;
- Incident management and regulatory contacts;
- Data analysis and reporting; and
- Adaptive management triggers, responses, and reporting including a zero mortality threshold and reporting directives for caribou, Wood Bison, Grizzly Bear, Wolverine, Peregrine Falcon, Short-eared Owl, Horned

Grebe, Rusty Blackbird, Olive-sided Flycatcher, and Common Nighthawk directly affected by Project-related activities.

The scope of the existing draft WMMP should be updated to include all season monitoring and species potentially affected by the all season access road and airstrip use. Additional considerations for the draft WMMP includes incorporating:

- Including mortality thresholds for additional species at risk (e.g., Trumpeter Swan, Collared Pika), Moose, and Dall's Sheep;
- Monitoring, evaluating, and reporting harvest pressure, particularly along the Nahanni Range portions of the outfitter zone that is located outside the NNPR boundary;
- Educating and promoting First Nations voluntary reporting of harvests from along the all season access road; and
- Incorporating additional mitigation measures outlined in this document to minimize non-winter period potential effects (e.g., water pumping from Beaver and Trumpeter Swan ponds) and all potential species at risk.

10.0 CLOSURE

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

Respectfully submitted,
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REFERENCES

Anderson, R.B., S.J. Dyer, S.R. Francis, and E.M. Anderson. 2002. Development of a Threshold Approach for Assessing Impacts on Woodland Caribou in Yukon. Draft Report, version 2.1. Prepared for Environment Directorate, Northern Affairs Program. 64 pp.

Angold, P.G. 1997. The Impact of a Road upon Adjacent Heathland Vegetation: Effects on Plant Species Composition. Journal of Applied Ecology. 34: 409-417.

Auerbach, N.A., M.D. Walker and D.A. Walker. 1997. Effects of Roadside Disturbance on Substrate and Vegetation Properties in Arctic Tundra. Ecological Applications. 7(1): 218-235.

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*). *In*: The Birds of North America, No. 200 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and the American Ornithologists' Union, Washington, D.C.

AXYS Environmental Consulting Ltd. 2001. Thresholds for Addressing Cumulative Effects on Terrestrial and Avian Wildlife in the Yukon. Prepared for the Department of Indian and Northern Affairs. 120 pp.

Banci, V. 1994. Wolverine. The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx and Wolverine in the Western United States. Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.J. Lyon and W.J. Zielinski (Eds.). General Technical Report RM-254, U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. Ft. Collins, Colorado. 99-127 pp.

Banfield, A. 1974. The mammals of Canada. University of Toronto Press, Toronto, Canada. B.C. Wildlife Branch.

Barichello, N., J. Carey, K. Jingfors. 1987. *in* Government of Northwest Territories NWT Species Infobase. Environment and Natural Resources, GNWT, Yellowknife, NT. Web access: http://nwtspeciesatrisk.ca [November 2014].

Beak Consultants Limited (Beak). 1981. Prairie Creek Project Vegetation & Wildlife Studies, 1981. Prepared for Cadillac Explorations Ltd. Calgary, Alberta.

Beyersbergen, G.W., 2007. The 2005 International Trumpeter Swan Survey in Alberta, Saskatchewan, Manitoba, and the Northwest Territories. Canadian Wildlife Service Technical Report Series No. 485. Prairie and Northern Region. Edmonton, Alberta. 45 pp.

Bothwell et al. 2004. Fire regimes in Nahanni National Park and the Mackenzie Bison Sanctuary, Northwest Territories, Canada. Pages 43-54 in R.T. Engstrom et al. Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in Temperate Boreal and Montane Ecosystems. Tall Timbers Research Station, Tallahassee, FL.

Bromley and Trauger. ND. Birds of Yellowknife: A Regional Checklist. 12 pp.

Brown, C. R. and M. Bomberger Brown. 1999. Barn Swallow (*Hirundo rustica*), *in:* The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. Web access: http://bna.birds.cornell.edu/bna/species/452doi:10.2173/bna.452

Cambell, B.M, and Luckert, M.K. 2012. Uncovering the Hidden Harves: Valuation Methods for Woodland and Forest Resources. ISBN 1136549781. 278 pp.

Canadian Wildlife Service, Environment and Natural Resources, and Fisheries and Oceans Canada. 2014. Species at Risk in the NWT: 2014 edition. Government of Northwest Territories Department of Environment and Natural Resources, Yellowknife, NT. 84 pp.

Carlson, M. L. and M. Shephard.2007. Is the spread of non-native plants in Alaska accelerating? Meeting the challenge: invasive plants in Pacific Northwest ecosystems. Gen. Tech. Rep. T. B. R. Harrington, Sarah H. Portland, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 111-127.

Carrière, S. and S. Matthews. 2013. Peregrine Falcon Surveys along the Mackenzie River, Northwest Territories, Canada. Environment and Natural Resources, File Report No. 140. 64 pp.

Chruszsc, B., A.P. Clevenger, K.E. Gunson, and M.L. Gibeau. 2003. Relationships among grizzly bears, highways, and habitat in the Banff-Bow Valley, Alberta, Canada. Can. J. Zool. 81: 1378-1391.

Clark, J. 2003. Invasive Plant Prevention Guidelines. Bozeman, Montana: Centre for Invasive Plant Management.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2002. COSEWIC assessment and update status report on the Woodland Caribou *Rangifer tarandus* caribou in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 98 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2007a. COSEWIC assessment and update status report on the Peregrine Falcon *Falco peregrinus (pealei* subspecies – *Falco peregrinus* and *pealei anatum/tundrius – Falco peregrinus anatum/tundrius* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 45 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2007b. COSEWIC assessment and update status report on the Common Nighthawk *Cordeiles minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 25 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2007c. COSEWIC assessment and update status report on the Olive-sided Flycatcher *Contopus cooperi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 27 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2008. COSEWIC assessment and update status report on the Short-eared Owl *Asio flammeus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 24 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011. COSEWIC assessment and status report on the Collared Pika *Ochotona collaris* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 55 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011b. COSEWIC assessment and status report on the Barn Swallow *Hirundo rustica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 46 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012a. COSEWIC assessment and status report on the Grizzly Bear *Ursus arctos* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 98 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2012b. COSEWIC assessment and update status report on the Western Toad in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 71 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2013a. COSEWIC assessment and status report on the Little Brown Myotis *Myotis lucifugus*, Northern Myotis *Myotis septentrionalis* and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2013b. COSEWIC assessment and status report on the Harlequin Duck *Histrionicus histrionicus* Eastern population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 38 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2013c. COSEWIC assessment and status report on the Bank Swallow *Riparia riparia* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 57 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2014. COSEWIC assessment and status report on the Wolverine *Gulo gulo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 87 pp.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2014b. COSEWIC assessment and status report on the Nahanni Aster *Symphyotrichum nahanniense* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 39 pp.

Creighton, T.B. 2006. Predicting Mountain Woodland Caribou Habitat in the Mackenzie and Selwyn Mountains Through Correlation of Argos Collar Locations and MODIS Spectral Reflectance. M.Sc., Thesis submission to the School of Geography, Birkbeck College, University of London. 121 pp.

Deh Cho First Nations. ND. Contaminants in the Deh Cho II: a summary of five years of research under the Northern Contaminants Program. Fort Simpson, NT. 28 pp.

Deh Cho Land Use Planning Committee. ND. Cumulative Effects Management in the Dehcho Territory: preliminary assessment and results. Fort Providence, NT. 18 pp.

Department of Transportation (DOT). 2012. Northwest Territories Highway Traffic, 2011. Yellowknife, NT. 54 pp.

Wiebe, H. 2003. Deh Cho Land Use Planning Committee Wildlife Working Group Summary Report, November 24-28, 2003. Fort Providence, NT. 25 pp.

Deh Cho Land Use Planning Committee. 2005. Respect for the Land: The Dehcho Land Use Plan Background Report. Revised Draft – November 2005. 305 pp.

EBA Engineering Consultants Ltd. (EBA). 2003. A Spatial Analysis and Literature Review of Wildlife and Wildlife Habitat in the Deh Cho Territory, NWT. Prepared for the Deh Cho Land Use Planning Committee. 184 pp.

EBA Engineering Consultants Ltd. (EBA). 2010. 2009 Rare Plant and Wildlife Survey, Prairie Creek Mine Area and Winter Road, NT. Report prepared for Canadian Zinc Corporation. Yellowknife, NT.

EBA Engineering Consultants Ltd. (EBA). 2011. Reclamation Assessment, Invasive and Rare Plant Survey 2010, Prairie Creek Mine Access Road, NT. Report prepared for Canadian Zinc Corporation. Yellowknife, NT

EBA Engineering Consultants Ltd (EBA). 2011b. Avalon Rare Metals Inc. Developer's Assessment Report. Thor Lake Project. Northwest Territories. Vancouver, B.C.

Ecosystem Classification Group. 2007 (rev. 2009). Ecological Regions of the Northwest Territories – Taiga Plains. Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT, Canada. Viii + 173 pp. + folded insert map.

Environment Canada. 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. 138 pp.

Environment Canada. 2012b. Management Plan for the Northern Mountain Population of Woodland Caribou (*Rangifer tarandus caribou*) in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. 88 pp.

Environment Canada. 2014. Management Plan for the Rusty Blackbird (*Euphagus carolinus*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. 26 pp.

Environment and Natural Resources (ENR). 2010. Wood Bison Management Strategy for the Northwest Territories, 2010 – 2020. Web access: http://nwtspeciesatrisk.ca/sites/default/files/pdf/wood_bison_management_strategy.pdf [November 2014].

Environment and Natural Resources (ENR). 2014a. NWT Wildlife Management Information System. Government of the NWT, Yellowknife, NT. Projects: 134 NWT Wildlife Sightings, 140 NWT Amphibian and Reptile Observations 1849 to present, 145 Dehcho Historical Dall's Sheep Surveys 1981-87, Dehcho Bat Survey of Nahanni National Park Reserve and area 2006, Dehcho Nahanni Wood Bison Classification Surveys 1999-present, and NWT/NU Raptor Nest 1928-present.

Environment and Natural Resources (ENR). 2014b. Northwest Territories General Status Ranking Program. Web access: http://www.nwtspeciesatrisk.com/en/content/northwest-territories-general-status-ranking-program [November 2014].

Environment and Natural Resources (ENR). 2014c. Northern Mountain Caribou (Woodland Caribou [Northern Mountain Population]). Web access: http://nwtspeciesatrisk.ca/en/species/northern-mountain-caribou [November 2014].

Environment and Natural Resources (ENR). 2014d. Grizzly Bear. Web access: http://www.enr.gov.nt.ca/programs/bears/grizzly-bears [November 2014].

Environment and Natural Resources (ENR). 2014e. Peregrine Falcon. Web access: http://nwtspeciesatrisk.ca/en/species/peregrine-falcon-anatumtundrius-complex [November 2014].

Environment and Natural Resources (ENR). 2014f. Dall's Sheep. Web access: http://www.enr.gov.nt.ca/programs/moose-muskoxen-and-sheep/dall%E2%80%99s-sheep [November 2014].

Environment and Natural Resources (ENR). 2014g. NWT Virtual Herbarium. Compilation of specimen label information. Government of the NWT, Yellowknife, NT.

Environment and Natural Resources (ENR). 2014h. Raup's Willow. Web access: http://www.nwtspeciesatrisk.com/en/species/raups-willow [November 2014].

Environment and Natural Resources (ENR). 2014i. State of the Environment. Permafrost. Web access: http://www.enr.gov.nt.ca/state-environment/13-permafrost

Environment and Natural Resources (ENR) and Government of Canada. ND. Invaders of the Northwest Territories pamphlet. Invasive Alien Species Partnership Program, Government of Canada and Government of the Northwest Territories. 2 pp.

Farmer, A.M. 1993. The effects of dust on vegetation — a review. Environmental Pollution, 79: 63-75.

Ferrians, O.J., Kachadoorian, R. and Greene, G.W. 1970. Permafrost and Related Engineering Problems in Alaska. U.S. Department of the Interior. Geological Survey Professional Paper 678. Library of Congress catalog-card No. 76-602920.

Fournier, M.A., and J.E. Hines. 1999. Breeding ecology of the Horned Grebe *Podiceps auritus* in subarctic wetlands. Canadian Wildlife Service Occasional Paper No. 99. Ottawa, Ontario. 34 pp.

Garrison, B.A. 1999. Bank Swallow (*Riparia riparia*), *in:* The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. Web access: http://bna.birds.cornell.edu/bna/species/414doi:10.2173/bna.414

Gill, D. 1978. Large Mammals of the Macmillan Pass Area, Northwest Territories and Yukon. AMAX Northwest Mining Company Ltd, Vancouver, British Columbia. 59 pp.

Golder Associates Ltd. (Golder). 2010. Vegetation and Wildlife Assessment Report, Prairie Creek Mine, Northwest Territories. Prepared for Canadian Zinc Corporation.118 pp.

Golder Associates Ltd. (Golder). 2012. Draft Wildlife Mitigation and Monitoring Plan.

Golder Associates Ltd. (Golder). 2014a. Occupancy Pattern of Caribou in the Prairie Creek Mine Road and Surrounding Area. Prepared for Parks Canada Agency; Nahanni National Park Reserve, NT. 17 pp.

Golder Associates Ltd. (Golder). 2014b. Distribution of Caribou along the Proposed Prairie Creek Mine All-Season Road. Prepared for Canadian Zinc Corporation. 18 pp.

Government of Canada. 2014. Natural Resources Canada. EOSD. Available at: http://www.nrcan.gc.ca/forests/remote-sensing/13433

Government of Yukon. 2014. Mountain Goat (*Oreamnos americanus*). Web access: http://www.env.gov.yk.ca/animals-habitat/mammals/documents/Mountain_Goat.pdf [Novemeber 2014].

Gullickson, D., and M. Manseau. 2000. South Nahanni Woodland Caribou Herd Seasonal Range Use and Demography. Parks Canada Agency. 79 pp.

Gunn, A. 1998. Effect of Gravel Road and Tailing Pond Dust on Tundra Plant Communities near Lupin Mine, NWT: Final Report Submitted to West Kitikmeot Slave Study Society.

Gunn, A., J. Antoine, J. Boulanger, J. Bartlett, B. Croft, and A. D'Hont. 2004. Boreal Caribou Habitat and Land Use Planning in the Deh Cho Region, Northwest Territories. Department of Resources, Wildlife, and Economic Development. Manuscript Report No. 153. 57 pp.

Haber, E. 1997. Guide to Monitoring Exotic and Invasive Plants. National Botanical Services. Ontario: Prepared for Ecological Monitoring and Assessment Network, Environment Canada.

Hillman, G.R. 1987. Improving Wetlands for Forestry in Canada. Information Report NOR-X-288. Northern Forestry Centre, Edmonton.

Indian and Northern Affairs Canada (INAC). 2008. Northern Land Use Guidelines, Access: Roads and Trails. Available at: https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-NWT/STAGING/texte-text/nlug5_1323108964042_eng.pdf

Indian and Northern Affairs Canada (INAC). 2004. Beaver and Muskrat: Northwest Territories Contaminants Fact Sheets. Yellowknife, NT. 2 pp.

Jalkotzy, M,P and R.M. Nasserden. 1997. The Effects of Linear Development on Wildlife: A Review of Selected Scientific Literature. Prepared for the Canadian Association of Petroleum Producers. Arc Wildlife Services Ltd., Calgary, Alberta. 115 pp.

Jeglum, J.K. 1975. Vegetation-habitat changes caused by damming a peatland drainage-way in Northern Ontario. Canadian Field Naturalist, 89, 4, 400-412.

Johnson, D., N.J. Harms, N.C. Larter, B.T. Elkin, H. Tabel, and G. Wei. 2010. Serum biochemistry, serology, and parasitology of boreal caribou (*Rangifer tarandus caribou*) in the Northwest Territories, Canada. Journal of Wildlife Diseases v. 46(4): 1096-1107.

Johnson, D., N.C. Larter, B. Elkin, and D.G. Allaire. 2013. An Opportunistic Parasitological and Serological Examination of Nuisance Black Bears in the Dehcho Region of the Northwest Territories. Environment and Natural Resources, Manuscript Report No. 227. 70 pp.

Johnston, F.M. and S.W. Johnston. 2004. Impacts of Road Disturbance on Soil Properties and on Exotic Plant Occurrence in Subalpine Areas of the Austrialian Alps. Artic, Antarctic, and Alpine Research. Vol. 36, No.2 (May, 2004), pp. 201-207.

Kneteman, J., D. Vujnovic, and L. Wilkinson. 2010. Harlequin Duck Conservation Management Plan 2010-2015. Alberta Conservation Management Plan No. 4. 24 pp.

Lamprecht, R. and W. Graber. 1996. Modeling Dry Deposition of Dust Along the Dalton Highway. In J.F. Reynolds and J. D. Tenhunen (ed.). Landscape Function and Disturbance in Arctic Tundra. Ecological Studies Volume 120. Springer-Verlag Publishers. New York, NY. p. 325-346.

Larter, N.C. 2004. Mountain Goat Survey Flat River Area, Western Mackenzie Mountains, September 2004. Department of Environment and Natural Resources. Manuscript Report No. 157. 24 pp.

Larter, N.C. 2004b. *in* Government of Northwest Territories NWT Species Infobase. Environment and Natural Resources, GNWT, Yellowknife, NT. Web access: http://nwtspeciesatrisk.ca [November 2014].

Larter, N.C. 2012. Mountain Goat Survey Ragged Range area, Southern Mackenzie Mountains, August 2011. Department of Environment and Natural Resources. Manuscript Report No. 212. 25 pp.

Larter, N.C. and D.G. Allaire. 2007. History and Current Status of the Nahanni Wood Bison Population. Department of Environment and Natural Resources, GNWT. File Report No. 136. 44 pp.

Larter, N.C. and D.G. Allaire. 2010. Dehcho Boreal Caribou Study Progress Report, April 2010. Environment and Natural Resources, Fort Simpson, NT. 32 pp.

Larter, N.C. and D.G. Allaire. 2013. Mackenzie Mountain Non-Resident and Non-Resident Alien Hunter Harvest Summary 2012. Environment and Natural Resources, Manuscript Report No. 234. 93 pp.

Larter, N.C., and C. R. MacDonald. 2014. Multi-element, Radionuclide and Stable Isotope Analysis of Kidney and Muscle and *Trichinella* Presence in Mountain Goat (*Oreamnos americanus*) from the South Mackenzie

Mountain Region of the NWT. Environment and Natural Resources and Northern Environmental Consulting & Analysis Inc. Provided by Canadian Zinc Corp.

Larter, N.C., C.R. MacDonald, D. Muir, N.J. Harms, and D. Allaire. ND. Elemental and Radionuclide Concentrations in Kidney and Muscle Tissue of Northern Mountain Caribou (*Rangifer tarandus caribou*) from the Mackenzie Mountains, Northwest Territories. 2 pp.

Larter, N.C. and K. Kandola. 2010. Levels of arsenic, cadmium, lead, mercury, selenium, and zinc in various tissues of Moose harvested in the Dehcho, Northwest Territories. Circumpolar Health Supplements; Food Security and Our Environments. 5 pp.

Latour, P.B. 2003. Aerial surveys for geese, swans, and shorebirds at Mills Lake, NWT during the spring and fall migration periods: 1994-1997. Canadian Wildlife Service. Technical Report Series No. 407. 35 pp.

Lausen, C. 2006. Bat Survey of Nahanni National Park Reserve and Surrounding Areas, Northwest Territories, July – August 2006. Prepared for Parks Canada and Canadian Parks and Wilderness Society. Kaslo, British Columbia. 45 pp.

Lieffers, V.J. 1988. Sphagnum and cellulose decomposition in drained and natural areas of an Alberta peatland. Canadian Journal of Soil Science, 68, 755-761.

Lieffers, V.J. and R.L. Rothwell. 1987. Effects of drainage on substrate temperature and phenology of some trees and shrubs in an Alberta peatland. Canadian Journal of Forest Resources, 17, 97-104.

Markert, B. 1993. Plants as Biomonitors: indicators for heavy metals in the terrestrial environment. New York and Weinheim VCH Publishers Inc. and VCH Verlagsgesellschaft.

Miller, S.J., N. Barichello, and D. Tait. 1982. The Grizzly Bears of the Mackenzie Mountains, Northwest Territories. Completion Report No. 3. NWT Wildlife Service, Yellowknife, NT. 118 pp.

Mitchell, C.D. and M.W. Eichholz. 2010. Trumpeter Swan (*Cygnus buccinator*) *in:* The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. Web access: http://bna.birds.cornell.edu/bna/species/105

Mowat, G., K.G. Poole, D.R. Seip, D.C. Heard, R. Smith, and D. W. Paetkau. 2002. Grizzly and Black Bear Densities in Interior British Columbia. Canadian Forest Products Ltd. and B.C. Ministry of Water, Land and Air Protection. 38 pp.

Mulders, R. 1999. Wolverine Ecology, Distribution and Productivity in the Slave Geological Province. 1997 Annual Report to the West Kitikmeot Slave Study Society (WKSS). Yellowknife, NT. 14 pp + figs.

Myers-Smith, I.H., B.K. Arnesen, R.M. Thompson, F.S. Chapin III. 2006. Cumulative Impacts on Alaskan Arctic Tundra of a Quarter Century of Road Dust. Ecoscience 13(4): 503-510.

NatureServe. 2014. NatureServe Explorer. NatureServe Conservation Status. Available at: http://explorer.natureserve.org/ranking.htm

Nelson, T and M. Wulder. 2003. EOSD Land Cover Classification Legend Report. Version 2.

PACTeam Canada. 2003. A Spatial Analysis and Literature Review of Timber Potential in the Deh Cho Territory, NWT. Prepared for the Deh Cho Land Use Planning Committee.

Parks Canada. 1984. Nahanni National Park Reserve Resource Description and Analysis. Natural Resource Conservation Section, Parks Canada, Prairie Region, Winnipeg, Manitoba.

Parks Canada. 2013. Nahanni National Park Reserve of Canada Park Regulations. Web access: http://www.pc.gc.ca/eng/pn-np/nt/nahanni/activ/activ5.aspx [December 2014].

Parks Canada, Nahʔą Dehé Consensus Team, and Dehcho First Nations. 2009. Nahanni National Park Reserve of Canada, Nahʔą Dehé State of the Park Report 2009. 77 pp.

Polfus, J.L., M. Hebblewhite, and K. Heinemeyer. 2011. Identifying indirect habitat loss and avoidance of human infrastructure by northern mountain woodland caribou. Biological Conservation, 144 (2011): 2637-2646.

Polster, D.F. 2005. The role of invasive plant species management in mined land reclamation. Canadian Reclamation, Summer/Fall: 24-32

Prevost, M., A.P. Plamondon and P. Belleau. 1999. Effects of drainage of a forested peatland on water quality and quantity. Journal of Hydrology, 214, 14, 130-143.

Pyatt, F.B. and W.J. Haywood. 1989. Airborne particulate distribution and their accumulation in tree canopies. Environmentalist, 9: 291-298.

Rideout, C.B. and R.S. Hoffmann. 1975. *Oreamnos americanus*. The American Society of Mammalogists, 63: 1-6.

Resources, Wildlife and Economic Development (RWED) (now ENR). 2005. Dehcho Moose Programs: Moose Survey Along the Liard Valley, February 16-19, 2004. Web access: http://www.enr.gov.nt.ca/sites/default/files/dehcho_moose_program_04-05.pdf [November 2014].

Robertson, G.J. and R.I. Goudie. 1999. Harlequin Duck (*Histrionicus histrionicus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/466doi:10.2173/bna.466 [December 2014].

Salmo Consulting Inc., Axys Environmental Consulting Ltd., Forem Technologies Wildlife & Company Ltd. 2004. Deh Cho Cumulative Effects Study, Phase 1: Management Indicators and Thresholds. 172 pp.

Santelmann, M. V. and E. Gorham. 1988. The Influence of Airborne Road Dust on the Chemistry of Sphagnum Mosses. Journal of Ecology. 76: 1219-1231.

Schrader, B. and P. Hennon. 2005. Assessment of Invasive Species in Alaska and its National Forests. Anchorage, AK: USDA Forest Service, Regional Office.

Simmons, N. 1982. Seasonal Distribution of Dall's Sheep in the Mackenzie Mountains, Northwest Territories. File Report No. 21. NWT Wildlife Service, Yellowknife, NT. 47 pp.

Spatt, P.D. and M.C. Miller. 1981. Growth conditions and vitality of Sphagnum in a tundra community along the Alaska Pipeline Haul Road. Arctic 34(1): 48-54.

Species at Risk Committee. 2012. Species Status Report for Boreal Caribou (*Rangifer tarandus caribou*) in the Northwest Territories. Species at Risk Committee, Yellowknife, NT.

Stout, B.E., and F. Cook. 2003. Timing and location of wing molt in Horned, Red-Necked and Western Grebes in North America. Waterbirds, 26(1): 88-93.

Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. *eBird*: a citizen-based bird observation network in the biological sciences. Biological Conservation 142: 2282-2292.

Thompson, J.R., P.W. Mueller, W. Fluckiger and A.J. Rutter. 1984. The effect of dust on photosynthesis and its significance for roadside plants. Environmental Pollution, Ser. A(34): 171-190.

Tyler, G. 1989. Effects of Heavy Metals in Forest Ecosystems. Uptake, retention and toxicity of heavy metals in lichens, a brief review. Water, Air and Soil Pollution, Kluwer Academic Publishers B.V., 47(3-4): 321-333.

United States Environmental Protection Agency (US EPA). 1995. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources.

United States Department of Agriculture (USDA). 2006. USDA Forest Service Invasive Species Program Website. Retrieved February 2011, from http://www.fs.fed.us/invasivespecies/prevention.shtml

Van Zyll de Jong, C.G. and L.N. Carbyn. 2000. *in* Government of Northwest Territories NWT Species Infobase. Environment and Natural Resources, GNWT, Yellowknife, NT. Web access: http://nwtspeciesatrisk.ca [November 2014].

Walker, D.A. and K.R. Everett. 1987. Road dust and its environmental impact on Alaskan taiga and tundra. Arctic and Alpine Research 19(4): 479-489.

Walker, D.A. and K.R. Everett. 1991. Loess Ecosystems of Northern Alaska: Regional Gradient and Toposequence at Prudhoe Bay. Ecological Monographs, 61(4): 437-464

Weaver, J.L. 2006. Big Animals and Small Parks: Implications of Wildlife Distribution and Movements for Expansion of Nahanni National Park Reserve. Conservation Report No. 1. Wildlife Conservation Society. 108 pp.

Weaver, J.L. 2008. Conserving Caribou Landscapes in the Nahanni Trans-Border Region using Fidelity to Seasonal Ranges and Migration Routes. Wildlife Conservation Society. 84 pp.

Wildlife Collision Prevention Program. 2014. Wood Bison in NW Canada. Web access: http://www.wildlifecollisions.ca/woodbisonvehiclecollisions.htm#NWTSeasonal [November 2014].

Wilson, J.M and C.A. Haas. 2012. Important Wildlife Areas in the Western Northwest Territories. Environment and Natural Resources, Government of Northwest Territories, Yellowknife, NT.

Veitch, A. 2014. *in* Government of Northwest Territories NWT Species Infobase. Environment and Natural Resources, GNWT, Yellowknife, NT. Web access: http://nwtspeciesatrisk.ca [November 2014].

Veitch, A., R. Popko, and N. Whiteman. 2000. Classification of Woodland Caribou in the Central Mackenzie Mountains, Northwest Territories, August 1999. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. Manuscript Report No. 122. 24 pp.

Veitch, A., E. Simmons, M. Promislow, D. Tate, M. Swallow, and R. Popko. 2002. The Status of Mountain Goats in Canada's Northwest Territories. Web access: http://media.nwsgc.org/proceedings/NWSGC-2002/2002-Veitch%20et%20al.pdf [November 2014].

Personal Communications

Steve Gooderham, Regional Forester, ENR. November 24, 2014 via email.

APPENDIX A

TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of Tetra Tech EBA’s client. 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 Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

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2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. The Client warrants that Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by Tetra Tech EBA in its reasonably exercised discretion.

4.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX 8

MEMO

Date: September 4, 2014 HCP Ref No.: CZN6788

From: John Wilcockson

To: Dave Harpley, Canadian Zinc Corp

Subject: **All Season Road – Review of Stream Crossings in NNPR - DRAFT**

INTRODUCTION

On July 27 and 28, 2014, Canadian Zinc Corp (CZN) and Parks Canada (Parks) staff collaborated on a site review of stream crossings in the Nahanni National Park Reserve (NNPR) associated with CZN's proposed all-season road. Jonathan Tsetso (Parks), Garry Scrimgeour (Parks), David Harpley (CZN), and John Wilcockson (Hatfield Consultants) participated in the review, the purpose of which was to classify the crossings with respect to probability of fish presence. The data collected will be used to determine the scope of follow-up field studies, and aid in the selection of suitable crossing structures. All sites were accessed by helicopter. Where the helicopter could safely land, ground-based assessments were carried out, including the completion of habitat sheets. In other instances, an assessment, including photographs, was completed from the air at low level with repeated passes. Crossings classified as potentially fish-bearing that were not assessed previously will be the subject of additional habitat assessments, likely in September 2014.

The proposed all season road traverses the eastern side of the park from near the Mine (km 17) to the Silent Hills (km 100), a total of 83 km. Over this distance it traverses mountains, large flood plains, a karst plateau, wetlands and tree-covered hills. The all-season road will generally follow the footprint of the existing winter road with some exceptions. Options for crossings include clear-span bridges, open-bottom culverts and various sizes of conventional culverts. The type of crossing structure selected will be determined by crossing geometry, hydrologic properties and fish passage requirements.

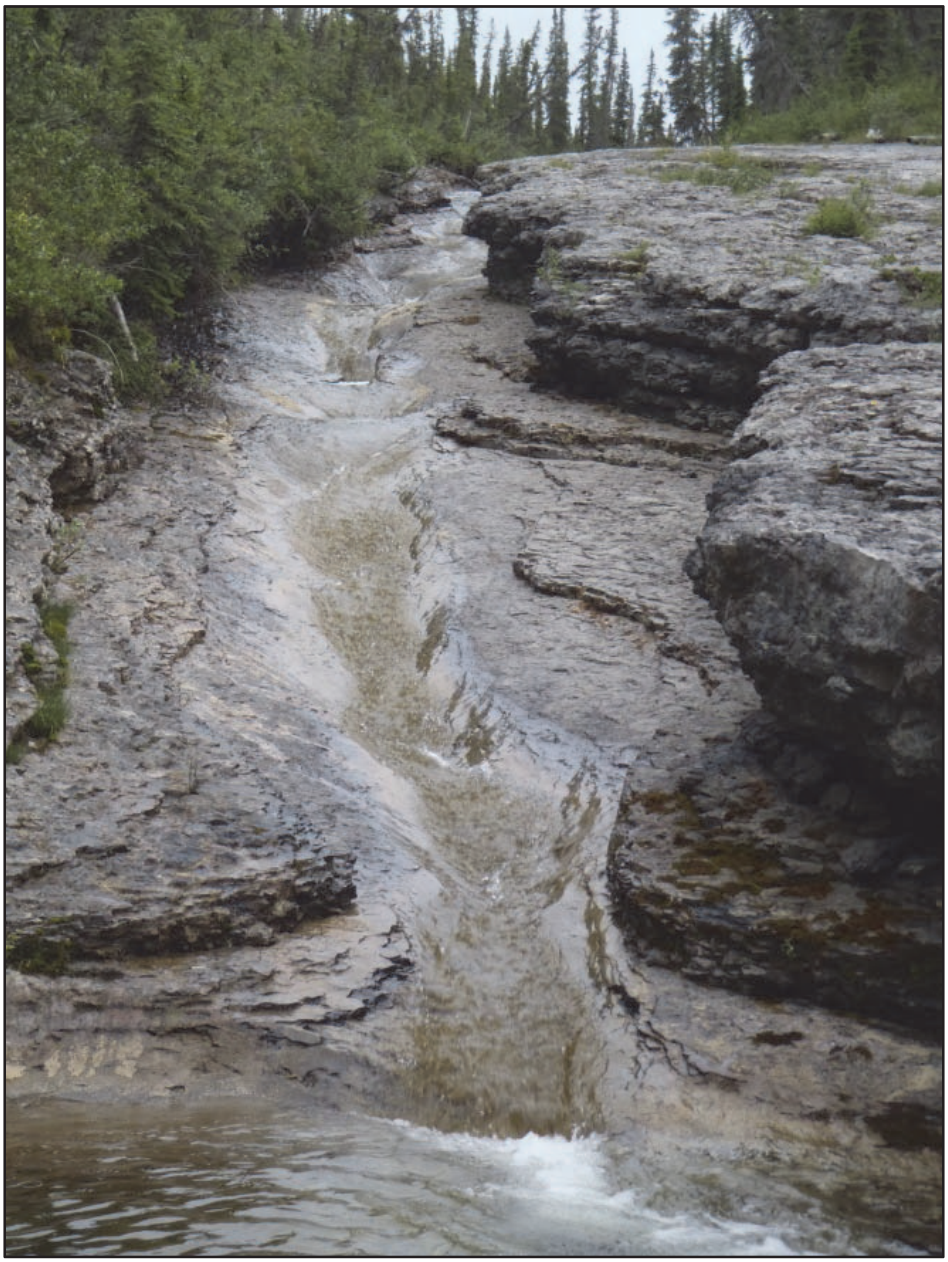
It was generally assumed that fish are present at all streams, unless weight of evidence suggests otherwise. The latter includes barriers to migration downstream, lack of a defined channel with flow, and shallow, warm oxygen-depleted water unlikely to sustain fish. Seven geographic areas are discussed in this memo below.

TRIBUTARY TO SUNDOG

The crossing of this tributary to Sundog Creek occurs at km 43.5 of the proposed all season road (based on the LiDar sheets reproduced by Allnorth). On July 27, CZN and Parks conducted a ground assessment of a 900 m section of the creek downstream of the crossing. There is a prolonged section of 10° to 12° slope over bedrock (Figures 1 to 4). The formation resembles a chute, with minimal back eddies or pools. While it would not be impossible for a fish to swim upstream during flood conditions, it is unlikely. Therefore, this feature is assumed to preclude

fish passage. Upstream of the chute, the habitat for fish improves, the gradient decreases and there are numerous pools, overhangs, backwaters and boulders. In this area, substrate consists primarily of bedrock, cobble and gravel. In 2005, electrofishing was conducted of a 40 m section of this reach and no fish were found (Bathurst 2005[1]). During the current investigation, CZN and Parks staff conducted additional electrofishing over a 300 m reach and also found no fish. These results indicate that the creek section downstream of the proposed road crossing is likely inaccessible to fish.

Figure 1 Upper chute on tributary to Sundog looking south (upstream), July 27, 2014.



[1] Bathurst, 2006. Canadian Zinc Prairie Creek Mine Winter Access Road Liard River (Km 175.5) to Prairie Creek Mine (Km 0). Report to Canadian Zinc.

Figure 2 **Flow over bedrock against cliff on tributary to Sundog, looking north, downstream, July 27, 2014.**

Figure 3 **Small cascade on tributary to Sundog, looking upstream, south, July 27, 2014.**

Figure 4 Lower chute on tributary to Sundog, looking upstream, south, July 27, 2014.

SMALL TRIBUTARIES TO POLJE CREEK

West of the Polje Creek crossing, the proposed road alignment travels along the side of a hill (km 45 to 53) and crosses several small tributaries of Polje Creek that were viewed from the air (Figure 5, 6 and 7). There were five small creeks with defined channels, and the locations of four of these are shown on the drawing provided as Attachment 1. The largest creek appeared to have a width of approximately 1.5 m. Ground-based assessments will need to be conducted on these creeks; however, observations from the air indicate that habitat upstream of the proposed crossing would be limited by flow as a result of the close proximity to the creek headwaters. The creeks with defined channels are located at km 46.7, 47, 49.3 and 54.3.

Figure 5 **Creek near km 47 (waypoint 37 on Attachment 1), tributary to Polje Creek, looking downstream, south, July 28, 2014.**

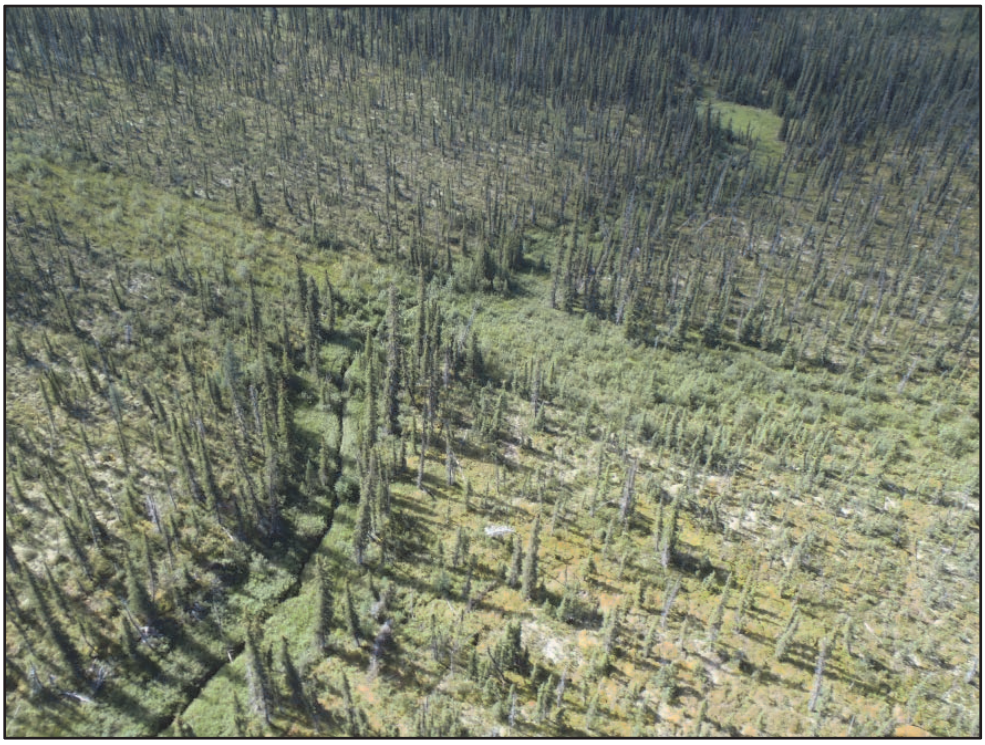
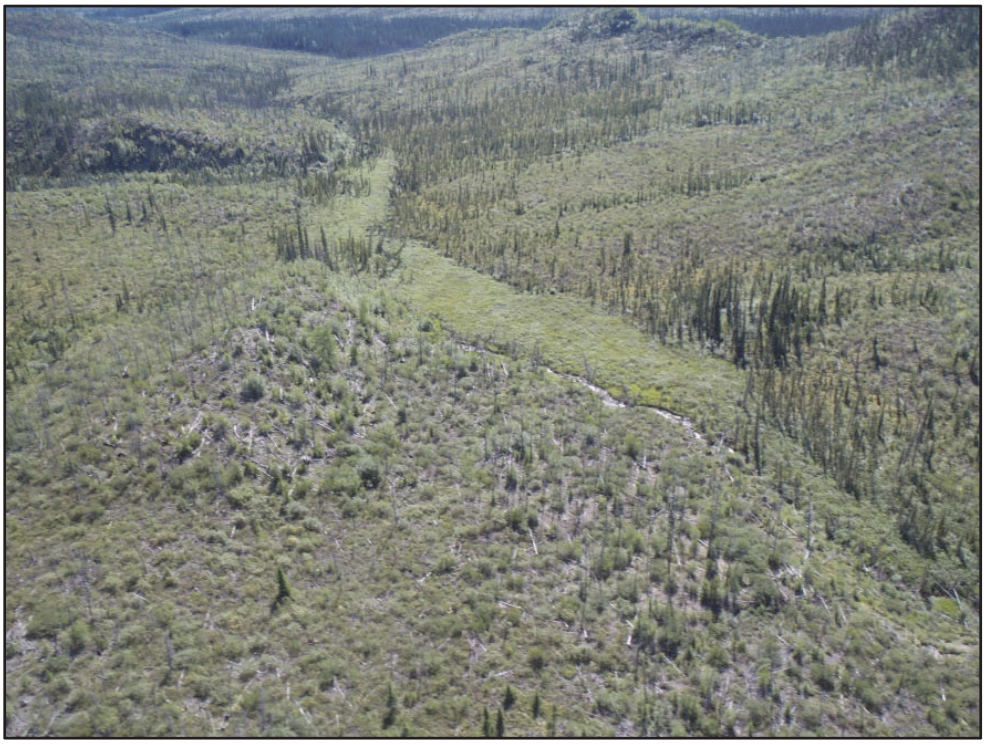


Figure 8 **Creek near km 49 (waypoint 34 on Attachment 1), tributary to Polje Creek, looking upstream, north, July 27, 2014.**

Figure 9 Creek near km 50 (waypoint 33 on Attachment 1), tributary to Polje Creek, looking downstream, south, July 28, 2014.



POLJE CREEK

A ground-based assessment was conducted on the Polje Creek Crossing and two smaller creek crossings to the west. Both of the smaller creeks were identified as tributaries to Polje Creek. The first tributary west of Polje Creek was small, having an average wetted width of 1.5 m; however, water quality appeared to be good, and there was abundant surface cover for fish (Figure 10). The second tributary, further to the west, did not have a defined channel and flow, if present, would occur subsurface under a blanket of moss, small plants and buried, decaying logs (Figure 11). The second tributary would not provide suitable habit for fish. Full habitat assessments were conducted on Polje Creek (Figure 12) and the first tributary to the west. Both contain good habitat for fish, including a "diversity of cover and habitat types including deep water pools, undercut banks, in-stream structure from overhanging vegetation and woody debris"(Dillon, 2009). Electrofishing was not conducted in Polje Creek as part of this reconnaissance investigation. During a previous survey, researchers were unable to capture fish and no fish were observed (Dillon, 2009[2]). Despite this, the investigators indicated that the creek is likely to support fish similar to those species found in Sundog Creek, and fish were found upstream previously.

[2] Dillon, 2009. Prairie Creek Mine Winter Road Re-alignment A, B, C, Re-routing to Nahanni Butte, Polje Creek Bypass Air and Ground Stream Crossing Fish Habitat Assessments. Memo to David Harpley, CZN by Craig Thomas, Dillon Consulting Limited, November 25, 2009.

Figure 10 First Tributary to Polje Creek Crossing, looking upstream, north, July 28, 2014.

Figure 11 Second Tributary to Polje Creek Crossing, looking south, July 28, 2014.

Figure 12 Polje Creek Crossing Creek at km 49 (WP33), looking downstream, south, July 28, 2014.

CREEKS DRAINING TO POLJES

There are a number of drainage pathways draining into the Poljes from km 55-63. None have a defined channel and their outlets 'hang' above the Poljes, making them inaccessible to fish.

INLET TO MOSQUITO LAKE

An air-based assessment was conducted of a small drainage area feeding into Mosquito Lake on July 28, 2014. Flow from Mosquito Lake is known to drain to the Poljes, which are considered to be inaccessible to fish. However, there is a possibility that Mosquito Lake hosts a resident population. From the air, the inflowing drainage appeared to enter a series of small wetlands (Figure 13). Channels were poorly defined and appeared to be low-gradient and filled with aquatic vegetation. It is considered unlikely that fish would use these inflow channels for migration. The habitat value of the wetlands appears to be similar to the littoral habitat, containing abundant aquatic vegetation. Therefore, due to the marginal, littoral-like habitat in the wetlands and channel, the inflow area is unlikely to provide any critical habitat to fish even if they are present in Mosquito Lake.

Figure 13 Inlet of Mosquito Lake, looking downstream, north, July 28, 2014.

TETCELA RIVER

An air-based assessment was conducted on the two Tetcela River crossings. Tetcela River is a larger river: at the crossings, the river was about 15 m wide and appeared to provide relatively deep, run-type habitat (Figure 14 and 15). Water appeared to be tea stained and turbid. This river appears to provide good fish habitat. Fish surveys by Beak (1982)[3] and Rescan (1994)[4] recorded presence of Arctic grayling, whitefish, northern pike, lake chub, slimy sculpin, and longnose sucker.

[3] Beak 1982 Summary Document. Prairie Creek Project, Water Quality and Aquatic Biology. Report prepared for Cadillac Explorations limited, Calgary, Alberta, February 1982. K4606B

[4] Rescan 1994 Prairie Creek Mine. Fisheries and Aquatic Resources Baseline Studies -1994

Figure 14 First Tetcela River Crossing, looking upstream, north, July 28, 2014.

Figure 15 Second Tetcela River Crossing, looking upstream, north, July 28, 2014.

FISHTRAP CREEK

A ground-based assessment was conducted by CZN and Parks staff (Garry Scrimgeour) on July 28. Due to the boggy conditions, it was not possible to reach the crossing location from the landing site. However, a representative location, about 50 m upstream, was assessed. Fishtrap Creek in the area of the crossing consists of a series of ponds, many with beaver dams (Figure 16 and 17). Flow at the representative location was low and the channel was filled with aquatic vegetation. Water striders and aquatic snails were observed. Dissolved oxygen concentrations were adequate for fish (8.54 mg/L), but it is likely that DO levels drop significantly in this system at night when aquatic plants start removing oxygen from the water column. The high water temperature, 20° C, would also limit the types of fish that could survive at the site. Garry Scrimgeour believed the presence of water striders indicates either the absence or low abundance of fish, given these insects tend to be easy prey for fish. Observations indicate that Fishtrap Creek in the area of the all season road crossing, which is very near the upstream catchment boundary, provides poor habitat for fish. Electro-fishing by Beak (1982)[5] failed to locate fish. In addition, a water quality assessment under ice by Beak (1981)[6] observed dissolved oxygen concentrations below 1 ppm, thus likely precluding fish overwintering.

Figure 16 Fishtrap Creek Crossing, looking downstream, south, July 28, 2014.

[5] Beak 1982 Summary Document. Prairie Creek Project, Water Quality and Aquatic Biology. Report prepared for Cadillac Explorations limited, Calgary, Alberta, February 1982. K4606B

[6] Beak 1981. Prairie Creek Project. Fisheries and Invertebrate Studies, 1981. Prepared for Cadillac Explorations Ltd. Calgary, Alberta. September, 1981. K4606

Figure 17 Fishtrap Creek Crossing, looking upstream, north, July 28, 2014.

Table 1 GPS Coordinates.

Location Name	Coordinates (UTMs)
Tributary to Sundog, midpoint of bedrock chutes	10 V 431407 6830537
Tributary to Polje Ck (approx. km 47, waypoint 37))	10 V 434571 6829304
Tributary to Polje Ck (approx. km 47.6, waypoint 40)	10 V 435177 6829130
Tributary to Polje Ck (approx. km 47.6, waypoint 36)	10 V 435193 6828981
Tributary to Polje Ck (approx. km 49.1, waypoint 34)	10 V 436433 6829080
Tributary to Polje Ck (approx. km 50.2, waypoint 33)	10 V 436877 6829835
First Tributary east of Polje Ck	10 V 440615 6830774
Second Tributary east of Polje Ck	10 V 440509 6830759
Polje Ck Crossing	10 V 440688 6830794
Outlet of Mosquito Creek	10 V 446766 6825508
Tetcel River Crossing	10 V 461330 6815569
Fishtrap Creek Crossing	10 V 465062 6813912

Attachment 1

Map of Polje Creek Tributaries, Prairie Creek Mine

434000 435000 436000 437000

6830000 6829000

WP 33 KP50 WP 37 WP 38 WP 39 KP47 WP 40 WP 36 KP48 WP 34 WP 35 KP49

Prairie Creek Mine
Polje Creek Tributaries

Legend

- Polje Creek Waypoints
- Bridge
- Culvert
- Access Road Update KPs
- Access Road Update
- Comment Lines
- Roads

Water Features

- CREEK - INDEF
- RIVERSHORE

Date: 8/22/2014
Projection: NAD 1983 UTM Zone 10N
Scale: 1:10,000
Author: ainglis
Last Modified By: ainglis
Checked By:
Revision #:

0 100 200 400
Metres

Map Location

Sources: Esri, HERE, DeLorme,

Path: C:\14-GP-0128_CanadianZinc-PrairieCreekMineRoad\2400-GIS\2420-MXD\Prairie_Creek_Mine_Polje_Creek_10k_B.mxd

Attachment 2

Field Notes from July 27 and 28, 2014

CZN6788 27 July '14

Purpose: First day of Road assessment - Sundog to cat camp + Polge (Bubbling Springs) Ck. Electrofishing Sundog + net/trap mosquito

Crew: John, Dave, Garry + Jon

Electrofishing settings used in ~~past~~ last year 425v ± 25v 30Hz
~~Duty cycle 12%~~ (Neal)
US: sculpin - 400v 50Hz 20DC
Trout - 40 Hz

Km 44 look at potential migration barrier prefer culvert over bridge.
Km 35-38 - possible re-alignment, shocking here.
Trib to Polge (bubbling springs)

Km 24 - falls
wp 10 drop of electrofishing gear. ~Km 36

Tetsela
44 fish migration barrier ... 47-49 alignment

CZN6788 27 July '14

WP 11 Catcamp

Km 43 Crossing 431569 6829953 WP 012

WP 13 ~~APP~~ Trib to Sundog long chute ~75m S
Photo + Photo north ~150m long against black coloured cliff 10° slope ~12° further upstream in chute

0431295 6830730
WP 14 Downstream pool,
~~Dave~~ saw fish ~10cm upstream of pool ~10°
Furthest D/S point

WP 15 S N , WP ~~17~~ 16 S N W pool
WP 17 S N WP 18 S N (not recorded)

1215 @ Sundog Ck realignment location #1
pH ~~9.51~~ 7.6°C 221 µS (AJ)
JW pH 8.60 8.68°C 260 µS (AK)

upstream riffle flows / depths

		depth	flow
Top	25	22cm	.29
~~Mid~~	50	40cm	.75
~~bottom~~ ~~75~~		26 cm	.61
Mid	25	32cm	.59
	50	46cm	.97
	75	22	.27
Bottom	25	28	.92
	50	32	1.20
	75	42cm	1.06

DO on meter 11.20 mg/L
94.8%
DO titration 10.8 mg/L

WP22 Sundog goes to ground.

Second sundog realignment site (Location ~~#2~~ A ~~Site A~~)
Top WP023 426356
6829278
Bottom WP024 426418
6829265
Cond 268.5/9.1°C / 7.40 (AK)

DO meter 99.4% 11.83 mg/L
pH 8.63 7.4°C 233 µS (AJ)
DO titration 10.2 mg/L
second sundog realign site
Location B

Top wpt 025 426255
6829318
Bottom wpt 026 426323
6829305

End ~ 1635.
Pilot late picking us up - decided to send just Garry + Dave to sundog trib to electrofish 1730 - 1815
back @ camp about 1835

For the sundog allignment locations, Jon and I did habitat sheets, while Garry + Dave electrofished

A sundog 1, ~~site A~~ 1348sec
ARGR FL (mm): 190, 183, 181, 192
SLSC FL (mm): 81, 92, 93, ?

Rite in the Rain

CZN6788 27 July '14

Settings for sites ~~A + B~~ 1 + 2
500v, freq: 50

For the Sundog Alligment, site 2
d/s location ("A") - no fish 327 sec
u/s " ("B") - no fish 188 sec

For trib to Sundog (visited earlier in day)
724 sec
wp 27 (431594 / 6829949)
to wp 28 (431514 / 6829743)
assume sinusosity of 2.0
assume welted width 2.5m

CZN6788 28 July '14

Purpose:- habitat ass @ Polje Creek crossings + assess trib's. Trapping near outlet of Mosquito. + Flying much of road alligment where ~~cros~~ there are crossings.

Crew:- Dave H, Garry S, Jonathan T, John W.

Broken high overcast took off @ 742.

Road alligment from air photos
~~WP 28~~

Picked up gear (nets + traps) + dropped at "dry" lake near polgi ck - then dropped ~~two~~ people in at a time to Polgi Ck. ~ km 53
wp 28 is landing spot created log landing pad.
Walked to two small trib's to west - second trib

Rite in the Rain

not flowing + no defined channel
~~gocs~~ moss, ~~sed~~ shrubs + holes w/ logs. walked further 100 m to confirm that second channel was not missed (wp 29, 277 m from landing site) Area. Photo WNES Labrador tea, dwarf spruce, lichen, moss, horsetail. Larch (?)

2nd stream west WP30
photo WNES (before this photo)

Following road back looking for tribs
WP 33 small defined channel
< 1m wide
WP 34/35 larger trib quite incised dead + falling trees in channel
WP 36 small defined channel
< 1m wide
WP 37 another small channel
< 1m wide (photo just before)
last 3 photos WP39

JW

WP 34/35 likely green dot on map
km 46.5
last 4 photos WP40

Polgies
Tetsela - last photo first crossing
Next photos second crossing
WP 41

Fish trap - last few + next few
WP 42
Flow ~0.02 m/s (Gary's estimate
Pen: 20.3°C 589 µS pH 8.08
YSI (DO calibrated) 19.7°C 11.3 mg/L
124% O_2 Sat pH 8.54 476 µS
Water striders noted on surface
Gary said that they are a good indicator for fish absence, since they get hammered by fish. Gary also believes that DO of Fish Trap would be much lower at night when aquatic plants start using O_2.

JW

Rite in the Rain

(14) CZN6788 28 July 14

Sampling site WP 043
Bank height ~ 1m
DO titration 9.8 mg/L
1345 finish
- collected nets + minnow traps + fish cat on way back,
- Took multiple photos of ~~wall~~ Sundog Creek realignment
- Back @ camp ate lunch + downloaded photos.
- went out w/ Dave to look @ Casket Ck comp habitat opened up some channels, saw a young grizzly. Then to water storage pond. took 4 cores for geotech purposes.

John Fellows

Attachment 3

Fish Habitat Data Sheets from July 27 and 28, 2014

Stream Habitat Information

Data Collectors JW, DH, Garry, Jon	**Date** 28 July	**Time (24 H)** 0942
Site Polge Ck Crossing	**Station** Main Creek (E of landing)	**Project** CEN6788
UTM NAD WP 31	**Upstream Northing**	**Upstream Easting**
Access Helecopter	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)	Length (m)				Velocity (60% depth or surface)		
(Run) (Riffle) Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall Other:	1						
Depth/Pool (m)	2						
Channel Slope (°)	3						
Wetted Width / 8 / 8 / 8 m	Channel Width (m)	/ 10 / 11 / 11		Unstable Banks (5%)			
Meander Frequency / / / / m	Regular / Irregular meanders			Bank slope (5°)	L 30	R 70	

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	1 %	Substrate (as cover)	— %
Instream Cover (logs, etc)	1 %	Instream vegetation	— %	Undercut Bank	2 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	20	-
% Gravel	60	0
% Cobble	20	50
% Boulder	—	—
% Bedrock	—	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	1 grass %

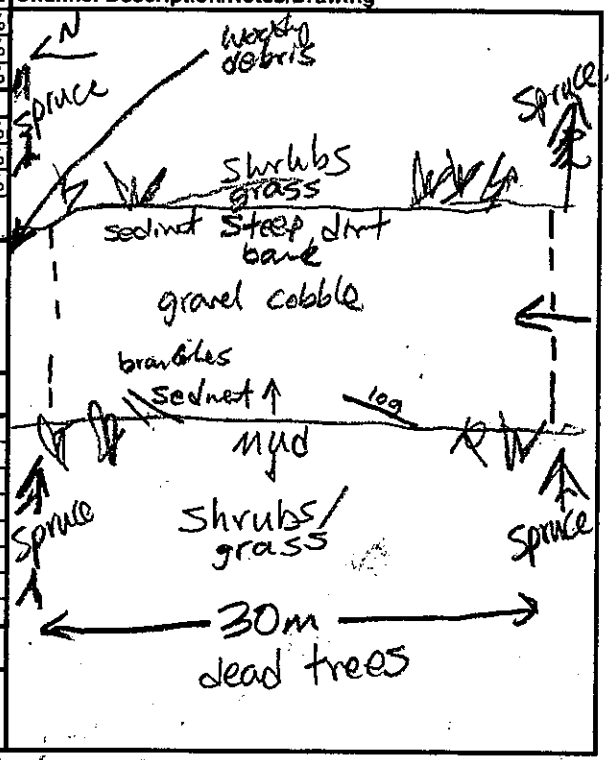
Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
(Roads) — evidence of old winter road	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	2 %	Overhanging Trees	1 %
Overhanging Grasses	1 %	Overhanging Shrubs	1 %

Channel Description/Notes/Drawing



Miscellaneous

High water mark	1m m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	— m	clear
Air Temperature	°C	
Cloud Cover (5%)	60 thin cirrus	
Wind Direction + speed (km/h)	N 2	

In situ Water Parameters / YSI / Titration

Sample Depth (m)		/		
Dissolved Oxygen (%)	97.6			
Dissolved Oxygen (mg/L)	12.21	10.8		
Secchi Depth (m)				
Temperature (°C)	6.2			
pH	8.39			
Turbidity (TCU)				
Conductivity (uS/cm)	353			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	(Shrubs)	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	NO

Photos dead trees

U/S D/S CC

Channel Features	#	Dimensions
Islands		
Bars		

Notes

- Flat ~~75%~~ 50% embedded stones
- Moose ~~feet~~ pits

Stream Habitat Information

Data Collectors Palae Ck Crossing	**Date** Small trib (west)	**Time (24 H)** 10:09
Site JW, DH, Gerry, Jon	**Station** 28 July	**Project** CEN6788
UTM NAD WP032	**Upstream Northing**	**Upstream Easting**
Access Helecoptor	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width 1.4 / 1.4 / 1.9 /		m	Channel Width (m)	1.6 / 1.6 / 2.0		Unstable Banks (5%)			
Meander Frequency / / / /		m	Regular / Irregular meanders			Bank slope (5°)	L 60	R 60	

Instream Cover

Instream Cover (Detritus)	— %	Instream Cover (Twigs/Sticks, etc)	20 %	Substrate (as cover)	— %
Instream Cover (logs, etc)	5 %	Instream vegetation	5 %	Undercut Bank	10 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	60	0
% Cobble	40	0
% Boulder	—	—
% Bedrock	—	-

Instream Vegetaion (Sum 100%)

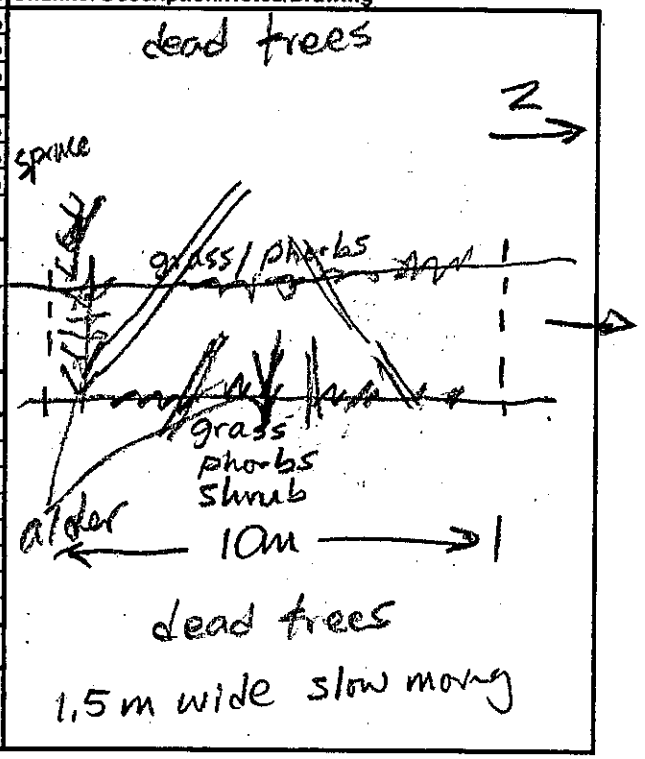
Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

old road r.o.w.

