Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

PO Box 1500
Yellowknife, NT
X1A 2R3

June 3, 2011

MVEIRB File Number: EA 0809-002

Mr. Chuck Hubert
Environmental Assessment Officer
Mackenzie Valley Environmental Impact Review Board
P.O. Box 938
YELLOWKNIFE NT, X1A 2N7
FAX: 766-7074

VIA EMAIL: chubert@reviewboard.ca

Re: Technical Report – Canadian Zinc Corporation – Proposed Prairie Creek Mine – EA0809-002

Indian and Northern Affairs Canada (INAC) is pleased to submit the attached technical report to the Mackenzie Valley Environmental Impact Review Board (REVIEW BOARD) on the proposed Canadian Zinc Corporation Prairie Creek Mine (EA0809-002).

This technical report represents our review of the information received between April 6, 2009 and May 18, 2011; this includes the Developer's Assessment Report (DAR), addendums to the DAR, responses to Information Requests, and information presented and provided during and following the two Technical Sessions hosted by the Board.

INAC notes that additional information was submitted by the Developer after May 18th; however, INAC was unable to review and incorporate this information within its technical report under the timelines specified by the Board.

INAC would like to thank the Board for the opportunity to present our technical review of the proposed Prairie Creek Mine. INAC would like to confirm our attendance at the upcoming Pre-Hearing Conference, currently scheduled for June 6, 2011. In addition, INAC staff will be present at the upcoming June 22nd Community Hearing in Nahanni Butte, as well as the June 23-24th Technical Hearings in Fort Simpson. INAC's retained consultants, Mr. Barry Zajdlik and Mr. John Brodie, will also be available to discuss our concerns and respond to the concerns of the Review Board and other parties at the upcoming Technical Hearing.

If you have any questions about this technical report, please do not hesitate to contact Krystal Thompson by phone at (867) 669-2595 or via email krystal.thompson@inac.gc.ca or Robert Jenkins at (867) 669-2574 or robert.jenkins@inac.gc.ca.

Sincerely,

Teresa Joudrie
Director
Renewable Resources and Environment

INDIAN AND NORTHERN AFFAIRS CANADA
TECHNICAL REPORT

for

CANADIAN ZINC CORPORATION
PROPOSED PRAIRIE CREEK MINE
EA0809-002

June 3, 2011

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Aquatic Effects Monitoring Program	AEMP
Canadian Zinc Corporation	CZN
Canadian Council of Ministers of the Environment	CCME
Closure and Reclamation Plan	CRP
Developer's Assessment Report	DAR
Environmental Assessment	EA
Environmental Effects Monitoring	EEM
Effluent Quality Criteria	EQC
Government of the Northwest Territories	GNWT
Indian and Northern Affairs Canada	INAC
Initial Dilution Zone	IDZ
Mackenzie Valley Environmental Impact Review Board	MVEIRB
Mackenzie Valley Land and Water Board	MVLWB
Mackenzie Valley Resource Management Act	MVRMA
Metal Mining Effluent Regulations	MMER
Nahanni National Park Reserve	NNPR
Northwest Territories	NWT
Northwest Territories Waters Act	NWTWA
Reference Condition Approach	RCA
Site Specific Water Quality Objectives	SSWQO
Water Quality Objective	WQO

NON TECHNICAL SUMMARY

Indian and Northern Affairs Canada (INAC) has legislated responsibilities for water management and protection that stem from the *Northwest Territories Waters Act* (NWTWA). INAC provides expert technical advice to regional resource management boards and is a Responsible Minister under the *Mackenzie Valley Resource Management Act* (MVRMA).

INAC and its retained experts have completed a technical review of the documents related to the Environmental Assessment (EA) of Canadian Zinc Corporation's proposed Prairie Creek Mine up to and including May 18, 2011. Additional information was provided following this date; however, INAC has not completed a critical review of this recent information within this report.

In this report, INAC provides specific comments related to water and environmental issues on the following nine topics:

1. Water Quality Objectives (WQO)
2. Effluent Quality and Effluent Quality Criteria (EQC)
3. Exfiltration Trench and Mixing Analysis
4. Mine Inflows
5. Water Balance and Storage
6. Tailings Storage and Recovery
7. Closure and Reclamation
8. Aquatic Effects Monitoring Program (AEMP)
9. Access Road

Where possible, INAC has provided recommendations to the Mackenzie Valley Environmental Impact Review Board (Review Board) to assist in its decision making process. If insufficient information is available to make a determination of significance, INAC has attempted to clarify for the Review Board why INAC was unable to reach a determination, and present a possible path forward to resolve any outstanding issues.

It is INAC's conclusion that the Prairie Creek Mine project, as currently proposed, presents a high level of risk for significant adverse impacts to water. These risks are associated with the Developer's proposed water management and effluent discharge strategies, and resulting implications on the receiving environment. INAC understands that the proponent has attempted to address these risks, particularly during the last few months of the review process. Much of the uncertainty and risk associated with the Prairie Creek Mine is attributed to the limiting factors of the natural environment in which the Mine is situated. The Prairie Creek Mine is located within a valley floodplain providing limited space for infrastructure and storage. Prairie Creek is the only suitable watercourse for effluent discharge.

Prairie Creek is a tributary of the South Nahanni River and the proposed development will discharge effluent approximately 7 km upstream of the Nahanni National Park Reserve (NNPR) boundary. NNPR is Canada's premier wild river national park and was established in 1976. The Nahanni was subsequently designated one of the first 12 United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites in 1978 and has been designated a Canadian Heritage River (Halliwell and Catto, 2003). In addition, a traditional/subsistence Arctic grayling fishery operates at the mouth of Prairie Creek, where it joins the South Nahanni River. Prairie Creek is highly variable and illustrates little to no trend, which presents challenges for effluent discharge and water management.

Considering the above, INAC must ensure that an adequate level of protection is provided to Prairie Creek and the downstream aquatic environment into which it flows. INAC must be confident that the contingencies proposed by the Developer during operations will provide this level of protection.

INTRODUCTION

Indian and Northern Affairs Canada (INAC) has a mandated responsibility to protect the environment and promote sustainable development in the Northwest Territories. INAC has legislated responsibilities for water management and protection that stem from the *Northwest Territories Waters Act* (NWTWA). INAC provides expert technical advice to regional resource management boards and is a Responsible Minister under the *Mackenzie Valley Resource Management Act* (MVRMA).

In our departmental capacity as an expert advisor, INAC and its retained consultants, Barry Zajdlik of Zajdlik & Associates and John Brodie of Brodie Consulting Limited, have conducted a technical review of the documents related to the Canadian Zinc Corporation's Prairie Creek Mine (EA0809-002). It should be noted that this technical report does not include information submitted by the Developer after May 18, 2011. INAC has not completed a critical review of this recent information within its report, as sufficient time for such a review was not available in advance of the Mackenzie Valley Environmental Impact Review Board's (Review Board) June 3, 2011, technical report deadline. INAC will review this information prior to the upcoming June 22-24, 2011 Public Hearings and will be able to discuss this information if necessary.

In this report, INAC provides specific comments related to water and environmental issues on the following nine topics:

1. Water Quality Objectives (WQO)
2. Effluent Quality and Effluent Quality Criteria
3. Exfiltration Trench and Mixing Analysis
4. Mine Inflows
5. Water Balance and Storage
6. Tailings Storage and Recovery
7. Closure and Reclamation
8. Access Road
9. Aquatic Effects Monitoring Program (AEMP)

In particular, INAC has key concerns relating to the WQOs (#1), water balance and storage (#5) and tailings storage (#6).

Where possible, INAC has provided recommendations to the Mackenzie Valley Environmental Impact Review Board to assist in its decision making process. If insufficient information is available to make a determination of significance, INAC has attempted to clarify for the Review Board why INAC was unable to reach a determination, as well as propose a path forward to resolve any issues.

INAC's TECHNICAL REVIEW

As part of its mandate, INAC and its retained experts, Zajdlik & Associates and Brodie Consulting Limited, have completed a technical review of the documents related to the Environmental Assessment (EA) of Canadian Zinc Corporation's Prairie Creek Mine. In conducting our review, INAC participated in information request stages and two technical sessions, in an attempt to resolve issues identified herein. INAC's review and technical report focuses mainly on the water-related aspects of the proposed project. This report presents INAC's outstanding concerns for key project specific components and the potential impact of the project to the downstream receiving environment.

INAC continues to maintain its position that Prairie Creek and the downstream environment into which it flows be provided a high level of protection. The level of protectiveness INAC feels must be allotted to Prairie Creek is derived from the fact that the downstream environment for the Prairie Creek Mine is the Nahanni National Park, which is also an UNESCO World Heritage Site. INAC's approach for Prairie Creek is consistent with the intent of the NWT Water Stewardship Strategy (Water Strategy), jointly released by the Government of the Northwest Territories (GNWT) and INAC in May 2010. This document outlines a strategy of protecting and preserving northern waters such that they "will remain clean, abundant, and productive for all time."

INAC's review has identified uncertainty in the project, including uncertainty with the contingencies provided by the Developer to deal with issues that are likely to arise during mine operations. In a technical report INAC typically endeavours to provide recommendations to the Review Board, which if implemented, would mitigate the potential for significant adverse impacts. If insufficient information is available to make a determination of significance, INAC has attempted to clarify for the Review Board why INAC was unable to reach a determination. INAC has also provided general recommendations for standard items that, in our opinion, are typically dealt with in the regulatory phase.

Although Canadian Zinc Corporation (CZN) has attempted to address some of the key issues and uncertainties with the Prairie Creek project, there are still a number of outstanding issues and concerns with respect to the proposed project in relation to potential impacts to the aquatic environment. Additional information is required to make a determination of significance in this regard.

Site Specific Water Quality Objectives and Effluent Quality Criteria

Reference: ToR Section 3.2.4 (Existing Water Quality); 3.2.5 (Development Description); 3.3.2 (Key Line of Inquiry: Minesite Water Quality); 3.3.3 (Ecological Integrity of the NNPR); 3.3.5 (Fish and Aquatic Habitat); 3.3.10 (Biophysical Environmental Monitoring and Management Plans); 3.4.4 (Cultural Impacts); 3.5 Closure and Reclamation; 3.6 (Cumulative Effects) IR1_INAC02, INAC05, INAC06, INAC07, INAC08, INAC09, INAC10, INAC11; IR2_INAC02-01; INAC02-02; INAC02-03; INAC02-04; INAC02-07; INAC02-08; INAC02-09; INAC02-10; INAC02-11; INAC02-12; INAC02-13; INAC02-14; INAC02-15; INAC02-16; Technical Meeting April 12, 2011 (discussions and additional information requests).

Response: DAR Section 3 (Assessment Boundaries); DAR Section 4 (Existing Biophysical Environment); DAR Section 6.16 (Development Description); DAR Section 7 (Public Engagement); DAR Section 8 (Impact Assessment – Mine Site Water Quality); DAR Section 9 (Impact Assessment - NNPR); DAR Section 10 (Impact Assessment - Other); DAR Section 12 (Closure and Reclamation Plan); DAR Section 13 (Cumulative Effects); IR1Response Document; incl. Appendix G; Appendix H; Appendix I; Appendix J; Appendix K; Appendix L; Appendix P; IR2 Response Document; incl. Appendix D; Appendix E ; Appendix F ; Appendix G ; Appendix L ; Appendix M ;Appendix O ; Appendix P ; Addendum to IR2 Response Appendix A ; Appendix B, Appendix C ; Appendix D ; Appendix E ; Appendix F ; Appendix G ; Appendix H ; Appendix I ; Appendix J ; Contingency Table (Table 1 May 6, 2011) ; Commitments Table (Table 2, May 6, 2011).

Issue:

CZN has proposed Site Specific Water Quality Objectives (SSWQOs) for Prairie Creek. Most of these SSWQOs are derived using Canadian Council of the Ministers of the Environment (CCME) guidance, which is toxicity based. INAC does not feel that this approach provides the appropriate level of protection for Prairie Creek. Since effluent quality criteria (EQCs) are derived to meet SSWQOs, INAC feels that the EQCs proposed by CZN are also not appropriate.

INAC is also concerned that effluent discharge meeting the Developer’s proposed Maximum Average Concentration criteria, under the “best case” mine inflow scenario, will cause exceedances of SSWQOs for some parameters at the edge of the mixing zone and at the park boundary. It is a safe assumption that should Maximum Grab Concentrations be utilized for discharge, additional exceedances will be observed.

Developer Conclusion:

The SSWQO derivation process follows an iterative framework proposed by Hatfield Consultants. This framework uses the Reference Condition Approach based benchmark as a first step, paired with consideration of other published guidelines and direct toxicity testing. If Prairie Creek water quality does not change from the upstream condition based on the predicted discharge effluent quality from the mine, the Reference Condition Approach based benchmark was adopted. However, if water quality modelling predicted a measurable change in specific water quality parameter(s) downstream of the mine under projected discharge concentration(s), a second tier assessment was initiated to assess for negative (acutely or chronically toxic) effects downstream. This second tier relied upon CCME guidelines or equivalent provincial guidelines as they are based on toxicity testing data. The Developer considers that the CCME limits provide a more defensible threshold for assessing the potential for toxic effects.

CZN proposed EQCs for the mine that considered a reduction to the EQCs issued under their current authorization and the Metal Mining Effluent Regulations (MMER). The Developer states that the intent of these limits is to avoid significant impacts, while maintaining operational flexibility and ensuring that the EQCs can reasonably and consistently be achieved. For low flow conditions in Prairie Creek, CZN recommends a different or additional regulatory approach to meet proposed SSWQOs.

Review Conclusion:

1. CZN’s approach to establish SSWQOs within Prairie Creek and associated EQCs at the end of pipe is flawed. SSWQOs should be developed using a Reference Condition Approach.
2. CZN has not accounted for exceedances of SSWQOs in the receiving environment when proposing EQCs for the water licence. This includes effluent discharges at Maximum Average, but also and more importantly discharges at the Maximum Grab Concentrations which are twice as high as concentrations modeled by CZN in the various tables provided in IR responses. CZN tables using the Maximum Average Concentrations show exceedances of some SSWQOs in Prairie Creek at the edge of the mixing zone and at the Park boundary.

Rationale:

INAC is very concerned about the derivation of SSWQOs for Prairie Creek using toxicologically based guidelines such as the CCME Water Quality Guideline (WQG) for the Protection of Aquatic Life. Many analytes-of-concern identified in mine effluent are naturally very low in Prairie Creek, in many instances below normal laboratory detection limits. Using CCME values to protect Prairie Creek in essence means that CCME limits are used as “pollute-up-to limits”. This is inconsistent with the CCME non degradation policy. Use of these limits as SSWQOs will only ensure that acutely toxic effects in Prairie Creek are not observed. They will not avoid the potential for a high level of change to occur in Prairie Creek and downstream within the NNPR.

Specific concerns with the Developer’s approach to deriving SSWQOs for the Prairie Creek Mine include (See also Appendix A and B):

- An aboriginal subsistence fishery exists at the mouth of Prairie Creek. It appears no consideration of this use has been accounted for in the development of SSWQOs. The potential for increases in mercury concentrations within aquatic organisms downstream of the effluent discharge point is possible. Research in Prairie Creek has shown increases in mercury concentration in Slimy Sculpin tissues near the mine site when compared to reference areas. Elevated mercury concentrations and loads must be further evaluated given the potential human health and subsistence/traditional use implications.
- Little dilution is available between the edge of the proposed initial dilution zone (IDZ) and the boundary of the NNPR. As such, any SSWQOs established for the edge of the IDZ will effectively apply to Prairie Creek within the NNPR as well.
- Mild enrichment has already been measured in Prairie Creek as a result of the existing development at the mine site. CCME limits will not necessarily reduce the level of loadings or concentrations to control enrichment and productivity.
- CCME guideline limits are not site specific;
- CCME guideline limits only consider aquatic exposure toxicity and do not consider dietary or bio-accumulative implications such as for cadmium, selenium, lead and mercury;
- CCME guideline limits do not account for synergistic effects of contaminants of potential concern. One such evaluation included synergistic effects of copper, lead and zinc (Copper *et al*, 2009).
- CCME guideline limits may not reflect keystone species. Protecting keystone species is important in deriving SSWQOs, and the CCME recognizes that the need to protect a keystone species may in some cases supersede the recommended environmental quality guideline protocol. Keystone species in Prairie Creek have not been explicitly identified.
- SSWQOs proposed for cadmium and zinc are of the same order of magnitude as 120 hr LC50 concentrations reported in the literature for bull trout. Water quality predictions provided by Canadian Zinc suggest that cadmium and zinc concentrations in Prairie Creek may exceed the lower level concentrations at which bull trout toxicity was observed. The contingency factor provided by the proposed SSWQOs for cadmium and zinc is likely insufficient.
- CZN’s assessment of effluent quality and mixing are based on a simulated process water, simulated treatment process, blending of effluent streams and simulated performance of the exfiltration system. Note all of these aspects have

implications for water balance and storage.
- Simulated process water quality has drastically differed between 2010 and 2011.
- The treatment process using ferric sulphate produced inconsistent toxicity results.

INAC's position is that SSWQOs must be derived such that they consider the natural variability of Prairie Creek. INAC recommends the use of the Reference Condition Approach consistently across all parameters to establish acceptable SSWQOs. The derivation process must take into consideration all available data for Prairie Creek, the suitability of all available data and incorporate statistical techniques that are suitable to censor data sets. The collection of additional baseline data should be included where required (e.g. ultra-low mercury sampling) INAC notes that ultra-low mercury analysis has not been conducted by the proponent.

Once the reference condition is established, associated SSWQOs will be generated (i.e. within the natural range of variability). At this point, discussions must take place amongst all interested parties to determine the appropriateness and practicality of these SSWQOs. For the Prairie Creek Mine, the following aspects would have to be considered in discussions regarding final establishment of SSWQOs:

- A traditional/subsistence Arctic Grayling fishery operates at the mouth of Prairie Creek where it joins the South Nahanni River.
- Prairie Creek is a tributary of the South Nahanni River and proposed development will discharge effluent approximately 7 km upstream of the Nahanni National Park Reserve (NNPR) boundary.
- Prairie Creek is ultra-oligotrophic, or in other words, is a watercourse having low productivity and is susceptible to large seasonal variation in flow volumes.
- Prairie Creek provides overwintering and migratory habitat for several fish species, including bull trout which are listed as "May be at Risk" by the GNWT (2011).
- Little dilution is available between the edge of the proposed initial dilution zone (IDZ) and the boundary of the NNPR. As such, any SSWQOs established for the edge of the IDZ will effectively apply to Prairie Creek within the NNPR as well.
- The Nahanni River was designated one of the first 12 UNESCO World Heritage Sites and it is designated as a Canadian Heritage River (Halliwell and Catto, 2003).
- Socio-economic considerations such as the implications to project design and development required to meet Reference Condition Approach based SSWQOs.

Following the establishment of agreeable SSWQOs, appropriate EQCs must be derived such that the downstream SSWQOs are always achieved at an assessment boundary deemed appropriate by all interested parties. INAC believes that the location of the assessment boundary should be determined hand-in-hand with the final establishment of SSWQOs. This philosophy is outlined in the recently released Mackenzie Valley Land and Water Board “Water and Effluent Quality Policy” (March, 2011). As such, defensible SSWQOs must be agreed upon before appropriate EQCs can be derived. The EQCs proposed by CZN are currently unacceptable to INAC as they do not meet this standard.

EQCs are intended to serve a dual regulatory and environmental protection role. In this specific case, they must control the level of change that will occur in an aquatic receiving environment due to discharges from the Prairie Creek Mine. CZN has proposed both Maximum Grab and Average EQC concentrations. Effluent mixing calculations provided by the company show that discharges at proposed Maximum Average Concentrations will result in exceedances of several downstream SSWQOs at the edge of the mixing zone (30 meters downstream) and at the NNPR boundary (approximately 7 kilometers downstream) during low Prairie Creek flow conditions. It is likely that exceedances would also occur during periods of mean flow in Prairie Creek if CZN deviated from or was unable to maintain the prescribed effluent blending prior to discharge.

Further, CZN did not complete an analysis of potential exceedances of SSWQOs for effluent discharges at proposed Maximum Grab Concentrations. Grab sample EQCs are greater than average concentrations so the number and magnitude of excursions above the SSWQOs would also be greater. It is also foreseeable that excursions from the SSWQOs would increase and include other parameters of concern, even under the high Prairie Creek flow scenario. Without an assessment of mixing and conditions in Prairie Creek under these discharge conditions (which are permissible for discharge under a water licence), INAC is unable to assess the potential for significant adverse impacts from the project. As noted previously, in-stream water quality does not change significantly between the edge of the IDZ, and the NNPR boundary. CZN does not describe how far downstream any impacts due to effluent discharged at the high end of the licence range would extend, nor provide an assessment of impacts to Prairie Creek under this scenario.

INAC recommends that defensible and acceptable EQCs should be established for Prairie Creek as part of this EA process. The derivation process must be based upon defensible and agreed upon SSWQOs and CZN must demonstrate how they could meet such SSWQOs under both Maximum Average and Maximum Grab effluent discharge conditions.

INAC notes that CZN has outlined potential regulatory approaches to be used in conjunction with their proposed EQCs to help ensure compliance. However, this discussion is premature until agreement is reached on acceptable SSWQOs for Prairie Creek. INAC’s position is that appropriate SSWQOs for Prairie Creek have not been provided and an environmentally protective basis has not been established for deriving EQCs for the Prairie Creek Mine.

It is imperative that SSWQOs be established prior to the completion of the environmental assessment phase of the project. Without this information, it is not possible to determine the potential for significant of adverse impacts from the project on the aquatic environment. To this end, the following recommendation proposes a collaborative approach towards the establishment of SSWQOs. INAC has also provided recommendations to ensure that discharge will only be authorized within the water licence in a manner to prevent SSWQOs from being exceeded.

Recommendations:

1. ***INAC recommends that the Developer be required to establish and present Site Specific Water Quality Objectives (SSWQOs) for the Prairie Creek Mine using the Reference Condition Approach consistently across all parameters. A committee consisting of the Developer and interested parties to the Environmental Assessment will evaluate the appropriateness and practicality of these generated SSWQOs. The committee will report back to the Review Board with a recommendation on appropriate SSWQOs for Prairie Creek, prior to the Review Board's closure of the public registry for EA0809-002.***

2. ***INAC recommends that Effluent Quality Criteria (i.e. Maximum Grab Concentrations) must be back calculated from SSWQOs based on the Best Estimate inflow prediction.***

3. ***INAC recommends that CZN must not discharge effluent that has concentration(s) above the stipulated Maximum Grab Concentrations in the Water Licence.***

4. ***INAC recommends that any discharge from the end-of-pipe must meet the Maximum Average Concentrations as stipulated by the Surveillance Network Program (SNP) in the Water Licence. Detailed instructions on the method and timing for sampling, deriving and reporting regulated average concentrations should be specifically outlined within the SNP.***

Water Management and Storage

Reference: ToR Sections 3.2.5 (Development Description); 3.3.2 (Key Line of Inquiry: Minesite Water Quality); 3.3.3 (Ecological Integrity of the NNPR); 3.3.5 (Fish and Aquatic Habitat); 3.3.10 (Biophysical Environmental Monitoring and Management Plans); 3.5 Closure and Reclamation; 3.6 (Cumulative Effects); IR1_INAC01; INAC02 ; INAC05 ; INAC06 ; INAC07 ; INAC09 ; IR2_INAC02-01; INAC02-02; INAC02-03; INAC02-04; INAC02-05; INAC02-06; INAC02-07; INAC02-10; INAC02-11; INAC02-12; INAC02-13; INAC02-14; INAC02-15; Technical Meeting April 12, 2011 (discussions and additional information requests).

Response: DAR Section 3 (Assessment Boundaries); DAR Section 4 (Existing Biophysical Environment); DAR Section 6 (Development Description); DAR Section 8 (Impact Assessment - Mine Site Water Quality); DAR Section 12 (Closure and Reclamation); IR1 Response Document; incl. Appendix G; Appendix H; Appendix I; Appendix J; Appendix K; Appendix L; IR2 Response Document; incl. Appendix D; Appendix E; Appendix F; Appendix G; Appendix L; Appendix M; Appendix N; Appendix P; Addendum to IR2 Response Appendix A ; Appendix B ; Appendix C ; Appendix D ; Appendix E ; Appendix F ; Appendix H ; Appendix I ; Appendix J ; Contingency Table (Table 1 May 6, 2011) ; Commitments Table (Table 2, May 6, 2011).

Issue:

Adequate storage is a key component of CZN's strategy for meeting SSWQOs in Prairie Creek. However, the available storage volume within the water storage pond (WSP) is not likely to provide adequate contingency to accommodate variations in mine inflows, variations in Prairie Creek flows, treatment plant upsets, or a combination of the above. Furthermore, CZN proposes no float tailings will remain on surface after mine closure and only 50,000 m^3 of float tailings will be stored in the water storage pond during operations.

Developer Conclusion:

The total volume of the WSP is estimated at approximately 450,000 m^3. However, the maximum water level of the WSP is 880 m and the minimum water level is 877 m which provides a total working volume of 225,000 m^3. The WSP will be split into two cells, Cell A will be used to store process/mill water and Cell B will be used to store mine water, waste rock and stockpile seepage water and sewage treatment plant effluent. Each cell has a total volume of 225,000 m^3. However, the working volume within each cell (between 877 and 880 m) is approximately 110,000 m^3. The cumulative difference in the water balance can not be plus or minus 110,000 m^3 because the cell would then be too full or empty. Approximately a 10% contingency volume, equal to 10,000 m^3, has been assumed for the annual water budget.

A series of water balances describe the water management strategy assuming low, best case, high and extreme mine inflows. Prairie Creek SSWQOs will be achieved by blending treated process water discharges with treated mine water discharges as required to meet effluent quality criteria. Higher volumes will be discharged during the summer months when Prairie Creek flows tend to be higher resulting in an overall lowering of the water level within each storage cell. Discharge volumes will be reduced during winter months when Prairie Creek flows are lower causing water levels within the cells to increase.

CZN proposes to ensure that blending effluent ratios remain above 4:1 mine/site water to process water. This would be done to ensure EQCs are met and there is no toxicological effect (i.e. the proportion of process water must not be greater than 20%). The further dilution of effluent on discharge to Prairie Creek would ensure that SSWQOs are met.

CZN suggests there will be sufficient void volume underground to accommodate all of the tailings. CZN also suggests that surface storage of only the first five months of float tailings is required during start up for paste backfill operations to run continuously during the 14-year mine life. Only 50,000 m^3 of float tailings will need to be temporarily stored within the mill water cell of the WSP. At the end of mine, these float tailings will be removed from the WSP and placed as paste backfill underground.

Reviewer Conclusion:

INAC has concerns with two elements of the WSP operation as proposed:

1. Maintaining the overall water balance in the event of operational upsets; and
2. Estimates regarding the volume of float tailings that will require temporary storage in the WSP during mine operation.

The water balances provided by CZN show how the site water balance could be maintained under several set scenarios. However, they do not adequately demonstrate that the site water management strategy can handle potential upset conditions. In addition, the inflow rates assumed by CZN are taken as static under each water balance scenario. It is likely that as the underground mine progresses, increased inflows will occur. It is presumed that more mine water would be discharged if higher inflow rates are experienced. The Developer concludes that mine water quality will improve as a result of these increased inflows. However, there is potential for mine water quality to stay the same or even degrade as the water interacts with paste backfill and other site water in Cell B (e.g. stockpile leachate; sewage treatment plant water).

Toxicity testing completed by CZN has identified that treated mill process water is acutely toxic to aquatic life. Treated mine water does not exhibit acute toxicity, so CZN's strategy is to discharge a blend of treated process and treated mine water. Toxicity testing has illustrated that acute and chronic toxicity can be controlled by blending the discharge. However, toxicity testing results to date have been inconsistent, and estimates of the actual level of toxicity in operational effluent are not completely definitive.

The Developer has concluded that there is no acute or chronic toxicity associated with its proposed effluent blend. However, it appears that the proponent is relying on an IC25 limit in making this determination (IC25 = 25% of the test organisms show impairment when exposed to effluent blend). If this is the case then the Developer's statement is correct. However if the IC10 is used, which is the typical method used in establishing water quality guidelines, the evaluation indicates that chronic toxicity may be exhibited by the effluent mixture at lower dilutions than those presented by CZN. INAC notes that the cause for toxicity reported in each toxicity assessment has not been definitively identified. Furthermore, INAC is unclear if changing the treatment chemicals to ferric chloride for the latest toxicity assessment has influenced the toxicity results. INAC understands that CZN wishes to revert back to the previous treatment method (i.e. ferric sulphate).

Limiting tailings storage in the WSP during operation to 50,000 m^3 assumes that selected access voids will be filled during active mining. This is theoretically possible to achieve through mine scheduling, but will likely prove extremely difficult to sustain. INAC believes that much of the tailings backfill plan relies on optimistic assumptions. CZN has not incorporated necessary conservative strategies or contingencies into paste backfilling plans and the estimates of temporary float tailings storage volume. Any scheduling conflicts or missed backfill targets will likely result in the need to store additional tailings in the WSP during operations. Adding additional tailings to the WSP will have implications for water storage capacity, mill water aging and retention times and WSP water quality. Any changes to WSP water quality would influence discharge quality and the ability to meet EQCs and SSWQOs.

It is expected that SSWQOs and EQCs will change if INAC's proposed approach, as defined in the previous section, is followed. Once SSWQOs and EQCs are established for the operation, there may be implications for water and tailings management, effluent blending and/or treatment.

Rationale:

CZN has endeavored to demonstrate that their water management strategy is sufficiently robust to manage mine water on the site while ensuring that their proposed SSWQOs will be achieved. The site water balance is a key component of CZN's overall operation, and maintaining the water balance will be critical to protecting the aquatic receiving environment.

