PRELIMINARY WATER QUALITY OBJECTIVES REPORT

KUDZ ZE KAYAH PROJECT

BMC-15-02-2351_019_Preliminary Water Quality Objectives_Rev3_161212

December 12, 2016

Prepared for:

BMC MINERALS (NO.1) LTD

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EXECUTIVE SUMMARY

Preliminary water quality objectives (pWQO) have been developed for a range of contaminants of potential concern (COPI) associated with the Kudz Ze Kayah (KZK) Project (the Project). The derivation of these pWQO has been performed following the methods outlined by Canadian Council of Ministers of the Environment (CCME) (2003) and is consistent with other permitted mining projects in Yukon. The background concentration procedure (BCP) was used to develop site-specific water quality objectives (SSWQO) for those COPIs for which the 95th percentile concentration at each receiving environment monitoring stations (Geona Creek, Finlayson Creek and South Creek) within the Project study area exceeded the CCME or British Columbia Ministry of Environment (BCMoE) water quality guidelines for protection of aquatic life. This resulted in SSWQOs for aluminum, cadmium, copper, fluoride, and zinc. Where the 95th percentile was lower than the generic CCME or BCMoE water quality guideline, then the most recent of the two guidelines was used.

A different approach was used to develop the pWQO for selenium. Selenium uptake by primary producers is a critical step in the accumulation of selenium in higher trophic levels of the freshwater food chain. Sulphate is documented to compete with selenium for uptake by primary producers. Laboratory testing using Finlayson Creek water demonstrated that selenium uptake by two primary producers was diminished in the presence of increasing sulphate concentrations. Therefore, a sulphate-dependent selenium SSWQO was developed. At baseline sulphate concentrations of 60 mg/L or less, the SSWQO was set equivalent to the BCMoE guideline (0.002 mg/L), but at higher sulphate concentrations, the selenium SSWQO is calculated using an equation based on the sulphate concentration.

Alternative approaches to the derivation of SSWQO for copper, lead, and zinc were also considered since they are primary COPIs for the Project. Biotic ligand modelling indicated that the time- and resource- intensive water effects ratio procedure (WERP) would be unlikely to produce higher SSWQO for these elements, however, elevated concentrations of dissolved organic carbon (DOC) present year-round in the downstream reach of Finlayson Creek (site KZ-26) and throughout the watershed during spring freshet may confer some protective effect against these three elements. This may allow the development of a seasonal (i.e., spring), or DOC-threshold based SSWQO using the WERP. A review of the aquatic species that are resident in the Project receiving environment identified several organisms (or surrogate species) that are particularly sensitive to copper, lead, and zinc chronic exposure. As such, the recalculation procedure, which reviews the resident species and compares them with the species used in toxicity databases that underpin the development of CCME and BCMoE water quality guidelines, is unlikely to produce SSWQO that are substantially different from the generic water quality thresholds for these three metals.

LIST OF ACRONYMS

AEG	Alexco Environmental Group Inc.
BCMoE	British Columbia's Ministry of Environment
BCP	Background Concentration Procedure
BLM	Biotic Ligand Modelling
BMC	BMC Minerals (No.1) Ltd.
CWQG	Canadian Water Quality Guidelines
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
COPI	Contaminants of Potential Interest
DOC	Dissolved Organic Carbon
DQA	Data Quality Assessment
pWQO	Preliminary Water Quality Objective
RCP	Recalculation Procedure
RSP	Resident Species Procedure
SSWQO	Site Specific Water Quality Objective
WERP	Water Effects Ratio Procedure
WQG	Water Quality Guideline
WQO	Water Quality Objective
YESAA	Yukon Environmental and Socio-economic Assessment Act

GLOSSARY

Background Concentration Procedure: a method that applies a statistical metric (e.g., 95th percentile) to existing baseline water quality data to develop site-specific water quality objectives.

Biotic Ligand Model: a numerical approach that uses the chemical composition of a water sample (e.g., dissolved organic carbon, calcium, magnesium, alkalinity content) alongside toxicological information to predict the toxicity of metals to aquatic biota.

Contaminants of Potential Concern: constituents that may be present at elevated levels in waters that drain Project infrastructure facilities during operations or following closure and may require mitigation measures to ensure that their concentrations can be reduced to an acceptable level.

Dissolved Organic Carbon: the concentration of organic carbon present in a water sample that has been filtered (<0.45 µm) prior to analysis.

Preliminary Water Quality Objectives: constituent concentration thresholds, often developed on a site specific basis, which are designed to be protective of the resident biota. They are subject to refinement as more baseline data is collected for the Project.

Recalculation Procedure: inspects the species toxicological database that was used to prepare the generic regulatory water quality guideline and then removes those species that are not resident at the site. Site-specific water quality objectives are then developed based on this screened toxicological data set using the same protocol that was used to formulate the generic water quality guideline.

Resident Species Procedure: accounts for both the sensitivity of species resident to a site and the influence of site water quality on toxicity. It involves the generation of a complete toxicological data set for constituents of interest using site water and resident species. Such site-specific toxicity data for a range of resident species are then used to derive site-specific water quality objectives.

Water Effects Ratio Procedure: provides a tool to modify generic water quality guidelines based on site-specific water quality characteristics. Toxicity tests are performed with an indicator or resident species using both laboratory water and site water. The results determine the WER, which is the ratio of constituent toxicity in site water compared to that in laboratory water. The calculated WER is then used to directly convert the generic water quality guideline to a site-specific water quality objective.

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1. INTRODUCTION

The KZK Project (the Project) is located 110 km southeast of Ross River, Yukon territory and is currently undergoing various studies to support a Yukon Environmental and Socio-economic Assessment Act (YESAA) Project Proposal by BMC Minerals (No. 1) Ltd. (BMC). As part of this process, it is necessary to develop a set of water quality objectives (WQO) for contaminants of potential concern (COPIs) in the receiving environment study area (Finlayson Creek, Geona Creek and South Creek) in which the Project may have potential effects. These WQO have been used to evaluate the Project performance as part of the Project planning process and to guide development of Project mitigations. For the Project, the development of WQO requires an evaluation of currently available generic water quality guidelines from relevant jurisdictions, and an evaluation of the potential usefulness of a range of methodologies for developing site specific water quality objectives (SSWQO).

Identification of preliminary water quality objectives (pWQO) allows for comparison with water quality predictions for effluent concentrations from the final compliance location. This allows the project design team (mine planners, water treatment, and aquatic scientists) to identify mitigations to their respective Project design elements (e.g. water treatment, discharge rates, covers) as required. The pWQO will be used in the Project Proposal to undertake the effects characterization for surface water quality and aquatic biota. The pWQO will be updated and finalised during the Water Licensing process using additional monitoring data collected during the YESAA process. This report and its appendices presents the pWQO for the Kudz Ze Kayah Project.

2. METHODOLOGY

2.1 HISTORIC WORK

The Project underwent environmental assessment and water licensing processes with its initial development under Cominco in the late 1990s. The supporting work for the project applications was presented in Cominco's Initial Environmental Evaluation (IEE, 1996). This work included predictions to changes in receiving environment water quality for the study area anticipated with mine operations and in post-closure. Water quality predictions and subsequent assessment focused only on aqueous ammonia, nitrite, copper, lead, and selenium. These predictions were compared with the Canadian Council of Resource and Environment Ministers (CCREM) generic water quality guidelines applicable at the time (CCREM, 1987).

2.2 PROJECT SSWQO DEVELOPMENT

Standard practice is to develop water quality objectives (WQO) for contaminants of potential concern (COPI) in the receiving waters. WQO can be generic (e.g. Canadian Water Quality Guidelines [CWQG] for the protection of aquatic life) or can be site specific water quality objectives (SSWQO) where they take into account background water quality conditions, resident species of aquatic resources, and other conditions present in the receiving environment. Such numerical water quality objectives can be utilized for evaluating potential effects, and as thresholds for further evaluation and action in adaptive management and monitoring programs.

Canadian Council of Ministers of the Environment (CCME) (2003) provides guidance for deriving numerical site specific water quality objectives and includes four procedures, which are the industry standard for establishing SSWQO for Canada and the Yukon. These procedures include the background concentration procedure (BCP), recalculation procedure (RCP), water effects ratio procedure (WERP), and the resident species procedure (RSP). The specific methodologies for evaluating SSWQO options for the primary COPIs are presented in the following sections 2.2.1 and 2.2.2. Section 0 presents the methods used to evaluate options for the remaining COPIs, and Section 2.2.4 outlines the methods used to select the preliminary WQOs from the options considered.

The preliminary water quality objectives have been developed utilising the COPIs determined through ongoing surface water monitoring, groundwater monitoring, and waste rock and tailings geochemical characterization. Parameters such as pH and TSS were not included as these will be regulated by established effluent quality standards.

In the preliminary evaluation of options for developing WQO, the available guidelines for the COPIs identified for the Project were compiled for the CCME and British Columbia's Ministry of Environment (BCMoE) guidelines for protection of aquatic life. Although many of the generic CWQG are numerically the same now under the Canadian Council of Ministers of the Environment (CCME) as they were in CCREM

in 1987, others have been updated with the results of further toxicity testing and research. In addition, (BCMoE) has published guidelines for the protection of aquatic life (BCMoE, 2016), with many of them based on more recent testing and research than CCME.

A more in-depth initial focus for consideration of SSWQO development was placed on the 1995 metal/metalloid COPIs (selenium, copper, lead) with the addition of zinc to reflect the economic minerals of the Project.

2.2.1 SELENIUM

After incorporation into the food chain, the biological effects from selenium occur through trophic transfer mechanisms and are highly site-specific. For example, overall primary productivity and the composition of the food chain both play a significant role in determining the assimilation of selenium up the food chain. Dissolved sulphate competes with dissolved selenate (which is likely the dominant form of selenium in flowing watercourses such as Geona Creek and Finlayson Creek) for uptake by aquatic primary producers such that selenium assimilation by primary producers is substantially modified (reduced) with increasing aqueous sulphate concentrations. Therefore, the selenium pWQO should consider the local sulphate concentration.

The approach pursued for the development of a sulphate-dependent site specific selenium water quality objective involved characterizing these relationships as a function of sulphate concentrations using both literature data and laboratory test work which employed site water. Relationships between selenium uptake and sulphate concentrations were evaluated using Finlayson Creek water and two primary producers – the alga *Pseudokirchneriella subcapitata* and the plant *Lemna minor*. The uptake of selenium by these organisms was examined in site waters amended with different selenium and sulphate concentrations and statistically significant correlations between the selenium enrichment factor in these primary producers and the dissolved sulphate concentration were identified. This relationship was then applied to a generic selenium guideline to generate a SSWQO formula.

Minnow Environmental was contracted to lead the development of the selenium SSWQO in collaboration with Nautilus Environmental. Further details of this work can be found in Appendix A, which presents the technical memorandum that outlines their methods and findings.

2.2.2 COPPER, LEAD AND ZINC

CCME (2003) indicates that there are four site specific approaches that may be suitable for the development of SSWQO for copper, lead, and zinc (given the status of these three metals as primary COPIs): BCP, WERP, RCP and RSP. The BCP is a statistical desktop exercise, and is undertaken with a suitable background water quality dataset (see section 0). Minnow Environmental was engaged to assist with evaluating the potential for the WERP and RCP to calculate SSWQOs. Appendix B outlines how Minnow utilized Biotic Ligand Modelling (BLM) as a proxy to evaluate the potential for the WERP to

develop a SSWQO. BLM provides an indication of the potential for the toxicity of certain metals to be altered (reduced) in site water due to the presence of modifying factors such as dissolved organic carbon (DOC). This toxicity modification could ultimately be characterized and applied to the generic guideline as a WERP, but this procedure is expensive and time consuming. The BLM gives a good indication of the potential for a useful WERP to be developed before embarking on the protocol.

Likewise, Minnow also investigated the potential to utilize the RCP by comparing the species sensitivities that underpin the toxicity databases utilized for the development of the generic CWQGs with the known species in the Project receiving waters. Similar to the BLM, this desktop comparison provides an indication of the potential for the RCP to result in a meaningful change in the CWQG for use as a SSWQO, prior to investing in the time required to undertake the procedure. Appendix C presents their methods and results for this investigation.

The RSP was not considered at this time as this procedure is most effectively undertaken following the completion of water quality predictions. The RSP may be undertaken in the future if deemed necessary.