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	%	Overhead Litter >150 mm (%)	%
Overhead Undercut Banks	%	Overhanging Trees	%
Overhanging Grasses	%	Overhanging Shrubs	%

Miscellaneous

High water mark	.60 m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	.60 m	clear
Air Temperature	°C	
Cloud Cover (5%)	Cirrus 60%	
Wind Direction + speed (km/h)	0	

In situ Water Parameters

pen probe titration

Sample Depth (m)			
Dissolved Oxygen (%)		60.5	
Dissolved Oxygen (mg/L)		8.45	7.2
Secchi Depth (m)			
Temperature (°C)	9.5		
pH	7.1	8.6	
Turbidity (TCU)			
Conductivity (uS/cm)	480		

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos Dead trees (forest fire)

Channel Features	#	Dimensions
Islands		
Bars		

Notes 4.8

APPENDIX 9

Hatfield CONSULTANTS

MEMO

Date: March 12, 2015 HCP Ref No.: CZN6788

From: John Wilcockson

To: David Harpley – Canadian Zinc Corporation

Subject: **Prairie Creek Proposed All Season Road - Stream Crossing Habitat Assessments, August and September, 2014**

1.0 INTRODUCTION

In 2014 Hatfield participated in two field programs to assess habitat at and near potential stream crossings associated with a proposed all-season road from the Prairie Creek mine (Km 0) to the Nahanni Butte connector road (Km 175]. Between July 27 and 29, 2014, John Wilcockson (Hatfield) and David Harpley (Canadian Zinc) visited or assessed from the air several locations from Km 36 to Km 173 on the proposed all-season road. Mr. Johnathan Tsetso and Dr. Garry Scrimgeour accompanied John and Dave on July 27 and 28 in order to assess crossings within the Park. Results of these site visits were summarized in two technical memos produced by Hatfield in 2014[1,2].

Chris Jaeggle (Hatfield Consultants) and David Harpley (Canadian Zinc) returned to the proposed road crossings between September 21 and 26, 2014. Fish habitat data were collected during both field programs; hydrological data also were collected in September. Data were intended to be used to support the selection of appropriate stream crossing structures at crossing locations selected by Canadian Zinc and engineers from Allnorth Consultants (Prince George, BC).

A summary of sites assessed and the type of assessment done is provided in Table 1. Results of a bathymetric study conducted on the Liard River at the proposed Liard River crossing on September 25, 2014 were provided in a separate document[3].

1 Hatfield Consultants. 2014. Habitat Assessment of Sundog Creek Channels for Realignment - Draft, Memo written for Canadian Zinc Corp, September 9, 2014.

2 Hatfield Consultants. 2014. All Season Road – Review of Stream Crossings in NNPR - Draft, Memo written for Canadian Zinc Corp, September 4, 2014.

3 Hatfield Consultants. 2014. September 25, 2014 Liard River Bathymetry and Bank Survey - Draft, Memo written for Canadian Zinc Corp, January 16, 2015.

Table 1 Matrix of stream data collected for assessment of a proposed all-season road to Prairie Creek Mine, August and September 2014.

Location	Coordinates	Date	Assessment from air only	Site Visit	Habitat Sheet filled out	hydrometric data recorded	Discussed in memos to Parks
July/August Program							
Sundog Location 2	10 V 426324 6829305	27-Jul	-	X	X	-	X
Sundog Location 1	10 V 427040 6829338	27-Jul	-	X	X	-	X
KP43.5 Tributary to Sundog	10 V 431394 6830360	27-Jul	-	X	-	-	X
KP45-53 Small Tribs to Polje Ck	10 V 434623 6829284	28-Jul	X	-	-	-	X
Polje Creek	10 V 440688 6830794	28-Jul	-	X	X	-	X
Trib to Polje Ck	10 V 440509 6830759	28-Jul	-	X	X	-	X
KP55-63 Creeks draining to Poljes	--	28-Jul	X	-	-	-	X
Inlet to Mosquito Lake	10 V 446766 6825508	28-Jul	X	-	-	-	X
KP87.7 Tetcela River	10 V 461330 6815569	28-Jul	X	-	-	-	X
Fishtrap Creek	10 V 465062 6813912	28-Jul	-	X	-	-	X
Various tribs to Liard River			X	-	-	-	-
September Program							
KP27.1 Sundog Creek	10 6828332 418911	22-Sep		X	X	-	-
KP27.5 Sundog Creek	10 6828089 419225	22-Sep		X	X	-	-
KP28.4 Sundog Creek	--	22-Sep		X	X	X	-
KP29.2 Sundog Creek	10 V 420601 6827089	22-Sep		X	X	-	-
KP39.8 Sundog Creek	11 6830273 428369	21-Sep		X	X	X	-
KP47.0 Polje Trib	10 6829338 434240	21-Sep		X	X	X	-
KP50.2 Polje Trib	10 6829737 436944	21-Sep		X	X	X	-
KP54.3	10 V 440622 6830769	26-Sep		X	X	X	-
KP87.7 Tetcela mainstem	10 V 460241 6812386	24-Sep		X	X	X	-
Tetcela trib - at old road	10 V 460369 6813941	24-Sep		X	X	X	-
Tetcela main - at old road	10 V 461369 6815670	24-Sep		X	X	X	-
KP122.8 Granger Trib	10 V 477151 6798715	23-Sep		X	X	X	-
KP123.7 Granger Main	10 V 478319 6799043	23-Sep		X	X	X	-
KP125.1 Granger Main	10 V 479157 6799517	23-Sep		X	X	X	-
KP131.3 Granger Trib	10 V 481988 6794966	26-Sep		X	X	X	-
KP133.7 Granger Trib	10 V 482671 6793161	24-Sep		X	X	X	-
KP135.6 Granger Trib	10 V 482380 6791274	25-Sep		X	X	X	-
KP136.7 Granger Trib	10 V 483132 6790094	26-Sep		X	X	X	-
KP154.4 Liard Trib	10 V 486500 6774900	22-Sep		X	X	X	-

2.0 PROCEDURES

2.1 GENERAL

Sites were accessed primarily by helicopter. The exception was Sun Dog Creek sites between Km 27.1 and 28, which were accessed by quads on September 22, 2014.

At all sites, photographs (Attachment A), field data (Attachment B and C) and field notes (Attachment D) were collected.

2.2 HABITAT DATA

Habitat data was collected using a fish habitat data sheet modeled after the RISC fish habitat datasheets[4]. Data collected at each site included stream width, depth, velocity, stream morphology, presence of cover for fish, substrate composition, instream vegetation, riparian vegetation and in-situ water quality variables (i.e. dissolved oxygen, temperature, pH and conductivity). An annotated site sketch was also made at each location. Stream flow measurements were recorded using a March-McBirney Flo-Mate Model 2000 at 60% of measured water depth and at several locations across a single transect perpendicular to flow, water depth was measured using a wading rod. Stream width was measured using an Eslon tape. DO was measured using a Lamotte dissolved oxygen titration kit, while conductivity, pH and temperature were measured using an Hanna HI 98129 pH EC TDS conductivity pen.

2.3 HYDROLOGIAL DATA

Hydrological data were collected at each of the sites visited in September 2014. At the preferred crossing location, Hatfield staff conducted surveys of the channel cross-section (from bank top to bank top), longitudinal stream-reach surveys (for channel slope), and flow and depth data along a single stream cross-section.

Channel cross-section and longitudinal surveys were conducted using a level survey kit, consisting of an engineer's level mounted onto a tripod, and a stadia rod. After setting up and levelling the tripod and engineer's level near the top of the bank, several points along the cross-section, including top of bank, high water mark, water level surface, stream bed, and several points between the top of bank and water surface, were surveyed. The top of bank survey point was given an arbitrary datum of 100.000 m, which was used to calculate relative elevations of the other survey points. The channel bed was also surveyed at several points upstream and downstream of the crossing area (longitudinal survey). This survey used the same arbitrary datum as the cross-section survey. Horizontal distance between each survey point was measured using an Eslon tape or a laser rangefinder. Longitudinal survey data was used to calculate an average channel reach slope.

Flow measurements were performed using an Eslon tape, a 2.0-m top-setting wading rod, and a Sontek Flowtracker Acoustic Doppler Velocimeter (ADV). Measurements consisted of horizontal distance (perpendicular to the flow direction, measured with an Eslon tape), depth of water (measured with the

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[4] BC Fisheries Information Services Branc, 2001, Reconnaissance (1:20 000) fish and fish habitat inventory standards and procedures, prepared for Resources Inventory Committee, April 2001 Ver 2.0.

wading rod), and average water velocity (measured with the ADV, positioned at 60% of the measured water depth, for forty seconds) at all measured at several points (panels) along the channel cross-section. Flow measurements typically consisted of at least twenty measurement panels per cross-section; however, channel size and morphology (i.e., roughness) dictated the number of panels that could be measured at each cross-section. Using the area-velocity method, instantaneous streamflow was then calculated from the data collected (Attachment E and F).

3.0 DATA

All data are attached to this memo as attachments:

- Attachment A - photographs;
- Attachment B - fish habitat field datasheets;
- Attachment C - hydrology field datasheets;
- Attachment D - scanned field note book;
- Attachment E - Hydrometric station cross–section/reach survey field record; and
- Attachment F - hydrometric measurement/site visit record.

For additional information, please contact either Chris Jaeggle or John Wilcockson at (604) 926-3261.

ATTACHMENTS

Attachment A

Photographs

Photograph 1 **Sundog Creek at Km 27.1, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 2 **Sundog Creek at Km 27.1, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 3 **Sundog Creek at Km 27.1, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 4 **Sundog Creek at Km 27.1, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 5 **Sundog Creek at KP27.2 facing north (upstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 6 **Sundog Creek at KP27.4 facing north-northeast (cross-steam), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 7 **Sundog Creek at Km 27.5, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 8 **Sundog Creek at Km 27.5, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 9 **Sundog Creek at Km 27.5, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 10 **Sundog Creek at Km 27.5, Prairie Creek all season road stream crossing study, September 22, 2014.**

Photograph 11 Tributary to Sundog Creek at Km 27.5, Prairie Creek all season road stream crossing study, September 22, 2014.

Photograph 12 Sundog Creek at Km 28.4, Prairie Creek all season road stream crossing study, September 22, 2014.

Photograph 13 Sundog Creek at Km 28.4, Prairie Creek all season road stream crossing study, September 22, 2014.

Photograph 14 Sundog Creek at Km 28.4, Prairie Creek all season road stream crossing study, September 22, 2014.

Photograph 15 Sundog Creek at Km 28.4, Prairie Creek all season road stream crossing study, September 22, 2014.

Photograph 16 Sundog Creek at KP29 facing east-southeast (downstream), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 17 Sundog Creek at Km 29.2, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 18 Sundog Creek at Km 29.2, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 19 **Sundog Creek at Km 29.2, Prairie Creek all season road stream crossing study, September 23, 2014.**

Photograph 20 **Sundog Creek at KP30.5 facing east-southeast (downstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 21 **Sundog Creek at KP 30.5 facing north-northwest (upstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 22 **Sundog Creek at KP30.7 facing west-northwest (upstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 23 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 24 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 25 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 26 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 27 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 28 Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 29 **Sundog Creek at Km 37.5, Prairie Creek all season road stream crossing study, July 27, 2014.**

Photograph 30 **Sundog Creek at KP37.8 facing east (downstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

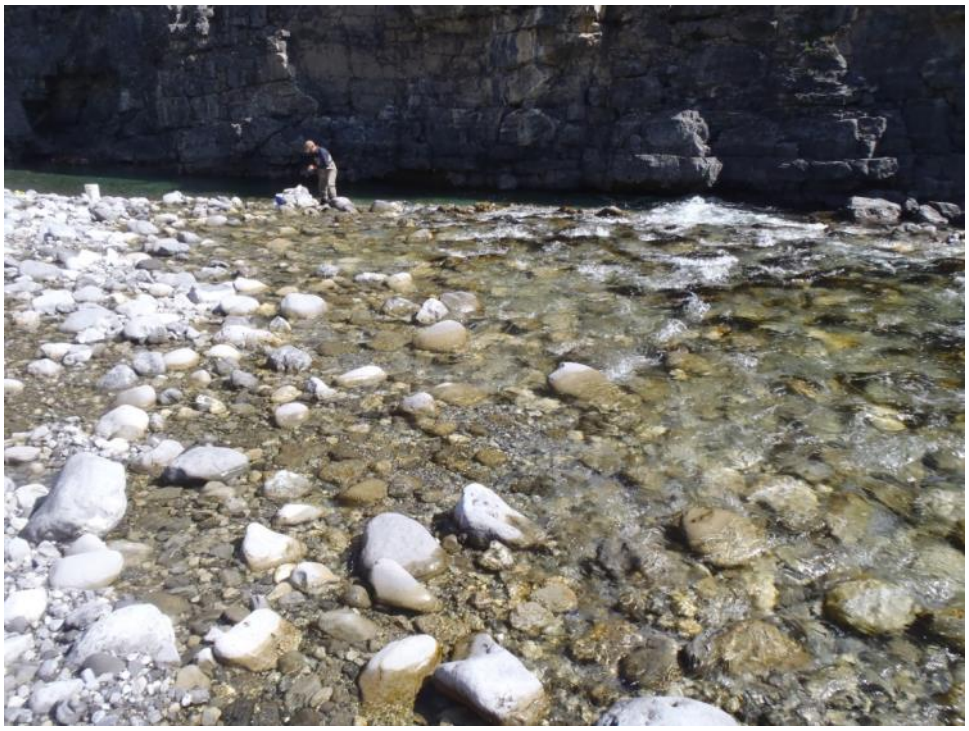
Photograph 31 Sundog Creek at Km 38 facing northeast (downstream), Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 32 Sundog Creek at Km 38.1, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 33 Sundog Creek at Km 38.1, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 34 Sundog Creek at Km 38.1, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 35 Sundog Creek at Km 38.1, Prairie Creek all season road stream crossing study, July 27, 2014.



Photograph 36 Sundog Creek at Km 38.1, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 37 **Sundog Creek at KP38.2 facing southwest (upstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 38 **Sundog Creek at KP38.2 facing northeast (downstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 39 **Sundog Creek at KP38.8 facing northeast (downstream), Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 40 **Sundog Creek at KP39.3 facing northeast (downstream), Cat Camp shown in top quarter of photo, Prairie Creek all season road stream crossing study, July 28, 2014.**

Photograph 41 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 42 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 43 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 44 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 45 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 46 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 47 Sundog Creek at Km 39.9, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 48 Tributary to Sundog Creek downstream of Km 43.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 49 Tributary to Sundog Creek downstream of Km 43.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 50 Tributary to Sundog Creek downstream of Km 43.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 51 Tributary to Sundog Creek downstream of Km 43.5, Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 52 Tributary to Sundog Creek downstream of Km 43.5 looking east (upstream), Prairie Creek all season road stream crossing study, July 27, 2014.

Photograph 53 Tributary to Poljie Creek at Km 46, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 54 Tributary to Poljie Creek at Km 46, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 55 Tributary to Poljie Creek at Km 46, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 56 Tributary to Poljie Creek at Km 47, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 57 **Tributary to Poljie Creek at Km 47, Prairie Creek all season road stream crossing study, September 21, 2014.**

Photograph 58 **Tributary to Poljie Creek at Km 47, Prairie Creek all season road stream crossing study, September 21, 2014.**

Photograph 59 Tributary to Poljie Creek at Km 47, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 60 Tributary to Poljie Creek at Km 47, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 61 Tributary to Poljie Creek at Km 49.1, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 62 Tributary to Poljie Creek at Km 49.1, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 63 Tributary to Poljie Creek at Km 49.1, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 64 Poljie Creek at Km 49.4, no tributary found, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 65 **Poljie Creek at Km 49.4, no tributary found, Prairie Creek all season road stream crossing study, September 21, 2014.**

Photograph 66 **Km 49.4, no tributary found, Prairie Creek all season road stream crossing study, September 21, 2014.**

Photograph 67 Tributary to Poljie Creek at Km 50.2, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 68 Tributary to Poljie Creek at Km 50.2, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 69 Tributary to Poljie Creek at Km 50.2, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 70 Tributary to Poljie Creek at Km 54.2, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 71 Tributary to Poljie Creek at Km 54.2, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 72 Tributary to Poljie Creek at Km 54.2, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 73 Tributary to Poljie Creek at Km 54.2, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 74 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 75 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 76 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 77 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 78 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 79 Tributary to Poljie Creek at Km 54.3, Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 80 Poljie Creek at Km 54.4, Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 81 Poljie Creek (Km 54.4), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 82 Poljie Creek (Km 54.4), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 83 Poljie Creek (Km 54.4), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 84 Poljie Creek (Km 54.4), Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 85 Poljie Creek (Km 54.4), Prairie Creek all season road stream crossing study, September 21, 2014.

Photograph 86 Poljie Creek (Km 54.5), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 87 Mosquito Lake (Km 64.6), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 88 Mosquito Lake inlet (Km 64.6), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 89 Mosquito Lake inlet (Km 64.6), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 90 Small Tributary to Tetcela River - Helicopter Recon (Km 86.7), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 91 **Small Tributary to Tetcela River - Helicopter Recon (Km 86.7), Prairie Creek all season road stream crossing study, September 24, 2014.**

Photograph 92 **Small Tributary to Tetcela River - Helicopter Recon (Km 86.7), Prairie Creek all season road stream crossing study, September 24, 2014.**

Photograph 93 Small Tributary to Tetcela River - Helicopter Recon (Km 86.8), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 94 Large Tributary to Tetcela River (first Tetcela crossing, Km 87.7), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 95 Large Tributary to Tetcela River (first Tetcela crossing, Km 87.7), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 96 Large Tributary to Tetcela River (first Tetcela crossing, Km 87.7), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 97 **Large Tributary to Tetcela River (first Tetcela crossing, Km 87.7), Prairie Creek all season road stream crossing study, September 24, 2014.**

Photograph 98 **Tetsela River Mainstem (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, September 24, 2014.**

Photograph 99 Tetsela River Mainstem (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 100 Tetsela River Mainstem (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 101 Tetsela River Mainstem (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 102 Tetsela River Mainstem (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 103 Mainstem Tetsela River (second Tetcela crossing, Km 90.1), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 104 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 105 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 106 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 107 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 108 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, July 28, 2014.

Photograph 109 Fish Trap Creek (Km 95), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 110 Unnamed Creek (KP 105), Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 111 Tributary of Gap Lake at Km 122.8, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 112 Tributary of Gap Lake at Km 122.8, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 113 Tributary to Gap Lake (200 m south of Km 122.8), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 114 Tributary to Gap Lake (approx. 500 m north of Km 122.8), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 115 South End of Gap Lake at Km 123.1, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 116 Flow out of Gap Lake (Km 123.1), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 117 Gap Lake flowing in to Granger River (Km 123.2), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 118 Gap Lake flowing in to Granger River (Km 123.2), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 119 Gap Lake flowing in to Granger River (Km 123.3), Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 120 Tributary to Granger River at Km 123.3, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 121 Granger River at Km 123.3, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 122 Granger River at Km 123.3, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 123 Granger River at Km 123.3, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 124 Granger River at Km 123.3, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 125 Granger River at Km 123.5, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 126 Debris fan some flow to Granger River at Km 123.5, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 127 Granger River at Km 123.5, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 128 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 129 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 130 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, July 29, 2014.

Photograph 131 Granger River at Km 127.7, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 132 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 133 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 134 Granger River at Km 123.7, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 135 Granger River at Km 125.1, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 136 Granger River at Km 125.1, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 137 Granger River at Km 125.1, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 138 Granger River at Km 125.1, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 139 Granger River at Km 125.1, Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 140 Tributary to Granger River at Km 131.3, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 141 Tributary to Granger River at Km 131.3, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 142 Tributary to Granger River at Km 131.3, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 143 Tributary to Granger River at Km 133.7, Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 144 Tributary to Granger River at Km 133.7, Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 145 Tributary to Granger River at Km 133.7, Prairie Creek all season road stream crossing study, September 24, 2014.

Photograph 146 Creek at Km 135.6, Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 147 Creek at Km 135.6, Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 148 Creek at Km 135.6, Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 149 Creek at Km 135.6, Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 150 Creek at Km 136.7, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 151 Creek at Km 136.7, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 152 Creek at Km 136.7, Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 153 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 154 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 155 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 156 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 157 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 158 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 159 Creek draining Triangle Lake (Km 144.7), Prairie Creek all season road stream crossing study, September 25, 2014.

Photograph 160 Bluefish Creek near Blurefish Lake (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 161 Bluefish Creek (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 162 Bluefish Creek (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 163 Bluefish Creek (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 164 Bluefish Creek (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 165 Bluefish Creek (~7 km west of 146 km), Prairie Creek all season road stream crossing study, September 26, 2014.

Photograph 166 Tributary to Liard River (Km 154.4), Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 167 Tributary to Liard River (Km 154.4), Prairie Creek all season road stream crossing study, September 23, 2014.

Photograph 168 Tributary to Liard River (Km 154.4), Prairie Creek all season road stream crossing study, September 23, 2014.

Attachment B

Fish Habitat Field Datasheets

Stream Habitat Information

Data Collectors John W / Jon T	**Date** 27 July '14	**Time (24 H)** 1330
Site Pool	**Station** Sundog 1 (200m U/S of Km 37)	**Project** CEN - all season road
UTM NAD	**Upstream Northing** 0427064	**Upstream Easting** 6829319
Access	**Downstream Northing** 0427078	**Downstream Easting** 6829372

Morphology

Stream Morphology Types (%)		Length (m)				Velocity (60% depth or surface)		
Run / Riffle / (Pool)		Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall / Other:		1	44cm	1200cm	1400cm	0	0	0.32
Depth/Pool (m)	1.4	2	18 cm	42cm	72 cm	0.14	0.41	0.24
Channel Slope (°)	0.5°	3	24cm	20cm	46 cm	0.24	0.25	0.24
Wetted Width	.6 / 13 / 17 / m	Channel Width (m)	1621	1621	157	Unstable Banks (5%)		
Meander Frequency	~~4~~ / / / m	Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	0 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	5% %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)			cliff	all one side	

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay		-
% Silt		-
% Sand	15	-
% Gravel	40	0
% Cobble	40	50
% Boulder	5	50
% Bedrock	—	-

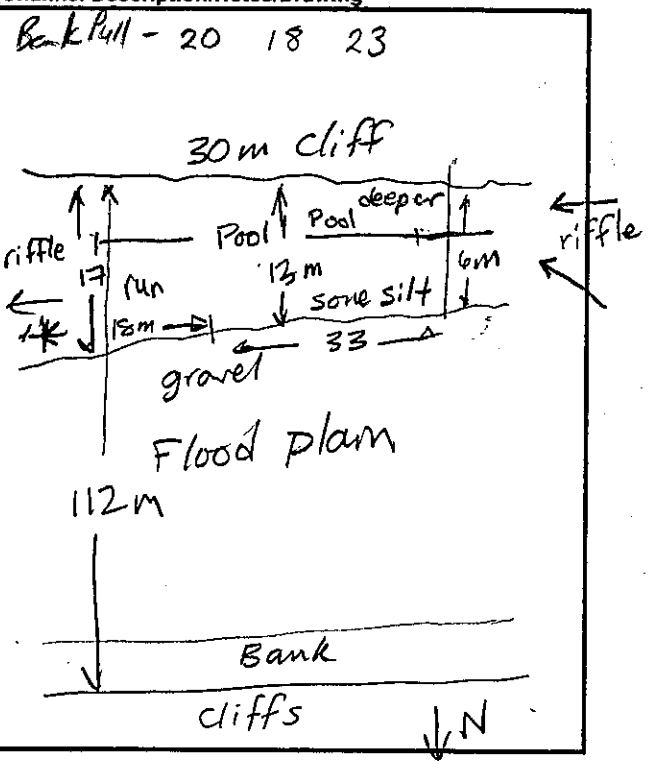
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	<1 %
Periphyton	%
Filamentous	0 %
Aquatic Moss	<5 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	5 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

High water mark	1.5 m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	— m	Cloudy
Air Temperature	21 °C	dry
Cloud Cover (5%)	8/10	
Wind Direction + speed (km/h)	NE 5	

In situ Water Parameters

Sample Depth (m)	0			
Dissolved Oxygen (%)	99.8			
Dissolved Oxygen (mg/L)	11.2			
Secchi Depth (m)	—			
Temperature (°C)	8.6			
pH	8.60			
Turbidity (TCU)	—			
Conductivity (uS/cm)	260			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	(Hills)	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos canyon

		Channel Features	#	Dimensions
		Islands		
		Bars		

Notes

X ↩

Stream Habitat Information

Data Collectors	Date	Time (24 H)
John W	27 July '14	0416
Site	**Station**	**Project**
Riffle (US of pool)	Sundog 1 (200 m US of Km 37)	CEN6788
UTM NAD	**Upstream Northing**	**Upstream Easting**
WP 20	427033	6829328
Access	**Downstream Northing**	**Downstream Easting**
WP 21	427055	6829544

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	(Riffle)	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	22	40	26	.29	.75	.61
Depth/Pool (m)	NA		2	32	46	22	.59	.97	.27
Channel Slope (°)	2°		3	28	32	42	.92	1.20	1.06
Wetted Width	10 / 9 / 11 m		Channel Width (m)	23 / 28 / 29 / *			Unstable Banks (5%)		
Meander Frequency	/ / / / m		Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	0 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	20	-
% Gravel	20	
% Cobble	20	
% Boulder	20	
% Bedrock		-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	<1 %
Periphyton	%
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

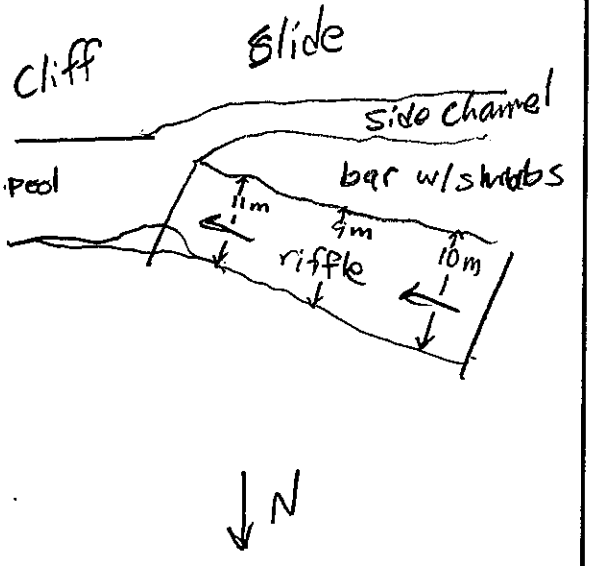
			Weather
High water mark	1.3	m	previous 24 H
Flood Evidence (Debris on plants, etc)		m	cloudy
Air Temperature	23	°C	dry
Cloud Cover (5%)	5		getting sunny
Wind Direction + speed (km/h)	NE 5		

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)	—	Side pond	1.0	
Temperature (°C)				
pH				
Turbidity (TCU)	—			
Conductivity (uS/cm)				

Channel Description/Notes/Drawing

Bankfull 23 28 29 * of active channel, not flood plain.



Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	(Hills)	Canyon

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes Some fairly thick brown algae growing on some boulders.

Stream Habitat Information

Data Collectors	Date	Time (24 H)
John.W / Jon.T	27-July-2014	15:26,
Site ~~1 (lower)~~ Sundog 2	**Station** ~~Sundog 2-1~~ A	**Project** CZN6788
UTM NAD	**Upstream Northing** 4263156	**Upstream Easting** 6829278
Access	**Downstream Northing** 426418	**Downstream Easting** 6829265

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	(Riffle)	(Pool) close to wall	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	8	11	10	0.13	0.34	0.26
Depth/Pool (m)			2	6	14	15	0.36	0.40	0.52
Channel Slope (°)	3°		3	11	22	44	0.08	0.27	0.31
Wetted Width	/ 27 / 15* / 9	m	Channel Width (m)	/ . /	/		Unstable Banks (5%)		
Meander Frequency	/ / / /	m	Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	2 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc): boulders

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	20	0
% Cobble	55 60	0
% Boulder	20	25
% Bedrock	5	-

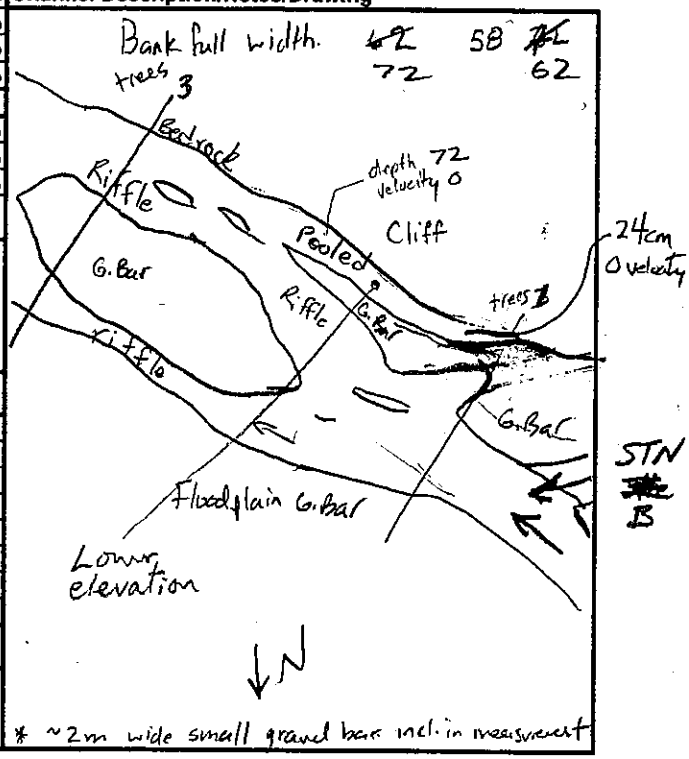
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	(Deciduous Forest)
Re-growth forest	(Shrubs)
Flooded	(Sedges)
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

			Weather
High water mark	1.4	m	previous 24 H
Flood Evidence (Debris on plants, etc)	—	m	cloudy
Air Temperature	22	°C	dry.
Cloud Cover (5%)	5		
Wind Direction + speed (km/h)	NE 5		

In situ Water Parameters

Sample Depth (m)	0			
Dissolved Oxygen (%)	101.7			
Dissolved Oxygen (mg/L)	12.19			
Secchi Depth (m)	—			
Temperature (°C)	7.4			
pH	8.63			
Turbidity (TCU)	—			
Conductivity (uS/cm)	233			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features	#	Dimensions
Islands		
Bars		

Notes

Slope = total slope of reach - slopes of individual channels will be lower.
Slope = 3%. Slightly more periphyton than Prairie.

Stream Habitat Information

Data Collectors	Date	Time (24 H)
JW, GS	27 July '14	1610 h
Site	**Station**	**Project**
Sundog realign 2	B	CEN6788
UTM NAD	**Upstream Northing**	**Upstream Easting**
	426255	6829318
Access	**Downstream Northing**	**Downstream Easting**
	426323	6829305

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	15	18	14	0.27	0.79	0.1
Depth/Pool (m)			2	80	75	68	0.12	0.14	0.05
Channel Slope (°)	3°		3	9	18	18	0.29	0.25	0.06
Wetted Width	3 / 4 / 5 /	m	Channel Width (m)	163 / 75 / 79			Unstable Banks (5%)		
Meander Frequency	/ / / /	m	Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	— %	Instream Cover (Twigs/Sticks, etc)	— %	Substrate (as cover)	— %
Instream Cover (logs, etc)	2 %	Instream vegetation	— %	Undercut Bank	2 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)	Tree + cliff face				

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	60	60
% Cobble	25	25
% Boulder	15	25
% Bedrock	—	-

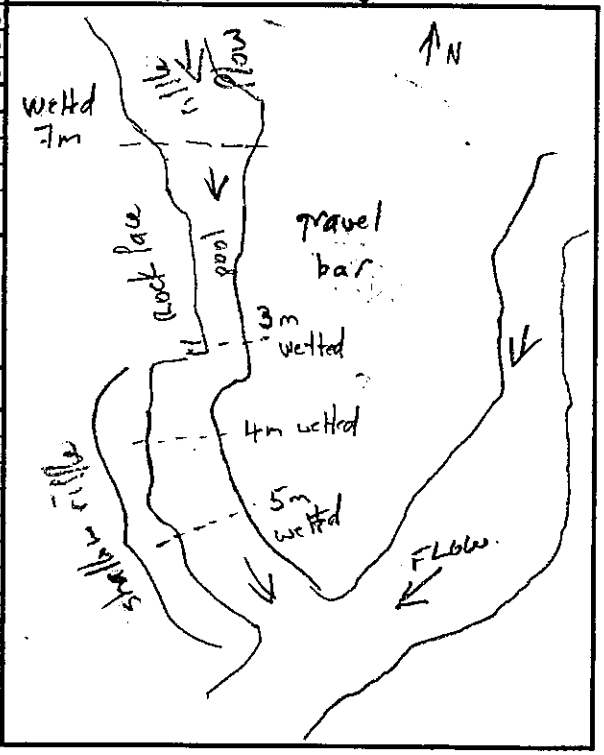
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) — circle

Mixed Forest	(Coniferous Forest)
Grasses	(Deciduous Forest)
Re-growth forest	(Shrubs)
Flooded	(Sedges)
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	— %	Overhead Litter >150 mm (%)	— %
Overhead Undercut Banks	— %	Overhanging Trees	— %
Overhanging Grasses	— %	Overhanging Shrubs	— %

Miscellaneous

High water mark	1.2 m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	— m	
Air Temperature	22 °C	
Cloud Cover (5%)	5	
Wind Direction + speed (km/h)	WS	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)	See Site A			
Secchi Depth (m)				
Temperature (°C)	See Site A			
pH				
Turbidity (TCU)				
Conductivity (uS/cm)				

Landscape (Beyond 25 m Buffer) — circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	(Hills)	Canyon

Visible Disturbance — circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes 3° slope

Stream Habitat Information

Data Collectors: JW, DH, Garry, Jon	Date: 28 July '14	Time (24 H): 0942
Site: Polge Ck Crossing	Station: Main Creek (E of landing)	Project: CEN6788
UTM NAD: WP 31	Upstream Northing: 10V 440688 (centre)	Upstream Easting: 6830794
Access: Helicopter	Downstream Northing:	Downstream Easting:

Morphology

Stream Morphology Types (%): Run / (Riffle) / Pool / Fall / Other:

Depth/Pool (m)	Channel Slope (°)	Wetted Width	Meander Frequency
		8 / 8 / 8 m	/ / / / m

Length (m)				Velocity (60% depth or surface)		
Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
1						
2						
3						

Channel Width (m): 10 / 11 / 11

Unstable Banks (5%)

Bank slope (5°): L 30 R 70

Instream Cover

Instream Cover (Detritus)	8 %	Instream Cover (Twigs/Sticks, etc)	1 %	Substrate (as cover)	— %
Instream Cover (logs, etc)	1 %	Instream vegetation	— %	Undercut Bank	2 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	20	-
% Gravel	60	0
% Cobble	20	50
% Boulder	—	—
% Bedrock	—	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	1 grass %

Riprian Zone (25 m Buffer) circle

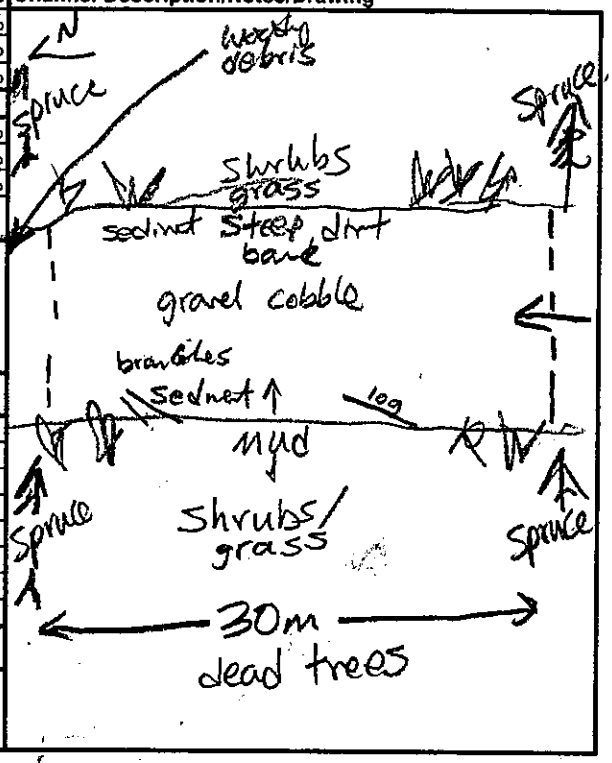
Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
(Roads)	Cutlines

evidence of old winter road

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	2 %	Overhanging Trees	1 %
Overhanging Grasses	1 %	Overhanging Shrubs	1 %

Channel Description/Notes/Drawing



Miscellaneous

High water mark	1m m	previous 24 H
Flood Evidence (Debris on plants, etc)	— m	clear
Air Temperature	°C	
Cloud Cover (5%)	60 thin cirrus	
Wind Direction + speed (km/h)	N 2	

Weather

In situ Water Parameters / YSI / Titration

Sample Depth (m)		/		
Dissolved Oxygen (%)	(97.6)	/		
Dissolved Oxygen (mg/L)	(12.21)	10.8		
Secchi Depth (m)				
Temperature (°C)	6.2			
pH	8.39			
Turbidity (TCU)				
Conductivity (uS/cm)	355			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	(Shrubs)	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	NO

Photos dead trees

U/S D/S CC

Channel Features

Channel Features	#	Dimensions
Islands		
Bars		

Notes

- Flat ~~75%~~ 50% embedded stones
- Moose ~~feet~~ prints.

Stream Habitat Information

Data Collectors: Pelage Ck Crossing	Date: Small trib (west)	Time (24 H): 10:09
Site: JW, DH, Gerry, Jon	Station: 28 July '14	Project: CEN6788
UTM NAD: WP032	Upstream Northing: 10V 440615 (centre)	Upstream Easting: 6850774
Access: Helecoptor	Downstream Northing:	Downstream Easting:

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width 1.4 / 1.4 / 1.9 / m			Channel Width (m) 1.6 / 1.6 / 2.0			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L 60 R 60			

Instream Cover

Instream Cover (Detritus)	— %	Instream Cover (Twigs/Sticks, etc)	20 %	Substrate (as cover)	— %
Instream Cover (logs, etc)	5 %	Instream vegetation	5 %	Undercut Bank	10 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	60	0
% Cobble	40	0
% Boulder	—	—
% Bedrock	—	-

Instream Vegetaion (Sum 100%)

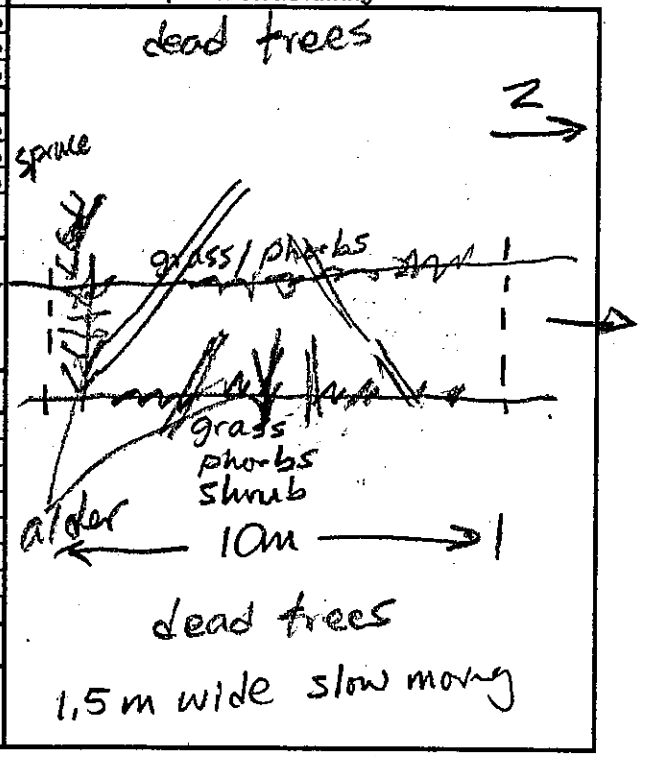
Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

old road r.o.w.

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	%	Overhead Litter >150 mm (%)	%
Overhead Undercut Banks	%	Overhanging Trees	%
Overhanging Grasses	%	Overhanging Shrubs	%

Miscellaneous

		Weather
High water mark	.6 m	previous 24 H
Flood Evidence (Debris on plants, etc)	.6 m	clear
Air Temperature	°C	
Cloud Cover (5%)	Cirrus 60%	
Wind Direction + speed (km/h)	0	

In situ Water Parameters

pen probe titration

Sample Depth (m)			
Dissolved Oxygen (%)		60.5	
Dissolved Oxygen (mg/L)		8.45	7.2
Secchi Depth (m)			
Temperature (°C)	9.5		
pH	7.1	8.6	
Turbidity (TCU)			
Conductivity (uS/cm)	480		

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos Dead trees (forest fire)

Channel Features	#	Dimensions
Islands		
Bars		

Notes 4.8

Stream Habitat Information

Data Collectors CJ, DH	**Date** 21-Sep-2014	**Time (24 H)** 9:50
Site KP 50.2 (Pdjie Trib.)	**Station** KP 50.2	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6829737	**Upstream Easting** 436944
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 0.50 m			Channel Width (m) / / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L R			

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	20 %	Substrate (as cover)	%
Instream Cover (logs, etc)	10 %	Instream vegetation	0 %	Undercut Bank	5 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Some fallen logs in channel, some causing steps, smaller sticks also

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay		-
% Silt	90	-
% Sand	10	-
% Gravel		
% Cobble		
% Boulder		
% Bedrock		-

Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	80 %	Overhead Litter >150 mm (%)	20 %
Overhead Undercut Banks	5 %	Overhanging Trees	5 %
Overhanging Grasses	10 %	Overhanging Shrubs	10 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	10 °C	
Cloud Cover (5%)	95%	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	0.15			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	11.4			
Secchi Depth (m)	—			
Temperature (°C)	3.6			
pH	7.8			
Turbidity (TCU)	—			
Conductivity (uS/cm)	500			

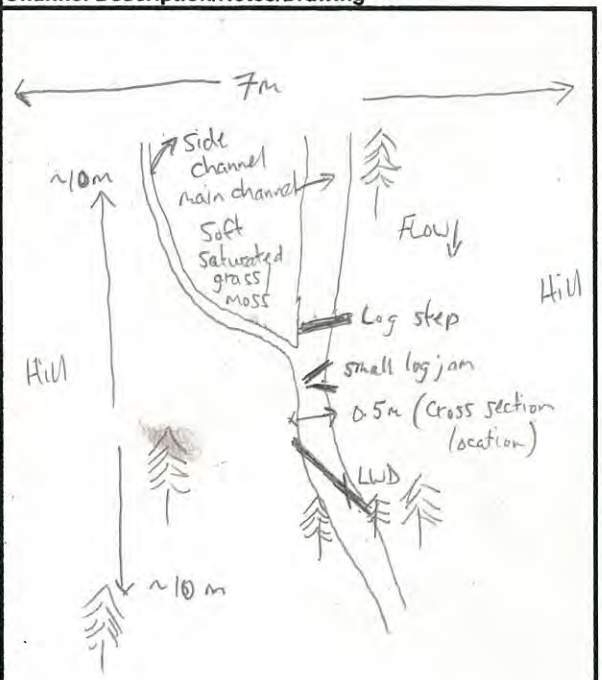
Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Channel Description/Notes/Drawing



Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes Side channel partially flowing, but mostly standing water on marshy ground.

Stream Habitat Information

Data Collectors CJ, DH	**Date** 21-Sep-14	**Time (24 H)** 14:15
Site KP 47.0	**Station**	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6829338	**Upstream Easting** 434240
Access Heli / Hiking	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 0.55 m			Channel Width (m) / / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) L R		

Instream Cover

Instream Cover (Detritus)	40 %	Instream Cover (Twigs/Sticks, etc)	10 %	Substrate (as cover)	~~5~~ % 40
Instream Cover (logs, etc)	5 %	Instream vegetation	0 %	Undercut Bank	5 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay		-
% Silt	20	-
% Sand	80	-
% Gravel		
% Cobble		
% Boulder		
Bedrock		-

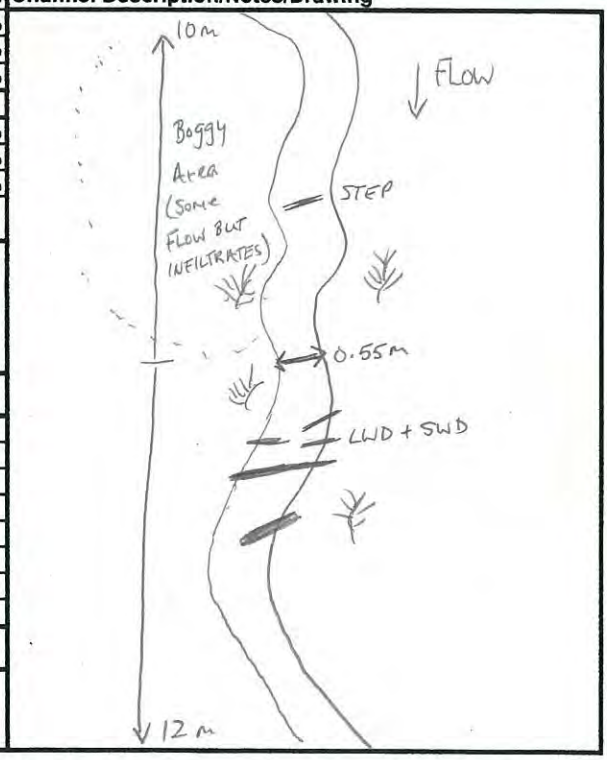
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	%	Overhead Litter >150 mm (%)	5 %
Overhead Undercut Banks	60 %	Overhanging Trees	0 %
Overhanging Grasses	5 %	Overhanging Shrubs	30 %

Miscellaneous

High water mark	m	Weather
Flood Evidence (Debris on plants, etc)	– m	previous 24 H
Air Temperature	15 °C	
Cloud Cover (5%)	10%	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	~~0.2~~ 0.15			
Dissolved Oxygen (%)	–			
Dissolved Oxygen (mg/L)	10.2			
Secchi Depth (m)	–			
Temperature (°C)	3.7			
pH	7.2			
Turbidity (TCU)	–			
Conductivity (uS/cm)	305			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors	Date	Time (24 H)
CJ, DH	21-SEP-14	17:00
Site KP 39.8 SUNDOG	Station	Project
UTM NAD	~~Upstream~~ Northing 6830273	~~Upstream~~ Easting 428369
Access Heli	Downstream Northing	Downstream Easting

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)	0.0		2						
Channel Slope (°)			3						
Wetted Width / / / 0.0 m			Channel Width (m) 0.0 / / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L R			

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	95 %
Instream Cover (logs, etc)	0 %	Instream vegetation	5 %	Undercut Bank	0 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay		-
% Silt	5	-
% Sand	~~30~~ CJ	-
% Gravel	30	
% Cobble	50	5
% Boulder	15	20
% Bedrock		-

Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	5 %

Miscellaneous

		Weather
High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	°C	
Cloud Cover (5%)		
Wind Direction + speed (km/h)		

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)				
pH				
Turbidity (TCU)				
Conductivity (uS/cm)				

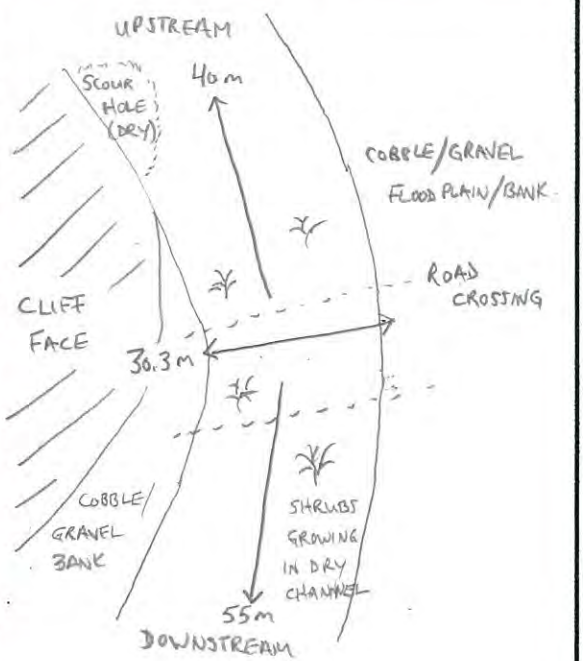
Landscape (Beyond 25 m Buffer) circle

~~Mixed Forest~~	~~Coniferous Forest~~	~~Roads~~
~~Grasses~~	~~Deciduous Forest~~	~~Cutlines~~
~~Re-growth forest~~	~~Shrubs~~	~~Hills~~

Visible Disturbance circle

~~Surface Debris~~	~~Culvert~~
~~Beaver Dam~~	~~Weir~~
~~Collapsed Bank~~	

Channel Description/Notes/Drawing



Photos

Channel Features	#	Dimensions
Islands		
Bars		

Notes Stream is dry. No riparian buffer: only a few shrubs and a cobble/gravel floodplain.