The provided water balances assume that continuous discharge will occur; except for process water which will not discharge during February and March. Continuous discharge is required for mine water in order to balance out mine inflows. An assessment has not been conducted to evaluate effects to the short term and annual water balance from upsets that would stop these required discharges. This may include poorer than expected water quality from the mine or mill, issues with the water treatment plant, or exceedances of EQCs.

CZN's response to queries regarding contingencies, in the event of water management difficulties (e.g. pump failures, exfiltration pipe issues, treatment plant offline, etc.) is that more water will be stored in the WSP. Depending on the nature, timing and frequency of the above noted upsets over the year, the entire contingency volume could be exceeded during the following winter low discharge period. Confounding this issue, the volume of discharge during the winter may be restricted in order to meet SSWQOs during winter low flow conditions in Prairie Creek.

CZN's water balance requires that the pond level be drawn down to the proposed 877 m minimum prior to winter. Under this scenario, an upset or excursion from the water balance during the fall would mean CZN would not be able to discharge water during a period when it is imperative to draw down the WSP water level to maximize storage potential. Thus, depending on the water level at the start of winter operations, there is a potential for winter storage issues since discharge volumes may need to be restricted to meet SSWQOs during low flow conditions in Prairie Creek, at the same time water levels in the WSP are highest. A late spring, where Prairie Creek flows remain low for an extended period, would make this situation even worse.

Additionally, the water balances do not identify how any changes to mill water (e.g. changes in ore chemistry, higher rate of mill water recycling and shorter aging of flotation chemicals in late summer and fall) could impact the apportionment of water that is released to the receiving environment. Any change in mill water quality could cause exceedances of EQCs or SSWQOs. If so, the apportionment of mill water would need to be reduced and storage of mill water would be required. If this condition persisted for weeks or months, CZN may then need to implement contingencies to remediate the storage issues, such as, recycle mill water and lower the proportion of mine water used for the process feed. It is expected that this scenario would make the concentrations in the mill water worse over time. This could lead to potential acute toxicity issues in the effluent or chronic toxicity issues in the immediate receiving environment and make managing the release of this water to Prairie Creek more difficult. Such issues would only amplify the need for additional water storage capacity, as failing to meet EQCs, SSWQOs or acute toxicity would trigger a non-compliance with water licence conditions, requiring all discharge to stop until issues are rectified.

As an example, an EQC or acute toxicity failure in early spring could mean that the 10,000 m^3 contingency would be exceeded in approximately 4.4 days. Shipping samples out for compliance testing may require from 2 days to a week, even under a rush order.

Cumulative storage over winter (Best Estimate *)	96,833 m3
Difference in inflows between April and May (Best Estimate**)	26.3 L/s
Difference in inflows in cubic meters/day	2,272 m3
Number of days to exceed 10,000 m^3	4.4 days

*Taken from Appendix C, Table 3 – Developer Response to IR Round 2 Addendum
**Taken from Appendix C, Table 1 – Developer Response to IR Round 2 Addendum

INAC requires that the water management scheme and water balance clearly illustrate that the available contingency is sufficient to maintain adequate effluent quality under a range of conditions, including upsets to operations (e.g. pump failures, power outages, transfer pipe failures, spills, EQC or SSWQO exceedances, late spring conditions, etc.). This demonstration would be required after acceptable SSWQOs are developed for Prairie Creek and acceptable EQCs are derived, as these will influence discharge blending and the overall water management strategy.

In addition to the above concerns, and more notably, upsets to float tailings management and paste backfill operations have serious implications for site water management (Appendix C-F). The Developer is stating that 100% of voids in the underground will be filled using paste backfill. INAC believes that the assumptions required to achieve 100% placement of tailings are not practically feasible for the following reasons:

1. The assumptions require 100% filling of voids, which is theoretically possible but likely difficult to achieve in practice.
2. The assumptions require that all paste be placed at the maximum achievable density. Upset conditions may require that some backfill be placed as conventional slurry tailings, which will significantly reduce backfill density.
3. Cost saving measures may lead to increased use of DMS material in paste to reduce cement requirements over the life of mine.
4. Cost saving measures may lead to placement of development waste in stopes (as backfill in lieu of much more costly paste backfill).

If estimates that are more conservative are used, the volume of tailings that would need to be stored within the WSP over the life of mine would progressively increase. It is also likely that the majority of tailings used to close the mine openings would need to be stored on surface and accessible at the end of the mine operation. This material could be used as backfill once necessary infrastructure and equipment were removed from the workings. Estimated tailings storage volumes over the life of mine suggest that approximately 230,000 m^3 of tailings could require surface storage towards the end of mining operations. This is equivalent to the entire volume of Cell A and would not leave any space to store and recycle the acutely toxic process water (entire volume of WSP ~450,000 m^3). Increased tailings storage in the WSP will have critical implications for water storage, effluent aging and effluent blending during the course of operations. Ultimately, this condition would cause significant adverse impacts to Prairie Creek.

Considering the above, INAC must be confident that tailings backfill plans and temporary storage contingencies available during mine operation are adequate. The extent to which any proposed contingencies would reduce or eliminate the risk to the downstream aquatic environment must be clear. Given the uncertainties that INAC has outlined above, INAC is unable at this time to complete a determination with respect to the significance of the proposed tailings backfill plan on mine water management and effluent quality discharged to Prairie Creek over the life of the project. The latter being a Key Line of Inquiry identified in the Terms of Reference for the Prairie Creek Mine Project.

INAC suggests the following information is required to complete an assessment of the potential for significant adverse impacts resulting from temporarily storing float tailings on surface during the life of mine:

- CZN's proposed underground mine plan, paste backfill schedule and float tailings handling and storage plan such that only 50,000 m^3 of float tailings are placed in the WSP, and no other float tailings accrue in the WSP;
- Contingencies and conservatisms for the backfill schedule including tailings handling and storage;
- Calculations that confirm the preferred ratio of float tailings, DMS, treatment plant sludge and cement required to ensure the underground is completely backfilled and no surface float tailings remain, using conservative estimates of relevant physical properties;
- Descriptions of how temporarily stored tailings will be recovered from the WSP at the end of operations;
- Contingencies in the event that tailings are left at the surface and within the WSP; and
- Descriptions of any impacts from the mine post closure if tailings remain on the floodplain.

The following recommendations are made to ensure the proposed operational volume of the WSP is maintained and that temporary tailings staging areas are properly managed to avoid the potential for significant adverse impacts from the operation.

Recommendations:

1. INAC recommends that the Developer provide the following information regarding tailings and water management prior to closure of the public record for EA0809-002:

a) A detailed mining and paste backfill schedule be produced by CZN to demonstrate that float tailings will not accrue in Cell A of the WSP.

b) A detailed description of all operational contingencies that may be implemented to maintain the working capacity of the WSP for the life of the mine, if or when required.

This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.

2. INAC recommends that the WSP must be operated such that the water level does not impinge on the 1 m freeboard level. The freeboard must be reserved for short-term emergency situations.

3. INAC recommends that any temporary float tailings stored on the surface be stored in predesigned and approved lined containment areas that have specified capacity limits that must not be exceeded.

4. INAC recommends that any Dense Media Separation (DMS) tailings that do not proceed to the Paste Backfill Plant must be transported and stored within the Waste Rock Pile (WRP) as per CZN's operating plan. Any temporary DMS facilities must be predesigned, lined and approved to contain DMS and leachate; their maximum specified storage capacity must not be exceeded.

In-stream Mercury Concentrations

Reference: ToR Section 3.3.2 (Key Line of Inquiry: Minesite Water Quality), IR_INAC09, IR_INAC02-01, IR_INAC02-03.
Response: DAR Section 4.6, pg100; DAR Section 8.5, pp 270-271; IR1 Response Appendix J; IR2 Response Appendix F ; Response to Commitments Appendix C. Supplemental: DAR Appendix 7, DAR Appendix 8, IR2 Response Appendix D, IR2 Response Appendix N, IR2 Addendum Appendix D, IR2 Addendum Appendix F, IR2 Addendum Appendix G.

Issue:

CZN has not quantified the existing mercury concentrations in Prairie Creek, and therefore cannot reliably estimate mercury related impacts resulting from their proposed operation. Mercury concentrations may be of concern during both operation and post-closure.

Developer Conclusion:

CZN has predicted mercury concentrations in Prairie Creek assuming that the existing mercury concentration is 0.020 ug/L. Predicted mercury concentrations in Prairie Creek downstream of mining operations are predicted to vary from 0.019 to 0.025 ug/L under assumed Best Estimate mine water inflow rates. CZN notes that CCME guideline limits for the Protection of Freshwater Aquatic Life for mercury is 0.026 ug/L.

An assessment by Hatfield concludes that conditions found in Prairie Creek would not favour formation of methylmercury, and any free inorganic mercury will tend to be bound strongly to oxyhydroxides of magnesium and iron.

Modeling conducted by CZN suggests that mercury in mine water discharges post-closure will be attenuated by geochemical processes. Consultants completing this work for CZN recommend a more detailed review of the literature and/or attenuation studies over the mine operating period to further evaluate the mobility of mercury in the local groundwater system.

Reviewer Conclusion:

INAC has reviewed the mercury assessment and finds that a more thorough assessment of potential mercury related impacts is required. Monitoring for mercury concentrations in the receiving environment and fish tissue after the initiation of operations does not identify the significance of mercury accumulation and the potential for significant adverse impacts from the project. Effects levels and measurement endpoints need to be established during the EA to ensure unacceptable levels in fish and the aquatic ecosystem do not occur. These concerns are shared with local Aboriginal groups who conduct subsistence fishing in lower reaches of Prairie Creek.

Rationale:

- Mercury will be present in effluent discharges from the proposed treatment plant at concentrations ranging from 0.01 to 0.48 ug/L. This concentration is sufficient to trigger the requirement for fish tissue studies under the Metal Mining Effluent Regulation.
- The CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life notes that the mercury guideline was developed based on the CCME protocol, and that this protocol does not address exposure through food or bio-accumulation to higher trophic levels. The CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life further note that "…if the ultimate management objective for mercury is to protect higher trophic level aquatic life and/or those wildlife that prey on aquatic life, more stringent site-specific application of these water quality guidelines may be necessary."
- Studies conducted to date (Spencer *et al*, 2008) have documented an increase in fish tissue mercury concentrations downstream of the mine site.
- Existing concentrations of mercury in Prairie Creek water and sediment upstream of the mine site have not been established.
- An aboriginal subsistence fishery exists at the mouth of Prairie Creek.
- Canadian Zinc has completed only a qualitative assessment of the potential for mercury to bio-accumulate in Prairie Creek.

Recommendation:

Presently, insufficient information has been provided to assess whether mercury bio-accumulation will occur within Prairie Creek to a degree that will affect use of Prairie Creek downstream of the proposed development. INAC provides the following recommendation to the Review Board on this issue. INAC notes that this would be included within the process of determining SSWQOs as proposed previously:

1. ***INAC recommends that CZN collect and analyze additional samples (seasonally representative) using a sufficiently low detection limit to permit development of a site specific water quality objective for mercury in Prairie Creek using the Reference Condition Approach. This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

2. ***INAC recommends that CZN identify whether increases in mercury concentrations resulting from their discharge can meet this Reference***

Condition Approach objective, and quantify the level of impact in Prairie Creek resulting from increased concentrations of mercury. This evaluation should consider both the operational and post-closure period. This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.

Initial Dilution Zone (IDZ) and Dilution in Prairie Creek

Reference: ToR Section 3.3.2 (Key Line of Inquiry: Minesite Water Quality), IR_INAC06, IR_INAC02-01, IR_INAC02-02, IR_INAC02-03, IR_INAC02-08 and IR_INAC02-10.

Response: DAR Section 8.1, DAR Section 8.3, DAR Section 8.4, DAR Section 8.5, DAR Section 8.6, DAR Section 9.1, DAR Section 10.2.2, DAR Appendix 7, DAR Appendix 10, IR1 Response Appendix J, IR1 Response Appendix K, IR2 Response pp 30-31, IR2 Response Appendix D, IR2 Response Appendix F, IR2 Response Appendix L, IR2 Response Appendix M, IR2 Response pp 32-33, IR2 Response Appendix N, IR2 Response Appendix O, IR2 Response Appendix P, IR2 Response pg 36, IR2 Addendum Appendix C, IR2 Addendum Appendix D and IR2 Addendum Appendix F.

Issue:

The amount of dilution in Prairie Creek between the edge of the proposed initial dilution zone (IDZ) and points downstream of the mine site (e.g. the NNPR Boundary is approximately 7 km downstream) is not large. As such, any exceedances of SSWQOs occurring outside an IDZ will also occur within the NNPR.

Developer Conclusion:

Tables provided by CZN estimating in-stream concentrations of metals in Prairie Creek at both Harrison Creek and the NNPR boundary show very little decrease at the NNPR boundary compared to Harrison Creek. CZN suggests that the concentrations at the NNPR boundary may be lower than presented because attenuation will occur naturally within Prairie Creek.

Plume modeling indicates that the effluent plume will comprise greater than 1% of the total Prairie Creek flow volume at the greatest distance from the mine site modeled (2 km) under some stream flows.

Reviewer Conclusion:

INAC is in partial agreement with the Developer's assessment. Natural attenuation will occur to some degree during operation and closure within Prairie Creek. However, the degree of potential attenuation has not formally been quantified during operation or closure. As such, INAC is concerned that any exceedances of SSWQOs that occur outside an IDZ will also occur within the NNPR boundary.

Rationale:

- Tables provided by Prairie Creek indicate very little change in parameter concentrations between Harrison Creek and Prairie Creek.
- Natural attenuation is identified as a mechanism that could reduce concentrations at the NNPR boundary to a greater extent than is reported in the tables. However, any reduction due to natural attenuation has not been quantified.
- The MMER defines the effects zone of an effluent discharge to be within the zone where the volume of the effluent plume comprises greater than 1% of the total stream flow volume. Modeling indicates that the effluent plume will comprise greater than 1% of the total Prairie Creek flow volume to a distance of greater than 2 km under some stream flows conditions.
- As mentioned within previous sections of this technical report, INAC maintains that selection of an assessment boundary (i.e. IDZ), would have to be completed in conjunction with the establishment and acceptance of SSWQOs for Prairie Creek.

Recommendation:

INAC provides the following recommendation proposing a path forward to resolve this issue:

1. INAC recommends that in-stream water quality must meet SSWQOs, derived using the Reference Condition Approach, at the edge of a predefined assessment boundary (e.g. vertical mixing zone, horizontal mixing zone, NNPR boundary). The location of the assessment boundary for the Prairie Creek Mine would have to be determined in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.

Effluent Discharge

Reference: ToR Section 3.3.2 (Key Line of Inquiry: Minesite Water Quality), IR_INAC06, IR_INAC02-01, IR_INAC02-02.

Response: DAR Table B pg 48, DAR Section 6.3.7, DAR Section 6.16, DAR Table 7.2 pg 257, DAR Section 8.7.2, DAR Section 10.2.4, DAR Section 10.2.5, IR1 Response Appendix K, IR2 Response Appendix E, IR2 Addendum Appendix A, IR2 Addendum Appendix B. Supplemental: Prairie Creek Mine, Outfall Designs – Preliminary Construction Details, Draft, Northwest Hydraulic Consultants, October 5, 2010; Prairie Creek Mine, Outfall Performance – Downstream Mixing Analysis, Draft, Northwest Hydraulic Consultants, October 6, 2010.

Issue:

CZN proposes to use an exfiltration trench as a discharge mechanism to promote mixing of their effluent with Prairie Creek. Exfiltration trenches are not routinely used for effluent discharge into receiving waters. CZN has identified that effluent may be discharged directly into Harrison Creek as a contingency in the event that the exfiltration trench can not be used.

Developer Conclusion:

An exfiltration trench will provide the required level of mixing within Prairie Creek. Two discharge pipes of different lengths will be installed into Prairie Creek in order to provide redundancy in the event one of the pipes fails, and to allow discharge into Prairie Creek when the width of the creek is reduced during ice covered conditions. Effluent will be discharged through the trench using either gravity feed or pumping. Pumping will be used during the winter to reduce the potential for freezing during winter months.

A bubbler will be installed in the trench as a clearing mechanism in the event that sedimentation within the exfiltration trench reduces discharge efficiency.

CZN asserts that there is a very low likelihood that the exfiltration pipe will become obstructed by particulate in the effluent since discharge from the water treatment plant is expected to be very clear.

A contingency proposed by CZN is to discharge directly to Harrison Creek in the event that the exfiltration pipe cannot be used.

CZN provided references for two other facilities that use exfiltration trenches as an effluent discharge structure.

Reviewer Conclusion:

INAC concurs with the Developer that discharging through a culvert or diffuser is not a viable option for the proposed operation. The proposed exfiltration trench is a reasonable strategy and may provide enhanced mixing; however, this application is not proven.

Any discharge through a culvert directly into Harrison Creek must be under emergency conditions only. The level of mixing achieved through this direct discharge is likely to be insufficient. Any effluent stream discharged in this fashion should not include a process water component.

Rationale:

- The references provided by CZN were contacted. One reported that they did not use an exfiltration trench, but discharged through ports that extended above the riverbed. The second reference identified that they used an exfiltration trench and provided the following information on the operation of the discharge structure:
    1. Complete mixing does not occur within the trench, and discrete effluent jets enter the receiving water body. Mixing appears to occur approximately 100 yards downstream of the trench.
    2. They experienced an incident where the exfiltration pipe was plugged by leaves, and had to be re-habilitated.
    3. The pipe broke at a point where there was provision for a lateral line, resulting in differential movement of portions of the pipe. The pipe had to be excavated and repaired.

  The facility did not know why they were not achieving mixing within the trench and were seeing discrete jets entering the receiving water body.
- Canadian Zinc's original discharge proposal was to use a culvert and initial mixing calculations suggested that the plume would extend up to 1,360 m downstream before mixing was achieved.

Successful operation of the exfiltration trench is key to meeting water quality objectives within Prairie Creek. INAC feels this strategy will likely be the best option for achieving mixing of effluent under various creek conditions. However, there appears to be potential for complications to arise from the exfiltration pipe. INAC provides the following recommendations to be certain that if licensed, this discharge system is closely monitored and it meets its performance requirements. If there are issues with the pipe or effluent mixing, the mining operations must stop and address the issue immediately.

Recommendations:

1. ***INAC recommends that the final design of the trench and twinned pipe configuration should account for potential failure mechanisms, such as described above.***

2. ***INAC recommends that Canadian Zinc evaluate the requirement for a screen or equivalent structure on the upstream end of the discharge pipe to minimize the potential for debris entering the exfiltration pipe and causing a blockage.***

3. ***INAC recommends that the performance of the exfiltration trench be monitored as part of the SNP, to confirm that adequate performance is achieved.***

4. ***INAC recommends that no effluent be discharged via the culvert into Harrison Creek unless an emergency situation has been declared for the site by the Mackenzie Valley Land and Water Board (MVLWB). Any discharges to Prairie Creek via Harrison Creek must be short term in duration to avoid potentially increased effects to the environment from the mine site. During this scenario a specific Emergency Plan, approved by the MVLWB, must be followed by CZN. This Emergency Plan should include a complete shut down of mining and milling operations.***

Post Closure Conditions

Reference: ToR Section 3.5, IR_INAC09, IR_INAC02-03, IR_INA02-14, IR_INAC02-16, IR_INAC02-17,

Response: DAR Section 8.4, DAR Section 8.6.2, DAR Section 8.9.4, DAR Section 9.1.1, DAR Section 9.3.1, DAR Section 10.2.3, DAR Section 12.0, DAR Appendix 27, IR1 Response Appendix J, IR2 Response pp 32-33, IR2 Response pg 42, IR2 Response Appendix N,:

Issue:

There is a potential for long-term closure and water quality issues. These closure issues could cause significant adverse impacts to Prairie Creek.

Developer Conclusion:

CZN's draft closure plan includes complete backfilling of the underground mine, removal of surface facilities on the Prairie Creek floodplain (unless relevant parties wish some to remain), and covering the Waste Rock Pile (WRP) in the Harrison Creek valley. Continuing research elements are associated with each of these main reclamation actions. Hydrogeological and geochemical data will be collected routinely during operations in order to update predictions of the behaviour of the backfill and groundwater and surface water quality after mine closure.

Mine closure will involve removal of berms, installing a cover on the Waste Rock Pile, and potentially establishing surface water runoff controls. Immediately after closure works have been completed, disturbed surfaces may be erodible and may periodically require repair until they have stabilized.

Reviewer Conclusion:

The draft closure plan is insufficient to address many of the concerns for closure. There is little discussion or details on the predicted long-term performance of closed mine components. Any potential long-term effects on Prairie Creek resulting from the operation should be described and evaluated as part of the impact assessment process.

Below is an excerpt of a revised version of Table 5 from the DAR Addendum, 'Impact Significance Matrix – Fish and Aquatic Habitat' that was provided by CZN in their response to the first round of IRs (pp. 60). This table shows that many post closure water quality considerations are ranked as Moderate to High.

			Geographic Extent	Duration	Frequency	Variance	Reversibility
Water quality, post-closure	Rank	Low	Moderate	High	High	Moderate	High
	Basis	Near baseline	Portion of Prairie Ck	Perpetuity	Perpetually continuous	Flow variation	Hard to resolve

Furthermore, depending upon the success of the paste backfill operation over the 14-year mine life, tailings may remain on surface after the underground openings have been completely closed. These tailings will require permanent surface disposal. CZN has not identified an area for permanent tailings disposal on surface or provided any assessment of impacts for long term tailing storage on the surface.

Rationale:

- INAC's Mine Site Reclamation Policy (2002), identifies that a mine must design for closure. As such, closure aspects must be discussed and described during the environmental assessment for a project as it may be that a site cannot be closed in an environmentally acceptable manner. CZN has identified some general closure plans and projected potential post closure conditions. However, CZN has provided very little assessment of the post closure impacts to Prairie Creek.

- INAC remains concerned about the amount and quality of post closure mine water. INAC is also concerned about the potential avenues for this water to reach Prairie Creek as it is not clear how much water will connect through the alluvial aquifer, surface from mine portals, and connect to Harrison Creek since it is assumed that this is occurring as part of the pre-mining condition (see DAR Section 8.3). Concerns have been raised regarding the concentration of metals such as mercury, zinc, lead, cadmium, etc. It has been demonstrated that leachate from paste backfill is of poor quality but that the volume of leachate would be less than the natural groundwater in the area allowing for better quality once it reaches Prairie Creek. How much better has yet to be demonstrated. The Developer has proposed a groundwater monitoring plan as a contingency at closure.

- CZN has not indicated what they would do if the groundwater monitoring plan identified poor water quality entering Prairie Creek. They have not discussed what the long-term (e.g. 10, 50, 100 yrs) impacts of this water would be on the downstream environment.

- CZN indicates that tailings, mill rock and development rock will not generate ARD, but the material will leach metals. CZN has assumed that the quality of seepage water will not be an issue during operations. CZN has also suggested that a 1 to 2 meter cover will be placed on the waste rock cover that will reduce and eliminate infiltration into the Waste Rock Pile (WRP). CZN suggests that final cover requirements will be determined following seepage monitoring during operations. INAC notes that it take some time for waste rock seepage to produce poor water quality and there is a potential for the cover designs to be inadequate if designed on average seepage water quality over the life of the mine. Until seepage quality is more precisely determined in the post closure phase, INAC cannot assess the potential long term impact of seepages on Harrison Creek and potential impact to Prairie Creek.

- CZN also indicates that hydrocarbon impacted soil will be disposed in the waste rock pile. This material will be placed in a lined cell with the intent to reclaim and reuse this material at closure. INAC assumes that this material will be land farmed and that leachate from precipitation and frequent watering/turnover events would need to be managed. CZN has provided no information on these aspects or to what standard contaminated material would be reclaimed. The standard must be based on the future use of the area, therefore; an industrial standard would not be acceptable. Additional information should be provided demonstrating that leachate from this material will not influence surface water collection, discharge points, or groundwater during operations and following closure.

- CZN's current closure plan does not discuss the potential for tailings stored on the Prairie Creek floodplain post closure. The plan specifically states that this is not preferred, as the tailings would present a "long term risk of exposure and leaching" (Draft Closure and Reclamation Plan, pp.7). The closure and reclamation plan must include discussion on these aspects and the potential impacts.

Recommendation:

1. ***INAC recommends that post closure water quality must meet SSWQOs derived using a Reference Condition Approach. This would be determined in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

2. ***INAC recommends that CZN develop a Preliminary Closure and Reclamation Plan, during the regulatory phase prior to water licence issuance. The plan must be developed in consultation with regulators,***

stakeholders and other interested parties. The plan should developed in accordance with INAC's Mine Site Reclamation Guidelines (January 2007) or subsequent version.

Aquatic Effects Monitoring Program (AEMP) and Adaptive Management

Issue: Aquatic effects of the project must be identified and responded to in advance of negative impacts.

References:

1. Aquatic Effects Monitoring Final Plan. Canadian Zinc. Prepared by Dr. Monique Dube. June 2, 2010
2. DAR Volume 1 of 4, Section 6.18 Water Monitoring.
3. Response to IR DFO_10 – September 2010
4. MVEIRB October 6-7, 2010 Technical Session Transcripts
5. Response to Round Two Information Requests – Appendix O: Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine. Prepared by Hatfield Consultants, February 28, 2011.
6. May 6, 2011 correspondence from Canadian Zinc Corporation to MVEIRB "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report"

Developer Conclusion:

An AEMP will be designed and implemented for the project in accordance with INAC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories – 2007" (May 6, 2011 correspondence from Canadian Zinc Corporation to THE REVIEW BOARD "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report").

Reviewer Conclusion:

INAC agrees with the Developer that an AEMP and Adaptive Management Framework should be developed for the Prairie Creek Mine Development in accordance with INAC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories – July 2009."

Components of documents provided to date during the EA do not fully reflect the intent of INAC's AEMP guidelines.

Rationale:

The Developer has submitted two documents during the environmental assessment regarding aquatic effects monitoring. These include the "Aquatic Effects Monitoring Final Plan June 2, 2010" prepared by Pugsley/Dube Consulting Inc. and "Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine. DRAFT" prepared by Hatfield Consultants on February 2, 2011.

The 2010 document submitted by the proponent stated that:

> *"A Monitoring program requires three key components; 1) Surveillance Network Program (SNP); 2) AEMP; and 3) an adaptive management loop"*

The document goes on to describe the proposed intent and approach to developing an appropriate Aquatic Effects Monitoring Program:

> *"AEMPs in particular can tell use if the water quality standards set for a receiving environment are being met. The AEMP includes definition of the boundaries of a study area, selection of monitoring stations in a rigorous and statistically valid study design, selection of indicators that are at least consistent with indicators in the SNP, determination of a reference baseline against which future change will be judged, development of triggers and targets tied to actions in a tiered monitoring strategy, to obtain sufficient information to determine the cause of any environmental effects if they do occur."*

The second document provided by the proponent in February 2011 was intended to build upon the 2010 document, and provide further detail on operational aquatic monitoring, specifically, what aquatic monitoring activities should the mine undertake once it becomes operational and what are appropriate frequencies of measurement, triggers and management/monitoring actions.

It was stated that:

"Aquatic monitoring programs will include the following elements:

> *1. Routine monitoring of effluent quantity and quality (including both chemistry and toxicity);*
>
> *2. Routine water quality and quantity monitoring in Prairie Creek (referred to by Dubé [2010] as a Surveillance Network Program [SNP]);*
>
> *3.Biological monitoring in the Prairie Creek watershed, following Environmental Effects Monitoring guidelines (referred to by Dubé [2010] as the AEMP); and*

> *4. Monitoring as required by any authorizations or compensation agreements associated with Section 35(2) of the Fisheries Act (administered by Fisheries and Oceans Canada)."*

The document goes on to discuss proposed monitoring under items 1-3 as listed above, as well as "Action Triggers and Responses" in relation to observed monitoring results. With respect to a proposed AEMP, it was stated that the program would follow Environmental Effects Monitoring (EEM) guidance under the MMER. Action triggers and responses proposed included:

> *1. Measured concentration(s) of permitted water quality variables in effluent exceed relevant Effluent Quality Criterion in the Effluent Discharge Permit;*
>
> *2. Effluent is acutely toxic to rainbow trout or Daphnia magna;*
>
> *3. Concentration(s) of one or more AOC in Prairie Creek downstream of mine discharge (measured at downstream edge of IDZ) exceed relevant SSWQO;* ***or***
>
> *4. Biological monitoring indicates an effect on fish, fish habitat, or fish tissue that exceeds significance criteria defined by the federal EEM program.*

Proposed response from the Developer included the following:

- *Confirm the trigger condition;*
- *Quantify effects of the trigger event in the receiving environment;*
- *Take corrective action.*

INAC defines aquatic effects monitoring as "watching closely for changes to the water environment through observations or measurements." Both Traditional Knowledge-based and western science-based observations provide information on the quality of the water, the amount of water, and the health of the fish and insects (organisms) that live in the water. An Aquatic Effects Monitoring Program is a program undertaken by a developer to measure the effects of the development project (such as a mine, oil and gas facility, or hydro development), on the water environment. In the NWT, AEMPs have generally been a requirement of the water licences issued by the regional land and water boards (such as the Mackenzie Valley Land and Water Board). AEMPs provide an early warning of any negative effects of a development project on the water environment. This early warning system is used to manage the project to reduce these effects.

INAC believes that monitoring to evaluate project effects on the aquatic environment is necessary and appropriate for operations at the Prairie Creek Mine, and that it is the responsibility of the Developer to conduct such monitoring and assessment.

At the October 7, 2010, technical session held by the Review Board, INAC was pleased with the Developer's approach to aquatic effects monitoring, as it aligned within the approach defined within INAC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, July 2009."

This document provides a basis for incorporating Traditional Knowledge in an efficient and effective manner, integrating AEMP development activities with those conducted in support of environmental assessments, and harmonizing the requirements for aquatic effects monitoring with those associated with the Environment Canada's Environmental Effects Monitoring (EEM) program. These key aspects are intended to streamline the AEMP development process and ensure that all interests and needs are effectively met.