2.2.3 OTHER COPIs

Although not contemplated as COPIs in the 1996 submission, many other metals and aqueous contaminants have the potential to be released from mining activities and to effect the health of local and downstream aquatic ecosystems. For these parameters, we have used the BCP to identify pWQO. This is an evaluation of background water quality concentrations where statistical metrics such as the 95th percentile, maximum, or mean plus two standard deviations may be used to develop a SSWQO for parameters where background concentrations are naturally elevated and routinely exceed the CWQG (CCME, 2003). This condition is not uncommon for proposed mining projects, where runoff drains mineralized areas.

For parameters where background concentrations are not naturally elevated, generic water quality guidelines for the protection of aquatic life have been used for proposed WQOs. CCME or BCMOE generic guidelines have both been considered for these parameters. Many of these guidelines are hardness or pH dependent and in these cases the dependency has been presented in the summary table. The water quality modelling will predict hardness concentrations for use in developing initial WQO for these parameters, but in application during mining operations, observed hardness or pH will be used for real-time WQO determination. For the purposes of evaluation, the lower quartile of the observed hardness/pH has been selected to define a conservative working value for the WQO, which is observed during the lower streamflow periods when the Creeks are most sensitive. Ammonia WQOs are based on water temperature and pH. The median observed laboratory pH and field temperature were used to develop the ammonia WQOs. Laboratory pH was used rather than field pH as it was more alkaline and therefore conservative in establishing the ammonia WQO.

These statistics were generated using the combined database of water quality data collected by:

- Cominco in 1994 and 1995;

- Cominco, Teck-Cominco, and Teck biannually between 2000 and 2014 for Water Use Licence Monitoring; and

- AEG monthly between April 2015 and October 2016.

These data are included in its entirety as Appendix D. A data quality assessment (DQA) was undertaken prior to statistical calculations, as part of the baseline surface water quality characterization report (AEG, 2016). As part of this assessment, the historic 1994-1995 Cominco data were assessed such that data with relatively poor (i.e., high) detection limits that formed outliers to the entire dataset (defined as values greater than average concentration plus or minus three standard deviations) were examined and removed where appropriate. Similarly, 1994-1995 data associated with high levels of field blank contamination were also examined and removed where appropriate. Further details regarding this DQA are provided by AEG (2016). Overall, the Cominco 1994-1995 dataset was deemed fit for use.

When data were reported by the laboratories as less than a detection limit, the statistical analysis used a value equal to half the detection limit.

2.2.4 PRELIMINARY WATER QUALITY OBJECTIVE SELECTION

The information generated through the methodologies outlined above was compiled where appropriate for Geona Creek (KZ-9), Finlayson Creek – 100 m downstream of confluence with Geona Creek (KZ-15), Finlayson Creek at Robert Campbell Highway (KZ-26), and South Creek (KZ-13). These locations are shown on Figure 2-1 relative to proposed Project infrastructure.

Consistent with CCME (2003) guidelines in developing SSWQO using the BCP, the 95th percentile of background metals concentrations was selected as the statistical basis for the pWQO for parameters whose concentrations exceeded generic guidelines (CCME, 2016 and BCMOE, 2015). These were calculated on a site by site basis using the data collected to date for each site. CCME (2003) also discuss other statistical approaches to calculating SSWQO using the BCP such as the mean plus two standard deviations. This alternative approach was also investigated, however, the results were typically comparable to, or markedly higher than the 95th percentile. As such, the 95th percentile was preferred in order to increase conservatism in the SSWQO developed using the BCP.

The most recently adopted or developed water quality guideline was selected as the pWQO for parameters where baseline concentrations are lower than generic WQGs (Table 2-1 and Table 2-2; e.g., total silver guideline for CCME established in 2015 was set as the pWQO as BCMOE guideline was developed in 1996). Where final CCME and BCMoE guidelines were published in the same year, BCMoE guidelines were preferred since they are developed for freshwaters of British Columbia, which share many similarities with those of Yukon. In the case of antimony, a final guideline is not available with CCME or BCMOE, therefore the working guideline reported by the BCMOE (2015) has been used to identified as

the pWQO for thoroughness and is to be used for comparison purposes only until a final guideline is reported. This approach was not used for selenium since a sulphate-dependent SSWQO was developed as outlined in Section 2.2.1 and Appendix A. Alternative approaches that used BLM or resident biota to determine SSWQO were also explored for copper, lead, and zinc (discussed in Section 2.2.2 and Appendices B and C).

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 2-1
SURFACE WATER QUALITY AND
HYDROLOGY MONITORING LOCATIONS

NOVEMBER 2016

Legend

◆ Hydrometric Station

🔺◆ Water Quality and Hydrometric Station

🔺 Water Quality Sampling Location

◆ Seep

═══ Tote Road/Proposed Access Road

─── Proposed Mine Road

─── Contour (40 m interval)

─── Watercourse

Waterbody

Location of Proposed Mine Infrastructure

BMC Minerals (No.1) Ltd. Mineral Claim Areas

		Coord (UTM Zone 9N)			
Station	**Type**	**Easting**	**Northing**	**Elevation**	**Source of Elevation**
KZ-13	WQ and Automated Hydrology	416482	6811653	1324	16m DEM
KZ-15	WQ and Automated Hydrology	414802	6822418	1221	1995
KZ-16	WQ and Automated Hydrology	414622	6822352	1230	1995
KZ-17	WQ and Automated Hydrology	414727	6822357	1222	1995
KZ-18	WQ	414698	6819726	1311	LiDAR
KZ-2	WQ and Automated Hydrology	414726	6814654	1423	LiDAR
KZ-21	WQ and Automated Hydrology	417494	6827454	1099	16m DEM
KZ-22	WQ and Automated Hydrology	417372	6827796	1092	16m DEM
KZ-26	Automated Hydrology	420107	6835643	950	16m DEM
KZ-26	WQ	419893	6835692	951	16m DEM
KZ-7	WQ and Hydrology	415225	6817163	1356	LiDAR
KZ-6	WQ	415325	6816659	1370	LiDAR
KZ-9	WQ and Automated Hydrology	414686	6819717	1304	LiDAR
KZ-9 Seep E	Seep	414745	6819667	1309	LiDAR
KZ-9 Seep W	Seep	414660	6819670	1307	LiDAR
Seep 3	Seep	414741	6818473	1346	LiDAR
Seep 4	Seep	415123	6816538	1316	LiDAR
Seep 5	Seep	414767	6819178	1383	LiDAR

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Table 2-1: BCMoE and CCME Guidelines Considered as pWQO for Total Constituents with 95th Percentile Baseline Concentrations that do not Exceed Canadian Water Quality Guidelines

Constituent	CCME Guideline Date	BCMoE Guideline Date	Long Term Water Quality Guideline
Aluminum, Total	1987 [a]	Not available	0.005 mg/L if pH < 6.5; 0.1 mg/L if pH ≥ 6.5
Ammonia-N	2001	2009	Temperature and pH dependent (see Table 3-2 for values)
Antimony, Total	Not available	No final guideline	0.009 mg/L (British Columbia working water quality guideline for antimony (III)
Arsenic, Total	1997	2002	0.005 mg/L
Cadmium, Total	2014	No guideline for total cadmium	0.00004 mg/L if hardness (as CaCO₃) < 17 mg/L 10^{0.83(log[hardness]) − 2.46}/1000 (mg/L) if hardness ≥ 17 mg/L and ≤ 280 mg/L 0.00037 mg/L if hardness > 280 mg/L
Copper, Total	1987	1987	0.002 mg/L if hardness ≤ 50 mg/L; (0.04*(hardness))/1000 (mg/L) if hardness > 50 mg/L and < 187 mg/L
Cyanide, Total	1987	Not available	0.005 mg/L (as free CN)
Cyanide, Weak Acid Dissociable	Not available	1986	0.005 mg/L
Fluoride	1987	No long term guideline	0.12 mg/L
Iron, Total	1987	No long term guideline	0.3 mg/L
Lead, Total	1987	1987	(3.31 + e^[1.273 ln (hardness+D3) - 4.704])/1000 (mg/L) if hardness > 8 mg/L
Manganese, Total	Not available	2001	0.0044*hardness + 0.605 mg/L if hardness ≥ 37 mg/L and ≤ 450 mg/L
Mercury, Total	2003	2001	0.000026 mg/L
Molybdenum, Total	1999	1986	0.073 mg/L
Nickel, Total	1987	Same as CCME	0.025 mg/L if hardness (as CaCO3) ≤ 60 mg/L or unknown, (e^{0.76[ln(hardness)]+1.06})/1000 mg/L if hardness > 60 mg/L and ≤ 180 mg/L, 0.15 mg/L if hardness > 180 mg/L
Nitrate-N	2012	2009	3 mg/L
Nitrite-N	1987	2009	0.02 mg/L if chloride <2 mg/L; Guideline increases by 0.02 mg/L increments for every 2 mg/L chloride increase between 2 and 10 mg/L; 0.2 mg/L if chloride >10 mg/L
Selenium, Total	1987	2014	0.002 mg/L
Silver, Total	2015	1996	0.00025 mg/L
Sulphate	Not available	2013	128 mg/L if hardness ≤ 30 mg/L; 218 mg/L if hardness > 30 mg/L and ≤ 75 mg/L; 309 mg/L if hardness > 75 mg/L and ≤ 180 mg/L; 429 mg/L if hardness > 180 mg/L and ≤ 250 mg/L
Thallium, Total	1999	No final guideline	0.0008 mg/L
Uranium, Total	2011	No final guideline	0.015 mg/L
Zinc, Total	1987	1999	0.0075 mg/L if hardness ≤ 90 mg/L; (7.5 + 0.75*(hardness − 90))/1000 mg/L if hardness > 90 mg/L

[a] Green shading indicates guideline used for site specific water quality objective

Table 2-2: BCMoE and CCME Guidelines Considered as pWQO for Dissolved Constituents with 95th Percentile Baseline Concentrations that do not Exceed Canadian Water Quality Guidelines

Constituent	CCME Guideline Date	BCMoE Guideline Date	Chronic Water Quality Guideline
Aluminum, dissolved	Not available	2001 [a]	$e^{[1.6-3.327(pH)+0.402(pH)^2]}$ mg/L if pH < 6.5 0.05 mg/L if pH ≥ 6.5
Cadmium, dissolved	Not available	2015	$(e^{(0.736 \cdot \ln(hardness)-4.943)})/1000$ mg/L for hardness between 3.4 and 285 mg/L
Iron, dissolved	Not available	2008	0.35 mg/L short term maximum

[a] Green shading indicates guideline used for site specific water quality objective

3. RESULTS

A summary of the results of all investigations and calculations undertaken in this preliminary exercise is presented in Table 3-1 for total and dissolved parameters. Parameter-specific findings are summarized in the sections below. Table 3-1 identifies the recommended pWQO selected from the various methods considered.

3.1 SELENIUM

The results of the site-specific selenium uptake testwork and their application to the development of a SSWQO for selenium are presented in Appendix A. Selenium uptake in two primary producers, *Pseudokirchneriella subcapitata* and *Lemna minor*, was examined at 0.002 mg/L and 0.01 mg/L selenium in the presence of between five and six different sulphate concentrations, which ranged between 60 mg/L and 550 mg/L (Appendix A). The selenium enrichment factor (EF; ratio of the selenium concentration in the primary producer to the selenium concentration in the water) showed a strong positive correlation with dissolved sulphate for *P. subcapitata* at both 0.002 mg/L selenium and 0.01 mg/L selenium, and for *L. minor* at 0.01 mg/L selenium. No relationship could be produced at 0.002 mg/L selenium for *L. minor* since tissue selenium concentrations were below the detection limit in the majority of tests run. The site-specific EFs determined ranged from 32 to 182 L/kg, which is lower than the median EF documented for lotic environments (i.e. running water systems such as streams and rivers) of 400 L/kg reported by the USEPA (2016), suggesting a low site-specific selenium enrichment for Finlayson Creek waters.

The three sets of experiments (*P. subcapitata* at both 0.002 mg/L selenium and 0.01 mg/L selenium, and *L. minor* at 0.01 mg/L selenium) all produced similarly sloped relationships between dissolved sulphate concentration and selenium EF, allowing the data to be combined to produce one relationship (Appendix A). The background sulphate concentration in the Finlayson Creek water used in these experiments was 60 mg/L. Therefore, it was assumed that the generic BCMoE selenium water quality guideline (0.002 mg/L) would apply at sulphate concentrations ≤60 mg/L. For Geona and Finlayson Creek waters with dissolved sulphate concentrations higher than 60 mg/L, the SSWQO is calculated based on the sulphate concentration, since higher sulphate levels ameliorate selenium uptake. Therefore, the selenium SSWQO can be calculated as:

Total Selenium SSWQO (mg/L) = 0.002 mg/L at sulphate ≤60 mg/L; and

Total Selenium SSWQO (mg/L) = $(0.1736*[\text{sulphate}]^{0.597})/1000$ at sulphate >60 mg/L.