Stream Habitat Information

Data Collectors	**Date** 22-Sep-14	**Time (24 H)** 16:30
Site Sunday Creek	**Station** Kp 27.1	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6828332	**Upstream Easting** 418911
Access ATV / Hiking	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 20	Riffle 80	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	0.15	0.20	0.21	5 sec / 4m	6.5 sec / 4m	6 sec / 4m
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 8.5 m			Channel Width (m) 14.5 / / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) L		R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	100 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	~~30~~	-
% Gravel	30	
% Cobble	40	
% Boulder	30	
% Bedrock	0	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

High water mark	m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	°C	
Cloud Cover (5%)	5	
Wind Direction + speed (km/h)	40 km/h E	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)				
pH				
Turbidity (TCU)				
Conductivity (uS/cm)				

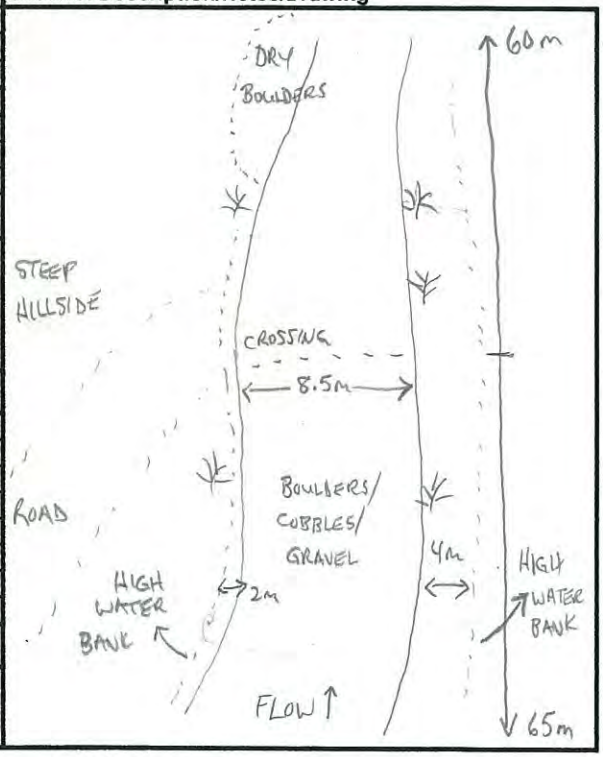
Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Channel Description/Notes/Drawing



Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors	Date	Time (24 H)
CJ, DH	22-Sep-14	17:00
Site: Sundog Creek	Station: KP 27.5	Project: CZN 6788
UTM NAD	Upstream Northing: 6828089	Upstream Easting: 419225
Access: Hiking / ATV	Downstream Northing	Downstream Easting

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle 50	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall 50	Other:		1	0.10	0.19	0.32	5 sec/ 3m	5 sec/ 3m	6 sec/ 3m
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 13.2 m			Channel Width (m) 19.51 / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) L		R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	100 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	5	-
% Gravel	20	
% Cobble	45	
% Boulder	30	
% Bedrock	0	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

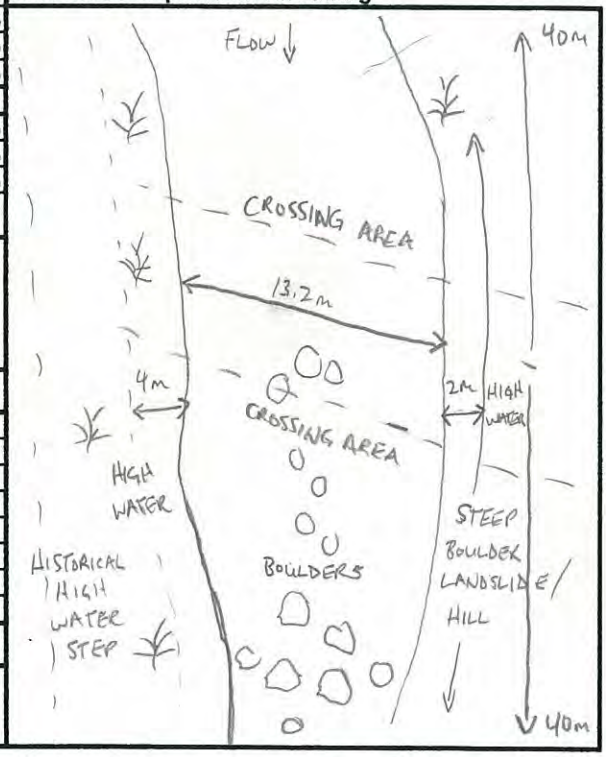
Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Channel Description/Notes/Drawing



Miscellaneous

High water mark	m	Weather: previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	10 °C	
Cloud Cover (5%)	5%	
Wind Direction + speed (km/h)	40 km/h E	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)	7.5			
pH	7.8			
Turbidity (TCU)				
Conductivity (uS/cm)	448			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	Date 22-Sep-14	Time (24 H) 17:50
Sundog Creek	Station KP 28.4	Project CZN 6788
UTM NAD	Upstream Northing	Upstream Easting
Access Hiking / ATV	Downstream Northing	Downstream Easting

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle 50	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall 50	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 5 m			Channel Width (m) 20.6 / / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) L		R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	100 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	0	-
% Gravel	20	
% Cobble	40	
% Boulder	40	
% Bedrock	0	-

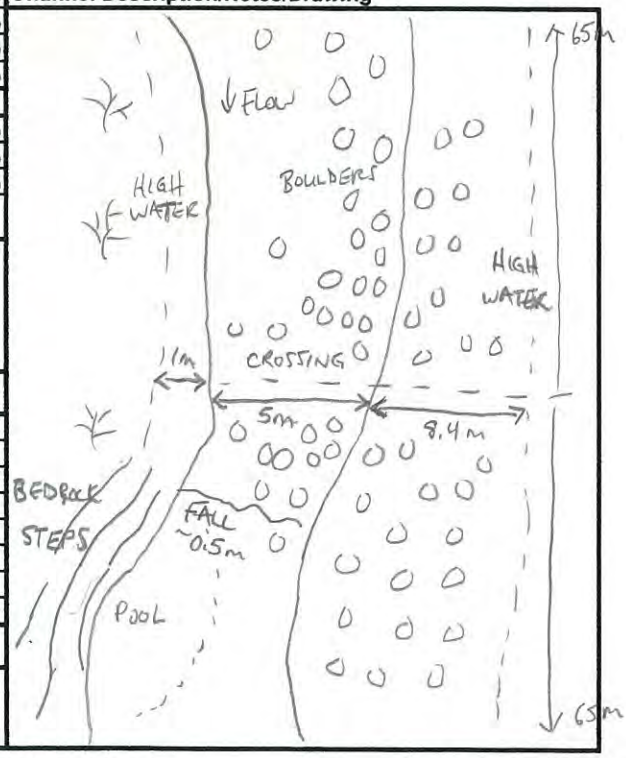
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

		Weather
High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	10 °C	
Cloud Cover (5%)	5 %	
Wind Direction + speed (km/h)	20 km/h NE	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)	7.1			
pH	7.7			
Turbidity (TCU)				
Conductivity (uS/cm)	440			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 23-Sep-14	**Time (24 H)** 9:45
Site Sunday Creek	**Station** KP 29.2	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6827089	**Upstream Easting** 420601
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m) 2.5 m				Velocity (60% depth or surface)		
Run	Riffle 20	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall 80	Other:		1	0.6	0.8	0.8	5	6.5	7.5
Depth/Pool (m)			2	~~0.8~~					
Channel Slope (°)			3	~~0.8~~					
Wetted Width / / / 8.0 m			Channel Width (m) 19.5 / / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L		R	

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	100 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	5	-
% Gravel	10	
% Cobble	15	
% Boulder	70	
% Bedrock	0	-

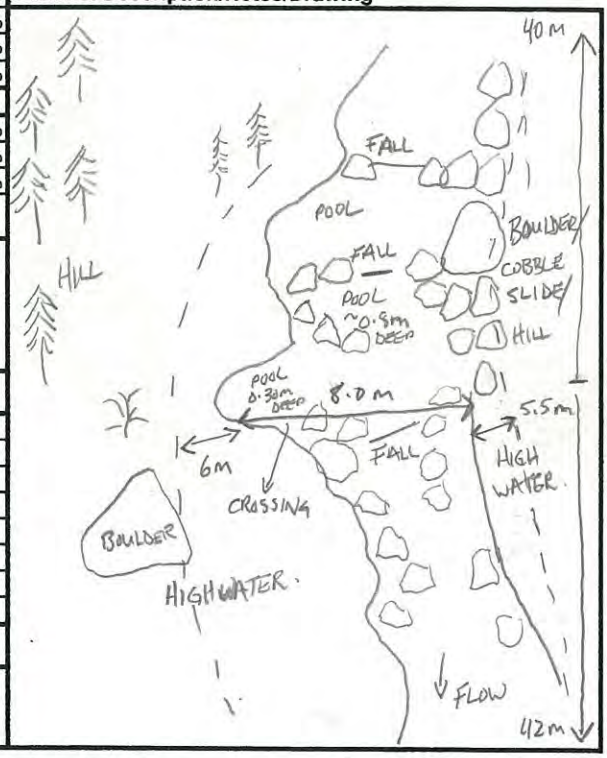
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

		Weather
High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	7 °C	
Cloud Cover (5%)	0 %	
Wind Direction + speed (km/h)	5 km/h E	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)	3.9			
pH	8.0			
Turbidity (TCU)				
Conductivity (uS/cm)	447			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

0.5 6.5 14.5 20

Stream Habitat Information

Data Collectors	Date	Time (24 H)
CJ, DH	23-Sep-14	13:40
Site Liard Trib.	**Station** Kp 154.4	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6774900	**Upstream Easting** 486500
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m) Measured with ADV Flow meter				Velocity (60% depth or surface)		
Run 90	Riffle 10	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1		0.10			0.053 m/s	
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 0.75 m			Channel Width (m) 1.15 / . / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) . L		R

Instream Cover

Instream Cover (Detritus)	20 %	Instream Cover (Twigs/Sticks, etc)	10 %	Substrate (as cover)	60 %
Instream Cover (logs, etc)	5 %	Instream vegetation	5 %	Undercut Bank	5 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	10	-
% Sand	30	-
% Gravel	45	
% Cobble	15	
% Boulder	0	
Bedrock	0	-

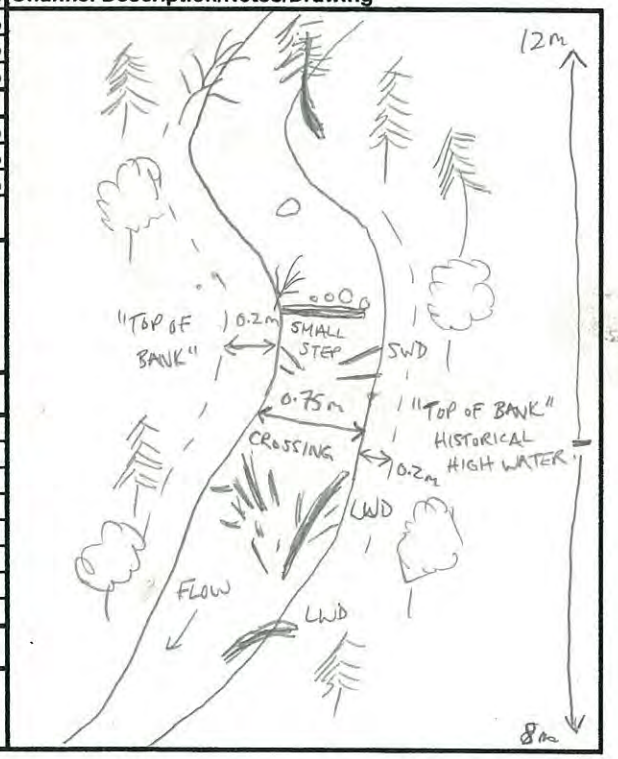
Instream Vegetaion (Sum 100%)

Rooted Emergent	0	%
Rooted Submergent	0	%
Rooted Floating	0	%
Free-floating	0	%
Floating Algae	0	%
Attached Algae	0	%
Periphyton	100	%
Filamentous	0	%
Aquatic Moss	0	%
Flooded Terrestrial Plants	0	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	15 %
Overhead Undercut Banks	10 %	Overhanging Trees	60 %
Overhanging Grasses	5 %	Overhanging Shrubs	10 %

Miscellaneous

High water mark	0.25 m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	10 °C	
Cloud Cover (5%)	2%	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	11.2			
Secchi Depth (m)	—			
Temperature (°C)	8.4			
pH	7.7			
Turbidity (TCU)	—			
Conductivity (uS/cm)	515			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes Channel too shallow for more velocity mmts

Stream Habitat Information

Data Collectors CJ, DH	**Date** 23-Sep-14	**Time (24 H)** 15:20
Site Grainger Trib.	**Station** KP 122.8	**Project** CEN 6788
UTM NAD	**Upstream Northing** 6798715	**Upstream Easting** 477151
Access Heli.	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 60	Riffle 40	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 1.6 m			Channel Width (m) / / / 1.75			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L		R	

Instream Cover

Instream Cover (Detritus)	5 %	Instream Cover (Twigs/Sticks, etc)	15 %	Substrate (as cover)	55 %
Instream Cover (logs, etc)	15 %	Instream vegetation	0 %	Undercut Bank	10 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	5	-
% Clay	0	-
% Silt	5	-
% Sand	30	-
% Gravel	5	
% Cobble	20	
% Boulder	35	
Bedrock		-

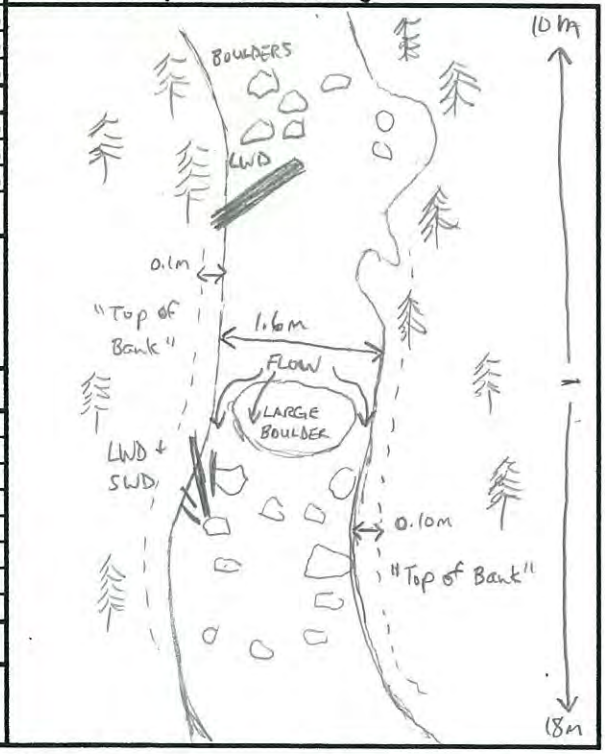
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	100 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	5 %	Overhead Litter >150 mm (%)	15 %
Overhead Undercut Banks	20 %	Overhanging Trees	40 %
Overhanging Grasses	5 %	Overhanging Shrubs	15 %

Miscellaneous

		Weather
High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	10 °C	
Cloud Cover (5%)	30%	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	0.15			
Dissolved Oxygen (%)	-			
Dissolved Oxygen (mg/L)	10.4			
Secchi Depth (m)	-			
Temperature (°C)	8.0			
pH	7.4			
Turbidity (TCU)	—			
Conductivity (uS/cm)	421			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 23-Sep-14	**Time (24 H)** 17:10
Site Grainger main channel	**Station** KP 123.7	**Project** 6788
UTM NAD	**Upstream Northing** 6799643	**Upstream Easting** 478319
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 40	Riffle 60	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 5.85 m			Channel Width (m) 15.3 / . / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) . L R			

Instream Cover

Instream Cover (Detritus)	15 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	60 %
Instream Cover (logs, etc)	0 %	Instream vegetation	25 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	6	-
% Clay	0	-
% Silt	5	-
% Sand	10	-
% Gravel	10	
% Cobble	35	
% Boulder	40	
% Bedrock	0	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	60 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	%
Periphyton	10 %
Filamentous	10 %
Aquatic Moss	20 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	60 %	Overhead Litter >150 mm (%)	25 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	15 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	12 °C	
Cloud Cover (5%)	30%	
Wind Direction + speed (km/h)	25 kph W	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	10.6			
Secchi Depth (m)	—			
Temperature (°C)	6.4			
pH	7.4			
Turbidity (TCU)	—			
Conductivity (uS/cm)	370			

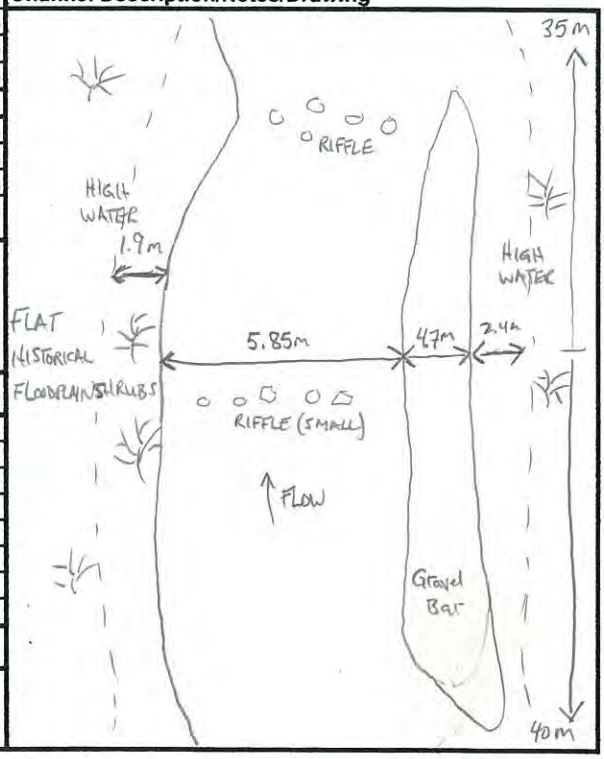
Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Channel Description/Notes/Drawing



Photos

Channel Features

	#	Dimensions
Islands		
Bars	1	4.7 m wide 35m long

Notes Dry side channel (2.4m wide) on RB — separated from main channel by gravel bar noted above.

Stream Habitat Information

Data Collectors CJ, DH	**Date** 23-Sept-14	**Time (24 H)**
e Grainger mainstem	**Station** KP 125.1	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6799517	**Upstream Easting** 479156
Access Heli / Hiking	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 50	Riffle 50	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / m			Channel Width (m) / / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L R			

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	100 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	~~10~~ 0	-
% Clay	0	-
% Silt	0	-
% Sand	0	-
% Gravel	20	
% Cobble	50	
% Boulder	20	
Bedrock	10	-

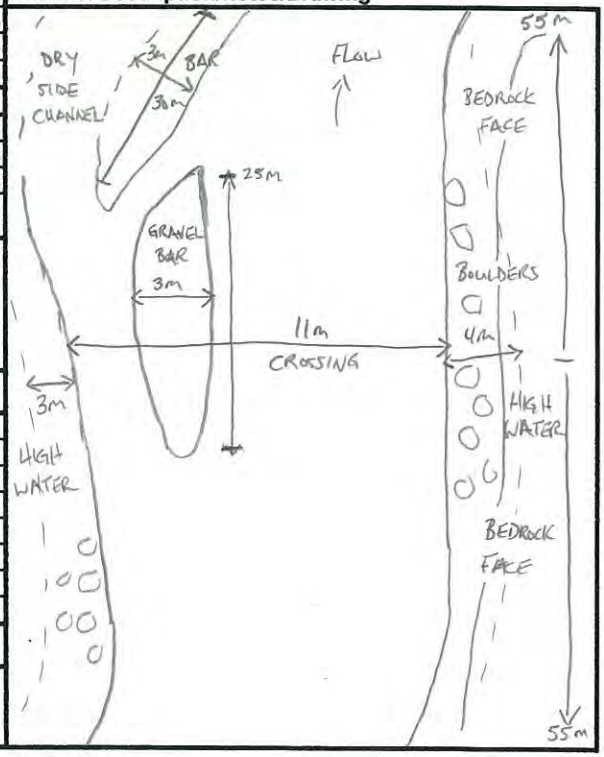
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	16.0 °C	
Cloud Cover (5%)	none	
Wind Direction + speed (km/h)	20 kph W	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	12.2			
Secchi Depth (m)	—			
Temperature (°C)	5.7			
pH	7.7			
Turbidity (TCU)	—			
Conductivity (uS/cm)	395			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 24-Sep-14	**Time (24 H)** 9:00
e ~~Chrainagh Creek~~ Trib 4	**Station** KP 133.7	**Project**
UTM NAD	**Upstream Northing** 6793161	**Upstream Easting** 482671
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)				Length (m)				Velocity (60% depth or surface)		
Run	Riffle 100	Pool		Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:			1						
Depth/Pool (m)				2						
Channel Slope (°)				3						
Wetted Width	/ / / 1.7 m			Channel Width (m)	/ . / 2.6m			Unstable Banks (5%)		
Meander Frequency	/ / / / ~~2.6~~ m			Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	5 %	Instream Cover (Twigs/Sticks, etc)	5 %	Substrate (as cover)	90 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	10 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	20	-
% Gravel	0	
% Cobble	40	20
% Boulder	40	30
Bedrock	0	-

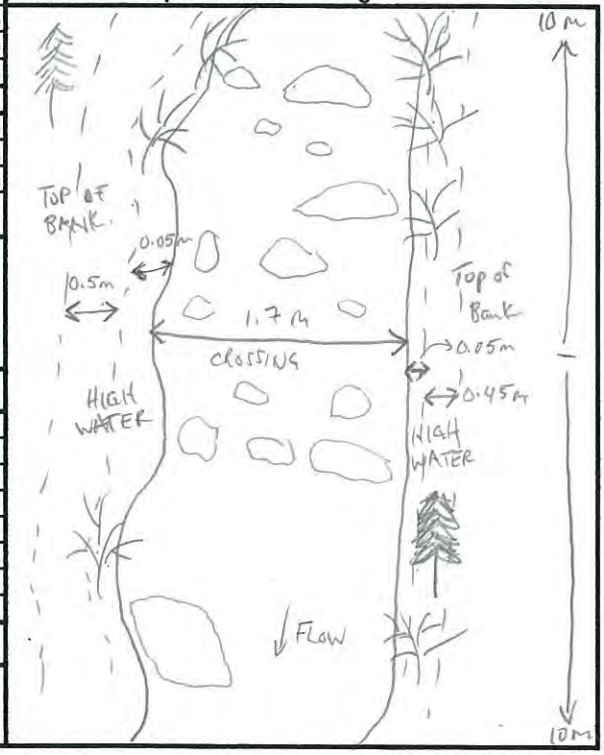
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	100 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
(Grasses)	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	5 %	Overhead Litter >150 mm (%)	5 %
Overhead Undercut Banks	10 %	Overhanging Trees	15 %
Overhanging Grasses	5 %	Overhanging Shrubs	60 %

Miscellaneous

		Weather
High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	8 °C	
Cloud Cover (5%)	80 %	
Wind Direction + speed (km/h)	5 kph E	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	12.6			
Secchi Depth (m)	—			
Temperature (°C)	4.4			
pH	7.7			
Turbidity (TCU)	—			
Conductivity (uS/cm)	429			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
(Grasses)	Deciduous Forest	Cutlines	
Re-growth forest	(Shrubs)	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 24-Sep-14	**Time (24 H)** 14:00
e Tetcela mainstem	**Station** KP ~~86.8~~ 87.7	**Project** CZN C788
UTM NAD	**Upstream Northing** ~~679~~ 6812386	**Upstream Easting** ~~482668~~ 460241
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run ~~60~~ 90	Riffle 10	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / 16.3 / ~~42.7~~ m			Channel Width (m) 22.1 / / /				Unstable Banks (5%)		
Meander Frequency / / / / m			Regular / Irregular meanders				Bank slope (5°) L		R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	5 %	Substrate (as cover)	85 %
Instream Cover (logs, etc)	5 %	Instream vegetation	5 %	Undercut Bank	5 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	10	-
% Clay	0	-
% Silt	0	-
% Sand	5	-
% Gravel	~~45~~	
% Cobble	40	
% Boulder	0	
Bedrock	0	-

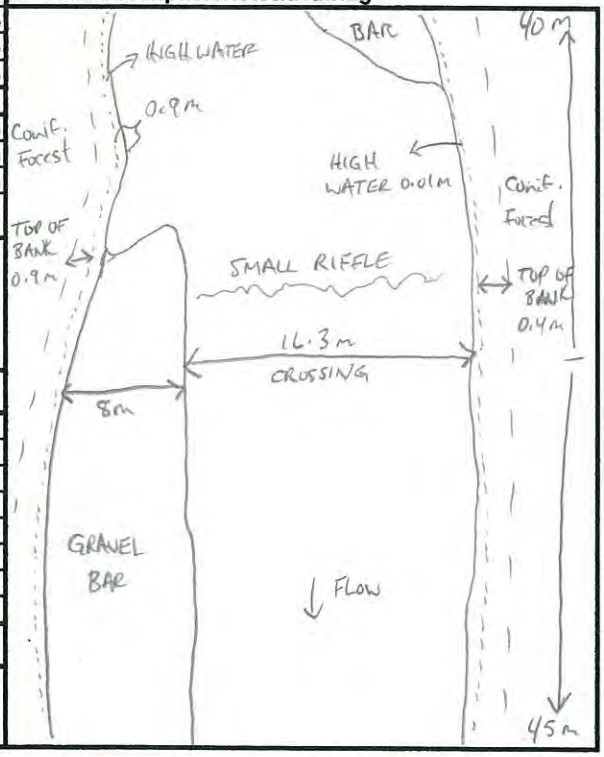
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	10 %	Overhanging Trees	25 %
Overhanging Grasses	15 %	Overhanging Shrubs	25 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	8 °C	
Cloud Cover (5%)	100%	
Wind Direction + speed (km/h)	Calm	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	-			
Dissolved Oxygen (mg/L)	12.8			
Secchi Depth (m)	-			
Temperature (°C)	5.7			
pH	7.8			
Turbidity (TCU)	-			
Conductivity (uS/cm)	177			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 24-Sep-14	**Time (24 H)** 16:30
Site Tetcela Trib.	**Station** At Old Road	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6813941	**Upstream Easting** 460369
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 50	Riffle 50	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 4.9 m			Channel Width (m) / . / 17.2			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) . L		R	

Instream Cover

Instream Cover (Detritus)	5 %	Instream Cover (Twigs/Sticks, etc)	5 %	Substrate (as cover)	80 %
Instream Cover (logs, etc)	5 %	Instream vegetation	0 %	Undercut Bank	5 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	5	-
% Clay	0	-
% Silt	0	-
% Sand	20	-
% Gravel	0	
% Cobble	40	
% Boulder	35	
% Bedrock	0	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	5 %	Overhead Litter >150 mm (%)	5 %
Overhead Undercut Banks	10 %	Overhanging Trees	30 %
Overhanging Grasses	0 %	Overhanging Shrubs	10 %

Miscellaneous

High water mark	m	previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	8 °C	
Cloud Cover (5%)	90%	
Wind Direction + speed (km/h)	Calm	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	–			
Dissolved Oxygen (mg/L)	12.1			
Secchi Depth (m)	–			
Temperature (°C)	7.7			
pH	7.81			
Turbidity (TCU)	–			
Conductivity (uS/cm)	575			

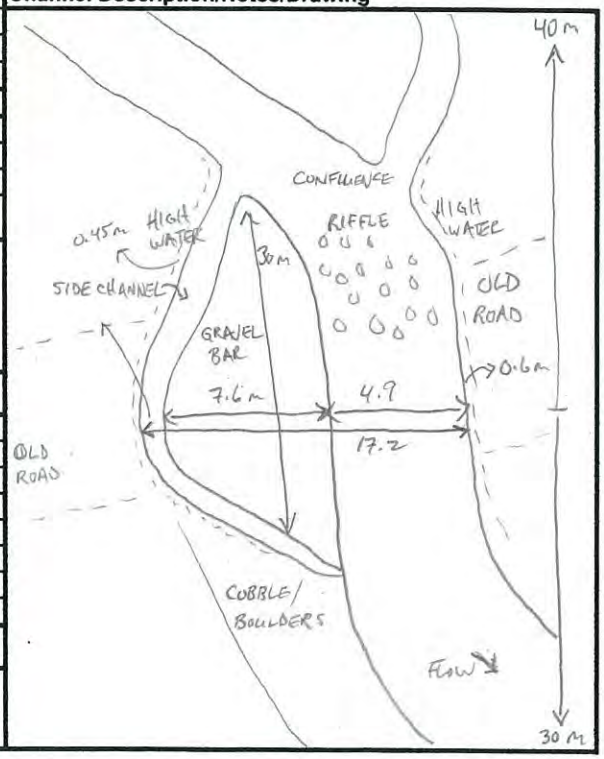
Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Channel Description/Notes/Drawing



Photos

Channel Features

	#	Dimensions
Islands		30m long x 7.6m wide
Bars	1	

Notes Lots of LWD washed up on LB, evidence of past flooding
Very little flow in side channel

Stream Habitat Information

Data Collectors CJ, DH	**Date** 24-Sep-14	**Time (24 H)** 17:15
te Tetcela mainstem	**Station** Old Road Crossing	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6815670	**Upstream Easting** 461370
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 90	Riffle 10	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 15.4 m			Channel Width (m) 25.4 / / /			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L R			

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	0 %
Instream Cover (logs, etc)	2 %	Instream vegetation	10 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	5	-
% Clay	0	-
% Silt	0	-
% Sand	15	-
% Gravel	35	20
% Cobble	40	30
% Boulder	5	
% Bedrock	0	-

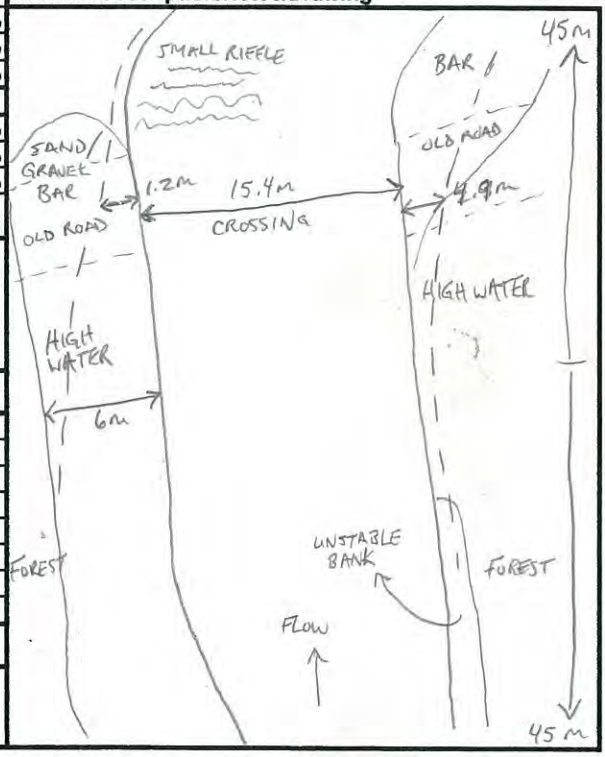
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	100 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	10 %
Overhanging Grasses	0 %	Overhanging Shrubs	5 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	8 °C	
Cloud Cover (5%)	70%	
Wind Direction + speed (km/h)	Calm	

In situ Water Parameters

Sample Depth (m)	0.10			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	11.2			
Secchi Depth (m)	—			
Temperature (°C)	5.9			
pH	7.9			
Turbidity (TCU)	—			
Conductivity (uS/cm)	786			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 25-Sep-14	**Time (24 H)** 18:45
Site GRAINGER TRIB.	**Station** KP 135.6	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6791279	**Upstream Easting** 482380
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run 50	Riffle 50	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width / / / 0.9 m			Channel Width (m) / / / 2.8			Unstable Banks (5%)			
Meander Frequency / / / / m			Regular / Irregular meanders			Bank slope (5°) L R			

Instream Cover

Instream Cover (Detritus)	40 %	Instream Cover (Twigs/Sticks, etc)	~~10~~ 5 %	Substrate (as cover)	~~20~~ 15 ~~20~~ %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	~~10~~ 5 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	10	-
% Clay	0	-
% Silt	20	-
% Sand	10	-
% Gravel	50	
% Cobble	0	
% Boulder	20	
% Bedrock	0	-

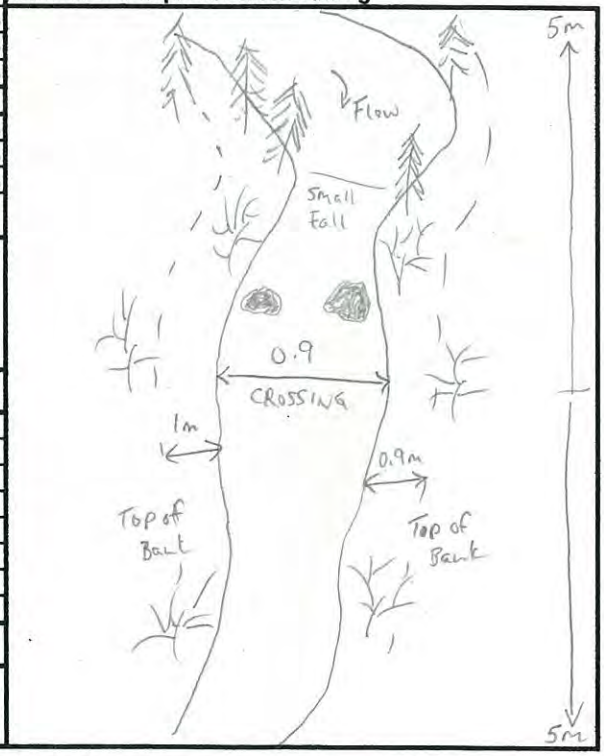
Instream Vegetaion (Sum 100%)

Rooted Emergent	%
Rooted Submergent	%
Rooted Floating	%
Free-floating	%
Floating Algae	%
Attached Algae	%
Periphyton	%
Filamentous	%
Aquatic Moss	%
Flooded Terrestrial Plants	%

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	%	Overhead Litter >150 mm (%)	%
Overhead Undercut Banks	%	Overhanging Trees	%
Overhanging Grasses	%	Overhanging Shrubs	%

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	5 °C	
Cloud Cover (5%)	100	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	0.05			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	12.6			
Secchi Depth (m)	—			
Temperature (°C)	4.5			
pH	8.2			
Turbidity (TCU)	—			
Conductivity (uS/cm)	490			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ DH	**Date** 26-Sep-14	**Time (24 H)** 11:00
Site Grainger Trib.	**Station** KP 136.7	**Project** CZN 6788
UTM NAD	**Upstream Northing** 6790094	**Upstream Easting** 483132
Access Heli.	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle 100	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width	/ / / 0.7 m		Channel Width (m)	/ . / 1.4			Unstable Banks (5%)		
Meander Frequency	/ / / / m		Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	5 %	Instream Cover (Twigs/Sticks, etc)	5 %	Substrate (as cover)	10 %
Instream Cover (logs, etc)	0 %	Instream vegetation	5 %	Undercut Bank	2 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	10	-
% Gravel	0	—
% Cobble	80	30
% Boulder	10	50
% Bedrock	0	-

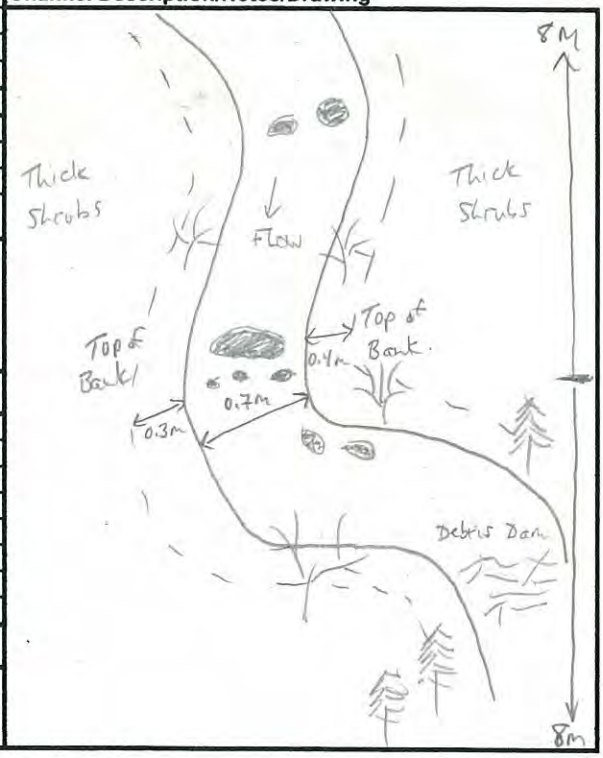
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	1 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	20 %
Filamentous	0 %
Aquatic Moss	80 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	2 %	Overhead Litter >150 mm (%)	3 %
Overhead Undercut Banks	2 %	Overhanging Trees	~~25~~ 5 %
Overhanging Grasses	5 %	Overhanging Shrubs	25 %

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	5 °C	
Cloud Cover (5%)	100 %	
Wind Direction + speed (km/h)	calm	

In situ Water Parameters

Sample Depth (m)	0.05			
Dissolved Oxygen (%)	—			
Dissolved Oxygen (mg/L)	11.8			
Secchi Depth (m)	—			
Temperature (°C)	5.7			
pH	7.9			
Turbidity (TCU)	—			
Conductivity (uS/cm)	462			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Stream Habitat Information

Data Collectors CJ, DH	**Date** 26-Sep-14	**Time (24 H)** 12:10
Site Grainger Trib.	**Station** KP ~~1311~~ 131.3	**Project** CEN 6788
UTM NAD	**Upstream Northing** 6794966	**Upstream Easting** 481988
Access Heli	**Downstream Northing**	**Downstream Easting**

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle 100	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1						
Depth/Pool (m)			2						
Channel Slope (°)			3						
Wetted Width	/ / / 0.85 m		Channel Width (m)	/ . / 2.7m			Unstable Banks (5%)		
Meander Frequency	/ / / / m		Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	2 %	Instream Cover (Twigs/Sticks, etc)	2 %	Substrate (as cover)	10 %
Instream Cover (logs, etc)	0 %	Instream vegetation	5 %	Undercut Bank	2 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)					

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	0	-
% Clay	0	-
% Silt	0	-
% Sand	20	-
% Gravel	20	10
% Cobble	30	10
% Boulder	30	50
% Bedrock	10	-

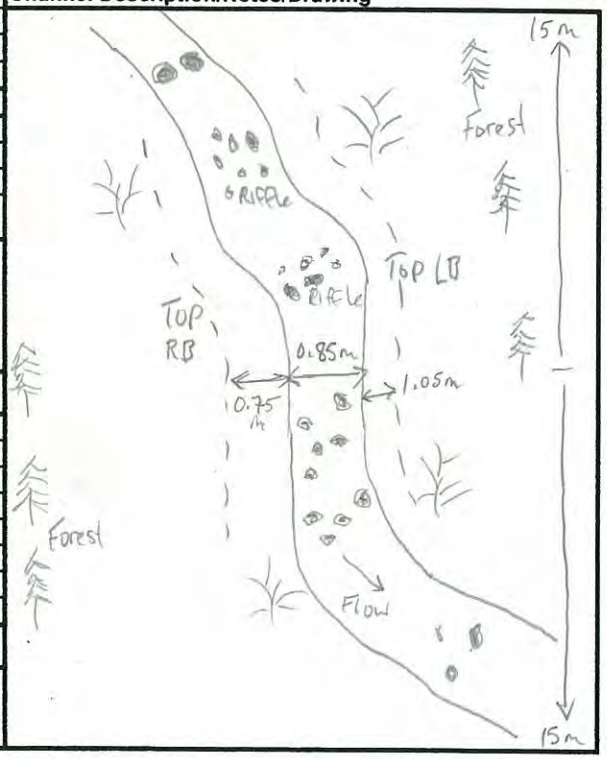
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	100 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	Coniferous Forest
Grasses	Deciduous Forest
Re-growth forest	Shrubs
Flooded	Sedges
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	%	Overhead Litter >150 mm (%)	%
Overhead Undercut Banks	%	Overhanging Trees	%
Overhanging Grasses	%	Overhanging Shrubs	%

Miscellaneous

High water mark	m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	m	
Air Temperature	5 °C	
Cloud Cover (5%)	100 %	
Wind Direction + speed (km/h)	3 kph E	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)				
Temperature (°C)	5.2			
pH	7.8			
Turbidity (TCU)				
Conductivity (uS/cm)	457			

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	Hills

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

Attachment C

Hydrology Field Datasheets

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 50.2
Reach:	-
UTM:	

	Initials	Date
Field Personnel:	CJ, BH	21-Sep-14
Data Entry:	CJ	21-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB HW	0.5	0.959				
1	1.00			0.969		
2	1.2			1.229		
Top of RB	2.4			1.322		
RB	3.1			1.648	WL = 0.187 cut	
in channel	3.3			2.194	= 0.280 cut	
in channel	3.5			2.288	= 0.206 cut	
in channel	3.9			2.217		
Top LB	4.1			1.614		
	4.6			1.351		
	5.7			1.243		
	6.4			1.400		
	6.9			1.485		
LB HW	7.2			1.343		
DS 1	6 DS			2.737		
DS 2	10 DS			3.050		
US 1	5 US			1.949		
US 2	10 US			1.604		

Notes:

HW = high water mark

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	0,35	0	
LB	0,74	0.02	
1	0,37	0,22	0.113
2	0,43	0.27	0.120
3	0,52	0,30	0.012
4	0,64	0.25	0.001
5	0,71	0.18	0.0

Flow Measurement Details:	
Start Time:	10:20
End Time:	10:30
Method:	Wading
Equipment:	ADV
River Condition:	Low flow
Weather:	Cloudy, calm, 10

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 47.0
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	21-SEP-14
Data Entry:	CJ	21-SEP-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
LB HWL	11.2	1.176				
1	8.8			1.238		
2	7.6			1.357		
3	7.2			1.315		
4	7.0			1.140		
5	6.3			1.122		
Top of LB	5.5			1.244		
Mid LB	5.0			1.645	cut 1.135	
In channel	4.9			1.954	0.210	
"	4.75			2.033	0.120	
"	4.5			1.977		
RB Mid	4.4			1.644		
Top RB	3.8			1.317		
	3.1			1.126		
	2.2			1.140		
	1.7			0.905		
	1.3			0.858		
DS 1	DS 5m			2.180		
DS 2	12m			2.470		
DS 3	20			2.843		
US 1	7			1.829		
US 2	14			1.517		
US 3	22			1.198		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	4.4		
LB	4.95		
1	4.5	0.15	0.098
2	4.6	0.14	0.283
3	4.7	0.16	0.300
4	4.8	0.17	0.232
5	4.9	0.16	0.164

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 54.3
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	21-Sep-M
Data Entry:		
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
LB HW	7.3	2.275				
Bottom HW	6.8	~~2.602~~		2.602		
	6.2			2.464		
LB	5.9			2.533		
LB WL	5.6			3.149	cut = 0.110	
WL middle	5.1			3.209	= 0.195	
RB WL	4.4			3.207	cut = 0.195	
RB	4.0			2.470		
RB HW	~~4.8~~ 2.4			2.061		
DS 1	~~8~~ 10			3.546		
DS 2	22			3.781		
US 1	10			3.207		
	17			3.142		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	4.33		
LB	5.55		
1	4.4	0.11	0.036
2	4.6	0.13	0.042
3	4.8	0.16	0.038
4	5.0	0.16	0.046
5	5.2	0.17	0.035
6	5.4	0.16	0.003

Flow Measurement Details:	
Start Time:	~ 16:00
End Time:	16:10
Method:	Wading
Equipment:	ADV
River Condition:	Low flow
Weather:	Overcast, calm, 15

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	6788
Site Name:	KP 39.8 SUNDOG
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CT, DH	24-SEP-14
Data Entry:		
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB HW	2.00	1.351				
	3.4			1.646		
	4.6			2.057		
	6.2			2.285		
	8.7			2.448		
	11.9			2.468		
	15.0			2.300		
	17.9			2.214		
	19.2			2.229		
	21.2			2.378		
	24.4			2.012		
	26.8			1.911		
	28.5			1.889		
	28.7			1.945		
	31.3			1.528		
LB HW	32.3			0.979		
US 1	36			2.202		
	20			2.351		
CENTRE	0			2.363		
DS 1	27			2.791		
DS 2	55			3.763		

Notes:

No water in channel.

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	
Site Name:	ICP 27.5
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	22-Sep-14
Data Entry:	CJ	22-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB HW	-2.2	1.429				
Bottom HW ~~bank~~ bottom	0.4			1.998		
	1.1			2.388		
	1.8			2.556		
RB edge	2.7			2.745		
channel ~~middle~~	3.8			2.889	cut = 0.15	
channel ~~mid~~	4.3			3.031	= 0.30	
channel ~~LB~~	5.3			3.023	= 0.32	
	6.3			2.817	= 0.08	
LB edge	8.4			2.670		
	11.3			2.453		
	14.3			2.324		
bottom	18.8			2.063		
LB HW ~~bank~~	22.2			1.930		
LB HW	22.7			1.678		
← DS 1 (top of fall)	13			3.584		
~~DS 2~~	~~37~~					
~~DS of pool~~				€		
us 1	14			2.543		
us 2	23			2.079		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	2.9		
LB	7.9		
1	3.7	0.14	0.604
2	4.2	0.26	0.135
3	4.7	0.26	0.325
4	5.2	0.21	0.790
5	6.1	0.15	0.120

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

RB to 1st measurement, no flow - boulders.

5th measurement to LB, no flow.

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	
Site Name:	Kp 154.4
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	23-Sep-14
Data Entry:	CJ	23-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB Hist HW	0.0	1.565				
	0.6			1.878		
RB HW	0.8			2.134		
WL RB	0.9			2.315	cut = 0.04	
WL	1.3			2.335	cut = 0.06	
WL	1.55			2.356	cut = 0.08 =0.05	
WL LB	1.85			2.326		
LB HW	1.9			2.142		
CJ ~~LB Hist HW~~	2.6			1.650		
LB Hist. HW	3.0			1.547		
DS 1	5.0			2.549		
DS2	9.0			2.817		
				~~2.148~~		
US1	7.0			2.148		
US 2	12.0			1.879		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	1.1		
LB	1.9		
1			
2			
3			

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 122.8
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	23-Sept-14
Data Entry:	CJ	23-Sept-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
Top of LB	0.5	0.812				
	1.0			1.091		
LB HW	1.25			1.381	~~0~~	
LB edge	1.2			1.545	cut = 0.~~07~~0	
in channel	1.8			1.764	= 0.295	
"	1.6			1.522	= 0.05	
"	2.1			1.591	= 0.11	
	2.4			1.690	= 0.215	
~~RB edge~~	2.5			1.609	= 0.14	
	2.6			1.688	= 0.21	
RB edge	2.7			1.699	= 0.22	
RB HW	2.7			1.310		
	2.9			0.971		
Top of RB	3.4			0.849		
US 1	15			1.590		
US 2	19			1.479		
DS 1	6			1.963		
DS 2	-3			2.089		
DS 3	-14			2.060		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	2.8		
LB	1.1		
1	1.3	0.15	0.003
2	1.5	0.21	0.132
3	1.7	0.13	0.123
4	1.9	0.12	0.082
5	2.1	0.13	0.019
6	2.3	0.24	0.029
7	2.5	0.18	0.0

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	123.7
Reach:	
UTM:	

	Initials	Date
Field Personnel:	DH, CJ	23-Sep-14
Data Entry:	CJ	23-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
Upper Floodplain LB ~~HW~~	0.0	1.527				
LB HW	0.7			1.572		
HW bottom	0.9			1.911		
	1.8			2.292		
LB edge	2.6			2.449		
in channel	3.3			2.605	cut = 0.139	
"	3.8			2.654	= 0.20	
"	4.4			2.601	= 0.14	
"	5.1			2.707	= 0.21	
"	5.7			2.552	= 0.06	
"	6.0			2.703	= 0.190	
"	6.7			2.758	= 0.27	
"	7.1			2.681	= 0.19	
"	8.0			2.589	= 0.09	
RB edge	8.7			2.510		
Bar	10.0			2.348		
"	11.0			2.187		
"	12.5			2.306		
Bar Side Channel	13.4			2.716		
"	14.2			2.816		
"	15.2			2.768		
"	15.8			2.611		
~~Bank~~ RB HW	16.0			2.487		
	16.5			2.087		
Upper Floodplain	17.0			1.944		
US 1	16.0			2.522		
US 2	34.0			2.500		
DS 1	19.0			3.052		
DS 2	40.0			3.755		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
LB	3.0		
RB	8.85		
1	3.6	0.10	0.366
2	4.2	0.10	0.954
3	4.8	0.15	0.189
4	5.9	0.16	0.142
5	6.3	0.21	0.436
6	6.7	0.23	0.468
7	7.4	0.15	0.034
8	8.0	0.09	0.362

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CEN 6788
Site Name:	KP 125.1 (Groundage)
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, JA	23-Sept-14
Data Entry:		
Data Check:		

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
upper Floodplain	0.0	1.144				
"	0.65			1.088		
LB HW	1.6			1.724		
~~LB edge~~	2.4			2.685		
LB edge	5.1			2.467		
in channel	6.0			2.600	cut = 0.12	
"	8.6			2.763	= 0.29	
"	7.2			2.786	= 0.20	
"	7.9			2.758	= 0.28	
"	8.6			2.608	= 0.11	
~~RB edge~~	10.0			2.508	= 0.02	
RB edge ~~RB edge~~	~~tork~~ 11.2			2.461	= ~~0.80~~	
	12.5			2.437		
RB HW	13.7			2.086		
BEDROCK FACE ~~RB HW~~	14.5			1.520		
US 1	24			2.508		
US 2	33			2.545		
DS 1	18			2.722		
DS 2	33			3.068		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
LB	5,2		
RB	10,0		
1	6,3	0,16	0,112
2	6,5	0,20	0,025
3	6,7	0,25	0,163
4	6,9	0,27	0,370
5	7,1	0,25	0,426
6	7,3	0,28	0,485
7	7,5	0,24	0,540
8	7,7	0,25	0,530
9	7,9	0,19	0,462
10	8,1	0,18	0,320
11	8,45	0,06	0,191

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 133.7
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	24-Sep-14
Data Entry:	CJ	24-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
Top RB	0.90	1.224				
RB HW	1.4			1.673		
RB edge	1.45			1.858		
in channel	1.6			1.964	cut = 0.14	
"	1.7			1.871	= 0.04	
"	1.9			1.936	= 0.095	
"	2.0			2.014	= 0.18	
"	2.3			1.968	= 0.14	
"	2.6			1.983	= 0.16	
LB edge	3.0			1.889	= 0.05	
LB HW	3.05			1.651		
CB Top Bank	3.5			1.308		
				~~1.993~~ 1.993		
US 1	6.0			1.951		
US 2	11.0			~~2.412~~		
				~~2.947~~ 2.412		
DS 1	5.0			2.947		
DS 2	8.0					

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
LB	3.05		
RB	1.4		
1	2.1	0.06	0.093
2	2.35	0.13	0.253
3	2.6	0.11	0.063
4			

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 87.7
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	24-Sep-14
Data Entry:	CJ	24-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB Top	2.7	0.536				
RB HW	3.6			0.982		
RB edge	4.5			1.478		
RB WL edge	10.3			1.501		
In channel	14.9			1.567	cut = 0.03	
"	17.0			1.671	= 0.01	
"	19.8			1.774	= 0.18	
"	22.5			1.817	= 0.02	
"	23.2			1.840	= 0.23	
"	24.5			1.748	= 0.16	
"	25.8			1.779	= 0.20	
	26.3			1.841	= 0.26	
LB WL edge	26.6			1.825	= 0.24	
LB HW	26.6			1.166		
~~LB Top~~	27.6			0.065		
Top ~~Channel~~ LB	28.0			0.048		
US1	23			1.550		
US2	39			1.529		
DS1	18			2.061		
DS2	43			2.407		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	9.9		
LB	26.6		
1	16.3	0.05	0.753
2	17.3	0.12	0.678
3	18.3	0.13	0.788
4	19.3	0.12	0.952
5	20.3	0.16	0.688
6	21.3	0.16	0.747
7	22.3	0.16	0.934
8	23.3	0.19	0.424
9	24.3	0.15	0.445
10	25.3	0.14	0.255

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	Old Road at Tsitsutl Trib.
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	24-Sep-14
Data Entry:	CJ	24-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
LB Top Bank	0.0	1.178				
	0.3			1.425		
LB HW	0.5			1.879		
LB WL edge	1.1			2.249		
in channel	2.5			2.525	cut = 0.27	
"	3.6			2.615	= 0.36	
"	4.3			2.653	= 0.41	
RB WL edge	6.0			2.249		
Gravel bar	7.4			2.010		
"	10.4			1.877		
"	11.6			1.525		
"	13.0			1.499		
LB HW	13.6			1.838		
WL edge	14.3			1.952		
in side channel	15.3			2.046	= 0.09	
"	15.9			2.133	= 0.17	
RB WL edge	16.6			2.028		
RB HW	16.75			1.585		
	16.85			1.395		
RB Top Bank	17.2			1.295		
US 1	17			2.227		
US 2	25			1.665		
DS 1	14			2.471		
DS 2	32			2.690		

Bar { LB

side channel {

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	6.0		
LB	1.05		
1	1.7	0.09	0.033
2	2.1	0.08	0.023
3	2.6	0.28	0.039
4	2.95	0.22	0.042
5	3.5	0.32	0.074
6	3.8	0.39	0.103
7	4.3	0.39	0.082
8	4.85	0.24	0.101
9	5.4	0.16	0.111
~~LB~~	~~14.3~~ BAR		
10	15.1	0.05	0.010
RB	16.3		
LB	14.3		

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	Old Road at Tetcela mainstem
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	24-Sep-14
Data Entry:	CJ	24-Sep-14
Data Check:		

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
RB Top Bank	0.6	0.806				
	2.2			1.183		
RB HW	2.9			1.515		
RB WL edge	7.8			2.140		
in channel	11.7			2.248	cut = 0.100	
"	13.6			2.292	= 0.15	
"	17.4			2.339	= 0.20	
"	20.2			2.401	= 0.28	
"	21.9			2.374	= 0.26	
LB WL edge	23.1			2.127		
LB HW	24.3			1.789		
	25.4			1.342		
LB Top Bank	26.0			1.259		
DS 1	16			2.339		
DS 2	31			2.555		
US 1	19			2.432		
US 2	31			2.424		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	7.9		
LB	22.9		
1	9.2	0.05	0.173
2	10.7	0.06	0.362
3	11.9	0.14	0.315
4	13.2	0.13	0.534
5	14.6	0.12	0.513
6	15.9	0.14	0.519
7	16.9	0.16	0.525
8	17.9	0.17	0.578
9	18.9	0.20	0.636
10	19.9	0.22	0.680
11	20.9	0.21	0.576
12	21.9	0.20	0.451

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 135.6 (GRAINGER TRIB)
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	25-Sep-14
Data Entry:	CJ	25-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
Top LB	0.6	1.819				
LB HW	1.25			2.395		
WL edge	1.3			2.[illegible]	cut = 0.095	
In channel	1.5			2.592	= 0.055	
RB edge	1.8			2.565	= 0.025	
HW	1.8			2.338		
	2.3			1.800		
RB Top	2.8			1.563		
DS1	6.0			2.885		
DS2	11.0			3.176		
US1	5.0			2.154		
US2	10.0			1.995		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
RB	1.9		
LB	1.0		
1	1.6	0.10	0.104
2	1.8	0.086	0.229
3	1.3	0.103	0.212

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 136.7
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	26-Sep-14
Data Entry:	CJ	26-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
Top LB	0.7	1.340				
HW	1.05			1.708		
WL edge	1.1			1.828	cut = 0.05	
in channel	1.35			1.891	= 0.015	
"	1.6			1.878	= ~~0.065~~ CJ 0.1	
WL edge	1.8			1.830	= 0.05	
HW	1.9			1.691		
Top RB	2.1			1.550		
US 1	4.0			1.675		
US 2	8.0			1.118		
DS 1	5.0			2.146		
DS 2	8.0			2.610		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
LB	0.95		
RB	1.75		
1	1.2	0.08	0.238
2	1.1	0.08	0.036

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Hatfield Consultants Hydrometric Visit Fieldsheet

Project:	CZN 6788
Site Name:	KP 131.3
Reach:	
UTM:	

	Initials	Date
Field Personnel:	CJ, DH	26-Sep-14
Data Entry:	CJ	26-Sep-14
Data Check:		

Hatfield CONSULTANTS

Cross-Section/Longitudinal Reach Survey:

Mmt:	Offset	BS (m):	HI (m):	FS (m):	Elevation (m):	Photo?
LB Top	~~0.15~~ 0.5	1.518				
	~~3.65~~ 1.1			1.702		
HW	1.5			2.099		
WL edge	1.55			2.357	cut = 0.05	
in channel	1.9			2.439	= 0.12	
"	2.0			2.433	= 0.13	
WL edge	2.45			2.308	= 0.02	
HW	2.85			2.127		
RB Top	3.2			1.831		
DS 1	8.0			2.699		
DS 2	15.0			2.943		
US 1	5.0			1.955		
US 2	11.0			1.395		

Notes:

Flow Measurement:			
Mmt:	Offset	Depth (m):	Velocity (m/s):
LB	1.55		
RB	2.1		
1	1.7	0.09	0.091
2	1.85	0.10	0.007
3	2.0	0.10	0.188
4	2.2	0.04	0.377

Flow Measurement Details:	
Start Time:	
End Time:	
Method:	
Equipment:	
River Condition:	
Weather:	

Flow Measurement Notes:

Attachment D

Scanned Field Note Book

CONTENTS

PAGE	REFERENCE	DATE

CZN 6788 25 July '14 ①

Purpose: Trip up to mine.
Left Vancouver @ 9:15 on central mountain air. Transfered to Villers early afternoon. Arrived @ mine before dinner. Dave + I on CMA, Earnie + Brian (road engineering technicians) joined us @ Ft Nelson. Garry Scrimgeour arrived at dinner. General safety orientation and ATV orientation Talked w/ Garry after dinner Eat about plan tomorrow.

Calibration of 02-2907AK

pre		post	23.1
7.01	6.63	7.11	
4.01	3.88	3.96	
1413	1245	1415	

02-4776AJ

pre		post	23.4
7.01	6.87	6.7.01	
4.01	4.09	3.97	
1413	1170	1415	

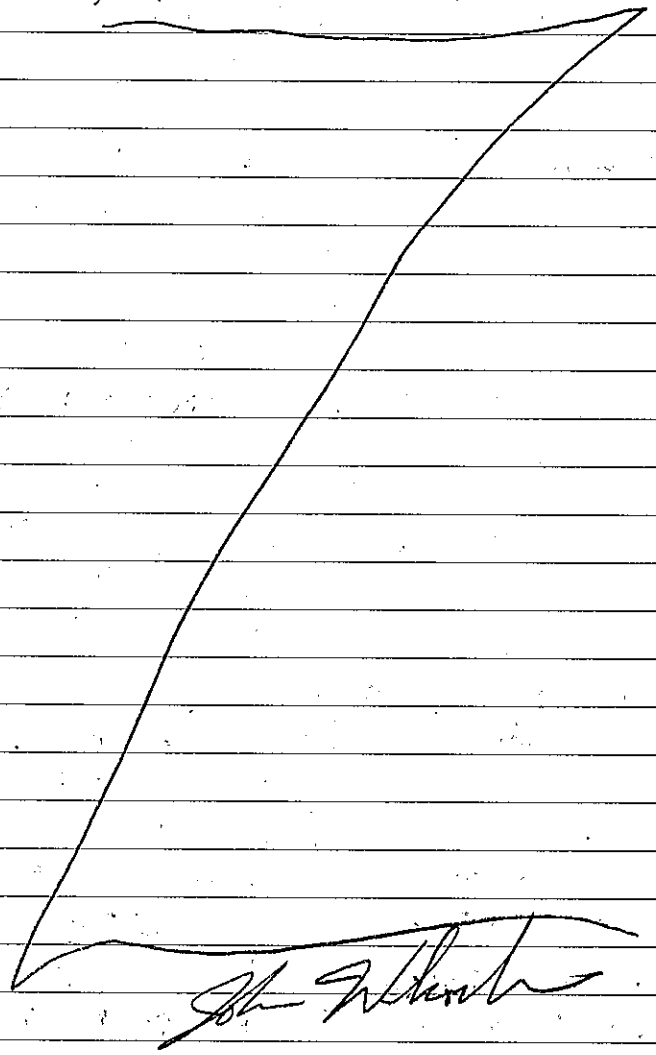
calibration solution info →

Rite in the Rain

(2) CZN6788 25 July '14

Hanna Calibration sachets

pH 4.01 Lot 6406 Exp 07 18
7.01 4628 Exp 06 17
1413 µS/cm 6111 Exp 05 18



(3) CZN6788 26 July '14

Purpose: Cabin sampling on Prairie

Crew: John W + Garry S.

Weather: Clear, cool in morning

leaving warehouse @ 8AM

Started d/s of mine closest to Harrison, so we were close to mine in case we forgot anything

~~Site~~ Parks Site 43 ≃ 3.1 km d/s and then proceeding to site 46 and site 44, which is just upstream of the confluence with Galeena Ck (which is also on the opposite side of Prairie). All sites had very low periphyton densities. Finished about 2pm. For the benthos used the bucket rince approach, discarding the heavy sand/gravel substrate. Next sampled 47, which is located at the southern

JW

Rite in the Rain

most corner of the water storage pond. Then 73, which was just d/s of the AEMP reference location while at the site, walked upstream to last years' sampling location and noted a ~~strong~~ substantial increase in periphyton density on rocks. 13PC-Ref is just upstream of a confluence of a small stream. Water appears to be entering Prairie Creek through coarse material u/s of the confluence. Garry noted damp soil + water between rocks on left bank of Prairie, apparently from the trib. Garry suggested assessing nutrients from the trib and Prairie in a couple locations in an attempt to characterize natural variability of nutrients in Prairie Ck. Next Stn 72 ~1 km S of Casket Ck.

GW

Periphyton was still very low, but slightly higher than most d/s locations. This site may also received some influence from a trib. Noted "dr Seuess" flowers in bloom in flood plain. Never seen these before, suggesting that warm dry summer thus far, may be advancing growth/maturity of local natural systems. Took a photo.

Rite in the Rain

CZN6788 27 July'14

Purpose: First day of Road assessment - Sundog to Cat camp + Polge (Bubbling Springs) Ck. Electrofishing Sundog + net/trap mosquito

Crew: John, Dave, Garry + Jon

Electrofishing settings ~~used in past~~ last year 425v ± 25v 30HZ
~~Duty cycle~~ 12% (Neal)
US: sculpin - 400v 50HZ 20DC
Trout - 40 HZ

Km 44 look at potential migration barrier prefer culvert over bridge.
Km 35-38 - possible re-alignment, shocking here.
Trib to Polge (bubbling springs)

Km 24 - falls
wp 10 drop of electrofishing gear. ~Km 36

Tetsela
44 fish migration barrier 47-49 alignment

GW

CZN6788 27 July'14 (7)

WP 11 Catcamp
431569
6829953
Km 43 Crossing WP 012

WP 13 Trib to Sundog long Chute ~75m S
Photo + Photo north ~150 m long against black colored cliff 10° slope ~12° further upstream in chute

0831295
6830730
WP 14 Downstream pool, ~~Dave~~ saw fish ~10cm upstream of pool ~10° Furthest D/S point

WP 15 S N, WP ~~17~~ 16 S N W pool
WP 17 S N WP 18 S N (not recorded)

1215 @ Sundog Ck realignment location #1
pH ~~9.5~~ 7.6°C 221 µS (AJ)
GW pH 8.60 8.68°C 260 µS (AK)

upstream riffle flows / depths

		depth	flow
Top	25	22cm	.29
~~Mid~~	50	40cm	.75
~~bottom~~	~~75~~	26 cm	.61
Mid	25	32cm	.59
	50	46cm	.97
	75	22	.27
Bottom	25	28	.92
	50	32	1.20
	75	42cm	1.06

DO on meter 11.20 mg/L
94.8%

DO titration 10.8 mg/L

WP22 Sundog goes to ground.

Second sundog realignment site (Location ~~#2A~~ ~~Site A~~)

Top wpt 023 426356
6829278

Bottom WP 024 426418
6829265

Cond 268 µS / 9.1°C / 7.40 (AK)

DO meter 99.4% 11.83 mg/L
pH 8.63 7.4°C 233 µS (AJ)
DO titration 10.2 mg/L

second sundog realign site
Location B

Top wpt 025 426255
6829318

Bottom wpt 026 426323
6829305

End ~ 1635.

Pilot late picking us up - decided to send just Garry + Dave to sundog trib to electrofish 1730 - 1815
back @ camp about 1835

For the sundog allignment locations, Jon and I did habitat sheets, while Garry + Dave electrofished

A sundog 1, ~~site A~~ 1348sec
ARGR FL (mm): 190, 183, 181, 192
SLSC FL (mm): 81, 92, 93, ?

Rite in the Rain

Settings for sites ~~A + B~~ 1 + 2
500v, freq: 50

For the Sundog Alligment, site 2
d/s location ("A") - no fish 327 sec
u/s " ("B") - no fish 188 sec

For trib to Sundog (visited earlier in day)
724 sec
wp 27 (431594 / 6829949)
to wp 28 (431514 / 6829743)
assume Sinuosity of 2.0
assume wetted width 2.5m

CZN 6788 28 July '14

Purpose:- habitat ass @ Polje Creek crossings + assess trib. Trapping near outlet of Mosquito. + Flying much of road alligment where ~~cros~~ there are crossings.

