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June 15, 2012

MVEIRB File Number: EA 0809-004

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Re: Technical Report – Fortune Minerals Limited – NICO Project – EA0809-004

Aboriginal Affairs and Northern Development Canada (AANDC) is pleased to submit the attached technical report to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) on the proposed Fortune Minerals Limited NICO Project (EA0809-004).

AANDC would like to thank the Board for the opportunity to present our technical review of the proposed NICO Project. The Department and its retained consultant, Mr. Barry Zajdlik of Zajdlik & Associates, will be available to present our concerns at the upcoming technical hearing in Yellowknife on July 31, 2012.

If you have any questions about this technical report, please do not hesitate to contact Mr. Robert Jenkins at (867) 669-2574 or robert.jenkins@aandc.gc.ca.

Sincerely,

Teresa Joudrie
Director
Renewable Resources and Environment

ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT CANADA
TECHNICAL REPORT

for

FORTUNE MINERALS LIMITED
PROPOSED NICO PROJECT
EA0809-004

June 15, 2012

TABLE OF CONTENTS

APPENDICES

ACRONYMS

Aboriginal Affairs and Northern Development Canada	AANDC
Aquatic Effects Monitoring Program	AEMP
Best Available Treatment Technology	BATT
Biochemical Reactor	BCR
Canadian Council of Ministers of the Environment	CCME
Closure and Reclamation Plan	CRP
Contaminants of Potential Concern	COPCs
Developer's Assessment Report	DAR
Environmental Assessment	EA
Environmental Effects Monitoring	EEM
Effluent Quality Criteria	EQC
Government of the Northwest Territories	GNWT
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
Northwest Territories	NWT
Northwest Territories Waters Act	NWTWA
Reverse Osmosis	RO
Site Specific Water Quality Objectives	SSWQO
Water Quality Objective	WQO

NON TECHNICAL SUMMARY

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

AANDC and its retained experts have completed a technical review of the documents related to the Environmental Assessment (EA) of Fortune Minerals Limited's proposed NICO Project up to and including June 5, 2012[1].

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

1. Water Quality Objectives (WQO)
2. Aquatic Effects Monitoring Program (AEMP)
3. Closure and Reclamation (CRP)

Where possible, AANDC has provided recommendations to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) to assist in its decision making process.

[1] AANDC did not conduct a technical review of the Toxicity Threshold Risk Assessment provided by Fortune in May 2012.

INTRODUCTION

AANDC has a mandated responsibility to protect the environment and promote sustainable development in the Northwest Territories. AANDC's legislated responsibilities for water management and protection stem from the *Northwest Territories Waters Act* (NWTWA). AANDC 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, AANDC and its retained consultants, Mr. Barry Zajdlik of Zajdlik & Associates and Mr. John Brodie of Brodie Consulting Limited, have conducted a technical review of documents related to Fortune Minerals Limited's (Fortune's) NICO Project (EA0809-004). In this report, AANDC provides specific comments related to water and environmental issues on the following three topics:

1. Water Quality Objectives (WQO)
2. Aquatic Effects Monitoring Program (AEMP)
3. Closure and Reclamation

Where possible, AANDC has provided recommendations to the Mackenzie Valley Environmental Impact Review Board (MVEIRB) to assist in its decision making process.

AANDC's TECHNICAL REVIEW

AANDC has completed a technical review of the documents related to the Environmental Assessment (EA) of Fortune Minerals Limited's NICO Project. In conducting our review, AANDC participated in information request stages, one technical session, and one meeting directly with the proponent[2], in an attempt to resolve issues identified herein. AANDC's review and technical report focuses mainly on the water-related aspects of the proposed project.

[2] AANDC did not conduct a technical review of the Toxicity Threshold Risk Assessment provided by Fortune in May 2012.

Site Specific Water Quality Objectives

Issue:

Fortune Minerals has proposed Site Specific Water Quality Objectives (SSWQOs) for Nico and Peanut Lakes. Proposed SSWQOs are based solely upon a review of toxicity literature. Existing background concentrations (i.e. non-degradation principle) or the ability to meet lower limits (e.g. CCME or Provincial type water quality guidelines) through effluent treatment (i.e. pollution prevention principle) were not considered, although it is apparent that the proposed use of a Reverse Osmosis (RO) treatment system will produce high quality effluent. Treated effluent from the operation will be capable of consistently achieving significantly lower concentrations than the proposed SSWQOs.