The baseline sulphate concentrations for Geona Creek at KZ-9 and Finlayson Creek at KZ-15 and KZ-26 range from <0.5 to 41.7 mg/L, <0.5 to 37.3 mg/L, and 13.3 to 47.6 mg/L, respectively. The sulphate concentrations predicted at these sites during operations and closure from the water quality model will be used and are anticipated to be between 130 and 300 mg/L, which corresponds to selenium pWQO of 0.0032 and 0.0052 mg/L, respectively. It should be noted that the pWQO for sulphate (309 mg/L for KZ-9

and KZ-15, and 429 mg/L for KZ-26, Table 3-1), is hardness-dependent and will be increased for KZ-9 and KZ-15 to 429 mg/L for certain months of the year using preliminary hardness results from the water quality model. No SSWQO for selenium was developed for South Creek (KZ-13) since no effluent discharges to this watercourse are planned during operations or any closure periods.

3.2   COPPER, LEAD AND ZINC

The results of the biotic ligand modelling and the associated implications regarding the utility of the water-effect ratio (WER) Procedure to develop SSWQO for these elements is presented in Appendix B. The Windward, PNEC.pro, and Bio-Met biotic ligand models were used to predict chronic no-effect concentrations for copper and zinc for sampling events performed between April 2015 and December 2015 at water quality stations in Geona Creek (KZ-17) and Finlayson Creek (KZ-15 and KZ-26). Since DOC is a required input for all three models, only datasets that contained DOC could be used, which excluded data collected prior to April 2015. The Windward BLM was also used to predict acute effect concentrations for lead since it is the only model that can be applied to that parameter. The BLM results obtained for each sample dataset were compared to the USEPA standard to produce site-specific WER for copper, zinc, and lead. A WER >2 suggests that the WER Procedure may be potentially useful in deriving a SSWQO.

The predicted WERs for copper, zinc, and lead all showed a strong positive correlation with DOC, with the highest WERs observed during freshet for all three elements (Appendix B). Site KZ-26, located near the mouth of Finlayson Creek, generally returned the highest estimated WERs due to its higher DOC content, however, lower DOC concentrations observed farther upstream on Finlayson Creek, and in Geona Creek appear to limit the application of the WER Procedure. There is the potential to use the WER Procedure to develop a season-specific SSWQO based on the high DOC concentrations observed during freshet, but the WERP would likely be of limited use at other times of the year when DOC levels are lower.

The potential utility of the RCP in developing SSWQO for copper, lead, and zinc was also investigated by Minnow (Appendix C). The aquatic species that are resident in the Project area were reviewed and their sensitivity to copper, lead, or zinc exposure was assessed based on literature data. Numerous species (or a reasonable surrogate species) that are sensitive to copper, lead, and zinc exposure were identified as being resident in the Project receiving environment, including Arctic grayling, cladocerans (water fleas) and green algae. This suggests there is limited potential for the application of the Recalculation Procedure to result in a SSWQO that differs meaningfully from the generic WQG for these parameters.

Given the limitations to the usefulness of applying the WERP or RCP effectively for copper, lead and zinc, these parameters have been treated in a similar fashion to all other remaining metal parameters, in terms of identifying pWQOs (Section 3.3 below).

3.3 OTHER COPIS

The pWQOs for total and dissolved constituents other than selenium have been selected using either the generic WQG or by using the BCP to calculate a SSWQO for parameters that have naturally elevated background concentrations in Project receiving waters (Table 3-1). Using the BCP, the 95th percentile total concentration was used as a site-specific pWQO for the concentration of the following elements (Table 3-1):

- Total aluminum at KZ-9 (0.19 mg/L), KZ-13 (0.58 mg/L), and KZ-26 (0.15 mg/L);

- Total cadmium at KZ-9 (0.00029 mg/L);

- Total copper at KZ-13 (0.0048 mg/L);

- Fluoride at KZ-26 (0.13 mg/L);

- Total iron at KZ-9 (2.1 mg/L), KZ-13 (0.95 mg/L), and KZ-26 (0.78 mg/L); and

- Total zinc at KZ-13 (0.016 mg/L).

Where the 95th percentile concentration was lower than the generic CCME or BCMoE water quality threshold, then the most recent guideline was used.

The ammonia-N guideline is dependent on the temperature and pH of the sample collected, however, for reference purposes, monthly ammonia-N pWQOs are presented in Table 3-2 based on the average temperature and pH of waters observed at each sample location.

Table 3-1: Preliminary Water Quality Objectives (pWQO) for Constituents at Kudz Ze Kayah Project.

Parameter		Laboratory Detection Limit	KZ-9 95th percentile mg/L	KZ-15 95th percentile mg/L	KZ-13 95th percentile mg/L	KZ-26 95th percentile mg/L	CCME Guidelines - Aquatic Life (mg/L) KZ-9[e]	KZ-15[d]	KZ-13[c]	KZ-26[h]	BCMoE Guidelines - Aquatic Life (mg/L) KZ-9[e]	KZ-15[d]	KZ-13[c]	KZ-26[h]	KZ-9 (mg/L)	KZ-9 pWQO Rationale	KZ-15 (mg/L)	KZ-15 pWQO Rationale	KZ-13 (mg/L)	KZ-13 pWQO Rationale	KZ-26 (mg/L)	KZ-26 pWQO Rationale
Aluminum, total	mg/L	0.0005	0.19	0.048	0.58	0.15	0.1[a]	0.1[a]	0.1[a]	0.1[a]	-	-	-	-	0.19	95th percentile> generic guidelines	0.10	CCME is most recent guideline	0.58	95th percentile> generic guidelines	0.15	95th percentile> generic guidelines
Ammonia-N	mg/L	0.005	0.065	0.045	0.028	0.052	0.86[b]	0.86[b]	0.86[b]	0.28[i]	1.1[b]	1.13[b]	1.13[b]	0.37[i]	pH and temperature dependent	BCMOE is most recent guideline	pH and temperature dependent	BCMOE is most recent guideline	pH and temperature dependent	BCMOE is most recent guideline	pH and temperature dependent	BCMOE is most recent guideline
Antimony, total	mg/L	0.00002	0.000070	0.000041	0.000038	0.00016	-	-	-	-	0.0090	0.0090	0.0090	0.0090	0.0090	Only a working guideline with BCMOE	0.0090	Only a working guideline with BCMOE	0.0090	Only a working guideline with BCMOE	0.0090	Only a working guideline with BCMOE
Arsenic, total	mg/L	0.00002	0.00104	0.00072	0.0015	0.0021	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	CCME is most recent guideline	0.0050	CCME is most recent guideline	0.0050	CCME is most recent guideline	0.0050	CCME is most recent guideline
Cadmium, total	mg/L	0.000005	0.00029	0.00012	0.000042	0.000052	0.00022	0.00021	0.00011	0.00028	-	-	-	-	0.00029	95th percentile> generic guidelines	hardness dependent	CCME is most recent guideline	hardness dependent	CCME is most recent guideline	hardness dependent	CCME guideline
Chloride, total	mg/L	0.5	1.10	1.1	0.88	1.2	120	120	120	120	150	150	150	150	120	CCME is most recent guideline	120	CCME is most recent guideline	120	CCME is most recent guideline	120	CCME is most recent guideline
Copper, total	mg/L	0.00005	0.0023	0.0019	0.0048	0.0019	0.0032	0.0032	0.002	0.004	0.0058	0.0056	0.0024	0.0078	hardness dependent	BCMOE is most recent guideline	hardness dependent	BCMOE is most recent guideline	0.0048	95th percentile> generic guidelines	hardness dependent	BCMOE is most recent guideline
Cyanide, Total	mg/L	0.0005	0.00102	0.00074	0.00099	0.00100	0.005[j]	0.005[j]	0.005[j]	0.005[j]	-	-	-	-	0.005	CCME guideline	0.005	CCME guideline	0.005	CCME guideline	0.005	CCME guideline
Cyanide, Weak Acid Dissociable	mg/L	0.0005	0.00134	0.00080	0.00073	0.00091	-	-	-	-	0.005	0.005	0.005	0.005	0.005	Only a guideline with BCMOE	0.005	Only a guideline with BCMOE	0.005	Only a guideline with BCMOE	0.005	Only a guideline with BCMOE
Fluoride	mg/L	0.01	0.088	0.11	0.054	0.13	0.12	0.12	0.12	0.12	-	-	-	-	0.12	CCME guideline	0.12	CCME guideline	0.12	CCME guideline	0.13	95th percentile> generic guidelines
Iron, total	mg/L	0.001	2.1	0.22	0.95	0.78	0.3	0.3	0.3	0.3	-	-	-	-	2.11	95th percentile> generic guidelines	0.3	CCME is most recent guideline	0.95	95th percentile> generic guidelines	0.78	95th percentile> generic guidelines
Lead, total	mg/L	0.000005	0.0022	0.00061	0.00030	0.00053	0.0051	0.0049	0.0017	0.0070	0.0084	0.0082	0.0050	0.011	hardness dependent	BCMOE is most recent guideline	hardness dependent	BCMOE is most recent guideline	hardness dependent	BCMOE is most recent guideline	hardness dependent	BCMOE is most recent guideline
Manganese, total	mg/L	0.00005	0.15	0.060	0.16	0.094	-	-	-	-	1.2	1.2	0.9	1.5	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE
Mercury, total	mg/L	0.000002	0.0000085	0.0000073	0.0000050	0.0000077	0.000026	0.000026	0.000026	0.000026	0.000020	0.000020	0.000020	0.000020	0.000026	CCME is most recent guideline	0.000026	CCME is most recent guideline	0.000026	CCME is most recent guideline	0.000026	CCME is most recent guideline
Molybdenum, total	mg/L	0.00005	0.0012	0.0014	0.00088	0.0012	0.073	0.073	0.073	0.073	1.0	1.0	1.0	1.0	0.073	CCME is most recent guideline	0.073	CCME is most recent guideline	0.073	CCME is most recent guideline	0.073	CCME is most recent guideline
Nickel, total	mg/L	0.00002	0.0012	0.0020	0.0017	0.0030	0.13	0.12	0.066	0.15	-	-	-	-	hardness dependent	CCME guideline	hardness dependent	CCME guideline	hardness dependent	CCME guideline	hardness dependent	CCME guideline
Nitrate-N	mg/L	0.002	0.20	0.21	0.15	0.25	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	CCME is most recent guideline	3.0	CCME is most recent guideline	3.0	CCME is most recent guideline	3.0	CCME is most recent guideline
Nitrite-N	mg/L	0.002	0.0025	0.0025	0.0025	0.0025	0.06	0.06	0.06	0.06	0.02	0.02	0.02	0.02	0.02	BCMOE is most recent guideline	0.02	BCMOE is most recent guideline	0.02	BCMOE is most recent guideline	0.02	BCMOE is most recent guideline
Selenium, total	mg/L	0.00004	0.0014	0.0014	0.00034	0.0010	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002 or equation	BCMOE is most recent guideline	0.002 or equation	BCMOE is most recent guideline	0.002 or equation	BCMOE is most recent guideline	0.002 or equation	BCMOE is most recent guideline
Silver, total	mg/L	0.000005	0.000016	0.000013	0.000017	0.000017	0.00025	0.00025	0.00025	0.00025	0.0015	0.0015	0.000050	0.0015	0.00025	CCME is most recent guideline	0.00025	CCME is most recent guideline	0.00025	CCME is most recent guideline	0.00025	CCME is most recent guideline
Sulphate	mg/L	0.5	35	37	16	45	-	-	-	-	309	309	218	429	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE
Thallium, total	mg/L	0.000002	0.000006	0.0000030	0.0000059	0.0000030	0.0008	0.0008	0.0008	0.0008	-	-	-	-	0.0008	CCME guideline	0.0008	CCME guideline	0.0008	CCME guideline	0.0008	CCME guideline
Uranium, total	mg/L	0.000002	0.0020	0.0050	0.0016	0.0037	0.015	0.015	0.015	0.015	-	-	-	-	0.015	CCME guideline	0.015	CCME guideline	0.015	CCME guideline	0.015	CCME guideline
Zinc, total	mg/L	0.0001	0.034	0.011	0.016	0.0090	0.03[g]	0.03[g]	0.03[g]	0.03[g]	0.048	0.045	0.0075	0.087	hardness dependent	BCMOE is most recent guideline	hardness dependent	BCMOE is most recent guideline	0.016	95th percentile> generic guidelines	hardness dependent	BCMOE is most recent guideline