Crew:- Dave H, Gary S, Jonathan T, John W.

Broken high overcast took off @ 742.

Road allignment from air photos

~~WP 28~~

Picked up gear (nets + traps) + dropped at "dry" lake near polgi ck - then dropped ~~two~~ people in at a time to Polgi Ck. ~ km 53
WP 28 is landing spot created log landing pad.
Walked to two small trib to west - second trib

Rite in the Rain

not flowing + no defined channel ~~grass~~ moss, ~~sed~~ shrubs + holes w/ logs. walked further 100 m to confirm that second channel was not missed (WP29, 277 m from landing site). Area. Photo WNES Labrador tea, dwarf spruce, lichen, moss, horsetail. Larch (?)

2nd stream west WP30 photo WNES (before this photo)

Following road back looking for tribs

WP 33 small defined channel < 1m wide

WP 34/35 larger trib gushe encised dead + falling trees in channel

WP 36 small defined channel < 1m wide

WP 37 another small channel < 1m wide (photo just before

last 3 photos WP39

JW

WP 34/35 likely green dot on map km 46.5

last 4 photos WP40

Polgyes

Tetsela - last photo first crossing

Next photos second crossing WP 41

Fish trap - last few + next few WP 42

Flow ~0.02 m/s (garry's estimate

Pen: 20.3°C 589 µS pH 8.08

YSI (DO calibrated) 19.7°C 11.3 mg/L 124% O_2 Sat pH 8.54 476 µS

Water striders noted on surface Gary said that they are a good indicator for fish absence, since they get hammered by fish. Gary also believes that DO of Fish Trap would be much lower at night when aquatic plants start using O_2.

JW

Rite in the Rain

CZN6788 28 July 14

Sampling site WP 043
Bank height ~ 1m
DO titration 9.8 mg/L
1345 finish
- collected nets + minnow traps + fish cat on way back.
- Took multiple photos of ~~wall~~ Sundog Creek realignment
- Back @ camp ate lunch + downloaded photos.
- went out w/ Dave to look @ Casket Ck comp habitat opened up some channels, saw a young grizzly.
Then to water storage pond. took 4 cores for geoteck purposes.

CZN6788 29 July 14

Purpose: Flying road east of park to characterize # crossings

Crew: John W., Dave, H + Brian + Eamie from AllNorth

Broken cloud ~ 80%
Departing 8 AM.
using blue camera w/ gps
Road engineers looking at Tetsela + Fish trap
Exploring new route east of silent hills, higher elevation :: less/ smaller stream crossings (photo before) + after - draws, but brush too dense to see water.
→ Grange gap + back
two large moose, then
stream ~ 3-4m wide,
new route is close to 104 + km10 but further west - prefer top of ridge to hill side - East slopes typically more unstable

Rite in the Rain

Checking out airstrip
WP 051
wetland lots of beaver dams, instream veg. flow not some loss of connectivity, Iron sheen observed in some locations - crossing to south -
Granger gap dropped off + walking west to culvert crossing of wet land WP 52/53 as close as we can get to channel south of Granger Lake, wet dont have waders on.
0948, May take road south to avoid channel from Granger Lake channel + bottom of fan.
- Signs of beaver activity (trails) + moose foot prints
54 - Fan - mostly dry except near Granger some surface flow Flow of Granger appears to double as it passes fan = lots of sub surface flow.
On south side flow coming out from draw next to cliff WP 055

JW

From refuling will take a look at 2 wetland crossings
Inlet to Granger Lake comes from beaver impounded lake some riffle + some swampy low flow (in middle).
Downstream Granger gap river crossing.
WP 56
KM 137
138
WP 57 defined channel <1m
58 " " <1m
59 dry stream
60 small stream
61 outwash from slope

Refuling again at 1227
1249 take off
start 138km
141 1/2 km (took photo of)
WP 062 bridge.
Last photo KM 151 - mostly dry fan - some standing water amongst tall trees.
(WP 63)

JW

Rite in the Rain

(18) CZN6788 29 July '14

Battery just about dead on blue camera

144 km

wp 65 <154km

wp 68 crossing [illegible] just downstream in rock crossing

wp 69 crossing of Liard

Km 163 Km 165.5

Km 164 Km 168.4

Km 172.2

1430 - finish w/ helicopter wait till 1680 for Islander out of Nahanni Butte.

1700 take off arrive 1830 mountain time

Overnight in Fort Nelson

~~1515 Pacific~~ f

1315 pacific flight (central mountain air) home next day

Rite in the Rain

(20) CZN 6788 21-SEP-14

CHRIS JAEGGLE

DAVID HARPLEY

- DEPARTED MINE AT 8:30.
- ARRIVED AT KP 50.2 (TRIBUTARY TO POLJE)
  - FLOW MMT, CROSS SECTION AND REACH SURVEY.
  - HABITAT ASSESSMENT.

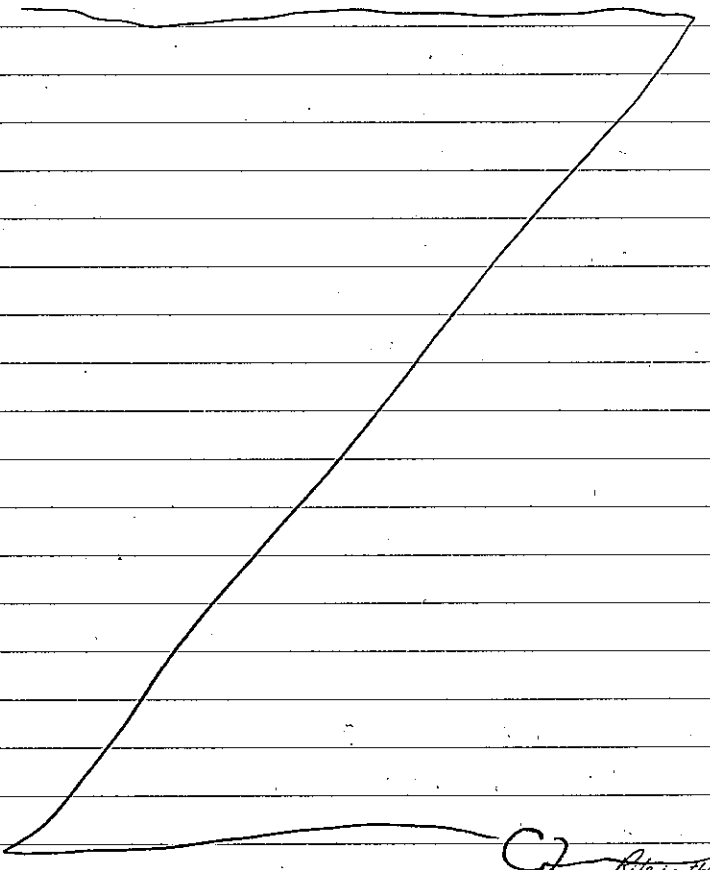
- ARRIVED AT KP 49.1 CROSSING (POLJE TRIB.)
  - NO ASSESSMENT NEEDED - ALL FLOW GOES INTO GROUND (UNDER SLOUGHED BANKS) - NOT FISH BEARING CREEK!

- ARRIVED AT KP 49.4.
  - NO VISIBLE WATER FLOWING INTO MAIN POLJE CHANNEL - NO ASSESSMENT.
- PICKED UP BY HELICOPTER.

- ARRIVED AT KP 46
  - NO WATER - NO ASSESSMENT.
- ARRIVED AT KP 47.
  - FLOW MMT, CROSS-SECTION AND REACH SURVEY.
  - HABITAT ASSESSMENT
- ARRIVED AT ~~KP 54.3~~ KP 54.3 (POLJE MAIN CHANNEL).
  - FLOW MMT, CROSS SECTION AND CHANNEL SURVEYS.
- ARRIVED AT 54.4.
  - SEDIMENT SAMPLING.

(21)

- PICKED UP BY HELI.
- ARRIVED AT KP 39.8 (SUNDOG).
  - COMPLETELY DRY, INCLUDING SUNDOG MAIN CHANNEL.
  - CROSS SECTION AND REACH SURVEYS.
  - PARTIAL HABITAT ASSESSMENT (SEE FIELD SHEET).
  - COLLECTED SEDIMENT SAMPLES.
- RETURNED TO MINE AT 19:00.



(22) CZN 6788 22-Sep-14

CHRIS JAEGGLE

DAVID HARPLEY

- HAD TO WAIT FOR REPLACEMENT HELICOPTER FIRST THING IN THE MORNING (BROKEN FUEL PUMP ON 407 SO AN ASTAR BEING SENT).
- FIRST CREW DEPARTED IN ASTAR AROUND 10^{30}.
- WHILE WAITING, RECEIVED CALL SAYING THAT DUE TO HIGH WINDS THE HELI. WAS GROUNDED.
- AROUND 2^{30} (14^{30}) DAVID AND I DECIDED TO GO TO SUNDOG CREEK VIA ATV.
- ARRIVED AT KP 27.1 AFTER HIKING FROM ATVs (PARKED AT 26 KM DUE TO LANDSLIDE ACROSS ROAD).
- ~~HT~~ - HABITAT ASSESSMENT.
- HIKED TO KP 27.5.
  - HABITAT ASSESSMENT.
- HIKED TO KP 28.4,
  - FLOW MMT, CROSS SECTION AND REACH SURVEY, HABITAT ASSESSMENT.
- HIKED BACK TO ATVS AND THEN DROVE BACK TO MINE.
- ARRIVED BACK MINE AT 21^{20}.

NOTE! Diss. O_2 not measured as one reagent spilled while on ATV - COULD NOT DO TITRATION.

(23) CZN 6788 23-SEP-14

CHRIS JAEGGLE, DAVID HARPLEY.

- LEFT MINE IN HELI AT ~ 8^{45}.
- STOPPED AT KP 27.5 (SITE FROM YESTERDAY)
  - COLLECTED D.O. SAMPLE → 10.8 mg/L.
- ARRIVED AT KP 29.2 (SUNDOG CREEK).
  - HABITAT ASSESSMENT AT CROSSING.
  - SEDIMENT SAMPLED.
  - PICKED UP BY HELI.
- ARRIVED AT KP 154.4 (LIARD TRIB.)
  - HABITAT ASSESSMENT, CROSS SECTION AND REACH SURVEYS. ONLY ONE VELOCITY MMT DONE DUE TO LARGE BOULDERS THROUGHOUT CREEK.
- PICKED UP BY HELI AND DROPPED AT KP 122.8 (GRAINGER TRIB.)
  - HABITAT ASSESSMENT, CROSS SECTION AND REACH SURVEY, FLOW MMT.
- PICKED UP BY HELI. AND DROPPED AT KP 123.7 (GRAINGER MAINSTEM).
  - HABITAT ASSESSMENT, CROSS-SECTION AND REACH SURVEY, FLOW MMT.
- HIKED TO KP 125.1 (GRAINGER MAINSTEM).
  - HABITAT ASSESSMENT, CROSS-SECTION AND REACH SURVEYS, FLOW MMT, SEDIMENT SAMPLING.
- RELOCATED TO NAHANNI BUTTE VIA HELI.

(24) CZN 6788 · 24-SEP-14

CHRIS JAEGGLE

DAVID HARPLEY

- LEFT NAHANNI BUTTE IN HELI.
- 8^{50} ARRIVED AT KP 133.7 (GRAINGER TRIB.)
  - HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEY.
- 14^{00} ARRIVED AT KP 87.7 (TETCELA MAINSTEM).
  - HABITAT ASSESSMENT, CROSS SECTION AND REACH SURVEY, FLOW MMT.
- 16^{30} ARRIVED AT ~~KP~~ "OLD ROAD AT TETCELA TRIBUTARY".
  - HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEYS, SEDIMENT SAMPLING.
- 17^{15} ARRIVED AT "OLD ROAD AT TETCELA MAINSTEM".
  - HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEYS, SEDIMENT SAMPLING.
- ON FLIGHT BACK TO NAHANNI BUTTE, STOPPED AT "FISHTRAP" AND "UNNAMED CREEK" TO COLLECT WATER QUALITY SAMPLES AND PERFORM IN-SITU MMTS.
- ARRIVED BACK IN NAHANNI BUTTE AT 19:30.

CJ

(25) CZN 6788 24-SEP-14

CHRIS JAEGGLE

DAVID HARPLEY

~~H~~ IN-SITU WATER QUALITY MEASUREMENTS NOT ON FIELDSHEETS:

- FROM FISHTRAP SITE:
  - pH: 7.87
  - Temp: 11.4 °C
  - Conductivity: 810 µS
  - Diss. O_2: 12.0 mg/L
- From Unnamed Creek:
  - Diss. O_2: 9.8 mg/L

CJ

Rite in the Rain

(26) CZN 6788 25-Sep-14

CHRIS JAEGGLE

DAVID HARBLEY.

LIARD RIVER US RB SURVEY.

MMT	OFFSET ~~REF~~	READING	NOTE
TOP RB	~~-3.5~~	0.081	
	-1.9	0.474	
HW	-1.3	0.989	
	3.8	2.009	
	13	3.199	
	24	4.725	
WL	38	6.071	
	LB SURVEY		
~~TOP~~ HW	-1.0	0.161	
	0.2	1.613	
	2.0	2.233	
	7.0	3.610	
	17	4.971	CJ
WL	35	5.674	

CJ

(27) CZN 6788 25-Sep-14

CHRIS JAEGGLE

DAVID HARBLEY.

- 8[10] DEPARTED NAHANNI BUTTE VIA HELI.
- WEATHER DICTATED THAT WE RETURN, DUE TO LOW CEILING AND LOW TEMP (FREEZING RAIN POSSIBLE).

- DECIDED TO PERFORM LIARD BATHYMETRY SURVEY INSTEAD OF HELI SITES. DEPARTED VIA BOAT AROUND 10[30].
- PERFORMED BATHYMETRY OF CROSSING (AND OPTIONAL) AREAS WITH DEPTH SOUNDER.
  - DEPTH SOUNDER OFFSET = 0.148 m
- PERFORMED BANK SURVEYS ON LB AND RB OF MAIN PROPOSED CROSSING AREA (SEE DATA ON PG 25).
- DURING BATHYMETRY SURVEY, ALSO RECORDED SIMULTANEOUS PHOTOS AND GPS WAYPOINTS (LABELLED "1B to 19B").
- RETURNED TO NAHANNI BUTTE AROUND 14[30] TO WAIT OUT WEATHER.
- WEATHER LIFTED ENOUGH AND DEPARTED IN HELI AT 16[30].
- ARRIVED AT KP 144.7 (TRIANGLE LAKE OUTLET).
  - FROM OUTLET PAST CROSSING IS HIGHLY BEAVER IMPOUNDED AND IMPASSABLE FOR FISH - SEE PHOTOS.
  - NO ASSESSMENT FOR HABITAT, FLOW, ETC.

Rain

(28) - CONTINUED FROM PG 27:

- ARRIVED AT KP 135.6 (GRAINGER TRIB.)
  - HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEYS.
- ARRIVED BACK IN NAHANNI BUTTE AT 9[30].

(29) CZN C788 26-SEP-14

CHRIS JAEGGLE

DAVID HARPLEY

10[35] - DEPARTED NAHANNI BUTTE VIA HELI, AFTER WEATHER DELAYS.

11[00] - ARRIVED AT KP 136.7 (GRAINGER TRIB.)
- HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEYS.

12[10] - ARRIVED AT KP 131.3 (GRAINGER TRIB.).
- HABITAT ASSESSMENT, FLOW MMT, CROSS SECTION AND REACH SURVEYS.

13[15] - ARRIVED AT BLUEFISH CREEK
- WATER QUALITY SAMPLING AND IN-SITU MMTS, SEDIMENT SAMPLING.
- IN-SITU WQ:

pH: 7.93
Temp: 5.90 °C
Cond: 495 µS
D.O. 12.6 mg/L

- FLEW AROUND DOING AERIAL RECONNAISSANCE AND MOVING OTHER CREWS AROUND.
- RETURNED TO NAHANNI BUTTE AT. 16[00].
- FLEW TO FT. SIMPSON AT 18[00].

Attachment E

Hydrometric Station Cross–Section/Reach Survey Field Record

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 28.4 (Sundog Creek)

UTM Location: -

Visit Date: September 22, 2014

Visit Time: 16:30

Cross-Section/Bank Survey Data

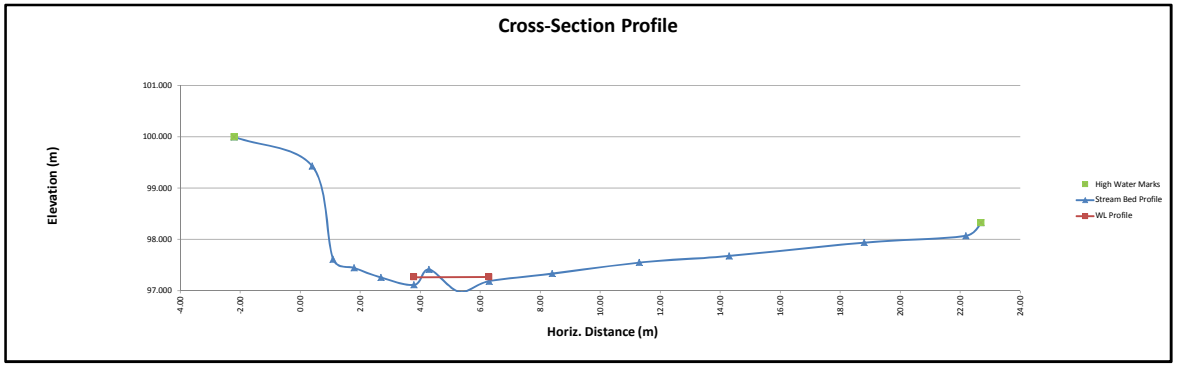
Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
RB High Water Mark	-2.20	1.429			100.000
RB High Water Mark Step Bottom	0.40		1.998		99.431
1	1.10		2.388		97.612
2	1.80		2.556		97.444
RB WL edge	2.70		2.745		97.255
Channel Bed #1	3.80		2.889		97.111
WL #1	3.80			0.150	97.261
Channel Bed #2	4.30		3.031		97.411
WL #2	4.30			0.300	97.711
Channel bed #3	5.30		3.023		96.977
WL #3	5.30			0.320	97.297
Channel bed #4	6.30		2.817		97.183
WL #4	6.30			0.080	97.263
LB WL edge	8.40		2.670		97.330
3	11.30		2.453		97.547
4	14.30		2.324		97.676
5	18.80		2.063		97.937
LB High Water Mark Step Bottom	22.20		1.930		98.070
LB High Water Mark	22.70		1.678		98.322

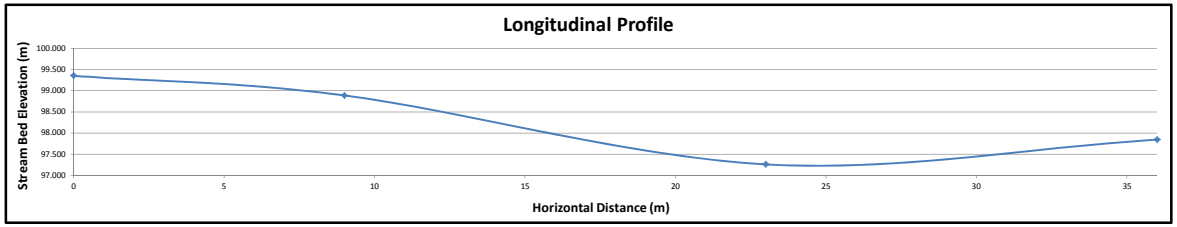
Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	14.0	2.543	98.886	Riffle	
	23.0	2.079	99.350	Riffle	
At Cross-section	0.0		97.261	Riffle	
Downstream	13.0	3.584	97.845	Riffle	

Slope Data:	
Horizontal Distance Surveyed:	36.0
Change in Channel Elevation:	1.505
Average Channel Slope (%):	4.181

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.429
Datum elevation (m):	100.000





General Notes:

Field Personnel:	CJ, DH	Trip Date:	22-Sep-14
Data Entry Personnel:	CJ	Date:	6-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 39.8 (Sundog Creek Tributary)

UTM Location: 428369 E, 6830273 N

Visit Date: September 21, 2014

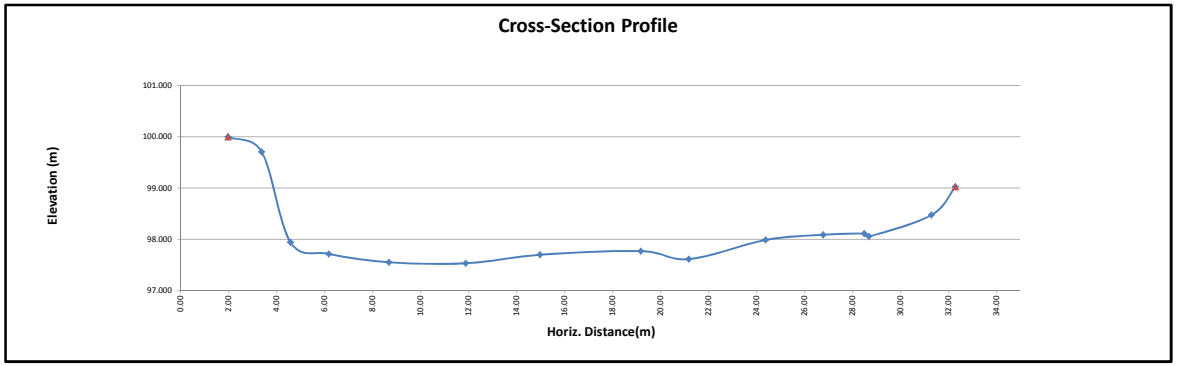
Visit Time: 17:00

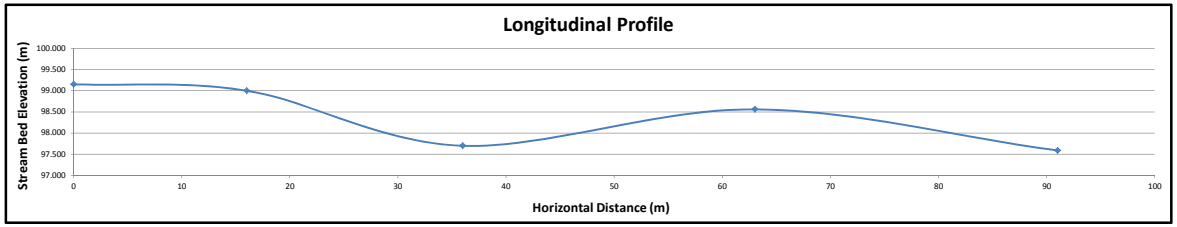
Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
RB High Water Mark	2.00	1.351			100.000
1	3.40		1.646		99.705
2	4.60		2.057		97.943
3	6.20		2.285		97.715
4	8.70		2.448		97.552
5	11.90		2.468		97.532
6	15.00		2.300		97.700
7	17.90		2.214		97.700
8	19.20		2.229		97.771
9	21.20		2.387		97.613
10	24.40		2.012		97.988
11	26.80		1.911		98.089
12	28.50		1.889		98.111
13	28.70		1.945		98.055
14	31.30		1.528		98.472
LB High Water Mark	32.30		0.979		99.021

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.351
Datum elevation (m):	100.000





Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	20.0	2.351	99.000		
	36.0	2.202	99.149		
At Cross-section	0.0	2.363	97.700		
Downstream	27.0	2.791	98.560		
	55.0	3.763	97.588		

Slope Data:

Horizontal Distance Surveyed:	91.0
Change in Channel Elevation:	1.561
Average Channel Slope (%):	1.715

General Notes:

-River channel was completely dry

Field Personnel:	CJ, DH	Trip Date:	21-Sep-14
Data Entry Personnel:	CJ	Date:	6-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 47.0 (Polje Creek Tributary)

UTM Location: 434240 E, 6829338 N

Visit Date: September 21, 2014

Visit Time: 14:15

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of RB	1.30	0.858			100.000
1	1.70		0.905		99.953
2	2.20		1.140		98.860
3	3.10		1.126		98.874
RB High Water Mark	3.80		1.317		98.683
RB WL edge	4.40		1.644		98.356
Channel bed #1	4.50		1.977	0.120	98.023
WL #1	4.50				98.143
Channel bed #2	4.75		2.033	0.210	98.143
WL #2	4.75				98.353
Channel bed #3	4.90		1.954	0.135	98.046
WL #3	4.90				98.181
LB WL edge	5.00		1.645		98.355
LB High Water Mark	5.50		1.244		98.756
4	6.30		1.122		98.878
5	7.00		1.140		98.860
6	7.20		1.315		98.685
7	7.60		1.357		98.643
8	8.80		1.238		98.762
Top of LB	11.20		1.176		98.824

Channel Slope Survey Data

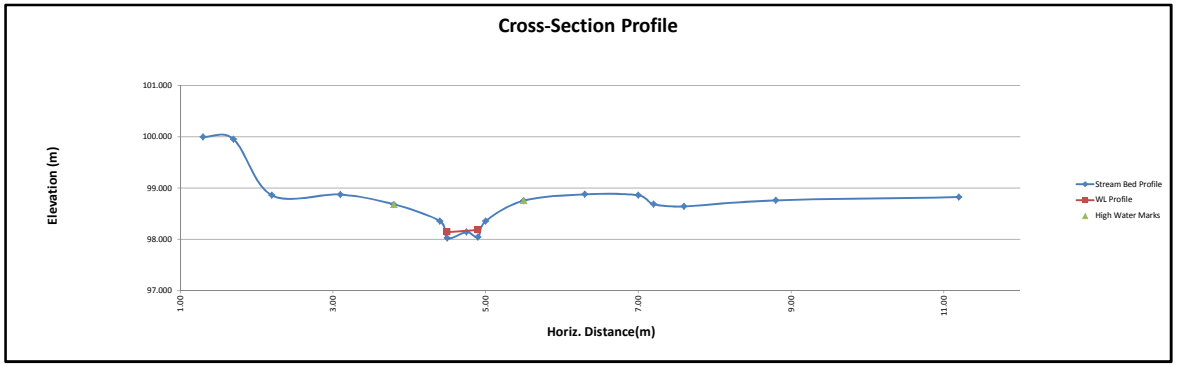
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	7.0	1.829	99.029	Run	
	14.0	1.517	99.341	Run	
	22.0	1.198	99.660	Run	
At Cross-section	0.0		98.143	Run	
Downstream	5.0	2.180	98.678	Run	
	12.0	2.470	98.388	Run	
	20.0	2.843	98.015	Run	

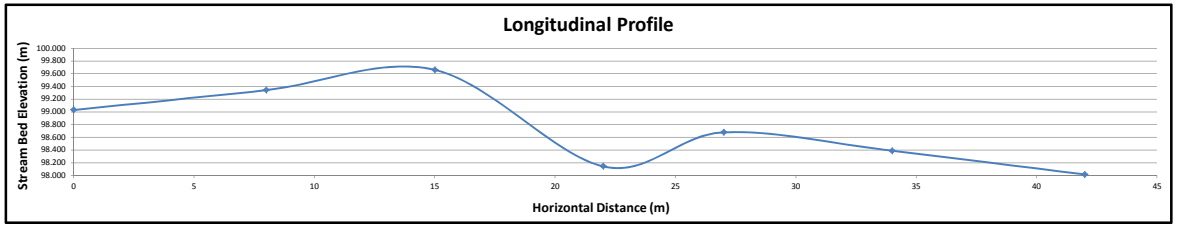
Slope Data:

Horizontal Distance Surveyed:	42.0
Change in Channel Elevation:	1.645
Average Channel Slope (%):	3.917

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	100.858
Datum elevation (m):	100.000





General Notes:

Field Personnel:	CJ, DH	Trip Date:	21-Sep-14
Data Entry Personnel:	CJ	Date:	30-Sep-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 50.2 (Polje Tributary)

UTM Location: 436944 E, 6829737 N

Visit Date: September 21, 2014

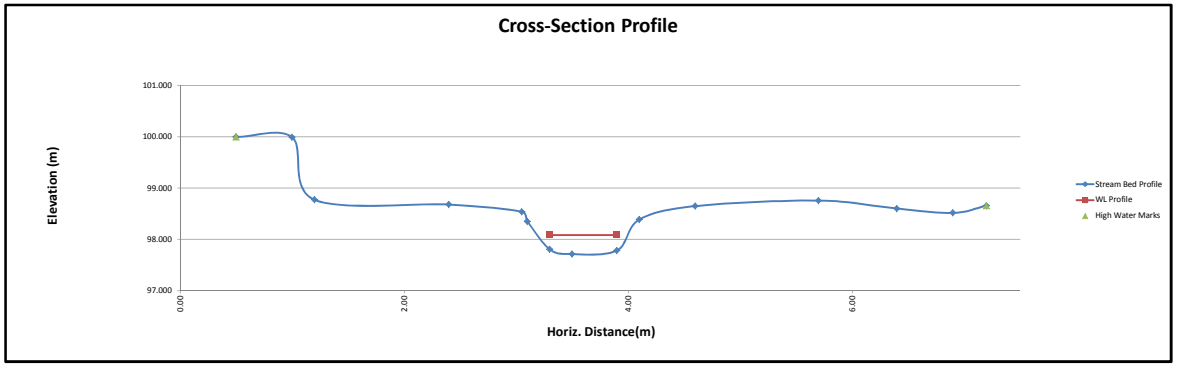
Visit Time: 9:50

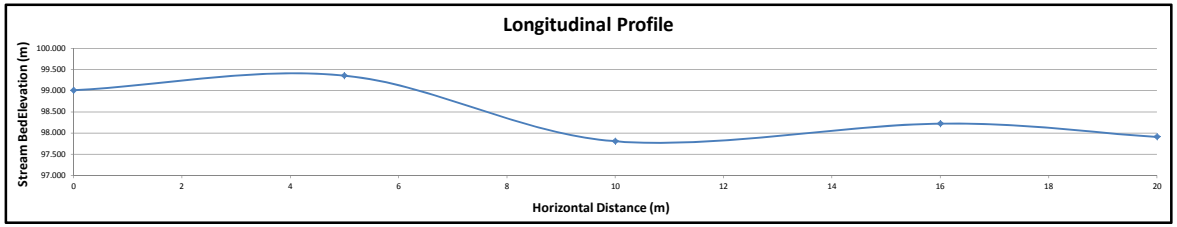
Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
RB High Water Mark	0.50	0.959			100.000
1	1.00		0.969		99.990
2	1.20		1.229		98.771
Top of RB	2.40		1.322		98.678
RB WL edge	3.05		1.461		98.539
channel bed #1	3.10		1.648		98.352
channel bed #2	3.30		2.194	0.280	97.806
WL elevation	3.30				98.086
channel bed #3	3.50		2.288		97.712
LB WL edge	3.90		2.217		97.783
Top of LB	4.10		1.614		98.386
3	4.60		1.351		98.649
4	5.70		1.243		98.757
5	6.40		1.400		98.600
6	6.90		1.485		98.515
LB High Water Mark	7.20		1.343		98.657

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	100.959
Datum elevation (m):	100.000





Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	5.0	1.949	99.010	Run	
	10.0	1.604	99.355	Run	
At Cross-section	0.0		97.806	Run	
Downstream	6.0	2.737	98.222	Run	
	10.0	3.050	97.909	Run	

Slope Data:

Horizontal Distance Surveyed:	20.0
Change in Channel Elevation:	1.446
Average Channel Slope (%):	7.230

General Notes:

Field Personnel:	CJ, DH	Trip Date:	21-Sep-14
Data Entry Personnel:	CJ	Date:	30-Sep-14
Data Check Personnel:	TL	Date:	28-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 54.3 (Polje Creek Tributary)

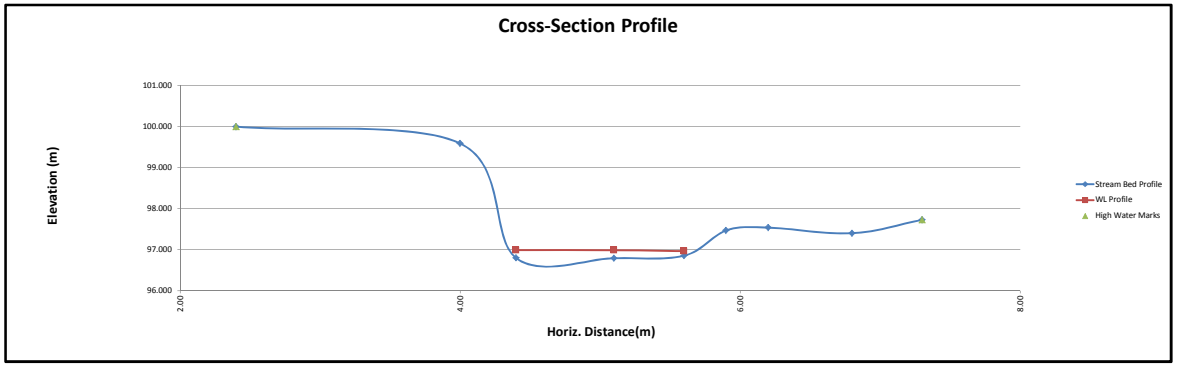
UTM Location: 440622 E, 6830769 N

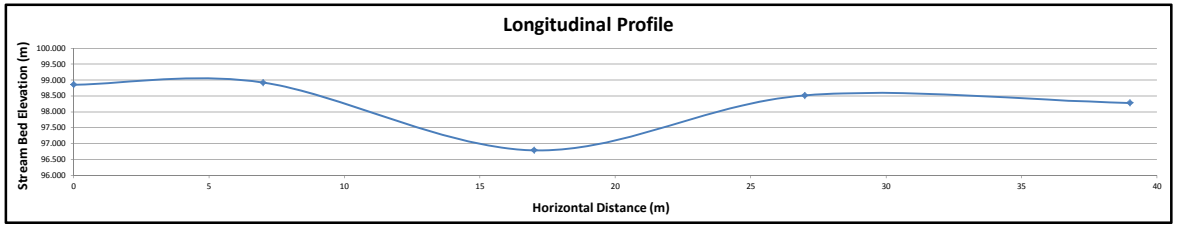
Visit Date: September 21, 2014

Visit Time: 15:45

Cross-Section/Bank Survey Data					
Mmt #:	**Offset**	**BS (m):**	**FS (m):**	**Cut (m):**	**Elevation (m):**
RB High Water Mark	2.40	2.061		-	**100.000**
RB WL edge	4.00		2.470	-	99.591
channel bed	4.40		3.207	0.195	96.793
WL	4.40				96.988
channel bed	5.10		3.209	0.195	96.791
WL	5.10				96.986
channel bed	5.60		3.149	0.110	96.851
WL	5.60				96.961
LB WL edge	5.90		2.533	-	97.467
1	6.20		2.464	-	97.536
Bottom of HW Step	6.80		2.602	-	97.398
LB High Water Mark (Step)	7.30		2.275	-	97.725

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	102.061
Datum elevation (m):	100.000





Channel Slope Survey Data					
Measured Data			**Calculated Data**	**Channel Reach Notes**	
Direction from Cross-section	**Distance from Cross-section**	**Survey Reading**	**Elevation (m)**	**Morphology**	**Substrate**
Upstream	10.0	3.207	98.854	Run	
	17.0	3.142	98.919	Run	
At Cross-section	0.0		96.791	Run	
Downstream	10.0	3.546	98.515	Run	
	22.0	3.781	98.280	Run	

Slope Data:	
Horizontal Distance Surveyed:	39.0
Change in Channel Elevation:	0.639
Average Channel Slope (%):	1.638

General Notes:

Field Personnel:	**CJ, DH**	**Trip Date:**	**21-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**30-Sep-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 87.7 (Tetcela River)

UTM Location: 460241 E, 6812386 N

Visit Date: September 24, 2014

Visit Time: 14:00

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of RB	2.70	0.536			100.000
RB High Water Mark	3.60		0.982		99.554
1	4.50		1.478		99.058
RB WL edge	10.30		1.501		99.035
Channel bed #1	14.90		1.567		98.969
WL #1	14.90			0.030	98.999
Channel bed #2	16.30		1.567		98.949
WL #2	16.30			0.050	98.999
Channel bed #3	17.30		1.567		98.949
WL #3	17.30			0.120	98.999
Channel bed #4	18.30		1.567		98.879
WL #4	18.30			0.130	98.999
Channel bed #5	19.30		1.567		98.869
WL #5	19.30			0.120	98.999
Channel bed #6	19.80		1.774		98.762
WL #6	19.80			0.180	98.942
Channel bed #7	20.30		1.774		98.782
WL #7	20.30			0.160	98.942
Channel bed #8	21.30		1.774		98.782
WL #8	21.30			0.160	98.942
Channel bed #9	22.30		1.774		98.782
WL #9	22.30			0.160	98.942
Channel bed #10	23.30		1.774		98.752
WL #10	23.30			0.190	98.942
Channel bed #11	24.30		1.774		98.792
WL #11	24.30			0.150	98.942
Channel bed #12	25.30		1.774		98.802
WL #12	25.30			0.140	98.942
Channel bed #13	25.80		1.779		98.757
WL #13	25.80			0.200	98.957
Channel bed #14	26.30		1.841		98.695
WL #14	26.30			0.260	98.955
LB WL edge	26.60		1.825		98.711
LB High Water Mark	26.60		1.166		99.370
2	27.60		0.065		100.471
Top of LB	28.00		0.048		100.488

Channel Slope Survey Data

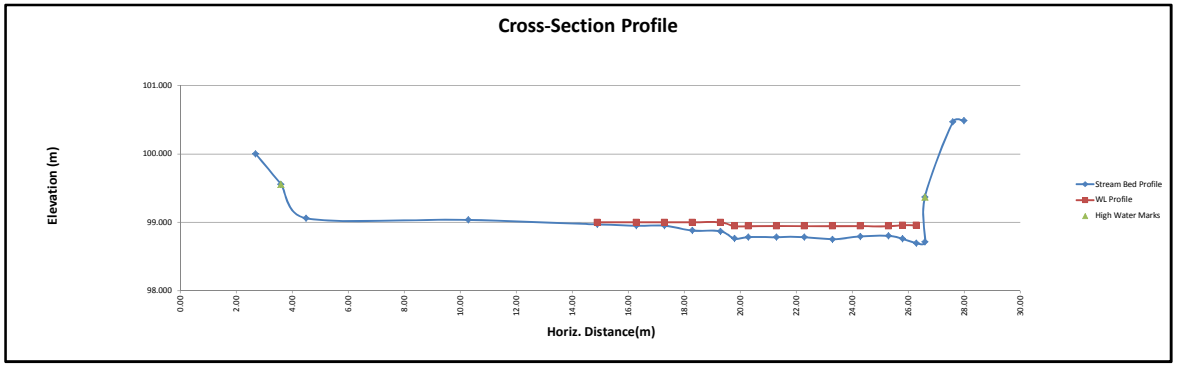
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	23.0	1.550	98.986	Run	
	39.0	1.529	99.007	Riffle	
At Cross-section	0.0		98.949	Run	
Downstream	18.0	2.061	98.475	Run	
	43.0	2.407	98.129	Run	

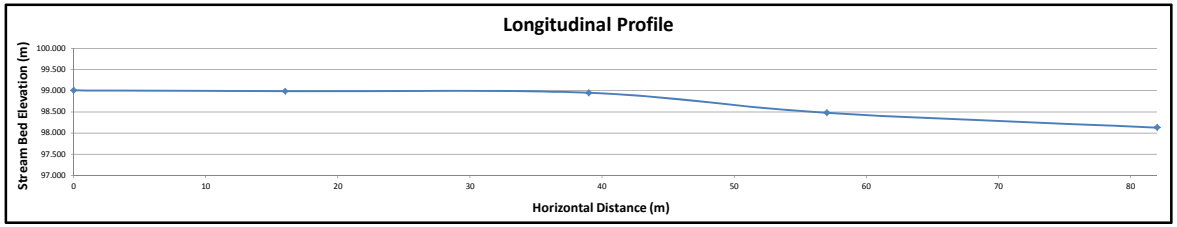
Slope Data:

Horizontal Distance Surveyed:	82.0
Change in Channel Elevation:	0.878
Average Channel Slope (%):	1.071

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	100.536
Datum elevation (m):	100.000





General Notes:

Field Personnel:	CJ, DH	Trip Date:	24-Sep-14
Data Entry Personnel:	CJ	Date:	8-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 122.8 (Grainger Tributary)

UTM Location: 477151 E, 6798715 N

Visit Date: September 23, 2014

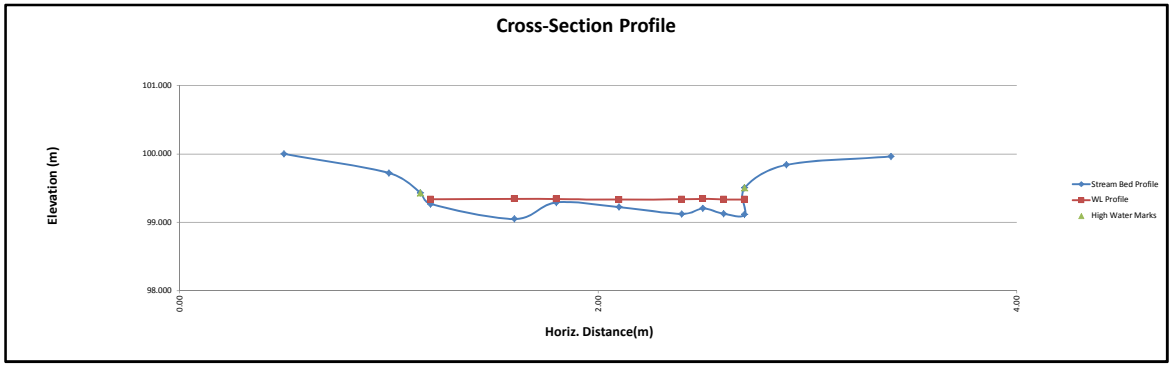
Visit Time: 15:20

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of LB	0.50	0.812			100.000
1	1.00		1.091		99.721
LB High Water Mark	1.15		1.381		99.431
LB edge	1.20		1.545		99.267
LB edge WL	1.20			0.070	99.337
Channel bed #1	1.60		1.764		99.048
WL #1	1.60			0.295	99.343
Channel bed #2	1.80		1.522		99.290
WL #2	1.80			0.050	99.340
Channel bed #3	2.10		1.591		99.221
WL #3	2.10			0.110	99.331
Channel bed #4	2.40		1.690		99.122
WL #4	2.40			0.215	99.337
Channel bed #5	2.50		1.609		99.203
WL #5	2.50			0.140	99.343
Channel bed #6	2.60		1.688		99.124
WL #6	2.60			0.210	99.334
RB edge	2.70		1.699		99.113
RB edge WL	2.70			0.220	99.333
RB High Water Mark	2.70		1.310		99.502
2	2.90		0.971		99.841
Top of RB	3.40		0.849		99.963

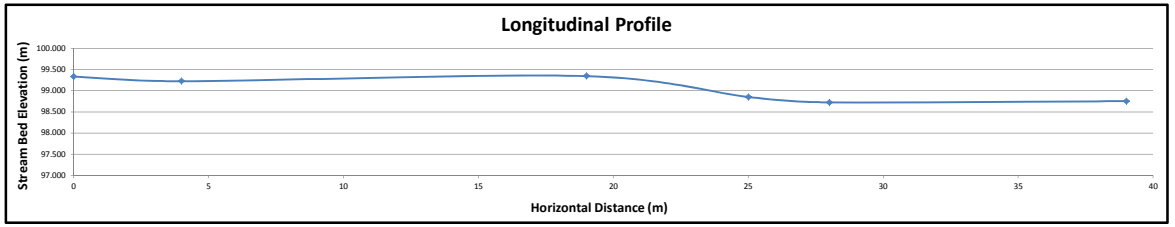
Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	100.812
Datum elevation (m):	100.000



Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	15.0	1.590	99.222	Riffle	
	19.0	1.479	99.333	Riffle	
At Cross-section	0.0		99.343	Riffle	
Downstream	6.0	1.963	98.849	Run	
	9.0	2.089	98.723	Run	
	20.0	2.060	98.752	Run	



General Notes:

-Large boulders throughout channel

Slope Data:	
Horizontal Distance Surveyed:	39.0
Change in Channel Elevation:	0.610
Average Channel Slope (%):	1.564

Field Personnel:	CJ, DH	Trip Date:	23-Sep-14
Data Entry Personnel:	CJ	Date:	7-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 123.7 (Grainger River)

UTM Location: 478319 E, 6799043 N

Visit Date: September 23, 2014

Visit Time: 17:10

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
LB Upper Floodplain	0.00	1.527			100.000
LB High Water Mark (On Step)	0.70		1.572		99.955
LB Step Bottom	0.90		1.911		99.616
1	1.80		2.292		99.235
LB WL edge	2.60		2.449		99.078
Channel bed #1	3.30		2.605		98.922
WL #1	3.30			0.139	99.061
Channel bed #2	3.80		2.654		98.873
WL #2	3.80			0.200	99.073
Channel bed #3	4.40		2.601		98.926
WL #3	4.40			0.140	99.066
Channel bed #4	5.10		2.707		98.820
WL #4	5.10			0.210	99.030
Channel bed #5	5.70		2.552		98.975
WL #5	5.70			0.060	99.035
Channel bed #6	6.00		2.703		98.824
WL #6	6.00			0.190	99.014
Channel bed #7	6.70		2.758		98.769
WL #7	6.70			0.270	99.039
Channel bed #8	7.10		2.681		98.846
WL #8	7.10			0.190	99.036
Channel bed #9	8.00		2.589		98.938
WL #9	8.00			0.090	99.028
RB WL edge (Gravel bar edge)	8.70		2.510		99.017
Gravel bar	10.00		2.348		99.179
Gravel bar	11.00		2.187		99.340
Gravel bar	12.50		2.306		99.221
Dry Side Channel	13.40		2.716		98.811
Dry Side Channel	14.20		2.816		98.711
Dry Side Channel	15.20		2.768		98.759
Dry Side Channel	15.80		2.611		98.916
RB High Water Mark	16.00		2.437		99.090
2	16.50		2.087		99.440
RB Upper Floodplain	17.00		1.944		99.583

Channel Slope Survey Data

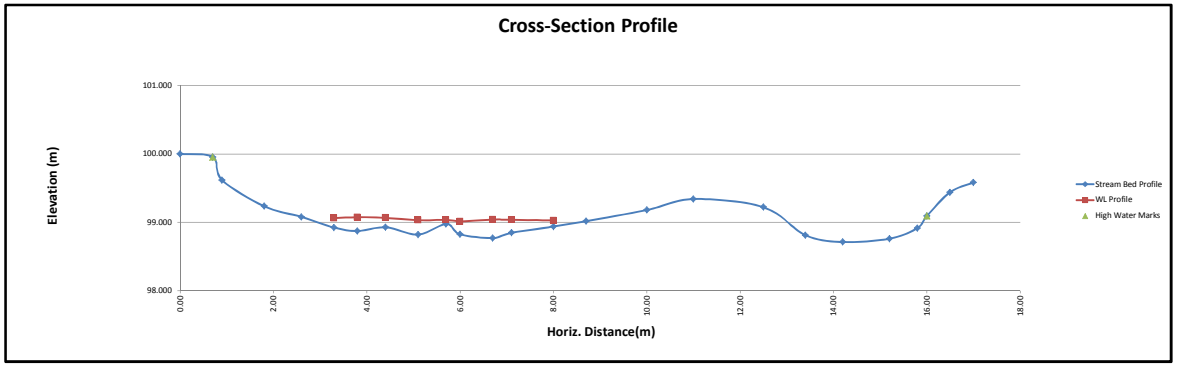
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	16.0	2.522	99.005	Run	
	34.0	2.500	99.027	Run	
At Cross-section	0.0		99.014	Riffle	
Downstream	19.0	3.052	98.475	Riffle	
	40.0	3.755	97.772	Run	

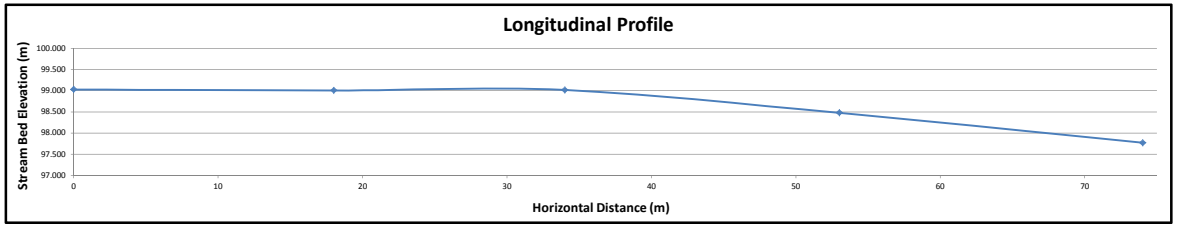
Slope Data:

Horizontal Distance Surveyed:	74.0
Change in Channel Elevation:	1.255
Average Channel Slope (%):	1.696

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.527
Datum elevation (m):	100.000





General Notes:

-A gravel bar followed by a dry side channel are present on the right side of the active channel.

Field Personnel:	CJ, DH	Trip Date:	23-Sep-14
Data Entry Personnel:	CJ	Date:	7-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 125.1 (Grainger River)

UTM Location: 479156 E, 6799517 N

Visit Date: September 23, 2014

Visit Time: 18:30

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
LB Upper Floodplain	0.00	1.144			**100.000**
1	0.65		1.088		100.056
LB High Water Mark	1.60		1.724		99.420
2	2.40		2.085		99.059
LB WL edge	5.10		2.467		98.677
Channel bed #1	6.30		2.600		98.544
WL#1	6.30			0.120	98.664
Channel bed #2	6.50		2.608		98.336
WL#2	6.50			0.200	98.536
Channel bed #3	6.70		2.608		98.286
WL#3	6.70			0.250	98.536
Channel bed #4	6.90		2.608		98.266
WL#4	6.90			0.270	98.536
Channel bed #5	7.10		2.608		98.286
WL#5	7.10			0.250	98.536
Channel bed #6	7.30		2.608		98.256
WL#6	7.30			0.280	98.536
Channel bed #7	7.50		2.608		98.296
WL#7	7.50			0.240	98.536
Channel bed #8	7.70		2.608		98.286
WL#8	7.70			0.250	98.536
Channel bed #9	7.90		2.608		98.346
WL#9	7.90			0.190	98.536
Channel bed #10	8.10		2.608		98.356
WL#10	8.10			0.180	98.536
Channel bed #11	8.45		2.608		98.476
WL#11	8.45			0.060	98.536
Channel bed #12	8.60		2.608		98.426
WL #12	8.60			0.110	98.536
Channel bed #13	10.00		2.508		98.636
WL #13	10.00			0.020	98.656
RB WL edge	11.20		2.461		98.683
3	12.50		2.437		98.707
RB High Water Mark	13.70		2.086		99.058
RB bedrock face	14.50		1.520		99.624

Channel Slope Survey Data

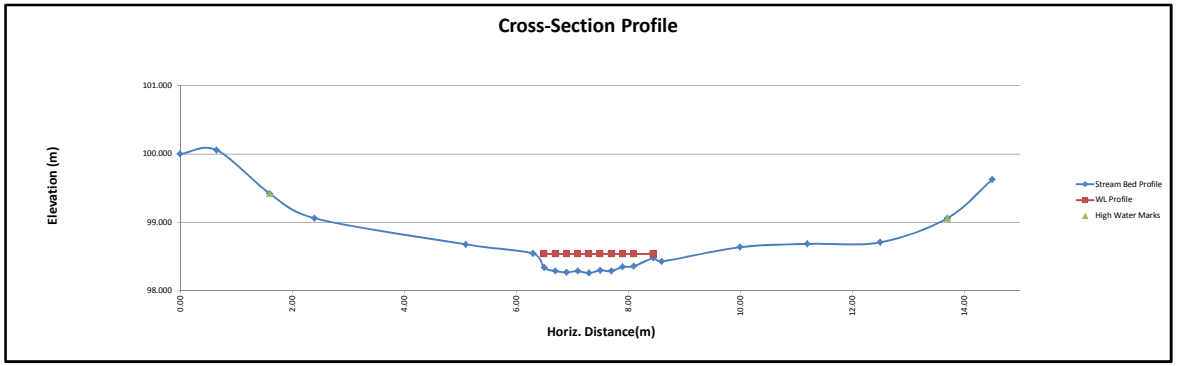
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	24.0	2.508	98.636	Run	
	33.0	2.545	98.599	Run	
At Cross-section	0.0		98.256	Run	
Downstream	18.0	2.722	98.422	Riffle	
	33.0	3.068	98.076	Riffle	

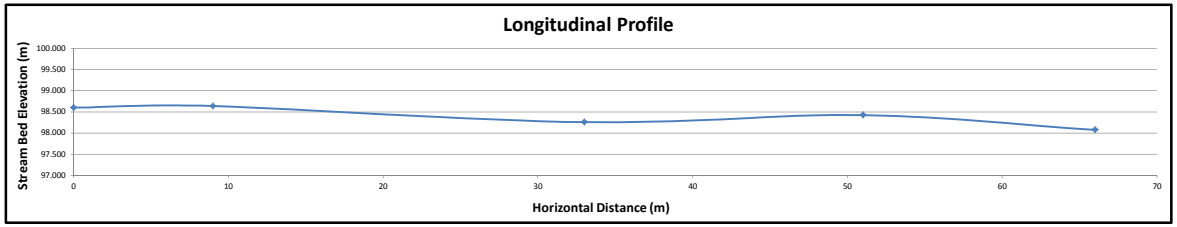
Slope Data:

Horizontal Distance Surveyed:	66.0
Change in Channel Elevation:	0.560
Average Channel Slope (%):	0.848

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.144
Datum elevation (m):	100.000





General Notes:

-Gravel bars and dry side channel (LB) are downstream of surveyed cross section

Field Personnel:	CJ, DH	Trip Date:	23-Sep-14
Data Entry Personnel:	CJ	Date:	7-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 131.3 (Grainger Tributary)

UTM Location: 481988 E, 6794966 N

Visit Date: September 26, 2014

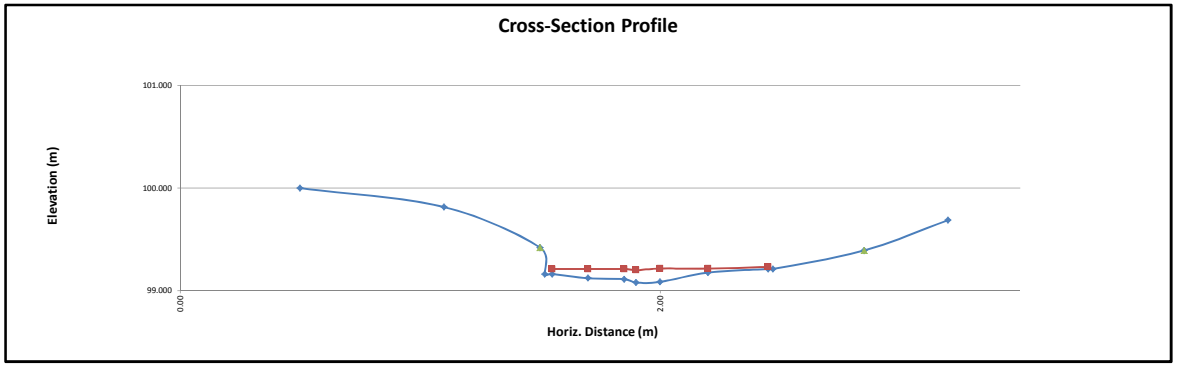
Visit Time: 12:10

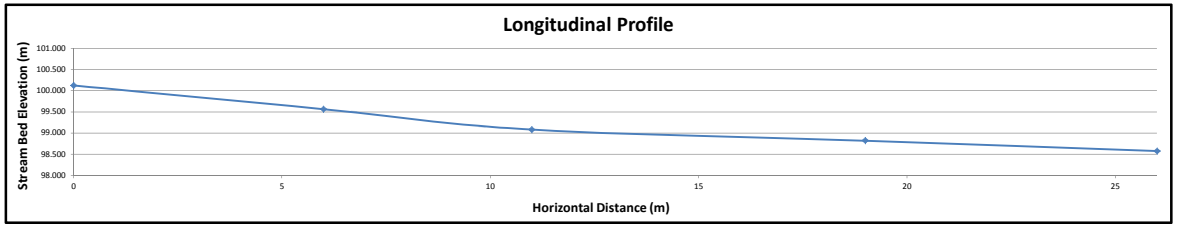
Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of LB	0.50	1.518			100.000
1	1.10		1.702		99.816
LB High Water Mark	1.50		2.099		99.419
LB WL edge	1.52		2.357		99.161
Channel bed #1	1.55		2.357		99.161
WL #1	1.55			0.050	99.211
Channel bed #2	1.70		2.357		99.121
WL #2	1.70			0.090	99.211
Channel bed #3	1.85		2.357		99.111
WL #3	1.85			0.100	99.211
Channel bed #4	1.90		2.439		99.079
WL #4	1.90			0.120	99.199
Channel bed #5	2.00		2.433		99.085
WL #5	2.00			0.130	99.215
Channel bed #6	2.20		2.433		99.175
WL #6	2.20			0.040	99.215
Channel bed #7	2.45		2.308		99.210
WL #7	2.45			0.020	99.230
RB WL edge	2.47		2.308		99.210
RB High Water Mark	2.85		2.127		99.391
Top of RB	3.20		1.831		99.687

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.518
Datum elevation (m):	100.000





Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	5.0	1.955	99.563	Riffle	
	11.0	1.395	100.123	Riffle	
At Cross-section	0.0		99.079	Riffle	
Downstream	8.0	2.699	98.819	Riffle	
	15.0	2.943	98.575	Riffle	

General Notes:

-Lots of embedded cobble and boulders throughout the channel.