INAC's AEMP guidelines define an eight-step process for designing and conducting monitoring of the water environment. This step-by-step process is also referred to as the AEMP framework. INAC believes that these steps should be followed during the development of Canadian Zinc's AEMP for the Prairie Creek Mine.

STEP 1: IDENTIFICATION OF ISSUES AND CONCERNS

The first step in the AEMP development process involves identifying issues and concerns regarding the water environment that Aboriginal governments/organizations and interested parties may have about a development project. By asking for input from all interested parties at this stage, a preliminary list of stressors that may be of concern is documented and the Developer can make changes to the project description while considering the issues and concerns.

STEP 2: PROBLEM FORMULATION FOR AQUATIC EFFECTS MONITORING

During the second step, the final list of possible stressors is completed, and then each stressor is looked at to see if it could have effects on the water environment or human health. Next, the ways a stressor can affect the water environment need to be determined (such as elevated levels of a chemical changing the quality of the water). The parts of the water environment that could be affected, such as fish, plants, birds, sediment, water quality, need to be recorded. These are called receptors. Diagrams are prepared that show how each stressor is linked to parts of the water environment that could be affected. These diagrams are called conceptual site models. These models are then used to identify the parts of the water environment that need to be protected and what will be measured to determine if the water environment is being adequately protected.

STEP 3: DEVELOPMENT OF DATA QUALITY OBJECTIVES AND CONCEPTUAL STUDY DESIGN

This step of the process identifies the important parts of an AEMP and helps determine what the monitoring program will look like. This step also determines what types of information and how much data are needed to evaluate the effects of the development project on the water environment. The levels of stressors that would harm the water environment (called Action Levels) are identified. The data quality objectives also describe how the AEMP results will be used to determine if the development project has caused negative effects on the water environment.

STEP 4: DEVELOPMENT OF DETAILED AEMP DESIGN

Step four in the AEMP development process builds on the conceptual study design to develop a detailed AEMP design through:

- Selection of an appropriate monitoring program design;
- Selection of sampling locations;
- Confirmation of appropriate effects sizes;
- Determination of necessary sample sizes; and,
- Identification of appropriate sampling frequencies

A variety of design options are available for AEMPs in the NWT. All of these designs rely on comparison of data collected in an exposed area(s) (i.e., impacted areas) to data collected in an unexposed area (i.e., reference area).

STEP 5: DOCUMENTATION AND VERIFICATION OF THE SAMPLING DESIGN

Various plans will be prepared during this step to describe the procedures to be followed by the people conducting field sampling since it is important that the data is collected properly. There will be specific guidance for all field work (to collect high quality data and information), and a plan to make sure the people collecting samples or visiting the site take all safety precautions necessary. Changes to any of these plans by the Developer should be reviewed by interested parties and approved by the regulatory boards.

STEP 6: IMPLEMENTATION OF THE AEMP

This step begins following the approval of the AEMP by the regulatory board. It involves the collection of environmental samples, Traditional Knowledge, and other information and the analysis of the results to produce data (for example, laboratory measurements for water quality data). The plans developed in Step 5 must be carefully followed for all types of data and information collection.

STEP 7: EVALUATION, COMPILATION, ANALYSIS, INTERPRETATION AND REPORTING OF AEMP RESULTS

Once data and information have been collected under the AEMP (both Traditional Knowledge and western science based), it needs to be evaluated, compiled, analyzed, interpreted and reported by the Developer. This data is compared to baseline data to see if there are changes.

STEP 8: APPLICATION OF AEMP RESULTS WITHIN A MANAGEMENT RESPONSE FRAMEWORK

Management response, also commonly known as adaptive management, is a way to continually improve the management of the development project by learning from the information collected year after year by the AEMP. For example, the results of the AEMP could lead to a change in the amount or location of waste that is released from a development project, if the AEMP results show that a certain chemical being discharged had a negative effect on the water environment.

However, upon reviewing the subsequent document prepared for the proponent by Hatfield Consultants, INAC was concerned that this approach was no longer proposed, considering the Developer's statement, that AEMP development would follow Environmental Effects Monitoring (EEM) guidance. In INAC's opinion, EEM requirements for monitoring are a valuable component of an Aquatic Effects Monitoring Program, but on its own does not constitute an AEMP.

INAC was also concerned with the Developer's proposed action levels and associated management response as it relies on observation of an observed negative effect or licensed exceedance for a management response to be invoked. The INAC guidelines stress the importance of developing low, medium, and high action levels. High action levels correspond to maximum acceptable changes in environmental conditions, as established by the environmental assessment. In this manner, it is envisioned that a management response would be invoked in advance of a high action level to prevent that situation from being reached. Exceedance of a High Action Level should not be permitted and the appropriate management response would be to take immediate action to reverse the problem.

Following a technical meeting held with the proponent in April 2011, INAC requested that the Developer provide a commitment under the environmental assessment to follow INAC's Guidelines during the development of their AEMP. Canadian Zinc Corporation included this commitment within their May 6, 2011 commitments table submitted to THE REVIEW BOARD. INAC is pleased with this commitment and looks forward to working with the Developer and other interested parties in designing a comprehensive and appropriate AEMP and Adaptive Management Framework for the Prairie Creek Mine.

INAC provides the following recommendation in regards to aquatic effects monitoring and adaptive management. INAC feels that should this measure not be implemented, significant adverse impacts to the aquatic environment could occur.

Recommendations:

1. ***INAC recommends that Canadian Zinc Corporation follow the "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009" in the development of its Aquatic Effects Monitoring Program, action levels, and related management response framework for the Prairie Creek Mine. This work should commence in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

Access Road – Land Disturbance, Road Construction and Operation

Issue: Land disturbance resulting from access road construction and operation

References:

1. DAR Volume 1 Sections 6.21, 6.22, 6.23, 6.24
2. Canadian Zinc Corporation. Prairie Creek Mine Developers Assessment Report. Addendum. May 2010. Section 6.0 Access Road Improvements.
3. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011
4. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011. Appendix B.
5. May 6, 2011 correspondence from Canadian Zinc Corporation to THE REVIEW BOARD "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report"

Developer Conclusion:

Road construction methods will be utilized to protect the ground surface and organic mat (Appendix B – Developer Response to IRs Round Two – March 2011).

Reviewer Conclusion:

INAC agrees with the Developer that the ensuring the ground is frozen prior to road construction will prevent disturbance to the underlying ground surface. However, local ground temperature measurements should be used in defining the commencement of road construction and the duration of the operating season.

Rationale:

Canadian Zinc Corporation is proposing the construction and use of an approximately 180 km access road from the mine site to the Liard Highway. The access route is a combination of the existing alignment constructed and operated in the 1980s and four proposed re-alignments. This road will be constructed and operated on a seasonal (winter) basis from approximately November 1st to March 31st of each year. There are two transfer facilities proposed near the Liard River and the Tetcela River.

The proposed access road crosses a number of watercourses. Methods utilized at these crossings will include snow-fill, temporary span structures, or bridge structures. The on-land portion of the existing alignment will be built by clearing and roughly levelling the bed, and then allowing the ground to freeze. Methods used to construct and maintain the access road are identified within Appendix B of the proponents responses to the second round of IRs (March 2011). Canadian Zinc is proposing that the re-aligned portions of the access road be constructed in a similar manner.

INAC is concerned about the potential for land disturbance along the access route as a result of road construction and operation. Historically, the road was constructed from the Liard River crossing northward towards the mine site. Such methods would reduce the length of the transportation season as road construction north of the Liard River crossing could not occur until the Liard River ice bridge could be established. Canadian Zinc is now proposing to lengthen the transportation season by constructing the road from both the north and south ends of the access road. INAC is not opposed to a change in road construction methodology which would provide an extended transportation period. However, INAC is concerned that such a change in road construction methods may not provide sufficient time for the land surface to freeze and provide a suitable surface for heavy equipment and transport of materials.

Canadian Zinc submitted a document describing the road construction and operation techniques which will be utilized during the project. This document was prepared by Kledo Construction Ltd, a road builder based out of British Columbia (Appendix B – Response to IR Round 2). As stated within that document:

> *Low ground pressure dozers (typically a Caterpillar D5 or 6, and more recently a blade equipped Snowcat) would enter onto the right of way in early November to plow the snowfall from the cleared right of way to the edges, maximizing the area available to construct the road. The snow would be stored in windrows at the edge of the road for later use. Skilled equipment operators removed all the snow and herbaceous vegetation cover without removing the root mat or damaging the moss covering.*
>
> *After the exposed ground was exposed to night time freezing temperatures typically -15o Celsius for 2-3 nights, road construction would begin. Any significant delay beyond 3 days due to warm or cold weather or operational delays could sometimes affect the success of the next phase.*
>
> *In the second phase, water tank trucks with a capacity of 10m3 (10,000 litres) were used to carry fresh water from approved borrow pits, ponds and lakes to the road surface. Typically the first loads were ½ the full volume to protect the trucks from breaking through the thin frozen upper layer of root mat and soils. In the first pass, up to 6 loads of water would be applied per kilometre. Usually this first pass was about 11/2 lanes wide for a one way off-highway road with pullouts. One measure of a good road builder and the longevity and strength of his road was how well he could have the water penetrate into the soils. Good absorption*

and deep penetration of water provided a sound base to build the road surface. Volume of water used in this phase on average may accumulate to 30 m3 per kilometre, but can be highly variable depending on ground conditions. Muskeg may require more water while overland forested conditions may require less water.

Once the base was built, for the third phase, usually one road grader and two water trucks would work together constructing an ice surface. The water truck would apply water and the grader would sweep snow from the plowed windrow onto the freshly watered surface. Mixing of the snow and water would be used to fill in voids and smooth out the road. Typically, day time temperatures of -25° Celsius made for good freezing conditions and maximizing construction.

It is clear that the proponent will be relying on frozen ground conditions to construct its road and to prevent disturbance to the underlying land surface, and to the underlying permafrost, if present. However, it appears that the proponent will also be relying on calendar dates and operational experiences to commence road construction.

INAC agrees with the use of low pressure ground vehicles during the early phases of road construction to promote freezing of the underlying ground surface. Acceptable vehicles can be defined within the regulatory phase.

However, INAC is concerned about the subjective nature of determining when water trucks and other heavy equipment can initiate road construction. The use of such heavy equipment on the land in advance of frozen ground conditions (in the case of road construction) or following frozen ground conditions (in the case of road operation) could result in rutting of the land surface. In addition, disturbance of the organic layer during these periods could facilitate degradation of permafrost, which could result in thaw settlement of the land surface.

INAC is of the opinion that the main construction of the access road (phase II as described within the Kledo Construction document) should commence after frozen ground conditions have been confirmed through local measurements and that operation of the road should cease once local measurements indicate that unfrozen conditions are imminent. This could be accomplished through the installation of ground temperature cables in each of the 11 vegetation units along the winter access route, if frozen ground is to be relied upon for road construction and operation. This would provide confirmation to the proponent that the ground surface is frozen and available for construction and operation, as well as provide an indication of when road operation should cease in order to protect the underlying terrain.

INAC provides the following recommendations to mitigate against potential effects to the land surface and permafrost caused by construction and operation of the access route.

INAC feels that should these recommendations not be implemented, significant adverse impacts could occur as a result of land disturbance associated with access road construction and operation.

Recommendations:

1. ***INAC recommends that local ground temperature measurements define the commencement of road construction activities using equipment other than low pressure ground vehicles, in areas where road construction relies on frozen ground.***

2. ***INAC recommends that local ground temperature measurements define the duration of the road operating season, in areas where road operation relies on frozen ground*.**

Access Road – Permafrost Degradation, Road Construction and Operation

Issue:

Degradation of permafrost due to access road construction and operation

References:

1. DAR Volume 1 Sections 6.21, 6.22, 6.23, 6.24
2. DAR Volume 3 of 4. Appendix 16. Terrain Assessment Report Prairie Creek Mine Northwest Territories. Prepared by Golder and Associates March 2010.
3. Canadian Zinc Corporation. Prairie Creek Mine Developers Assessment Report. Addendum. May 2010. Section 6.0 Access Road Improvements.
4. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011.
5. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011. Appendix B.
6. May 6, 2011 correspondence from Canadian Zinc Corporation to THE REVIEW BOARD "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report"

Developer Conclusion:

In level areas underlain by permafrost, the organic layer will be retained in a viable and uncompacted state to help maintain the thermal status of the ground along the route. The existing access road route appears to have generally performed well in this regard, and has very few examples of thaw settlement. Maintaining an organic layer along the road route where ground ice is suspected is preferred, where possible (DAR Volume 1 of 4, Section 6.21.2).

Road construction methods will be utilized to protect the ground surface and organic mat (Appendix B – Developer Response to IRs Round Two – March 2011).

Side hill cuts and fills will generally be avoided except where the evidence is that the ground is free of ice rich permafrost. Cut material will be used if appropriate, or used elsewhere, but not discarded downslope (May 6, 2011 Commitments Table).

Reviewer Conclusion:

- INAC agrees with the Developer that the ensuring the ground is frozen prior to road construction will prevent disturbance to the underlying ground surface.

- INAC agrees with the Developer that maintaining the organic layer in an uncompacted state will prevent disturbance to underlying permafrost.
- INAC agrees that avoidance of side hill cut and fills in ice rich ground will prevent potential mass movement associated with degradation of ice-rich permafrost.
- INAC concludes that a permafrost assessment is required to determine the location of permafrost. Where permafrost is present, mitigation measures to ensure the integrity of permafrost must be implemented.
- INAC concludes that monitoring of permafrost along the access route is needed to evaluate the success of mitigation measures.

Rationale:

CZN is proposing the construction and use of an approximately 180 km access road from the mine site to the Liard Highway. The access route is a combination of the existing alignment constructed and operated in the 1980s and four proposed re-alignments. This road will be constructed and operated on a seasonal (winter) basis from approximately November 1st to March 31st of each year. There are two transfer facilities proposed near the Liard River and the Tetcela River.

The proposed access road crosses a number of watercourses. Methods utilized at these crossings will include snow-fill, temporary span structures, or bridge structures. The on-land portion of the existing alignment will be built by clearing and roughly levelling the bed, and then allowing the ground to freeze. Methods used to construct and maintain the access road are identified within Appendix B of the proponents responses to the second round of IRs (March 2011). Canadian Zinc is proposing that the re-aligned portions of the access road be constructed in a similar manner.

INAC is concerned about the potential for land disturbance and permafrost degradation along the access route as a result of road construction and operation.

The proponent has committed to maintain the thermal status of the ground along the route. In other words, to ensure that permafrost is maintained. However, no specific permafrost investigations have been carried out during this assessment. The proponent does recognize that ice-rich ground should be experienced along the access route. INAC also expects that permafrost conditions will be encountered along the route, as it traverses an area of discontinuous permafrost, where ice rich ground may be present along some side slopes and within low-lying terrain with an organic cover. Further, INAC agrees with the proponent that maintenance of the organic layer in a viable and uncompacted state will aid in the maintenance of the underlying permafrost. Operational methods to achieve this goal must be developed on a site specific basis. INAC notes that it will be difficult to maintain permafrost conditions along slopes, especially where cut and fill techniques will be employed. INAC is pleased that the proponent has committed to the avoidance of side hill cut and fills in ice rich ground.

However, INAC is concerned that no characterization of permafrost conditions along the route has been conducted. In this regard, the proponent is unable to determine areas where operational methods will have to be developed and implemented to ensure the integrity of the underlying permafrost. In addition, it is unclear at to how the proponent will evaluate the success of its operational methods to achieve this goal. Installation and operation of ground temperature monitoring stations along the road, and within adjacent undisturbed terrain, would provide the best means of evaluating any effects to permafrost as a result of road construction and operation.

INAC provides the following recommendations to mitigate against potential effects to permafrost caused by construction and operation of the access route. INAC feels that should these recommendations not be implemented, significant adverse impacts could occur.

Recommendations:

1. INAC recommends a permafrost assessment be conducted along the access route to identify areas requiring implementation of measures to ensure the integrity of the underlying permafrost. Road construction/operation methods to maintain the organic layer in permafrost areas should be defined in advance of initial road construction.

2. INAC recommends that construction of access through side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Where unavoidable, site-specific stabilization measures should be developed and approved by regulators prior to implementation.

3. INAC recommends that ground temperature monitoring data should be collected along the access road itself and in adjacent undisturbed terrain where permafrost is present, to evaluate the success of operational measures to prevent the degradation of underlying permafrost.

Access Road – Sediment Inputs

Issue:

Water quality impacts associated from increased sediment inputs

References:

1. DAR Volume 1 Sections 6.21, 6.22, 6.23, 6.24
2. DAR Volume 3 of 4. Appendix 14. Prairie Creek Mine Winter Road Re-Alignment Air and Ground Stream Crossing Fish Habitat Assessments: Memo Report, Dillon Consulting Limited, November 25, 2009
3. DAR Volume 3 of 4. Appendix 16. Terrain Assessment Report Prairie Creek Mine Northwest Territories. Prepared by Golder and Associates March 2010.
4. Canadian Zinc Corporation. Prairie Creek Mine Developers Assessment Report. Addendum. May 2010. Section 6.0 Access Road Improvements.
5. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011.
6. Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011. Appendix B.
7. May 6, 2011 correspondence from Canadian Zinc Corporation to THE REVIEW BOARD "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report"

Developer Conclusion:

- In level areas underlain by permafrost, the organic layer will be retained in a viable and uncompacted state to help maintain the thermal status of the ground along the route. The existing access road route appears to have generally performed well in this regard, and has very few examples of thaw settlement. Maintaining an organic layer along the road route where ground ice is suspected is preferred, where possible (DAR Volume 1 of 4, Section 6.21.2).
- Road construction methods will be utilized to protect the ground surface and organic mat (Appendix B – Developer Response to IRs Round Two – March 2011).
- Side hill cuts and fills will generally be avoided except where the evidence is that the ground is free of ice rich permafrost. Cut material will be used if appropriate, or used elsewhere, but not discarded downslope (May 6, 2011 Commitments Table).
- CZN will not be introducing any physical footprints within the high water mark of crossings, other than snow and ice. The latter would be for bank protection as

necessary. Another alternative is to use matting which would be removed on seasonal road closure (Canadian Zinc Corporation. Prairie Creek Mine. Responses to Second Round of Information Requests. March 2011).

Reviewer Conclusion:

- INAC agrees with the Developer that the ensuring the ground is frozen prior to road construction will prevent disturbance to the underlying ground surface.
- INAC agrees with the Developer that maintaining the organic layer in an uncompacted state will prevent disturbance to underlying permafrost.
- INAC agrees that avoidance of side hill cut and fills in ice rich ground will prevent potential mass movement associated with degradation of ice-rich permafrost.
- INAC agrees that the use of matting and avoidance of physical disturbance within the high water mark will prevent sediment input to watercourses along the access road.

Rationale:

Canadian Zinc Corporation is proposing the construction and use of an approximately 180 km access road from the mine site to the Liard Highway. The access route is a combination of the existing alignment constructed and operated in the 1980s and four proposed re-alignments. This road will be constructed and operated on a seasonal (winter) basis from approximately November 1st to March 31st of each year. There are two transfer facilities proposed near the Liard River and the Tetcela River.

The proposed access road crosses a number of watercourses. Methods utilized at these crossings will include snow-fill, temporary span structures, or bridge structures. The on-land portion of the existing alignment will be built by clearing and roughly levelling the bed, and then allowing the ground to freeze. Methods used to construct and maintain the access road are identified within Appendix B of the proponents responses to the second round of IRs (March 2011). Canadian Zinc is proposing that the re-aligned portions of the access road be constructed in a similar manner.

INAC is concerned about the potential for water quality impacts from increased sediment inputs along the access route. Increased sediment load to watercourses along the access route could degrade local water quality and potentially affect fish and fish habitat. Canadian Zinc has confirmed within the DAR that fish are present within several watercourses along the access route, and that the Tetcela and Grainger River are considered to have over-wintering habitat.

Access road construction and operation could facilitate sediment input into water through the following pathways:

a. Erosion of banks and approaches to stream crossings.
b. Rutting of the land surface caused by road construction or operation during unfrozen conditions. Water moving along these channels may facilitate sediment load into watercourses downgradient.
c. Disturbance of the organic layer along the access route and associated thaw settlement of the land surface due to permafrost degradation. Water moving along these channels may facilitate sediment load into watercourses downgradient.
d. Cut and fill techniques along slopes containing ice rich soil may facilitate a mass movement/slope failure. This may result in sediment movement into adjacent watercourses or drainages.

With respect to (a), INAC believes that such impacts can be mitigated by assessing the erosion sensitivity of the banks and approaches pre-construction. If highly erodible materials are present along the banks and approaches to a crossing, mitigation measures should be implemented prior to construction (e.g. bank stabilization and/or runoff control measures). If a site is deemed to be of low risk for erosion, the measures as indicated by the proponent within the DAR appear to be appropriate. However, routine monitoring should be conducted along the entire route during operations and maintenance/mitigation, if necessary, should be performed in as timely a manner as possible. INAC notes and is pleased that the proponent has committed to implementing bank stabilization measures at Prairie Creek and Funeral Creek where past erosion problems have been observed.

With respect to (b), (c),and (d), INAC feels that the recommendations as provided within Access Road issues described previously would contribute to preventing the rutting of the land surface, thaw settlement and/or mass movement associated with the degradation of permafrost. Further, as mentioned within these previous sections, INAC recommends that construction of side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Accordingly, these recommendations would prevent/mitigate against the potential for sediment laden runoff to enter downgradient watercourses as a result of these mechanisms.

INAC recommends the following measures to prevent risks associated with the increased sediment input to watercourses along the access route. INAC believes that should these measures not be implemented that significant adverse impacts could occur:

Recommendations:

1. INAC recommends that a Sediment and Erosion Control Plan be developed in advance of mine operations. This Plan should include an assessment of the erosion sensitivity of the mine site as well as proposed

watercourse crossings along the access route. Further, site-specific mitigation measures to prevent erosion should be defined.

2. ***INAC recommends that erosion control measures identified within the Plan be implemented in advance of operations.***

3. ***INAC recommends that routine monitoring of erosion susceptibility at watercourse crossings along the access road should be conducted. If issues are identified, maintenance/mitigation measures should be implemented in as timely a manner as possible.***

4. ***INAC recommends that local ground temperature measurements define the commencement of road construction activities using equipment other than low pressure ground vehicles, in areas where road construction relies on frozen ground.***

5. ***INAC recommends that local ground temperature measurements define the duration of the road operating season, in areas where road operation relies on frozen ground.***

6. ***INAC recommends a permafrost assessment be conducted along the access route to identify areas requiring implementation of measures to ensure the integrity of the underlying permafrost. Road construction/operation methods to maintain the organic layer in permafrost areas should be defined in advance of initial road construction.***

7. ***INAC recommends that construction of access through side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Where unavoidable, site-specific stabilization measures should be developed and approved by regulators prior to implementation.***

8. ***INAC recommends that ground temperature monitoring should be collected along the access road itself and in adjacent undisturbed terrain where permafrost is present, to evaluate the success of operational measures to prevent the degradation of underlying permafrost.***

<u>Access Road – Post Closure</u>

Issue:

Post Closure Impacts

References:

1. DAR Volume 1 Sections 6.21, 6.22, 6.23, 6.24
2. DAR Volume 4 of 4. Appendix 27. Prairie Creek Mine Preliminary Closure and Reclamation Plan February 2010.
3. Canadian Zinc Corporation. Prairie Creek Mine Developers Assessment Report. Addendum. May 2010. Section 6.0 Access Road Improvements.

Developer Conclusion:

Closure objective as presented for offsite infrastructure, including the access road is the following: Remove all contaminated materials and wastes. Restore land surfaces. Modify Funeral Creek road bed to promote stable long-term runoff. (DAR Volume 4 of 4. Appendix 27. Prairie Creek Mine Preliminary Closure and Reclamation Plan. February 2010).

Reviewer Conclusion:

INAC recommends that the entire length of the access road be included within the Prairie Creek Mine Closure and Reclamation Plan.

Rationale:

INAC is concerned about the lack of clarity regarding the ultimate closure and reclamation of the access road. Currently, the access road and transfer facilities are included within the Preliminary Closure and Reclamation Plan (PCRP) within the mine component of "Offsite Infrastructure." As taken from the PCRP:

> ***Objectives:*** *Remove all contaminated materials and wastes. Restore land surfaces. Modify Funeral Creek road bed to promote stable long-term runoff.*
>
> ***Progressive and Post-Closure Reclamation:*** *The off-site infrastructure at the transfer facilities will be salvaged, taken to the mine for disposal, or taken to a suitable off-site disposal location. The sites will be reclaimed by scarifying the surfaces to promote natural invasion by native species. The all season road bed along Funeral Creek will be modified to promote revegetation and clean natural*

> *runoff. The road bed and culverts will be removed at stream crossings. The remaining bed will be scarified and given a gentle slope towards the creek. This will avoid channel formation on the bed and erosion. Coarse material or organic material will be placed along the bed adjacent to the creek to prevent sediment discharge until vegetation has established.*
>
> ***Post-Closure Monitoring:*** *The stability of the roadbed and outer slope, and progress of revegetation, will be monitored during post-closure monitoring episodes.*

It is unclear as to whether or not these activities will be conducted specifically at Funeral Creek or along all watercourses along the access road, if required. It is also unclear to INAC as to whether or not the Developer has considered implications to closure from selected road construction techniques. For example, the placement of aggregate fill on flat terrain where permafrost is present. Difficulties will arise during closure to remove this fill without affecting the underlying organic layer.

INAC feels strongly that the entire length of the access road should be included within the Prairie Creek Mine closure plan, as post closure issues associated with watercourse crossings, land, and permafrost along the route could occur. Post closure issues could include erosion and transport of sediment laden water into watercourses, slope failures/mass movements, and permafrost degradation from alterations to the organic layer along the access route. INAC notes that the details of the closure plan can be discussed and developed once the project proceeds to the regulatory phase.

To this end INAC recommends the following measure to ensure that adequate closure planning occurs for the entire Prairie Creek Mine development, ensuring that closure is conducted in a manner to prevent post closure environmental effects. Without this measure INAC feels that significant adverse impacts could occur.

RECOMMENDATION:

1. ***INAC recommends that the Closure and Reclamation Plan include the entire length of the access road.***

Access Road - Spills

Issue:

Terrestrial and/or aquatic impacts resulting from spills along the access road.

References:

1. DAR Volume 1 Sections 6.21, 6.22, 6.23, 6.24
2. DAR Volume 4 of 4. Appendix 28. Prairie Creek Project 2010 Fuel Spill Contingency Plan. January 2010.
3. DAR Volume 4 of 4. Appendix 33. MSDS for Ethylene Glycol, Sodium Sulfide Flakes, and Sulphuric Acid.
4. Canadian Zinc Corporation. Prairie Creek Mine Developers Assessment Report. Addendum. May 2010. Section 6.0 Access Road Improvements.
5. Response to Round Two Information Requests. Appendix I. Spill Assessment and Contingency Planning. Submitted March 2011.
6. May 6, 2011 correspondence from Canadian Zinc Corporation to THE REVIEW BOARD "RE: Environmental Assessment EA0809-002, Prairie Creek Mine Commitments to Provide Information, April 12 Technical Meeting Progress Report"

Developer Conclusion:

- CZN commits to producing a Spill Contingency Plan (SCP) suitable for operations at the mine and along the access road for all reportable spills. CZN accepts that such a plan must be in place before operations commence. CZN recommends that this be a condition of operating permits (Response to Round Two Information Requests. Appendix I. Spill Assessment and Contingency Planning. Submitted March 2011).
- In preparing an appropriate SCP, CZN will consult and refer to relevant guidelines, such as INAC's 2007 "Guidelines for Spill Contingency Planning", and will reference in the plan where this has been done (Response to Round Two Information Requests. Appendix I. Spill Assessment and Contingency Planning. Submitted March 2011).
- The SCP will address all potentially hazardous substances used at the mine or transported along the road. The substances considered will include all materials that have the potential to impact the environment or human health, and will include fuel, water treatment chemicals and mineral concentrates. The locations and quantities of all of the substances considered at the mine site, along the access road, and at the transfer stations will be detailed, and locations of storage shown on accompanying maps. Particular attention will be paid to substances

that occur in liquid form and significant volumes, such as fuel and sulphuric acid, due to the risk of rapid migration and impact. Worst case scenarios will be considered in greater detail, specifically for those sections of the road considered more sensitive than others (Response to Round Two Information Requests. Appendix I. Spill Assessment and Contingency Planning. Submitted March 2011).

Reviewer Conclusion:

- INAC agrees with the Developer that a SCP must be developed and will be a condition of operating permits.
- INAC agrees that a SCP should be developed in consultation with relevant guidelines, such as INAC's 2007 "Guidelines for Spill Contingency Planning."
- INAC feels that the consequence of spills, by product type, should be evaluated both along the access route as well as at the mine site. This evaluation should be used to define necessary preventative/mitigation measures to be implemented in advance of operations, as well as assist in the development of response procedures during operations.

Rationale:

As mentioned previously, INAC has responsibilities for land and water protection under such legislation as the MVRMA and NWTWA. Of particular concern to INAC is the occurrence of spills and subsequent response and follow-up. To this end, INAC has developed "Guidelines for Spill Contingency Planning, April 2007" which it provides to Developers as guidance in their development of a Spill Contingency Plan. A Spill Contingency Plan is a requirement of water licences issued by regional Land and Water Boards within the NWT.

Accordingly, the specific details of the spill contingency plan can be discussed and finalized during the regulatory phase of the project. However, during the environmental assessment phase, the proponent must describe the potential for spills to occur and the consequence ("significance") to the environment should a spill incidence arise.

In March 2011 the Developer provided additional details on its approach to spill assessment and contingency planning. A general description of the different sections of the access route was provided in relation to spill risk, although how these risk determinations were reached and how the associated consequence level was derived was not described.