Parameter		Laboratory Detection Limit	KZ-9 95th percentile mg/L	KZ-15 95th percentile mg/L	KZ-13 95th percentile mg/L	KZ-26 95th percentile mg/L	CCME Guidelines - Aquatic Life (mg/L) KZ-9[d]	KZ-15[c]	KZ-13[b]	KZ-26[e]	BCMOE Guidelines - Aquatic Life (mg/L) KZ-9[e]	KZ-15[d]	KZ-13[c]	KZ-26[e]	KZ-9 (mg/L)	KZ-9 pWQO Rationale	KZ-15 (mg/L)	KZ-15 pWQO Rationale	KZ-13 (mg/L)	KZ-13 pWQO Rationale	KZ-26 (mg/L)	KZ-26 pWQO Rationale
Aluminum, dissolved	mg/L	0.0005	0.021	0.015	0.031	0.018	-	-	-	-	0.050[a]	0.050[a]	0.050[a]	0.050[a]	0.050	Only a guideline with BCMOE	0.050	Only a guideline with BCMOE	0.050	Only a guideline with BCMOE	0.050	Only a guideline with BCMOE
Cadmium, dissolved	mg/L	0.000005	0.000088	0.000059	0.000025	0.000025	-	-	-	-	0.00028	0.00027	0.00015	0.00035	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE	hardness dependent	Only a guideline with BCMOE
Iron, dissolved	mg/L	0.001	0.26	0.033	0.31	0.072	-	-	-	-	0.35	0.35	0.35	0.35	0.35	Only a guideline with BCMOE	0.35	Only a guideline with BCMOE	0.35	Only a guideline with BCMOE	0.35	Only a guideline with BCMOE

[a] based on pH >6.5
[b] based on pH 8 and temperature 10°C
[c] based on hardness of 61, lower quartile hardness for KZ-13
[d] based on hardness of 140, lower quartile hardness for KZ-15
[e] based on hardness of 144, lower quartile hardness for KZ-9
[f] based on Arsenic (III), but applied for total
[g] this if for current approved guideline, while draft guideline is currently out for review
[h] based on hardness of 196, lower quartile hardness for KZ-26
[i] based on pH 8.5 and temperature 10°C
[j] guideline is for free cyanide

[shaded] indicates value used for site specific water quality objective

Table 3-2: Preliminary Water Quality Objectives for Ammonia (mg/L as N) by Month at Kudz Ze Kayah Project.

Month	Sampling Locations			
	KZ-13 South Creek	KZ-9 Geona Creek	KZ-15 Finlayson Creek	KZ-26 Finlayson Creek
January	1.3	1.3	0.80	0.51
February	1.3	1.5	0.80	0.51
March	1.8	0.99	1.2	0.64
April	1.0	2.1	0.80	0.50
May	2.1	1.7	1.5	0.98
June	1.4	0.90	0.91	1.2
July	1.9	1.6	1.3	0.73
August	1.9	1.2	0.91	0.58
September	2.0	1.2	1.2	0.76
October	1.5	1.0	0.78	0.63
November	1.0	0.80	0.51	0.64
December	2.1	2.1	1.3	0.80

4. SUMMARY

Preliminary water quality objectives have been developed consistent with the procedures outlined by CCME (2003). The background concentration procedure was used to develop SSWQOs for elements that had a 95th percentile concentration which exceeded the generic water quality guideline provided by CCME or BCMoE (whichever is most recent). This comprised:

- Total aluminum, cadmium, and iron at KZ-9;

- Total aluminum, copper, iron and zinc at KZ-13; and

- Total aluminum, iron and fluoride at KZ-26.

Where the 95th percentile concentration was lower than the generic CCME or BCMoE water quality threshold, the most recent guideline was used, with the exception of selenium. Laboratory tests using Finlayson Creek water confirmed literature observations that selenium uptake by primary producers is inhibited by increasing sulphate concentrations. Therefore, a SSWQO for selenium was developed based on the sulphate concentration of the water such that:

- Where sulphate ≤60 mg/L, selenium SSWQO = 0.002 mg/L; and

- Where sulphate >60 mg/L, selenium SSWQO (mg/L) = $(0.1736*[\text{sulphate}]^{0.597})/1000$.

Given the status of copper, lead, and zinc as primary COPIs, alternative approaches to their SSWQO development were also assessed. Biotic ligand modelling indicated that the resource-intensive water-effects ratio procedure (WERP) would be unlikely to result in alternative, higher SSWQO for copper, lead, or zinc, although elevated concentrations of DOC at site KZ-26 and present throughout the watershed during spring freshet may modify toxicity of these metals, perhaps allowing for the development of seasonal (i.e., spring), or DOC-threshold based WERP SSWQO. Similarly, a review of the aquatic biota that are resident in the Project's receiving environment indicates that the Recalculation Procedure is also unlikely to result in SSWQO that are different from the generic WQG for these three metals.

5. REFERENCES

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APPENDIX A.

Evaluation of Selenium Uptake in Aquatic Primary Producers and Application of Uptake Relationships to the Development of a Site-Specific Water Quality Objective at BMC Minerals Kudz Ze Kayah Project (Minnow Environmental Inc., Nautilus Environmental)

January 18, 2016

Mr. Scott Keesey
Senior Environmental Manager
Alexco Environmental Group
#3 Calcite Business Centre
151 Industrial Rd.,
Whitehorse, Yukon
Y1A 2V3

Dear Mr. Keesey,

Re: Evaluation of Selenium Uptake in Aquatic Primary Producers and Application of Uptake Relationships to the Development of a Site-Specific Water Quality Objective at BMC Minerals Kudz Ze Kayah Project
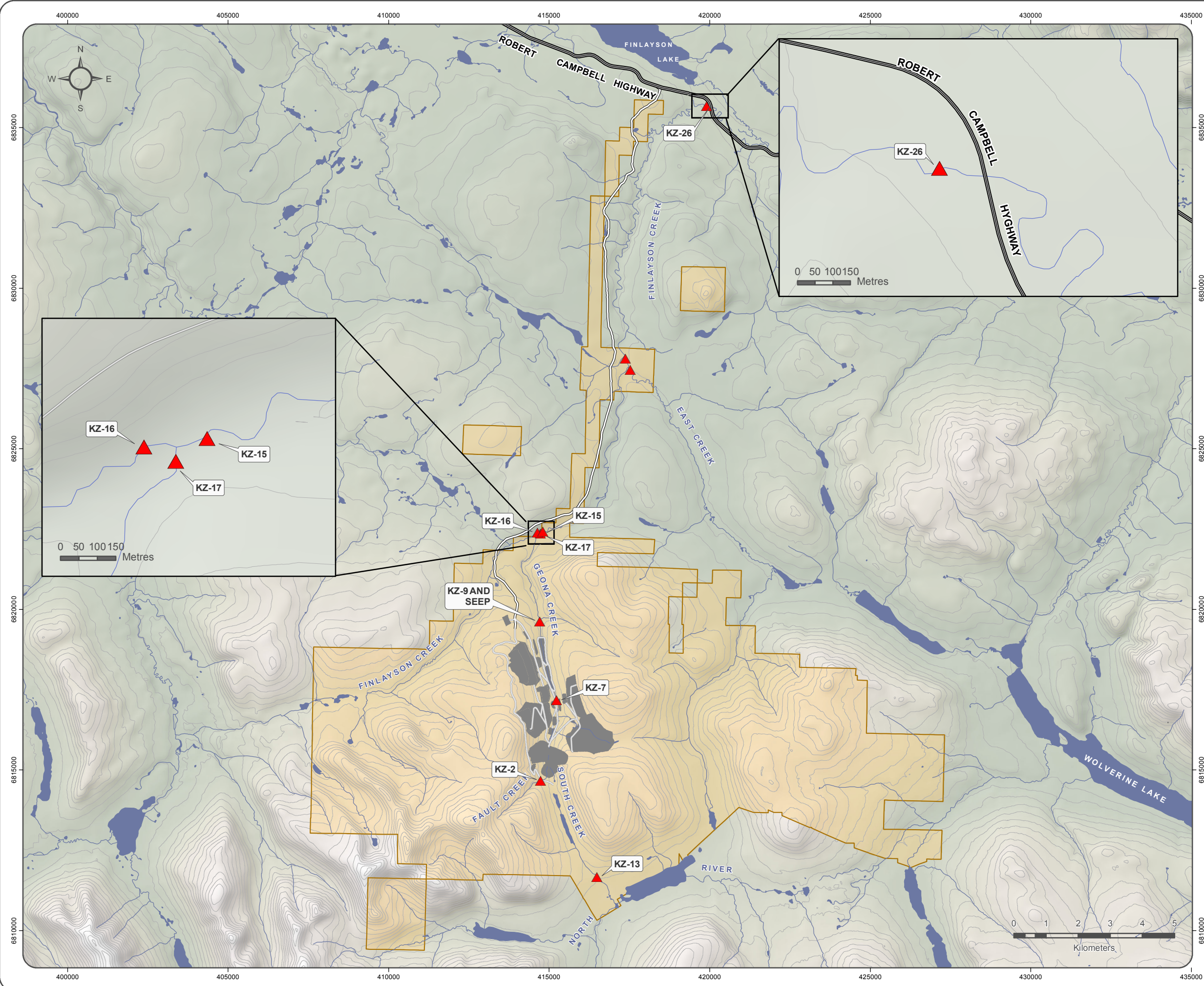
Minnow Environmental Inc. (Minnow) is pleased to provide a brief letter report examining the results of site-specific selenium uptake testing and their utility in deriving a site-specific water quality objective (SSWQO) for selenium at the BMC Minerals Kudz Ze Kayah Project.

Project Background

The BMC Minerals Kudz Ze Kayah Project is located in Yukon Territory, approximately 110 kilometers southeast of the community of Ross River. The project lies primarily within the Geona Creek watershed (Figure 1). Geona Creek flows to Finlayson Creek, which in turn is a tributary to the Finlayson River, and ultimately the Frances, Liard and MacKenzie rivers. An initial environmental evaluation of the project by a previous owner indicated that water quality of Geona and Finlayson creeks would potentially be impacted by mine water discharge, particularly based on concentrations of copper, selenium, zinc, ammonia and nitrite (Cominco 1996). It is expected that this mine water will be treated prior to discharge during the operational period. The evaluation reported herein can contribute to the design criteria for water treatment.

Technical Background

Potential effects associated with selenium in aquatic environments require evaluation that differs from metals such as copper and zinc because chronic effects of selenium occur following incorporation into the food chain, biotransformation to organic forms (seleno-amino acids) and transfer through the food chain (e.g., Janz 2012). Because overall productivity and the

1

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 1

WATER QUALITY MONITORING STATIONS

FEBRUARY 2017

Legend:

▲ Surface Water Quality Stations

━━ Robert Campbell Highway

══ Tote Road/Proposed Access Road

── Proposed Mine Road

── Contour (40m interval)

── Watercourse

■ Waterbody

■ Location of Proposed Mine Infrastructure

■ BMC Minerals (No.1) Ltd. Claims

Map labels: KZ-26, KZ-16, KZ-15, KZ-17, KZ-9 AND SEEP, KZ-7, KZ-2, KZ-13

ROBERT CAMPBELL HIGHWAY, FINLAYSON LAKE, FINLAYSON CREEK, EAST CREEK, GEONA CREEK, FAULT CREEK, SOUTH CREEK, NORTH RIVER, WOLVERINE LAKE

ALEXCO ENVIRONMENTAL GROUP

minnow environmental inc. A Trinity Consultants Company

characteristics of food chains differ substantially among aquatic systems, incorporation of aqueous selenium into the food chain, and transfer through the food chain, is highly site-specific. In general, low productivity systems with simple food chains are less sensitive to selenium than higher productivity systems with longer food chains (Stewart et al. 2010; Orr et al. 2012; USEPA 2015) and lotic (running water) systems (i.e., creeks and rivers) are less sensitive to selenium than lentic (still water) systems (wetlands, ponds and lakes; Adams et al. 2000; Hamilton and Palace 2001; Orr et al. 2006; USEPA 2015). A recent review by the USEPA (2015) indicated that incorporation of selenium into aquatic food chain is approximately 3.8 times lower in lotic environments (median water-to-primary producer enrichment 360-fold) than in lentic environments (median water-to-primary producer enrichment 1,370-fold).