Fortune has made reference to these Toxicity Thresholds (previously proposed as SSWQOs) as end of pipe limits in discussions of effluent treatment.

Current modeling predictions suggest that the proposed toxicity thresholds will likely not be exceeded. Any potential exceedances are largely a result of conservative estimates of aerial deposition of dust from the site. On this basis, AANDC did not conduct a thorough or rigorous review of the Toxicity Based Risk Assessment provided by the company in April 2012. AANDC maintains that a critical review of this submission was not warranted and would be counterproductive given that the expected effluent quality from the mine was orders of magnitude below these Toxicity Threshold concentrations. AANDC believes that relying on toxicity threshold concentrations as SSWQOs could be used in the future as an argument to negate requirements for implementing Best Management Practices.

References:

1. Terms of Reference Section 3.3.2 Key line of Inquiry: water quality;
2. Terms of Reference Appendix C: Water quality;
3. DAR Section 3.0 Project Description;
4. DAR Section 6.0 KLOI: Water Quality;
5. DAR Appendix 7.I Water Quality Modeling Methods;
6. DAR Appendix 7.VII Site Specific Water Quality Objectives;
7. DAR Appendix 11.I Effects of the NICO Project on Surface Water Quality;
8. NICO Project (EA0809-004) Update for the Developer's Assessment Report, September 30, 2011;
9. NICO Cobalt Gold Bismuth Copper Project, Aquatic Risk Assessment, Golder Associates, April 2012;

10. NICO Cobalt Gold Bismuth Copper Project, Incorporation of Water Quality Predictions for Reverse Osmosis Water Treatment Option into Human Health and Ecological Risk Assessments, Golder Associates, April 13, 2012;
11. NICO Project: Update of Receiving Water Quality Predictions for the Operations Period with Revised Effluent Treatment Facility Discharge Quality, Golder Associates, April 13 2012;
12. Bench Scale Passive Treatment Testing Results Technical Memorandum, Golder Associates, May 4, 2012.
13. Response to IR AANDC_1, IR AANDC_2, IR AANDC_8, IR AANDC_12, IR AANDC_13, IR EC_12, IR TG_28,

Developer Conclusion:

The Developer initially identified Contaminants of Potential Concern (COPCs) by comparing the predicted quality of the water entering the effluent treatment plant during operations and water in the pit lake during closure against CCME Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CCME Guidelines) and baseline concentrations. Parameters that exceeded either of these conditions were identified as COPCs, and SSWQOs were developed for these parameters for Nico and Peanut Lakes. Objectives were then derived using toxicological information alone.

Fortune conducted an evaluation of effluent treatment options that was guided in part by the ability to achieve a high level of water quality, at the end of the discharge pipe, for as many chemicals as possible.

Water quality model predictions generated by Fortune indicate concentrations of aluminum, iron and arsenic in Nico, Peanut and/or Burke Lake may become elevated to levels that could cause toxicity during operations. Additionally, model predictions indicate that concentrations of chromium, mercury, silver and thallium in Nico and Peanut Lakes may become elevated to levels that exceed national guidelines (i.e. CCME Guidelines) during operations, and most contaminants are elevated above baseline concentrations. However, these predicted increases are largely driven by conservative assumptions of fugitive dust contributions, and therefore, maximum modelled concentrations are not expected to actually be observed during operations. Impacts to water quality are not expected to be significant.

Review Conclusion:

AANDC views SSWQO as the “Standard for Water” which should be maintained in order to preserve the present and future integrity and uses of an aquatic ecosystem. Consequently, SSWQOs must consider a number of factors such as use of the aquatic ecosystem, existing background concentrations, or objectives that may be reasonably achieved through the use of Best Management Practices and effluent treatment

technologies.

In AANDC's opinion, the values provided by Fortune as SSWQOs in the DAR are more correctly identified as Toxicity Thresholds. The Department does not believe that Toxicity Thresholds should be automatically adopted as SSWQOs for Nico Lake and Peanut Lake, and the downstream aquatic ecosystem, as these thresholds do not fully consider all the factors which define the desired "Standard for Water" downstream of the NICO Project.

AANDC maintains that increases in contaminant concentrations in the receiving environment should be minimized in order to provide the greatest confidence that impacts from a project will also be minimized. Only after consideration of mitigation measures and effluent treatment should toxicity literature and/or risk assessments be considered in the derivation of SSWQOs.