Slope Data:

Horizontal Distance Surveyed:	26.0
Change in Channel Elevation:	1.548
Average Channel Slope (%):	5.954

Field Personnel:	CJ, DH	Trip Date:	26-Sep-14
Data Entry Personnel:	CJ	Date:	8-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name:	KP 133.7 (Grainger Tributary)	**Visit Date:**	September 24, 2014
UTM Location:	482671 E, 6793161 N	**Visit Time:**	9:00

Cross-Section/Bank Survey Data

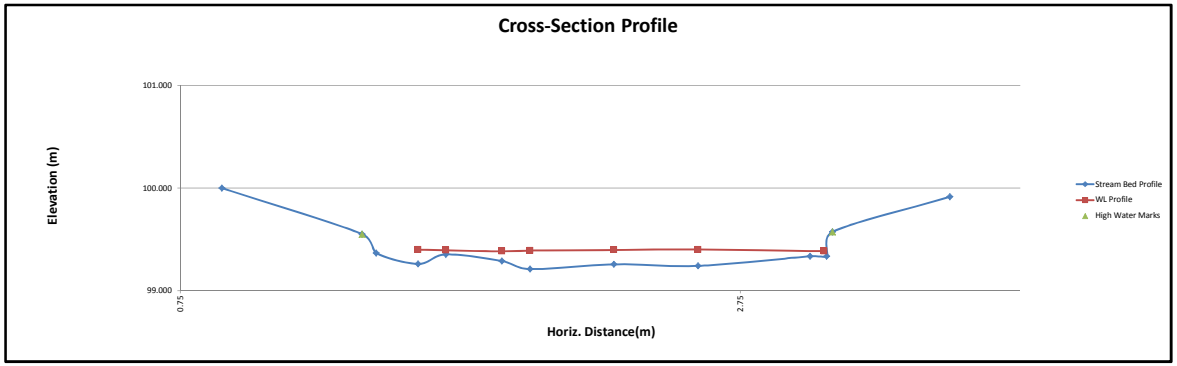
Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of RB	0.90	1.224			**100.000**
RB High Water Mark	1.40		1.673		99.551
RB WL edge	1.45		1.858		99.366
Channel bed #1	1.60		1.964		99.260
WL #1	1.60			0.140	99.400
Channel bed #2	1.70		1.871		99.353
WL #2	1.70			0.040	99.393
Channel bed #3	1.90		1.936		99.288
WL #3	1.90			0.095	99.383
Channel bed #4	2.00		2.014		99.210
WL #4	2.00			0.180	99.390
Channel bed #5	2.30		1.968		99.256
WL #5	2.30			0.140	99.396
Channel bed #6	2.60		1.983		99.241
WL #6	2.60			0.160	99.401
Channel bed #7	3.00		1.889		99.335
WL #7	3.05			0.050	99.385
LB WL edge	3.06		1.889		99.335
LB High Water Mark	3.08		1.651		99.573
Top of LB	3.50		1.308		99.916

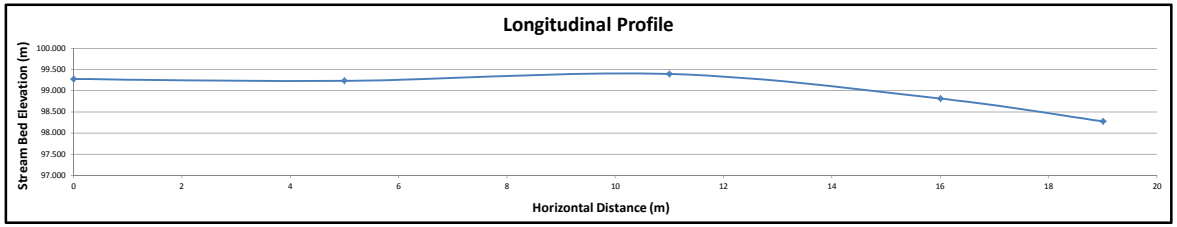
Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	6.0	1.993	99.231	Riffle	
	11.0	1.951	99.273	Riffle	
At Cross-section	0.0		99.393	Riffle	
Downstream	5.0	2.412	98.812	Riffle	
	8.0	2.947	98.277	Riffle	

Slope Data:	
Horizontal Distance Surveyed:	19.0
Change in Channel Elevation:	0.996
Average Channel Slope (%):	5.242

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.224
Datum elevation (m):	100.000





General Notes:

Field Personnel:	CJ, DH	Trip Date:	24-Sep-14
Data Entry Personnel:	CJ	Date:	7-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 135.6 (Grainger Tributary)

UTM Location: 482380 E, 6791274 N

Visit Date: September 25, 2014

Visit Time: 18:45

Cross-Section/Bank Survey Data

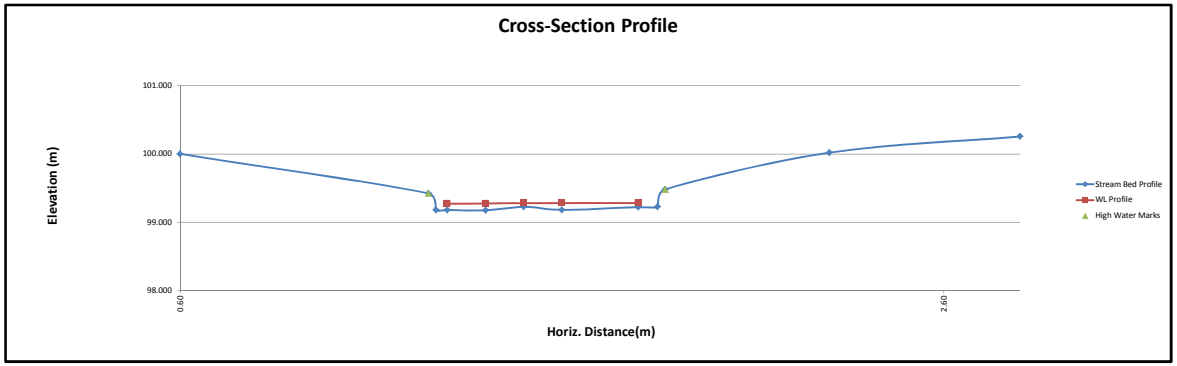
Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of LB	0.60	1.819			**100.000**
LB High Water Mark	1.25		2.395		99.424
LB WL edge	1.27		2.640		99.179
Channel bed #1	1.30		2.640		99.179
WL #1	1.30			0.095	99.274
Channel bed #2	1.40		2.640		99.174
WL #2	1.40			0.100	99.274
Channel bed #3	1.50		2.592		99.227
WL #3	1.50			0.055	99.282
Channel bed #4	1.60		2.592		99.182
WL #4	1.60			0.100	99.282
Channel bed #5	1.80		2.592		99.222
WL #5	1.80			0.060	99.282
RB WL edge	1.85		2.592		99.227
RB High Water Mark	1.87		2.338		99.481
1	2.30		1.800		100.019
Top of RB	2.80		1.563		100.256

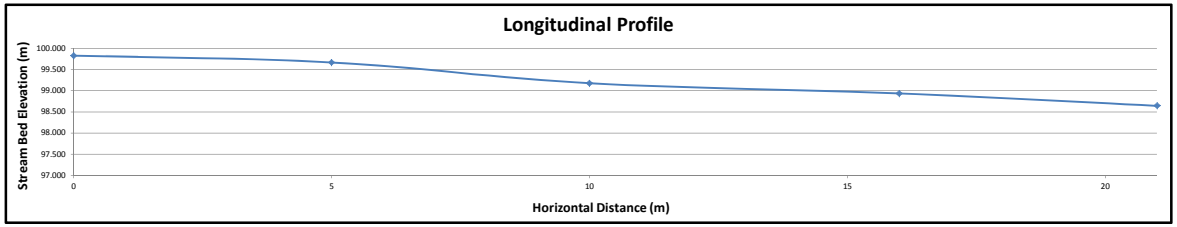
Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	5.0	2.154	99.665	Riffle	
	10.0	1.995	99.824	Riffle	
At Cross-section	0.0		99.174	Run	
Downstream	6.0	2.885	98.934	Run	
	11.0	3.176	98.643	Riffle	

Slope Data:	
Horizontal Distance Surveyed:	21.0
Change in Channel Elevation:	1.181
Average Channel Slope (%):	5.624

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.819
Datum elevation (m):	100.000





General Notes:

-Large cobble and boulders throughout stream

Field Personnel:	CJ, DH	Trip Date:	25-Sep-14
Data Entry Personnel:	CJ	Date:	8-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 136.7 (Grainger Tributary)

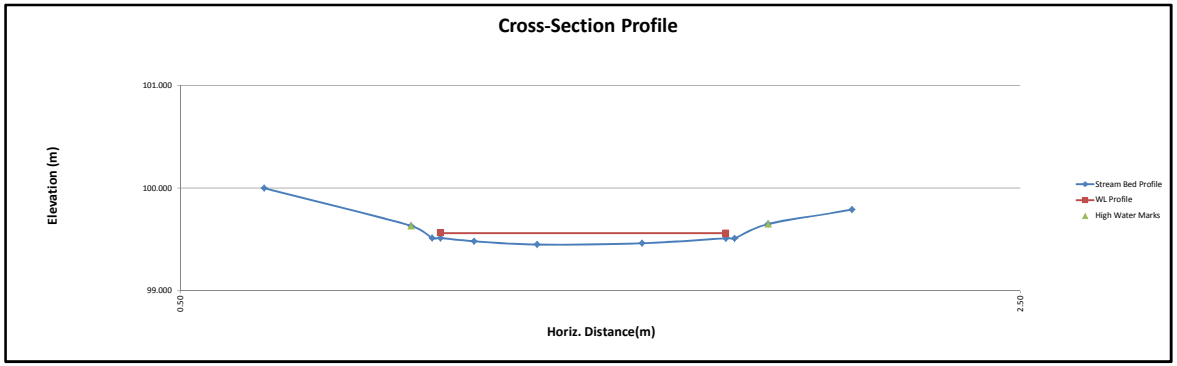
UTM Location: 483132 E, 6790094 N

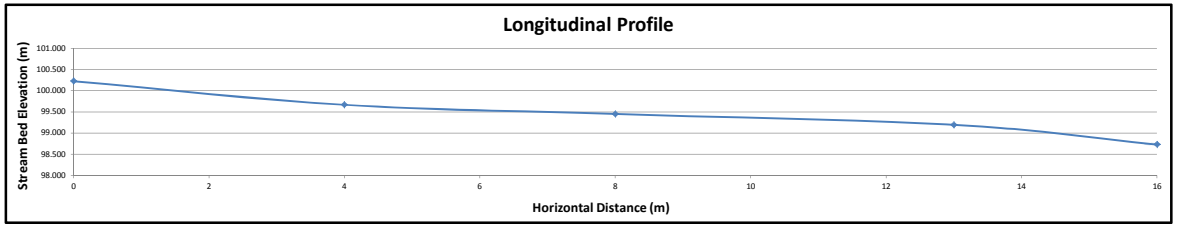
Visit Date: September 26, 2014

Visit Time: 11:00

Cross-Section/Bank Survey Data					
Mmt #:	**Offset**	**BS (m):**	**FS (m):**	**Cut (m):**	**Elevation (m):**
Top of LB	0.70	1.34			**100.000**
LB High Water Mark	1.05		1.708		99.632
LB WL edge	1.10		1.828		99.512
Channel bed #1	1.12		1.828		99.512
WL #1	1.12			0.050	99.562
Channel bed #2	1.20		1.828		99.482
WL #2	1.20			0.080	99.562
Channel bed #3	1.35		1.891		99.449
WL #3	1.35			0.015	99.464
Channel bed #4	1.60		1.878		99.462
WL #4	1.60			0.100	99.562
Channel bed #5	1.80		1.830		99.510
WL #5	1.80			0.050	99.560
RB WL edge	1.82		1.830		99.510
RB High Water Mark	1.90		1.691		99.649
Top of RB	2.10		1.550		99.790

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.340
Datum elevation (m):	100.000





Channel Slope Survey Data					
Measured Data			**Calculated Data**	**Channel Reach Notes**	
Direction from Cross-section	**Distance from Cross-section**	**Survey Reading**	**Elevation (m)**	**Morphology**	**Substrate**
Upstream	4.0	1.675	99.665	Riffle	
	8.0	1.118	100.222	Riffle	
At Cross-section	**0.0**		99.449	Riffle	
Downstream	5.0	2.146	99.194	Riffle	
	8.0	2.610	98.730	Riffle	

Slope Data:	
Horizontal Distance Surveyed:	16.0
Change in Channel Elevation:	1.492
Average Channel Slope (%):	9.325

General Notes:

-Large boulders throughout stream.

-A debris dam was present several meters downstream of the cross section

Field Personnel:	**CJ, DH**	**Trip Date:**	**26-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: KP 154.4 (Liard Tributary)

UTM Location: 486500 E, 6774900 N

Visit Date: September 23, 2014

Visit Time: 13:40

Cross-Section/Bank Survey Data

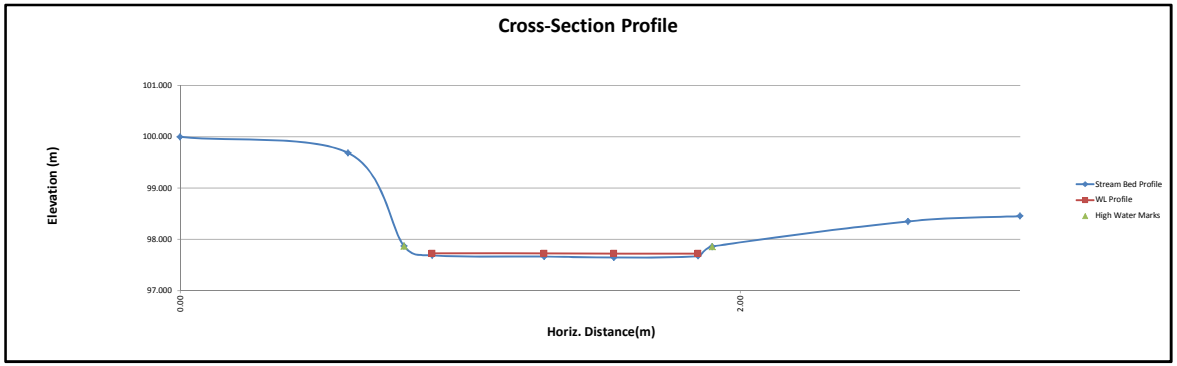
Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
RB Historical High Water Mark	0.00	1.565			100.000
1	0.60		1.878		99.687
RB High Water Mark	0.80		2.134		97.866
Channel bed #1	0.90		2.315		97.685
WL #1	0.90			0.040	97.725
Channel bed #2	1.30		2.335		97.665
WL #2	1.30			0.060	97.725
Channel bed #3	1.55		2.356		97.644
WL #3	1.55			0.080	97.724
Channel bed #4	1.85		2.326		97.674
WL #4	1.85			0.050	97.724
LB High Water Mark	1.90		2.142		97.858
2	2.60		1.650		98.350
LB Historical High Water Mark	3.00		1.547		98.453

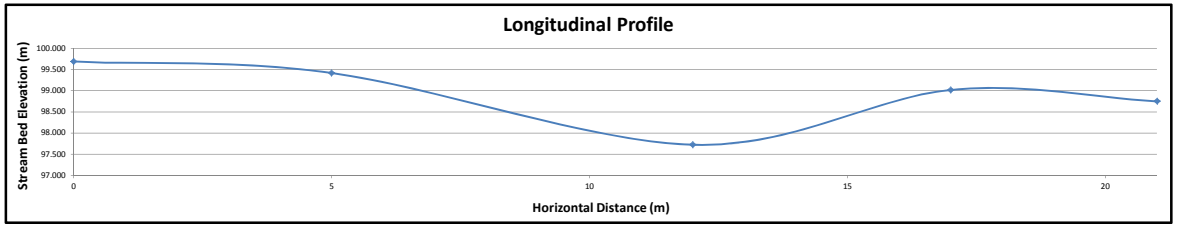
Channel Slope Survey Data

Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	7.0	2.148	99.417	Run	
	12.0	1.879	99.686	Run	
At Cross-section	0.0		97.725	Run	
Downstream	5.0	2.549	99.016	Run	
	9.0	2.817	98.748	Run	

Slope Data:	
Horizontal Distance Surveyed:	21.0
Change in Channel Elevation:	0.938
Average Channel Slope (%):	4.467

Survey Information:	
Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.565
Datum elevation (m):	100.000





General Notes:

-Discharge measurement not conducted due to extremely low water depths. One velocity measurement taken in mid-channel: 0.053 m/s.

Field Personnel:	CJ, DH	Trip Date:	23-Sep-14
Data Entry Personnel:	CJ	Date:	6-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: Old Road at Tetcela River (Mainstem)

UTM Location: 461370 E, 6815670 N

Visit Date: September 24, 2014

Visit Time: 17:15

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of RB	0.60	0.806			100.000
1	2.20		1.183		99.623
RB High Water Mark	2.90		1.515		99.291
RB WL edge	7.80		2.140		98.666
Channel bed #1	9.20		2.248		98.608
WL #1	9.20			0.050	98.658
Channel bed #2	10.70		2.248		98.598
WL #2	10.70			0.060	98.658
Channel bed #3	11.70		2.248		98.558
WL #3	11.70			0.100	98.658
Channel bed #4	13.60		2.292		98.514
WL #4	13.60			0.150	98.664
Channel bed #5	14.60		2.292		98.544
WL #5	14.60			0.120	98.664
Channel bed #6	15.90		2.292		98.524
WL #6	15.90			0.140	98.664
Channel bed #7	17.40		2.339		98.467
WL #7	17.40			0.200	98.667
Channel bed #8	17.90		2.339		98.497
WL #8	17.90			0.170	98.667
Channel bed #9	18.90		2.339		98.467
WL #9	18.90			0.200	98.667
Channel bed #10	19.90		2.339		98.447
WL #10	19.90			0.220	98.667
Channel bed #11	20.90		2.374		98.482
WL #11	20.90			0.210	98.692
Channel bed #12	21.90		2.374		98.432
WL #12	21.90			0.260	98.692
LB WL edge	23.10		2.127		98.679
LB High Water Mark	24.30		1.789		99.017
2	25.40		1.342		99.464
Top of LB	26.00		1.259		99.547

Channel Slope Survey Data

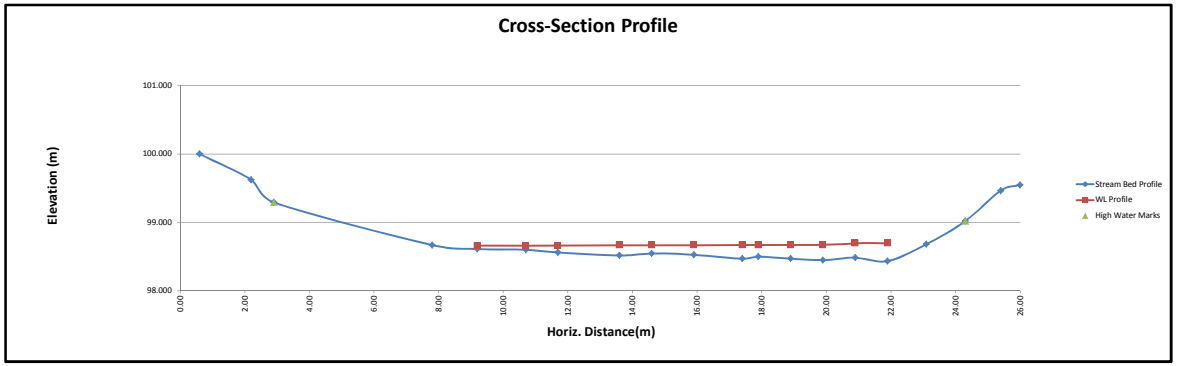
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	19.0	2.432	98.374	Run	
	31.0	2.424	98.382	Run	
At Cross-section	0.0		98.447	Run	
Downstream	16.0	2.339	98.467	Run	
	31.0	2.555	98.251	Riffle	

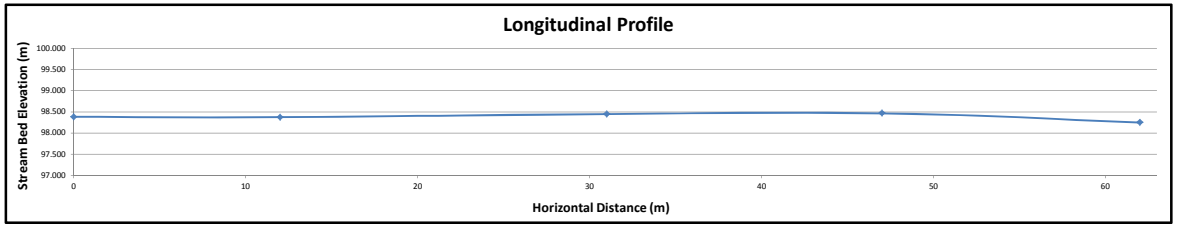
Slope Data:

Horizontal Distance Surveyed:	62.0
Change in Channel Elevation:	0.131
Average Channel Slope (%):	0.211

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	100.806
Datum elevation (m):	100.000





General Notes:

Field Personnel:	CJ, DH	**Trip Date:**	24-Sep-14
Data Entry Personnel:	CJ	**Date:**	8-Oct-14
Data Check Personnel:	TL	**Date:**	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Station Stream Cross-Section/Reach Survey Field Record

Site Name: Old Road at Tetcela Tributary

UTM Location: 460369 E, 6813941 N

Visit Date: September 24, 2014

Visit Time: 8-Oct-14

Cross-Section/Bank Survey Data

Mmt #:	Offset	BS (m):	FS (m):	Cut (m):	Elevation (m):
Top of LB	0.00	1.178			100.000
1	0.30		1.425		99.753
LB High Water Mark	0.50		1.879		99.299
LB (main channel) WL edge	1.10		2.249		98.929
Channel bed #1	1.70		2.525		98.833
WL #1	1.70			0.090	98.923
Channel bed #2	2.10		2.525		98.843
WL #2	2.10			0.080	98.923
Channel bed #3	2.50		2.525		98.653
WL #3	2.50			0.270	98.923
Channel bed #4	2.95		2.525		98.703
WL #4	2.95			0.220	98.923
Channel bed #5	3.60		2.615		98.563
WL #5	3.60			0.360	98.923
Channel bed #6	3.80		2.615		98.533
WL #6	3.80			0.390	98.923
Channel bed #7	4.30		2.615		98.533
WL #7	4.30			0.390	98.923
Channel bed #8	4.85		2.615		98.683
WL #8	4.85			0.240	98.923
Channel bed #9	5.40		2.615		98.763
WL #9	5.40			0.160	98.923
RB (main channel) WL edge	6.00		2.249		98.929
Gravel bar	7.40		2.010		99.168
Gravel bar	10.40		1.877		99.301
Gravel bar	11.60		1.525		99.653
Gravel bar	13.00		1.499		99.679
Gravel bar	13.60		1.838		99.340
LB (of bar) WL edge	14.30		1.952		99.226
Side channel bed #1	15.30		2.046		99.132
Side channel WL #1	15.30			0.090	99.222
Side channel bed #2	15.90		2.133		99.045
Side channel WL #2	15.90			0.170	99.215
RB (of bar) WL edge	16.60		2.028		99.150
RB High Water Mark	16.75		1.585		99.593
2	16.85		1.395		99.783
Top of RB	17.20		1.295		99.883

Channel Slope Survey Data

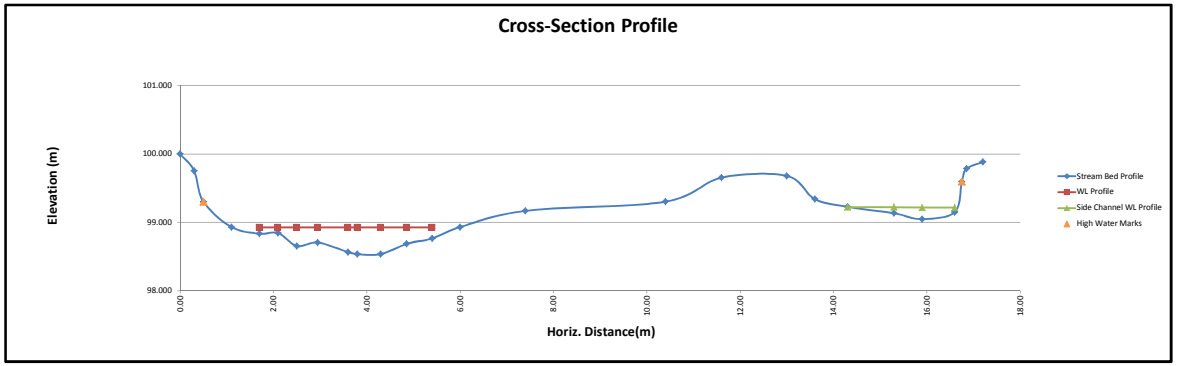
Measured Data			Calculated Data	Channel Reach Notes	
Direction from Cross-section	Distance from Cross-section	Survey Reading	Elevation (m)	Morphology	Substrate
Upstream	17.0	2.227	98.951	Riffle	
	25.0	1.665	99.513	Riffle	
At Cross-section	0.0		98.533	Riffle	
Downstream	14.0	2.471	98.707	Run	
	32.0	2.690	98.488	Run	

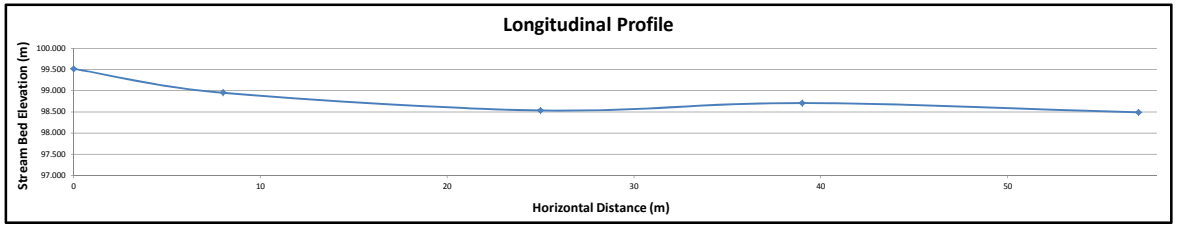
Slope Data:

Horizontal Distance Surveyed:	57.0
Change in Channel Elevation:	1.025
Average Channel Slope (%):	1.798

Survey Information:

Equipment Used:	Engineer's Level & Stadia Rod
Height of Instrument (HI) (m):	101.178
Datum elevation (m):	100.000





General Notes:

-Upstream of the crossing, two channels converge at the end of a large gravel bar, which is followed by a sizeable riffle.
-At the stream crossing, flows are slightly diverged into a main channel and small side channel by another gravel bar. There is very little flow in the side channel.

Field Personnel:	CJ, DH	Trip Date:	24-Sep-14
Data Entry Personnel:	CJ	Date:	8-Oct-14
Data Check Personnel:	TL	Date:	30-Oct-14
Entered Digitally in the Field:	No		

Attachment F

Hydrometric Measurement/Site Visit Record

Hydrometric Measurement / Site Visit Record

Site: KP 27.1 (Sundog Creek)
UTM Location: 418911 E, 6828332 N

Site Visit Date: September 22, 2014
Site Visit Time (MST): 16:30

Hatfield CONSULTANTS

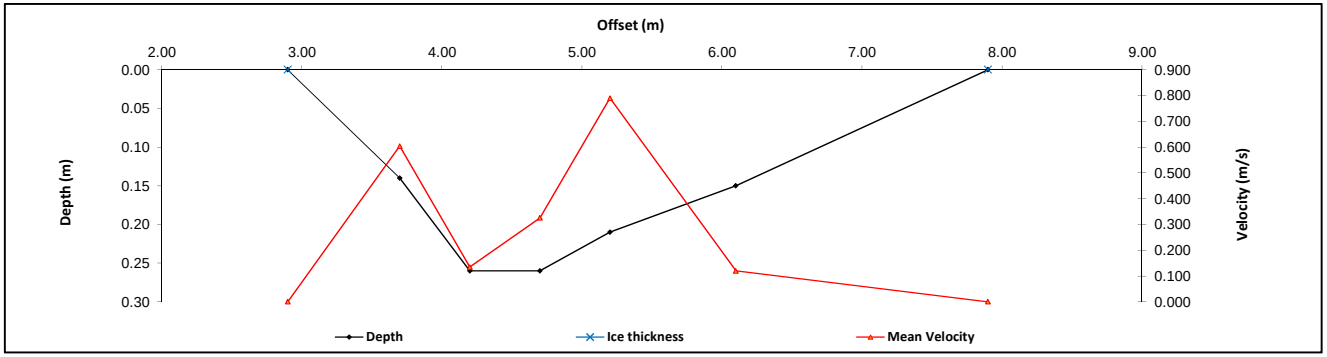
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	2.90	0.00	0.00		0.000		0.000		0.000	1.00	0.40	0.00	0.000	0.00	0.000	
1	3.70	0.14		0.08	0.604					1.00	0.65	0.14	0.604	0.09	0.055	22%
2	4.20	0.26		0.16	0.135					1.00	0.50	0.26	0.135	0.13	0.018	7%
3	4.70	0.26		0.16	0.325					1.00	0.50	0.26	0.325	0.13	0.042	17%
4	5.20	0.21		0.13	0.790					1.00	0.70	0.21	0.790	0.15	0.116	46%
5	6.10	0.15		0.09	0.120					1.00	1.35	0.15	0.120	0.20	0.024	10%
LB	7.90	0.00	0.00		0.00		0.00		0.00	1.00	0.90	0.00	0.000	0.00	0.000	
													Total Flow		**0.255**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	16:45
Meas. End Time (MST):	16:55
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Sunny, windy, 15 C



Flow characteristics:

Total Flow:	**0.255**	**(m^3/s)**
Cross Section Area:	**0.70**	**(m^2)**
Wetted Width:	**5.00**	**(m)**
Hydraulic Depth:	**0.14**	**(m)**
Mean Velocity:	**0.36**	**(m/s)**
Froude Number:	**0.31**	

General Notes:

-Lots of boulders in the channel making flow measurement difficult - lots of eddy effects.
-less than 20 measurements collected due to the rough channel morphology

Field Personnel:	CJ, DH	Trip Date:	22-Sep-14
Data Entry Personnel:	CJ	Date:	6-Oct-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Measurement / Site Visit Record

Site: KP 47.0 (Polje Creek Tributary)
UTM Location: 434240 E, 6829338 N

Site Visit Date: September 21, 2014
Site Visit Time (MST): 14:15

Hatfield CONSULTANTS

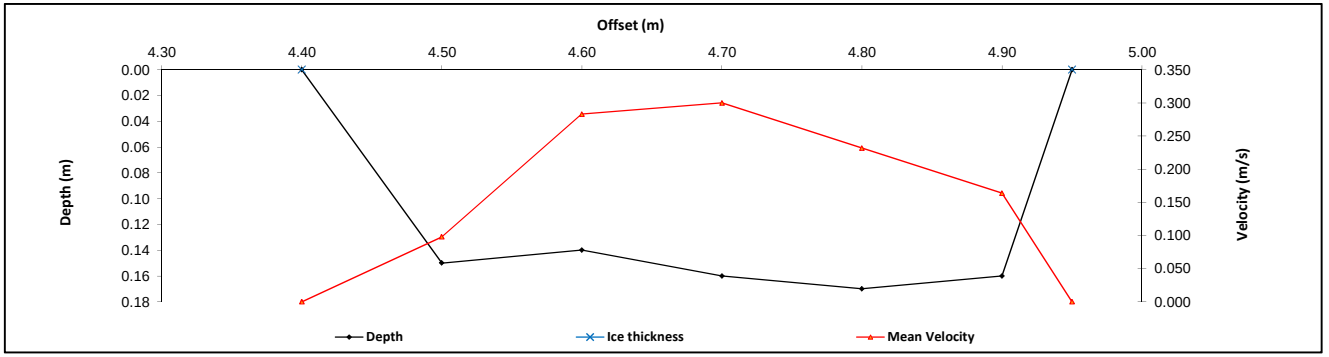
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	4.40	0.00	0.00		0.000		0.000		0.000	1.00	0.05	0.00	0.000	0.00	0.000	
1	4.50	0.15		0.09	0.098					1.00	0.10	0.15	0.098	0.01	0.001	9%
2	4.60	0.14		0.08	0.283					1.00	0.10	0.14	0.283	0.01	0.004	25%
3	4.70	0.16		0.10	0.300					1.00	0.10	0.16	0.300	0.02	0.005	30%
4	4.80	0.17		0.10	0.232					1.00	0.10	0.17	0.232	0.02	0.004	24%
5	4.90	0.16		0.10	0.164					1.00	0.08	0.16	0.164	0.01	0.002	12%
LB	4.95	0.00	0.00		0.00		0.00		0.00	1.00	0.02	0.00	0.000	0.00	0.000	
													Total Flow		**0.016**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	14:30
Meas. End Time (MST):	14:40
Equipment:	ADV
Method:	Wading
River Condition:	low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Partial cloud, calm, 15



Flow characteristics:

Total Flow:	**0.016**	**(m^3/s)**
Cross Section Area:	**0.07**	**(m^2)**
Wetted Width:	**0.55**	**(m)**
Hydraulic Depth:	**0.13**	**(m)**
Mean Velocity:	**0.22**	**(m/s)**
Froude Number:	**0.19**	

General Notes:

-Not able to collect further velocity measurements due to very low water depths and presence of large cobble and boulders obstructing flow.

Field Personnel:	**CJ, DH**	**Trip Date:**	**21-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**30-Sep-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 50.2 (Polje Tributary)
UTM Location: 436944 E, 6829737 N

Site Visit Date: September 21, 2014
Site Visit Time (MST): 09:50

Hatfield CONSULTANTS

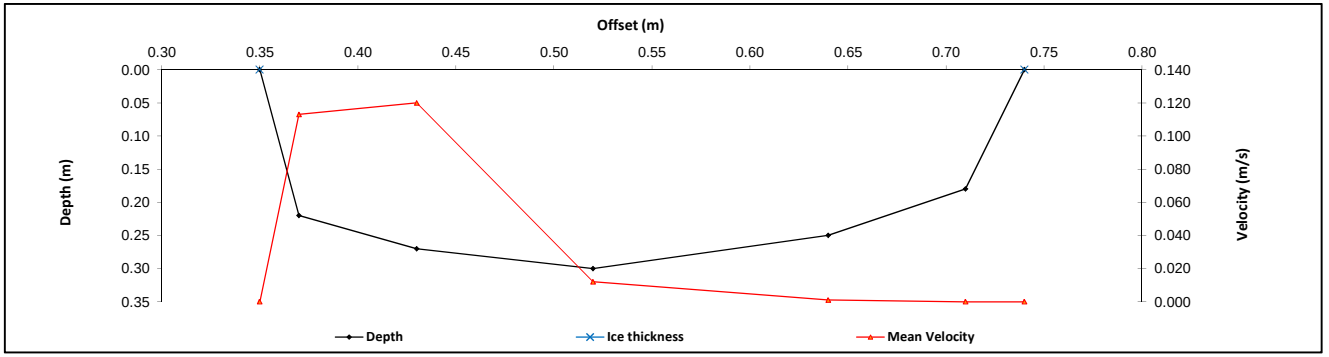
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	0.35	0.00	0.00		0.000		0.000		0.000	1.00	0.01	0.00	0.000	0.00	0.000	
1	0.37	0.22		0.13	0.113					1.00	0.04	0.22	0.113	0.01	0.001	26%
2	0.43	0.27		0.16	0.120					1.00	0.08	0.27	0.120	0.02	0.002	63%
3	0.52	0.30		0.18	0.012					1.00	0.11	0.30	0.012	0.03	0.000	10%
4	0.64	0.25		0.15	0.001					1.00	0.10	0.25	0.001	0.02	0.000	1%
5	0.71	0.18		0.11	0.000					1.00	0.05	0.18	0.000	0.01	0.000	0%
LB	0.74	0.00	0.00		0.00		0.00		0.00	1.00	0.02	0.00	0.000	0.00	0.000	
													Total Flow		**0.004**	**100%**

Flow Measurement Details:

Metering Section Location *(describe):*
At centre of road crossing

Meas. Start Time (MST):	10:20
Meas. End Time (MST):	10:30
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Overcast, calm, 10



Flow characteristics:

Total Flow:	**0.004**	**(m^3/s)**
Cross Section Area:	**0.09**	**(m^2)**
Wetted Width:	**0.39**	**(m)**
Hydraulic Depth:	**0.24**	**(m)**
Mean Velocity:	**0.04**	**(m/s)**
Froude Number:	**0.03**	

General Notes:

-Not able to collect further velocity measurements due to low water depths and presence of large cobble and boulders obstructing flow

Field Personnel:	CJ, DH	Trip Date:	21-Sep-14
Data Entry Personnel:	CJ	Date:	30-Sep-14
Data Check Personnel:	TL	Date:	29-Oct-14
Entered Digitally in the Field:	No		

Hydrometric Measurement / Site Visit Record

Site: KP 54.3 (Polje Creek Tributary)
UTM Location: 440622 E, 6830769 N

Site Visit Date: September 21, 2014
Site Visit Time (MST): 15:45

Hatfield CONSULTANTS

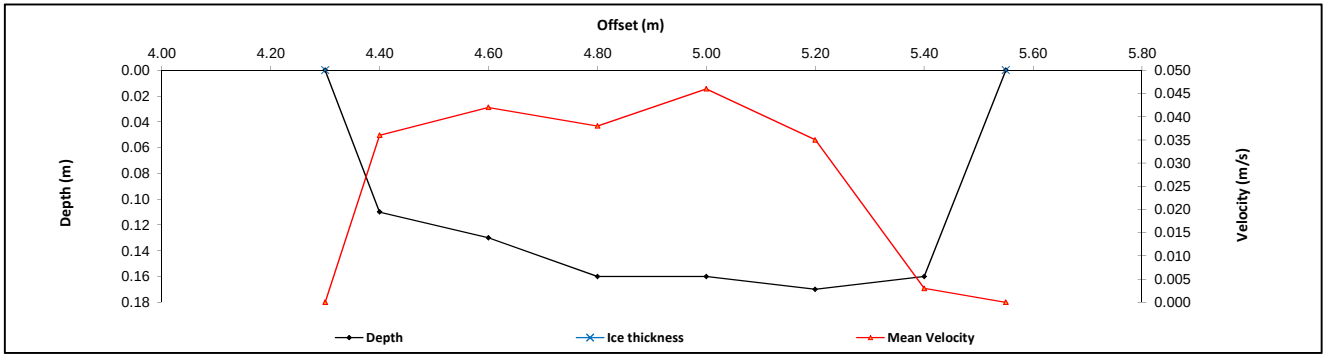
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	4.30	0.00	0.00		0.000		0.000		0.000	1.00	0.05	0.00	0.000	0.00	0.000	
1	4.40	0.11		0.07	0.036					1.00	0.15	0.11	0.036	0.02	0.001	11%
2	4.60	0.13		0.08	0.042					1.00	0.20	0.13	0.042	0.03	0.001	19%
3	4.80	0.16		0.10	0.038					1.00	0.20	0.16	0.038	0.03	0.001	22%
4	5.00	0.16		0.10	0.046					1.00	0.20	0.16	0.046	0.03	0.001	26%
5	5.20	0.17		0.10	0.035					1.00	0.20	0.17	0.035	0.03	0.001	21%
6	5.40	0.16		0.10	0.003					1.00	0.17	0.16	0.003	0.03	0.000	1%
LB	5.55	0.00	0.00		0.00		0.00		0.00	1.00	0.07	0.00	0.000	0.00	0.000	
													Total Flow		**0.006**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	16:00
Meas. End Time (MST):	16:10
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Overcast, calm, 15



Flow characteristics:

Total Flow:	**0.006**	**(m^3/s)**
Cross Section Area:	**0.17**	**(m^2)**
Wetted Width:	**1.25**	**(m)**
Hydraulic Depth:	**0.13**	**(m)**
Mean Velocity:	**0.03**	**(m/s)**
Froude Number:	**0.03**	

General Notes:

-Not able to collect further velocity measurements due to low water depths and presence of large boulders and cobble obstructing flow.

Field Personnel:	**CJ, DH**	**Trip Date:**	**21-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**30-Sep-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 87.7 (Tetcela River)
UTM Location: 460241 E, 6812386 N

Site Visit Date: September 24, 2014
Site Visit Time (MST): 14:00

Hatfield CONSULTANTS

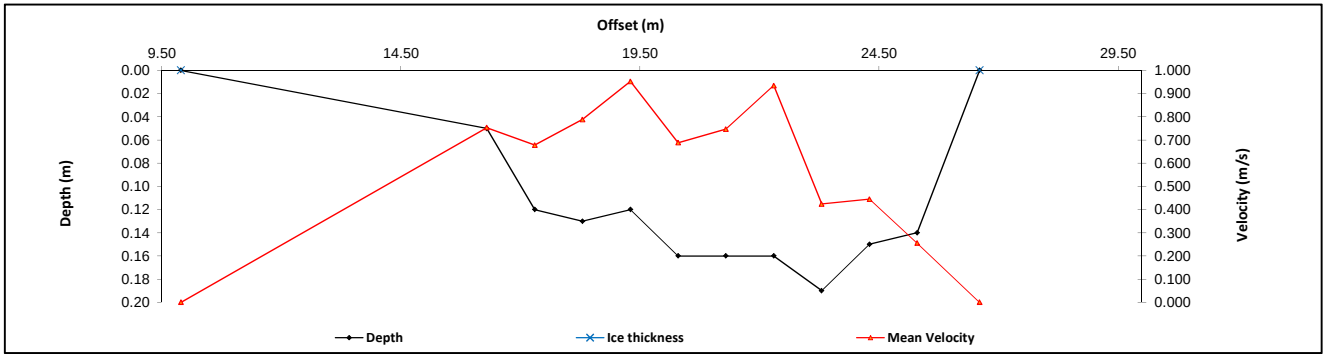
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	9.90	0.00	0.00		0.000		0.000		0.000	1.00	3.20	0.00	0.000	0.00	0.000	
1	16.30	0.05		0.03	0.753					1.00	3.70	0.05	0.753	0.19	0.139	14%
2	17.30	0.12		0.07	0.678					1.00	1.00	0.12	0.678	0.12	0.081	8%
3	18.30	0.13		0.08	0.788					1.00	1.00	0.13	0.788	0.13	0.102	10%
4	19.30	0.12		0.07	0.952					1.00	1.00	0.12	0.952	0.12	0.114	11%
5	20.30	0.16		0.10	0.688					1.00	1.00	0.16	0.688	0.16	0.110	11%
6	21.30	0.16		0.10	0.747					1.00	1.00	0.16	0.747	0.16	0.120	12%
7	22.30	0.16		0.10	0.934					1.00	1.00	0.16	0.934	0.16	0.149	15%
8	23.30	0.19		0.11	0.424					1.00	1.00	0.19	0.424	0.19	0.081	8%
9	24.30	0.15		0.09	0.445					1.00	1.00	0.15	0.445	0.15	0.067	7%
10	25.30	0.14		0.08	0.255					1.00	1.15	0.14	0.255	0.16	0.041	4%
LB	26.60	0.00	0.00		0.00		0.00		0.00	1.00	0.65	0.00	0.000	0.00	0.000	
													Total Flow		**1**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	14:15
Meas. End Time (MST):	14:25
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 8 C



Flow characteristics:

Total Flow:	**1.000**	**(m^3/s)**
Cross Section Area:	**1.54**	**(m^2)**
Wetted Width:	**16.70**	**(m)**
Hydraulic Depth:	**0.09**	**(m)**
Mean Velocity:	**0.65**	**(m/s)**
Froude Number:	**0.69**	

General Notes:

Field Personnel:	**CJ, DH**	**Trip Date:**	**24-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**7-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**30-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 122.8 (Grainger Tributary)
UTM Location: 477151 E, 6798715 N

Site Visit Date: September 23, 2014
Site Visit Time (MST): 15:20

Hatfield CONSULTANTS

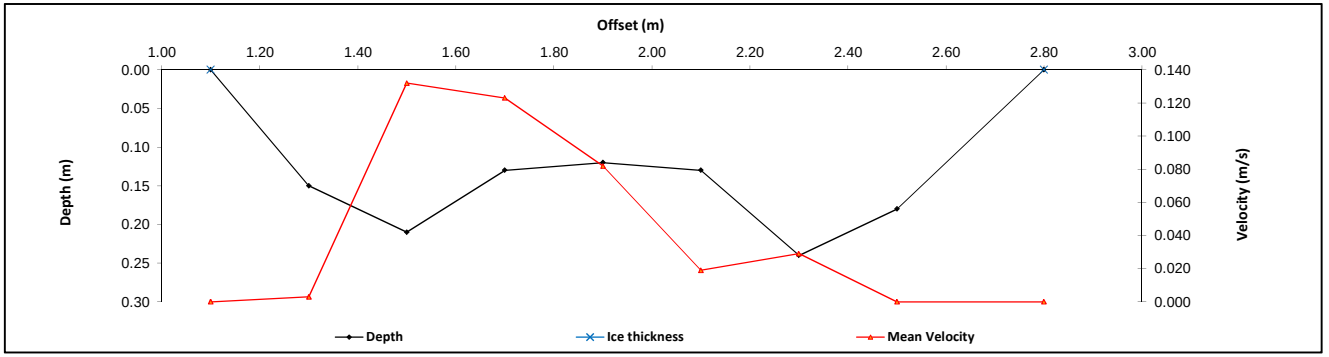
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	1.10	0.00	0.00		0.000		0.000		0.000	1.00	0.10	0.00	0.000	0.00	0.000	
1	1.30	0.15		0.09	0.003					1.00	0.20	0.15	0.003	0.03	0.000	1%
2	1.50	0.21		0.13	0.132					1.00	0.20	0.21	0.132	0.04	0.006	44%
3	1.70	0.13		0.08	0.123					1.00	0.20	0.13	0.123	0.03	0.003	25%
4	1.90	0.12		0.07	0.082					1.00	0.20	0.12	0.082	0.02	0.002	15%
5	2.10	0.13		0.08	0.019					1.00	0.20	0.13	0.019	0.03	0.000	4%
6	2.30	0.24		0.14	0.029					1.00	0.20	0.24	0.029	0.05	0.001	11%
7	2.50	0.18		0.11	0.000					1.00	0.25	0.18	0.000	0.05	0.000	0%
RB	2.80	0.00	0.00		0.00		0.00		0.00	1.00	0.15	0.00	0.000	0.00	0.000	
													Total Flow		**0.0127**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	15:40
Meas. End Time (MST):	15:50
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Straight Edge (e.g. bridge/pier)
Weather:	Partial cloud, calm, 10 C



Flow characteristics:

Total Flow:	**0.013**	**(m^3/s)**
Cross Section Area:	**0.24**	**(m^2)**
Wetted Width:	**1.70**	**(m)**
Hydraulic Depth:	**0.14**	**(m)**
Mean Velocity:	**0.05**	**(m/s)**
Froude Number:	**0.04**	

General Notes:

-Large boulders throughout channel obstructing the flow, not able to collect further velocity measurements

Field Personnel:	**CJ, DH**	**Trip Date:**	**23-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**7-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 123.7 (Grainger River)
UTM Location: 478319 E, 6799043 N

Site Visit Date: September 23, 2014
Site Visit Time (MST): 17:10

Hatfield CONSULTANTS

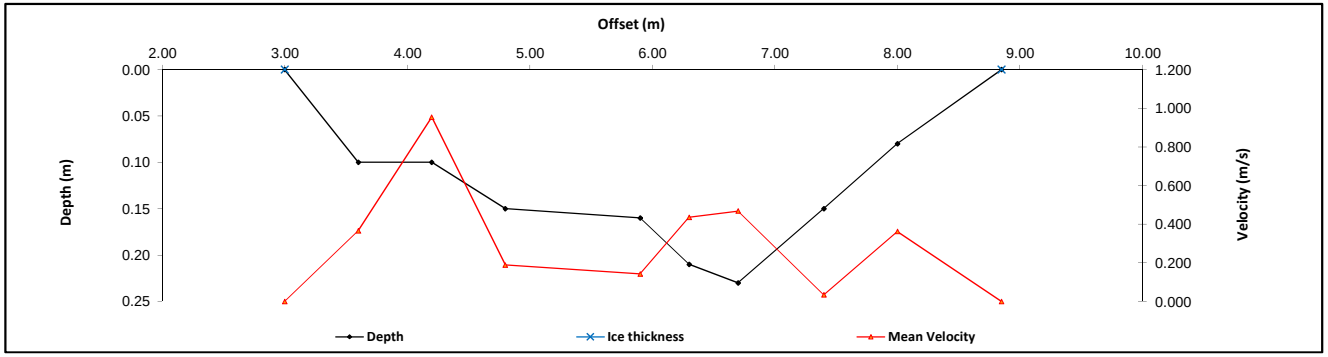
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	3.00	0.00	0.00		0.000		0.000		0.000	1.00	0.30	0.00	0.000	0.00	0.000	
1	3.60	0.10		0.06	0.366					1.00	0.60	0.10	0.366	0.06	0.022	9%
2	4.20	0.10		0.06	0.954					1.00	0.60	0.10	0.954	0.06	0.057	24%
3	4.80	0.15		0.09	0.189					1.00	0.85	0.15	0.189	0.13	0.024	10%
4	5.90	0.16		0.10	0.142					1.00	0.75	0.16	0.142	0.12	0.017	7%
5	6.30	0.21		0.13	0.436					1.00	0.40	0.21	0.436	0.08	0.037	15%
6	6.70	0.23		0.14	0.468					1.00	0.55	0.23	0.468	0.13	0.059	25%
7	7.40	0.15		0.09	0.034					1.00	0.65	0.15	0.034	0.10	0.003	1%
8	8.00	0.08		0.05	0.362					1.00	0.73	0.08	0.362	0.06	0.021	9%
RB	8.85	0.00	0.00		0.00		0.00		0.00	1.00	0.43	0.00	0.000	0.00	0.000	
													Total Flow		**0.24**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	17:30
Meas. End Time (MST):	17:40
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Partial cloud, windy, 12 C



Flow characteristics:

Total Flow:	**0.240**	**(m^3/s)**
Cross Section Area:	**0.73**	**(m^2)**
Wetted Width:	**5.85**	**(m)**
Hydraulic Depth:	**0.13**	**(m)**
Mean Velocity:	**0.33**	**(m/s)**
Froude Number:	**0.30**	

General Notes:

Field Personnel:	**CJ, DH**	**Trip Date:**	**23-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**7-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 125.1 (Grainger River)
UTM Location: 479156 E, 6799517 N

Site Visit Date: September 23, 2014
Site Visit Time (MST): 18:30

Hatfield CONSULTANTS

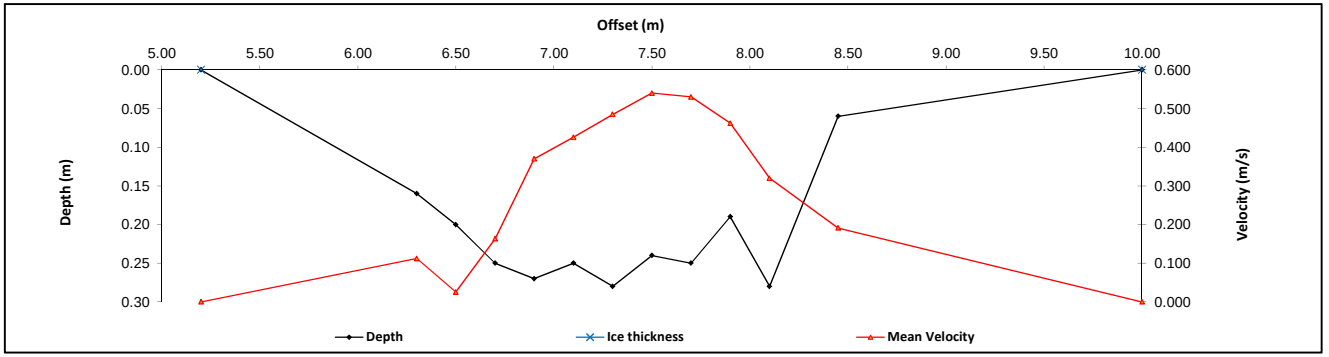
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	5.20	0.00	0.00		0.000		0.000		0.000	1.00	0.55	0.00	0.000	0.00	0.000	
1	6.30	0.16		0.10	0.112					1.00	0.65	0.16	0.112	0.10	0.012	6%
2	6.50	0.20		0.12	0.025					1.00	0.20	0.20	0.025	0.04	0.001	1%
3	6.70	0.25		0.15	0.163					1.00	0.20	0.25	0.163	0.05	0.008	4%
4	6.90	0.27		0.16	0.370					1.00	0.20	0.27	0.370	0.05	0.020	10%
5	7.10	0.25		0.15	0.426					1.00	0.20	0.25	0.426	0.05	0.021	11%
6	7.30	0.28		0.17	0.485					1.00	0.20	0.28	0.485	0.06	0.027	14%
7	7.50	0.24		0.14	0.540					1.00	0.20	0.24	0.540	0.05	0.026	13%
8	7.70	0.25		0.15	0.530					1.00	0.20	0.25	0.530	0.05	0.027	14%
9	7.90	0.19		0.11	0.462					1.00	0.20	0.19	0.462	0.04	0.018	9%
10	8.10	0.28		0.17	0.320					1.00	0.27	0.28	0.320	0.08	0.025	13%
11	8.45	0.06		0.04	0.191					1.00	0.95	0.06	0.191	0.06	0.011	6%
RB	10.00	0.00	0.00		0.00		0.00		0.00	1.00	0.78	0.00	0.000	0.00	0.000	
													Total Flow		**0.195**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
-Approx. 20m upstream of crossing (above gravel bar)

Meas. Start Time (MST):	18:45
Meas. End Time (MST):	18:55
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Clear, breezy, 10 C



Flow characteristics:

Total Flow:	**0.195**	**(m^3/s)**
Cross Section Area:	**0.62**	**(m^2)**
Wetted Width:	**4.80**	**(m)**
Hydraulic Depth:	**0.13**	**(m)**
Mean Velocity:	**0.31**	**(m/s)**
Froude Number:	**0.28**	

General Notes:

- Several gravel bars and a dry side channel are located downstream of measurement cross section.

Field Personnel:	**CJ, DH**	**Trip Date:**	**23-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**7-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 131.3 (Grainger Tributary)
UTM Location: 481988 E, 6794966 N

Site Visit Date: September 26, 2014
Site Visit Time (MST): 12:10

Hatfield CONSULTANTS

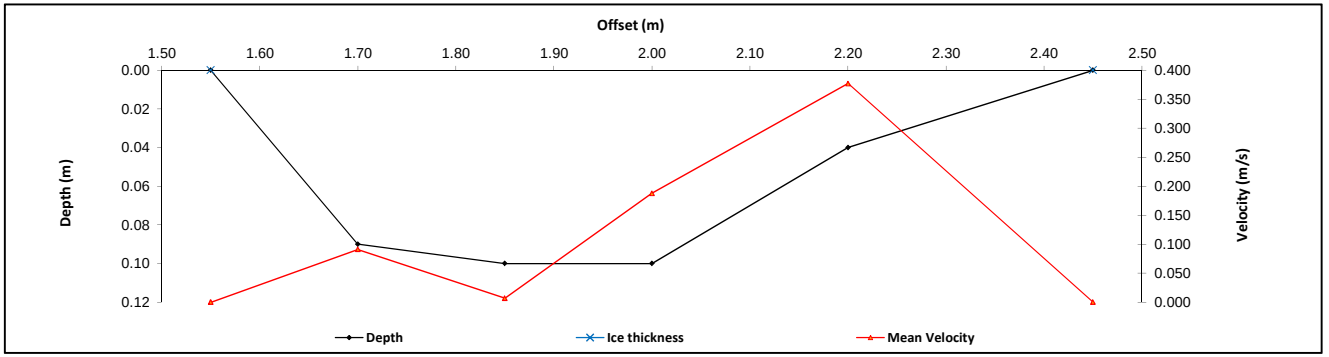
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	1.55	0.00	0.00		0.000		0.000		0.000	1.00	0.08	0.00	0.000	0.00	0.000	
1	1.70	0.09		0.05	0.091					1.00	0.15	0.09	0.091	0.01	0.001	15%
2	1.85	0.10		0.06	0.007					1.00	0.15	0.10	0.007	0.02	0.000	1%
3	2.00	0.10		0.06	0.188					1.00	0.18	0.10	0.188	0.02	0.003	41%
4	2.20	0.04		0.02	0.377					1.00	0.23	0.04	0.377	0.01	0.003	42%
RB	2.45	0.00	0.00		0.00		0.00		0.00	1.00	0.13	0.00	0.000	0.00	0.000	
													Total Flow		**0.00802**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	12:20
Meas. End Time (MST):	12:30
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, light breeze, 5 C



Flow characteristics:

Total Flow:	**0.008**	**(m^3/s)**
Cross Section Area:	**0.06**	**(m^2)**
Wetted Width:	**0.90**	**(m)**
Hydraulic Depth:	**0.06**	**(m)**
Mean Velocity:	**0.15**	**(m/s)**
Froude Number:	**0.19**	

General Notes:

-Lots of embedded cobble and boulders throughout the channel.