INAC feels that more information is necessary to determine the consequence of potential spills on the environment along the access route. As proposed, the access route is a transportation corridor for fuel, mineral concentrates, mill supplies and reagents, water treatment reagents, hazardous waste, and explosives components. The potential effects to land and water from spills of these products would vary. In addition, the response strategies would also differ by product. Some of these materials, for example water treatment reagents, readily dissolve in water and would not be easily recoverable if spilled into water, if at all.

It is unclear from the information provided by the proponent if their assessment of risk and consequence considered differences in the potential effects of a spill by various product and the different considerations in responding to spills of different product. INAC recommends that such an assessment be conducted. It may be safe to assume that the risk of a spill occurring may be similar if not the same for different products of concern, considering the transportation method (truck – either tanker or flatbed) is the same and the route, and the hazards within it, are the same. However, the consequences of different types of product spilled could differ due to differences in product behaviour and response options. For example, a fuel spill and sulphuric acid spill of the same volume into open water could have a different environmental consequence, as response strategies differ and each product has different ecotoxicological effects.

Such an assessment would provide the Developer with the ability to evaluate whether or not additional measures for spill prevention are required during the transportation of different products to and from the mine site.

INAC provides the following recommendation to ensure significant adverse impacts do not occur as a result of a lack of spill contingency planning.

Recommendations:

1. INAC recommends that an assessment of the risk and consequence of spills along the access road be conducted by product type. This evaluation should dictate operational procedures, implementation of preventative/mitigative measures, and response measures for potential spills.

CONCLUDING REMARKS

Canadian Zinc Corporation is proposing the development of a lead-zinc mine on Prairie Creek, located in the Dehcho Region of the Northwest Territories. INAC and its retained experts have completed a technical review of the documents related to the Environmental Assessment of this proposed development up to and including May 18, 2011. Where possible, INAC has provided recommendations to the Mackenzie Valley Environmental Review Board to assist in their decision-making process.

Prairie Creek is a tributary of the South Nahanni River and the proposed development will discharge effluent approximately 7 km upstream of the Nahanni National Park Reserve (NNPR) boundary. NNPR was established in 1976 and is Canada's premier wild river national park. The Nahanni was subsequently designated one of the first 12 UNESCO World Heritage Sites in 1978 and has been designated a Canadian Heritage River (Halliwell and Catto, 2003). In addition, a traditional/subsistence Arctic grayling fishery operates at the mouth of Prairie Creek, where it joins the South Nahanni River. Prairie Creek flows are highly variable and illustrate little to no trend, which presents challenges for effluent discharge and water management

Considering the above, INAC must ensure that an adequate level of protection is provided to Prairie Creek and the downstream aquatic environment into which it flows. INAC must be confident that the contingencies proposed by the Developer during operations will provide this level of protection.

It is INAC's conclusion that the Prairie Creek mine project, as currently proposed, presents a high level of risk for significant adverse impacts to water. These risks are associated with the Developer's proposed water management and effluent discharge strategies, and resulting implications on the receiving environment. INAC understands that the proponent has attempted to address these risks, particularly during the last few months of the review process. Much of the uncertainty and risk associated with the Prairie Creek Mine is attributed to the limiting factors of the natural environment in which the mine is situated. The Prairie Creek mine is located within a valley floodplain providing limited space for infrastructure and storage. Prairie Creek is the only suitable watercourse for effluent discharge.

INAC's remains concerned with uncertainties relating to the Developer's method for developing SSWQOs, the proposed water balance and water storage strategy, and tailings storage. INAC believes that these outstanding issues relate directly to assessing the impacts of the proposed project on the receiving environment and therefore are most appropriately dealt with during the Environmental Assessment. To this end, INAC has proposed a path forward to the Board in an effort to resolve these outstanding issues prior to the closure of EA0809-002.

INAC is committed to working with interested parties towards the resolution of outstanding issues identified during this process, and looks forward to the Board's decision in this regard.

SUMMARY OF RECOMMENDATIONS

Site Specific Water Quality Objectives and Effluent Quality Criteria

1. ***INAC recommends that the Developer be required to establish and present Site Specific Water Quality Objectives (SSWQOs) for the Prairie Creek Mine using the Reference Condition Approach. A committee consisting of the Developer and interested parties to the Environmental Assessment will evaluate the appropriateness and practicality of these generated SSWQOs. The committee will report back to the Review Board with a recommendation on appropriate SSWQOs for Prairie Creek, prior to the Review Board's closure of the public registry for EA0809-002.***

2. ***INAC recommends that Effluent Quality Criteria (i.e. Maximum Grab Concentrations) must be back calculated from SSWQOs based on the Best Estimate inflow prediction.***

3. ***INAC recommends that CZN must not discharge effluent that has concentration(s) above the stipulated Maximum Grab Concentrations in the Water Licence.***

4. ***INAC recommends that any discharge from the end-of-pipe must meet the Maximum Average Concentrations as stipulated by the Surveillance Network Program (SNP) in the Water Licence. Detailed instructions on the method and timing for sampling, deriving and reporting regulated average concentrations should be specifically outlined within the SNP.***

Water Management and Storage

1. ***INAC recommends that the Developer provide the following information regarding tailings and water management prior to closure of the public record for EA0809-002:***
   a. ***A detailed mining and paste backfill schedule be produced by CZN to demonstrate that float tailings will not accrue in Cell A of the WSP.***
   b. ***A detailed description of all operational contingencies that may be implemented to maintain the working capacity of the WSP for the life of the mine, if or when required.***

   This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.

2. ***INAC recommends that the WSP must be operated such that the water level does not impinge on the 1 m freeboard level. The freeboard must be reserved for short-term emergency situations.***

3. ***INAC recommends that any temporary float tailings stored on the surface be stored in predesigned and approved lined containment areas that have specified capacity limits that must not be exceeded.***

4. ***INAC recommends that any Dense Media Separation (DMS) tailings that do not proceed to the Paste Backfill Plant must be transported and stored within the Waste Rock Pile (WRP) as per CZN's operating plan. Any temporary DMS facilities must be predesigned, lined and approved to contain DMS and leachate; their maximum specified storage capacity must not be exceeded.***

<u>In-stream Mercury Concentrations</u>

1. ***INAC recommends that CZN collect and analyze additional samples (seasonally representative) using a sufficiently low detection limit to permit development of a site specific water quality objective for mercury in Prairie Creek using the Reference Condition Approach. This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

2. ***INAC recommends that CZN identify whether increases in mercury concentrations resulting from their discharge can meet this Reference Condition Approach objective, and quantify the level of impact in Prairie Creek resulting from increased concentrations of mercury. This evaluation should consider both the operational and post-closure period. This work would have to be completed in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

<u>Initial Dilution Zone (IDZ) and Dilution in Prairie Creek</u>

1. ***INAC recommends that in-stream water quality must meet SSWQOs, derived using the Reference Condition Approach, at the edge of a predefined assessment boundary (e.g. vertical mixing zone, horizontal mixing zone, NNPR boundary). The location of the assessment boundary for the Prairie Creek Mine would have to be determined in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

Effluent Discharge

1. ***INAC recommends that the final design of the trench and twinned pipe configuration should account for potential failure mechanisms, such as described above.***

2. ***INAC recommends that Canadian Zinc evaluate the requirement for a screen or equivalent structure on the upstream end of the discharge pipe to minimize the potential for debris entering the exfiltration pipe and causing a blockage.***

3. ***INAC recommends that the performance of the exfiltration trench be monitored as part of the SNP, to confirm that adequate performance is achieved.***

4. ***INAC recommends that no effluent be discharged via the culvert into Harrison Creek unless an emergency situation has been declared for the site by the Mackenzie Valley Land and Water Board (MVLWB). Any discharges to Prairie Creek via Harrison Creek must be short term in duration to avoid potentially increased effects to the environment from the mine site. During this scenario a specific Emergency Plan, approved by the MVLWB, must be followed by CZN. This Emergency Plan should include a complete shut down of mining and milling operations.***

Post Closure Conditions

1. ***INAC recommends that post closure water quality must meet SSWQOs derived using a Reference Condition Approach. This would be determined in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

2. ***INAC recommends that CZN develop a Preliminary Closure and Reclamation Plan, during the regulatory phase prior to water licence issuance. The plan must be developed in consultation with regulators, stakeholders and other interested parties. The plan should developed in accordance with INAC's Mine Site Reclamation Guidelines (January 2007) or subsequent version.***

Aquatic Effects Monitoring Program (AEMP) and Adaptive Management

1. ***INAC recommends that Canadian Zinc Corporation follow the "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009" in the development of its Aquatic Effects Monitoring Program, action levels, and related management response framework for the Prairie Creek Mine. This work should commence in conjunction with the establishment and evaluation of SSWQOs for Prairie Creek.***

Access Road – Land Disturbance, Road Construction and Operation

1. ***INAC recommends that local ground temperature measurements define the commencement of road construction activities using equipment other than low pressure ground vehicles, in areas where road construction relies on frozen ground.***

2. ***INAC recommends that local ground temperature measurements define the duration of the road operating season, in areas where road operation relies on frozen ground.***

Access Road – Permafrost Degradation, Road Construction and Operation

1. ***INAC recommends a permafrost assessment be conducted along the access route to identify areas requiring implementation of measures to ensure the integrity of the underlying permafrost. Road construction/operation methods to maintain the organic layer in permafrost areas should be defined in advance of initial road construction.***

2. ***INAC recommends that construction of access through side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Where unavoidable, site-specific stabilization measures should be developed and approved by regulators prior to implementation.***

3. ***INAC recommends that ground temperature monitoring data should be collected along the access road itself and in adjacent undisturbed***

terrain where permafrost is present, to evaluate the success of operational measures to prevent the degradation of underlying permafrost.

__**Access Road – Sediment Inputs**__

1. ***INAC recommends that a Sediment and Erosion Control Plan be developed in advance of mine operations. This Plan should include an assessment of the erosion sensitivity of the mine site as well as proposed watercourse crossings along the access route. Further, site-specific mitigation measures to prevent erosion should be defined.***

2. ***INAC recommends that erosion control measures identified within the Plan be implemented in advance of operations.***

3. ***INAC recommends that routine monitoring of erosion susceptibility at watercourse crossings along the access road should be conducted. If issues are identified, maintenance/mitigation measures should be implemented in as timely a manner as possible.***

4. ***INAC recommends that local ground temperature measurements define the commencement of road construction activities using equipment other than low pressure ground vehicles, in areas where road construction relies on frozen ground.***

5. ***INAC recommends that local ground temperature measurements define the duration of the road operating season, in areas where road operation relies on frozen ground.***

6. ***INAC recommends a permafrost assessment be conducted along the access route to identify areas requiring implementation of measures to ensure the integrity of the underlying permafrost. Road construction/operation methods to maintain the organic layer in permafrost areas should be defined in advance of initial road construction.***

7. ***INAC recommends that construction of access through side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Where unavoidable, site-specific stabilization measures should be developed and approved by regulators prior to implementation.***

8. ***INAC recommends that ground temperature monitoring should be collected along the access road itself and in adjacent undisturbed terrain where permafrost is present, to evaluate the success of operational measures to prevent the degradation of underlying permafrost.***

<u>Access Road – Post Closure</u>

1. ***INAC recommends that the Closure and Reclamation Plan include the entire length of the access road.***

<u>Access Road - Spills</u>

1. ***INAC recommends that an assessment of the risk and consequence of spills along the access road be conducted by product type. This evaluation should dictate operational procedures, implementation of preventative/mitigative measures, and response measures for potential spills.***

REFERENCES

Cooper, N.L. J. R. Bidwell and A. Kumar. 2009. Toxicity of copper, lead, and zinc mixtures to *Ceriodaphnia dubia* and *Daphnia carinata*. Ecotoxicology and Environmental Safety. 72(5):1523-1528.

Halliwell, D and S. Catto. 2003. How and why is aquatic quality changing at Nahanni National Park Reserve, NWT, Canada. Env. Mon. Assess. 88:243-281.

Spencer, P., Bowman, MF, Dube, MD. 2008. A multi-trophic level approach to monitoring the effects of metal mining in otherwise pristine and ecologically sensitive rivers in Northern Canada. Interg. Environ. Assess. Manag. 4:327-343.

Appendix A – Zajdlik and Associates

Review of Prairie Creek Effluent Related Documentation
March 21, 2011

Review of Prairie Creek Effluent Related Documentation

Prepared for:

P. Green and N. Richea
Indian and Northern Affairs Canada

Prepared by:

Zajdlik & Associates Inc.

March 21st, 2011

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Table 1: Table of Acronyms

Acronym	Definition
CCME	Canadian Council of Ministers of the Environment
COPC	contaminants of potential concern
CZN	Canadian Zinc
ECx	Effect Concentration of "x" percent
EEM	environmental effects monitoring
INAC	Indian and Northern Affairs Canada
IR	information request
NHC	Northwest Hydraulic Consultants
NOECSs	no observed effects concentrations
SSWQO	site specific water quality objective
WER	water effects ratio
WQG	water quality guidelines

1 Introduction

This document reviews the following documents:

a) Updated Outfall Design (Oct. 5th, 2010);
b) Updated outfall performance - downstream mixing analysis - DRAFT (Oct. 6th, 2010);
c) Appendix M – NHC analysis of streamflow trends Oct. 25th, 2010;
d) Hatfield, March 2, 2011a memo - Prairie Creek Mine - Water Quality Benchmarks and Assessment of Potential Aquatic Effects.
e) Spencer, P., M.F. Bowman, and M.G. Dubé. 2008. A Multitrophic Approach to Monitoring the Effects of Metal Mining in Otherwise Pristine and Ecologically Sensitive Rivers in Northern Canada. Integrated Environmental Assessment and Management. 4(3):327–343.
f) SRC (Saskatchewan Research Council). 2010. Memo: Additional Site-Specific Water Quality Objectives for Prairie Creek, NWT. September 1st, 2010.
g) INAC-Provided Water Quality Data
h) Hatfield, February 28, 2011Proposed Aquatic Monitoring Framework for CZN's Prairie Creek Mine. DRAFT
i) Halliwell D.R and S. Catto. 2003. How and why is aquatic quality changing at Nahanni National Park Reserve, NWT, Canada? Environ. Monit. Assess. 88:243-281.
j) Nautilus Environmental. 2011a. Toxicity Testing on Synthetic Effluent Samples Final Toxicity Test Report. April 6, 2011.
k) Nautilus Environmental. 2011b. Toxicity Identification Evaluation of Mill Water Sample Draft Report. April 8, 2011.

The reviews are conducted in order to assist in the development of information requests and in the development of INAC's technical report as part of the environmental assessment process. Reviews of specific documents are presented in section 3 and comments pertaining to general topics related to aquatic monitoring are presented in section 4. These two sections are summarized in section 2 immediately below.

2 Summary of Recommendations

This section summarizes recommendations. Details and specific recommendations are provided in the preceding sections, particularly sections 3.5.1, 3.6.1, 3.7.1, 3.8.2, 3.10.1 and 3.11.1.

2.1 A Path Forward

RCA benchmarks have been recommended as SSWOQs by Halliwell and Catto (2003) and SRC (2010). I am also suggesting this level of protection in the context of interested parties concerns expressed due to proximity of the Prairie Creek mine to a National Park and a UNESCO World Heritage Site as well as other concerns and uncertainties with respect to SSWQWOs derived using other methods expressed in the body of the review.

The choice of RCA benchmarks as SSWQOs is pragmatic in that RCA benchmarks are eminently applicable, are relatively simple to estimate, are almost certainly less expensive to estimate than northern species toxicity distribution-based estimates and they acknowledge that naturally occurring concentrations of some elements already exceed national guidelines.

The proponent and others have expressed concerns regarding slow progress through and beyond the environmental assessment which may be delayed given the current uncertainty and lack of consensus[1]. The adoption of RCA benchmarks as SSWQOs would reduce an important, (if not the most important) impediment to conclusion of the environmental assessment of the Canadian Zinc mine potential impacts.

Finally, given that some of the uncertainties regarding non RCA benchmark SSWQOs are attributable to modelling assumptions[2] that can only be addressed when the mine is operational, demonstrable lack of effects during the initial phase of mine operation using RCA benchmarks as SSWQOs may lead to use of SSWQOs estimated using methods other than RCA benchmarks.

2.2 The Reference Condition Approach

Some of the current RCA benchmarks are poorly estimated and inconsistent with other publications. Recommendations for improving the RCA benchmarks are presented below.

- Re-estimate the nitrite RCA SSWQOs using measures of central tendency and dispersion that acknowledge: 1) censored data; and possibly; 2) data that may arise from a mixture of statistical distributions.

- Determine why the nitrite RCA benchmark presented by Hatfield (2011a) (1.03 mg/L as nitrogen) is higher than that presented in SRC (2010) (0.80 mg/L as nitrogen) and does not acknowledge the aberrant observation. Removal of this observation leads to a nitrite RCA benchmark of 0.014 mg /L (as nitrogen). Note that if as suspected, many of the nitrite data represent detection limits the estimated mean is biased upwards.

- Investigate the remaining data (particularly nitrite, Ag, P and ammonia and likely As and Sb) for the presence of censored observations presented as detection limits rather than measurements, and if necessary, re-estimate RCA SSWQOs.

- Review the data collection procedures, analytical methods, site locations, etc. to ensure that data collected by Halliwell and Catto (2003) are comparable to those presented by Canadian Zinc. If data are comparable, augment the dataset used by Canadian Zinc and re-estimate SSWQOs.

2.3 The Aquatic Effects Monitoring Program

INAC (2009) provides guidance on designing aquatic effects monitoring programs (AEMPs) in the Northwest Territories. That guidance emphasizes the importance of problem formulation and community consultation. The AEMP proposed in Hatfield (2011b) states: "The AEMP will follow

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[1] Noted during participation in technical meeting with proponent and stakeholders on April 12th, 2011.
[2] The proponent is commended on the use worst-case estimates in many modelling scenarios.

federal EEM (environmental effects monitoring) guidance" and following this guidance is required under law. Community consultation is not mentioned.

It is important to note that implementation of guidance in INAC (2009) does not proscribe federal EEM guidance and the use of INAC (2009) guidance ensures that community concerns are addressed through aquatic effects monitoring which links measurement endpoints to expressed concerns, and levels of unacceptable change back to mine management. The detailed EEM design document that "will be prepared for the mine for its First Cycle of EEM studies and submitted to Environment Canada" (Hatfield, 2011b) should be augmented with:

Community inputs on relevant measurement endpoints and levels of unacceptable change that are built into the proponent's AEMP.

A necessarily[3] non-exhaustive list of additional measurement endpoints, effects levels and sampling locations is provided below.

- Especial consideration may be necessary for bull trout as Prairie Creek may comprise critical spawning habitat or a passage to critical spawning habitat.

- The multiplication of SSWQOs and statements regarding use of these higher SSWQOs in Hatfield (2011b) makes the new, higher SSWQOs rather than the lower values agreed to, the *de facto* SSWQOs. The proponent should demonstrate the protectiveness of these modified SSWQOs, continue to use the SSWQOs agreed upon or preferentially, use RCA benchmarks as SSWQOs.

- Use ordination scores for enumerated benthic macroinvertebrates and plankton that fall within the 95% probability ellipse[4] of the reference condition.

- Use the following summary metrics for the benthic macroinvertebrate and planktonic communities: richness, abundance, Shannon-Weiner diversity and Simpson's dominance. Summary metrics for the fish community should be developed in conjunction with the Department of Fisheries and Oceans and in cognizance of the impact of repeatedly sampling fish communities in small water bodies.

- The exposure area which may extend into Nahanni National Park (Please refer to section 4.1) which determines where samples to estimate measurement endpoints are collected.

- Detailed biomagnification measurement endpoints (Please refer to section 4.2) should be included.

- Nutrient loadings to mitigate increased nutrient enrichment (Please refer to section 4.3)

[3] Because community consultation and problem formulation has not occurred.
[4] This is consistent with the approach that will be adopted by Parks Canada although Parks Canada will use a 99% probability ellipse (G. Scrimgeour, pers. comm.)

3 Detailed Review Comments

Detailed review comments are provided based on order within the document reviewed. If appropriate, syntheses and recommendations are presented at the end of each sub-section.

3.1 Updated Outfall Design (Oct. 5th, 2010)

This section refers to:

Northwest Hydraulic Consultants. 2010a. Prairie Creek Mine Outfall design – preliminary construction details. DRAFT. Oct. 5th, 2010.

Note that this document (and therefore possibly review comments) is superseded by Northwest Hydraulic Consultants (2011), reviewed in section 3.4.

Northwest Hydraulic Consultants state: "The system will need to include a flap gate or other device to prevent backflow when the creek is at flood stage, when gravity outflow will not be possible. This implies that during freshet, the catchment pond must have sufficient capacity to hold all treated mine process water, drainage water and any other waters gathered on site.

3.2 Updated Outfall Performance - Downstream Mixing Analysis - DRAFT (Oct. 6th, 2010);

This section refers to:

Northwest Hydraulic Consultants. 2010b. Prairie Creek Mine Outfall performance – downstream mixing analysis. DRAFT. Oct 6th, 2010.

Note that this document (and therefore possibly review comments) is superseded by Northwest Hydraulic Consultants (2011), reviewed in section 3.4.

- The mixing analysis focuses on metals identified in another report. This report is not reviewed and therefore no comment on whether the analytes listed include all analytes of potential concern is possible at this time.

- Mixing analysis was conducted using information collected at the Cadillac mine using data from 1974 to 1990. Given that climate change is affecting precipitation patterns and timing of critical water-flow events such as freshet and ice-up; the relevance of a water quality record terminated 20 years ago should be discussed.

- The water flow regime is separated into two periods; open water and ice cover. The period-specific data are summarized using the average and the 7Q10 flow. It is not clear why the 7Q10 flow was chosen rather than another combination of low-flow period (the choice of 7-days) and recurrence interval (the choice of 10 years).

  Certainly the recurrence interval (10 years) should reflect some fraction of the expected mine operating life that is greater than 1 to ensure a conservative temporal scale. The current choice of 7-days may reflect weekly patterns in mine operations but is certainly not reflective of any natural temporal scales.

- The outflow design is based on estimated mine drainage flow rates. There is no discussion on how the mine drainage flow rates were estimated. However the authors state that using the mine drainage flow rates provided, no significant effect on mixing analysis occur. A description of uncertainty around the mine drainage rates and inclusion of this uncertainty in the mixing analysis would better define worst-case scenarios.

- The estimated mixing zone for selenium is very long, exceeding 1 km.

3.3 Appendix M – NHC analysis of Streamflow trends Oct. 25th, 2010

This section refers to:

Northwest Hydraulic Consultants. 2010c. Regional Streamflow Time Series Trend Analysis. October 25, 2010.

Note that this document (and therefore possibly review comments) is superseded by Northwest Hydraulic Consultants (2011), reviewed in section 3.4.

- Data from four water gauges in the region of Prairie Creek are normalized using gauge-specific data collected between 1975 to 1990 (which is the period of record for the Prairie Creek, Cadillac Mine gauge). Data are normalized in two ways; by the average of yearly average flows and by the average of yearly peak flows.

- The normalized data are plotted and 10 year running average for preceding years are presented for the Liard and South Nahanni river gauges. The authors conclude that there are no obvious trends in mean or peak flows. However the South Nahanni gauge 10 year running average does appear to indicate an upward trend.

- No statistical tools were used to test for trends nor was a rationalization for using a 10 year running average provided. Other "backwards-and-forward" smoothers may provide a different interpretation of the data.

3.4 NHC Mixing analysis for Exfiltration trench outfall to Prairie Creek

This section refers to:

Northwest Hydraulic Consultants. 2011. Mixing analysis for exfiltration trench outfall to Prairie Creek – DRAFT. February 11th, 2011.

This document is reviewed primarily as it is an important background document with respect to Hatfield (2011a) reviewed in section 3.5.

- A variety of explicit assumptions and choices were made in modelling (choice of dimensionless mixing coefficient, choice of monthly outfall discharge scenario most likely to correspond to selected stream discharge scenario, etc.). The model predictions should be corroborated with analysis under a variety of discharge ratios (process to mine drainage water) and flow conditions, once discharge begins.

3.5 Appendix D – Hatfield Memo - Water Quality Benchmarks and Assessment of Potential Aquatic Effects

This section reviews:

Hatfield. 2011a. Memo - Prairie Creek Mine - Water Quality Benchmarks and Assessment of Potential Aquatic Effects. March 2' 2011.

- Pg. 2. The statement is made that guidelines based on regional data do not provide realistic thresholds for potential effects in the aquatic receiving environment. Whether this is correct is debatable but it is correct that organisms and communities are adapted to these conditions. Deviations from these conditions represent uncertainty with respect to the long term viability of the existing communities.

- Pg. 2 The paradigm for choosing a SSWQO (site specific water quality objective) switches from a reference condition background approach to a toxicologically based approach if the former cannot be met in the receiving environment. The option to treat (or further treat) effluent is not discussed.

- Section 1.0 discusses derivation of SSWQOs. CCME WQGs are generic guidelines not site-specific guidelines. Some of the generic guidelines acknowledge the effects of some (but not all) known toxicity modifying factors; In this case adjustment of the generic guideline by using the site-specific toxicity modifying factor measurements makes the guidelines more applicable to a given site. However this adjustment alone does not comprise a SSWQO.

- Section 1.1 advocates use of CCME (Canadian Council of Ministers of the Environment) WQG (water quality guidelines) in addition to other guidelines when CCME guidelines do not exist. However the CCME non degradation policy (CCME, 1999) states that:

"*The degradation of the existing water quality should always be avoided. The natural background concentrations of parameters and their range should also be taken into account in the design of monitoring programs and the interpretation of the resulting data.*"

The use of CCME WQGs as proposed by Hatfield (2011a) thus comprises pollute-up-to limits. Other reasons for not adopting generic CCME WQGs as site-specific water quality objectives are:

  - CCME WQGs are not site-specific;

  - Species used in derivation of a CCME WQG may not reflect local more sensitive species.

- CCME WQGs do not acknowledge biomagnification potential. CCME (2007) states: "These issues of bioaccumulation and biomagnification are not addressed formally in the derivation sections, but should be considered in a case-by-case approach during the guideline derivation of particular substances, if appropriate and/or required". With respect to mercury, British Columbia (1989) states: "Thus measurements of total Hg in water alone cannot confirm that a Hg problem exists in a waterbody, even if the measurement exceeds the criteria."

- Species used in derivation of a CCME WQG may not reflect keystone species. The protection of keystone species in aquatic ecosystems is of such importance in deriving water quality guidelines that CCME (2007) includes a special protection clause that in some cases supersedes the recommended environmental quality guideline protocol. CCME (2007) states:

"To allow for flexibility in the regional or site-specific implementation, if it can be demonstrated that a data point below the recommended guideline is for a species at risk within a given province/territory or region/site, for a species of commercial or recreational importance, or for an "ecologically important" species, then jurisdictions may use that data point as the basis for deriving the applicable guideline value."

The keystone species in the Prairie Creek watershed are to the best of my knowledge, currently unknown. In fact Bowman et al (2009) comment on lack of biotic information in this region and the discovery of two species in Prairie Creek hitherto not found in the Yukon or Northwest Territories.

- CCME WQGs do not consider the possible synergistic effects of contaminants of potential concern (COPC). One classic example is the effect of cationic metals on ionoregulation as described recently in Birceanu et al (2008) in the context of the biotic ligand model. Another evaluation of synergistic effects of metals that likely will be in the Canadian Zinc effluent (copper, lead and zinc) is provided in Cooper et al (2009).

- CCME WQGs consider only aquatic exposure and not dietary implications such as those shown for Cd (Franklin et al, 2005).

- Two of the guidelines presented by Hatfield (2011a) are proposed CCME guidelines rather than current CCME guidelines. Both proposed guidelines represent increases from the current CCME guidelines. For Cd the increase is more than a 600% increase from the current Cd limit of 0.063 µg/L after hardness adjustment $0.063\ \mu g/L^{i} = 10^{\{0.86[\log_{10}(\text{hardness})] - 3.2\}}$. The increase in Zn guidelines from the non-hardness adjusted current CCME guideline to the proposed (and hardness adjusted) is greater than16%.

  Note that Table 1 (Hatfield, 2011a) uses two different hardness values are used to adjust for hardness to Cd (hardness = 210 mg/L) and Zn (hardness = 200 mg/L).

- Hatfield (2011a) presents the RCA-derived benchmark for nitrite (as nitrogen) in mg/L as 1.030 mg/L which is inconsistent with SRC (2010).

- Pg. 3, The RCA derived value for nitrite in Table 1 is substantively higher than the current CCME WQG, so much so that investigation of the RCA benchmark was initiated. This investigation is presented in section 3.8. The conclusion presented therein is that the nitrite RCA benchmark is likely incorrect and that other benchmarks should be investigated.

- Appendix A1. Iterative SSWQO Derivation Approach and Whole Effluent Toxicity Testing – Proposal

    - Canadian Zinc is predicting that exceedances of proposed (not accepted) SSWQOs will be exceeded under low flow conditions: "Testing with simulated effluents to date has indicated that, under low river flows, concentrations of some metals or ions can exceed the derived SSWQOs (SGS-CEMI 2010). The exceedances are broken down by mine drainage flow rates. At this time the stated mine drainage flow rates have not been compared to the range of predicted mine drainage flow rates.

    - In section 3.0, Canadian Zinc provides the following paradigm for modifying SSWQOs:

        - Step A: The proposed method for derivation of SSWQOs compares toxicity test derived no observed effects concentrations (NOECSs) with RCA benchmarks and CCME WQGs. Possibilities are:
            - If highest NOEC is > CCME WQG or RCA benchmark, choose higher of the two latter numbers.

            - If highest NOEC is < CCME WQG or RCA benchmark, use RCA benchmark.