One means of developing a water quality objective (WQO) for selenium is by food chain modelling (e.g., Presser and Luoma 2010), whereby a tissue quality guideline (e.g., a fish egg/ovary tissue guideline; widely considered to be the most accurate estimate of no-effect concentration; e.g., Janz 2012; DeForest et al. 2012) is used to back-calculate a WQO. This can be done by using the tissue quality guideline as a starting point and applying Trophic Transfer Functions (TTFs; the ratio of selenium in a trophic level to selenium in the level immediately below) and Enrichment Functions (EFs; the ratio of selenium in primary producers [the first trophic level] to selenium in water) based on field or laboratory data to calculate the corresponding water value. Essentially, this involves moving backwards through the typical food chain model of selenium accumulation (e.g., moving backwards through Figure 2). Characterizing the EF and TTFs in a model food chain can be onerous. However, by far the greatest step-increase in selenium concentration occurs at the very base of the food chain (i.e., the EF; Stewart et al. 2010; Presser and Luoma 2010; Orr et al. 2012). Subsequent to incorporation at the base of the food chain, where it is bio-transformed to seleno-amino acids, trophic transfer generally results in similar concentrations at increasing trophic levels (i.e., TTFs are near 1; Figure 2). Therefore, by characterizing the EF (accumulation from water to primary producers), the greatest source of site-specific variability can be addressed.

Recent research has shown that sulphate can substantially reduce the incorporation of selenium into an aquatic food chain by competition with selenate, the dominant form of selenium in flowing aquatic systems such as Geona and Finlayson creeks (Williams et al. 1994; Lo et al. 2012). Such competition is consistent with the chemical similarity of selenate and sulphate. Therefore, it would take more selenium to cause uptake and effects the higher the sulphate concentration present. Relationships between selenium uptake and sulphate concentrations in Finlayson Creek water (Station KZ-15; Figure 1) were evaluated using two primary producers – the alga *Pseudokirchneriella subcapitata* and the plant *Lemna minor* (Nautilus 2016). All methodology and results of the uptake testing are provided in that report (Appendix A). This letter report applies the findings of the uptake study to the derivation of a potential SSWQO for selenium in Finlayson Creek.
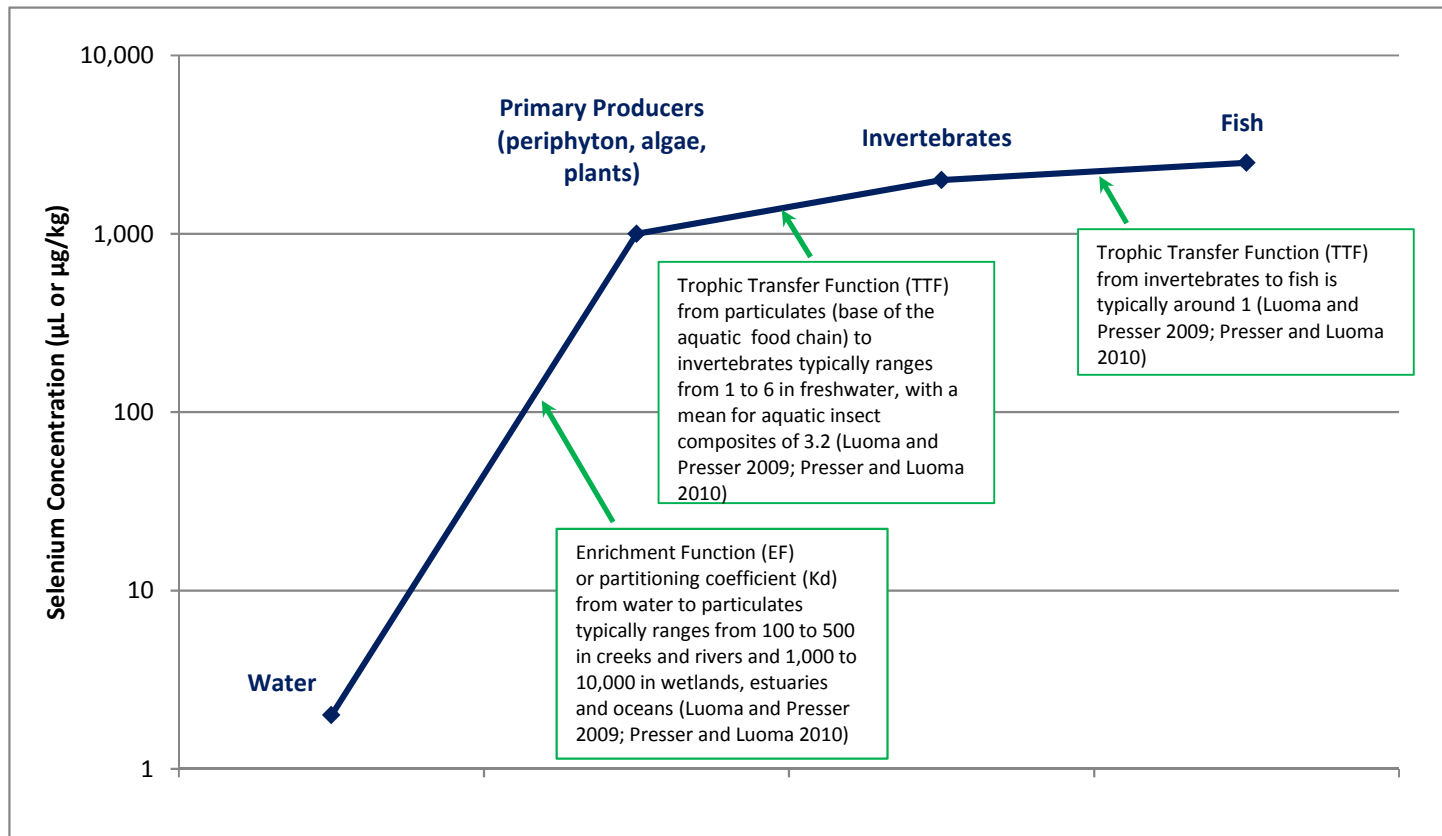
Figure 2: Schematic of selenium incorporation to the aquatic food chain and trophic transfer

SSWQO Derivation

Based on testing conducted in Finlayson Creek and laboratory test waters, Nautilus (2016) reported clear, linear, statistically significant relationships between selenium EFs and sulphate concentrations for *P. subcapitata* at 2 ppb selenium and 10 ppb selenium, and for *L. minor* at 10 ppb selenium (Figure 3). A relationship could not be developed for *L. minor* at 2 ppb selenium as this combination resulted in tissue selenium concentrations below the method detection limit (Nautilus 2016). The site-specific EFs at two different selenium concentrations ranged from 32 (site water amended with 2 µg/L selenium and 250 mg/L sulphate) to 182 (site water amended with 2 µg/L selenium and no additional sulphate). These values are lower than the median water-to-primary producer enrichment function for lotic environments calculated from USEPA (2015) data (360-fold), suggesting low site-specific enrichment. The three relationships appeared to be similar and statistical tests of their slopes using Analysis of Covariance (ANCOVA) indicated that slopes did not differ significantly (Appendix B). Therefore, the data were combined to produce one relationship. The two datasets for *P. subcapitata* were averaged by taking the geometric mean of the EF reported at 2 ppb and 10 ppb selenium, yielding a relationship defined by the equation: Selenium EF = $1{,}791 * \text{Sulphate}^{-0.597}$ (Figure 4).

The relationship defining the reduction in EF with increasing sulphate concentration can be used to derive a SSWQO for selenium that is based on sulphate concentration. At sulphate concentration equivalent to background (approximately 60 mg/L), it is logical to assume that a generic guideline for selenium would apply at the site. Although some discussion of what this guideline should be is required, one option is the generic British Columbia guideline of 2.0 µg/L selenium (BCMOE 2014). An alternative is the USEPA (2015) chronic criterion for lotic systems (running waters) of 4.8 µg/L selenium. The latter is specific to lotic systems, which have inherently lower EFs and are therefore inherently less sensitive to selenium (than lentic systems [ponded waters]), but should not be applied to any areas of ponded habitat. By making the guideline applicable at 60 mg/L sulphate, it can be adjusted for additional sulphate which ameliorates selenium uptake according to the equation defined above (Table 1). Although it may be desirable to simplify the equations, the relationships result in the following SSWQO for selenium if the BCMOE guideline were to be adopted (Figure 5):

> 2.0 µg/L selenium at sulphate ≤ 60 mg/L, and
> $0.1736 * (\text{sulphate})^{0.597}$ µg/L selenium at sulphate > 60 mg/L.

If the USEPA criterion is adopted, the equivalent equations (Figure 5) are:

> 4.8 µg/L selenium at sulphate ≤ 60 mg/L, and
> $0.4166 * (\text{sulphate})^{0.597}$ µg/L selenium at sulphate > 60 mg/L
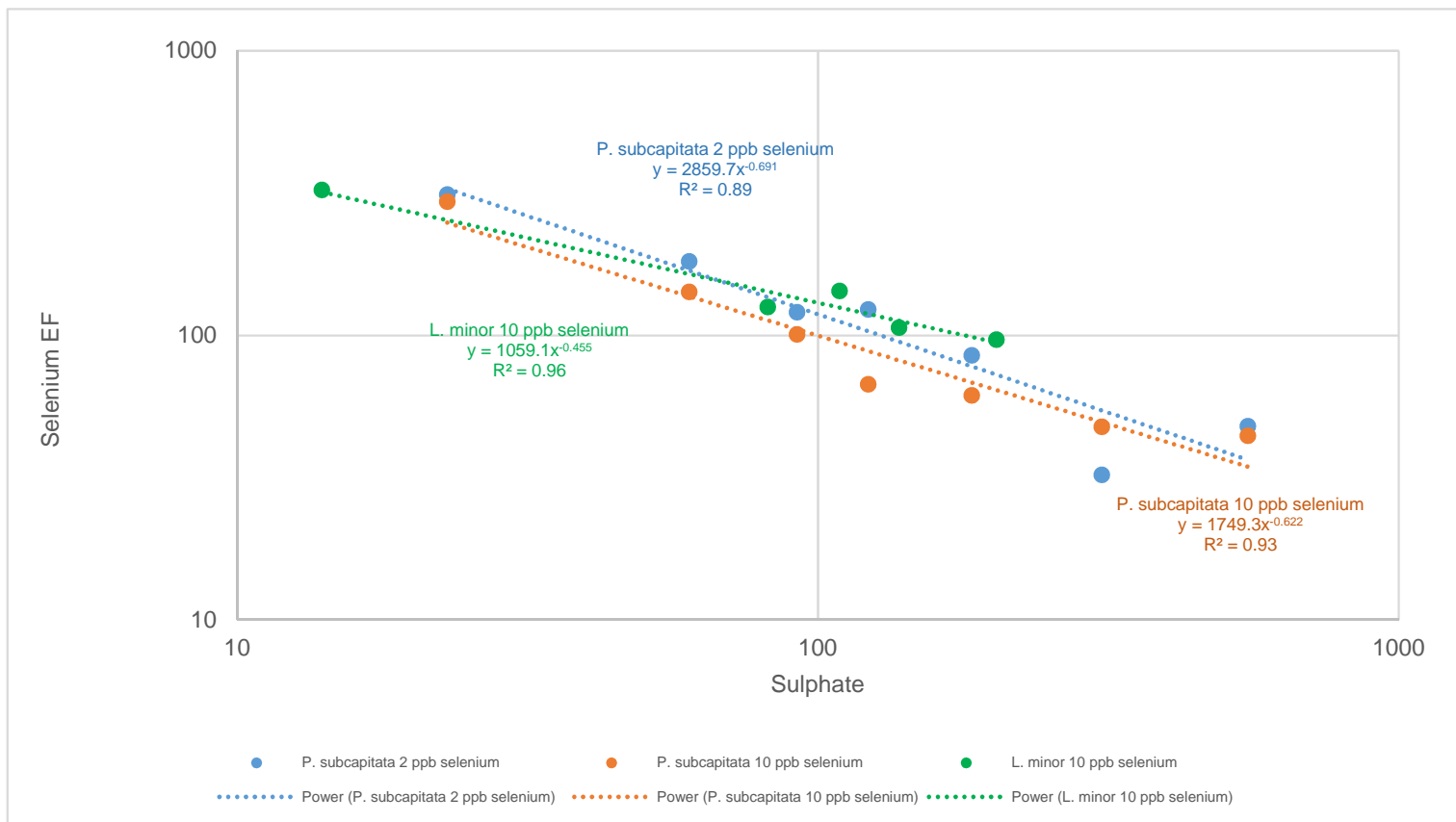
Figure 3: Relationships between selenium enrichment function (EF) and sulphate concentration (Nautilus 2016)