Field Personnel:	**CJ, DH**	**Trip Date:**	**26-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**30-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 133.7 (Grainger Tributary)
UTM Location: 482671 E, 6793161 N

Site Visit Date: September 24, 2014
Site Visit Time (MST): 09:00

Hatfield CONSULTANTS

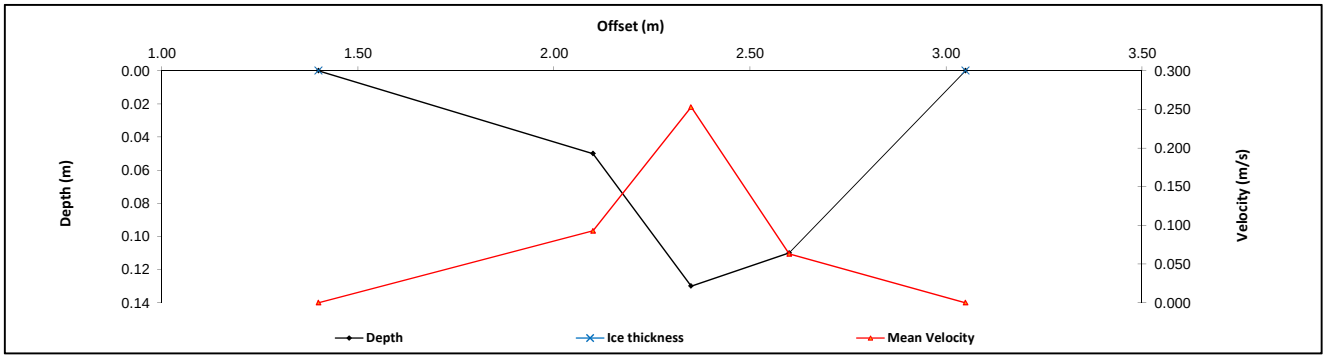
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	1.40	0.00	0.00		0.000		0.000		0.000	1.00	0.35	0.00	0.000	0.00	0.000	
1	2.10	0.05		0.03	0.093					1.00	0.48	0.05	0.093	0.02	0.002	17%
2	2.35	0.13		0.08	0.253					1.00	0.25	0.13	0.253	0.03	0.008	64%
3	2.60	0.11		0.07	0.063					1.00	0.35	0.11	0.063	0.04	0.002	19%
LB	3.05	0.00	0.00		0.00		0.00		0.00	1.00	0.23	0.00	0.000	0.00	0.000	
													Total Flow		**0.013**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	9:20
Meas. End Time (MST):	9:30
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 8 C



Flow characteristics:

Total Flow:	**0.013**	**(m^3/s)**
Cross Section Area:	**0.09**	**(m^2)**
Wetted Width:	**1.65**	**(m)**
Hydraulic Depth:	**0.06**	**(m)**
Mean Velocity:	**0.14**	**(m/s)**
Froude Number:	**0.18**	

General Notes:

-Not able to collect further velocity measurements due to very low water depths and the presence of large boulders and cobble obstructing flow.

Field Personnel:	**CJ, DH**	**Trip Date:**	**24-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**7-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 135.6 (Grainger Tributary)
UTM Location: 482380 E, 6791274 N

Site Visit Date: September 25, 2014
Site Visit Time (MST): 18:45

Hatfield CONSULTANTS

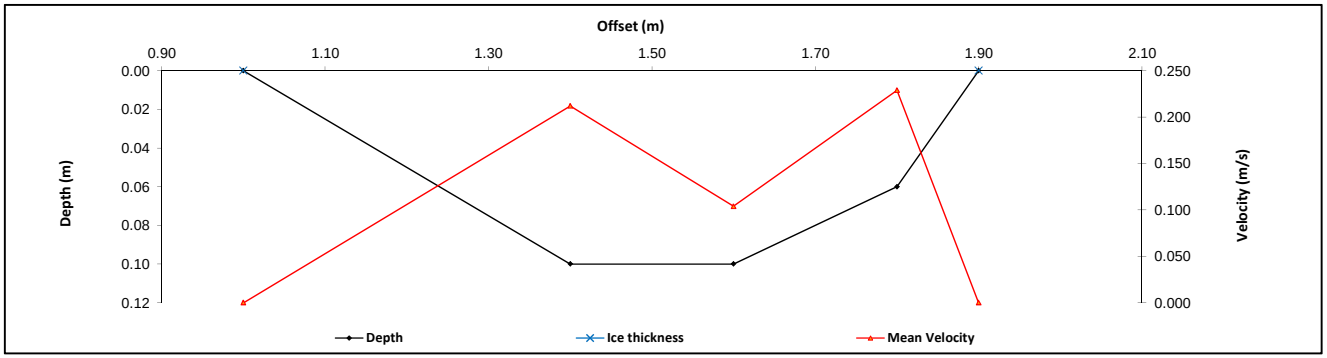
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	1.00	0.00	0.00		0.000		0.000		0.000	1.00	0.20	0.00	0.000	0.00	0.000	
1	1.40	0.10		0.06	0.212					1.00	0.30	0.10	0.212	0.03	0.006	61%
2	1.60	0.10		0.06	0.104					1.00	0.20	0.10	0.104	0.02	0.002	20%
3	1.80	0.06		0.04	0.229					1.00	0.15	0.06	0.229	0.01	0.002	20%
RB	1.90	0.00	0.00		0.00		0.00		0.00	1.00	0.05	0.00	0.000	0.00	0.000	
													Total Flow		**0.0105**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	19:00
Meas. End Time (MST):	19:10
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 5 C



Flow characteristics:

Total Flow:	**0.011**	**(m^3/s)**
Cross Section Area:	**0.06**	**(m^2)**
Wetted Width:	**0.90**	**(m)**
Hydraulic Depth:	**0.07**	**(m)**
Mean Velocity:	**0.18**	**(m/s)**
Froude Number:	**0.22**	

General Notes:

-Not able to collect further velocity measurements due to very low water depths and the presence of large boulders and cobble obstructing flow.

Field Personnel:	**CJ, DH**	**Trip Date:**	**25-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: KP 136.7 (Grainger Tributary)
UTM Location: 483132 E, 6790094 N

Site Visit Date: September 26, 2014
Site Visit Time (MST): 11:00

Hatfield CONSULTANTS

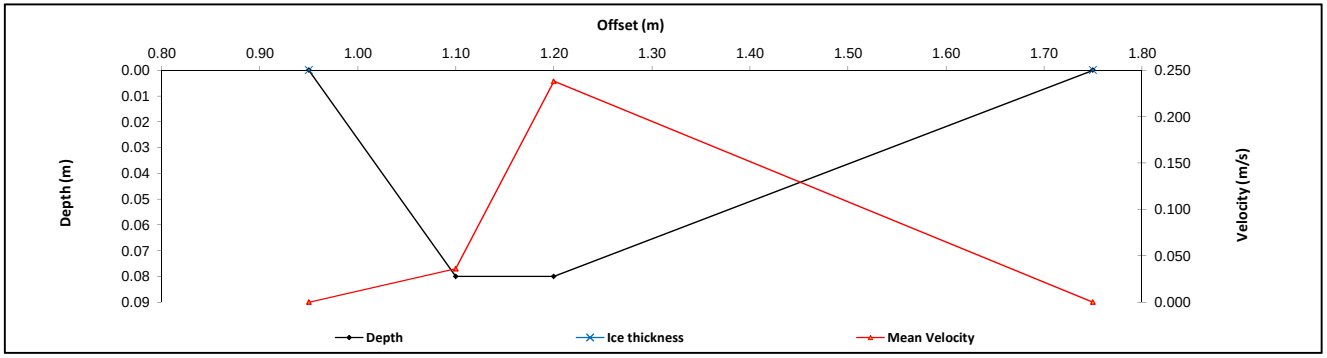
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	0.95	0.00	0.00		0.000		0.000		0.000	1.00	0.08	0.00	0.000	0.00	0.000	
1	1.10	0.08		0.05	0.036					1.00	0.13	0.08	0.036	0.01	0.000	5%
2	1.20	0.08		0.05	0.238					1.00	0.33	0.08	0.238	0.03	0.006	94%
LB	1.75	0.00	0.00		0.00		0.00		0.00	1.00	0.28	0.00	0.000	0.00	0.000	
													Total Flow		**0.007**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	11:15
Meas. End Time (MST):	11:20
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 5 C



Flow characteristics:

Total Flow:	**0.007**	**(m^3/s)**
Cross Section Area:	**0.04**	**(m^2)**
Wetted Width:	**0.80**	**(m)**
Hydraulic Depth:	**0.05**	**(m)**
Mean Velocity:	**0.18**	**(m/s)**
Froude Number:	**0.27**	

General Notes:

-Not able to collect further velocity measurements due to very low water depths and presence of large cobble and boulders obstructing flow

Field Personnel:	**CJ, DH**	**Trip Date:**	**26-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: Old Road at Tetcela River (Mainstem)
UTM Location: 461370 E, 6815670 N

Site Visit Date: September 24, 2014
Site Visit Time (MST): 17:15

Hatfield CONSULTANTS

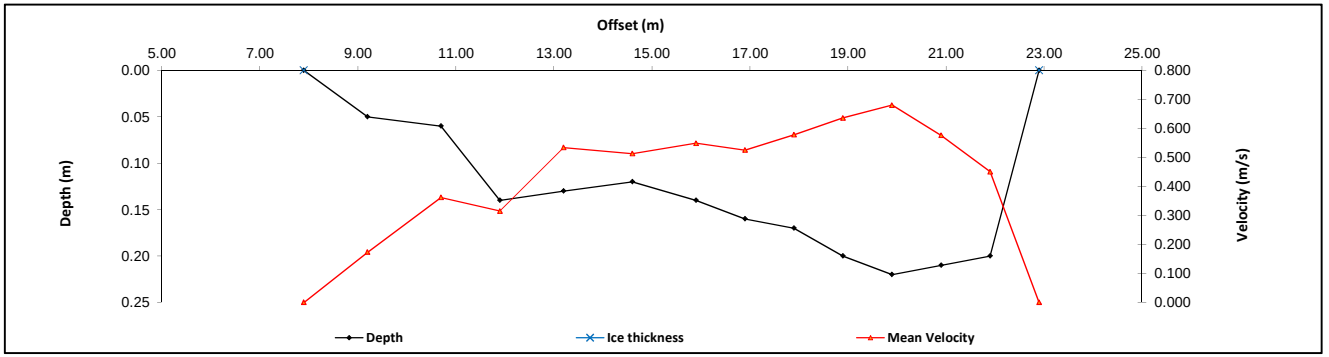
Flow Measurement:

		Measured Data								Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
RB	7.90	0.00	0.00		0.000		0.000		0.000	1.00	0.65	0.00	0.000	0.00	0.000	
1	9.20	0.05		0.03	0.173					1.00	1.40	0.05	0.173	0.07	0.012	1%
2	10.70	0.06		0.04	0.362					1.00	1.35	0.06	0.362	0.08	0.029	3%
3	11.90	0.14		0.08	0.315					1.00	1.25	0.14	0.315	0.18	0.055	5%
4	13.20	0.13		0.08	0.534					1.00	1.35	0.13	0.534	0.18	0.094	9%
5	14.60	0.12		0.07	0.513					1.00	1.35	0.12	0.513	0.16	0.083	8%
6	15.90	0.14		0.08	0.549					1.00	1.15	0.14	0.549	0.16	0.088	9%
7	16.90	0.16		0.10	0.525					1.00	1.00	0.16	0.525	0.16	0.084	8%
8	17.90	0.17		0.10	0.578					1.00	1.00	0.17	0.578	0.17	0.098	10%
9	18.90	0.20		0.12	0.636					1.00	1.00	0.20	0.636	0.20	0.127	12%
10	19.90	0.22		0.13	0.680					1.00	1.00	0.22	0.680	0.22	0.150	15%
11	20.90	0.21		0.13	0.576					1.00	1.00	0.21	0.576	0.21	0.121	12%
12	21.90	0.20		0.12	0.451					1.00	1.00	0.20	0.451	0.20	0.090	9%
LB	22.90	0.00	0.00		0.00		0.00		0.00	1.00	0.50	0.00	0.000	0.00	0.000	
													Total Flow		**1.03**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	17:25
Meas. End Time (MST):	17:35
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 8 C



Flow characteristics:

Total Flow:	**1.030**	**(m^3/s)**
Cross Section Area:	**1.98**	**(m^2)**
Wetted Width:	**15.00**	**(m)**
Hydraulic Depth:	**0.13**	**(m)**
Mean Velocity:	**0.52**	**(m/s)**
Froude Number:	**0.46**	

General Notes:

Field Personnel:	**CJ, DH**	**Trip Date:**	**24-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**29-Oct-14**
Entered Digitally in the Field:	**No**		

Hydrometric Measurement / Site Visit Record

Site: Old Road at Tetcela Tributary
UTM Location: 460369 E, 6813941 N

Site Visit Date: September 24, 2014
Site Visit Time (MST): 16:30

Hatfield CONSULTANTS

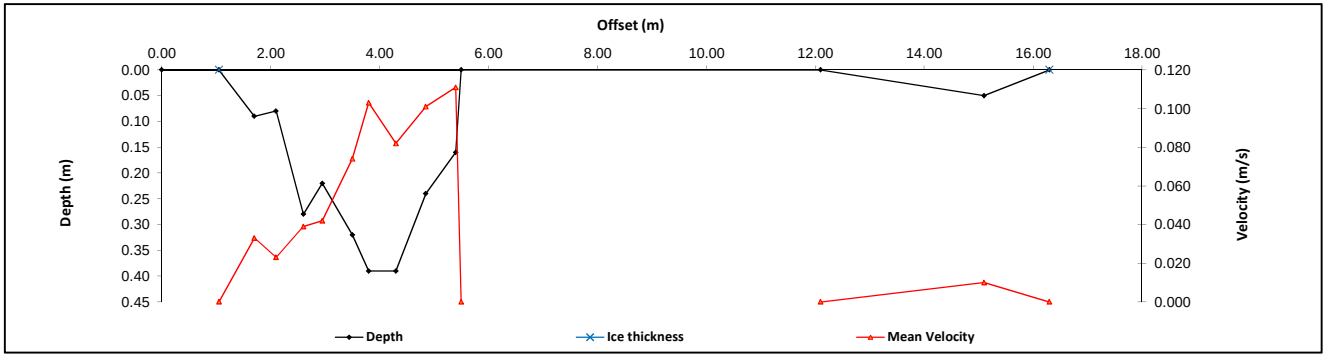
Flow Measurement:

Measured Data										Calculated Data						
Bank/ Mmt #	Offset (m)	Depth from bottom to WS (m)	WS to bottom of ice (m)	Depth of Obs. @ 0.6 Depth (m)	Velocity @ 0.6 Depth (m/s)	Depth of Obs. @ 0.8 Depth (m)	Velocity @ 0.8 Depth (m/s)	Depth of Obs. @ 0.2 Depth (m)	Velocity @ 0.2 Depth (m/s)	Velocity Correction Factor (m)	Pannel Width (m)	Effective Pannel Depth (m)	Effective Average Pannel Velocity (m/s)	Pannel Area (m^2)	Pannel Discharge (m^3/s)	Percent of total flow (%)
LB	1.05	0.00	0.00		0.000		0.000		0.000	1.00	0.33	0.00	0.000	0.00	0.000	
1	1.70	0.09		0.05	0.033					1.00	0.53	0.09	0.033	0.05	0.002	2%
2	2.10	0.08		0.05	0.023					1.00	0.45	0.08	0.023	0.04	0.001	1%
3	2.60	0.28		0.17	0.039					1.00	0.43	0.28	0.039	0.12	0.005	6%
4	2.95	0.22		0.13	0.042					1.00	0.45	0.22	0.042	0.10	0.004	6%
5	3.50	0.32		0.19	0.074					1.00	0.43	0.32	0.074	0.14	0.010	14%
6	3.80	0.39		0.23	0.103					1.00	0.40	0.39	0.103	0.16	0.016	22%
7	4.30	0.39		0.23	0.082					1.00	0.52	0.39	0.082	0.20	0.017	23%
8	4.85	0.24		0.14	0.101					1.00	0.55	0.24	0.101	0.13	0.013	18%
9	5.40	0.16		0.10	0.111					1.00	0.33	0.16	0.111	0.05	0.006	8%
10	5.50	0.00		0.00						1.00	5.45	0.00		0.00		
Bar	0.00	0.00		0.00												
11	12.10	0.00		0.00						1.00	7.55	0.00		0.00		
12	15.10	0.05		0.03	0.010					1.00	2.10	0.05	0.010	0.11	0.001	1%
LB	16.30	0.00	0.00		0.00		0.00		0.00	1.00	0.60	0.00	0.000	0.00	0.000	
													Total Flow		**0.074**	**100%**

Flow Measurement Details:

Metering Section Location *(describe)*:
At stream crossing

Meas. Start Time (MST):	16:50
Meas. End Time (MST):	17:00
Equipment:	ADV
Method:	Wading
River Condition:	Low flow
Channel Edges:	Trapezoidal Edge (e.g. stream)
Weather:	Cloudy, calm, 8 C



Flow characteristics:

Total Flow:	**0.074**	**(m^3/s)**
Cross Section Area:	**1.09**	**(m^2)**
Wetted Width:	**16.30**	**(m)**
Hydraulic Depth:	**0.07**	**(m)**
Mean Velocity:	**0.07**	**(m/s)**
Froude Number:	**0.08**	

General Notes:

-A gravel bar, with a small side channel, are present on the RB

Field Personnel:	**CJ, DH**	**Trip Date:**	**24-Sep-14**
Data Entry Personnel:	**CJ**	**Date:**	**8-Oct-14**
Data Check Personnel:	**TL**	**Date:**	**30-Oct-14**
Entered Digitally in the Field:	**No**		

APPENDIX 10

MEMO

Date: September 9, 2014 HCP Ref No.: CZN6788

From: John Wilcockson

To: David Harpley, Canadian Zinc Corp

Subject: **Habitat Assessment of Sundog Creek Channels for Realignment- DRAFT**

Canadian Zinc Corp (CZN), owner of the Prairie Creek Mine, is proposing to build an all-season road generally along the existing winter-road right of way. Along km 30-40, the road traverses the lower Sundog Creek floodplain. The current winter road alignment is located in the central part of the floodplain, and would result in multiple creek crossings in summer. For the all season road, CZN plans to maintain the alignment on the south edge of the floodplain, thereby largely avoiding contact with active creek channels. However, between km 37 and km 39, there are three locations approximately 1 km to 2 km west of Cat Camp where the active channel is currently on the south side of the floodplain and up against north-facing bedrock cliffs.

In order to maintain the all-season road on the south side and avoid creek crossings, these parts of the active channel will need to be moved further north. Sundog Creek has a large floodplain and the location of the active channels change from year to year. It is possible that natural changes to flow over time would remove the current active channel along the cliff face.

Habitat Characterization

The habitat that would be removed as a result of stream re-alignment consists primarily of pools, as well as some slow moving run and riffle habitat. The wetted width of the channel at site 1 and 2 was typically less than 15 m, and the deepest water (approximately 1.5m) occurred in the downstream pool, site 1. However, water depth was generally less than 40 cm. Maximum flow velocity was 1.2 m/s, in riffle habitat. Substrate consisted primarily of cobble and boulder, and there was some gravel and sand in the pool at site 1. Periphyton was observed on rocks in the upstream riffle habitat in site 1, but nowhere else in either of the sites. A low density of macrophytes were only observed within the side channel located immediately upstream of the rock face at site 1. This site also had a small amount of woody debris and boulders providing some cover to fish. Upstream and downstream of the study sites, Sundog Creek surface flows consisted primarily of riffle and run habitat. Pool habitat is less common.

Habitat Use

Electrofishing conducted by CZN and Parks staff while at the site indicated that fish were not using the pool/riffle habitat along the rock walls at the time. However, fish were found upstream and downstream of the largest cliff-bordered pool. Two slimy sculpin were caught downstream of the rock face, in riffle habitat. The remainder of fish, two slimy sculpin and four Arctic grayling, were caught in a small side channel upstream of the rock face at site 1. No fish were found in the pool or run habitat along the rock face.

Habitat Loss and Compensation

The re-direction of the channels away from the cliffs will result in the loss of some pool habitat; the largest pool at the time of the habitat assessment may be deep enough to provide overwintering habitat. However, creek levels are known to recede into the floodplain gravels as flows drop, so it is likely that, even if a pool exists in early winter, it will be shallower and will freeze to the bottom by the end of winter. In fact, at the time of the survey, there was no surface flow visible in sections of Sundog Creek upstream and downstream of the study area.

The preliminary conclusion based on the observations above are that the cliff faces at the two locations studied do not provide critical habitat. Pool and some run habitat would be lost along with cover provided by rough vertical rock faces. One option to re-create this habitat is to place several large boulders down the centre of the flood plain, and train the active channel to flow along the new alignment. This will serve two purposes: it will recreate pool habitat; and, it will keep flows away from the road and reduce armour requirements.

Figure 1 Lower realignment location, site 1, facing downstream, Sundog Creek, July 27, 2014.

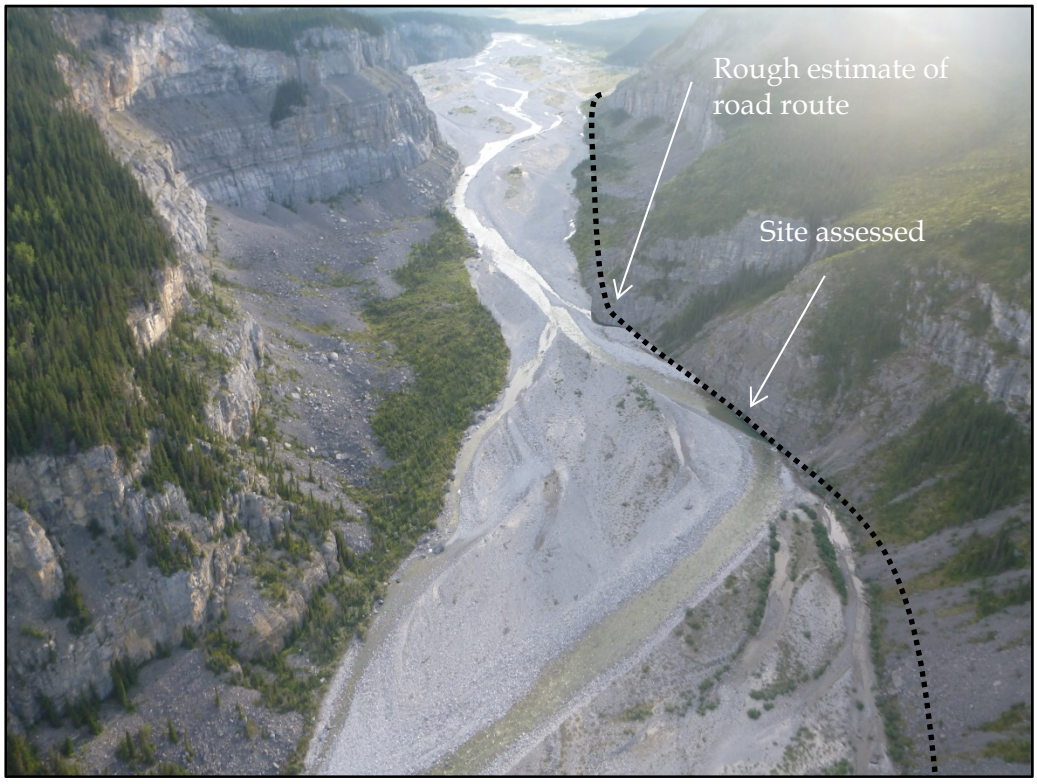


Figure 2 Lower realignment location, site 1, facing upstream, Sundog Creek, July 27, 2014.

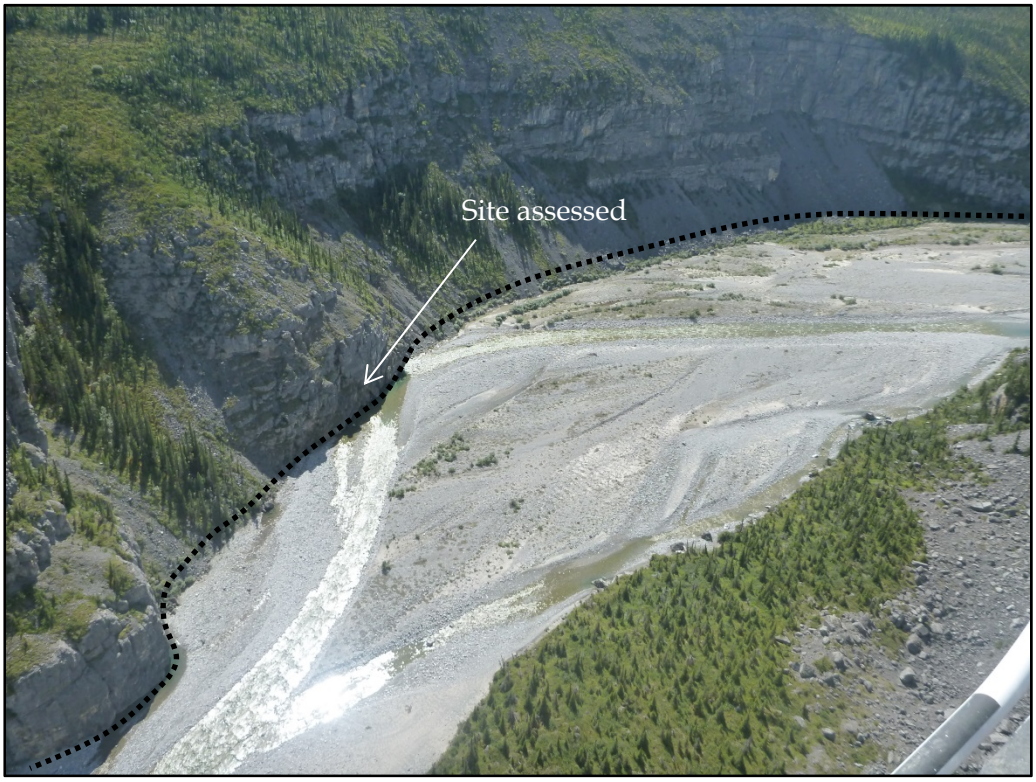


Figure 3 Lower realignment location, site 1, facing upstream, Sundog Creek, July 27, 2014.

Figure 4 Upper realignment location, sites 2A and 2B, facing upstream, Sundog Creek, July 27, 2014.

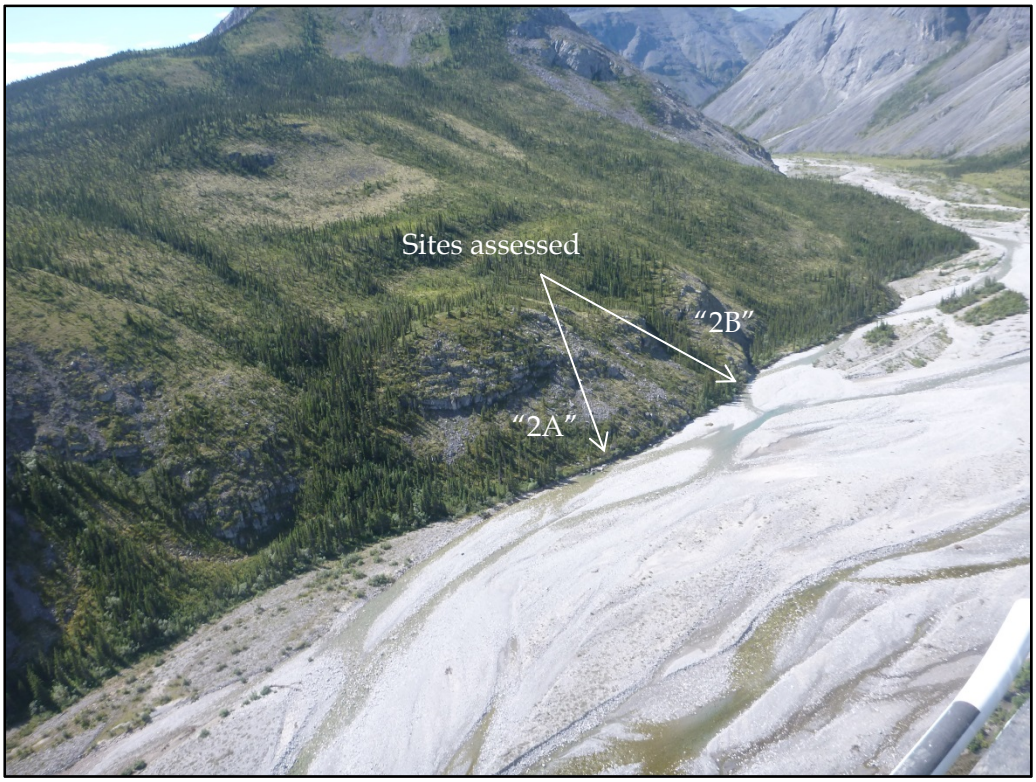


Figure 5 Upper realignment location, site 2B, facing upstream, Sundog Creek, July 27, 2014.

Figure 6 Upper realignment location, site 2A, facing downstream, Sundog Creek, July 27, 2014.

Figure 6 Upper realignment location, site 2A, facing downstream, Sundog Creek, July 27, 2014.

Figure 7 Upper realignment location, site 2A, facing downstream, Sundog Creek, July 27, 2014.

Table 1 GPS Coordinates.

Description	Coordinates (UTMs)
Lower Sundog Realignment (Site 1)	10 V 427079 6829372 (down-stream) 10 V 427032 6829328 (up-stream)
Upper Sundog Realignment (Site 2A)	10 V 426417 6829265 (down-stream) 10 V 426356 6829278 (up-stream)
Upper Sundog Realignment (Site 2B)	10 V 426324 6829305 (down-stream) 10 V 426255 6829318 (up-stream)

Attachment 1

Field Notes

CZN6788 27 July '14

Purpose: First day of 38
Road assessment - Sundog to cat camp + Polge (Bubbling springs) Ck. Electrofishing Sundog + net/trap mosquito

Crew: John, Dave, Garry + Jon

Electrofishing settings used ~~in past~~ last year 425v ± 25v 30Hz
Duty cycle 12% (Neal)
US: sculpin - 400v 50Hz 20DC
Trout - 40 Hz

Km 44 look at potential migration barrier prefer culvert over bridge.
Km 35-38 - possible re-alignment, shocking here.
Trib to Polge (bubbling springs)

Km 24 - falls
wp 10 drop of electrofishing gear. ~Km 36

Tetsela
44 fish migration barrier ... 47-49 - alignment GW

CZN6788 27 July '14

WP 11 Catcamp 431569 6829953

Km 43 Crossing WP 012

WP 13 ~~APP~~ Trib to Sundog long chute ~75m S
Photo + Photo north ~150 m long against black colored cliff 10° slope ~12° further upstream in chute

0431295 6830730
WP 14 Downstream pool, ~~Dave~~ saw fish ~10cm upstream of pool ~10° Furthest D/S point

WP 15 S N , WP ~~15~~ 16 S N w pool

WP 17 S N WP 18 S N (not recorded)

1215 @ Sundog Ck realignment location #1
pH ~~9.5~~ 7.6°C 221 µS (AJ)
GW pH 8.60 8.68°C 260 µS (AK)

upstream riffle flows / depths

		depth	flow
Top	25	22cm	.29
~~Mid~~	50	40cm	.75
~~bottom~~	~~75~~	26 cm	.61
Mid	25	32cm	.59
	50	46cm	.97
	75	22	.27
Bottom	25	28	.92
	50	32	1.20
	75	42cm	1.06

DO on meter 11.20 mg/L
94.8%

DO titration 10.8 mg/L

WP22 Sundog goes to ground.

Second sundog realignment site (Location ~~#2~~ A) ~~site A~~

Top wp023 426356
6829278

Bottom WP024 426418
6829265

Cond 268 µS/9.1°C / 7.40 (AK)

DO meter 99.4% 11.83 mg/L
pH 8.63 7.4°C 233 µS (AJ)
DO titration 10.2 mg/L

second sundog realign site
Location B

Top wpt 025 426255
6829318

Bottom wpt 026 426323
6829305

End ~ 1635.

Pilot late picking us up - decided to send just Garry + Dave to sundog trib to electrofish 1730 - 1815
back @ camp about 1835

For the sundog allignment locations, Jon and I did habitat sheets, while Garry + Dave electrofished

A sundog 1, ~~site A~~ 1348sec
ARGR FL (mm): 190, 183, 181, 192
SLSC FL (mm): 81, 92, 93, ?

Rite in the Rain

(10) CZN6788 27 July '14

Settings for sites ~~A + B~~ 1 + 2
500v, freq: 50

For the Sundog Alignment, site 2
d/s location ("A") - no fish 327 sec
u/s " ("B") - no fish 188 sec

For trib to Sundog (visited earlier in day)
724 sec
wp 27 (431594 / 6829949)
to wp 28 (431514 / 6829743)
assume sinusosity of 2.0
assume wetted width 2.5m

Attachment 2

Habitat Sheets

Stream Habitat Information

Data Collectors John W / Jon T	**Date** 27 July '14	**Time (24 H)** 1330
Site Pool	**Station** Sundog 1 (200m U/S of Km 37)	**Project** CZN - all season road
UTM NAD	**Upstream Northing** 0427064	**Upstream Easting** 6829319
Access	**Downstream Northing** 0427078	**Downstream Easting** 6829372

Morphology

Stream Morphology Types (%): Run / Riffle / (Pool) / Fall / Other:

Depth/Pool (m)	1.4
Channel Slope (°)	0.5°
Wetted Width	.6 / 13 / 17 / m
Meander Frequency	. / / / m

Depth Transect (m)	@ 25% width	50%	75%	Velocity (60% depth or surface) 25%	50%	75%
1	44cm	1200cm	1400cm	0	0	0.32
2	18 cm	42cm	72 cm	0.14	0.41	0.24
3	24cm	20cm	46 cm	0.24	0.25	0.24

Length (m): Channel Width (m) 1621 / 1621 / 157

Regular / Irregular meanders

Unstable Banks (5%) Bank slope (5°) L R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	0 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	5% %

Woody Debris Description (log jams, fallen trees, beaver activity, etc): Cliff all one side

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics		-
% Clay		-
% Silt		-
% Sand	15	-
% Gravel	40	0
% Cobble	40	50
% Boulder	5	50
% Bedrock	—	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	<1 %
Periphyton	%
Filamentous	0 %
Aquatic Moss	<5 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	5 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

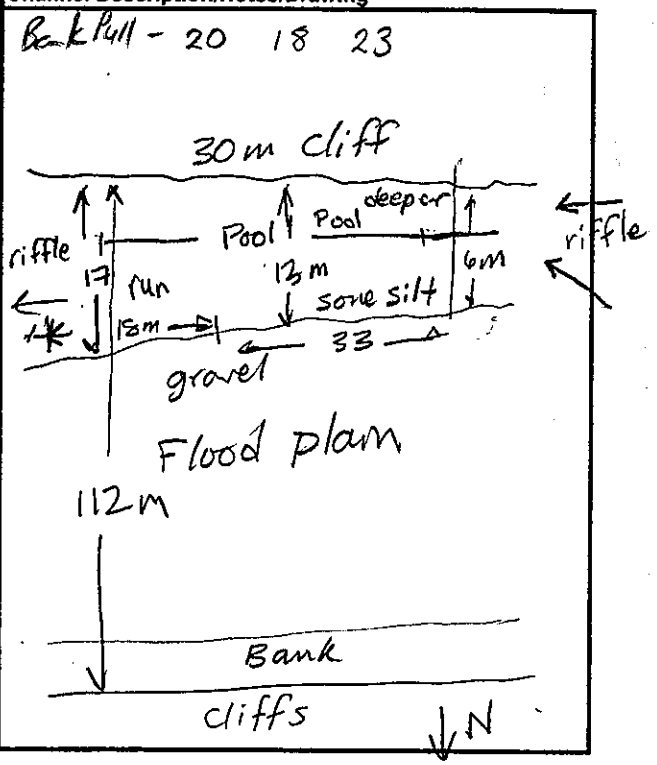
Miscellaneous

		Weather
High water mark	1.5 m	previous 24 H
Flood Evidence (Debris on plants, etc)	— m	Cloudy
Air Temperature	21 °C	dry
Cloud Cover (5%)	8/10	
Wind Direction + speed (km/h)	NE 5	

In situ Water Parameters

Sample Depth (m)	0
Dissolved Oxygen (%)	99.8
Dissolved Oxygen (mg/L)	11.2
Secchi Depth (m)	—
Temperature (°C)	8.6
pH	8.60
Turbidity (TCU)	—
Conductivity (uS/cm)	260

Channel Description/Notes/Drawing



Landscape (Beyond 25 m Buffer) circle

Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	(Hills)	canyon

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes

X ←N

Stream Habitat Information

Data Collectors	Date	Time (24 H)
John W	27 July '14	0416
Site	**Station**	**Project**
Riffle (US of pool)	Sundog 1 (200 m US of Km 37)	CEN6788
UTM NAD	**Upstream Northing**	**Upstream Easting**
WP 20	4274033	6829328
Access	**Downstream Northing**	**Downstream Easting**
WP 21	4271055	6829544

Morphology

Stream Morphology Types (%)				Length (m)				Velocity (60% depth or surface)		
Run	(Riffle)	Pool		Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:			1	22	40	26	.29	.75	.61
Depth/Pool (m)	NA			2	32	46	22	.59	.97	.27
Channel Slope (°)	2°			3	28	32	42	.92	1.20	1.06
Wetted Width	10 / 9 / 11	m		Channel Width (m)	23 / 28 / 29 / *			Unstable Banks (5%)		
Meander Frequency	/ / / /	m		Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	0 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %

Woody Debris Description (log jams, fallen trees, beaver activity, etc)

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	20	-
% Gravel	20	
% Cobble	20	
% Boulder	20	
% Bedrock		-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	<1 %
Periphyton	%
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) circle

Mixed Forest	(Coniferous Forest)
Grasses	Deciduous Forest
Re-growth forest	(Shrubs)
Flooded	Sedges
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

Miscellaneous

High water mark	1.3	m
Flood Evidence (Debris on plants, etc)		m
Air Temperature	23	°C
Cloud Cover (5%)	5	
Wind Direction + speed (km/h)	NE 5	

Weather: previous 24 H cloudy dry getting sunny

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)	—	See pond site	1.0	
Temperature (°C)				
pH				
Turbidity (TCU)	—			
Conductivity (uS/cm)				

Landscape (Beyond 25 m Buffer) circle

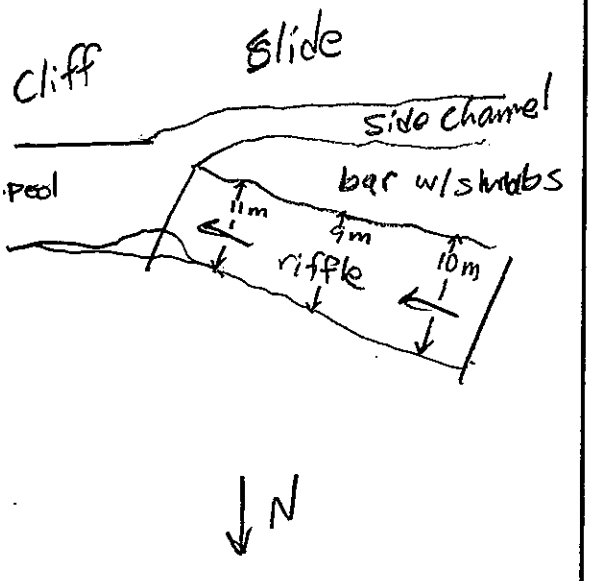
Mixed Forest	(Coniferous Forest)	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	(Hills)	Canyon

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Channel Description/Notes/Drawing

Bankfull · 23 28 29 * of active channel, not floodplain.



Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes · Some fairly thick brown algae growing on some boulders.

Stream Habitat Information

Data Collectors	Date	Time (24 H)
John.W / Jon.T	27-July-2014	15:26,
Site ~~1 (lower)~~ Sundog 2	**Station** ~~Sundog 2nd~~ A	**Project** CZN6788
UTM NAD	**Upstream Northing** 4726356	**Upstream Easting** 6829278
Access	**Downstream Northing** 426418	**Downstream Easting** 6829265

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	(Riffle)	(Pool) close to wall	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	8	11	10	0.13	0.34	0.26
Depth/Pool (m)			2	6	14	15	0.36	0.40	0.52
Channel Slope (°)	30		3	11	22	44	0.08	0.27	0.31
Wetted Width	/ 27 / 15* / 9	m	Channel Width (m)	/ /	/		Unstable Banks (5%)		
Meander Frequency	/ / / /	m	Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	0 %	Instream Cover (Twigs/Sticks, etc)	0 %	Substrate (as cover)	2 %
Instream Cover (logs, etc)	0 %	Instream vegetation	0 %	Undercut Bank	0 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)				boulders	

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	20	0
% Cobble	55 60	0
% Boulder	20	25
% Bedrock	5 —	-

Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer)

circle

Mixed Forest	(Coniferous Forest)
Grasses	(Deciduous Forest)
Re-growth forest	(Shrubs)
Flooded	(Sedges)
Roads	Cutlines

Overhead Cover

Overhead Litter <150 mm	0 %	Overhead Litter >150 mm (%)	0 %
Overhead Undercut Banks	0 %	Overhanging Trees	0 %
Overhanging Grasses	0 %	Overhanging Shrubs	0 %

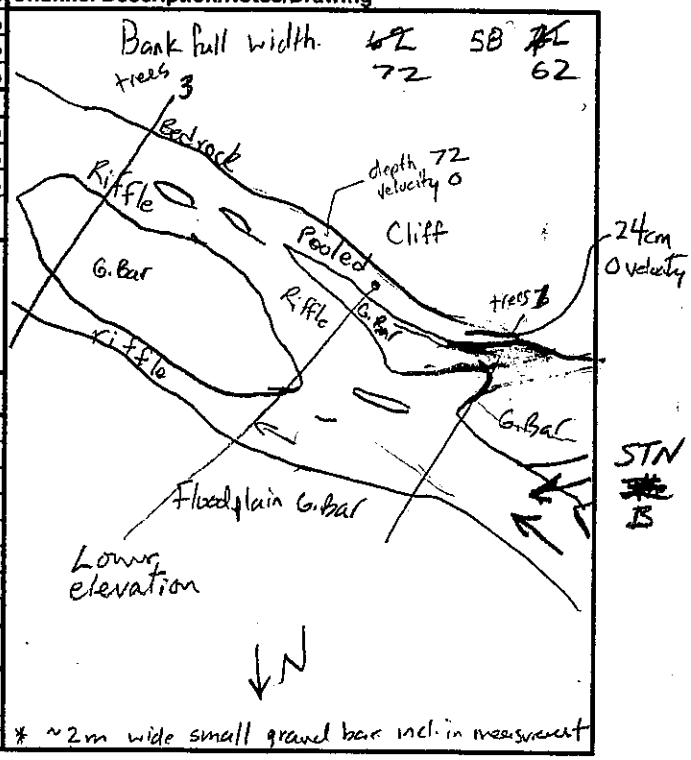
Miscellaneous

			Weather
High water mark	1.4	m	previous 24 H
Flood Evidence (Debris on plants, etc)	—	m	cloudy dry.
Air Temperature	22	°C	
Cloud Cover (5%)	5		
Wind Direction + speed (km/h)	NE 5		

In situ Water Parameters

Sample Depth (m)	0			
Dissolved Oxygen (%)	101.7			
Dissolved Oxygen (mg/L)	12.19			
Secchi Depth (m)	—			
Temperature (°C)	7.4			
pH	8.63			
Turbidity (TCU)	—			
Conductivity (uS/cm)	233			

Channel Description/Notes/Drawing



* ~2m wide small gravel bar incl. in measurement

Landscape (Beyond 25 m Buffer) circle

Mixed Forest	Coniferous Forest	Roads	
Grasses	Deciduous Forest	Cutlines	
Re-growth forest	Shrubs	Hills	

Visible Disturbance circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos

Channel Features

	#	Dimensions
Islands		
Bars		

Notes Slope = total slope of reach - slopes of individual channels will be lower. Slope = 3%. Slightly more periphyton than Prairie.

Stream Habitat Information

Data Collectors JW, GS	**Date** 27 July '14	**Time (24 H)** 1610 h
Site Sundog realign 2	**Station** B	**Project** CZN6788
UTM NAD	**Upstream Northing** 426255	**Upstream Easting** 6829318
Access	**Downstream Northing** 426323	**Downstream Easting** 6829305

Morphology

Stream Morphology Types (%)			Length (m)				Velocity (60% depth or surface)		
Run	Riffle	Pool	Depth Transect (m)	@ 25% width	50%	75%	25%	50%	75%
Fall	Other:		1	15	18	14	0.27	0.79	0.1
Depth/Pool (m)			2	30	76	68	0.12	0.14	0.05
Channel Slope (°)	30		3	9	18	18	0.29	0.25	0.06
Wetted Width	3 / 4 / 5 /	m	Channel Width (m)	163 / 75 / 79			Unstable Banks (5%)		
Meander Frequency	/ / / /	m	Regular / Irregular meanders				Bank slope (5°)	L	R

Instream Cover

Instream Cover (Detritus)	— %	Instream Cover (Twigs/Sticks, etc)	— %	Substrate (as cover)	— %
Instream Cover (logs, etc)	2 %	Instream vegetation	— %	Undercut Bank	2 %
Woody Debris Description (log jams, fallen trees, beaver activity, etc)	Tree + cliff face				

Substrate Composition (Sum 100%)

		Embed. (%)
% Organics	—	-
% Clay	—	-
% Silt	—	-
% Sand	—	-
% Gravel	60	60
% Cobble	25	25
% Boulder	15	25
% Bedrock	—	-

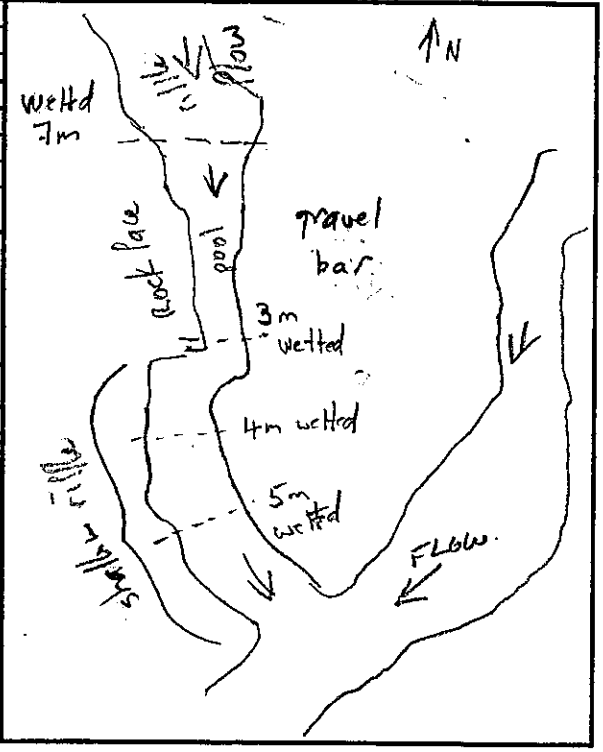
Instream Vegetaion (Sum 100%)

Rooted Emergent	0 %
Rooted Submergent	0 %
Rooted Floating	0 %
Free-floating	0 %
Floating Algae	0 %
Attached Algae	0 %
Periphyton	0 %
Filamentous	0 %
Aquatic Moss	0 %
Flooded Terrestrial Plants	0 %

Riprian Zone (25 m Buffer) — circle

Mixed Forest	(Coniferous Forest)
Grasses	(Deciduous Forest)
Re-growth forest	(Shrubs)
Flooded	(Sedges)
Roads	Cutlines

Channel Description/Notes/Drawing



Overhead Cover

Overhead Litter <150 mm	— %	Overhead Litter >150 mm (%)	— %
Overhead Undercut Banks	— %	Overhanging Trees	— %
Overhanging Grasses	— %	Overhanging Shrubs	— %

Miscellaneous

High water mark	1.2 m	**Weather** previous 24 H
Flood Evidence (Debris on plants, etc)	— m	
Air Temperature	22 °C	
Cloud Cover (5%)	5	
Wind Direction + speed (km/h)	W5	

In situ Water Parameters

Sample Depth (m)				
Dissolved Oxygen (%)				
Dissolved Oxygen (mg/L)				
Secchi Depth (m)	50 cm			
Temperature (°C)	5			
pH				
Turbidity (TCU)				
Conductivity (uS/cm)				

Landscape (Beyond 25 m Buffer) — circle

Mixed Forest	(Coniferous Forest)	Roads
Grasses	Deciduous Forest	Cutlines
Re-growth forest	Shrubs	(Hills)

Visible Disturbance — circle

Surface Debris	Culvert
Beaver Dam	Weir
Collapsed Bank	

Photos Canyon

Channel Features	#	Dimensions
Islands		
Bars		

Notes 3° Slope

APPENDIX 11

MEMO

Date: January 16, 2015 HCP Ref No.: CZN6788

From: Chris Jaeggle

To: David Harpley – Canadian Zinc Corporation

Subject: **September 25, 2014 Liard River Bathymetry And Bank Survey**

1.0 INTRODUCTION

On September 25, 2014, Chris Jaeggle (Hatfield Consultants) and David Harpley (Canadian Zinc) performed a bathymetric survey of the Liard River in an area proposed for an all-season road crossing. The proposed crossing is located approximately six kilometres downstream of the community of Nahanni Butte, NWT, and directly downstream of the confluence of the South Nahanni and Liard Rivers (Figure 1). The purpose of the bathymetric survey was to identify channel morphology to assist in locating the future crossing.

Figure 1 Study site location.

Data collection also included a topographic survey of each river bank to determine bank slope(s), and the collection of annotated bank photos (with corresponding GPS coordinates) which were taken throughout the bathymetric survey. Following is a discussion of procedures followed and a summary of data gathered.

The weather during the survey was approximately 5°C and rainy, with moderate wind.

2.0 PROCEDURES

2.1 BATHYMETRIC SURVEY

The bathymetric survey was conducted from a small power boat owned and operated by Leon Konisenta, Nahanni Butte resident. The depth sounder used for the survey, a Lowrence HDS-7 (Gen 2), consisted of a transducer and a control module/GPS unit. Equipment accuracy is ±10cm for depth and ± 5m for gps location of track lines. The transducer was attached to the transom at the rear of the boat, 15 cm below the water surface. The control module was used to configure the data collection and GPS settings, following the user manual instructions.

The survey began on the upstream right bank (defined as the bank on the right when looking downstream) and proceeded downstream at 5-10 km/h, at a distance of approximately 5 m away from the bank. The boat travelled the length of the study area along the right bank, crossed the river and completed a similar survey of the left bank. The boat then returned to the starting point and then travelled downstream, sweeping from bank-to-bank following a serpentine path. Upon reaching the downstream end of the study area, the data collection cycle was ended. Collected data were saved to the control module.

Annotated photographs were taken of the river banks throughout the bathymetry survey, with GPS coordinates collected at each of the photograph locations (Figure 2). The photographs are attached to this memo.

Upon return from the field, Hatfield staff transferred bathymetry data from the depth sounder into DrDepth© software to generate a bathymetric chart. A coordinate grid was placed over the bathymetric chart using GIS software. Due to the large study area and the large horizontal distance between the serpentine survey tracks, the extrapolation and interpolation intervals in the DrDepth© software were maximized to 25 m and 250 m, respectively.

2.2 RIVER BANK SURVEYS

A single transect was surveyed on each bank of the river approximately where the crossing was expected to be located. Equipment included a level survey kit, consisting of an engineer's level (Can-Measure, Model CM-24) mounted onto a tripod, and a stadia rod. After setting up and levelling the tripod and engineer's level near the top of the bank, several points were surveyed, including top of bank, high water mark, water level surface, and several points between the top of bank and water surface. The top of bank survey point was given an arbitrary datum of 100.00 m, which was used to calculate relative elevations of the other survey points. Note that although the datum for both banks was 100.00 m, the datum of each bank was independent of the other bank. Horizontal distance between each survey point also was measured using a digital laser rangefinder. An overall bank slope was calculated for each bank, as well as the slope between the water surface and high water mark (i.e., the floodplain), and the slope between the high water mark and the top of bank., Table 1 provides the survey and slope data.

3.0 DATA AND RESULTS

The results of the bathymetry survey are provided as a bathymetric chart (Figure 3). The chart shows that the shallowest areas of the channel are located in the downstream third of the study area. Depths in this

area range from 2-8 m. The deepest areas of the channel are located in the upstream third of the study area, closer to the left bank of the river, where depths are up to 20 m.

Bank slopes were calculated from the river bank survey results. The right bank had a slope of 12.9% from the water's edge to the high-water mark (i.e., the floodplain) and a slope of 41.3% from the high-water mark to the top of the bank. On the left bank, the high-water mark co-occurred with the top of the bank assumed for the survey, although the actual top of the bank was more than 6m higher and the slope rises steeply, greater than 60 degrees. The slope of the left bank from the water's edge to the high-water mark/top of bank was 15.3%. Table 1 below provides the survey data used to calculate the bank slopes. Photographs of the right and left bank are provided in Attachment 2. All photographs were taken during the bathymetry survey, and coordinates for the locations of these photos can be found in Attachment 1.

Figure 3 Bathymetry of the Liard River near Prairie Creek Mine, September 2014.

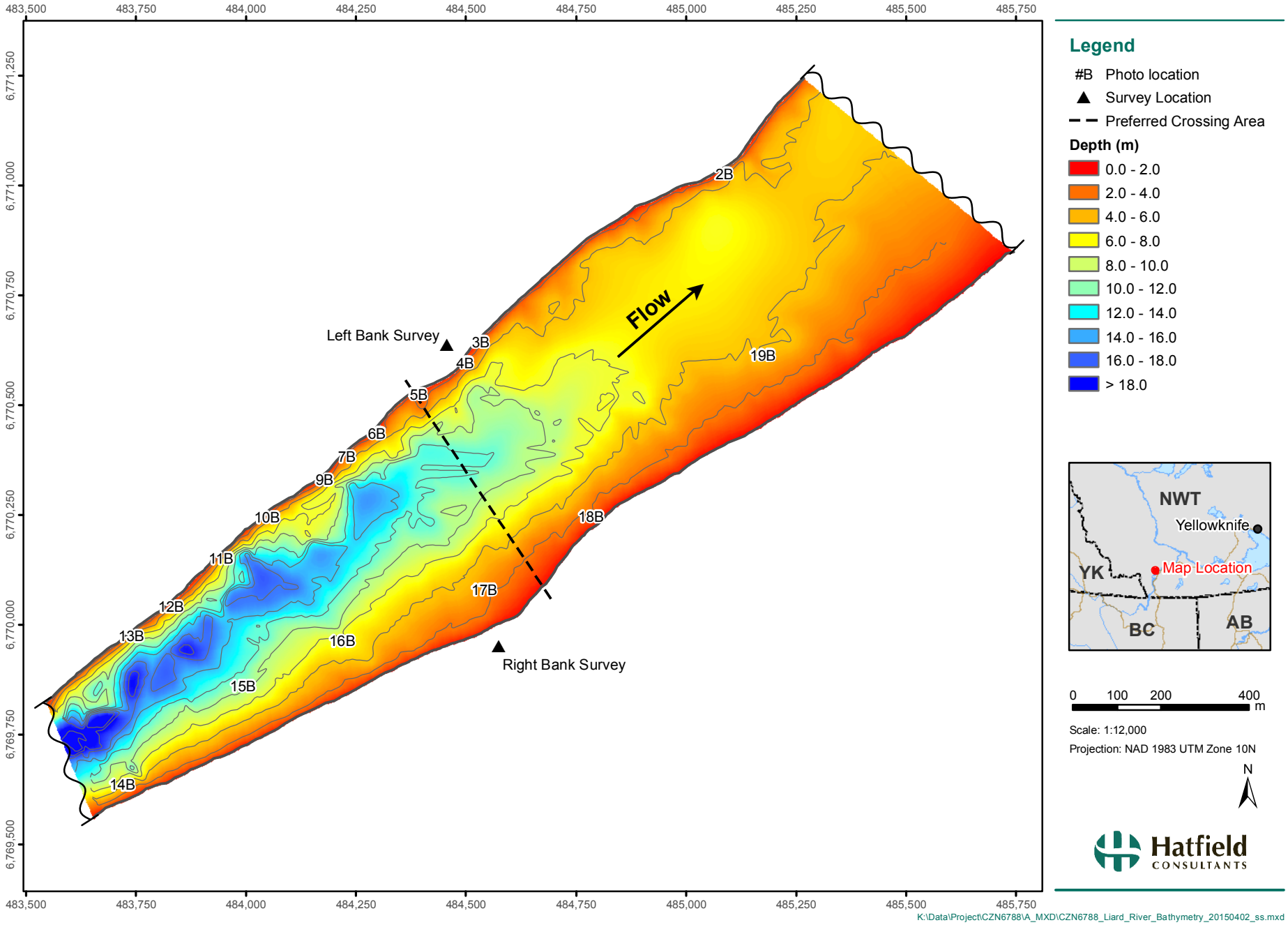


Table 1 Bank survey data.

River Bank	Measurement ID	Horiz. Distance (m)	Elevation (m) [1]
Right Bank	Top of Bank	41.5	100.00
Right Bank	1	39.9	99.61
Right Bank	High Water Mark	39.3	99.09
Right Bank	2	34.2	98.07
Right Bank	3	25	96.88
Right Bank	4	14	95.36
Right Bank	Water Level	0	94.01
Left Bank	High Water Mark/Top of Bank	36	100.00
Left Bank	1	34.8	98.55
Left Bank	2	33	97.93
Left Bank	3	28	96.55
Left Bank	4	18	95.19
Left Bank	Water Level	0	94.49

[1] Arbitrary value of 100.00 m set at the top of each bank.

For additional information, please contact either Chris Jaeggle or John Wilcockson at (604) 926-3261.

Attachment 1 GPS coordinates of Liard River bank photos.

Photo Name	UTM Coordinates (Zone 10V)
2B	485087 E, 6771031 N
3B	484533 E, 6770648 N
4B	484498 E, 6770601 N
5B	484392 E, 6770529 N
6B	484296 E, 6770441 N
7B	484229 E, 6770388 N
9B	484178 E, 6770334 N
10B	484048 E, 6770249 N
11B	483943 E, 6770155 N
12B	483830 E, 6770045 N
13B	483740 E, 6769978 N
14B	483719 E, 6769640 N
15B	483994 E, 6769865 N
16B	484219 E, 6769967 N
17B	484542 E, 6770084 N
18B	484785 E, 6770251 N
19B	485175 E, 6770618 N

Attachment 2 Photographs of Liard River banks in survey area.

Photograph 2B - Left Bank.

Photograph 3B – Left Bank.

Photograph 4B – Left Bank

Photograph 5B – Left Bank

Photograph 6B – Left Bank

Photograph 7B – Left Bank

Photograph 9B – Left Bank

Photograph 10B – Left Bank

Photograph 11B – Left Bank

Photograph 12B – Left Bank

Photograph 13B – Left Bank

Photograph 14B – Right Bank

Photograph 15B – Right Bank

Photograph 16B – Right Bank

Photograph 17B – Right Bank

Photograph 18B – Right Bank

Photograph 19B – Right Bank

APPENDIX 12

Fort Liard feels cut off from NWT due to poor road

Highway 7 reconstruction to be done in pieces over many years

Roxanna Thompson
Northern News Services
Published Thursday, June 2, 2011

ACHO DENE KOE/FORT LIARD - An official with the hamlet of Fort Liard says the community has closer ties with B.C. than the NWT because of the condition of Highway 7.