        - Step B: If predicted analytes (note text refers to metals only) exceed revised SSWQOs conduct water effects ratio (WER) testing.
            - WERs are an acknowledged method for adapting generic WQOs to a specific site. Two limitations are that the choice of toxicity test species be acceptable surrogates for resident species and the effect of temporal changes in water quality. The latter is emphasized in CCME (2003). CCME (2003) and particularly US EPA (1994) provide guidance on estimating WERs.

            - If toxicity is higher using Prairie Creek water than when using laboratory water the ratio of effects concentrations will be > 1 ($EC_{x,PC} / EC_{x, Lab} > 1$). The proponent will multiply this ratio with the SSWQO from the previous step to produce a higher SSWQO. If toxicity is lower using Prairie Creek water than when using laboratory water the resulting ratio is < 1 and multiplication of this ratio with the SSWQO from the previous step would produce a lower SSWQO. This latter scenario is not included as an option.

        - Step C: Re-compare predicted AOCs against re-revised SSWQOs.
            - If predicted AOC concentrations > re-revised SSWQOs generate a northern species toxicity distribution curve. It is likely but not clear that this refers to the species sensitivity distribution approach used to derive WQGs by CCME.

- If the estimated objective based on the northern species toxicity distribution curve is greater than the previous SSWQO then choose it, otherwise use the previous SSWQO.

- One implication of this tiered approach is that the latter methods are "better" than former methods as they are used to estimate SSWQO that supersede previous SSWQOs. This is likely correct.

- Another implication is that the paradigm will generate the highest possible effects-based SSWQO.

- Concerns with the overall approach:

  - There is no discussion of effluent treatment options in conjunction with development of SSWQOs[5]. The paradigm presented is designed to increase SSWQOs for those analytes predicted to exceed a lower WQO until a SSWQO can be met.

  - The process for deriving SSWQOs ends with derivation of a northern species toxicity curve and a statement that this approach will not likely be necessary. However if this last method does not generate a SSWQO that can be met the requirement for effluent treatment must be discussed as otherwise the mine will not meet SSWQOs.

  - There is a hierarchy with respect to defensibility in the methods for generating effects-based [6]SSWQOs. In my opinion, this is likely: CCME WQGs slightly less than WERs and both of these lower than the northern species toxicity curves[7]. The more defensible methods may produce lower estimates of SSWQOs than less defensible methods. Will these lower estimates based on "better" methods supersede higher estimates?

  - This is (aside from the initial use of RCA benchmarks) an effects-based approach to estimating a WQO. It presumes that the effects being tested:
    - are relevant to the receiving environment in question;
    - acknowledge loadings to the environment; and,
    - acknowledge bioaccumulation and biomagnification.

- Concerns with the details of the approach:
  - NOECs are universally condemned as the estimate is a function of the toxicity test concentrations chosen and are inversely proportional to the quality of the toxicity test data.
  - Details for estimating WERs particularly the implications of seasonal variation in water quality are not discussed.

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[5] Note that mitigative measures are discussed if toxicity in effluent is observed. This is discussed in subsequent sections.
[6] Note that RCA benchmarks comprise an entirely different approach to protecting the receiving environment and are not included in this discussion.
[7] This presumes that WERs and northern species toxicity curves follow "acceptable protocols", use "appropriate" species, etc.

        - The derivation of a SSWQO using a northern species toxicity curve is not discussed.

- Attachment 2: Pre-operations Toxicity Testing Decision Tree

    - Discusses mitigation of acute toxic effects after causative factors/analytes are identified. Note that metal mining effluent regulations preclude effluent that is acutely toxic. There is no discussion of options if causative factors/analytes are not identified which is not uncommon in Toxicity Identification/Evaluation studies.

    - Discusses mitigation of chronic toxic effects after causative factors/analytes are identified but only if effects represent possible ecological risk. It may be wise to choose chronic test responses that connote an ecologic risk at a pre-specified effects concentration. Environment Canada (2002) suggests that "Where sublethal toxicity data has an IC25 result (i.e., effluent concentration where a 25% inhibition is observed in the exposed test organisms) of less than 30%, it is recommended that mines calculate the geographic extent of the response in the exposure area and identify the zone where the concentration of effluent is comparable to the IC25 result." The implication is that a chronic effect of 25% or greater in effluent concentrations < 30% are cause for concern.

      Again, there is no discussion of options if causative factors/analytes are not identified which is not uncommon in Toxicity Identification/Evaluation studies.

- Attachment 2: Pre-operations Site-Specific Water Quality Objective Derivation Decision Tree.
    - Comments made in review of section 3.0 are relevant.

- Section 2.0 Proposed Initial Dilution Zone
    - Figure 1.
        - Figure 1 is conducted for <u>average</u> ice-covered and open water periods conditions and not minimal dilution. The top panel shows that under ice, dilution appears to reach an asymptote at 2km. At this point, 1.6% of the river volume is comprised of Canadian Zinc effluent. The distance downstream this effluent concentration persists is unknown.
        - The bottom panel shows that in the open water season an asymptote is not reached within 2 km downstream of Canadian Zinc. At a distance of 2 km between 0.65 and 1.0% of Prairie Creek water is composed of Canadian Zinc effluent. The distance downstream this effluent concentration persists is not known.

3.5.1 Recommendations

1. Given the unique nature of Nahanni National Park, proximity of the Park to the Canadian Zinc mine and minimal additional dilution in Prairie Creek between the initial dilution zone and the Park boundary, consideration should be given to using RCA benchmarks. This approach is presented by SRC (2010) who states: "This approach is specifically listed (in reference to Canadian Environmental Sustainability Indicators) for the determination of site-specific objectives for As, Fe, ammonia, nitrite, and phosphorus in the NWT".

While it is possible to use a mixture of RCA benchmarks and other guidelines/objectives a mixture of types of guidelines/objectives is less defensible than a set of SSWQOs that are underpinned by a consistent philosophy of protection. This idea is also discussed by Dubé (2010) who states: "In our experience, however, regulators in the Prairie and Northern Region of Environment Canada have recently adopted the reference condition approach across all variables, and we expect that this will be the preferred approach in this case given the sensitive nature of the downstream water body."

2. The less desirable paradigm for generating a mixture of SSWQOs types should discuss additional treatment of effluent as an alternative to raising SSWQOs.

3. Consider the arguments presented above regarding non-applicability of CCME WQGs to the Prairie Creek watershed.

4. If the set of RCA benchmarks is not adopted as SSWQOs, the lower of SSWQOs generated using a WER, northern species toxicity distribution curve or other guideline should be used.

3.6 Spencer et al (2008)

This section refers to:

Spencer, P., M.F. Bowman, and M.G. Dubé. 2008. A Multitrophic Approach to Monitoring the Effects of Metal Mining in Otherwise Pristine and Ecologically Sensitive Rivers in Northern Canada. Integrated Environmental Assessment and Management. 4(3):327–343.

This document is reviewed to better understand the Prairie Creek receiving environment.

Spencer et al (2008) conducted biological and chemical monitoring at three sites in Prairie Creek proximal to Canadian Zinc in the open-water season of 2006. These are at the portal discharge into Harrison Creek (near-field or point source discharge), areas 3km above the zone of influence (reference) and areas 2km downstream from the near-field sites. Measurement endpoints include metal concentrations in water, sediment, and liver and flesh of slimy sculpin (*Cottus cognatus*); benthic algal and macroinvertebrate abundance, richness, diversity, and community composition; and various slimy sculpin measures reflecting condition.

With respect to aqueous sampling a single water grab was collected. These data are of interest to corroborate the RCA benchmarks. Nitrate measurements in mg/L are 0.09, 0.1 and 0.08 for upstream, nearfield and farfield locations respectively. These measurements are similar to those discussed in section 3.8. Nitrite data (which is of specific interest) following discussions in section 3.5 are not presented.

Spencer et al (2008) concluded that observed biological differences in Prairie Creek indicate mild enrichment downstream of the mine site. They also comment on future activities stating that: "Although the biological effects of mining activities appear to be limited at present, evidence of environmental metal concentrations above national guidelines and associated metal accumulation in the liver tissue of sculpin suggests that there is serious potential for increased mining activity to affect biological communities in northern rivers."

3.6.1 Recommendation

- Acknowledge the concern expressed by Spencer et al (2008) with respect to bioaccumulation by setting tissue concentration action triggers that preclude adverse effects on biological communities.

3.7 Saskatchewan Research Council (2010)

This section refers to:

SRC (Saskatchewan Research Council). 2010. Memo: Additional Site-Specific Water Quality Objectives for Prairie Creek, NWT. September 1st, 2010.

SRC (2010) provides SSWQOs as RCA benchmarks. This decision is rationalized as follows: "The mean + 2SDs approach was used as this is the site-specific method listed in the Canadian Environmental Sustainability Indicators (CESI, 2008) report for use in lotic systems in the Northwest Territories (NWT).

SRC (2010) provides nitrite data. The mean and standard deviation for the 28 nitrite (as nitrogen) measurements in mg/L are 0.08 and 0.36, respectively. SRC (2010) provides the mean + 2 standard deviations as 0.80 in the same units.

Note that the sample size reported for nitrite (28) is incorrect based on data presented in Table 1, therein.

3.7.1 Recommendations

- Reconcile the difference in nitrite RCA benchmark provided by SRC (2010) with that provided by the proponent. Also address comment by SRC (2010) regarding unusual nitrite observation as discussed in section 3.8.1.

3.8 INAC-Provided Water Quality Data

This section uses data provided by INAC in electronic format: YELLOWKN-#453341-v1-PRAIRIE_CREEK_ADDITIONA_WQO_DATA_.XLS. It contains water quality data collected in the Prairie Creek vicinity <u>and appears virtually identical to data found in SRC (2010)</u>.

The data were reviewed from the perspective of adequacy for generating reference condition approach water quality objectives. The initial criterion for adequacy employed herein is the coefficient of variation. It is assumed that sampling and analytical methods, site selection, etc. are consistent with the purpose of estimating site-specific water quality objectives. Summary statistics are presented below.

Table 2: Summary Statistics for Prairie Creek Water Quality Variables (a)

	Total Fe (μg/L)	Total As (μg/L)	Total Ag (μg/L)	Total Sb (μg/L)	Dissolved Sulphate (mg/L)
n	68	69	66	66	43
mean	48.5588	0.2446	0.0295	0.2441	67.7953
SD	90.2087	0.1578	0.0370	0.1806	25.7458
mean + 2SD	228.9762	0.5603	0.1034	0.6053	119.2870
CV	1.8577	0.6452	1.2545	0.7402	0.3798

Table 3: Summary Statistics for Prairie Creek Water Quality Variables (b)

	Total Ammonia -N (mg/L)	Nitrate - N (mg/L)	Nitrite - N (mg/L)	P (mg/L)	TDS (mg/L)
n	59	27	27	35	20
mean	0.0048	0.1387	0.0762	0.0069	274.4000
SD	0.0039	0.0462	0.3625	0.0044	69.1264
mean + 2SD	0.0126	0.2311	0.8012	0.0157	412.6529
CV	0.8184	0.3332	4.7559	0.6434	0.2519

The preceding two tables show that the coefficient of variation is greater than 100% for total Fe, total Ag and much greater than 100% for nitrite. The data collected for these three analytes exhibit an undue[8] amount of variation and are examined in greater detail below. Note that these data differ at least with respect to sample size from those presented in Hatfield (2011a) and SRC (2010). With respect to nitrite at least (other analytes not checked) there is an error in the reported sample size. Nitrite data are examined in greater detail below due to the very large coefficient of variation.

[8] Subjective comment made on the basis of experience with environmental data analysis.

3.8.1 Nitrite Data

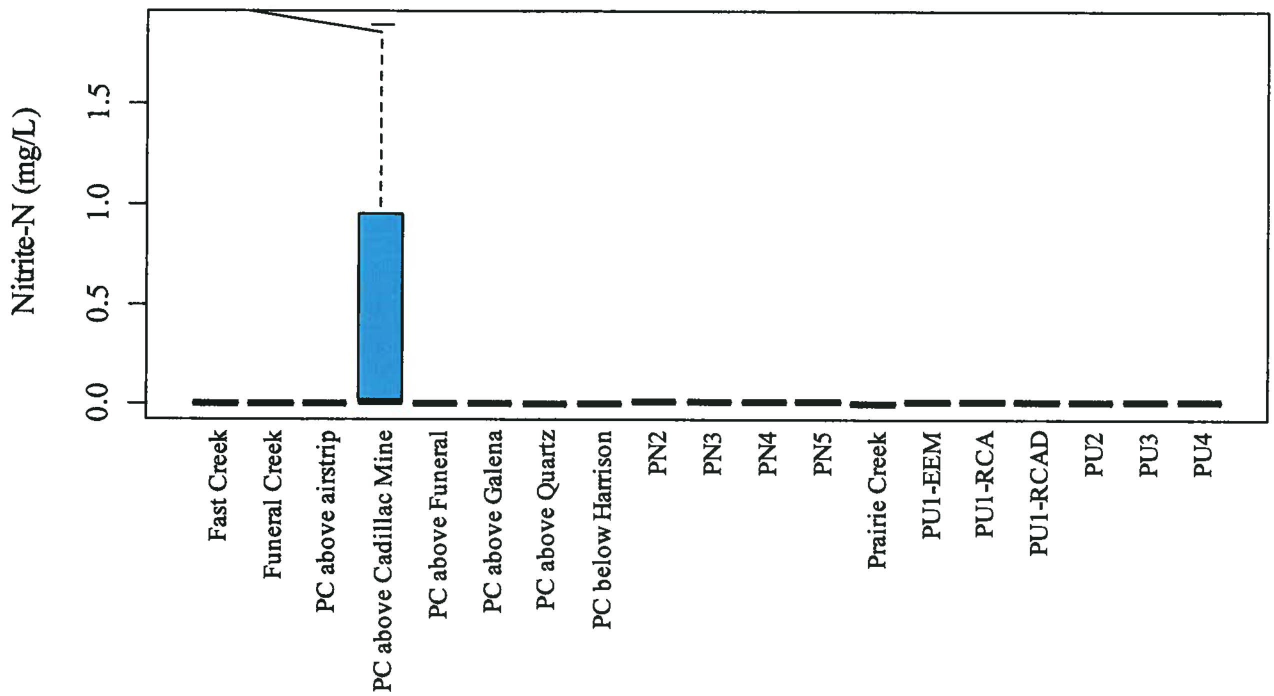

Figure 1: Nitrite Data

Figure 1 is dominated by one large nitrite value (1.89 mg/L) recorded on June 16th, 2008 in Prairie Creek above Cadillac mine. This observation is omitted for the subsequent graphic.

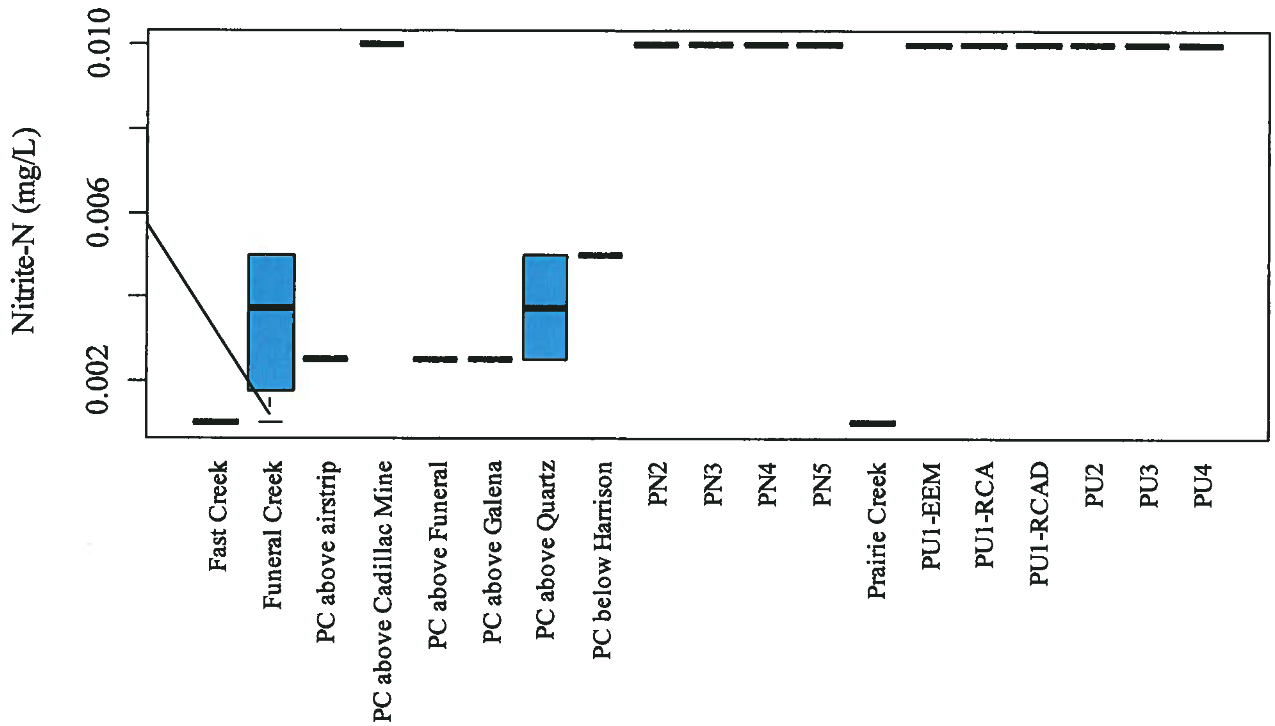

Figure 2: Restricted Nitrite Data

In comparison with Figure 1, Figure 2 shows the overwhelming effect of the single observation recorded. This observation was also flagged and investigated by SRC (2010). They suggest that other analytes measured on the same sample are not unusual and that the sample does not appear to be contaminated. SRC (2010) questions the legitimacy of the nitrite objective due to this observation. The RCA nitrite benchmark using this value is 0.80 mg/L (as nitrogen) which is lower than that presented in Hatfield (2011a).

Omission of this observation and re-estimation of the mean (0.006462) and standard deviation (0.003768) results in an estimated coefficient of variation of slightly more than 58% and an RCA SSWQ of 0.01400 mg/L which is approximately 1/10th that estimated using the entire dataset.

Figure 2 also shows that many of the nitrite measurements are identical at different stations. The observed nitrite values are tabulated below.

Table 3: Observed Nitrite Data

Observation Reported (mg/L)	Count
0.001	3
0.0025	6
0.005	4
0.01	13
1.89	1

It is apparent that are unlikely number of measurements that are repeated. This suggests that many of the observations reported are actually detection limits.

3.8.2 Recommendations

The Reference Condition Approach

1. Re-estimate the nitrite RCA SSWQOs using measures of central tendency and dispersion that acknowledge: 1) censored data; and possibly; 2) data that may arise from a mixture of statistical distributions.

2. Determine why the nitrite RCA benchmark presented by Hatfield (2011a) (1.03 mg/L as nitrogen) is higher than that presented in SRC (2010) (0.80 mg/L as nitrogen) and does not acknowledge the aberrant observation. Removal of this observation leads to a nitrite RCA benchmark of 0.014 mg /L (as nitrogen). Note that if as suspected, many of the nitrite data represent detection limits the estimated mean is biased upwards.

3. Investigate the remaining data (particularly nitrite, Ag, P and ammonia and likely As and Sb) for the presence of censored observations presented as detection limits rather than measurements, and if necessary, re-estimate RCA SSWQOs.

4. Please refer to comments in section 3.11.1 regarding additional data.

3.9 Toxicity Identification and Evaluation

This section reviews the results and conclusions presented in:

Nautilus Environmental. 2011a. Toxicity Testing on Synthetic Effluent Samples Final Toxicity Test Report. April 6, 2011.

Nautilus Environmental. 2011b. Toxicity Identification Evaluation of Mill Water Sample Draft Report. April 8, 2011.

Review comments are presented in point form and summarized at the end of the section.

- Nautilus Environmental (2011b) found higher mortality in *Daphnia magna* at lower concentrations of synthetic mine effluent than at higher concentrations. This is attributed to an interaction with the Prairie Creek dilution water. If this unusual result persists, toxicity testing may need to be carried out at various distances (commensurate with prescribed dilution percentages) from the exfiltration trench.

- The effluent mixtures described in Nautilus Environmental (2011b) were created from samples held longer than the holding times specified in Environment Canada toxicity test protocols. It is not clear what effect this has on the observed toxicity test results.

- The effluent mixtures described in Nautilus Environmental (2011b) did not affect rainbow trout survival or duckweed growth. However daphnids were affected; *Ceriodaphnia dubia* "displayed a substantial reduction in reproduction in both mixtures", and "mixture 1 exhibited a small degree of adverse effect on survival of *D. magna*, whereas mixture 2 did not". The authors conclude that effects observed in cladocerans are attributable to mill water (not mine water).

- Toxicity identification and evaluation for *Ceriodaphnia dubia* exposed to mill water by Nautilus Environmental (2011b) was not able to determine the cause of observed toxicity.

- Nautilus Environmental (2011b) found that *Ceriodaphnia dubia* toxicity with mill water was inconsistent with testing using mixtures of mill and mine water.

In summary, despite efforts to create conservative mixtures of mill and mine water and to (commendably) understand observed toxicity through toxicity identification and evaluation the studies initiated by the proponent raise more questions. These are:

1. How would the mixture toxicity be affected by holding times that meet Environment Canada holding time requirements?

2. How would more[9] time in the clarifying pond affect toxicity test results?

3. Why does toxicity with at least one measurement endpoint increase with increasing dilution?

4. What is the cause of the observed toxicity?

At this point in time even the absence of effects in rainbow trout and duckweed is not as reassuring as it should be due to unknown answers to questions 1 and 2. Overall the toxicity test results do not point to the absence (or near certainty thereof) of possible effects in Prairie Creek. Finally note that the single species toxicity tests do not speak to biomagnification and possibly, community based effects.

3.10 Proposed Aquatic monitoring Framework for Canadian Zinc's Prairie Creek Mine

This section reviews:

Hatfield. 2011b. Proposed Aquatic monitoring Framework for CZN's Prairie Creek Mine Feb 28, 2011.

The proposed aquatic monitoring framework primarily[10] re-iterates Environment Canada (2002) EEM requirements. Some elements of the Northwest Territories AEMP Guidance (INAC, 2009) such as problem formulation and measurement endpoints are not explicitly stated although they are implied, particularly the latter in the context of Environment Canada (2002) measurement endpoints. One key element, stakeholder consultation with respect to measurement endpoints and allowable effects levels has not to my knowledge occurred.

[9] It is my understanding based upon a teleconference with the proponent that water will be retained in the clarifying pond for some time; certainly "more" than the time used to create and hold the synthetic mixtures used in this set of experiments.
[10] Detailed comparison with the EEM program requirements not conducted as these are a requirement for Canadian Zinc.

These consultations will likely lead to questioning the relevance of at least some of the proposed toxicity tests particularly *Lemna minor* in a dynamic lotic environment and the absence of other measurement endpoints such as metals in edible fish tissues[11].

More specific comments are provided below; these are summarized at the end of this sub-section.

- In section 3.0 the following statement is made: "No triggers have been established for sub-lethal toxicity testing conducted as part of EEM studies. " This statement is incorrect at least from the perspective of investigating spatial extent of effects. Environment Canada (2002) suggests that "Where sublethal toxicity data has an IC25 result (i.e., effluent concentration where a 25% inhibition is observed in the exposed test organisms) of less than 30%, it is recommended that mines calculate the geographic extent of the response in the exposure area and identify the zone where the concentration of effluent is comparable to the IC25 result."

- Before and after control impact analyses are only possible if there is very strong congruence between monitoring locations, methods (including sample collection, preservation, transport, analytical protocols, time of sample collection, etc.) and there is replication. With respect to Spencer et al (2008) only one water sample was collected at each location.

- In section 3.0 the use of kick-and-sweep sampling is proposed. If kick and sweep can be done (i.e. water is shallow, low-flowing and not very large substrate) then a tube sampler can be used instead. A problem with kick-and-sweep sampling is that density varies with kicker inducing variability. A tube sampler provides a quantitative estimate of density whereas kick-and-sweep sampling does not.

- Section 4.1. Assessing the likelihood of biological effects in Prairie Creek using toxicity testing (in conjunction with other information) will be enhanced if species found within the watershed are tested.

- The statement is made that "An effect level of 20% on two or more species will be considered ecologically relevant". It is not clear what "ecologically relevant" means. The relevance or import of any effect level should be established before testing occurs. The statement should likely read: ""An effect level of 20% on two or more species will be considered ecologically <u>significant</u>". The difference between "relevant" and "significant" is that the latter implies action should occur where the former implies the results are "interesting".

  Given the expressed concerns regarding safeguarding a National Park and UNESCO World Heritage Site, a sublethal effect of 10% should be considered ecologically significant. Note CCME WQGs include EC10s and even NOECs in guideline derivation.

- If acute toxicity of effluent to rainbow trout is observed, possible corrective action may occur (following a period of confirmatory testing). Although *Daphnia magna* is also tested for acute lethality no corrective action or increased frequency of monitoring is triggered by acute lethality in D. *magna*. The extra protection afforded the receiving environment by protecting against acute toxicity to a member of another phyla should be considered. Note that it is my

[11] Note that a detailed problem formulation/consultation process as discussed in INAC (2009) would demonstrably link monitoring of metal residues in lower trophic levels with metal residues in edible fish tissues obviating initial concerns with the proposed monitoring framework.

understanding that such a requirement is being considered for inclusion under Metal Mining Effluent Regulations.

- Section 4.3 refers to reference condition benchmarks; concerns noted with the derivation of these benchmarks are presented in section 3.8.

- Section 4.3.1 defines a "minor excursion" as a concentration that is less than 1.5 times the RCA benchmark (if the concentration is < 1.5 times the maximum historical upstream concentration, or < 5 times a SSWQO based on a CCME WQG. The rationalization for this factor for CCME WQGs is that guidelines have a 10 fold margin of safety. Exceedances of SSWQOs defined as minor excursions will trigger no action. One concern with this approach is that newer CCME WQGs do not have such a margin of safety and thus the adjustment becomes indefensible. Other concerns are expressed below.

- Section 4.3.2 defines a "major excursion" as a concentration that is greater than 1.5 times the RCA benchmark or greater than 5 times a SSWQO based on a CCME WQG.

  A concern with these two definitions is that the increased SSWQOs (more than 5 times the SSWQO in the case of CCME WQG-based SSWQO) become the *de facto* SSWQO. This practice contravenes the intent of a SSWQO. Action should follow exceedance of a specified SSWQO, not a multiple of that objective.

  If a major excursion is measured water samples will be collected upstream, at the edge of the initial dilution zone and from the effluent. If effluent chemistry meets quality criteria then no action is taken.

  An exceedance of a SSWQO objective means that the effluent quality criteria are incorrect. Exceedances of a SSWQO agreed to (and not a multiple thereof) should trigger re-calculation of the effluent quality criteria.

- Section 4.4 Inclusion of the comment that the Confirmation of Effect and Investigation of Magnitude and Extent studies under the EEM program will not likely be required for the Canadian Zinc mine indicates a desire for quick resolution.

- Section 6.0 is a thoughtful conclusion to the monitoring report. One addition is that "any effects of effluent released from the Prairie Creek Mine on the aquatic environment are effectively measured, understood and mitigated as necessary.

3.10.1 Recommendations

Primary concerns expressed above are reiterated here along with recommendations for resolution. Secondary concerns are not re-expressed.

1. INAC AEMP (2009) guidance does not appear to have been followed; particularly problem formulation stages and community consultation.

2. The absence of explicit problem formulations leaves open questions such as: "Is the list of COPC comprehensive?". At this point in time the answer to this question is not clear. Other

questions that would be answered through explicit problem formulation include "Have the most sensitive measurement endpoints given expected releases been selected?". Other unanswered questions are possible.

3. Any community consultation or consultation with other parties with respect to measurement endpoints or allowable effects levels should be included in the proposed monitoring framework. If this consultation has not occurred provision for such consultation and consequent amendment of the proposed monitoring framework should be included in the current proposed framework. The importance of consultation on measurement endpoints and allowable effects levels cannot be overstated.

4. The multiplication of SSWQOs and statements regarding use of these higher SSWQOs makes the new, higher SSWQOs rather than the lower values agreed to, the *de facto* SSWQOs. The proponent should demonstrate the protectiveness of these modified SSWQOs or continue to use the SSWQOs agreed upon.

3.11 Water Quality in Nahanni National Park

This section reviews:

Halliwell D.R and S. Catto. 2003. How and why is aquatic quality changing at Nahanni National Park Reserve, NWT, Canada? Environ. Monit. Assess. 88:243-281;

with the objective of understanding background water quality in Prairie Creek. Thus, not all aspects of this paper are mentioned and seeming omissions are deliberate.

Halliwell and Catto (2003) collected water quality data for the purpose of developing water quality objectives for major streams entering the Nahanni River. Data were collected at 13 sites from 1988 to 1991 and 1992 to 1997. At this point in time details of the sampling collection (flow regimes, temporal considerations, etc.) are not examined in detail. The key observations are that:

- Background data that may be useful for augmenting the SSWQO database compiled by Canadian Zinc are available.
- The authors have generated SSWQO for the mouth of Prairie Creek that were not cited by the proponent. These SSWQOs are presented below and compared with those provided in Hatfield (2011a).