Rationale:

Two terms are commonly used in the context of effluent discharged from a development: SSWQO and Effluent Quality Criteria (EQC). EQC represent a regulatory limit that applies at a company's last point of control, which is typically the end of the effluent discharge pipe. SSWQOs are described above as the desired "Standard for Water" in an aquatic ecosystem.

SSWQOs are typically set for a waterbody with the expectation that they will be achieved at a downstream "assessment boundary" located at the edge of the mixing zone, otherwise referred to as an Initial Dilution Zone (IDZ). EQC allow for mixing of the effluent stream with the receiving environment within the mixing zone in order to bring the concentrations of parameters down to SSWQOs at the edge of the mixing zone. Therefore, if a company is meeting their EQCs at the point of discharge then, in principle, the downstream SSWQOs will also be consistently achieved.

AANDC acknowledges that setting EQCs is a regulatory requirement; however, AANDC believes that the "Standard for Water" downstream of a discharge should be determined in the EA phase. AANDC believes it is this process that facilitates the assessment of potential adverse effects from the Project.

AANDC recommends that derivation of SSWQOs for a receiving waterbody should consider both environmental and social factors that may include, but are not limited to:

- Natural background concentrations.
- Existing human use of the water (such as for drinking or fishing).
- Assimilation/mixing capacity.
- Long-term Chronic Toxicity exposure in the receiving environment,

- Single and joint-action toxicity of analytes being released,
- Degradation, transport and sequestration mechanisms.
- Chemical characteristics that modify toxicity (such as hardness, pH, organic matter, etc.).
- Protecting ecosystem diversity which will provide protection for critical species such as ecological “keystone” species.

These factors determine if, how, and to what extent the receiving water can accept contaminants. However if numerical values are not determined, the EA must, at a minimum, specifically define the level of protection for downstream water quality (e.g. fish can still be eaten at current consumption levels by the most at-risk consumers; water can be consumed by humans, etc).

Regarding determining appropriate SSWQOs for the NICO Project, a number of national and NWT specific policy documents provide guidance. These documents include: the NWT Water Strategy, the Mackenzie Valley Land and Water Board Water and Effluent Quality Management Policy, and, documents produced by the Canadian Council of Minister’s of the Environment (CCME). Selected concepts for water protection and preservation provided in these documents that require consideration when establishing SSWQOs, include:

> *“Waters that flow into, within or through the NWT are substantially unaltered in quality, quantity and rates of flow.” – Goal of the NWT Water Stewardship Strategy* (AANDC and GNWT, 2010)
>
> *“For waters of superior quality or that support valuable biological resources, the CCME non-degradation policy states that the degradation of the existing water quality should always be avoided.”* (CCME, 1999)
>
> *“Residents of the NWT have expressed a desire to lead in the area of water stewardship. This means setting high standards to hold residents and others responsible and accountable.” (AANDC and GNWT, 2010, Section 1.3, pg 9)*
>
> “*Pollution Prevention: The use of processes, practices, materials, products, or energy that avoid or minimize the creation of pollutants and waste and reduce overall risk to human health and the environment.” (MVLWB, 2011, Guiding Principle of WEQMP)*
>
> *“The Boards expects Developers to identify and implement waste prevention and/or minimization measures, whenever feasible.”* (MVLWB, 2011).
>
> *“Note that in accordance with the Boards’ objective to minimize waste discharge, proponents are expected to minimize and, where feasible, to prevent waste from*

> *entering water in the NWT. Therefore, and consistent with the CCME nondegradation policy, the Boards may set EQC that are more stringent than what is necessary to meet water quality standards in the receiving environment." (*MVLWB, 2011)

In addition to these policy statements, use of a Best Available Treatment Technology (BATT) is also generally considered best practice for minimizing environmental impacts from effluent discharges.

These principles speak to the practice of minimizing impacts to the receiving aquatic ecosystem by limiting the amount of waste discharged and minimizing degradation of receiving water quality. As noted previously, smaller changes in receiving water quality provide greater confidence that the important components of the receiving aquatic ecosystem will be preserved.