The highway, also known as the Liard Trail, was reopened to light vehicles on May 20 after being closed to all traffic between Checkpoint and Fort Liard for two weeks because of rough conditions found in five sections between kilometres 172 and 203. Fort Liard, however, felt few effects from the closure, said John McKee, the hamlet's senior administrative officer.

"We gave up on the road a few years ago," he said.

The community and businesses within it receive the majority of their supplies from Fort Nelson, B.C. Even the bulk of the community's mail comes three times a week from the south through Fort Nelson, McKee said. The highway closure may have resulted in some delays in the additional mail that comes from Fort Simpson, he said.

During its closure McKee said complaints weren't, as you'd expect, made regularly about the highway.

"You hear the odd one," he said.

Fort Liard residents are more concerned about the shorter portion of Highway 7 that connects the hamlet to the B.C. border and south. The hamlet is more like an enclave of B.C. than a part of the territory, said McKee.

The failing conditions of Highway 7 can be traced back to the original materials that were used in its construction in the late 1970s and early 1980s, said Earl Blacklock, the manager of public affairs and communications with the Department of Transportation.

The materials aren't as suitable for highway construction as what would be used today, he said. That factor combined with weather conditions and high moisture content, particularly from spring runoff, as well as the weight of vehicles on the highway means work to rebuild the road can't happen as fast as the road is breaking down, he said.

"There's a need for the road to be reconstructed, basically, in its entirety and we need to prioritize that work," Blacklock said.

The highway's deterioration caught up with the department in 2008. That spring the highway had to be closed to all traffic on five separate occasions between May 22 and the end of June.

In 2010 the highway was closed to all heavy vehicles for at least the majority of May. This year's closure also began as a restriction on heavy vehicles. It was the first full closure since 2008.

"It's top of mind for us in terms of continuing the rebuilding to bring it to the point it won't have these problems in the future," Blacklock said about the highway.

The highway's reconstruction is already in progress. This year the department has budgeted $4 million to be used on the highway. Part of that money will be used to reconstruct the section between kilometres 105 and 107.

The portions of the highway that will be reconstructed next will be decided on through a number of factors including ongoing inspections. Information and input is also gathered from other sources including contractors and communities, he said.

Although no exact timeline has been set for the complete reconstruction of the highway, Blacklock said it won't be done in the next few years.

"It's a big job and it's a big task and it's a big problem especially because in some parts of the highway we have to rebuild it from the ground up," he said.

Highway 7, however, is only the department's highest priority, as with any highway, when it needs work in order to reopen it for service. All highway reconstructions, including that of Highway 7, are given equal weight within the territory, Blacklock said.

APPENDIX 13

CANADIAN ZINC CORPORATION

ENGAGEMENT RECORD

Party Engaged: Naha Dehe Dene Band (NDDB)

Date/Time: January 15, 2014 / 11:45 am to 12:30 pm

Location: Nahanni Butte Gym, NT

NDDB Attendees: Acting Chief Peter Marcellais, James Betsaka, Jane Konisenta, Joan Ekotla, Tammy Matou, Tom Betsaka, Helen Ekotla, Lorraine Vital, Voilet Tesou, Leon Konisenta

CZN Attendees: Alan Taylor, David Harpley, Chris Reeves, Wilbert Antoine

Issues Discussed:

1. Corporate Status
2. Security Payment Status
3. All Weather Access Road Application

Issues Resolved:

1. Alan Taylor gave an overview of 2013 programs and plans for 2014:
    - There were many training programs at the Mine during the summer, including trainingship (general trades), diamond driller, and road construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN getting wage subsidies. A summary of the overall success of the Silver Lining training programs was provided.
    - Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond driller training program.
    - Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
    - While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction.

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Therefore, CZN will embark on an optimization program, and has hired Tetra Tech Engineering to assist. The program seeks to reduce costs where possible, and more accurately estimate the total cost of construction. To obtain more detailed costs and engineering designs, CZN will be sending in a group of engineers (from Tetra Tech) to the Mine site next week, and the company will subsequently be issuing tender packages for the main components required to complete construction. If all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015. The earliest possible commercial production at the project would be late 2015.

2. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

3. David Harpley informed NDDB that CZN intends to apply to use the access road in all seasons. The attached document was provided which explains CZN's rationale for the planned application. James Betsaka indicated that the Band will support the proposed application and road use.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

PETER MARCELLAIS
Name

Signature

Photos:

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NOTES FOR ENGAGEMENT MEETINGS

January 14th, 2014 – LKFN, ADK
January 15th, 2014 – NDDB

OPERATING PERMITS

Letter of Dec. 9, 2013 to MVLWB re FMEA

The Water Licence (WL) requires a Failure Modes and Effects Analysis, mostly related to mine water management. CZN has requested that this be deferred until after CZN has done some dewatering of the Mine this summer, which will generate important data.

Letter of Dec. 22, 2013 to MVLWB re Security and Length of Permits

The WL and Land Use Permit (LUP) require CZN to post a total of $17.7 million to cover reclamation security. $9 million of is to cover all existing site liabilities. The permits require CZN to post $6 million immediately, and $3 million at the start of operations. The Water Board erred because CZN is not liable for all existing liabilities as a result of a Release issued by the Crown. CZN is only currently liable for those liabilities related to its Surface Lease, estimated at $2 million. CZN has proposed to post security of $2 million immediately, and the remaining $7 million over the first 2 years of operations.

Time will be required to complete final engineering, raise capital and construct the Mine. This will eat significantly into the term of the permits, and is not helpful for raising capital. CZN has asked the Board to either extend the period of the permits, or defer their start dates.

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ACCESS ROAD

Access Road permits currently allow winter use of the road only. CZN's operating plans include early winter opening of the road from the Mine to a mid-way point. Concerns were raised in the environmental assessment (EA) process regarding early winter ground conditions, and this may be an operational constraint. In addition, winter access only means that all supplies must be brought in over a few months, and mineral concentrates are stranded at the Mine until the next winter, negatively affecting cash flow. However, the cost to upgrade the road to all season status is significant.

CZN proposes to apply to have the road permits amended to allow all season use at a time of its choosing. Initial road use would be winter only. The next step would be to upgrade the western portion for all season use to allow all mineral concentrates to be transported to the mid-way point. A second airstrip would also be built to improve air access in bad weather. After that, CZN would consider upgrading the eastern portion for all season use, which would be the most expensive.

In CZN's opinion, all season road access presents a significant economic opportunity for all parties in the region. The Ram Plateau is a unique area and the karst landscape is a great tourist and cultural attraction. There is an opportunity to promote greater use of, and access to, the Nahanni National Park Reserve, and with greater aboriginal involvement. This could include greater day and air access, and perhaps overnight accommodation for tourists and researchers. A multi-party collaborative approach is required to realize these benefits, and to finance the upgrade of the eastern portion of the road.

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CANADIAN ZINC CORPORATION

ENGAGEMENT RECORD

Party Engaged:	LiidliiKue First Nation(LKFN)
Date/Time:	January 14, 2014 / 1:00 pm to 2:50 pm
Location:	LKFN Boardroom, Fort Simpson, NT
LKFN Attendees:	Chief Minnie Letcher, Jim Antoine, Betty Hardisty, Emma Amundson, Liza McPherson, Dan Hillman
LKFN Guest:	Chief Harry Deneron (Acho Dene Koe First Nation)
CZN Attendees:	Alan Taylor, David Harpley, Chris Reeves, Wilbert Antoine *Joseph Lanzon (Call-in)

Issues Discussed:

1. IBA Commitment Presentation
2. Review the IBA Status
3. Corporate Status
4. Security Payment Status
5. All WeatherAccess Road Application
6. ProcurementContracts*
7. Nahendeh Aboriginal Economic Development Update*

Issues Resolved:

1. A cheque was provided by CZN to satisfy an IBA commitment.

2. A discussion was held regarding IBA Status. The Chief and Council will act as LKFN's IBA Representatives until further notice. Chief Minnie suggested having these IBA meetings scheduled to coincide with the first Tuesday of each month when they typically have their meeting. IBA meetings should be arranged with Alesha (LKFN).

3. Alan Taylor gave an overview of 2013 programs and plans for 2014:
   - There were many training programs at the Mine during the summer, includingtrainingship (general trades), diamond driller,and road

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construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN getting wage subsidies. A summary of the overall success of the Silver Lining training programs was provided.

- Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond drillertraining program.
- Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
- While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction. Therefore, CZN will embark on an optimization program,and has hired Tetra Tech Engineering to assist. The program seeks to reduce costs where possible, and more accurately estimate the total cost of construction. To obtain more detailed costs and engineering designs, CZN will be sending in a group of engineers (from Tetra Tech) to the Mine site next week, and the company will subsequently be issuing tender packages for the main components required to complete construction. If all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015.The earliest possible commercial production at the project would be late 2015.

4. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

5. David Harpley informed LKFN that CZN intends to apply to use the access road in all seasons. Chief Minnie suggested that in the application, the road should be referred to as all-weather and not all-season.The attached document was provided which explains CZN's rationale for the planned application.

6. A discussion was held regarding the process for tendering onfuture contracts. While IBA holders would have priority on opportunities to secure contracts, CZN expressed concern that the Nahendeh Aboriginal Economic Committee (NAEC) could also provide involvement for surrounding communities and could help CZN further it's commitment to GNWT to reduce economic seepage to southern contractors. CZN gave a brief history of the company's involvement going back to the Fort Liard meeting in 2010.

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Issues Unresolved:

6. Chief Minnie advised that LKFN council is currently not in favour of NAEC participation as similar past collaborations have not been productive. However, the Band is amenable to further discussion and consideration.

Signature of Party Representative Confirming Accuracy of Engagement Record:

MINNIE LETCHER
Name

Signature CHIEF, LKFN

Photos:

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CANADIAN ZINC CORPORATION

ENGAGEMENT RECORD

Party Engaged: Acho Dene Koe First Nation (ADK)

Date/Time: January 14, 2014 / 11:00 am to 12:00 pm

Location: CZN Regional Office, Fort Simpson, NT

ADK Attendees: Chief Harry Deneron

CZN Attendees: Alan Taylor, David Harpley, Chris Reeves, Wilbert Antoine

Issues Discussed:

1. Corporate Status
2. Security Payment Status
3. All Weather Access Road Application

Issues Resolved:

1. Alan Taylor gave an overview of 2013 programs and plans for 2014:
    - There were many training programs at the Mine during the summer, including trainingship (general trades), diamond driller, and road construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN giving wage subsidies as all site trainee were CZN employees. A summary of the overall success of the Silver Lining training programs was provided.
    - Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond driller training program.
    - Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
    - While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction. Therefore, CZN will embark on an optimization program, and has hired Tetra Tech Engineering to assist. The program seeks to reduce costs where possible, and more accurately estimate the total cost of construction. To obtain more detailed costs and engineering designs, CZN will be sending in a group of engineers (from Tetra Tech) to the Mine site next week, and the company will subsequently be issuing tender packages for the main components required to complete construction. If

all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015. The earliest possible production of the first mineral concentrates at the project would be late 2015.

2. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

3. David Harpley informed the Chief that CZN intends to apply to use the access road in all seasons. The attached document was provided which explains CZN's rationale for the planned application.

   The Chief indicated his support for the Prairie Creek Mine because the project will help other things in the region. The project could help get funding to improve the highway near Fort Liard. The Chief was careful not to speak for others who are more directly impacted by the project, but he generally supports industry and wonders if the upcoming Devolution (Bill C-15) will help Prairie Creek. He mentioned he was on his way to Yellowknife shortly to speak on Devolution in front of the legislative standing committee.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

Harry Deneron
Name

Signature

Photos:

Photo 1: CZN Meeting with Chief Harry Deneron,

JEAN MARIE RIVER FIRST NATION
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April 9, 2014

Julian Morse
Regulatory Officer
Mackenzie Valley Land and Water Board
7th Floor-4910 50th Avenue,
Yellowknife, NT X1A 2P6

Re: CZN's Proposed All Weather Road Application for the Prairie Creek Mine

Dear Mr. Morse,

On February 14, 2014 I had an opportunity to meet with Wilbert Antoine, Manager of Northern Development with Canadian Zinc Corporation in Fort Simpson. Mr. Antoine provided me with an update on CZN's activities and their intent to apply in the very near future to upgrade the winter road into the Prairie Creek Mine for all weather use. The intent of the application is to allow the mine to transport minerals to market, and bring in supplies year round.

This letter is to notify you that, as the designated representative of the Jean Marie River First Nation, we support CZN's application.

Yours truly,

for Chief Stanley Sanguez
Jean Marie River First Nation
Jean Marie River, NT

ENGAGEMENT RECORD

Date of Engagement: February 19th, 2014

Party Engaged: Sambaa Ke Dene Band

Location: SKDB Office, Trout Lake, NT

Party Attendees: Chief Dolphus Jumbo and Ruby Jumbo

CZN Attendees: Wilbert Antoine

Issues Discussed:

1. Corporate Status
2. Security Payment Status
3. All Weather Access Road Application

Issues Resolved:

1. Wilbert Antoine gave an overview of 2013 programs and plans for 2014:
    - There were many training programs at the Mine during the summer, including trainingship (general trades), diamond driller, and road construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN getting wage subsidies. Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond driller training program.
    - Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
    - While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction. CZN will embark on an optimization program, and has hired Tetra Tech Engineering to assist, early January the mine was temporary open for the Tetra Tech firm to do some estimates. The program seeks to reduce costs where possible, and more accurately estimate the total cost of

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construction. If all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015. The

2. David Harpley intends to apply to use the access road in all seasons. The attached document was provided which explains CZN's rationale for the planned application.

3. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

4. A discussion was held regarding the process for tendering on future contracts. While IBA holders would have priority on opportunities to secure contracts, CZN expressed concern that the Nahendeh Aboriginal Economic Committee (NAEC) could also provide involvement for surrounding communities and could help CZN further it's commitment to GNWT to reduce economic seepage to southern contractors. CZN gave a brief history of the company's involvement going back to the Fort Liard meeting in 2010.

Issues Unresolved:

Signature of Party Representative Confirming Accuracy of Engagement Record:

_____ _____

Name Signature

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ENGAGEMENT RECORD

Party Engaged: Dehcho First Nation (DCFN)

Date/Time: January 14, 2014 / 4:00 pm to 4:30 pm

Location: DCFN Fort Simpson office, NT

DCFN Attendees: Grand Chief Herb Norwegian

CZN Attendees: Alan Taylor, David Harpley, Wilbert Antoine

Issues Discussed:

1. Corporate Status
2. Security Payment Status
3. All Weather Access Road Application

Issues Resolved:

1. Alan Taylor gave an overview of 2013 programs and plans for 2014:
    - There were many training programs at the Mine during the summer, including trainingship (general trades), diamond driller, and road construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN getting wage subsidies. A summary of the overall success of the Silver Lining training programs was provided.
    - Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond driller training program.
    - Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
    - While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction. Therefore, CZN will embark on an optimization program, and has hired Tetra Tech Engineering to assist. The program seeks to reduce costs

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where possible, and more accurately estimate the total cost of construction. To obtain more detailed costs and engineering designs, CZN will be sending in a group of engineers (from Tetra Tech) to the Mine site next week, and the company will subsequently be issuing tender packages for the main components required to complete construction. If all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015. The earliest possible commercial production at the project would be late 2015.

2. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

3. David Harpley informed the Grand Chief that CZN intends to apply to use the access road in all seasons. The attached document was provided which explains CZN's rationale for the planned application.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

_____ _____

Name Signature

Photos:

CANADIAN ZINC CORPORATION

ENGAGEMENT RECORD

Date of Engagement: February 18th, 2014

Party Engaged: Fort Simpson Metis Nation (FSMN)

Location: FSMN Office, Fort Simpson, NT

Party Attendees: President Marie Lafferty

CZN Attendees: Wilbert Antoine

Issues Discussed:

1. Corporate Status
2. Security Payment Status
3. All Weather Access Road Application

Issues Resolved:

1. Wilbert Antoine gave an overview of 2013 programs and plans for 2014:
    - There were many training programs at the Mine during the summer, including trainingship (general trades), diamond driller, and road construction and slashing on the access road. All programs were successful and much appreciated, and trainees were employed with CZN getting wage subsidies. Surface exploration drilling was completed near the Mine site spanning 2 months. This included the diamond driller training program.
    - Baseline aquatic surveys were carried out in the South Nahanni basin in preparation for operations.
    - While CZN has all the necessary operating permits, the financial markets are not conducive to raising the money required for construction. CZN will embark on an optimization program, and has hired Tetra Tech Engineering to assist, early January the mine was temporary open for the Tetra Tech firm to do some estimates. The program seeks to reduce costs where possible, and more accurately estimate the total cost of

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construction. If all of the plans and financing falls into place this year, the winter road would be opened in early 2015 so that construction materials can be taken to site and to enable construction to begin in 2015. The

2. CZN intends to apply to use the access road in all seasons. The attached document was provided which explains CZN's rationale for the planned application.

3. CZN submitted letters to the Water Board in December regarding deferral of a Failure Modes and Effects Analysis, and alteration of security payment terms in connection with the operations Land Use Permit and Water Licence. A summary of CZN's positions was explained by providing the attached document.

4. A discussion was held regarding the process for tendering on future contracts. While IBA holders would have priority on opportunities to secure contracts, CZN believes that the Nahendeh Aboriginal Economic Committee (NAEC) could also provide involvement for surrounding communities and could help CZN further it's commitment to GNWT to reduce economic seepage to southern contractors.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

MARIE LAFFERTY
Name

Marie Lafferty
Signature

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ENGAGEMENT RECORD

Party Engaged: Naha Dehe Dene Band (NDDB)

Date/Time: November 28, 2014 / 2 pm

Location: Nahanni Butte Gym, NT

NDDB Attendees: Band Council members Tammy Matou, Lena Marcellais; Elders, Elsie Marcellais, Jean Marie Konisenta, Raymond Vital, Laura Vital; Community members Helen Ekotla, Marlene Konisenta, Violet Tesou, Doris McPherson, Romeo Betsaka.

CZN Attendees: Alan Taylor, David Harpley, Wilbert Antoine

Issues Discussed:

1. Project Status
2. All Season Access Road Studies

CZN gave a power-point presentation (attached) to update Band members on the project schedule and items that are being worked on, and to provide interim results of studies conducted this summer related to the all season road proposal.

Alan Taylor noted that financing is required to advance the project, but that much work is on-going to fine-tune the project, and obtain firm costs for construction.

David Harpley summarized the results of work on the access road, and advised that CZN is working to address those issues raised by the community during scoping for the EA. In this respect, stream crossings have been classified as major and minor, and all fish-bearing crossings are considered to be major. Data has been collected to determine the appropriate crossing structures for these. Photographs were shown of wetland crossings. Fishtrap Creek will be crossed close to its headwaters where beaver dams are common. Figures were provided showing that Bluefish Creek and its basin are not crossed at all.

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Mr. Harpley advised that CZN is pursuing an initiative that would see a “no shooting” corridor established along the road, for safety reasons and to deter hunting by people from outside the region which could lead to a decline in caribou and moose numbers. CZN asked for feedback from members on this idea. One member was unsure about the extent of the proposed corridor, and CZN advised that it would likely be 1 km from the centre-line of the road. Another member said they were concerned about increased hunting and a possible decline in numbers of animals. Another member asked why an all season road is needed when a winter road is already available.

Issues Resolved:

It was agreed that CZN would repeat the presentation and engage in further discussion with the community when more members are present in January at the time of the annual Winterfest.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

_____ _____

Name Signature

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PRAIRIE CREEK MINE:

COMMUNITY MEETING

November, 2014

CANADIAN ZINC CORPORATION

Agenda

- Project History to Date
- Current and Future Activities
- Mine Development Schedule
- All Season Road

CANADIAN ZINC CORPORATION

Project History to Date

- Cadillac
- San Andreas
- Canadian Zinc
  - Exploration
  - Pre-Feasibility
  - EA and Permitting

CANADIAN ZINC CORPORATION

Current and Future Activities
Mine Site

- Underground re-opening
- Decline tunnel dewatering
- Underground drilling

CANADIAN ZINC CORPORATION

Current and Future Activities Office

- Determine costs for equipment
- Engineering design
- Construction cost estimation
- Source financing

CANADIAN ZINC CORPORATION

Mine Development Schedule

- 2016 Winter Road
- Construction spring-fall 2016
- Commissioning from fall 2016

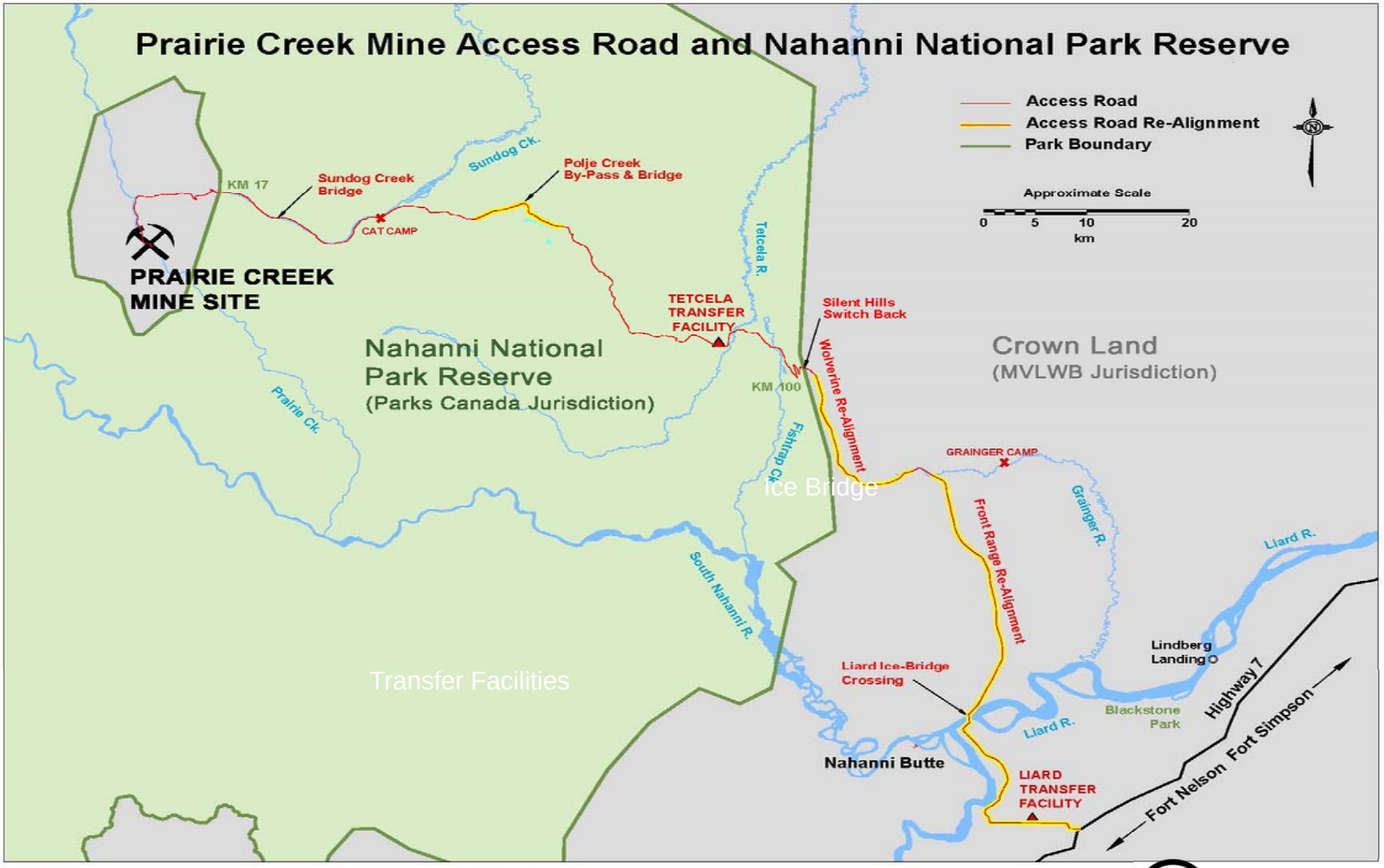
CANADIAN ZINC CORPORATION

All Season Road EA – Progress

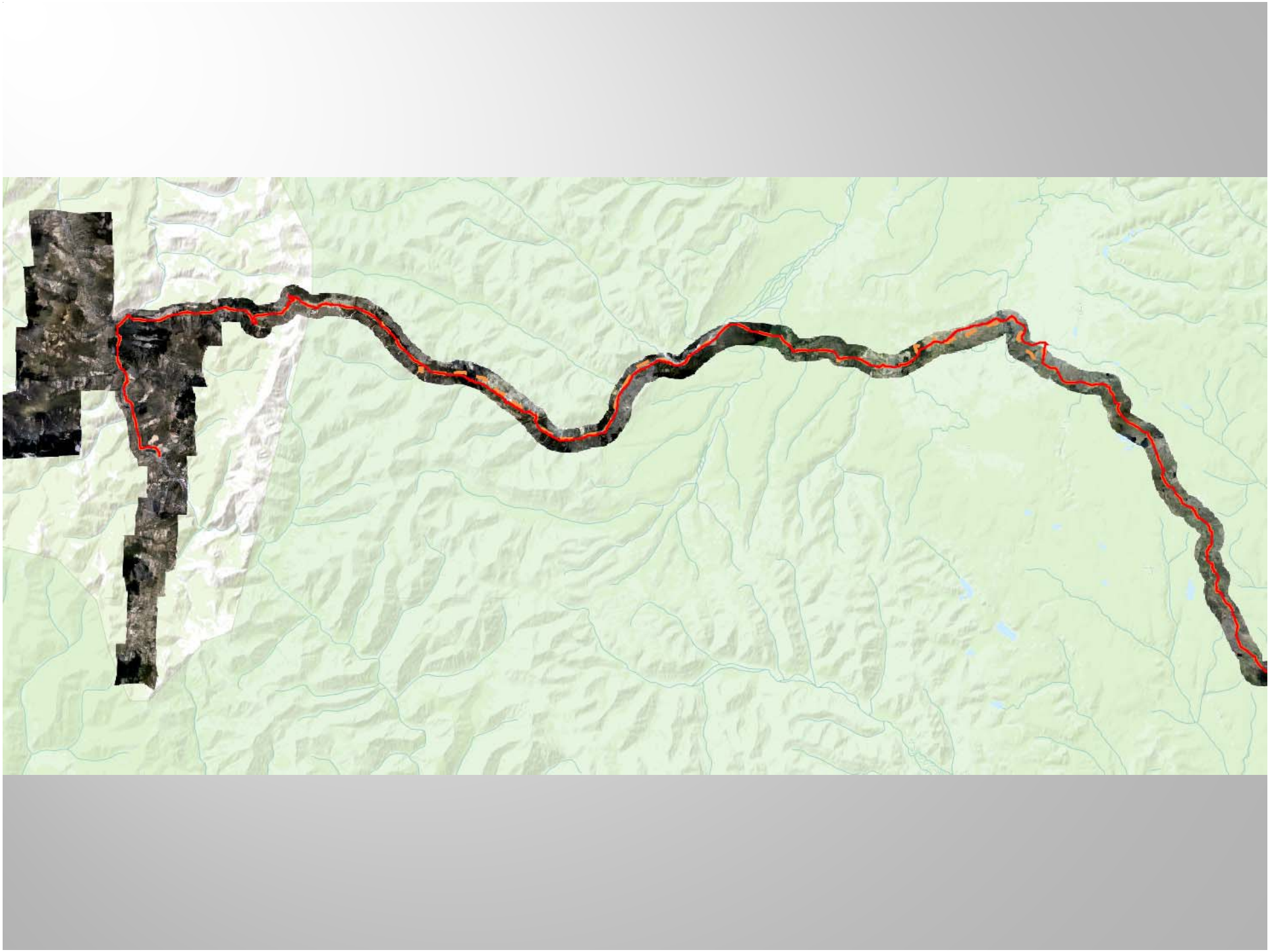
- Two field investigation programs
- Alignment
- Creek crossings
- Wildlife
- Wetlands
- Airstrip
- Access control

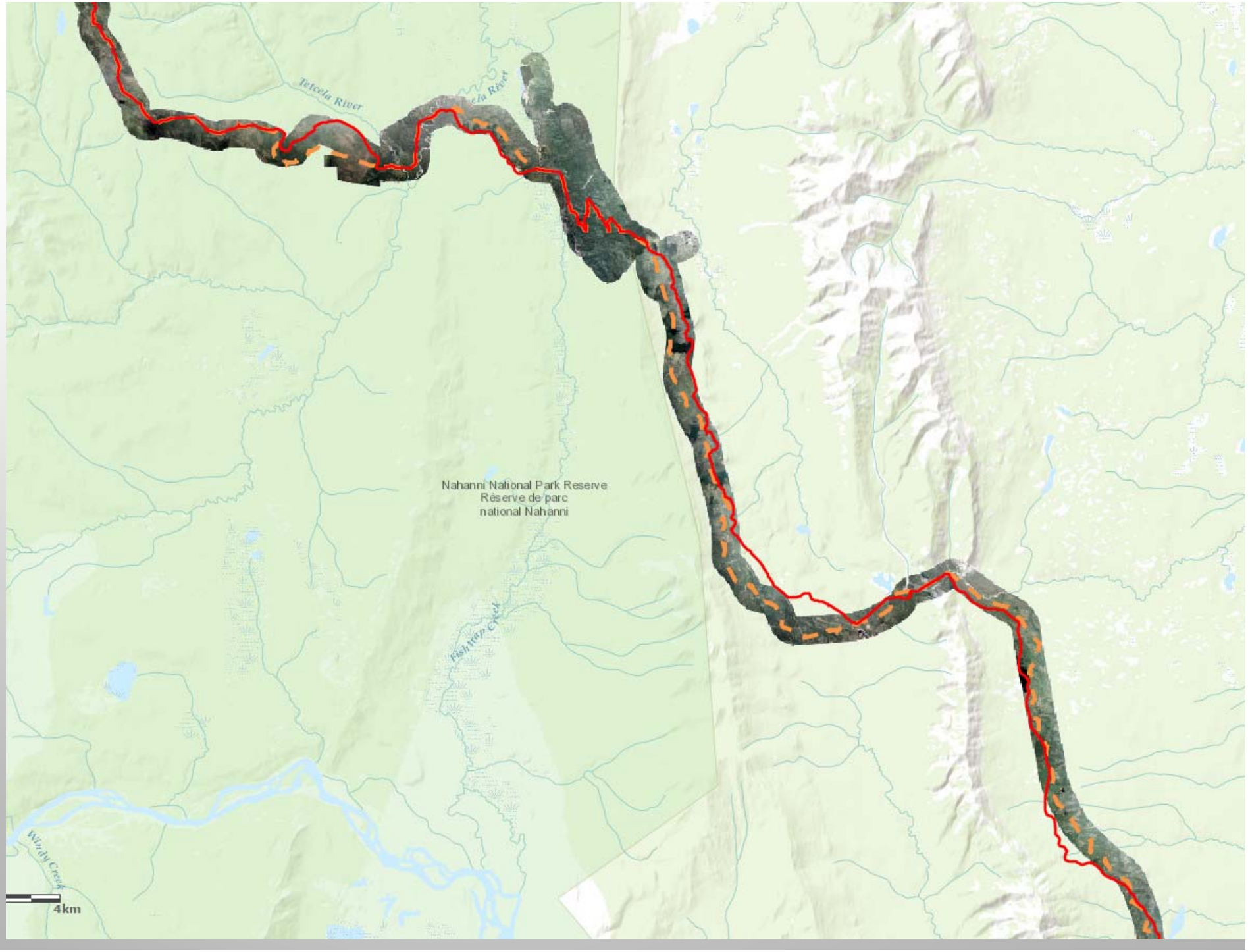
CANADIAN ZINC CORPORATION

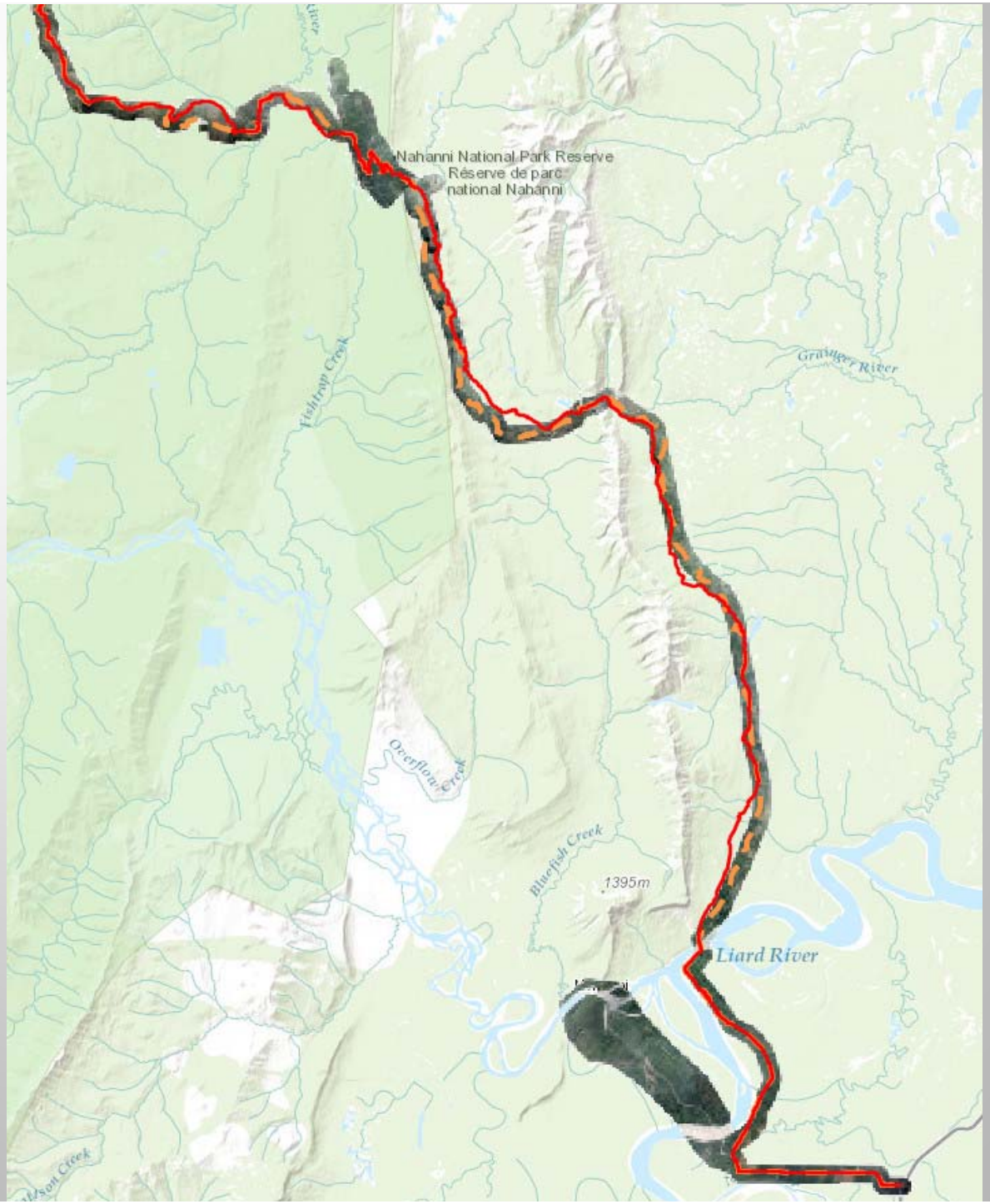
Access Road Alignment



CANADIAN ZINC CORPORATION




Nahanni National Park Reserve
Réserve de parc
national Nahanni
4km


Nahanni National Park Reserve
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Fishtrap Creek
Grainger River
Otterflow Creek
Bluefish Creek
1395m
Liard River

Creek Crossings

- Major crossings – large and fish-bearing streams
- Minor crossings – small and non-fish-bearing streams
- In the absence of reliable data, fish assumed to be present

CANADIAN ZINC CORPORATION

Sundog Creek Km 28

Sundog Creek Km 29

Sundog Creek Km 37

Sundog Creek Km 38

Polje Creek Km 54

Tetcela Tributary Km 88

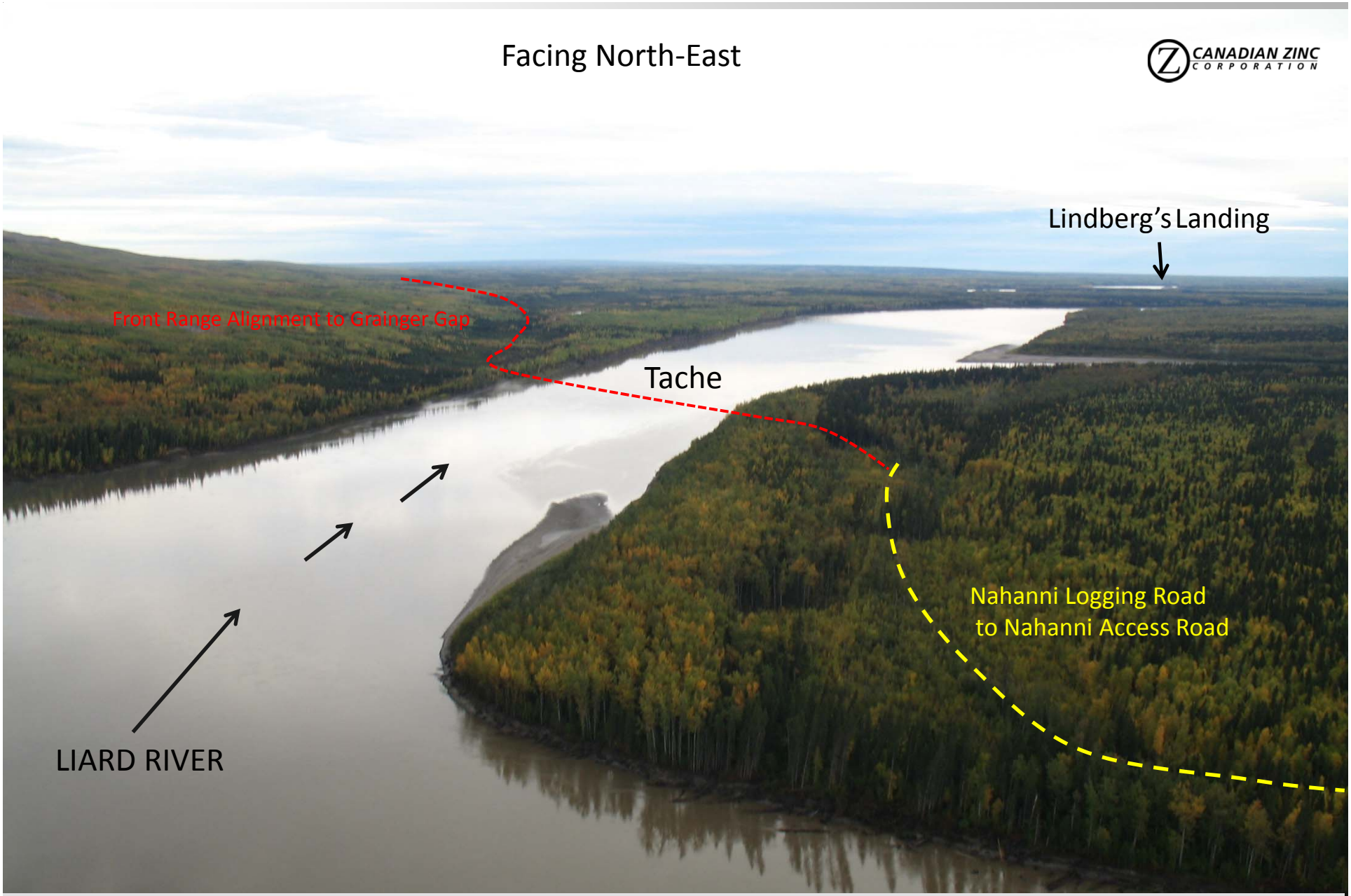
Tetcela River Km 90

Grainger River Km 123

Grainger River West of Grainger Gap

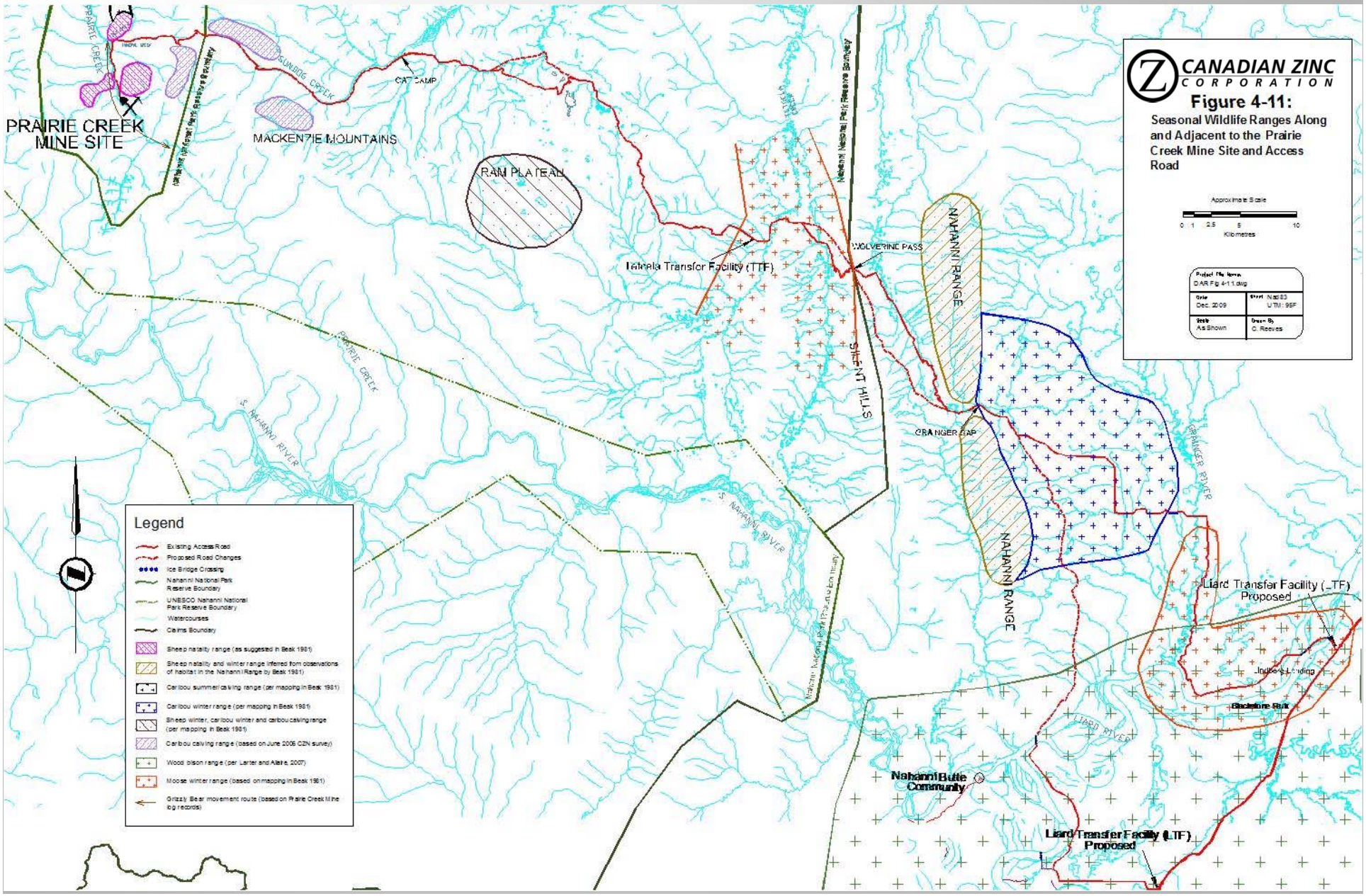
Grainger River Km 125

Facing North-East



Location of Liard Crossing: Ice Bridge, Barge Landings and Staging Areas

Wildlife


CANADIAN ZINC CORPORATION
Figure 4-11:
Seasonal Wildlife Ranges Along and Adjacent to the Prairie Creek Mine Site and Access Road
PRAIRIE CREEK MINE SITE
MACKENZIE MOUNTAINS
RAM PLATEAU
CAT CAMP
SUNBIRD CREEK
Tehtela Transfer Facility (TTF)
WOLVERINE PASS
NAHANNI RANGE
SILENT HILLS
GRANGER GAP
GRANGER RIVER
PRAIRIE CREEK
S. NAHANNI RIVER
LIARD RIVER
Liard Transfer Facility (LTF) Proposed
Nahanni Butte Community
Legend
Existing Access Road
Proposed Road Changes
Ice Bridge Crossing
Nahanni National Park Reserve Boundary
UNESCO Nahanni National Park Reserve Boundary
Watercourses
Claims Boundary
Sheep natality range (as suggested in Beak 1981)
Sheep natality and winter range inferred from observations of habitat in the Nahanni Range by Beak 1981)
Caribou summer/calving range (per mapping in Beak 1981)
Caribou winter range (per mapping in Beak 1981)
Sheep winter, caribou winter and caribou calving range (per mapping in Beak 1981)
Caribou calving range (based on June 2006 CZN survey)
Wood bison range (per Larter and Allaire, 2007)
Moose winter range (based on mapping in Beak 1981)
Grizzly Bear movement route (based on Prairie Creek Mine log records)

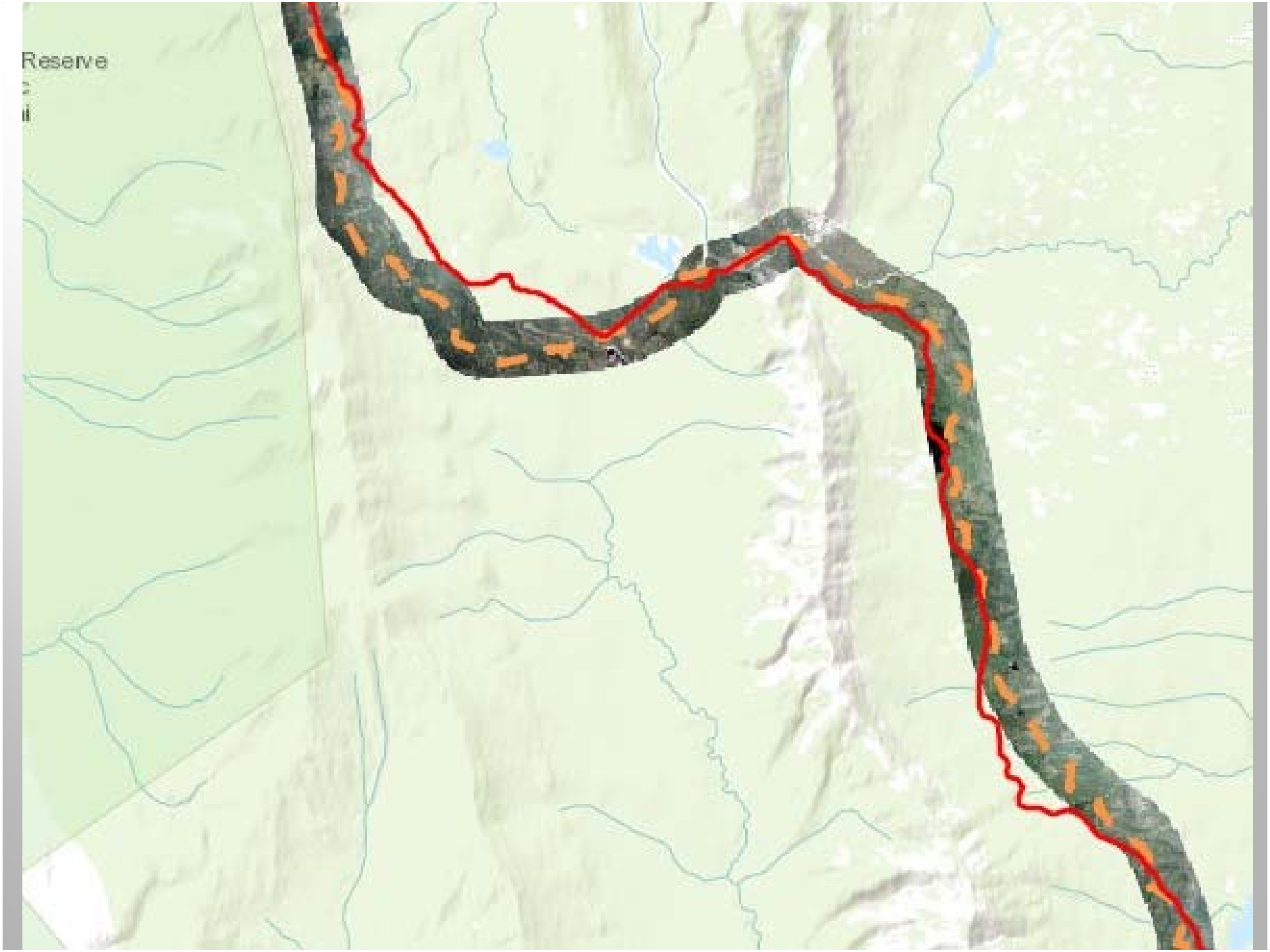
Wetlands

- Fishtrap Creek
- Bluefish Creek

CANADIAN ZINC CORPORATION

Fishtrap Creek Km 95

Fishtrap Downstream


Reserve

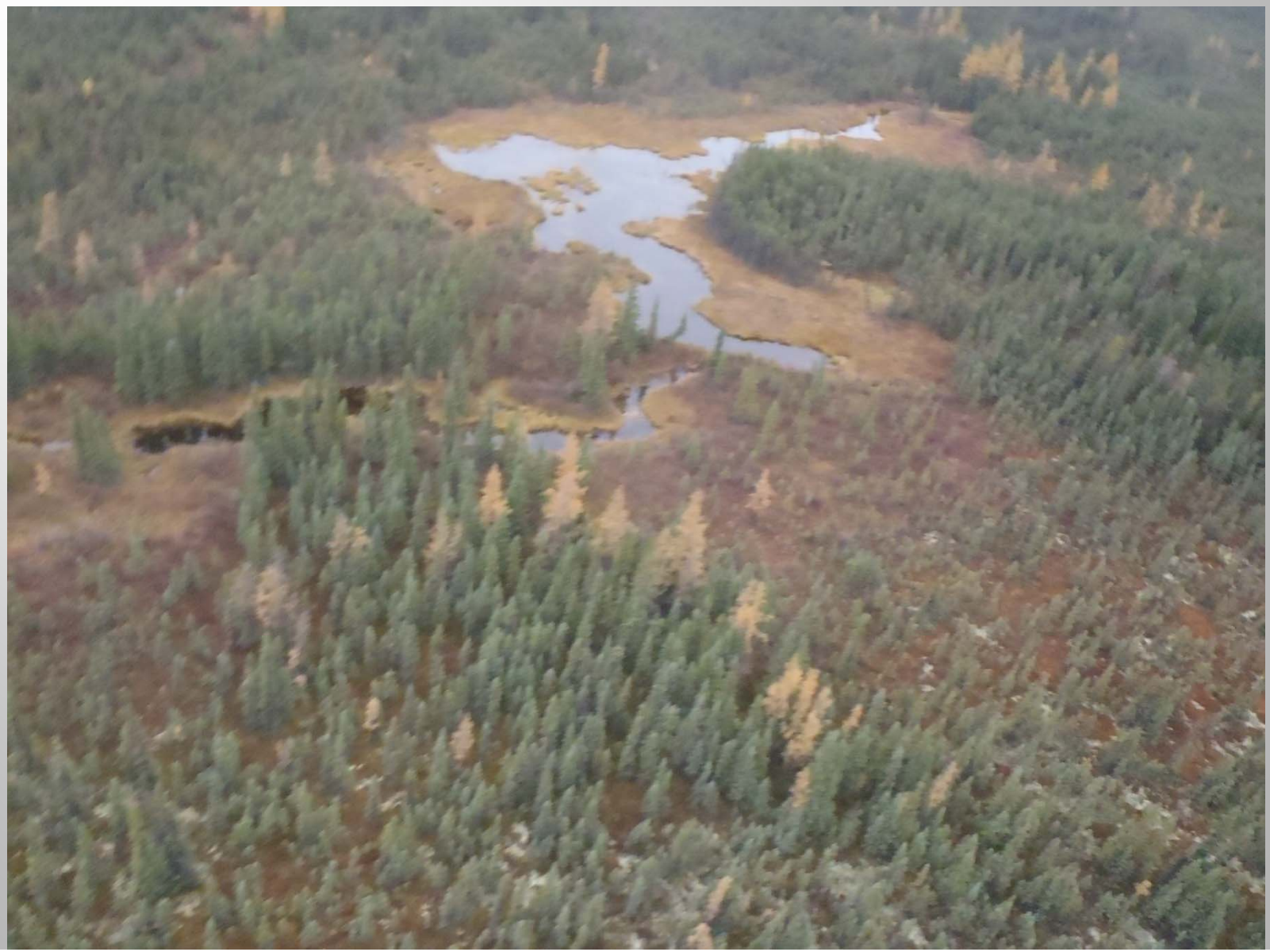
Bluefish Creek

Bluefish Creek South of Bluefish Lake

Bluefish Creek mid-way between Bluefish Lake and Grainger Gap

Bluefish Creek further upstream

Bluefish Creek further upstream

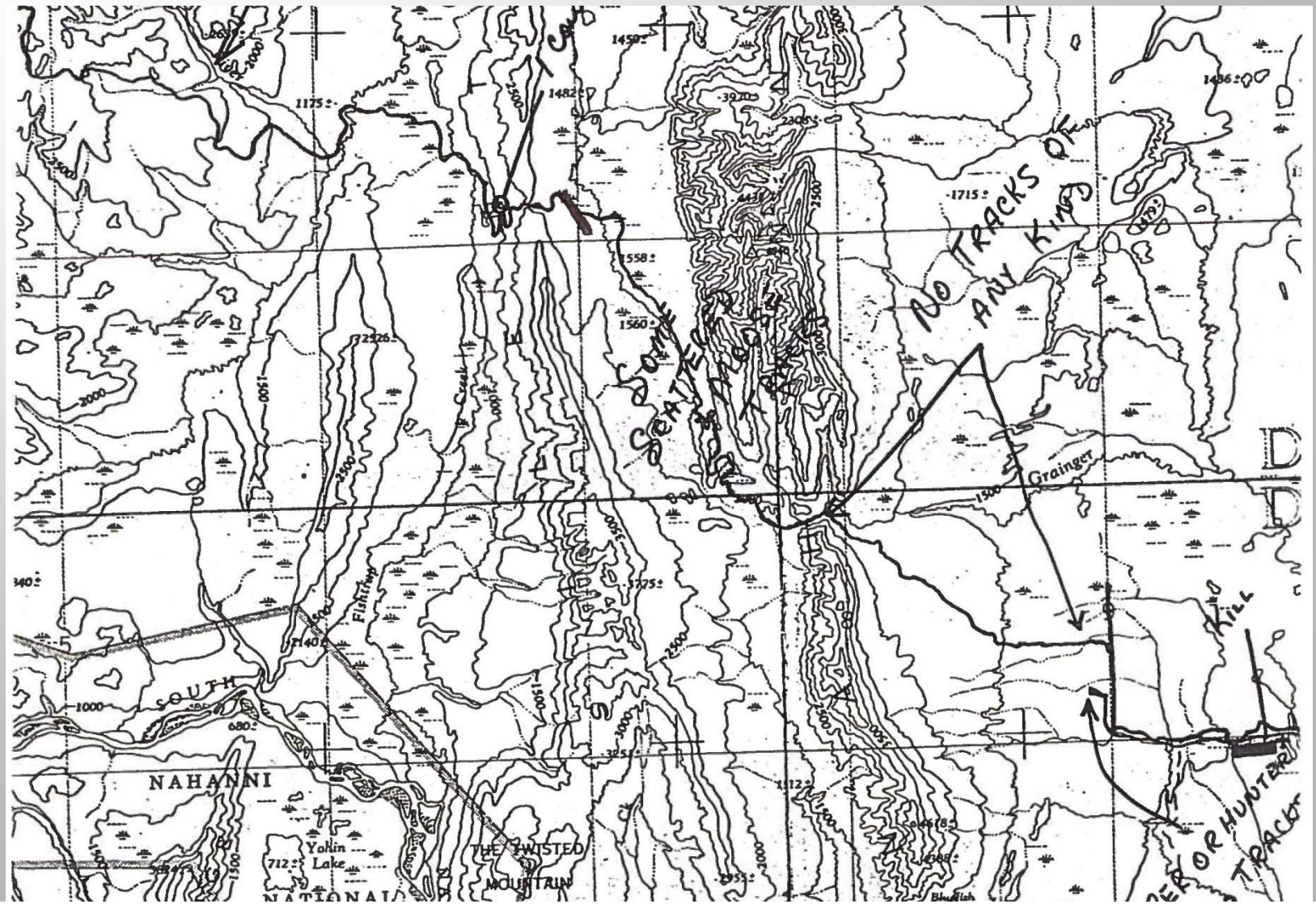


Airstrips

- Previously used at Cat Camp and Wolverine Pass
- Parks believe they can't authorize in the NNPR
- Re-establish Wolverine Pass strip

CANADIAN ZINC CORPORATION

Old Airstrip Locations



Wolverine Airstrip

Access Control

- Private barge for Liard crossing
- Summer check-point at Grainger Gap
- No-shooting corridor?

CANADIAN ZINC CORPORATION

- Thank you
- Questions?

CANADIAN ZINC CORPORATION

ENGAGEMENT RECORD

Party Engaged: Liidlii Kue First Nation (LKFN)

Date/Time: November 28, 2014 / 11 am

Location: LKFN Band Office, Fort Simpson, NT

LKFN Attendees: Band Council members; Betty Hardisty, Cindy Browning, Jim Antoine; LKFN Executive Director, Lisa McPherson; Nogha Enterprises, General Manager, Dan Hillman; Kathy Tsetso.

CZN Attendees: Alan Taylor, David Harpley, Wilbert Antoine

Issues Discussed:

1. Project Status
2. All Season Access Road Studies

Alan Taylor started the meeting by again extending the Company's condolences regarding the passing of Chief Minnie Letcher. Mr. Taylor noted that financing is required to advance the project, and that the construction schedule has been delayed. He advised that much work is on-going to fine-tune the project, and obtain firm costs for construction based on bids for various packages.