Table 4: Comparison of Canadian Zinc and Halliwell and Catto Proposed SSWQOs

Analyte	Units	Canadian Zinc RCA Benchmark	Current CCME	CCME Proposed	Canadian Zinc Alternative	Halliwell and Cato Prairie Creek Mouth LTO[12]	Halliwell and Cato Prairie Creek Mouth STO[13]
Cd	µg/L	0.172	0.017	0.38		0.1	0.1
Cu	µg/L	2.53	4			0.5	0.6
Pb	µg/L	1.13	7			0.7	1.1
Se	µg/L	2.16	1	35	20	0.6*	1*
Zn	µg/L	22.65	30			5.4	9.4
Sb	µg/L	0.606					
As	µg/L	0.56	5			0.2*	0.3*
Fe	µg/L	229	300			66.7	178.2
Hg	µg/L	0.034	0.026				
Ag	µg/L	0.103	0.1			0.1	0.2
NH_3-N	mg/L	0.013	0.239				
NO_3-N	mg/L	0.23	2.9				
NO_2-N	mg/L	1.03	0.06		0.5		
Nitrate/Nitrite	mg/L					0.1347	0.1704
Total P	mg/L	0.016	0.004 /<50%				
SO4	mg/L	119.3				36.3629	49.46
TDS	mg/L	413					

SSWQOs based on long term objectives proposed by Halliwell and Catto are always lower than those proposed by Canadian Zinc; often substantively so. This may be due to the use of the 90th percentile rather than a mean + 2 standard deviations.

3.11.1 Recommendations

1. Review the data collection procedures, analytical methods, site locations, etc. to ensure that data collected by Halliwell and Catto (2003) are comparable to those presented by Canadian Zinc.

2. If data are comparable, augment the dataset used by Canadian Zinc and re-estimate SSWQOs.

[12] LTO (long term objective) = average historical values
[13] STO (short term objective) = 90th percentile of historical values

4 General Concerns

This section does not contain a review of a specific document but rather broader topics related to aquatic monitoring.

4.1 The Exposure Area

Figure 1 (Hatfield 2011a) shows that under average (not extreme) ice-cover conditions, the predicted effluent concentration is approximately 1.6% two kilometers downstream of the exfiltration trench. The distance this effluent concentration will persist downstream is not known. It is my understanding that there is little dilution beyond this point to the Park boundaries. This may be particularly true in the winter.

Environment Canada (2003) states: "The exposure area(s) for EEM studies is the area where the effluent concentration is 1% or greater, reflecting a dilution[14] of no more than 1:100." Thus it is likely that under worst-case conditions the Canadian Zinc mine exposure area will extend into Nahanni National Park.

4.2 Biomagnification

The Canadian Zinc effluent will contain substances that can biomagnify (increased tissue concentrations at higher trophic levels relative to lower trophic levels). These substances include Hg, Se (CCME, 2007) and possibly[15] Cd (Croteau et al, 2005). Suggestions for addressing biomagnification are:

- Improve estimates of the background Hg concentrations with lower detection limits to ensure that expressed concerns are not in part attributable to a limitation of analytical chemistry.
- Conduct a literature review to identify trophic levels and quantify the energy flux across trophic levels in a northern montane environment.
- Conduct a literature review to identify biomagnification ratios across trophic levels identified in the previous step.
- Generate pre-emptive management triggers for substances that biomagnify.

This suggestion for proactive investigation of triggers is at odds with the recommendation by Hatfield (2011b) who state: "… instead of prescribing pre-defined triggers, fish-tissue results will be reviewed on a study-by-study basis, with recommendations for future studies discussed among regulators and other experts".

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[14] Environment Canada (2011) states that the plume delineation "document was prepared for the pulp and paper EEM program but can also be applied to the metal mining EEM program."
[15] There is contradictory evidence regarding biomagnification of Se in freshwater systems.

Finally it is important to reiterate that CCME WQGS do not address biomagnification potential or uptake of COPC through diet so adoption of CCME WQGs may not preclude significant biomagnification.

4.3 Nutrient Enrichment

There is evidence of nutrient enrichment prior to the mine operating (Spencer et al 2008). The degree of nutrient enrichment can only increase following mine operation and installation of a sewage treatment plan. A plan to manage nutrient loadings so that the effects of nutrient enrichment do not increase should be presented. Note that due to high flows and rapid initial dilution it is unlikely that effects of large loadings will be manifested proximal to the discharge point but rather at a point further downstream.

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[i] 0.063 μg/L $=10^{\{0.86[\log_{10}(\text{hardness})] - 3.2}$ using hardness as 210 mg/L and entered into CCME hardness adjustment formula as mg/L which is(oddly) inconsistent with output units. However using hardness units of μg/L produces nonsensical results.

Appendix B – Zajdlik and Associates

Addendum: Review of Prairie Creek Effluent Related Documentation
June 1, 2011

ADDENDUM - Review of Prairie Creek Effluent Related Documentation

Prepared for:

P. Green and N. Richea
Indian and Northern Affairs Canada

Prepared by:

Zajdlik & Associates Inc.

June 1st, 2011

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Table 1: Table of Acronyms

Acronym	Definition
EQC	environmental quality criteria/criterion
SSWQO	site specific water quality objective

Introduction

This document briefly reviews documents released by Canadian Zinc following the April 12th technical meeting held in Yellowknife up to May 26th 2010. The brief review is conducted in order to update the more thorough review of existing documents as of March 21st, 2011 (Zajdlik, B. 2011. Review of Prairie Creek Effluent Related Documentation. Prepared for: P. Green and N. Richea, Indian and Northern Affairs Canada, March 21st, 2011.)

The following documents are briefly reviewed:

Hatfield, 2011. Appendix J - Prairie Creek Mine – Supplementary whole effluent toxicity testing (Memo 7), May 11, 2011.

Hatfield, 2011. Appendix D - Prairie Creek Mine – Water Quality Objectives (Memo 1), May 11, 2011.

Hatfield, 2011. Appendix F - Prairie Creek Mine – Predictions of Prairie Creek Water Quality (Memo 3), May 11, 2011.

Hatfield, 2011. Appendix G - Prairie Creek Mine – Bioaccumulation of Mercury and Selenium in Fish (Memo 4) , May 9, 2011.

Hatfield, 2011. Appendix I -Prairie Creek Mine – Potential Enrichment Effects (Memo 6) , May 9, 2011.

Due to the very large number of citations of documents authored by Hatfield in 2011, the usual practice of subscripting years for multiple citations within a year is ignored within this document. Instead each memo cited is explicitly identified.

Brief Review Comments

Prairie Creek Mine – Supplementary Whole Effluent Toxicity Testing (Memo 7)

This section briefly reviews:

Hatfield, 2011. Appendix J - Prairie Creek Mine – Supplementary whole effluent toxicity testing (Memo 7), May 11, 2011.

Standard Environment Canada toxicity test methods were used to assess toxicity of simulated effluent comprised of mixtures of "new laboratory treated process water and treated mine water samples" to *Ceriodaphnia dubia* and *Daphnia magna*.

The major conclusions of this work are that:

- No acute toxicity to *D. magna* was observed even for the (simulated) worst-case scenario.
- *C. dubia* showed adverse reproductive effects at 40% of the 4:1 (treated mine water: treated process water) representing the worst case scenario. This is an improvement over the preceding set of toxicity tests where adverse reproductive effects were noted in 5% simulated effluent (using the same 4:1 ratio).
- With respect to sublethal effects Hatfield (2011) concludes that discharge of treated Prairie Creek mine effluent will result in no sub-lethal effects outside the initial dilution zone.

The major reservations regarding this work are not in the work conducted (which seems to be duly diligent and conservative due to use of worst-case scenarios) but rather with respect to the conclusions. The conclusion that there will be NO sublethal effects outside the dilution zone presumes that:

- Simulated effluent reflects real effluent. Like the previous set of toxicity test results, the degree to which the "new laboratory treated process water" reflects treated process water cannot be known *a priori*. Nor can it be known how well the treated mine water reflects actual treatment conditions.
- No single organism, multi-species assemblage or multi-generational measurement endpoint in Prairie Creek is more sensitive than reproduction in *C. dubia*.
- Predictions regarding maximum % effluent are valid and continue to hold as the capacity of the mine site to store tailings diminishes.

Considering the evidence and reservations, sublethal toxicity is not ruled out at least within the initial dilution zone and possibly further downstream.

Prairie Creek Mine – Water Quality Objectives (Memo 1)

This section briefly reviews:

Hatfield, 2011. Appendix D - Prairie Creek Mine – Water Quality Objectives (Memo 1) , May 11, 2011.

Comments are provided in point form below:

- In section 2.2, the decisions regarding how data were treated cannot be followed because the measurement-specific detection limits are not provided and the meaning of the following sentences is not clear:
    - "If the 90th percentile concentration was less than any non-detected measurements (or suspected non-detects), these specific measurements were eliminated from the calculation of the 90th percentile."

- "Shaded concentrations in (Table 1) indicate 90th percentiles calculated from datasets consisting primarily of non-detectable values. One of the following conditions were met."

- In section 2.3 the authors imply that reference condition benchmarks are used to predict potential effects of water quality on stream biota. This is not my position. Reference condition benchmarks are not used to predict effects. Rather, maintenance of water quality within the range of natural variability ensures that the existing biotic assemblages will continue to function as they currently do and no adverse effects are expected. If water quality parameters exceed the range of natural variability then adverse effects are possible.

- The analyte-specific rationalizations sections 2.3.1 through 2.3.15 are not reviewed at this time as my recommendation is to adopt reference condition benchmarks as SSWQOs.

- In section 2.4 the authors state that the list of recommended objectives <u>should</u> be sufficiently protective of the aquatic environment downstream of the Prairie Creek Mine. The authors do not, and in fact cannot, state that the recommended objectives <u>are</u> sufficiently protective of the aquatic environment downstream of the Prairie Creek Mine. However this statement can be made if reference condition benchmarks are adopted as SSWQOs.

- Section 2.4 and section 3.2: The management of effluent quality effectively manages downstream water quality. This is the approach used in pulp and paper mills and metal mines in Canada. As an additional safeguard, limits on loadings to the environment for a specified period of time are often imposed.

- Hatfield is proposing alternatives to this approach to protecting the environment for two stated reasons. These are:

  - Models over-predict downstream concentrations.
  - Loads to Prairie Creek are over-estimated.

  The first concern is correct and will lead to conservative environmental quality criteria (EQCs). The realism of the model can be improved by inclusion of terms to account for differential contributions of the various streams comprising the end-of-pipe discharge. This can lead to less conservative EQCs.

  The second concern is also correct with the implication that EQCs based on effluent with the highest proportion of process water will at times, be conservative. Proposed solutions to this conservatism include downstream water management strategies, load based criteria and use of seasonal EQCs.

Adoption of a water management strategy based on downstream measurements would require very rigorous, almost real-time monitoring and regulatory / enforcement feedback loops to ensure compliance. This type of monitoring would require a considerable level of effort and will be challenged by frequent sampling in all weather conditions.

Adoption of a daily load-based criterion is more practical if the daily allowable load will be sufficiently diluted during low flow periods so that water quality objectives are not exceeded outside the initial dilution zone. If a daily allowable load will cause water quality objectives to be exceeded outside the initial dilution zone then daily allowable loads will need to vary seasonally which also poses regulatory challenges.

The proponent should also consider additional treatment and holding capacity to dampen extremes in effluent quality so that EQCs are less conservative at times.

Prairie Creek Mine – Predictions of Water Quality (Memo 3)

This section briefly reviews:

Hatfield, 2011. Appendix F - Prairie Creek Mine – Predictions of Prairie Creek Water Quality (Memo 3), May 11, 2011.

Comments are provided in point form below:

- The predicted concentrations in Appendix F, pg. 8 are compared to the long term objectives generated by Halliwell and Catto (2003) below. Analytes for which comparisons are possible are highlighted; exceedances are highlighted. Aside from cadmium, predicted concentrations frequently exceed long term objectives.

Table 4 **Predicted concentrations of analytes of concern in Prairie Creek, downstream of the IDZ (from CZN 2011), screened against proposed objectives.**

Water Quality Variable	Proposed Objective (Derivation)	Mine Seepage Scenario	Open-Water Creek Flows Max (Jun)	Open-Water Creek Flows Mean (Jul)	Open-Water Creek Flows Min (Oct)	Winter Creek Flows (Ice-Covered) Max (Apr)	Winter Creek Flows (Ice-Covered) Mean (Dec)	Winter Creek Flows (Ice-Covered) Min (Mar)
Prairie Creek flows used in model (m^3/s)			38.2	10.2*	1.57	4.43	4.43	0.71*
Total Arsenic (µg/L)	5.0 (CCME)	Low	0.12	0.14	0.17	0.12	0.17	0.24
		Best	**0.13**	**0.16**	**0.21**	**0.12**	**0.18**	**0.31**
		High	0.14	0.19	0.26	0.13	0.21	0.42
		Extreme	0.15	0.22	0.49	0.27	0.55	1.90
Total Cadmium (µg/L)	0.38 (CCME)	Low	0.046	0.076	0.087	0.046	0.098	0.030
		Best	**0.046**	**0.076**	**0.086**	**0.046**	**0.098**	**0.031**
		High	0.046	0.075	0.085	0.046	0.098	0.031
		Extreme	0.046	0.075	0.082	0.046	0.093	0.037
Total Copper (µg/L)	5.17 (CCME)	Low	0.32	0.43	0.54	0.32	0.54	0.61
		Best	**0.34**	**0.47**	**0.63**	**0.32**	**0.59**	**0.77**
		High	0.37	0.56	0.76	0.34	0.65	1.07
		Extreme	0.39	0.62	1.33	0.70	1.52	4.89
Total Lead (µg/L)	7.0 (CCME)	Low	0.24	0.64	0.75	0.23	0.88	0.09
		Best	**0.24**	**0.64**	**0.77**	**0.23**	**0.89**	**0.13**
		High	0.24	0.67	0.79	0.24	0.90	0.21
		Extreme	0.25	0.68	0.88	0.32	1.04	1.14
Total Mercury (µg/L)	0.026 (CCME)	Low	0.021	0.024	0.024	0.021	0.025	0.020
		Best	**0.021**	**0.024**	**0.024**	**0.021**	**0.025**	**0.019**
		High	0.021	0.023	0.024	0.021	0.025	0.019
		Extreme	0.021	0.023	0.023	0.021	0.023	0.013
Total Selenium (µg/L)	2.22 (RCA)	Low	1.18	1.23	1.27	1.18	1.28	1.26
		Best	**1.18**	**1.25**	**1.30**	**1.18**	**1.30**	**1.31**
		High	1.19	1.27	1.34	1.18	1.31	1.40
		Extreme	1.20	1.29	1.51	1.30	1.58	2.58
Total Zinc (µg/L)	35 (CCME)	Low	4.30	6.01	6.71	4.28	7.28	4.01
		Best	**4.32**	**6.07**	**6.88**	**4.29**	**7.35**	**4.33**
		High	4.38	6.25	7.06	4.31	7.44	4.92
		Extreme	4.42	6.36	7.97	5.01	8.86	12.44
Ammonia (mg/L)	0.409 (CCME)	Low	0.007	0.009	0.017	0.006	0.014	0.039
		Best	**0.008**	**0.013**	**0.026**	**0.007**	**0.019**	**0.055**
		High	0.011	0.022	0.039	0.008	0.025	0.085
		Extreme	0.014	0.028	0.097	0.044	0.113	0.462
Nitrate (mg/L)	2.9 (CCME)	Low	0.16	0.18	0.24	0.16	0.22	0.41
		Best	**0.17**	**0.21**	**0.31**	**0.16**	**0.25**	**0.53**
		High	0.19	0.27	0.41	0.17	0.30	0.76
		Extreme	0.21	0.32	0.84	0.45	0.97	3.62
Total Phosphorous (mg/L)	0.004 (CCME)	Low	0.0022	0.0024	0.0026	0.0022	0.0027	0.0021
		Best	**0.0022**	**0.0024**	**0.0026**	**0.0022**	**0.0027**	**0.0021**
		High	0.0022	0.0025	0.0026	0.0022	0.0027	0.0022
		Extreme	0.0022	0.0025	0.0027	0.0022	0.0028	0.0029
Sulphate (mg/L)	200 (toxicity-based)	Low	71.8	78.5	84.9	71.5	85.3	88.0
		Best	**72.5**	**80.5**	**90.3**	**71.8**	**87.9**	**97.3**
		High	74.4	85.6	97.7	72.5	91.4	115
		Extreme	75.8	89.5	131	94	142	336
TDS (mg/L)	413 (RCA)	Low	274	282	290	273	291	290
		Best	**275**	**285**	**295**	**274**	**293**	**300**
		High	277	290	303	275	297	319
		Extreme	278	294	338	297	351	556

Shading indicates predicted concentrations exceeding the proposed site specific Water Quality Objectives.

Bold numbers indicate dilutions expected under more likely operating conditions (i.e., most likely mine-water flow scenario).

*Mean flows for the period, not the month.

Figure 1: Predicted Analyte Concentrations Compared with Long Term Objectives

The key point is that predictions and statements regarding exceedances are based upon proposed water quality objectives rather than accepted water quality objectives. Conclusions regarding predicted mine performance may change depending upon which set of water quality objectives is adopted.

Prairie Creek Mine – Bioaccumulation of Mercury and Selenium (Memo 4)

This section briefly reviews:

Hatfield, 2011. Appendix G - Prairie Creek Mine – Bioaccumulation of Mercury and Selenium in Fish (Memo 4) , May 9, 2011.

Comments are provided in point form below:

- If other predictions are met (notably no nutrient enrichment –discussed in section 0), a plausible argument for a lack of expected biomagnification issues regarding Hg is presented. This is not to say definitively that Hg biomagnification will not be problematic due to uncertainties associated with predicting Hg concentrations in a simulated effluent, modelling downstream water quality, adequacy of infrastructure over mine life, etc.

  Thus, a plan to 1) establish a defensible pre-operations baseline of Hg concentrations in critical environmental matrices; and 2) monitor for early changes in Hg concentrations in lower trophic levels and edible fish tissues as part of the AEMP should be part of the EA submission. The recommendation to biologically assess Hg concentrations is consistent with Parker et al (2010).

- Plausible arguments for a lack of Se biomagnification are presented by the proponent; the most compelling of which is use of a reference condition benchmark. Note that issues regarding estimation of reference condition benchmarks are presented elsewhere.

Prairie Creek Mine – Potential Enrichment Effects (Memo 6)

This section briefly reviews:

Hatfield, 2011. Appendix I -Prairie Creek Mine – Potential Enrichment Effects (Memo 6), May 9, 2011.

- Hatfield (2011) concludes that "The small, predicted increase in phosphorus in Prairie Creek is not expected to lead to high periphyton biomass, although additional increases above biomass currently present are expected." This statement is based on predicted concentrations presented in Hatfield (2011[1]).

The predicted changes in total phosphorous in Prairie Creek are estimated using the upstream total phosphorous concentration of 7 μg/L (Table 3, therein) and predicted downstream concentrations under mean and low flow conditions (Table 8, therein) below.

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[1] Hatfield. 2011a. Benchmarks and assessment of potential aquatic effects. Memo addressed to David Harpley, Canadian Zinc Corporation, Vancouver. March 2, 2011.

Table 2: Predicted Changes[2] in Total Phosphorous (mg/L) in Prairie Creek at Harrison Creek

	Jan	Feb	Mar	Apr	May	Jun
predicted total phosphorus under mean flow conditions	0.008	0.007	0.008	0.008	0.008	0.007
predicted total phosphorus under minimum flow conditions	0.011	0.011	0.012	0.019	0.008	0.008
increase in total phosphorous relative under minimum flows in Prairie Creek	0.004	0.004	0.005	0.012	0.001	0.001
increase in total phosphorous relative under mean flows in Prairie Creek	0.001	0	0.001	0.001	0.001	0
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
predicted total phosphorus under mean flow conditions	0.008	0.008	0.008	0.009	0.008	0.008
predicted total phosphorus under minimum flow conditions	0.008	0.009	0.009	0.01	0.009	0.011
increase in total phosphorous relative under minimum flows in Prairie Creek	0.001	0.002	0.002	0.003	0.002	0.004
increase in total phosphorous relative under mean flows in Prairie Creek	0.001	0.001	0.001	0.002	0.001	0.001

Table 2 shows that under mean flow conditions increases in total phosphorous range from 0 to 2 μg /L with a yearly monthly mean increase of 0.92 μg/L. Under minimum flow conditions, increases in total phosphorous range from 1 to 12 μg /L with a yearly monthly mean increase of 3.42 μg/L. Changes at the Park boundary are not estimated but based on predicted concentrations in Table 8 (therein) would not differ substantively from those presented in Table 2, above.

Bowman et al (2005) found that "low-level cultural eutrophication (0.1–3.8 μg/L increase in total phosphorus) of oligotrophic mountain rivers resulted in 4- to 30-fold increases in benthic algal abundance. If a similar effect occurs in Prairie Creek downstream of the point of discharge and into the park it is not clear how a 4-30 fold increase in benthic biomass would change biotic assemblages and possibly Hg methylation rates.

In conclusion, the absence of eutrophication effects has not been sufficiently demonstrated at this time to allay concerns.

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[2] While the concentration increases to not seem large in absolute terms, as a percentage increase the ranges are from 0 to 29% under average flow conditions and from 14 to 171% under minimum flow conditions.

Summary of Recommendations

This section summarizes recommendations. Details and specific recommendations are provided in the preceding sections

- Provide the raw data and measurement-specific detection limits used to estimate reference condition benchmarks.

- The proponent should consider additional treatment and holding capacity to dampen extremes in effluent quality so that EQCs are less conservative at times.

- A plan to 1) establish a defensible pre-operations baseline of Hg concentrations in critical environmental matrices; and 2) monitor for early changes in Hg concentrations in lower trophic levels and edible fish tissues as part of the AEMP should be part of the EA submission.

Summary of Conclusions

1. Conclusions regarding predicted mine performance may change depending upon which set of water quality objectives is adopted.

2. Sublethal toxicity is not ruled out, at least within the initial dilution zone and possibly further downstream.

3. The absence of eutrophication effects has not been sufficiently demonstrated at this time to allay concerns.

4. In the absence of eutrophication effects and given use of defensible reference condition benchmarks, biomagnification concerns regarding Hg and Se have been addressed. However given the degree of uncertainty and consequences of biomagnification, the absence of effects should be confirmed by targeted monitoring.

References

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Appendix C – Brodie Consulting Limited

Prairie Creek Mine – Tailings Management Issues
April 10, 2011

BRODIE
CONSULTING

MEMORANDUM

DATE: April 10, 2011

TO: Nathen Richea, Paul Green, INAC Water Resources
CC:

FROM: John Brodie, P. Eng. Cassandra Hall, P. Geo

SUBJECT: Prairie Creek Mine – Tailings Management Issues

This memo presents an evaluation of the proposed tailings management at the Prairie Creek Mine, as per the EA documentation and subsequent IR's. There are 2 significant concerns with the proposed development:

3. Practicality of placing all tailings in the underground workings, including stopes and access development drifts.
4. Implications for operation of the water storage pond (WSP).

Evaluation of the backfilling issues requires consideration of 3 separate steps:

4. Volume of excavated voids in the mine which could be backfilled.
5. Volume of tailings produced.
6. Determine the surplus/deficit of tailings.

Part 1 - Volume of Excavated Voids

According to the information provided, there is expected to be 4,995,000 tonnes of ore (Canadian Zinc Corporation, Response to 2nd IR's, March 2011 – INAC 2-14, page 40). This is mill feed of diluted ore at 15% dilution. The ore has a specific gravity of 3.25 and the waste rock dilution has a specific gravity of 2.8. Based on these values, the volume of the excavated stopes can be estimated as follows:

	Tonnes	Specific Gravity	In-situ Volume	
Ore (85%)	4,245,750	3.25	1,306,385	m3
Dilution (15%)	749,250	2.80	267,589	m3
Total Mill Feed	4,995,000		**1,573,974**	m3

Therefore, the excavated volume which is available for backfilling with tailings during the operating period of the mine is 1,573,974 m3. There is additional volume in the excavated access drifts and ramps throughout the mine. However these excavations are not available for backfilling until mining is complete.

At the end of mining, the access drifts and ramps could be backfilled with surplus tailings which is stored on surface. The volume of waste rock on surface is estimated to be 277,000 m3, which would have a swelled specific gravity of 1.9 and an insitu specific gravity of 2.7. Therefore, the volume of excavated drifts and ramps is estimated to be 195,000 m3.

The maximum potential volume of underground voids is 1,573,974 m3 + 195,000 m3 = 1,768,974 m3 (about 2% less than the 1,799,720 m3 reported in the IR response).

<u>Part 2 - Volume of Tailings</u>

The volume of tailings depends upon the mass of concentrate removed and the bulk density of the remaining material (the tailings).

There is a discrepancy in the information provided by the company, which makes this evaluation more difficult. In the DAR (Table 6-4) the mass of concentrate is 1,285,028 tonnes. This leaves 3,709,972 tonnes of tailings. In the IR response (Canadian Zinc Corporation, Response to 2nd IR's, March 2011 – INAC 2-14, page 41) there is 3,401,470 tonnes of tailings.

In both the DAR and the IR responses, the bulk density of the tailings is predicted to be 1.89 tonnes/m3, which is a reasonable estimate. Based on this value, the total volume of tailings to be produced by the mine ranges between 1,799,719 m3 (based on IR values) and 1,962,948 m3 (based on DAR values).

Part 3 – Surplus/Deficit of Tailings

The potential surplus of tailings on surface needs to consider 2 time periods:

3. end of reclamation (maximum practical backfilling completed)
4. end of operations (stopes backfilled, but drifts and ramps not backfilled) – this will determine the volume which must be temporarily stored in the WSP.

1 – End of Reclamation

Volume of tailings	1,962,948 m3 (high end of range)
Volume available in the mine	1,768,974 m3 (at end of mine life)
Surplus which remains on surface	193,974 m3

Note that the estimated surplus of 193,974 m3, assumes backfilling 100% of all underground openings. This is extremely unlikely. If only 5% were to remain not backfilled, the surplus on surface would rise to about 280,000 m3.

2 – End of Operations

Volume of tailings	1,962,948 m3 (high end of range)
Volume available in the stopes	1,573,974 m3 (at end of mine life)
Surplus which remains on surface	388,974,000 m3

Note that the estimated surplus of 388,974 m3, assumes backfilling 100% of all underground openings. This is extremely unlikely.

Conclusions

Canadian Zinc has proposed backfilling 100% of all tailings into the mined out underground workings. The above analysis shows that this is not possible, even if 100% of all voids could be backfilled. There will be 194,000 m3 of tailings on surface after all work is completed, under the most optimistic assumptions. Up to 280,000 m3 is a more probable surplus to remain on surface after all mining and reclamation is complete.

Even assuming 100% backfilling of all stopes during active mining, there will be at least 389,000 m3 of tailings stored in the WSP at the end of operations. This volume of tailings will reduce the volume available for storage of water during periods of low discharge.

It is very likely that the WSP will not have the expected retention capacity and that there will be discharges of water outside those periods of the year as suggested in the DAR and IR responses.

Appendix D – Brodie Consulting Limited

Prairie Creek Mine – Tailings Management Issues
April 14, 2011

BRODIE
CONSULTING

MEMORANDUM

DATE: April 14, 2011

TO: Nathen Richea, Paul Green, INAC Water Resources
CC:

FROM: John Brodie, P. Eng. Cassandra Hall, P. Geo

SUBJECT: Prairie Creek Mine – Tailings Management Issues

A first evaluation of the Prairie Creek tailings management plans was provided on April 10, 2011. That evaluation was discussed, via teleconference, with representatives of Canadian Zinc on April 12, 2011, at which time the company provided some points of clarification.

This memo presents an up-dated evaluation of the proposed tailings management at the Prairie Creek Mine. The 2 significant concerns with the proposed development as previously stated are still out-standing:

1. Practicality of placing all tailings in the underground workings, including stopes and access development drifts.
2. Implications for operation of the water storage pond (WSP).

Evaluation of the backfilling issues requires consideration of 3 separate steps:

1. Volume of excavated voids in the mine which could be backfilled.
2. Volume of tailings produced.
3. Determine the surplus/deficit of tailings.

Evaluation of the above 3 steps are shown in the tables at the end of this memo and described in the following sections.

Part 1 - Volume of Excavated Voids

There are 3 components to the determination of the potential volume of voids in the mine:

a) Volume of stopes,
b) Volume of new access development (ramps and drifts)
c) Volume of existing U/G development

This evaluation comes to virtually the same conclusion as the proponent on items a) and b), (within 2%). We have not asked for information concerning c), but a rough estimate based on information in the DAR suggests that this may be in the range of 32,000 m3, or possibly an addition 2% of potential void space.

As shown in Table 1, the maximum potential void space which might be filled is 1,800,739 m3, assuming 100% of all voids can be backfilled.

Part 2 - Volume of Tailings

The volume of tailings depends upon the mass of concentrate removed and the density of the remaining material (the tailings). This evaluation consists of determining the mass of tailings to be produced and then evaluation of the density of that material.

The mass of tailings is determined as follows and as calculated in the tables:

	mass of ore
less	mass of concentrate
less	mass of DMS Tailings to rock pile
=	mass of tailings to WSP &/or U/G backfill

The mass of tailings which is proposed to be placed in the mine, either during or following operations is 3,401,902 tonnes.

The volume which this mass of material will occupy depends upon the dry density of the material. Soil density can be expressed as **bulk density** or **dry density.** Bulk density is the mass of soil plus water in the pore space divided by the volume which is occupied by the soil/water mixture. Dry density is the mass of only the solids particles divided by the volume which is occupied. (*This can be envisioned by considering a bucket which is filled with dry sand up to the rim of the bucket. The mass of sand divided by the volume of the bucket is the dry density. Next, water could be poured into the bucket of sand. The water will fill the pore space between the sand particles. When no more water can be added to the bucket, the combined mass of the sand and the water divided into the volume of the bucket gives the bulk density.*)

In both the DAR and the IR responses, the dry density of the tailings is predicted to be 1.89 tonnes/m3. Based on this value, the total volume of tailings to be produced by the mine is 1,799,948 m3.

Part 3 – Surplus/Deficit of Tailings

The potential surplus of tailings on surface needs to consider 2 time periods:

1. end of reclamation (maximum practical backfilling completed)
2. end of operations (stopes backfilled, but drifts and ramps not backfilled) – this will determine the volume which must be temporarily stored in the WSP.