The Developer is proposing to use a RO treatment system followed by chemical precipitation of metals from the brine before recombining the treated brine with the RO permeate and discharging the blend into Peanut Lake. AANDC applauds the proponents decision to utilize a RO treatment system as a good quality effluent should be produced, which will minimize the impact of discharges from the project on the aquatic receiving environment.

However, in an effort to provide information on the potential upper concentrations of COPC that may cause impacts to the receiving water ecosystem, Fortune has relied on toxicological literature to derive SSWQOs. Furthermore, Fortune has incorporated some very conservative assumptions into their modeling predictions of impacts to water quality. The most conservative assumption may relate to the contributions of dusting and aerial deposition of contaminants to the aquatic receiving environment. This assumption is purported to be primarily responsible for the apparent increases in water quality parameters due to the project.

Fortune's rationale for including these conservative assumptions is that there are no defensible values that could be applied to the predicted dusting loadings that would represent the expected reduction in loadings due to using dust suppressants. AANDC accepts that there may not be scientific studies available that quantify reductions in dust loadings by incorporating mitigation measures such as using dust suppressants. However, experience at other mine sites such as Ekati suggest that, while a potential issue, the environmental impacts of dusting on the aquatic receiving environment can be mitigated using dust management strategies. AANDC notes that Fortune has already committed to implementing dust suppression strategies for their project; thus, more realistic modeling is possible that would more accurately predict implications from dust loadings to local waterbodies.

AANDC therefore maintains that dusting must not drive the derivation of SSWQOs for a typical mining development. The actual implications of dust on downstream water quality will not be realized until the mine is operational and therefore it would be appropriate to conduct suppressant trials and assessments of the impacts of dusting at that time. The Department believes that it is inappropriate to increase SSWQOs for the project based upon unmitigated dusting inputs to the receiving environment.

As mentioned at the beginning of this section, derivation of SSWQOs must consider the current and intended use of the downstream environment. It is the understanding of AANDC that the Tlicho people actively use the area downstream of the NICO Project for traditional activities including fishing, harvesting and residency; and that the Marian River system has particular cultural value. It is important that SSWQOs derived for the NICO project protect these specific uses of the system and do not preclude new uses now or into the future.

At this point, AANDC cannot propose specific numerical values as SSWQOs for the NICO Project. Therefore, AANDC feels that narrative statement regarding the level of protection for water downstream of the NICO project (during operations and closure) should be included within the environmental assessment. Specific statements include:

- Water quality changes due to mining activities will not significantly affect benthic macro-invertebrate and plankton abundance, taxonomic richness or diversity.
- Water quality changes due to mining activities will not significantly alter fish abundance or diversity or fish consumption at current levels.
- Water quality changes due to mining activities will not negatively affect areas utilized as traditional drinking water sources.
- Water quality changes due to mining activities will not significantly affect mammals or wildfowl using the area as a drinking water, food source or habitat, or the current ability for people to harvest these animals.
- Water quality in the Marian River remains unchanged.

As the RO treatment system will produce a good quality effluent, AANDC believes that SSWQOs should consider both existing background, as well as, CCME concentrations as they should be readily achievable for this project. Further, the SSWQO's should apply at the edge of a defined mixing zone within Peanut Lake. The Department believes that setting SSWQOs at these levels will minimize degradation and protect the intended downstream uses against effects of chronic toxicity, now and in the future.

Accordingly, AANDC makes the following recommendations regarding SSWQOs for the Fortune NICO Project:

RECOMMENDATION #1

AANDC recommends that the Report of EA should include narrative statements that describe the level of protection to be afforded to the aquatic receiving environment downstream of the Initial Dilution Zone. These statements could include:

- ***Water quality changes due to mining activities will not significantly affect benthic macro-invertebrate and plankton abundance, taxonomic richness or diversity.***
- ***Water quality changes due to mining activities will not significantly alter fish abundance or diversity or fish consumption at current levels.***
- ***Water quality changes due to mining activities will not negatively affect areas utilized as traditional drinking water sources.***
- ***Water quality changes due to mining activities will not significantly affect mammals or wildfowl using the area as a drinking water, food source or habitat, or the current ability for people to harvest these animals.***
- ***Water quality in the Marian River remains unchanged.***

RECOMMENDATION #2

AANDC recommends that final SSWQOs are based upon the use of the downstream aquatic environment, now and into the future. This could be achieved through consideration of:

- ***Natural background concentrations.***
- ***Existing human use of the water (such as for drinking or fishing).***
- ***Assimilation/mixing capacity.***
- ***Long-term Chronic Toxicity exposure in the receiving environment,***
- ***Single and joint-action toxicity of analytes being released,***
- ***Degradation, transport and sequestration mechanisms.***
- ***Chemical characteristics that modify toxicity (such as hardness, pH, organic matter, etc.).***
- ***Protecting ecosystem diversity which will provide protection for critical species such as ecological "keystone" species.***

RECOMMENDATION #3

AANDC recommends that Site Specific Water Quality Objectives derived for the Fortune NICO Project should, as a first step, consider the practically achievable

concentrations demonstrated for the RO effluent treatment system, existing background concentrations as well as available CCME Guidelines for the Protection of Freshwater Aquatic Life. Following this, derivation of SSWQOs from a review of available toxicity literature and/or developing new toxicological information, conducting of ecological risk assessments, etc. could be considered.

<u>RECOMMENDATION #4</u>

AANDC recommends that SSWQOs be achieved at the edge of a defined mixing zone within Peanut Lake.

Aquatic Effects Monitoring Program (AEMP) and Adaptive Management

Issue:

Aquatic effects from the project must be identified and responded to in advance of an adverse impact. AANDC's Aquatic Effects Monitoring Program Guidelines should be followed "as appropriate".

References:

1. DAR Section 18 Biophysical Monitoring Plans.
2. DAR Appendix 18.I Aquatic Effects Monitoring Program.

Developer Conclusion:

An AEMP will be designed and implemented for the project that will include provisions for biological monitoring as required under the Metal Mining Effluent Regulations (MMER) of the Federal *Fisheries Act*. The AEMP will consider AANDC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories – 2009" and the WLWB "draft Adaptive Management (Monitoring Response) Guidelines – 2010" as appropriate.

Reviewer Conclusion:

AANDC agrees with the Developer that an AEMP and Adaptive Management Framework are required for the Fortune NICO Project. However, AANDC would like to see a stronger commitment to follow AANDC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories – 2009" (AEMP Guidelines). The requirements of the MMER, in the context of an AEMP, are minimum standards and in all likelihood the AEMP will be much more rigorous and robust than the Environment Effect Monitoring (EEM) program. The requirements of an EEM program can and should be incorporated into a final AEMP as recommended in AANDC's guidelines.

Rationale:

The DAR contains a conceptual AEMP that provides an outline of a potential monitoring program for the project. A number of the elements of AANDC's AEMP guidelines are reflected in the AEMP outline, but additional discussions and technical review will be required as the AEMP is developed.

AANDC believes that the 2009 AEMP Guidelines provide a solid basis for first identifying the potential for and then monitoring project related effects to the

downstream receiving environment. This first goal is critical to the AEMP design and is directly related to the effects assessment that is developed in the EA. Also, and of equal importance, the AEMP provides a mechanism for incorporating Traditional Knowledge in an efficient and effective manner and harmonizing the requirements for aquatic effects monitoring with those associated with the EEM program. These key aspects are intended to streamline the AEMP development process and ensure that all interests and needs are effectively met.

AANDC'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. AANDC believes that this framework should be followed during the development of Fortune's final AEMP for the NICO project.

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. This process would include formulating appropriate statements about the acceptable level of change in the downstream environment as a result of the project.

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.

AANDC provides the following recommendation in regards to aquatic effects monitoring and adaptive management, 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 NICO Project.

Recommendation #5

***AANDC recommends that Fortune Minerals Limited be required to 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 NICO Project*.**

Closure and Reclamation

Issue:

At the end of mining, the open pit will be allowed to fill naturally over a period of approximately 120 years. Post closure seepage water quality from the Co-disposal Facility and overflow water from the flooded open pit may require treatment (active or passive) prior to discharge to the receiving environment.

References:

1. DAR Section 3.0 Project Description;
2. DAR Section 9.0 KLOI: Closure and Reclamation;
3. DAR Section 6.0 KLOI: Water Quality;
4. Response to IR AANDC_14, TG IR2_13, TG IR2_19, YKDFN IR2_3.1

Developer Conclusion:

The pit will naturally fill over a period of approximately 120 years. Active pumping from the Marian River could fill the pit in approximately 10 years. However, actively filling the pit will not negate the potential requirement for treating the pit water, so the extra cost associated with actively filling the pit is not justified.