Regarding the all season road proposal, David Harpley advised that CZN is pursuing initiatives that would deter un-authorized use of the road. One option is to install a gate similar to the road to the Nico project. However, this was possible because the Tlicho own the land, but the land in the Dehcho is currently public. Another option is a "no shooting" corridor established along the road, for safety reasons and to deter hunting by people from outside the region. Jim Antoine advised that there used to be a no-shooting corridor on the Liard Highway in the 90's. It seems the corridor ceased to exist due to a lack of resources to police it. Some members noted that additional resources would be required to institute a no-shooting corridor.

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Issues Resolved:

There was support among the Band members present for a no-shooting corridor for the access road and the Liard Highway, but members felt it is important to start with the access road and to look to extend the corridor to include the highway later.

Issues Unresolved:

None.

Signature of Party Representative Confirming Accuracy of Engagement Record:

_____ _____

Name Signature

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ENGAGEMENT RECORD

Party Engaged: Naha Dehe Dene Band (NDDB)

Date/Time: January 20, 2015 / 11.45 am

Location: Nahanni Butte Gym, NT

NDDB Attendees: Chief Mike Matou; Elders Elsie Marcellais, Jean Marie Konisenta, Laura Vital; Band Council members Peter Marcellais, Lorraine Vital, Tammie Matou, Jayne Konisenta; Band members Violet Tesou, David Konisenta, Burton Campbell, Jimmy Tonka, Megan Bertrand, Clayton Konisenta, Hank Matou, Steve Vital, Dean Marcellais.

CZN Attendees: Alan Taylor, David Harpley, Wilbert Antoine

Issues Discussed: Much of the meeting was a repeat of the meeting on November 28, 2014 when few Band members were present.

1. Project Status
2. All Season Access Road

CZN gave a power-point presentation (attached) to update Band members on the project schedule and items that are being worked on, provide interim results of studies conducted related to the all season road proposal, and discuss access control and tourism possibilities associated with the access road.

Alan Taylor noted that financing is required to advance the project, but that much work is on-going to fine-tune the project, and obtain firm costs for construction. Unfortunately, the mining industry is in a down-turn and the mine start-up schedule cannot presently be confirmed.

David Harpley summarized the results of work on the access road, and advised that CZN is working to address those issues raised by the community during scoping for the EA. In this respect, stream crossings have been classified as major and minor, and all fish-bearing crossings are considered to be major. Data has been collected to

determine the appropriate crossing structures for these. Photographs were shown of wetland crossings. Fishtrap Creek will be crossed close to its headwaters where beaver dams are common. Figures were provided showing that Bluefish Creek and its basin are not crossed at all.

Mr. Harpley showed proposed airstrip locations to support the road. He said the strip on the west side of the Ram is to replace the previously used Cat Camp strip. The old strip east of Wolverine Pass would only be used in winter, as it was before.

Mr. Harpley commented that CZN is aware that the biggest issue for the community related to the all season road is use by non-residents for hunting up to the park boundary. In that regard, CZN is pursuing initiatives that would provide additional access control over and above the manned security check-point, signage and the fact that the barge on the Liard River crossing would be private. CZN would like to see a “no shooting” corridor established along the road, for safety reasons and to deter hunting by people from outside the region which could lead to a decline in mainly moose numbers. Mr. Harpley also said that when land claims is settled, the road could be made private which would allow total control on access. CZN is investigating both of these initiatives.

Mr. Harpley said that CZN believes there is a significant tourism opportunity associated with the all season road. Multiple opportunities are available, such as guided walks, outfitting, tours on the Ram, and use of the Ram strip for flights by tourists accessing the area by road. CZN believes the road would make park tourism more affordable, and attract more visitors. A decision would need to be made regarding what type of vehicle would be allowed to travel to and within the park. A camp or campground could be established just before or inside the park. Travel from there in the park might then be by park vehicles only. Whatever the plan is, CZN sees it being strictly controlled, but ultimately, the community and the region will decide what the plan is, it is not for CZN to say.

CZN was asked how the environmental assessment was proceeding. Mr. Harpley said CZN is working on the assessment report, and after that, there would be a review phase, possibly a technical session, and definitely a public hearing.

CZN was asked about the Liard location and proximity to burial sites. After review, it was confirmed that the burial sites are several hundred metres upstream from the crossing location.

Burton Campbell commented that he thought only mine vehicles and small trucks should be allowed to use the road i.e. not RV’s.

Issues Resolved:

No issues were resolved, but that wasn't the intent of the meeting. It was intended to be an update and open discussion.

Issues Unresolved:

The extent of access control, and the tourism model.

Signature of Party Representative Confirming Accuracy of Engagement Record:

_____ _____

Name Signature

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PRAIRIE CREEK MINE:

COMMUNITY MEETING

January, 2015

CANADIAN ZINC CORPORATION

Agenda

- Current and Future Activities
- Mine Development Schedule
- All Season Road

CANADIAN ZINC CORPORATION

Current and Future Activities
Mine Site

- Underground re-opening
- Decline tunnel dewatering
- Underground drilling

CANADIAN ZINC CORPORATION

Current and Future Activities Office

- Determine costs for equipment
- Engineering design
- Construction cost estimation
- Source financing

CANADIAN ZINC CORPORATION

Mine Development Schedule

- 2016 Winter Road
- Construction spring-fall 2016
- Commissioning from fall 2016

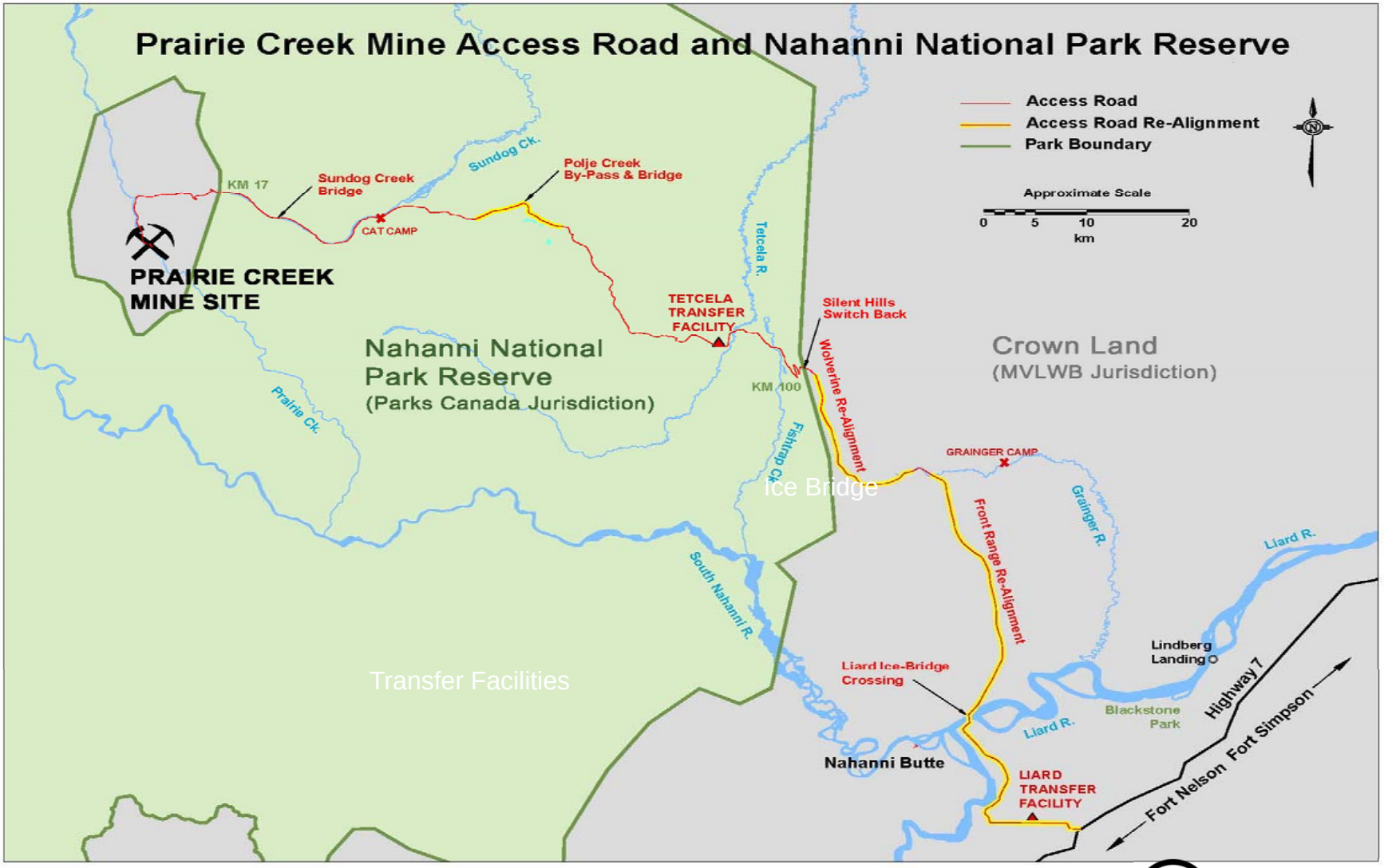
CANADIAN ZINC CORPORATION

All Season Road EA – Progress

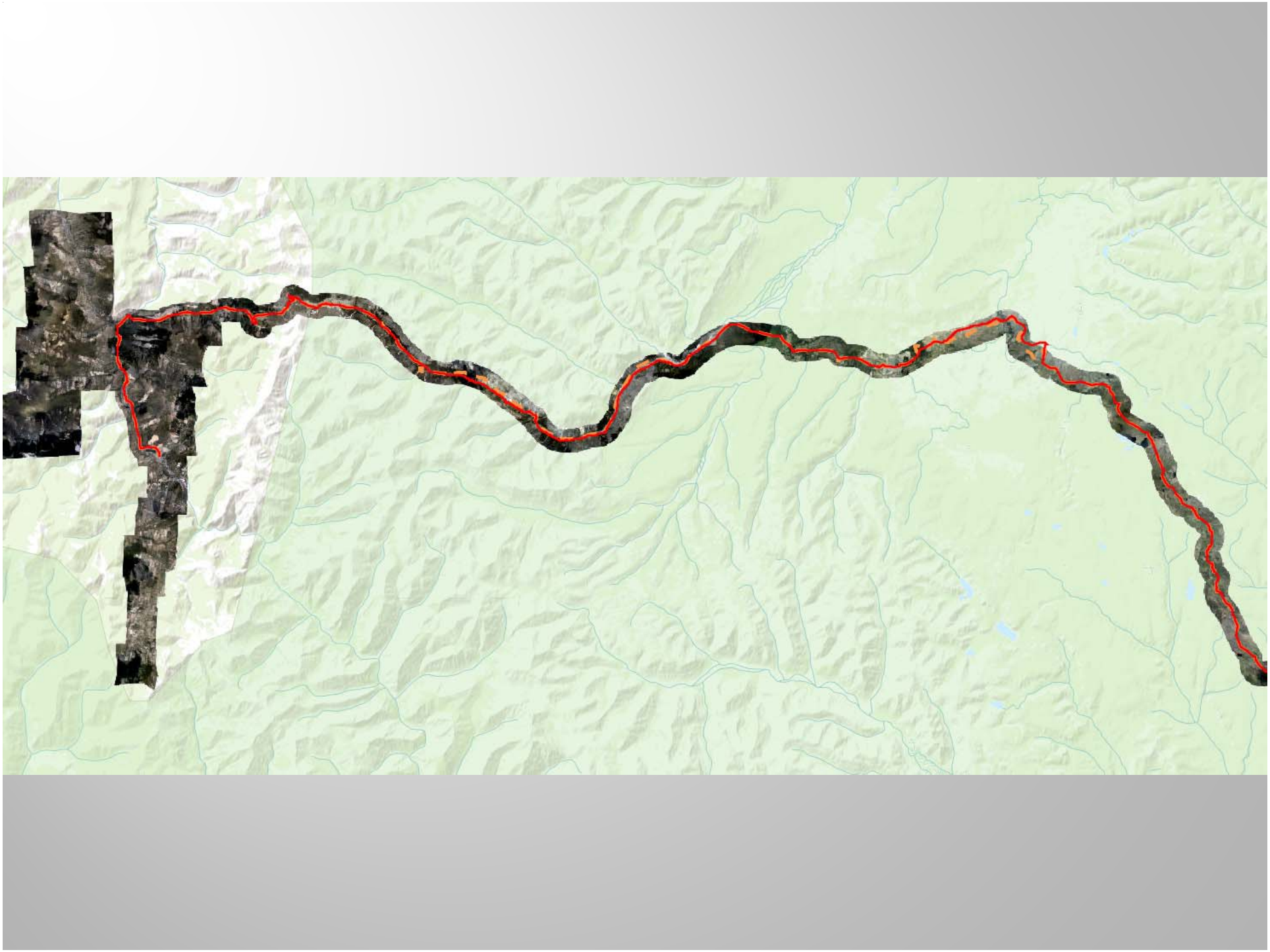
- Two field investigation programs
- Alignment
- Creek crossings
- Wildlife
- Wetlands
- Airstrip
- Access control
- Tourism Potential

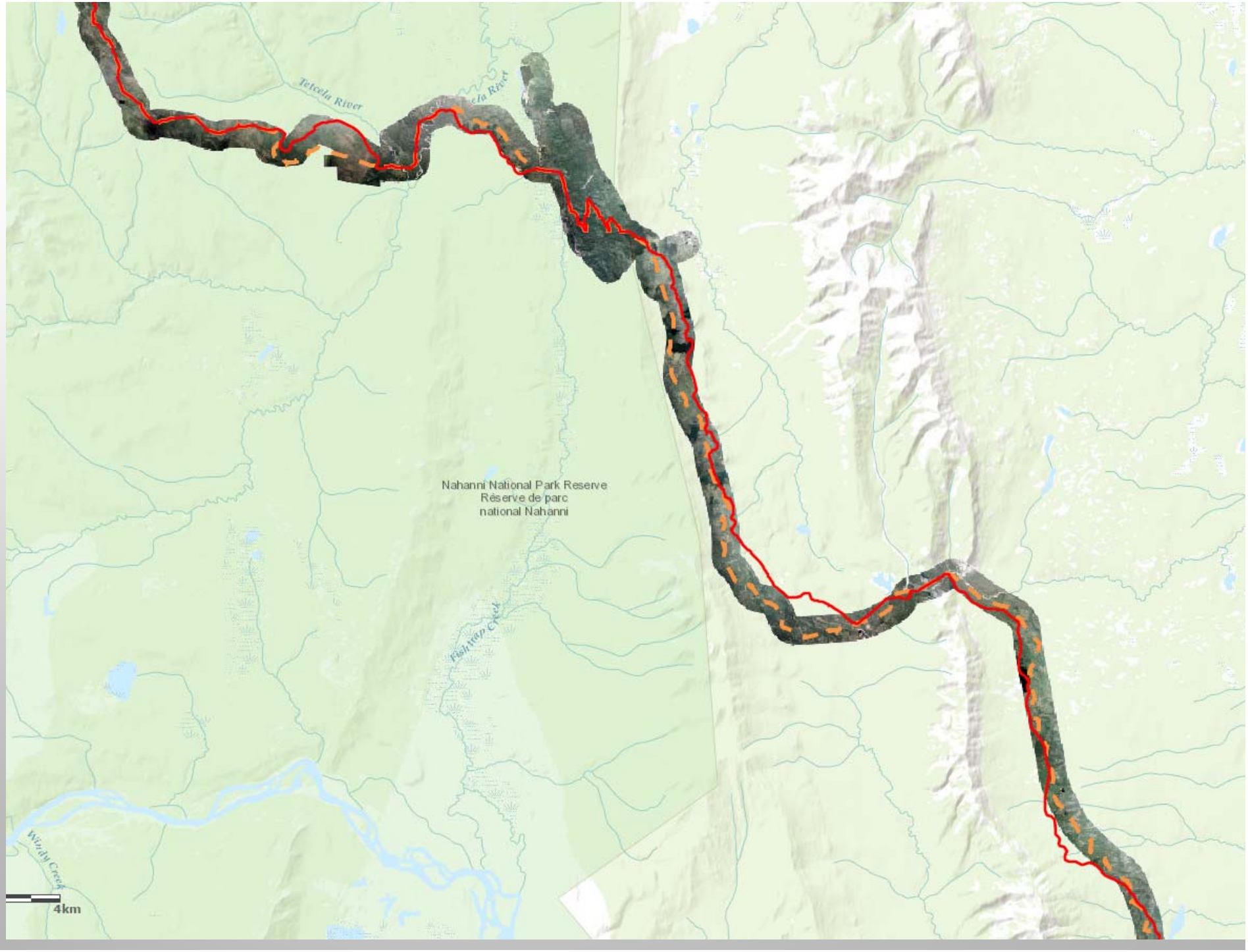
CANADIAN ZINC CORPORATION

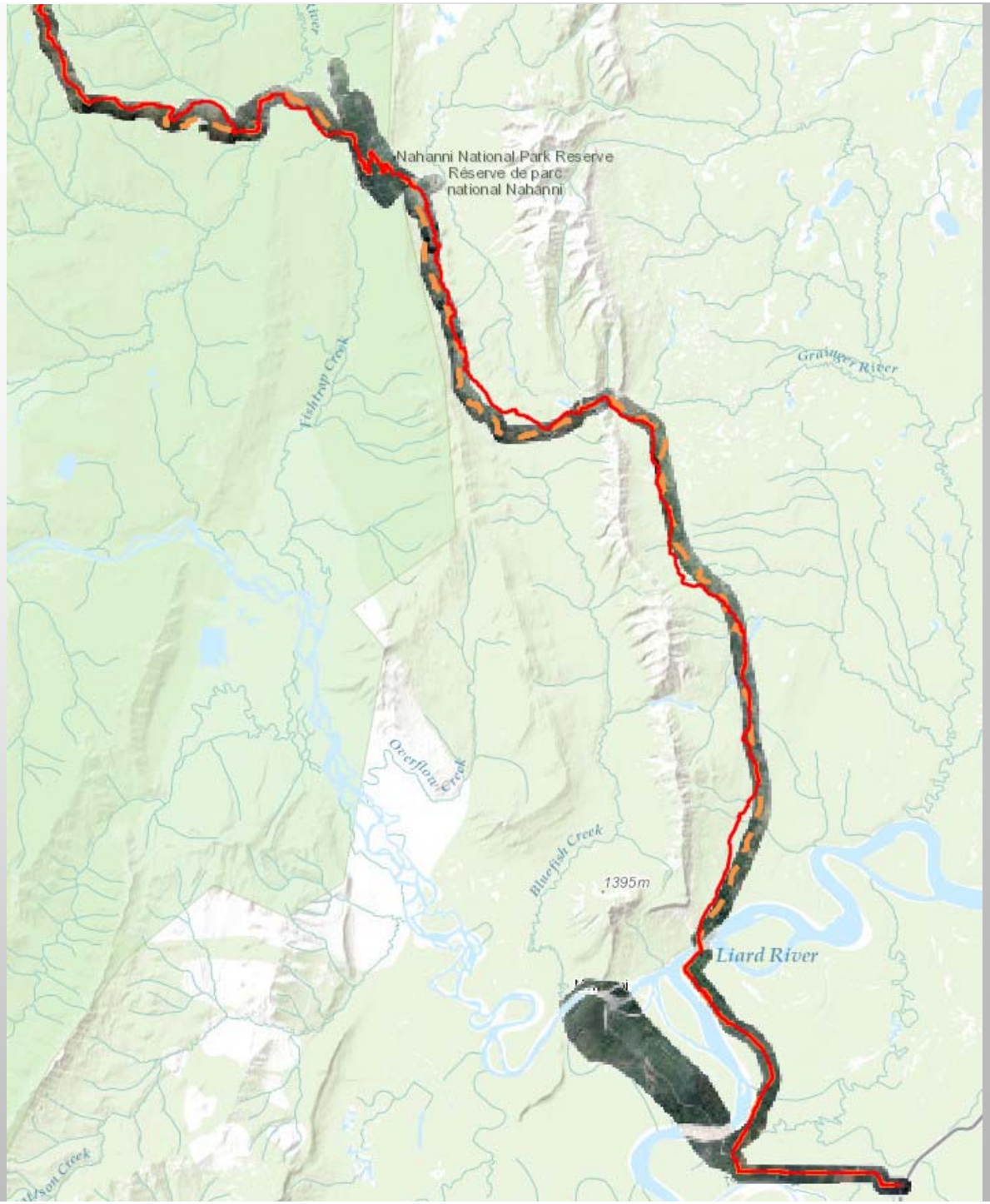
Access Road Alignment



CANADIAN ZINC CORPORATION




Nahanni National Park Reserve
Réserve de parc
national Nahanni
4km


Nahanni National Park Reserve
Réserve de parc
national Nahanni
Fishtrap Creek
Grainger River
Otterflow Creek
Bluefish Creek
1395m
Liard River

Creek Crossings

- Major crossings – large and fish-bearing streams
- Minor crossings – small and non-fish-bearing streams
- In the absence of reliable data, fish assumed to be present

CANADIAN ZINC CORPORATION

Sundog Creek Km 28

Sundog Creek Km 29

Sundog Creek Km 37

Sundog Creek Km 38

Polje Creek Km 54

Tetcela Tributary Km 88

Tetcela River Km 90

Grainger River Km 123

Grainger River West of Grainger Gap

Grainger River Km 125

SURVEY CONTROL			
DESCRIPTION	NORTHING	EASTING	ELEVATION
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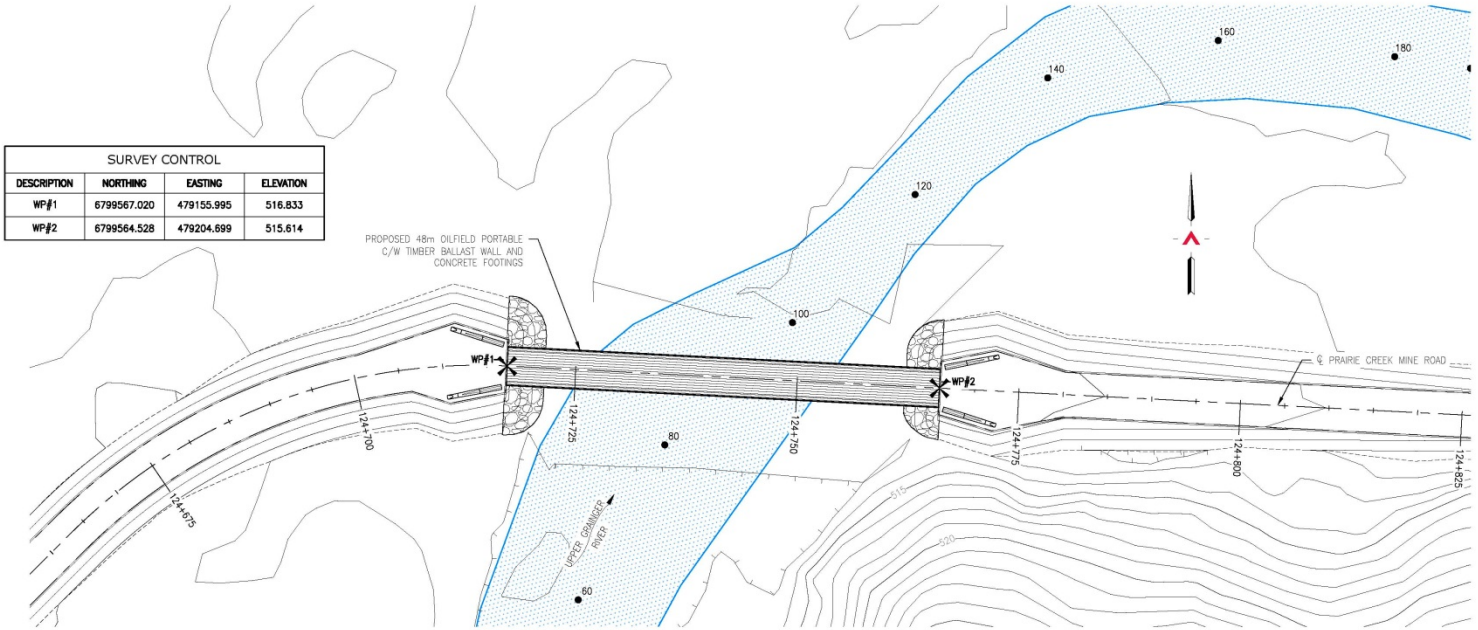
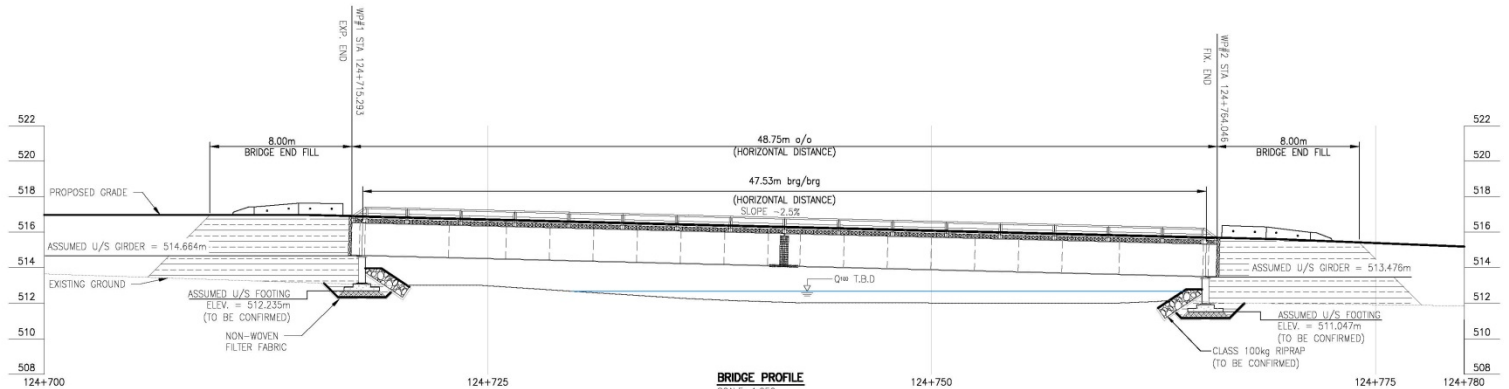
WP#2	6799564.528	479204.699	515.614



GENERAL ARRANGEMENT PLAN
SCALE: 1:500



BRIDGE PROFILE
SCALE: 1:250

REFERENCE DRAWINGS		
DRAWING NO	DRAWING DESCRIPTION/TITLE	REF
-	-	1

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REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
0	2014/12/12	ISSUED FOR REVIEW	IHY	WBM

CLIENT:
CANADIAN ZINC CORPORATION

Allnorth

CLIENT NO:		DRWN: IHY	DATE: 14/12/08
PROJECT NO:	14-GP-0128	DSGN: WBM	DATE: 14/12/08
DRAWING SIZE:	ANSI "B"	CHKD:	DATE:
SCALE:	AS NOTED	APVD:	DATE:

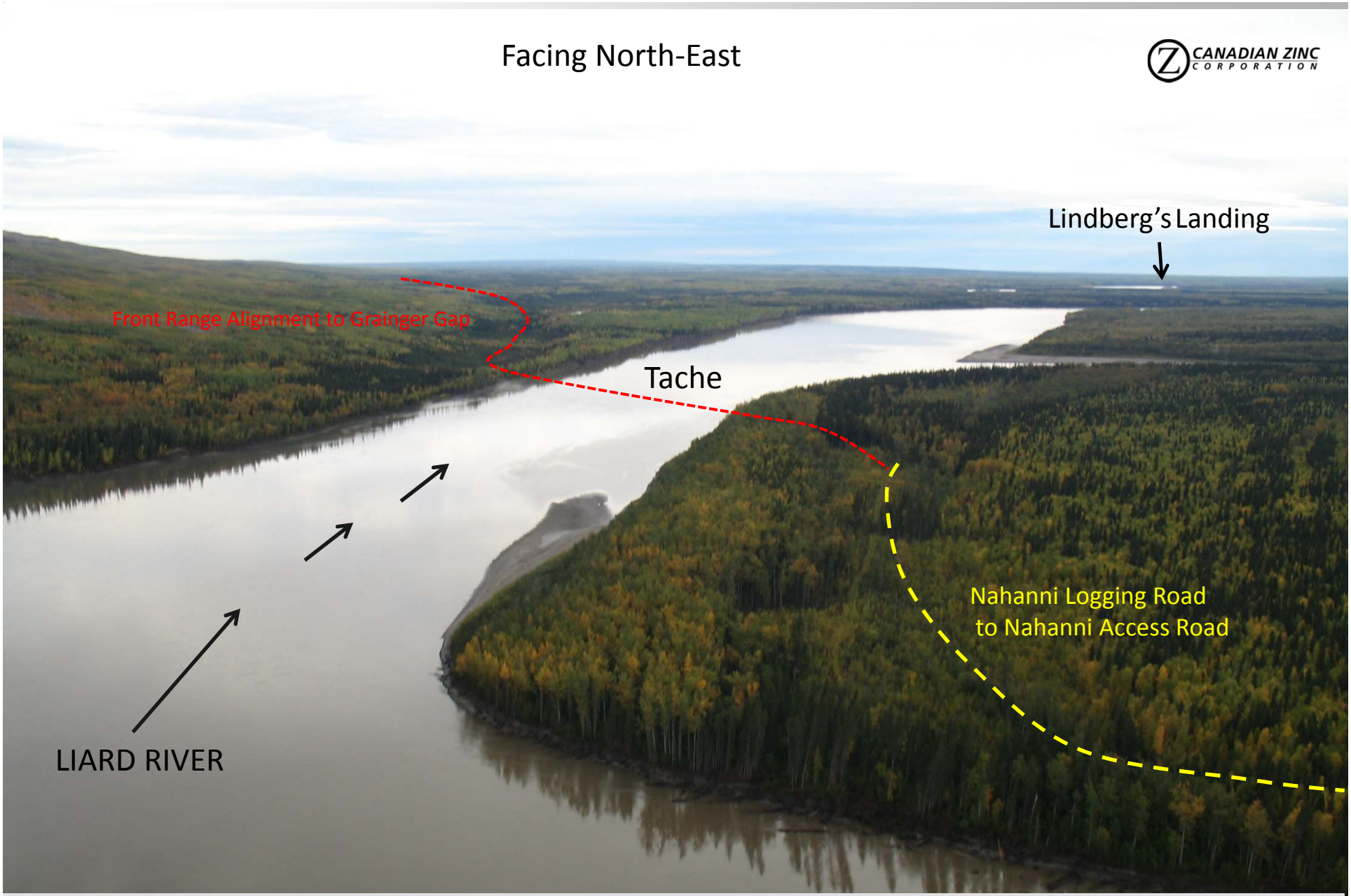
PROJECT:
STREAM CROSSING UPPER GRAINGER RIVER PRAIRIE CREEK MINE ROAD AT STA. 124+800

TITLE:
GENERAL ARRANGEMENT PLAN AND BRIDGE PROFILE

DWG NO:	REV:
14GP0128-124-1960-003	0

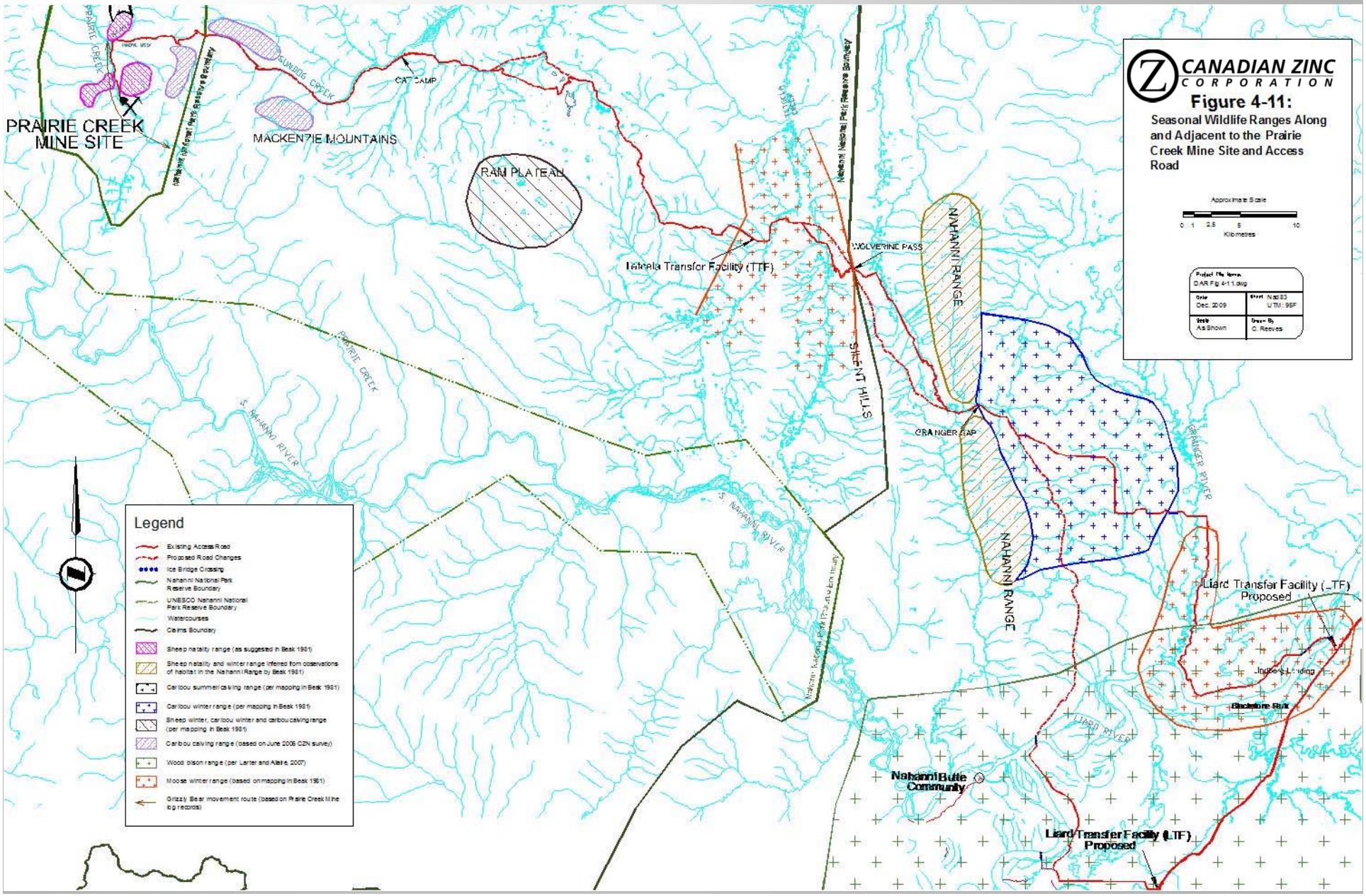
Date: 2014/12/16 | User: Tammy Beer | File: P:\GP\2014\14-GP-0128_CanadianZinc-PrairieCreekMineRoad\4.0\00-Drawings\1111-Civil\01-Production_Site Plans\14GP0128-124-1960_124+800 | Layout: 003 | Paper Size: 558.8mm x 431.8mm

Facing North-East



Location of Liard Crossing: Ice Bridge, Barge Landings and Staging Areas

Wildlife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CAT CAMP
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WOLVERINE PASS
NAHANNI RANGE
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Caribou calving range (based on June 2006 CZN survey)
Wood bison range (per Larter and Allaire, 2007)
Moose winter range (based on mapping in Beak 1981)
Grizzly Bear movement route (based on Prairie Creek Mine log records)

Wetlands

- Fishtrap Creek
- Bluefish Creek

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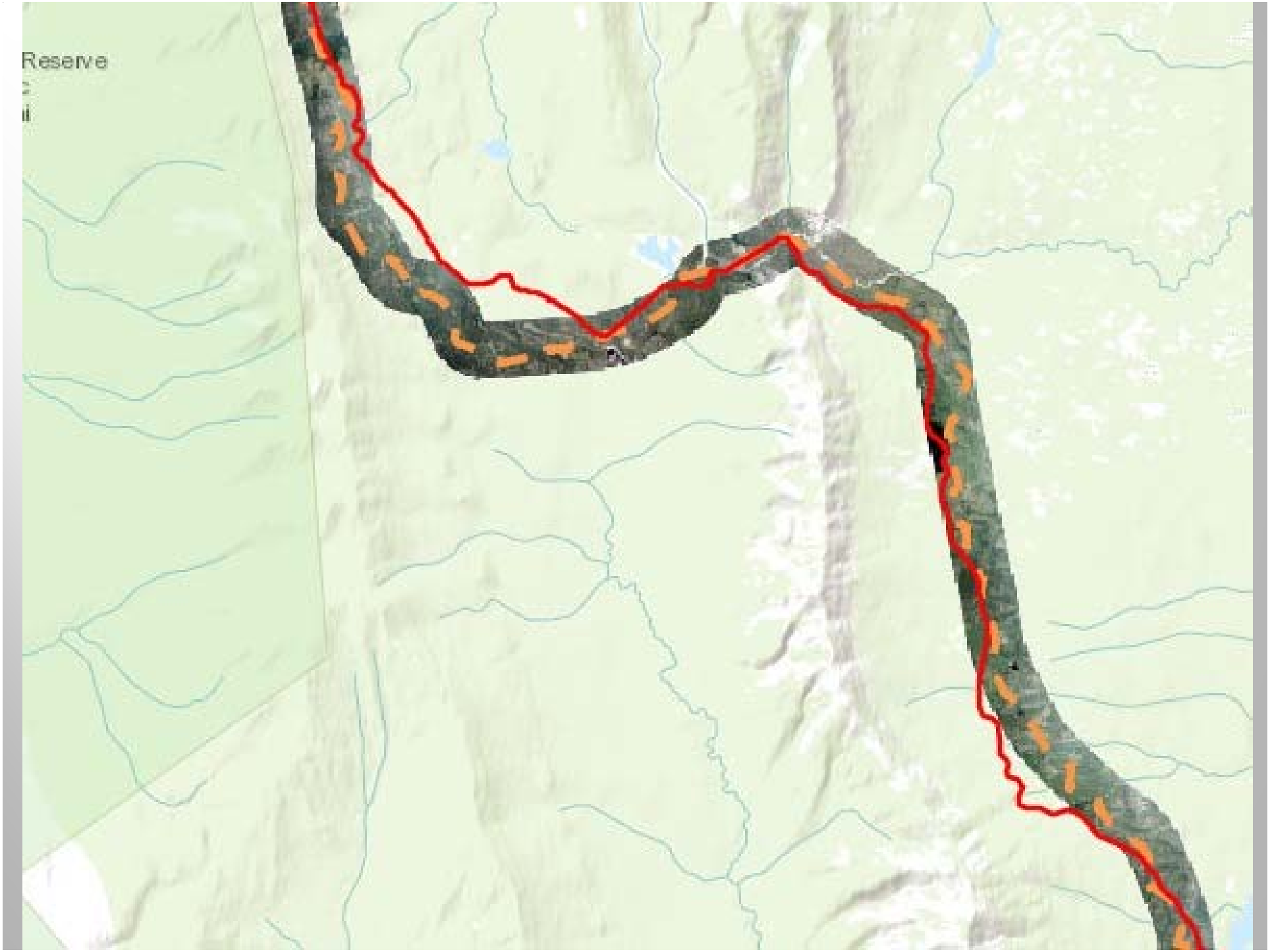
Fishtrap Creek Km 95

Fishtrap Downstream


Reserve

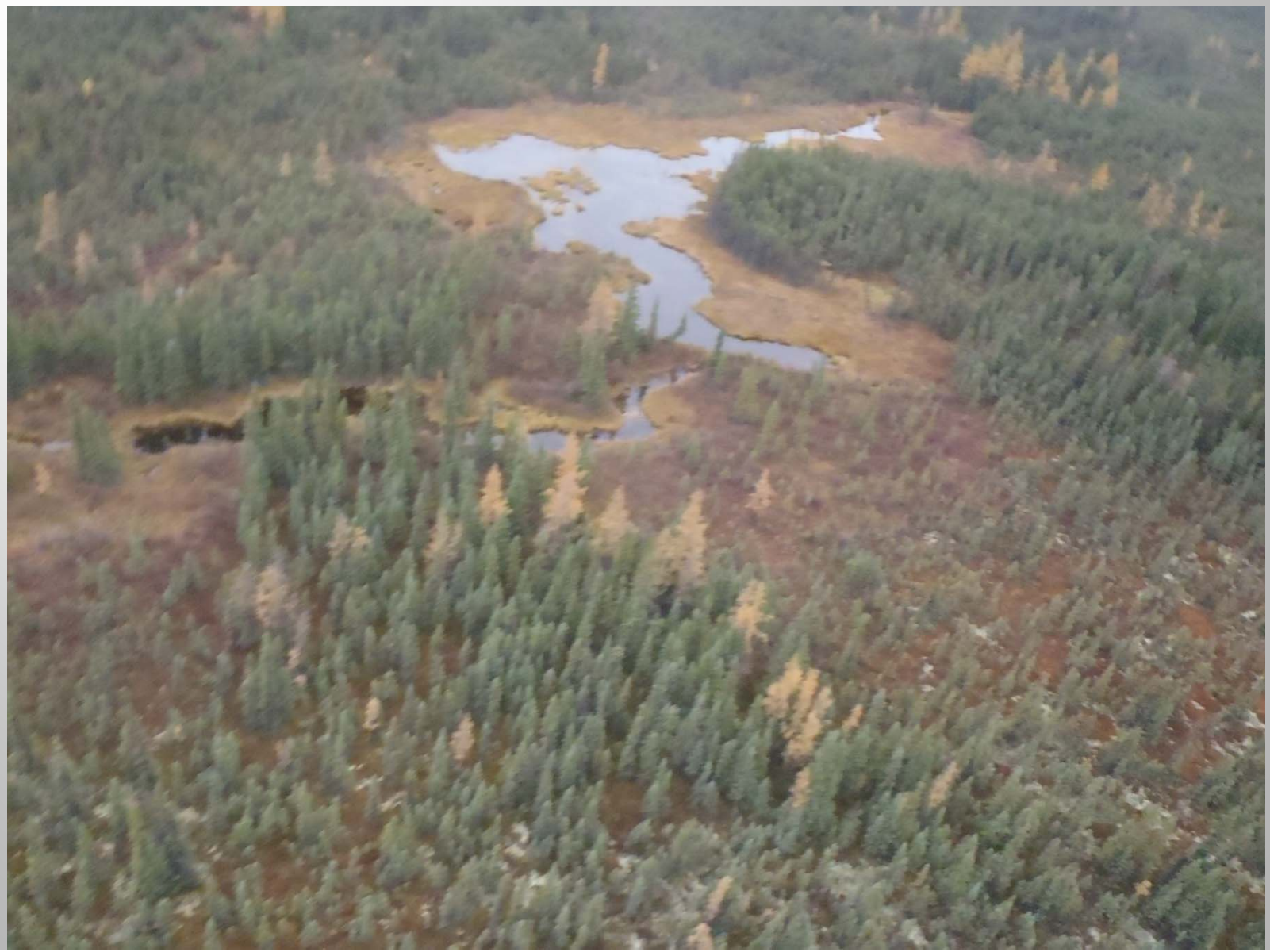
Bluefish Creek

Bluefish Creek South of Bluefish Lake

Bluefish Creek mid-way between Bluefish Lake and Grainger Gap

Bluefish Creek further upstream

Bluefish Creek further upstream



Airstrips

- Previously used at Cat Camp and Wolverine Pass
- Preferred location west of Ram
- Re-establish Wolverine Pass strip

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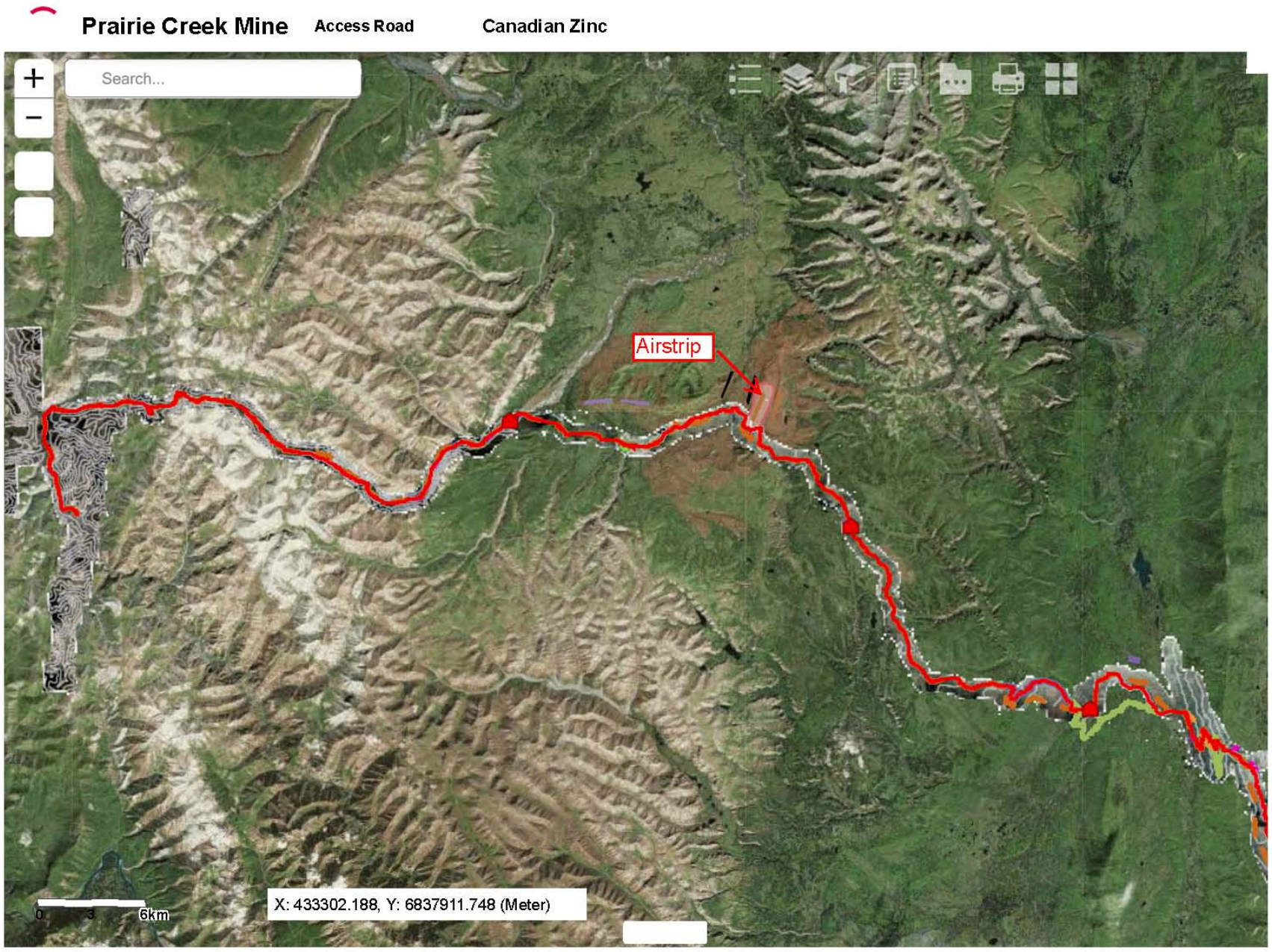
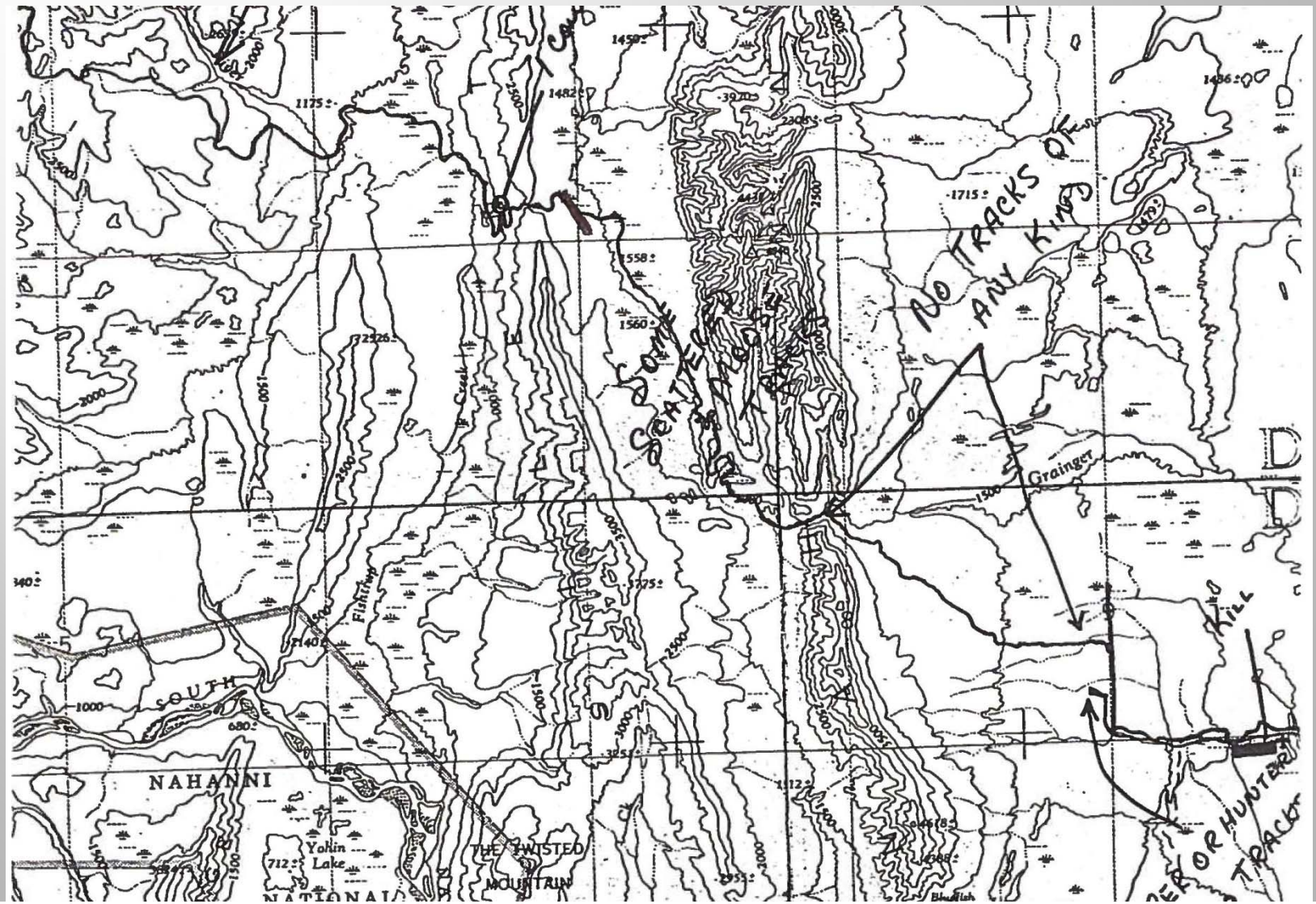

Prairie Creek Mine
Access Road
Canadian Zinc
Search...
Airstrip
0
3
6km
X: 433302.188, Y: 6837911.748 (Meter)

West of Ram Airstrip

Old Wolverine Airstrip



Wolverine Airstrip

Access Control

- Private barge for Liard crossing
- Summer check-point west of Liard River
- No-shooting corridor?
- Land claims settlement – private land?

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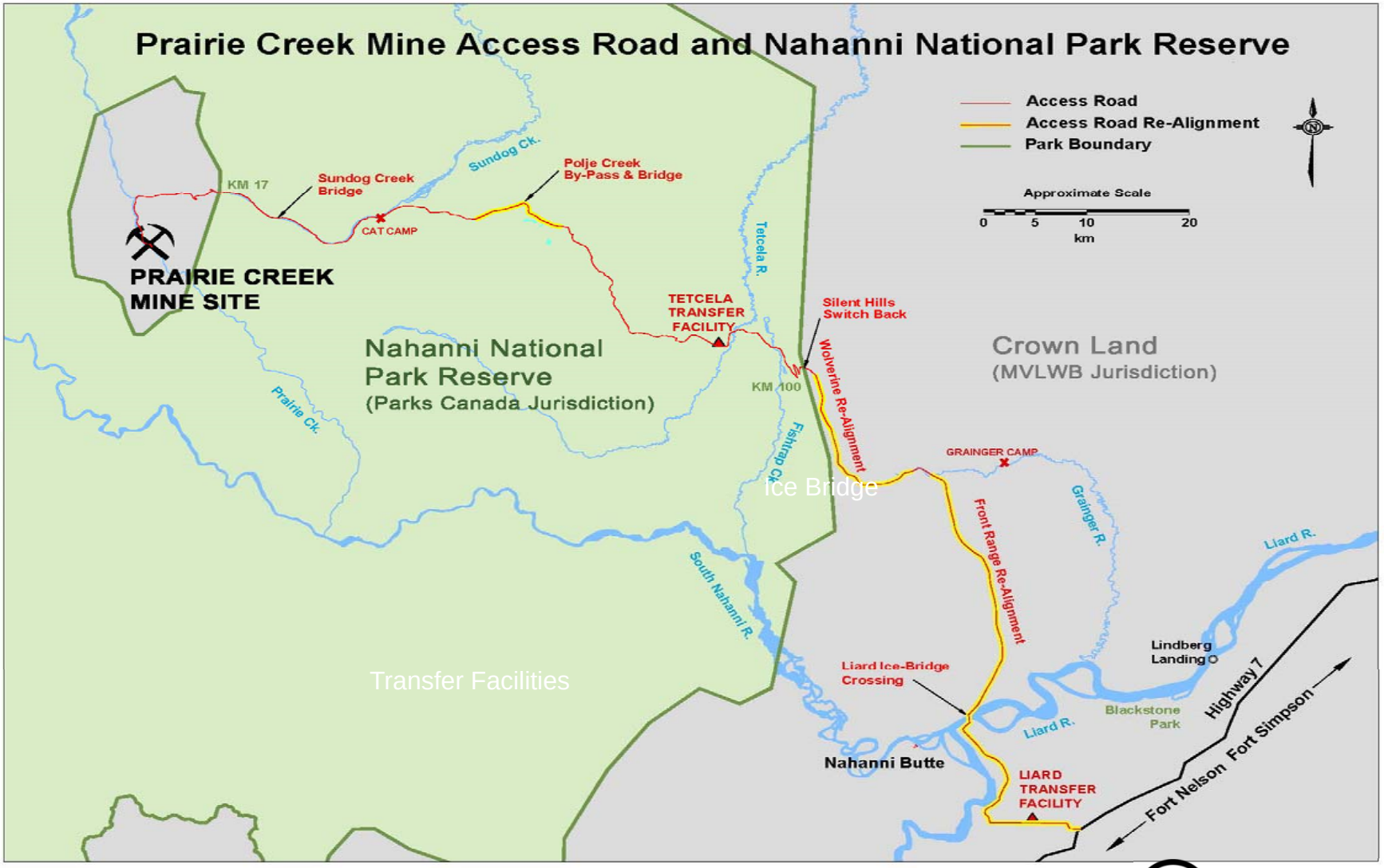
Tourism Potential



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- Thank you
- Questions?

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APPENDIX 14

Prairie Creek Mine
All Season Access Road
Engagement Plan

Background

CZN has had a regional presence in Fort Simpson for over a decade. CZN hired Wilbert Antoine as its Manager of Northern Development, based in Fort Simpson, in the summer of 2008. Mr. Antoine assumed the main community interaction function on behalf of CZN.

Also in 2008, CZN signed a Memorandum of Understanding (MOU) with Parks Canada relating to the expansion of the Nahanni National Park Reserve and the future operation of the Prairie Creek Mine. The parties agreed to make every reasonable effort to address issues of common interest and build a strong working relationship, including convening a Technical Committee to better identify, define and consider issues of common interest. The Committee met every 3-4 months, and in 2009, representatives of the Dehcho First Nation were invited and did attend.

CZN signed MOU's with the Naha Dehe Dene Band (NDDB) and the Liidlii Kue First Nation (LKFN) in 2008. These were a precursor to Impact Benefit Agreements (IBA).

CZN and the NDDB concluded an IBA in January 2011. This was followed by an IBA with the LKFN in June 2011, and a socio-economic agreement (SEA) with the GNWT in August 2011.

As a means of including all neighbouring communities in the Dehcho in the economic development of the Mine, CZN formed the Nahendeh Aboriginal Economic Council (NAEC) in 2010. The intent of the NAEC is to provide a vehicle for the potential involvement of local community development corporations in economic opportunities that cannot be addressed by the IBA communities.

CZN maintains a visible presence in the region as a result of the regional Fort Simpson office, by sponsoring and attending the annual Canadian Zinc Open in Fort Simpson since 2003, and by sponsoring and attending an annual Winterfest in Nahanni Butte since 2010.

Future Engagement

At this pre-construction stage, CZN will be continuing engagement with local aboriginal groups on many fronts, as follows:

- Wilbert Antoine will continue with his regular informal and formal meetings (at least monthly) with LKFN, DFN and the Fort Simpson Metis in Fort Simpson, and his informal meetings with the Chiefs of neighbouring communities during their visits into Fort Simpson, during which he will provide updates on all issues relating to CZN;
- Wilbert Antoine will continue with his visits approximately every 6 months to the community of Nahanni Butte, during which he will update Band members on all issues relating to CZN;
- regular telephone calls, teleconferences and meetings will take place with NAEC members regarding current and potential future contracts;

- Senior CZN management will meet with the LKFN Band council in mid-summer, and if requested, the NDDB council and DFN also. These meetings are usually open to the community to participate, at least in Nahanni Butte;
- Senior CZN management will meet with the NDDB council during Winterfest in January 2015, and the LKFN Band council and DFN also;
- Senior CZN management will be in contact with at least the NDDB and LKFN during the course of the expected EA and permitting processes.

In addition to the above, CZN's engagement personnel (numbering 3) receive telephone calls from Band members and/or their representatives on a weekly basis. As a result, there is an almost constant process of on-going discussion, feedback and issue resolution.