1 – End of Reclamation

Volume of tailings	1,799,948 m3
Volume available in the mine	1,800,739 m3
Surplus which remains on surface	nil

2 – End of Operations

Volume of tailings	1,799,948 m3
Volume available in the stopes	1,573,974 m3
Surplus in WSP	225,974 m3

Risk Factors

The above calculated volumes of tailings in backfill and in the WSP assume a number of ideal conditions are maximized throughout the entire mine life. The risk factors that would influence the ideal conditions are identified as follows:

- less than 100% backfilling of voids,
- fluctuations in paste density – not all paste placed at maximum achievable density,
- upset conditions leading to some backfill being placed as conventional slurry tailings (significant reduction in backfill density),
- cost saving measures lead to increased use of DMS material in paste to reduce cement requirements,
- cost saving measures lead to placement of development waste in stopes (as backfill in lieu of much more costly paste backfill).

The expectation that all of these risk factors will be avoided for the entire mine life is highly improbable.

All of these risk factors will tend to increase the amount of tailings in the WSP at the end of operations and after reclamation. Table 2 provides an example of this concern. The assumption for Table 2 is that only one risk factor is realized, namely that only 95% of the available voids can be backfilled. If that occurs, then the surplus which remains on surface after reclamation is 89,000 m3 and there may be up to 305,000 m3 of tailings in the WSP at the end of operations.

Conclusions

Canadian Zinc has proposed backfilling 100% of all tailings into the mined out underground workings. The above analysis suggests that this may possible, assuming a number of ideal conditions prevail for the entire mine life. That is unrealistic.

A slightly more plausible scenario is that about 90,000 m3 of tailings will remain on surface after all mining and reclamation is complete, assuming only one of many risk factors is realized.

The proponent has suggested that there will be not more than 50,000 m3 of tailings in the WSP during operations. This is most improbable. Even assuming that none of the potential risk factors occur during the mine operation, it is estimated that there will be about 225,000 m3 of tailings stored in the WSP at the end of operations.

If even one risk factor (less than 100% backfilling of void space) occurs, then this volume could increase to about 305,000 m3, which is most of the live storage space in the pond.

It is very likely that the WSP will not have the expected retention capacity and that there will be discharges of water outside those periods of the year as suggested in the DAR and IR responses.

Table 1

PROPOSED PRAIRIE CREEK MINE - ASSESSMENT OF TAILINGS MANAGEMENT

100 % of Voids Backfilled

Maximum Potential Void Space for Backfill

Stope Void				
	Tonnes	Specific Gravity	In-situ Volume	
Ore (85%)	4,245,750	3.25	1,306,385	m3
Dilution (15%)	749,250	2.80	267,589	m3
Total Mill Feed	4,995,000		**1,573,974**	m3

Access Drifts & Ramps - does not include existing development - see below

	tonnes	Specific Gravity	Volume	
Waste Rock	526,000	2.7	194,815	m3
ref: waste rock pile is 277,000 m3 at 1.9 t/m3 = 526,000 tonnes				
Existing U/G development			31950	m3
Maximum Potential Void Space for Backfill			**1,800,739**	**m3**

Volume of Tailings

	Tonnes	Specific Gravity	Volume	
Ore to mill	4,995,000			
DMS tailings to rock pile	308,070	1.89	163000	
Concentrate	1,285,028			
Tailings	3,401,902	1.89	**1,799,948**	m3

Surplus of Tailings on Surface (in WSP)		
at end of reclamation	**-791**	m3
at end of operations -before backfill of drift	**225,974**	m3

existing underground development void space			
assume drifts are 3 m x 3m		9	m3/m
level	length		
970	200		
930	2000		
880	1350		
	3550	m	
volume	**31950**	m3	

Table 2

	95% of voids backfilled				
Maximum Potential Void Space for Backfill					
Stope Void					
	Tonnes	Specific Gravity	In-situ Volume		
Ore (85%)	4,245,750	3.25	1,241,065	m3	0.95
Dilution (15%)	749,250	2.80	254,210	m3	0.95
Total Mill Feed	4,995,000		**1,495,275**	m3	
Access Drifts & Ramps - does not include existing development - see below					
	tonnes	Specific Gravity	Volume		
Waste Rock	526,000	2.7	185,074	m3	0.95
ref: waste rock pile is 277,000 m3 at 1.9 t/m3 = 526,000 tonnes					
Existing U/G development			30352.5	m3	0.95
Maximum Potential Void Space for Backfill			**1,710,702**	**m3**	

Volume of Tailings

	Tonnes	Specific Gravity	Volume	
Ore to mill	4,995,000			
DMS tailings to rock pile	308,070	1.89	163000	
Concentrate	1,285,028			
Tailings	3,401,902	1.89	**1,799,948**	m3

Surplus of Tailings on Surface (in WSP)		
at end of reclamation	**89,246**	m3
at end of operations -before backfill of drifts	**304,673**	m3

Appendix E – Brodie Consulting Limited

Prairie Creek Mine – Tailings Management Issues
May 9, 2011

— BRODIE —
CONSULTING

MEMORANDUM

DATE:	May 9, 2011
TO:	Nathen Richea, Paul Green, INAC Water Resources
CC:	
FROM:	John Brodie, P. Eng. Cassandra Hall, P. Geo
SUBJECT:	Prairie Creek Mine – Tailings Management Issues

Previous evaluations of the Prairie Creek tailings management plans were provided on April 10, 2011. On May 3, 2011, CZN provided a spreadsheet with their evaluation of tailings quantities and volumes. That spreadsheet is presented below.

This memo presents an evaluation of that spreadsheet, in comparison to the one provided April 14, 2011, by BCL. As stated previously, there are two issues with respect to the tailings management plan, namely:

3. The quantity of tailings which is to be stored in the WSP during operations. This is a critical issue because the storage of tailings reduces the capacity of the WSP to facilitate acceptable water quality and timing of the discharge of mine water to the environment.
4. The quantity of tailings which may remain on surface at the end of operations. This is important because the Project Description and EA is based upon the objective of no tailings on surface after mine closure.

In this memo, I will not repeat any of the previous evaluations. The focus here is on a review of the spreadsheet presented by CZN. Comments are linked to the row numbers of the CZN spreadsheet.

Implications for Operation of WSP

Row 1

Tonnes of mill feed: same value as per DAR: Agreed.

Row 2

DMS rock: same value as per DAR: Agreed.

Row 3

Float tailings: same value as per DAR: Agreed.

Row 4

concentrates: same value as per DAR: Agreed.

Row 5

Development rock: Page 196 of DAR states 277,000 m3 of waste rock will be placed on the waste rock pile. Assume 1.9 t/m3 for swelled (blasted) rock, this is 526,000 tonnes of rock. Assuming the insitu density is 2.75 t/m3, the excavated void would be 191,000 m3. This value is slightly greater than the value suggested by CZN in their recent spreadsheet, however the difference is not significant.

Commentary Rows 1 - 5

The mass of the various materials as listed by CZN are consistent with the DAR. All seem reasonable.

Row 6

Voids – Stopes: Agreed, this value is within a few percent of the value estimated by BCL in the April 14 memo.

Row 7

Voids – Development: See comment on row 5, above. The suggested total volume of development voids is reasonable.

Row 8

Total U/G void space: CZN's value of 1,799,720 m3 is virtually identical to the 1,800,739 m3 as estimated by BCL in the April 14 memo.

Row 9

Backfilled flotation tailings: Agreed

Row 10

Backfilled DMS tailings: Agreed

Row 11

Total mass of flotation and DMS tailings: Agreed

Row 12

Total volume of backfilled flotation and DMS tailings: Agreed, this is within a few percent of the volume estimated by BCL in the April 14 memo, subject to commentary on practical limitations as follows.

Commentary Rows 6 - 12

BCL substantially agrees with CZN on the volume of voids excavated in stopes which is available during operations. CZN's value for the volume of material which could be backfilled should be read as the theoretical upper limit.

The difference between total volume of stope voids and tailings is 235,000 m3 (CZN value: row 12 – row 6). This is very similar to the 225,000 m3 estimated by BCL in the April 14 memo. This amount, ~ 230,000 m3 is the minimum volume of tailings which will be in the WSP at the end of operations. It should be expected that the quantity of tailings in the WSP will continuously grow through the mine life to at least this volume. The specific implications for operation of the WSP are not assessed here, however, it should be expected that it will be ever less able to perform its intended function.

In addition, there are a number of factors which will tend to worsen the situation from the ideal case described above. These include:

- Periods of sub-optimal paste plant operation, resulting in lower density of backfill.
- Any backfill which is placed using non-paste methods, which will also yield lower density backfill.
- Increased use of DMS in backfill; this should be expected because it will avoid the cost of hauling DMS up-hill to the rock pile, and more importantly, reduce the cost of cement in backfill. Increased use of DMS will result in more flotation tailings being left in the WSP.
- Less than 100% backfilling of stope voids. Although the majority of the cut sections of each stope can be virtually 100% filled, the final cut below crown pillars, and below any location where the ore pinches to un-minable widths are impractical to completely fill, assuming that they are filled at all. If the mining operation relies on mill holes, these may remain unfilled as well.

Rows 13 – 15

Total to Waste rock pile: These values are not the same as in the DAR (page 196), however the difference is minor.

Rows 16 – 20

These present potential backfilling results if much higher paste density is achieved. We do not have data in the DAR to support this higher density prediction. As noted above, there are a number of factors which will tend to reduce the average tailings density. It does not seem appropriate to assess the DAR based upon unsubstantiated and potentially optimistic values.

Rows 21 – 29

It is not clear what is being assessed in these rows. Row 21 has 100,000 tonnes of mill feed in the first 5 months. The DAR states the mill process rate is 1200 tpd, which gives 180,000 tonnes of ore. The suggestion of 50,000 tonnes of flotation tailings in the WSP at the end of the first 5 months of operation may be reasonable if there is reduced through-put during startup. However, as stated above, BCL expected that the volume of tailings in the WSP will continuously grow through the mine life to a minimum total of about 230,000 m3. The prediction of the initial volume is somewhat unimportant to the implication for ultimate operation of the WSP.

Implications for Ultimate Backfilling

Rows 6 and 12 of the CZN spreadsheet suggest that it may be possible to place 100% of the tailings in the mine. In theory this is possible, but only if none of the operational backfill problems noted above occur, and virtually 100% of the development voids are also backfilled at the end of operations. This is improbable. It should be expected that there will be tailings on surface at the end of all practical mine closure activities.

Waste Quantities Table as prepared by CZN – May 3, 2011 (row numbering added by BCL)

Mine Life Quantities	Tonnes	%	m^3	*Row*
Mill Feed	4,995,000	100%		*1*
DMS Rock (DMS)	1,203,750	24%		*2*
Float Tails (FT)	2,506,222	50%		*3*
Concentrates	1,285,028	26%		*4*
Development rock (in situ)	404,200		144,357	*5*
Voids - stopes			1,533,076	*6*
Voids - development (new & existing)			266,644	*7*
Voids - total			1,799,720	*8*
Backfilled FT (100%)	2,506,222			*9*
Backfilled DMS @ 1:3 to FT*	835,407			*10*
Total backfill	3,341,629			*11*
Backfill volume @ 1.89 t/m^3 dry density#			1,768,058	*12*
DMS not backfilled, to Waste Rock Pile	368,343		194,890	*13*
Development Rock to Waste Rock Pile (1.4 swell)			202,100	*14*
Total to Waste Rock Pile			396,990	*15*
Backfill volume @ 2.17 t/m^3 dry density			1,539,921	*16*
Void remaining			259,799	*17*
Additional DMS backfilled	368,343		194,890	*18*
Development rock backfilled			64,908	*19*
Development Rock to Waste Rock Pile			137,192	*20*
With 5 months FT in Temporary Storage	**Tonnes**	**%**	**m^3**	*21*
Mill Feed Start-Up 5 months	100,000	100%		*22*
DMS Rock to Waste Rock Pile	24,099	24%		*23*
Float Tails to Water Storage Pond	50,175	50%		*24*
Float Tails after Start-Up to Backfill	2,456,047			*25*
Backfilled DMS @ 1:3 to FT	818,682			*26*
Total backfill without FT in WSP	3,274,730			*27*
Backfill volume @ 1.89 t/m^3 dry density			1,732,661	*28*
Backfill volume @ 2.17 t/m^3 dry density			1,509,092	*29*

30

*Conservative - Mine plan DMS:FT ratio is 1:2.8 *31*

#Conservative - Measured backfill dry density is 2.17 t/m^3 *32*

Appendix F – Brodie Consulting Limited

Prairie Creek Mine – Summary of EA Issues
Tailings management and Post-Closure Mine Drainage
May 26, 2011

BRODIE CONSULTING

MEMORANDUM

DATE:	May 26, 2011
TO:	Nathen Richea, Paul Green, INAC Water Resources
CC:	
FROM:	John Brodie, P. Eng. Cassandra Hall, P. Geo
SUBJECT:	Prairie Creek Mine – Summary of EA Issues Tailings Management & Post-Closure Mine Drainage

Tailings Management

The following presents a summary of the recent evaluations of the tailings management issues for the proposed Prairie Creek Mine. Previous correspondence on this was submitted on April 10, 14 and May 9, 2011. Those memos present initial comments and revisions based upon response by CZN. Despite those responses, the basic outstanding concerns remain.

As stated previously, there are two issues with respect to the tailings management plan, namely:

1. The quantity of tailings which is to be stored in the WSP during operations. This is a critical issue because the storage of tailings reduces the capacity of the WSP to facilitate acceptable water quality and timing of the discharge of mine water to the environment.
2. The quantity of tailings which may remain on surface at the end of operations. This is important because the Project Description and EA is based upon the objective of no tailings on surface after mine closure.

In this memo, I will not repeat any of the previous evaluations. The focus here is on a review of the spreadsheet presented by CZN. Comments are linked to the row numbers of the CZN spreadsheet.

Implications for Operation of WSP

BCL substantially agrees with CZN on the volume of voids excavated in stopes which is available during operations. CZN's value for the volume of material which could be backfilled should be read as the theoretical upper limit.

The difference between total volume of stope voids and the volume of tailings is 235,000 m3 (CZN value). This is essentially the same as the 225,000 m3 estimated by BCL in the April 14 memo. <u>This amount, about 230,000 m3 is the minimum volume of tailings which will be in the WSP at the end of operations.</u> It should be expected that the quantity of tailings in the WSP will continuously grow through the mine life to at least this volume. The specific implications for operation of the WSP are not assessed here, however, it should be expected that it will be ever less able to perform its intended function.

In addition, there are a number of factors which will tend to worsen the situation from the ideal case described above. These include:

- Periods of sub-optimal paste plant operation, resulting in lower density of backfill.
- Any backfill which is placed using lower density non-paste methods.
- Increased use of DMS tailings in the backfill; this should be expected because it will avoid the cost of hauling DMS up-hill to the rock pile, and more importantly, reduce the cost of cement in backfill. Increased use of DMS will result in more flotation tailings being left in the WSP.
- Less than 100% backfilling of stope voids. Although the majority of the cut sections of each stope can be virtually 100% filled, the final cut below crown pillars, and below any location where the ore pinches to un-minable widths are impractical to completely fill, assuming that they are filled at all. If the mining operation relies on mill holes, these may remain unfilled as well.

CZN has suggested in recent correspondence that test results indicate the actual paste density will be higher than the value used in their predictions in the DAR. It does not seem appropriate to assess the DAR based upon unsubstantiated and potentially optimistic values.

CZN has suggested that 50,000 tonnes of flotation tailings in the WSP at the end of the first 5 months of operation. However, as stated above, BCL expected that the volume of tailings in the WSP will continuously grow through the mine life to a minimum total of about 230,000 m3. The prediction of the initial volume is somewhat unimportant to the implication for ultimate operation of the WSP.

Implications for Ultimate Backfilling

CZN has suggested that they will place 100% of the tailings in the mine. In theory this is possible, but only if none of the operational backfill problems noted above occur, and virtually 100% of the development voids are also backfilled at the end of operations. This is improbable. It should be expected that there will be tailings on surface at the end of all practical mine closure activities.

Post-Closure Mine Drainage

CZN has provided predictions of the volume of water which will drain from the mine during operations and after closure. These are:

- Historic flow from 870 portal, up to 12.5 l/s, reference: RGC 2010, Table 3-8.
- Active mining: 40.7 l/s (best estimate), reference: RGC March 3, 2011 Table 5
- Post-closure Worst Case Scenario 4.2 l/s, reference: RGC March 3, 2011 page 17, para 3.

It is very likely that partial flooding of the mine up to the 880 portal, plus the presence of backfill in the stopes and drifts will reduce the rate of seepage that flows through the mine workings to the portal. However, post-closure drainage from the mine at < 50% of the current drainage would require a number of circumstances, including:

- Very tight backfill in all stopes and drifts. Certainly many stopes could be backfilled with low permeability tailings. However, the use of cut and fill mining is certain to create zones of broken rock on the top edge of each lift. This will leave zones of higher permeability material through out the backfill.

- Very little blast damage to the wall rock in the stopes. Blasting will create and open fractures in the wall rock. These will provide conduits for groundwater seepage around the tailings backfill.
- Very little relaxation of the host rock around the mined out stopes. Mining will create changes in the stress pattern in the rock. The strength of the backfill will be much lower than the surrounding rock. Consequently, a slight increase in the permeability of the host rock around the ore veins is likely.

Based upon the above points, it seems very optimistic to expect post-closure flow rate from the U/G mine to be much lower than the current rate of seepage. Seepage at rate which is at least the current rate should be expected.

There is a significant likelihood of post-closure drainage from the mine. Water quality of the drainage may be similar or elevated from current levels. Therefore, post-closure loading to Prairie Creek should be expected to be the same or greater than current levels.

Mitigation of this concern could be achieved by providing for long-term operation of the WSP (to regulate discharge when ample dilution is available), provision of some form of passive water treatment, or installing hydraulic bulkheads in the mine to ensure that the post-closure seepage rate is lower than current flows. One or more of these provisions should be included in the reclamation security for the operation.

Appendix G – Barry Zajdlik

Curriculum Vitae (CV)

ZAJDLIK & ASSOCIATES INC.

BARRY ZAJDLIK, PRINCIPAL

PROFESSIONAL EXPERIENCE

1991–present Zajdlik & Associates Inc. Rockwood, Ont.

Principal

- Project management, contract acquisition.
- Environmetrician, report writing.

1992–present Pollutech EnviroQuatics Pt. Edward, Ont.

Research Associate

- Statistical consultation on experimental design, analysis and interpretation.
- Project manager.

1989–1990 Department of Population Medicine Guelph, Ont.

Statistician

- Guidance in statistical design, analysis and interpretation to faculty and staff in biomedical statistics.
- Responsible for providing SAS seminars, computer support, (servicing, installation and purchasing), and custom Fortran and SAS programming.

1990-current Professional Activities

External Program/Project Manager

- Managed international CIDA program, manage projects for other consulting firms.

Lecturer

- An invited lecturer at various universities, governmental agencies, and professional societies with topics falling under the general umbrella of statistics and environmental science.

Panel Member

- An invited panel member at the federal (since 1993) and provincial (since 2000) governmental levels, on issues related to the application of statistics and environmental science.

Peer Reviewer

- Review papers published in the primary literature, book chapters and governmental documents, in the areas of environmental toxicology and statistics.

Legal

- Acted as expert witness, and provide reviews for legal proceedings.

R. R. # 3 • Rockwood, Ontario N0B 2KO • Phone (519) 856-9440
Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

PROJECT EXPERIENCE: RESEARCH

- **Develop Soil Sampling Protocols for Cryosols.** Cryosols cover a vast area of Canada and to date no systematic soil sampling protocol has been developed. Such a protocol is necessary to assess potential development effects in the Canadian North. INAC: 2008.
- **Applying SSD Concepts to Bimodal Distributions.** This project involved extending the current CCME paradigm for generating water quality guidelines to substances that exhibit target-specific effects and non-target effects. Environment Canada: 2007.
- **Investigate Spatio-Temporal Variability in Arctic Lakes.** Oil and gas exploration and development along the Mackenzie Valley corridor may lead to requirements for monitoring of lake water quality. The drivers of tundra lake water quality are not currently understood and are under investigation. Indian and Northern Affairs Canada: 2006-ongoing.
- **Toxicity Modifying Factors in Ammonia Toxicity to *D. magna*.** This project involves optimizing an experimental design to assess the simultaneous effects of pH and acclimation temperature on ammonia toxicity for Daphnia magna. The results will be used to improve the applicability of Canadian Water Quality Guidelines for ammonia. Ontario Ministry of Environment: 2006-ongoing.
- **Incorporate Toxicity Modifying Factors in the SSD Approach to Estimating Canadian Water Quality Guidelines.** The current water quality guidelines in Canada are generic and suffer from several shortcomings. New methods have been developed for use in Canada that obviate these shortcomings (work conducted by Zajdlik & Associates, Inc.). These new methods are still generic though. This project provides recommendations on how to make the new Canadian approach to generating water quality guidelines site-specific at least with respect to the principal toxicity modifying factors. CCME: February-April 2006.
- **Identify Statistical Models to Describe Species Sensitivity Distributions.** This project involved assessing the statistical and ecotoxicological and regulatory literature to determine what statistical models have been used globally to describe species sensitivity distributions. Then, 7 species sensitivity distributions were examined to generate a suite of statistical models that could potentially describe all species sensitivity distributions for derivation of water quality guidelines within Canada. Ontario Ministry of Environment / CCME: March-October, 2005.

PROJECT EXPERIENCE: EXPERIMENTAL DESIGN

- Review of Diavik Diamond Mine A21 Dike Monitoring Design. Department of Fisheries and Oceans: 2007
- Review of BHP Billiton Ekati Diamond Mine aquatic effects monitoring program. Indian and Northern Affairs Canada: 2007
- Design of environmental monitoring program to assess potential human and ecological effects of the Munitions Environmental Test Centre activities

R. R. # 3 • Rockwood, Ontario N0B 2KO • Phone (519) 856-9440
Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

within the St. Laurence River and interpretation of results. Department of National Defense: 2004-2007

- Moran, T., J. Houtby, J. Wenczler, and B. Zajdlik. 2005. Sarnia-Lambton Environmental Association 2003/2004 St. Clair River Biological Program – Integrated Sediment Monitoring Program. Prepared for the Sarnia-Lambton Environmental Association by Pollutech EnviroQuatics Limited, Point Edward, Ontario.
- Design of experiments to compare the hepatocyte toxicity test with the Environment Canada regulatory rainbow trout toxicity test. Ontario Ministry of Environment: 2003
- Redesign and interpretation of ongoing monitoring program to assess the potential cumulative ecological effects of uranium mines in northern Saskatchewan. Saskatchewan Environment: 2002 - 2004
- Design of fish consumption survey to determine age-specific consumption rates in a First-Nations community. GlobalTox Environmental Inc. 2004.
- Review of sampling plans to identify unexploded ordnance, Port Albert.
- Design of experiment to evaluate the relative sensitivity of trout hepatocyte and gill cell lines and the 96-hour acute lethality rainbow trout test, to spiked industrial effluents to evaluate utility as an Environment Canada test method.
- Design of experiments to assess the efficacy of As mitigation technologies under laboratory conditions. Ontario Centre for Environmental Technology Advancement: 2002
- Design of experiments to assess the efficacy of Hg separators for dental amalgams and creation of a federal guidance document for technology verification. Ontario Centre for Environmental Technology Advancement: 2002
- Design of experiments to determine the efficacy of As mitigation technologies in Bangladesh. Over 1, 000, 000 wells are contaminated with As. The WHO and Government of Bangladesh are using Canadian expertise in verifying environmental technologies to design a series of field and laboratory verification experiments that will be implemented by the British Geological survey. Ontario Centre for Environmental Technology Advancement: 2001-2002
- Design of *in situ* bivalve bioaccumulation study to assess potential movement of PCB congeners from an industrial site. Confidential.
- Design of adaptive soil sampling plans designed to reduce sampling costs and quantify the risk of undetected hot spots. The contaminants of concern were PAHs that had been stockpiled in a mixture containing highly and slightly contaminated soils. Confidential.
- Design of experiments to estimate relative sensitivity of a sublethal, flagellate bioassay to mining effluents. This research contract was awarded through CANMET.
- Design of numerous benthic community surveys to delineate spatial and temporal changes in areas, potentially impacted by heavy metals, PAHs,

PROJECT EXPERIENCE: EXPERIMENTAL DESIGN

chlorinated organic compounds and insecticides.

- Design of pharmacokinetic study investigating kinetic properties of PAHs. This study resulted in a paper (currently in manuscript form) on experimental design.
- Design of experiments investigating mechanisms of metal uptake in teleosts.
- Design of a biomonitoring program for a newly created Peruvian port that will be used to transport copper and zinc ores for refining.

PROJECT EXPERIENCE: ANALYSIS AND INTERPRETATION

- Geostatistical analyses of sediment quality indices. Department of National Defense. 2007
- Estimate thresholds for remediation using 26 types of soil toxicity tests conducted on 49 soil samples. Stantec Consulting Ltd. 2007
- Assessed effects of mine tailings on plant growth in both field and laboratory experiments and assessed congruence between same. Ontario Ministry of Environment. 2004.
- Determined probabilistic intervention criteria for soil B(a)P in the Ivy Avenue area of Toronto, based upon a human health risk-based intervention criterion. Ontario Ministry of Environment. 2004.
- Predicted financial liabilities to the DFO due to ownership of contaminated sites across Canada. Department of Fisheries and Oceans 2002-2005.
- Nonlinear calibrations to determine probable time to failure for groundwater As mitigation devices. Ontario Centre for Environmental Technology Advancement: 2005.
- Interpreted multivariate data to independently confirm conclusions regarding potential human health effects of the Sydney tar ponds. Nova Scotia Department of Health: 2003.
- Managed a risk assessment of the capability of marshland to retard movement of radionuclides. Pollutech EnviroQuatics: 2002.
- Validation of toxicity test endpoint calculations conducted under GLP.
- Determined probabilistic intervention criteria for soil Ni in the Rodney St. Area of Port Colborne, based upon a human health risk-based intervention criterion. Ontario Ministry of Environment: 2002.
- Determined exposure of Walpole Island First Nation residents to contaminants in fish. GlobalTox: 2003.
- Estimation of endpoints from problematic data generated by OECD method 201.
- An evaluation of methods used to interpret the *Vibrio fischeri* solid-phase luminescence test. Environment Canada, Waste at Sea is considering using the *Vibrio fischeri* test in determining the suitability of dredged materials for disposal at sea. Environment Canada: 2000.
- Developed the statistical component of the Canadian Environmental Technology Verification program. ETV Canada: 2000.

PROJECT EXPERIENCE: ANALYSIS AND INTERPRETATION

- Analysis and interpretation of TEQ emission rates used to determine the impact of wood stove combustion on dioxins and furan loadings. Environment Canada, Environmental Technology Centre: 2000.
- Analysis and interpretation of data generated by Cycle II EEM pulp and paper compliance monitoring programs (2 locations).
- Design and interpretation of a contaminated harbour assessment on the St. Lawrence River, using a sediment quality triad approach. Pollutech EnviroQuatics: 2000.
- Monte Carlo analysis of soil contaminant, volume estimates in an environment subject to tidal influences. Imperial Oil: 1999.
- Managed an ecological risk assessment to investigate the risks of remediation of contaminated sediments in the St. Clair River. Sarnia Lambton Environmental Association: 1999-2001.
- Determining the relationship between sediment, and porewater metal levels of lead in various forms to *Amphiporeia virginiana* following a spill of materials. Pollutech EnviroQuatics: 1999.
- A commentary on the statistical implications of compliance biological test design and interpretation.
- Estimation of limits of quantification used in setting criteria for the virtual elimination of PCBs and PCDDs in Canada. Environment Canada (Analysis and Methods Division).
- Interpretive guidance for bioassays using pollution gradient studies. The performance of sediment bioassays along a gradient of PAH and PCB contamination was examined. Concomitant sediment chemistry and benthic macroinvertebrate abundance data was used to link toxicity test responses with environmental measurements and effects using the sediment quality triad paradigm. Recommendations for the assessment of dredged materials in Canada prior to ocean disposal were given. Environment Canada, Ocean Disposal: 1999-2000.
- Analysis of round-robin data used to explore new methods for hydrocarbon analyses. BC MELP.
- Estimation of spatial extent of toxicant contamination in marine sediments following a spill event.
- Assessment of the correlation between metal contaminants in soil and crop yields and growth.
- Analysis of experiments to refine the standard operating procedure for an experimental biological test used to assess water quality of mining effluents. CANMET Research Grant.
- Analysis of air quality discontinuities resulting from process control changes in a chemical manufacturing plant.
- Consultation on sampling design for routine monitoring of dredged material disposal sites. Environment Canada.
- Predicting process control parameters in pilot effluent remediation studies to ensure effluent compliance.
- Estimation of "Safe Levels" of food additives using structural class to

conform to a defined risk. "Safe levels," were estimated using the 5th percentile of NOECs, and by an empirical bootstrapping method developed by Zajdlik & Associates. The effects of using various types on endpoints (mortality, blood, liver, gonadal, kidney, etc.), and stratifying factors such as sex, species tested, and structural class.