Seepage from the CDF and overflow water from the filled open pit may require treatment prior to discharge to Nico and Peanut Lakes. This water is expected to be amenable to passive treatment using wetlands, and testing will be completed during the mine's operating period to evaluate whether wetland treatment will be effective. Active treatment will be implemented in the event that wetlands are not deemed effective.

Passive treatment would consist of either a constructed wetland or biochemical reactor (BCR), while active treatment would likely consist of chemical precipitation or ion exchange. RO is not expected to be selected for post-closure water treatment. The passive systems will require regular maintenance on the order of every 25 to 100 years for the wetland and every 10 to 20 years for the BCR system. Regular monitoring would also be required and would start at a frequency of weekly and be reduced to monthly or quarterly as system performance became better understood.

Reviewer Conclusion:

AANDC's position on closure and reclamation related issues are based upon the "Mine Site Reclamation Policy for the Northwest Territories, Indian and Northern Affairs Canada, 2002". This policy was developed in response to a number of insolvencies and abandoned mine properties for which the Crown assumed environmental liability of the

site. The Policy describes the Department's expectations regarding mine site reclamation and forms the basis of a second document, AANDC's Mine Site Reclamation Guidelines for the Northwest Territories.

Several of the principles contained within the Reclamation Policy are of particular importance for the proposed NICO Project, including the following:

> *"Following mine closure, mining companies or their future owners should continue to be responsible for the site, including the remediation of any additional environmental complications which develop."*
>
> *"The total financial security for final reclamation required at any time during the life of the mine should be equal to the total outstanding reclamation liability for land and water combined"*
>
> *"The required standard of reclamation should be based on the 1994 Whitehorse Mining Initiative definition: "returning mine sites and affected areas to viable and, wherever practicable, self sustaining ecosystems that are compatible with a healthy environment and with human activities.""*

In addition, a key concept of the Mine Site Reclamation Guidelines is to:

> *"Design for Closure and Reclamation."*

The goal of this concept is to minimize long-term care and maintenance and to eliminate perpetual care requirements. Designing for "walk-away" scenarios with minimal maintenance, post-reclamation, is particularly important in the NWT due to the typically isolated location of mine sites and the resulting high access and transportation costs.

AANDC has two primary concerns with the current closure scenario for the proposed NICO Project:

- The length of time required for the pit to fill naturally; and
- The need for passive or active water treatment post-closure.

Two scenarios for flooding the open pit are discussed in the DAR: allowing the pit to fill naturally over a period of approximately 120 years and active flooding over a period of approximately 10 years by pumping water from the Marian River. AANDC strongly prefers to see the pit filled actively over a period of approximately 10 years. The Department believes this is more manageable from a mine development perspective and ensures that the proponent addresses outstanding reclamation liabilities as efficiently as possible.

Both the passive and active post-closure water treatment scenarios will require maintenance and monitoring activity. AANDC's preference is to identify a solution that does not require active maintenance and monitoring in perpetuity. Therefore, actively filling the pit post-closure is even more important to avoid perpetual treatment and maintenance of post-closure water treatment options. Under the Developer's preferred case, the full extent of the maintenance and monitoring requirements may not be confirmed until more than 120 years post-closure. This potentially means that a significant portion of security would need to be retained by the Crown for over a century.

Rationale:

Natural Flooding

Several advantages to allowing the pit to flood naturally are provided in the DAR and in the information request responses. These include:

- The slower filling rate will provide a greater likelihood of stratification occurring within the pit;
- The rate of acid generation and metal leaching off the exposed pit walls will reduce considerably over the 120 year time period, and the runoff entering the Open Pit from the CDF will be non-contact water;
- Passive flooding will provide time to develop, verify and implement methods of in-pit treatment; and
- There will be no discharge from the open pit for 120 years which will defer the onset of any environmental impacts to surface water.

The primary disadvantage identified for the passive flooding scenario is that it will require monitoring of the pit water over a significantly longer period of time (i.e. over a century).

The Department questions the benefits of naturally flooding the pit as put forth by the Developer. It is unclear how the reduced rate of acid generation and metal leaching over time in a passively filled pit provides advantages over actively filling the pit and submerging exposed pit walls over a shorter timeframe. It is generally accepted that submerging rock that is potentially acid generating is an effective means of mitigating against the onset of acidic conditions.