Both Species
$y = 1791.2x^{-0.597}$
$R^2 = 0.91$

● P. subcapitata   ● L. minor   ⋯⋯ Power (Both Species)
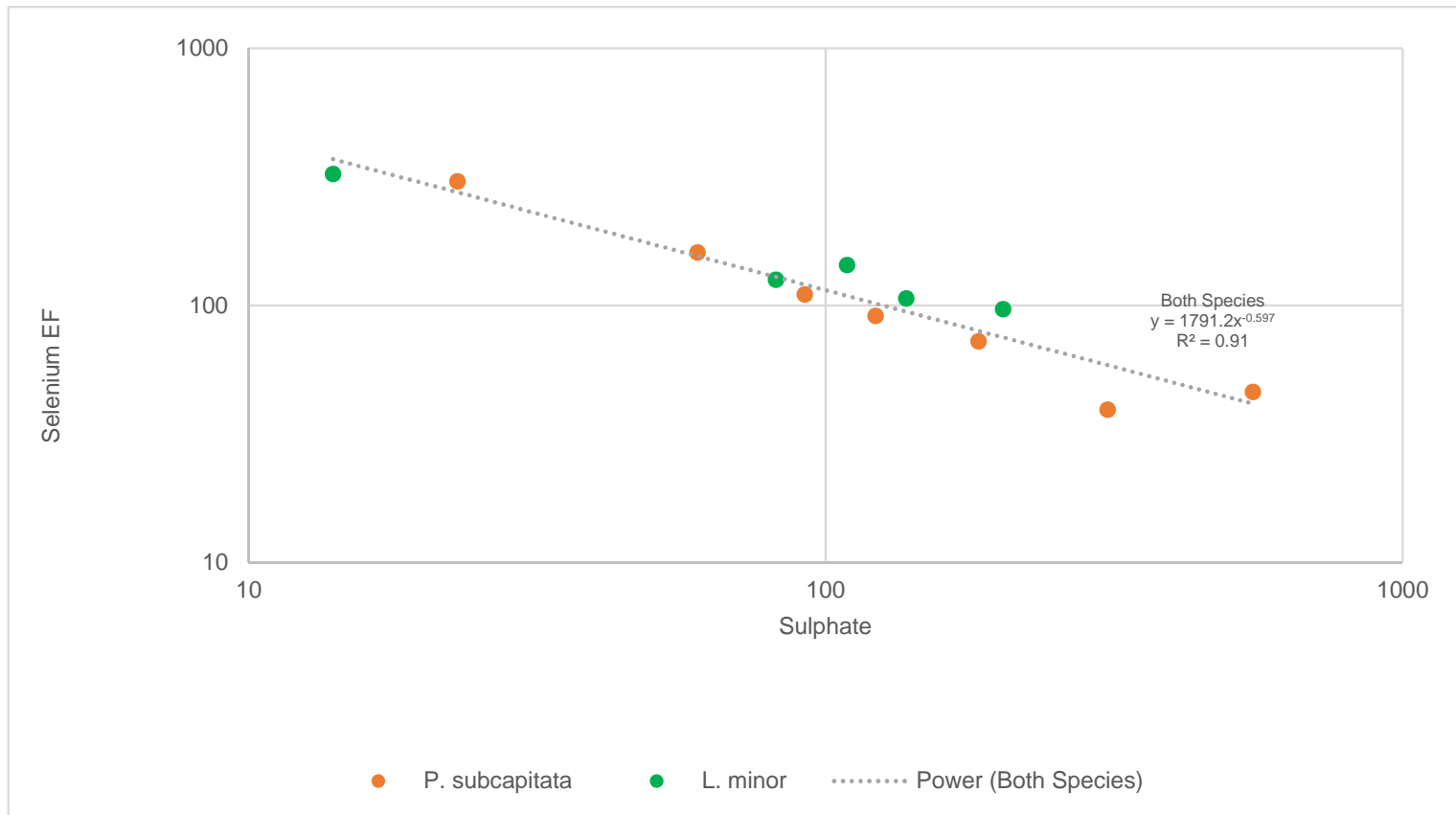
Figure 4: Combined primary producer selenium enrichment function (EF) and sulphate concentration (Nautilus 2016)

Table 1: Calculations of a preliminary SSWQO for selenium based on sulphate amelioration of selenium uptake

A) Adoption of the BCMOE (2014) generic guideline

Sulphate	Enrichment Function (EF)	Selenium Guideline / SSWQO
mg/L	unitless	µg/L
60	155	2.0
100	115	2.7
200	76	4.1
300	59	5.2
400	50	6.2

B) Adoption of the USEPA (2015) criterion for lotic environments (running water)

Sulphate	Enrichment Function (EF)	Selenium Guideline / SSWQO
mg/L	unitless	µg/L
60	155	4.8
100	115	6.5
200	76	9.8
300	59	12.5
400	50	14.9

^{1} selenium concentration under varying sulphate concentations that results in a selenium concentration in primary producers that is the same as at 2.0 ug/L selenium (the generic BCMOE guideline) and 25 mg/L sulphate

^{1} selenium concentration under varying sulphate concentations that results in a selenium concentration in primary producers that is the same as at 4.8 ug/L selenium (the USEPA criterion for running waters) and 25 mg/L sulphate

Figure 5:   Potential equations for a selenium SSWQO at the Kudz Ze Kayah Project.
top) with application of the generic BCMOE guideline as the base case
bottom) with application of the USEPA criterion for running water as the base cas

Summary

Testing of selenium uptake in two aquatic primary producers (the alga *P. subcapitata* and the plant *L. minor*) in water collected from Finlayson Creek and in laboratory water indicated low enrichment functions (EF) and indicated statistically significant, linear reduction in selenium uptake with increasing sulphate concentration. The significant reduction in EF caused by sulphate was used to calculate potential SSWQOs for selenium based on the generic BCMOE guideline and the USEPA criterion for running water. The former is considered to be more generically applicable to Geona and Finlayson creeks (i.e., including ponded habitat), and results in a potential SSWQO for 2.0 µg/L at 60 mg/L sulphate, 2.7 µg/L at 100 mg/L sulphate, 4.1 µg/L at 200 mg/L sulphate, etc., as defined by the equation: selenium SSWQO = $0.1736*(\text{sulphate})^{0.597}$ µg/L.

I trust that this brief letter report meets your requirements and expectations. If you have any questions or would like to discuss any aspect of this report, please do not hesitate to let me know.

Sincerely,
Minnow Environmental Inc.

Pierre Stecko, M.Sc., EP, RPBio
Aquatic Scientist & Principal

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APPENDIX A

**EVALUATION OF SELENIUM UPTAKE IN WATER
FROM THE KUDZ ZE KAYAH MINE PROJECT
BY PRIMARY PRODUCERS**

NAUTILUS (2016)

Evaluation of selenium uptake in water from the Kudz Ze Kayah mine project by primary producers

Final Report

Report date:

January 14, 2016

Submitted to:

Minnow Environmental

Victoria, BC

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SIGNATURE PAGE

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Senior Reviewer

This report has been prepared based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

1.0   INTRODUCTION

It is widely recognized that environmental risk associated with selenium is primarily linked to accumulation of organic selenium (as seleno-amino acids) through the food-chain (Young et al., 2010). Consequently, selenium water quality guideline development efforts have increasingly focused on tissue burdens of selenium, rather than measures in other environmental compartments such as water or sediment. For example, both the BC Ministry of Environment (BCMoE) and the U.S. Environmental Protection Agency (USEPA) have issued draft or finalized water quality benchmarks in which the importance of tissue burdens of selenium was emphasized.

Accumulation of selenium into the food-web is primarily modified at the primary producer level, where the bio-concentration of inorganic selenium from water into tissue commonly comprises two or three orders of magnitude, and varies considerably between sites. The bio-concentration factor (often referred to as an Enrichment Function [EF] or the K_d) is calculated by dividing the selenium concentration in biological tissues associated with the base of the food-web (e.g., primary producers such as plants, algae and periphyton) by the concentration in water. Once selenium is incorporated into the base of the food-chain, where it is transformed into seleno-amino acids, transfer between trophic levels in freshwater environments results in selenium concentrations that are generally similar between trophic levels. Consequently, variations in the uptake rate at the base of the food-chain (i.e., from water into primary producers) dominates the potential for differences in accumulation rates between sites (Presser and Luoma, 2010).

The Kudz Ze Kayah project is located in the Yukon, and is planned to be a base metal mine. Water quality predictions for the site have indicated that selenium may exceed the CCME and BC water quality guidelines of 1 and 2 µg/L, respectively, for the water column. Consequently, there is an interest in understanding whether increased selenium concentrations would be expected to result in accumulation of selenium in the food-web to concentrations that might pose an environmental risk. Sulphate is also expected to increase concurrently with selenium, and this constituent modifies uptake of selenium, when present as selenate (Williams et al, 1994; Lo et al., 2012), which is the expected form of selenium at the site. Consequently, this study was performed to evaluate uptake of selenium across a range of concentrations of sulphate.

The exposures described in this report provide an evaluation of the estimated site-specific uptake rate of selenium into an alga and a vascular plant under conditions that are anticipated

Nautilus Environmental   1

to occur at the site. The accumulation rate of selenium was assessed in water collected from the site, and in this water after adding different concentrations of major ions associated with future predicted conditions (in particular, calcium, magnesium and sulphate).

The exposure duration used in these tests was relatively short (i.e., 7 days); however, as a result of encompassing exponential growth phase for the algae, the cell density increased by over 3000-fold during the exposure. Because of the nature of the exposure, it is not possible to measure the cells for reaching "steady-state", since they are continually dividing. Similarly, for duckweed, the fronds multiplied by more than a factor of five relative to the start of the tests. Thus, the vast majority of cells or fronds in the test containers at the end of the exposure were produced using the ionic nutrients (including selenium) that were present in the test solutions. Thus, it is reasonable to assume that the cells are in equilibrium with the surrounding media, including the selenium concentration. Regardless, this test method provides a measure of relative uptake of selenium under differing water quality conditions.

2.0   METHODS

The site water was collected from Finlayson Creek at a water quality monitoring station referred to as KZ-15 (Finlayson Creek downstream of Geona Creek). The sample was transported by courier and was received in good condition.

The methods used here are based on methodology developed by Lo et al. (2012) for evaluation of the effect of water quality characteristics on uptake of selenium. The selenium-spiked waters were evaluated for uptake using 7-day exposures using a green alga (*Pseudokirchneriella subcapitata*) and duckweed (*Lemna minor*). The test waters were supplemented with nutrients required for growth of these species, and the exposures conducted in a constant environment room with lighting and temperature regimes which are suitable for culturing these species (Environment Canada 2007a; 2007b). In the case of *P. subcapitata*, nutrients were added at four-fold over the usual culture water in order to achieve sufficient cell growth for subsequent analysis of selenium in the cells. The test exposures were not replicated.

Selenium uptake was evaluated under current conditions and under conditions of elevated ionic strength that are predicted to occur in the environment. Selenium was introduced using sodium selenate, since selenate is expected to be the predominant form of selenium in lotic systems such as this (BC MoE 2014).

Uptake of selenium into algal cells and duckweed was measured in three water types:

1) A sample from the site was tested to evaluate selenium uptake under current conditions. This sample was amended with 0, 1, 2 and 10 µg/L Se.

2) An amended site water was created by supplementing the water with calcium and magnesium sulphates at a ratio of 6:1 Ca:Mg (on a mass basis) to achieve 500 mg/L sulphate in the water (note that the actual sulphate in this water was higher than 500 mg/L as a result of sulphate in the unamended site water, as well as sulphate present in the nutrients that were added). This water was diluted with unamended site water using a 0.5-times dilution series to achieve nominal concentrations of 31.2, 62.5, 125, 250, and 500 mg/L of supplemented SO_4. These dilutions were then each spiked with 2 and 10 µg/L Se.