- Triad analysis of industrial, municipal and agricultural inputs to a fluvial system. This multi-year study compared sediment chemistry, sediment toxicity tests and benthic macroinvertebrate community structure using the sediment quality triad paradigm. Sarnia Lambton Environmental Association
- Consultation on survey design for estimating daily nutrient intakes in Canada.
- Incidence of mammary gland tumours in ACK treated rats. The dose-response between level of ACK and incidence of tumours in rat was estimated, stratifying by tumour type.
- Determining the probability of detecting occasionally non-compliant industrial effluent under various sampling regimes.
- Interpretative Guidance for Bioassays using Pollution Gradient Studies. The performance of sediment bioassays along a gradient of metal contamination was examined. Concomitant sediment chemistry and benthic macroinvertebrate abundance data was used to link toxicity test responses with environmental measurements and effects using the sediment quality triad paradigm. Environment Canada (Waste at Sea).
- Geostatistical analysis of background levels of sediment associated metals. This contract explored the utility of existing background metals data sets in estimating background levels of metals in potential disposal sites. Environment Canada (Waste at Sea).
- Conducted a statistical comparison of various micro and kit toxicity tests to the standard rainbow trout and *Daphnia magna* for the Canadian mining industry on behalf of Natural Resources Canada (CANMET). Tests were compared in part, on the basis of sensitivity to an effluent and the specificity of a response to toxicant levels within an effluent.
- Participated in the development and validation of a rapid aggregation toxicity test for mining effluents. This is a sublethal, micro-scale flagellate bioassay that may be used to explore a hitherto, unexamined trophic level. Conducted through a research grant from CANMET.
- Explore relationships between benthic macroinvertebrate community structure and water and sediment metal levels under the Great Lakes Embayments and Harbours Investigation Program. MOE.
- Analysis and interpretation of three macroinvertebrate surveys implemented under the Pulp and Paper, Environmental Effects, Monitoring Program, Phase I.
- Analysis of toxicity test responses and water chemistry variables to identify potential sources of toxicity. This type of analysis is routinely done. In one instance, an analysis of egg toxicity in a flow through situation resulted in a reassessment of culpability.
- Analysis of multiple aquatic toxicity test types to determine most sensitive

PROJECT EXPERIENCE: ANALYSIS AND INTERPRETATION

test.

- Analysis of pharmacokinetic data using compartment models.
- Analysis of non-quantal toxicity test data using threshold models.
- Statistical modelling of the distribution of the combustion by-products of transformer fires containing PCB's. This predictive atmospheric disturbance model is used to determine evacuation areas downwind of PCB fires. Ontario Hydro.
- Analysis of problematic data arising from MOE Effluent Compliance tests. Problems include, no partial kills, heterogeneity of variance, etc.

PROJECT EXPERIENCE: CUSTOM PROGRAMMING

- Custom software for international technology verification. Ontario Centre for Environmental Technology Advancement: 2003
- Custom Excel macros to address statistical requirements of Environment Canada toxicity test methods. Private Sector Laboratories: 2002 – ongoing.
- Creation of statistical worksheets for the Canadian Environmental Technology Verification program. Ontario Centre for Environmental Technology Advancement: 2001
- Writing software capable of predicting the dispersion of combustion by-products of PCB transformer fires. Ontario Hydro
- Writing custom software to analyze captured video images consisting of arising from gel electrophoresis studies. University of Guelph

PROJECT EXPERIENCE: SOFTWARE VALIDATION

- Validation of algorithmic stability and implementation of statistical theory underlying the analysis of quantal response data using the "Stephan" program circulated by Environment Canada. ESG International.

PROJECT EXPERIENCE: PROJECT MANAGEMENT

- Managed projects within Zajdlik & Associates Inc. since company inception.
- Managed CIDA funded program in Bangladesh, April 2003.
- Provide external project management on an as-needed basis to Pollutech EnvrioQuatics.

PROJECT EXPERIENCE: LEGAL/ PEER REVIEW/GUIDANCE DOCUMENTS

- Expert Witness and Hearings
  - Diavik Diamond Mine AEMP Hearing, Rae Edzo, 2007.
  - Diavik Diamond Mine Technical Hearings, Yellowknife, 2005.
  - Crown vs. Hay Bay Genetics, Napanee, 2001
  - Crown vs. Provincial Papers, Thunder Bay, 2000
- Selected Guidance Documents

PROJECT EXPERIENCE: LEGAL/ PEER REVIEW/GUIDANCE DOCUMENTS

- Contributor to: CCME. 2007. A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life – Draft. July, 2007.
- Contributor to: Statistical Methods for Environmental Toxicity Tests. EPS 1/RM/46. Environment Canada. 2005.
- Author of: Guidance on Evaluating Environmental Monitoring Programs for Diamond Mines in the Canadian Arctic. Environment Canada. 2004.

- Selected Peer Reviews:
  - Aquatic Effects Monitoring Program Baseline – Diavik Diamond Mine. Department of Indian Affairs and Northern Development. 2006.
  - Aquatic Effects Monitoring Program – Ekati Diamond Mine. Department of Indian Affairs and Northern Development, Independent Environmental Monitoring Agency, Environment Canada. 2004
  - Cumulative Effects Monitoring Program - Review of ongoing monitoring program to assess the potential cumulative ecological effects of uranium mines in northern Saskatchewan. Saskatchewan Environment. 2002 – 2004.
  - Urinary As Study for the Greater Sudbury Area. Ontario Ministry of Environment. 2004
  - Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil. Environment Canada. 2004
  - Human Health Risk Assessment. Designated expert reviewer for Ontario Ministry of Environment. 2003
  - Ecological Risk Assessment Designated expert reviewer for Ontario Ministry of Environment. 2003
  - CCME. 1996. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. 2003
  - Statistical Guidance for Environment Canada Test Methods, Environment Canada, 2001- 2003
  - Part A: MOE Report Soil Investigation and Human Health Assessment for the Rodney Street Community: Port Colborne, Ontario Ministry of Environment, 2001.
  - Background Environmental Concentrations for the Sydney Tar Ponds, Nova Scotia Department of Health, 2001.
  - EPA. 1999. Emission test evaluation of a crematory at Woodlawn Cemetery in the Bronx, N.Y. Volume I of III. Office of Air Quality, Planning and Standards. EPA-454/R-99-049. For, Ontario Ministry of Environment, 2001

OPINION PAPERS

- Potential Statistical Models for Describing Species Sensitivity Distributions. Canadian Council of Ministers of the Environment. 2006.
- New Statistical Paradigms for Two-sample Toxicity Tests. U.S. EPA. 2005.
- Guidance on Evaluating Environmental Monitoring Programs for Diamond Mines in the Canadian Arctic. Environment Canada, 2005.
- Statistical Inference and the Species Sensitivity Distribution Approach to Deriving Water Quality Guidelines, Ontario Ministry of Environment, Canadian Council of Ministers of the Environment. 2004-2005.

SHORT COURSES

- Working with Large Datasets, Department of Fisheries and Oceans, Yellowknife - approximately 10 participants, 3 days, January 2008
- Statistics for Environmental Scientists, Environment Canada, Yellowknife - approximately 20 participants, 3 days, January 2006
- Introduction to the ANOVA Table, Annual Aquatic Toxicity Workshop, Waterloo, 7 participants, October 2005.
- Statistics for Environmental Scientists, Department of Indian Affairs and Northern Development - approximately 10 participants, 3 days, March 2005
- Applied Environmental Statistics, Bruce Nuclear – approximately 15 participants, 2 days, February 2005.
- Nonlinear Regression as Applied to Environment Canada Test Methods for Measuring Survival and Growth in Soil Using Terrestrial Plants. Environment Canada, Method Development and Technology Section, Charlottetown approximately 10 participants, October 2004.
- Statistics for Environmental Scientists, Ontario Ministry of Environment, - over 70 participants, 5 days, February 2004.
- What to Look for and How to Interpret a Benthic Invertebrate Report: From Bugs to Statistics. Zaranko and Zajdlik, Annual Aquatic Toxicity Workshop, Ottawa, approximately 10 participants, October 2003.
- An Introduction to Statistical Methods for Chronic Biological Testing, Annual Aquatic Toxicity Workshop, Québec, approximately 7 participants, October 1998.
- Statistical Issues in Toxicology, Annual Aquatic Toxicity Workshop, Calgary, Alberta, approximately 20 participants, October 1996.
- Statistical Methods and Software for Toxicological Data Analysis", Society of Environmental Toxicologists and Chemists, Annual Meeting, Denver, Colorado, 50 participants, November 1994.

PROFESSIONAL AFFILIATIONS AND COMMITTEES

- Member of Scientific Advisory Committee: "Development of an Environment Canada Test Method for Measuring Survival and Growth in Soil Using Terrestrial Plants. Environment Canada, Method Development and Technology Section, 2001-present.
- Member of the Cumulative Effects Monitoring, working group for northern Saskatchewan. Saskatchewan Environment. (2001-2004)
- Member of the "Advisory Committee on Statistics and Programs for Biological Tests" sponsored by the Technology Development Branch of Environment Canada. 1993-present.
- Panel Member, "The Statistics Workshop for Toxicological Testing", 1999 and 2001. Invitational Meeting under auspices of Environment Canada, Method Development and Application Section. Vancouver, British Columbia.
- Statistical Workshop Chairperson, 1995 Annual Aquatic Toxicity Workshop, St. Andrews, New Brunswick. This workshop addressed the topic of "Statistical Issues in Toxicity Testing."
- Member of the 1995, SETAC U.K. discussion group entitled "Ecotoxicological Statistics: Asking the right questions," Egham, Surrey, U.K.
- Chairperson, 1994 Aquatic Toxicity Workshops session entitled "Toxicological Statistics," Sarnia, Ontario.

PUBLICATIONS

Cott, P.A., A.M. Gordon, K.J. Bourassa, M. Lange and B.A. Zajdlik. 2009. Effects of Forest Fire on Young-of-the-year Northern Pike in the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences. In Press.

Kokelj S.V., B. Zajdlik and M.S. Thompson. 2009. The impacts of thawing permafrost on the chemistry of lakes across the subarctic boreal-tundra transition, Mackenzie Delta region, Canada. Permafrost and Periglacial Processes. In review.

Zajdlik, B.A. 2008. Scoping of Approaches Used to Deal with Bimodal Distributions of Pesticides in Aquatic Ecosystems. National Agri-Environmental Standards Initiative Technical Series Report No. 4-43. 90 p.

Zajdlik, B.A., D.G. Dixon and G. Stephenson. 2008. Estimating Water Quality Guidelines for Environmental Contaminants Using Multi-Modal Species Sensitivity Distributions: A Case Study with Atrazine. Human. Ecol. Risk Assess. In Press.

Macdonald, D. and B. Zajdlik. 2008. Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories. Prepared for Indian and Northern Affairs Canada, Northwest Territories.

ESG International and B. Zajdlik & Associates. 2002. Guidance Document for Acute Lethality Testing of Metal Mining Effluents. Prepared for Ontario Ministry of the Environment, Toronto, ON.

Zajdlik, B., G. Gilron, P. Riebel and G. Atkinson. 2001. The $500,000.00 fish. SETAC Globe, 2(1):28-30.

Jonczyk, E., G. Gilron and B. Zajdlik. Sea urchin fertilization assay: An evaluation of assumptions related to sample salinity adjustment and use of natural and synthetic marine waters for testing. Env. Tox. Chem. 20(4): 804-809.

Zajdlik, B.A., K. G. Doe and L. M. Porebski. 2000. Report on biological toxicity tests using biological gradients: Sydney Harbour. EPS/3/AT/2.

Zajdlik, B. and P. Riebel. 2000. The cost-benefit of EEM study design. Pulp & Paper Canada. 101(5): 46-48.

Porebski, L. M., K. G. Doe, B. A. Zajdlik, D. Lee, P. Pocklington, and J. Osborne. 1999. Evaluating the techniques for a tiered testing approach to dredged sediment assessment - a study over a metal concentration gradient. Env. Tox. Chem. 18:2600-2610.

PUBLICATIONS

Porebski, L., K. Doe, B. Zajdlik, D. Lee, P. Pocklington, G. Atkinson and J. Osborne. 1998. Interpretive guidance for bioassays using pollution gradient studies - Belledune, New Brunswick. WM-20.

Gilron, G., D. Lynn and B. A. Zajdlik. 1998. Further development and validation of a sublethal protozoan bioassay for mining effluents. Prepared for Public Works and Government Services on behalf of the National Biotechnology Strategy Program "Biotechnology for the mining environment".

Moran, T. S., and B. A. Zajdlik. 1995. Comparison of results from alternate toxicity tests with the acute Rainbow Trout bioassay for select mine effluents. Proc. Aquatics Effects Technology Evaluation First Annual Review, Nov. 1, 1995. Ottawa, Ontario.

Zajdlik, B. A. 1990. Analysis of irregularly spaced time series. MSc. Thesis University of Guelph.

Smith, I. R. and B. A. Zajdlik. 1989. Spontaneous regression of epidermal papillomas in white suckers, *Catastomus commersonii* from Lake Ontario. J. Fish Diseases.

PAPERS PRESENTED

Poirier, D. and B. Zajdlik. 2008. The Effects of low temperatures and low pH on the toxicity of ammonia to *Daphnia magna*. Aquatic Toxicity Workshop, Saskatoon, Oct. 2008.

Zajdlik, B.A. and D.D. MacDonald. Key Aquatic Effects Monitoring Program Concepts. Aquatic Effects Monitoring Program Guidelines Workshop. Oct. 21-22, 2008.

Zajdlik, B.A. 2008. Integrating Traditional Knowledge into the Testable Hypothesis. Science in the Changing North. Yellowknife.

Zajdlik, B.A., D.G. Dixon and G. Stephenson. 2007. Estimating Water Quality Guidelines For Atrazine and Diquat Using Multi-Modal Species Sensitivity Distributions. Society of Environmental Toxicology and Chemistry, Milwaukee.

Zajdlik, B.A., I.J. Young, J. Rebinczak, S. Barrett, B. Brady, P-Y Robidoux, G. Sunahara and H. Fanous. 2007. Integrating Sediment Quality Metrics to Prioritize UXO Clearance in an Aquatic Ecosystem. Society of Environmental Toxicology and Chemistry, Milwaukee.

Zajdlik, B.A. 2007. Choosing Environmental Quality Guidelines for the North. Science in the Changing North. Yellowknife.

Zajdlik, B.A., S. Kokelj and M. Thompson. 2007. Regional Variability in Water Quality of Tundra Lakes in the Mackenzie Delta. Environmental Studies across the Treeline. Yellowknife.

Scroggins, R., L. Taylor, Leana Van der Vliet and B. Zajdlik. 2007 Statistical Software Development Project. Aquatic Toxicity Workshop, Halifax, Nova Scotia.

Zajdlik, B.A. 2006. Key Elements of Aquatic Effects Monitoring Program in the North. Invitational: A workshop on "Guidelines for Aquatic Monitoring and Assessment of Development Projects in the NWT", sponsored by Indian and Northern Affairs Canada and Environment Canada, Yellowknife, April 11th-12th.

Zajdlik, B. A. 2006. Aquatic thresholds – conceptual and developmental challenges. Invitational: A workshop on "Thresholds: From Theory to Practice", co-sponsored by Indian and Northern Affairs Canada and Environment Canada, Yellowknife, March 13th-14th.

R. R. # 3 • Rockwood, Ontario N0B 2KO • Phone (519) 856-9440
Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

PAPERS PRESENTED

Zajdlik, B., G. Gilron, P. Riebel and G. Atkinson. 2000. The $500,000.00 fish. 27th Annual Aquatic Toxicity Workshop, St. John's, Newfoundland.

Zajdlik, B. A. L. M. Porebski, K. G. Doe and J. M. Osborne. 1999. Making inferences from a suite of biological tests. 26th Annual Aquatic Toxicity Workshop, Edmonton.

Porebski, B. A. Zajdlik, K. G. Doe and J. M. Osborne. 1999. Taking it to the creek - using an organic pollution gradient to evaluate techniques for dredged sediment assessment. 26th Annual Aquatic Toxicity Workshop, Edmonton.

Zajdlik, B. A. and P. Riebel. 1999. The cost-benefit of EEM study design. 85th Annual Meeting of the Pulp and Paper Technical Association. Montréal.

Jonczyk, E. G. Gilron and B. Zajdlik. 1998. Comparison of sea urchin fertilization test results using natural and synthetic marine water. 25th Annual Aquatic Toxicity Workshop, Québec City.

Zajdlik, B. A., T. S. Moran and S. Munro. 1997. Assessing spatial extent of impacted areas in the St. Clair River using the sediment quality triad. 24th Annual Aquatic Toxicity Workshop, Niagara Falls.

Zajdlik, B. A. 1997. Defining the word "replicate" in the context of sampling benthic macroinvertebrate communities. 24th Annual Aquatic Toxicity Workshop, Niagara Falls.

Jonczyk, E. G. Gilron and B. Zajdlik. 1997. Sample salinity adjustment for culturing and testing sea urchins. 24th Annual Aquatic Toxicity Workshop, Niagara Falls.

Gilron, G. L., D. H. Lynn, B. Zajdlik, J. Schroeder and C. Krawczyk. 1997. Development of a sublethal behavioural bioassay for mining effluents using the heterotrophic flagellate, *Polytomella papillata*. 24th Annual Aquatic Toxicity Workshop, Niagara Falls.

Zajdlik, B. A. Statistics: Why Bother? A Presentation to SETAC Laurentian Members, 1996. Guelph, Ontario.

Zajdlik, B. A. An introduction to threshold modelling of non-quantal bioassay data. 1995 Annual Aquatic Toxicity Workshop, St. Andrews, New Brunswick.

Zajdlik, B. A. A review of the ICp method. 1995 Annual Aquatic Toxicity Workshop, St. Andrews, New Brunswick.

R. R. # 3 • Rockwood, Ontario N0B 2K0 • Phone (519) 856-9440
Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

ZAJDLIK & ASSOCIATES INC.

PAPERS PRESENTED

Zajdlik, B. A., and D. G. Dixon. 1994. Statistical considerations in the design and analysis of experiments using a first-order single compartment model. 15th Annual Meeting of the Society of Environmental Toxicologists and Chemists.

Zajdlik, B. A., T. S. Moran and S. Munro. 1994. Survival analysis of Rainbow trout Oncoryhnchus mykiss egg hatchability data and environmental decision-making. 21st Annual Aquatic Toxicity Workshop, Sarnia.

Dutton, M. D., B. A. Zajdlik, D. G. Dixon and J. F. Klaverkamp. 1994. Reassessing interactions between bioenergetics and cadmium bioaccumulation in Rainbow trout. 21st Annual Aquatic Toxicity Workshop, Sarnia.

Zajdlik, B. A. 1993. Statistical Software and the Analysis of Toxicological Data. 20th Annual Aquatic Toxicity Workshop, Quebec City.

Smith, I. R., B. A. Zajdlik, H. W. Ferguson and M. A. Hayes. 1987. Alterations in serum chemistry in rainbow trout *Salmo gairdneri* with liver degeneration after partial hepatectomy or treatment with carbon tetrachloride or alpha-naphthyliso-thiocyanate. 14th Annual Aquatic Toxicity Workshop, Toronto

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Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

ZAJDLIK & ASSOCIATES INC.

EDUCATION

1991–1995 University of Waterloo Waterloo, Ont.

- Ph.D., Statistical Derivation of Environmental Quality Guidelines"
- Resumed, Spring 2006.

1987–1990 University of Guelph Guelph, Ont.

- MSc., Applied Statistics, Project Title "Analysis of Irregularly Spaced Time Series"

1982–1987 University of Guelph Guelph, Ont.

- BSc., Major: Aquatic Biology, Minor: Statistics

SCHOLARSHIPS AND AWARDS

- 2006 Ontario Ministry of Environment Strategic Partnership Grant
- 1994 University of Waterloo Graduate Scholarship
- 1992-1993 National Sciences and Engineering Research Scholarship
- 1991-1992 National Sciences and Engineering Research Scholarship
- 1989-1990 Ontario Graduate Scholarship
- 1988 University of Guelph Graduate Scholarship
- 1987 University of Guelph Graduate Scholarship

R. R. # 3 • Rockwood, Ontario N0B 2KO • Phone (519) 856-9440
Fax (519) 856-9446 • E-mail bzajdlik@sentex.net

Appendix H – John Brodie

Curriculum Vitae (CV)

M. John Brodie, P.Eng. (B.C & NWT/NU)

Education: B.A.Sc. Geological Engineering, University of British Columbia, 1982

Experience

Jan '95 - **Mine Reclamation Specialist, Brodie Consulting Ltd.**

Brodie Consulting has provided geotechnical and environmental services relating to mine reclamation on over 50 sites. This work has included:

- evaluation of closure plans and reclamation liability for new and existing mines,
- review of mine closure plans for abandoned mines,
- technical management of abandoned mines under government control,
- preparation of guidelines on mine closure planning and reclamation standards,
- development of the RECLAIM model for reclamation security estimates,
- discussion papers on factors in mine closure security,
- presentation of short courses on mine closure,
- risk characterization of mine closure hazards.

I am currently working on a long-term part-time basis as the Technical Manager for the Faro Mine closure planning project and Chief Engineer for the care and maintenance of the site.

Other current and recent projects include: design of 2 tailings dams at La Negra Mine, Mexico, pre-feasibility design of tailings dams in Texas and New Brunswick, development of a cost estimation methodology for the Peru Ministry of Mines, preparation of the closure plan for the Galore Creek Mine in B.C., evaluation of mine waste disposal options and costing on Kemess North mine for the CEAA Panel, lead engineer for rehabilitation of the B2 Dam at Giant Mine.

July '93 - Jan. '95 **Manager of Engineering, Reclamation Management Limited (RML)**

While with RML I led technical aspects of mine reclamation projects and was responsible for the environmental and engineering aspects of ongoing projects.

1987 - 1993 **Senior Geotechnical Engineer, Steffen Robertson And Kirsten Inc. (SRK)**

At SRK, I was involved in mine design, permitting and closure planning. This work included: environmental liability assessment, closure planning, control of acid rock drainage, design and construction of waste management facilities.

1983 - 1986 **Mine Geotechnical Engineer, Westmin Resources Ltd., Campbell River, B.C.**
Responsible for all aspects of the geotechnical program in a underground mine.

SUMMARY OF MINE CLOSURE PROJECTS **December 2008**

A site liability assessment or participation in mine closure planning has been conducted at following mines, through Brodie Consulting Ltd, or sub-contract to other firms or in previous employment. Involvement in many of these projects has been on behalf of a third party, such as government regulator or prospective purchaser.

Operating mines

1. Boliden Myra Falls, B.C.
2. Snip Mine, B.C.
3. Goldstream Mine, B.C.
4. Samatosum Mine, B.C.
5. Equity Silver Mine, B.C.
6. Quinsam Coal Mine, B.C.
7. Musselwhite Mine, Ont.
8. Hemlo Gold Mine, Ont.
9. Winston Lake Mine, Ont.
10. Mt. Nansen Mine, Yukon
11. Brewery Creek Mine, Yukon
12. Colomac Mine, N.W.T.
13. Diavik Diamond Mine, N.W.T.
14. Ekati Mine, N.W.T.
15. Miramar Con Mine, N.W.T.
16. Giant Mine, N.W.T.
17. Nanisivik Mine, Nunavut
18. Polaris Mine, Nunavut
19. Lupin Mine, Nunavut
20. Cerro De Pasco Mine, Peru
21. Jericho Diamond Mine, Nunavut

Proposed mines

1. Cerro Crucitas, Costa Rica
2. Galore Creek Mine, B.C.
3. Kemess North Mine, B.C.
4. Mt. Nansen Mine, Yukon
5. Dublin Gulch Mine, Yukon
6. Brewery Creek, Yukon
7. Western Copper, Yukon
8. BHP Diamonds, N.W.T.
9. Prarrie Creek Mine, NWT.
10. Doris North Mine, Nunavut

Closed Mines

1. Ainsworth Properties, B.C.
2. Silver Standard Mine, B.C.
3. Duthie Mine, B.C.
4. Britannia Mine, B.C.
5. Kitsualt Mine, B.C.
6. Baker Mine, B.C.
7. Laura/Peppa Mines, B.C.
8. Mt. Washington Mine, B.C.
9. Similco Mine, B.C.
10. Tulsequah Chief Mine, B.C.
11. Quirke I Mine, Ont.
12. Quirke II Mine, Ont.
13. Panel Mine, Ont.
14. Sturgeon Lake Mine, Ont.
15. Zenmac Mine, Ont.
16. McFinley Mine, Ont.
17. Whitehorse Copper Mine, Yukon
18. Ketza River Mine, Yukon
19. United Keno Hill Mine, Yukon
20. Cantung Mine, N.W.T.
21. Treminco/Ptarmigan Mine, N.W.T.
22. Holden Mine, Wash. USA
23. Pend Orielle Mine, Wash. USA
24. Solution Gold (Druid) Mine, Colorado, USA

Advanced Exploration & Bulk Sample Projects

1. Goose Lake Gold Project, Nunavut
2. Jericho Diamond Project, Nunavut
3. Boston Gold Project, Nunavut
4. Ulu Project, Nunavut
5. Nicholas Lake Project, N.W.T.

Note: Many sites appear more than once in the above lists due to ongoing involvement.

Brodie Consulting Ltd.
572 St. Andrews Place, West Vancouver, B.C., V7S 1V8
604-922-2034 fax 604-922-9520 Email: mjohnbrodie@shaw.ca

Relevant and Recent Key Project Experience

Faro Mine Closure Planning Office

- Technical manager for ongoing closure planning studies.
- Chief Engineer for ongoing care & maintenance of the Faro site

Aurcana Resources Inc.

- Design of drainage systems and dam raising methodology for 2 dams in central Mexico,
- Pre-feasibility design of tailings dam and impoundment liner for silver mine in Texas.

NovaGold Resources Inc.

- Preparation of mine closure plan and reclamation security for submission to B.C. government.

Canada Environmental Assessment

- Conceptual design and costing of alternative mine waste disposal strageties for the Kemess North Mine for consideration by the CEAA Panel and stakeholders

Vannessa Ventures Ltd.

- Preparation of mine closure plan – Las Crucitas Project, Costa Rica

CIDA – PERCAN

- Preparation of mine reclamation costing methodology for Peru Ministry of Mines
- Technical training sessions on mine reclamation costing for Peruvian industry and government engineers.

Indian & Northern Affairs Canada, N.W.T.

- Jericho Mine, Doris North Mine, Meadowbank Mine, review of closure plans and closure security
- Snap Lake project, geotechnical review for Environmental Assessment,
- Estimation of mine closure costs for Diavik, Ekati, Cantung, Colomac, Giant & Ptarmigan mines.
- Training government staff in method of estimating mine closure liability.
- Recommendations on mine closure guidelines for mine permitting.
- Project manager/technical advisor for water management and site maintenance of the Colomac Mine.

Indian & Northern Affairs Canada, Yukon

- Design of bulkhead to control drainage from mine workings
- Pre-feasibility closure plan development, Mt. Nansen Mine,
- Estimation of mine closure costs on Brewery Creek, Mt. Nansen, Western Copper & Dublin Gulch mines.
- Preparation of guidelines on mine closure and discussion paper on reclamation security issues.

Public Works & Government Services

- Giant Mine, ongoing engineering relating arsenic storage bulkheads and chamber water management
- Giant Mine, Lead engineer (under sub-contract to SRK) for re-construction of the B2 Dam,
- Design and construction supervision of bulkhead 14A for containment of arsenic waste
- Giant Mine, development of plan, budget and risk characterization for long-term care and maintenance,
- Discovery Mine, review of sediment management options for clay borrow pit.

Ontario Ministry of Northern Development and Mines

- Prepared the feasibility report; "Mine Assets In Reclamation Security".

Publications

1. Brodie, M. J., *Issues & Methods In Mine Reclamation Costing*, Canadian Institute, Vancouver, 2005.

2. Brodie, M. J and Cronk, M. *Management of Arsenic Confining Bulkheads at Giant Mine*, 2003, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, Alta.

3. Brodie, M. J. and Milburn, D. (2001), *The "RECLAIM" Model*; Northern Latitudes Mining Reclamation Workshop, Whitehorse, Yukon

4. Brodie, M. J. and Thompson, N. (2001), Colomac Mine Site Maintenance & Closure Planning of an Orphaned Site; Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, Alta.

5. Brodie, M. J. (1998): *"Acquisitions and Mine Closure Liability"*. Canadian Mining Journal, Aug.1998.

6. Brodie, M. J. (1994): *"Corporate Considerations In Mine Decommissioning"*. Proceedings of District 6 Canadian Institute of Mining Annual General Meeting, Vancouver, B.C., October 11 - 15.

7. Brodie, M. J. and Chapman, J. T. (1993): *"Development of Rehabilitation Plans For Acid Rock Drainage Control at Two Closed Underground Mines"*. Proceedings of the Seventeenth Annual British Columbia Mine Reclamation Symposium, Port Hardy, B.C., May 4 - 6.

8. Brodie, M. J. and Healey, P.M. (1993): *"Design and Installation of a Lined Mill-Effluent Containment Facility"*. Geosynthetics '93 Conference, Vancouver, B.C., March, 1993.

9. Brodie, M. J., Robertson, A. MacG. and Gadsby, J.W. (1992): "Cost Effective Closure Plan Management for Metal Mines". Proceedings of the Sixteenth Annual British Columbia Mine Reclamation Symposium, Smithers, B.C., June 15 - 18.

10. Brodie, M. J. and Healey, P.M. (1992): *The Design and Installation of an Effluent Containment Facility"*. Geotechnical Fabrics Report , Volume 10 Number 3, April.

11. Brodie, M. J., Broughton, L. M. and Robertson, A. MacG. (1991): *"A Conceptual Rock Classification System for Waste Management and a Laboratory Method for ARD Prediction from Rock Piles"*. Second International Conference on the Abatement of Acidic Drainage, Montreal.

12. Chance, A.V. and Brodie, M. J. (1987): *"Rock Mechanics at the Westmin HW Mine"*. CIM Convention.

Presentations

- CIDA PERCAN
  - Reclamation Cost Estimation – 2 day short course, , August 2006, Lima Peru
  - Introduction to PERU-RECLAIM – 2 day short course, October 2006, Lima Peru

- Introduction to Mine Reclamation, half day short course, May 2003, ARCSAC, Edmonton, Alta.

- Mine Technical Short Course, 5 days Oct/Nov. 2002, INAC, Iqaluit, Nunavut, (one of four presenters)

- RECLAIM Model and Mine Reclamation, ½ short course, Nov. 1997 and Nov. 2000, Yellowknife, NWT

- Mine Decommissioning and Reclamation Workshop, April 1994 CIM Convention, Toronto, Ontario, (one of five presenters)