Further, it is not clear why in-pit treatment methods could not reasonably be developed and finalized during the operating and active filling period (approximately 25 years). In other mining operations across the north, issues related to pit water quality are being addressed in advance of closure. Further, active filling is being conducted in order to properly manage issues at the site when closure activities are still ongoing at the site.

Finally, although final SSWQOs and upstream EQCs have yet to be determined, the proponent has committed to treating post closure water to a level which will be protective of the downstream aquatic environment. Accordingly, discharge from the mine, whether it occurs in year 10 following closure or year 120, should be at a level appropriate to protect downstream use of the system.

Active Flooding

No advantages were provided for actively flooding the pit, but several disadvantages were put forth including:

- The capital and operational costs of pumping infrastructure;
- Actively filling the pit will not negate the requirement for treating pit overflow water; and
- Active flooding will result in fully mixed as opposed to stratified pit water.

It appears to AANDC that the primary disadvantage of actively filling the pit is financial in nature. In either scenario the water will have to be treated to a level protective of the downstream receiving environment, so these arguments are nullified. With regard to the stratification of water, the DAR indicates that only a small degree of stratification may occur (3% of the filled volume of 28,000,000 cubic metres) under the natural filling scenario. The rest of the pit water will be fully mixed and any stratification will not make a substantial difference to the composition of the flooded open pit water quality at initial discharge. Therefore, it appears there is little to no advantage or disadvantage for stratified pit water.

It is important to note that current closure scenarios at other open pit mines in the NWT include actively filling the pits. This decision was reached in response to community and regulatory feedback, and on the basis that the length of filling time would introduce a higher degree of uncertainty with regards to the long-term water quality management at the pit lakes. Furthermore, the excessive financial burden (i.e. in the form of security provisions) was not desirable to proponents.

Post-Closure Water Quality Predictions

Post-closure water quality predictions suggest that some level of treatment will be required, under both filling scenarios. Passive treatment systems are preferred, but active treatment is a possibility. However, even passive systems will require some level of monitoring and maintenance as described in the response to TG IR2 13.

AANDC's Reclamation Policy also identifies closure implementation considerations that stem from the Mine Reclamation Principles and the following consideration is of particular relevance to the current closure scenario:

"Ensuring the site is left in a condition which will minimize or eliminate long-term care and maintenance requirements."

While the passive treatment systems proposed for the NICO Project may require less maintenance and monitoring than an active system, the need for maintenance and monitoring has not been eliminated. The situation is further compounded under the proposed long-term flooding scenario, where a program of maintenance and monitoring may need to be initiated 120 years after the end of mining when the pit waters overflow.

Accordingly, the post-closure period proposed for the NICO project presents a high risk and a long-term liability for the Crown. AANDC's position is to eliminate the requirement for any additional maintenance and monitoring activity at a site as soon as possible after the end of mining. A number of assumptions were required to generate the closure predictions presented to date and AANDC expects that the closure scenarios will be refined as additional information is gathered during site operations. AANDC believes that additional effort should be put into developing the closure scenarios, during operations, with the goal of eliminating any requirement for perpetual care and maintenance.

In considering these points, AANDC makes the following recommendations regarding the proposed closure scenarios for the open pit at the NICO Project:

RECOMMENDATION #6

AANDC recommends that active flooding of the open pit be the preferred closure scenario for the Fortune NICO Project, unless additional information collected during the operations phase of the project determines that the passive filling scenario provides significant advantages, beyond financial benefit, from a closure perspective.

RECOMMENDATION #7

AANDC recommends that a key element of the closure planning process, during operations, should be to identify and develop methods to eliminate the need for passive or active long-term treatment of water leaving the site post-closure.

CONCLUDING REMARKS

Fortune Minerals Limited is proposing the development of a cobalt, gold, copper and bismuth mine, located in the Tlicho region of the Northwest Territories. AANDC and its retained experts have completed a technical review of the proposed project. Where possible, AANDC has provided recommendations to the Mackenzie Valley Environmental Review Board to assist in their decision-making process.

The location of the proposed Fortune NICO Project is within an area currently used by the Tlicho people for traditional activities. Any effects of the proposed project should be limited such that they do not impact or limit usage of this area by the Tlicho, now and into the future. AANDC understands that the Marian River is of particular importance and warrants protection to a high level of confidence.