3) A laboratory-prepared water was evaluated after supplementing with a range of selenium concentrations in order to benchmark the results against prior uptake studies conducted in the laboratory. This laboratory water was amended with 0, 1, 2 and 10 µg/L Se.

At the end of the exposures, the tissues were rinsed with selenium-free water. For *P. subcapitata*, algal cells were rinsed in deionized water with 15 mg/L sodium bicarbonate to reduce osmotic stress on the cells. The rinsing and centrifugation process was repeated three times. Following the final rinse and decanting of overlaying water, the algal pellet was frozen at -20°C. For *L. minor*, macrophytes were rinsed in deionized water, dabbed dry using Kim-wipes and frozen at -20°C. The concentration of selenium in the tissues was measured by the Analytical Chemistry Group at the University of Missouri after freeze-drying the samples. Concentrations of sulphate and selenium in the exposure waters were measured at test initiation by CARO Analytical (Edmonton, AB) using ion chromatography.

3.0   RESULTS

Pseudokirchneriella subcapitata
Measured selenium and sulphate concentrations in the exposure waters, selenium concentrations in the algal cells and calculated EF values are summarized in Table 1. The average EF values measured in laboratory water and site water were 339 and 185, respectively. The average EF values measured in sulphate-amended site waters ranged from 39 to 110. Uptake in site water was approximately 45% lower relative to laboratory water, while uptake in sulphate-amended site waters ranged from 68 to 88% lower relative to laboratory water.

Results of uptake tests using *P. subcapitata* in lab water and samples collected from the site supplemented with major ions are shown in Figure 1. Selenium uptake into algal cells increased in a very consistent manner with increasing waterborne selenium. Linear regression analyses found that waterborne selenium had a significant effect on tissue selenium concentrations ($p < 0.05$). The relationship between tissue selenium and selenium in water was best explained by a power function, which is linear on a log x-axis, log y-axis scale.

Amending the site water with sulphate resulted in a decrease in uptake of selenium relative to un-amended site water (Figure 1), demonstrating that the higher ionic strength reduced the selenium bioaccumulation. The EF values decreased with increasing sulphate concentration, as shown in Figure 2. With one exception, the EF values also decreased with increasing selenium at each sulphate concentration.

Lemna minor
Measured selenium and sulphate concentrations in the exposure waters, selenium concentrations in *L. minor* tissue, and EF values are summarized in Table 2. The quantity of tissue that was produced in the test (approximately 0.1 to 0.2 g) was not sufficient to result in detectable concentrations of selenium in a number of the samples, indicating that the concentrations of selenium were close to the detection limit in the tissues as a result of the small sample volumes. Regardless, the data for exposure to 10 µg/L Se produced detectable selenium in four of the five site water exposures, as well as in the laboratory water; the EF values for these exposures decreased with increasing sulphate, as shown in Figure 3.

Table 1. Measured tissue concentrations of selenium in *Pseudokirchneriella subcapitata*, exposed to different levels of selenium and sulphate.

Water type	Water Se (µg/L)		Sulphate	Tissue Se	Enrichment function
	Added	Measured	(mg/L)	(mg/kg dw)	
Lab	0	<0.5	23	ND	NC
	1	1.1	23	0.464	421.6
	2	2.1	23	0.656	312.4
	10	10.2	23	3.010	295.1
Site	0	0.6	60	0.143	237.6
	1	1.8	60	0.346	192.4
	2	2.6	60	0.472	181.6
	10	10.4	60	1.476	141.9
Site amended with 31.2 mg/L SO$_4$	2	2.7	92	0.326	120.6
	10	10.2	92	1.026	100.6
Site amended with 62.5 mg/L SO$_4$	2	2.7	122	0.333	123.2
	10	12.3	122	0.826	67.2
Site amended with 125 mg/L SO$_4$	2	2.7	184	0.230	85.1
	10	10.5	184	0.646	61.5
Site amended with 250 mg/L SO$_4$	2	2.6	308	0.084	32.3
	10	10.5	308	0.501	47.7
Site amended with 500 mg/L SO$_4$	2	2.8	550	0.134	47.9
	10	10.6	550	0.470	44.3

ND = Not Detected, NC = Not Calculable

Figure 1. Uptake of selenium into *Pseudokirchneriella subcapitata* in amended site water compared with laboratory water.
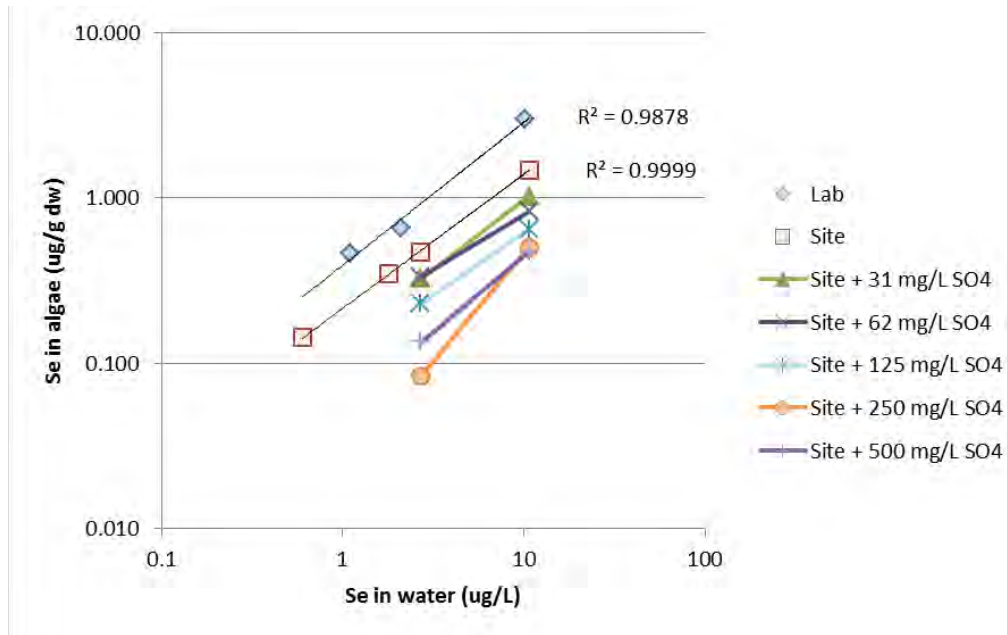
Figure 2. *Pseudokirchneriella subcapitata* enrichment function compared to sulphate concentration in site water amended with magnesium and calcium sulphate. The equation presented is based on the geometric mean data for each sulphate concentration.
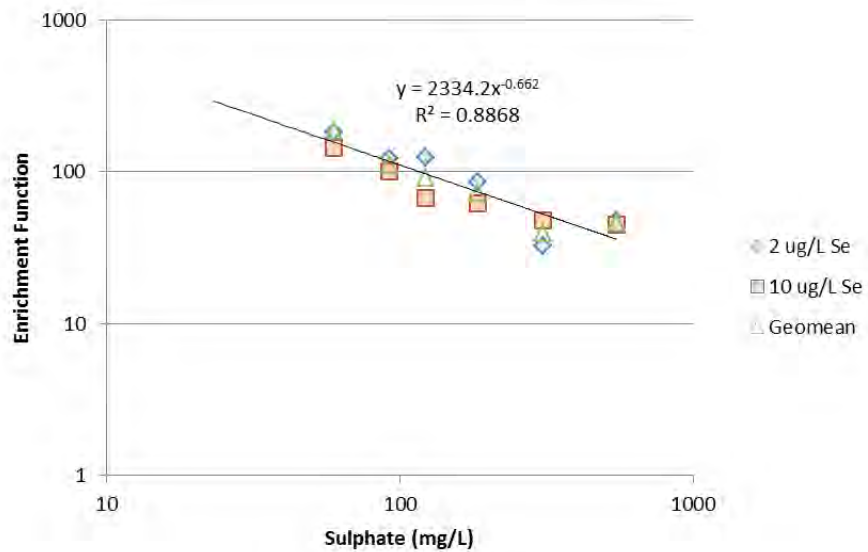
Table 2. Measured tissue concentrations of selenium in *Lemna minor* exposed to different levels of selenium and sulphate.

Water type	Water Se (µg/L)		Sulphate	Tissue Se	Enrichment function
	Added	Measured	(mg/L)	(mg/kg dw)	
Lab	0	<0.5	14	0.645	NC
	1	1.1	14	0.472	429.4
	2	2	14	ND	NC
	10	6.8	14	2.207	324.5
Site	0	0.7	82	ND	NC
	1	1.7	82	0.387	227.8
	2	2.6	82	0.188	72.3
	10	10.9	82	1.369	125.6
Site amended with	2	2.6	109	0.404	155.3
31.2 mg/L SO$_4$	10	10.4	109	1.491	143.3
Site amended with	2	2.6	138	ND	NC
62.5 mg/L SO$_4$	10	9.6	138	1.022	106.5
Site amended with	2	2.6	203	ND	NC
125 mg/L SO$_4$	10	9.6	203	0.927	96.6
Site amended with	2	2.7	324	0.357	132.1
250 mg/L SO$_4$	10	10.1	324	ND	NC

ND = Not Detected, NC = Not Calculable

Figure 3. *Lemna minor* enrichment function compared to sulphate concentration in laboratory water and site water amended with magnesium and calcium sulphate. The equation presented is based on data for 10 µg/L Se exposure at each sulphate concentration, including both laboratory and site waters.
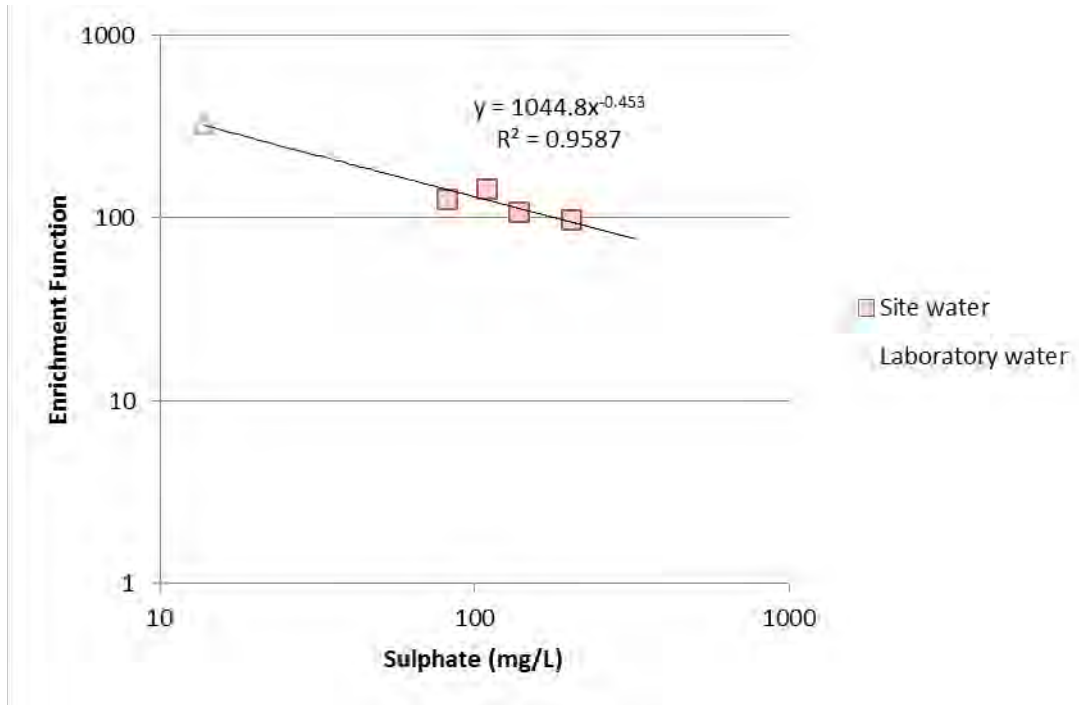
4.0   DISCUSSION

The results for amended site water shown in Figure 2 for *P. subcapitata* and Figure 3 for *L. minor* indicated that higher ionic strength associated with predicted future conditions would be expected to reduce the bioaccumulation rate of selenium relative to current conditions, likely as a result of interaction between sulphate and selenate, since sulphate has been shown to reduce uptake of selenate into primary producers (Lo et al. 2012; Williams et al. 1994). The slopes of these relationships were -0.662 and -0.453, respectively. The data for *L. minor* were confounded by proximity to the detection limit, and may be less accurate than the results presented for *P. subcapitata*.