AANDC has provided recommendations within this report that relate to minimizing the potential impacts of this proposed development both in magnitude and temporal extent. Setting SSWQOs to levels that are readily achievable using the proposed effluent treatment system will minimize the potential effects to water quality, and will provide a higher level of confidence that the downstream aquatic ecosystem, including the Marian River, will see minimal impacts. Actively filling the pit will likely reduce the overall closure timeframe, which would reduce the period during which use of the area is altered. These recommendations support the overall goal of minimizing impacts to traditional use of this area.

AANDC thanks the Board for providing an opportunity to participate in this process, and looks forward to the Board’s decision on this project.

SUMMARY OF RECOMMENDATIONS

Site Specific Water Quality Objectives and Effluent Quality Criteria

RECOMMENDATION #1

AANDC recommends that the Report of EA should include narrative statements that describe the level of protection to be afforded to the aquatic receiving environment downstream of the Initial Dilution Zone. These statements could include:

- ***Water quality changes due to mining activities will not significantly affect benthic macro-invertebrate and plankton abundance, taxonomic richness or diversity.***
- ***Water quality changes due to mining activities will not significantly alter fish abundance or diversity or fish consumption at current levels.***
- ***Water quality changes due to mining activities will not negatively affect areas utilized as traditional drinking water sources.***
- ***Water quality changes due to mining activities will not significantly affect mammals or wildfowl using the area as a drinking water, food source or habitat, or the current ability for people to harvest these animals.***
- ***Water quality in the Marian River remains unchanged.***

RECOMMENDATION #2

AANDC recommends that final SSWQOs are based upon the use of the downstream aquatic environment, now and into the future. This could be achieved through consideration of:

- ***Natural background concentrations.***
- ***Existing human use of the water (such as for drinking or fishing).***
- ***Assimilation/mixing capacity.***
- ***Long-term Chronic Toxicity exposure in the receiving environment,***
- ***Single and joint-action toxicity of analytes being released,***
- ***Degradation, transport and sequestration mechanisms.***
- ***Chemical characteristics that modify toxicity (such as hardness, pH, organic matter, etc.).***
- ***Protecting ecosystem diversity which will provide protection for critical species such as ecological "keystone" species.***

RECOMMENDATION #3

AANDC recommends that Site Specific Water Quality Objectives derived for the Fortune NICO Project should, as a first step, consider the practically achievable concentrations demonstrated for the RO effluent treatment system, existing background concentrations as well as available CCME Guidelines for the Protection of Freshwater Aquatic Life. Following this, derivation of SSWQOs be derived from a review of available toxicity literature and/or developing new toxicological information, conducting of ecological risk assessments, etc. could be considered.

RECOMMENDATION #4

AANDC recommends that SSWQOs be achieved at the outlet of Peanut Lake.

Aquatic Effects Monitoring Program (AEMP) and Adaptive Management

Recommendation #5

***AANDC recommends that Fortune Minerals Limited be required to 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 NICO Project*.**

Closure and Reclamation

RECOMMENDATION #6

AANDC recommends that active flooding of the open pit be the preferred closure scenario for the Fortune NICO Project, unless additional information collected during the operations phase of the project determines that the passive filling scenario provides significant advantages, beyond financial benefit, from a closure perspective.

RECOMMENDATION #7

AANDC recommends that a key element of the closure planning process, during operations, should be to identify and develop methods to eliminate the need for passive or active long-term treatment of water leaving the site post-closure.

REFERENCES

AANDC and GNWT, 2010. Northern Voices, Northern Waters – The NWT Water Stewardship Strategy.

Canadian Council of Minister's of the Environment, 1999. Canadian Environmental Quality Guidelines, Canadian Water Quality Guidelines for the Protection of Aquatic Life.

MacKenzie Valley Land and Water Board, 2011. Water and Effluent Quality Management Policy.

Appendix A

Barry Zajdlik CV

ZAJDLIK & ASSOCIATES INC.

B A R R Y Z A J D L I K , P R I N C I P A L

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.

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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

PROJECT EXPERIENCE: EXPERIMENTAL DESIGN

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.

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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

PROJECT EXPERIENCE: ANALYSIS AND INTERPRETATION

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

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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.

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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.

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ZAJDLIK & ASSOCIATES INC.

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.

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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.

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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 11^{th}-12^{th}.

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 13^{th}-14^{th}.

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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.

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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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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

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