It should be noted that the actual site-related EF values may differ from the EF values reported here as a result of differing assemblages of species, seasonal fluctuations etc., and there are limitations to the accuracy of the predictions made here for this factor. However, the tissue selenium concentrations would be expected to change in a manner that is similar to that described here, assuming that sulphate exhibits a consistent relationship among species, which appears to be the case (Lo et al. 2015). Presence of selenite or significant depositional areas, where anoxic sediment may occur, in the system would cause a deviation from that described here, since sulphate does not compete with selenite for uptake sites. However, since the receiving environment is a fast-flowing system, these conditions would not be expected.

5.0 REFERENCES

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APPENDIX A – Chemistry

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Selenium Analysis
by Instrumental Neutron Activation Analysis

TO: Bryon Shore / James Elphick
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                4 – 6125 12 Street SE
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RE: Measurement of Selenium in Algae and Lemna
                Project #PJ15-005
                MURR Project No. 2205 Set 27

DATE: November 10, 2015

We have completed the analyses of the samples received under the above referenced project. Sixty (60) algae and lemna samples were received frozen and deemed viable for accurate determinations of total selenium concentration.

An aliquot of the freeze dried, homogenized samples were taken and analyzed for selenium. The whole sample wet and dry matter content was determined for each sample.

ANALYSIS NOTES:

1.   The samples were held in a freezer upon receipt until analysis.

2.   Samples were allowed to thaw at room temperature and then weighed as received to obtain a wet mass, re-frozen, and then freeze-dried.

3.   Following freeze-drying, dry masses were obtained for all samples. A wet-to-dry ratio was obtained for each sample.

4.   A homogenized aliquot of each sample was weighed into a pre-cleaned high-density polyethylene vial and irradiated in a thermal-neutron flux to induce Se-77m, a radioactive excited state of Se-77. This excited state decays by isomeric transition;

emitting a gamma-ray having an energy of 162 keV, which is quantitatively measured by high-resolution gamma-ray spectroscopy.

5. Sample aliquot wet masses were calculated by multiplying the sample aliquot dry mass by the wet-to-dry ratio. "Wet mass Se PPMs" were derived from this calculated aliquot wet mass.

6. Selenium concentrations were determined by standard comparison using certified single-element selenium standards traceable to the U.S. National Institutes of Standards and Technology (NIST).

7. Replicate samples of NIST Standard Reference Material 1577 Bovine Liver, having a certified selenium concentration of 1.1 +/- 0.1 PPM were analyzed with the samples. The average Se concentration of these three QC samples was determined to be 1.169 ± 0.147 PPM.

8. The abbreviation "ND" in the concentration columns indicates that the presence of a measurable Se peak was Not Detected during analysis.

9. Table Descriptions:
    a. Table 1
        i. Columns 1 & 2 list the MURR IDs and client IDs, respectively.
        ii. Column 3 lists the matrix as described by the client.
        iii. Column 4 lists the calculated wet mass in grams of the sample aliquot.
        iv. Column 5 lists the dry mass in grams of the lyophilized sample aliquot.
        v. Column 6 lists the wet-to-dry ratio as determined from sample aliquot wet and dry mass measurements.
        vi. Column 7 lists the % dry matter, which is the inverse of the wet-to-dry ratio expressed as a percent.
        vii. Column 8a lists the selenium concentration in parts per million (PPM) on a dry mass basis. *[Note: PPM is equivalent to micrograms Se per gram of sample (µg/g)].*
        viii. Column 8b lists the selenium concentration in parts per million (PPM) on a wet mass basis. These data should be used with caution because the as-received samples had variation in their moisture content.

    b. Table 2
        This table reports the mean and standard deviation for the selenium concentrations measured in the replicate quality control samples (NIST SRM 1577 Bovine Liver). The measured value of 1.169 +/- 0.147 PPM Se is in good agreement with the certified value of 1.1 +/- 0.1 PPM Se.

Table 1. Selenium concentration (PPM) and Dry Matter Content in Biological Samples.

1	2	3	4	5	6	7	8a	8b
MURR ID	Client ID	Matrix	Wet Mass (g)	Aliquot Dry Mass (g)	Wet-to-Dry Ratio	% Dry Matter	Se PPM Dry Mass	Se PPM Wet Mass
2205-27-1	15-1220 AG CTL 0	ALGAE	1.11301	0.06146	18.11	5.5	ND	ND
2205-27-2	15-1220 AG CTL 1	ALGAE	0.95264	0.04109	23.18	4.3	0.464	0.020
2205-27-3	15-1220 AG CTL 2	ALGAE	0.71832	0.03309	21.71	4.6	0.656	0.030
2205-27-4	15-1220 AG CTL 10	ALGAE	1.08553	0.06322	17.17	5.8	3.010	0.175
2205-27-5	15-1220 AG 0-0	ALGAE	0.95943	0.05934	16.17	6.2	0.143	0.009
2205-27-6	15-1220 AG 0-1	ALGAE	0.78450	0.04312	18.19	5.5	0.346	0.019
2205-27-7	15-1220 AG 0-2	ALGAE	0.67404	0.03784	17.81	5.6	0.472	0.027
2205-27-8	15-1220 AG 0-10	ALGAE	1.00164	0.05954	16.82	5.9	1.476	0.088
2205-27-9	15-1220 AG 31-2	ALGAE	1.09158	0.06448	16.93	5.9	0.326	0.019
2205-27-10	15-1220 AG 31-10	ALGAE	0.89530	0.05280	16.96	5.9	1.026	0.061
2205-27-11	15-1220 AG 62-2	ALGAE	0.91438	0.06675	13.70	7.3	0.333	0.024
2205-27-12	15-1220 AG 62-10	ALGAE	0.85870	0.06340	13.54	7.4	0.826	0.061
2205-27-13	15-1220 AG 125-2	ALGAE	1.14519	0.07077	16.18	6.2	0.230	0.014
2205-27-14	15-1220 AG 125-10	ALGAE	0.94029	0.07316	12.85	7.8	0.646	0.050
2205-27-15	15-1220 AG 250-2	ALGAE	0.96589	0.09075	10.64	9.4	0.084	0.008
2205-27-16	15-1220 AG 250-10	ALGAE	1.04469	0.06894	15.15	6.6	0.501	0.033
2205-27-17	15-1220 AG 500-2	ALGAE	0.93888	0.09537	9.84	10.2	0.134	0.014
2205-27-18	15-1220 AG 500-10	ALGAE	0.59991	0.06407	9.36	10.7	0.470	0.050
2205-27-19	15-1220 LM CTL 0	LEMNA	0.10108	0.00768	13.16	7.6	0.645	0.049
2205-27-20	15-1220 LM CTL 1	LEMNA	0.21777	0.01409	15.46	6.5	0.472	0.031
2205-27-21	15-1220 LM CTL 2	LEMNA	0.22119	0.01509	14.66	6.8	ND	ND
2205-27-22	15-1220 LM CTL 10	LEMNA	0.16374	0.01245	13.15	7.6	2.207	0.168
2205-27-23	15-1220 LM 0-0	LEMNA	0.16357	0.01243	13.16	7.6	ND	ND
2205-27-24	15-1220 LM 0-1	LEMNA	0.13014	0.01129	11.53	8.7	0.387	0.034
2205-27-25	15-1220 LM 0-2	LEMNA	0.14303	0.01256	11.39	8.8	0.188	0.017
2205-27-26	15-1220 LM 0-10	LEMNA	0.14178	0.01365	10.39	9.6	1.369	0.132
2205-27-27	15-1220 LM 31-2	LEMNA	0.10968	0.01000	10.97	9.1	0.404	0.037
2205-27-28	15-1220 LM 31-10	LEMNA	0.17682	0.01438	12.30	8.1	1.491	0.121
2205-27-29	15-1220 LM 62-2	LEMNA	0.13596	0.01242	10.95	9.1	ND	ND
2205-27-30	15-1220 LM 62-10	LEMNA	0.12761	0.01319	9.67	10.3	1.022	0.106
2205-27-31	15-1220 LM 125-2	LEMNA	0.13210	0.01357	9.73	10.3	ND	ND
2205-27-32	15-1220 LM 125-10	LEMNA	0.06147	0.00676	9.09	11.0	0.927	0.102
2205-27-33	15-1220 LM 250-2	LEMNA	0.08846	0.01074	8.24	12.1	0.357	0.043
2205-27-34	15-1220 LM 250-10	LEMNA	0.10834	0.01145	9.46	10.6	ND	ND
2205-27-35	15-1220 LM 500-2	LEMNA	0.11712	0.01331	8.80	11.4	ND	ND
2205-27-36	15-1220 LM 500-10	LEMNA	0.10406	0.01214	8.57	11.7	ND	ND

Table 2. Selenium concentration measured in quality control samples (NIST SRM 1577 Bovine Liver)

QC ID	n	mean Se conc. (PPM)	s.d.	NIST cert. Se conc. PPM (s.d.)
NIST SRM 1577	3	1.69	0.147	1.1 +/- (0.1)

APPENDIX B

**STATISTICAL COMPARISON OF THE SLOPES
OF SELENIUM ENRICHMENT FUNCTIONS
BY ANALYSIS OF COVARIANCE**

Appendix Table B.1: Statistical comparison of the slopes of the selenium Enrichment Function versus sulphate concentration relationship for: 1) *Pseudokirchneriella subcapitata* **at 2 µg/L selenium; 2)** *Pseudokirchneriella subcapitata* **at 10 µ/L selenium; and 3)** *Lemna minor* **at 10 µg/L selenium**

A) Descriptive Statistics

Group	Sample size	Mean	Standard Deviation
P. subcapitata at 2 µg/L selenium	7	129.0	95.2
P. subcapitata at 10 µg/L selenium	7	108.3	89.2
L. minor at 10 µg/L selenium	5	159.3	94.1
ALL	19	129.4	89.8

B) Levene's Test of Equality of Error Variances [1]

Dependent Variable = Selenium EF

F statistic	Degrees of Freedom 1	Degrees of Freedom 2	Signficance	Result
0.1790	2	16	0.8378	non-signicant

[1] Tests the null hypothesis that the error variance of the dependent variable is equal across groups (Intercept+Group+Sulphate+Group * Sulphate)

C) Analysis of Covariance (ANCOVA)

Dependent Variable = Selenium EF

Source	Type III Sum of Squares	Degress of Freedom	Mean Square	F statistic	Significance	Result	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	80853.96339	5	16170.7927	3.2735	0.0394		0.5573	16.3674	0.7220
Intercept	291263.2781	1	291263.2781	58.9610	0.0000		0.8193	58.9610	1.0000
Group	12103.70806	2	6051.8540	1.2251	0.3255		0.1586	2.4502	0.2209
Sulphate	54406.24768	1	54406.2477	11.0136	0.0055		0.4586	11.0136	0.8656
Group * Sulphate	12429.6285	2	6214.8143	1.2581	0.3166	non-significant	0.1622	2.5162	0.2259
Error	64219.12082	13	4939.9324						
Total	463034.79	19							
Corrected Total	145073.0842	18							
a	Computed using alpha = .05								
b	R Squared = .557 (Adjusted R Squared = .387)								

D) Estimated Marginal Means [2]

Dependent Variable: Selenium EF

Group	Mean	Standard Error	95% Confidence Intervals	
			Lower	Upper
P. subcapitata at 2 µg/L selenium	137.2	26.8	79.3	195.0
P. subcapitata at 10 µg/L selenium	114.9	26.8	57.1	172.8
L. minor at 10 µg/L selenium	90.2	43.8	-4.4	184.8

[2] Covariates appearing in the model are evaluated at the following values: Sulphate = 169.68.

APPENDIX B.

Biotic Ligand Modelling of Copper, Lead and Zinc to Evaluate the Potential for Derivation of Site-Specific Water Objectives at the BMC Minerals Kudz Ze Kayah Project (Minnow Environmental Inc.)

January 19, 2016

Mr. Scott Keesey
Senior Environmental Manager
Alexco Environmental Group
#3 Calcite Business Centre
151 Industrial Rd.,
Whitehorse, Yukon
Y1A 2V3

Dear Mr. Keesey,

Re: Biotic Ligand Modelling of Copper, Lead and Zinc to Evaluate the Potential for Derivation of Site-Specific Water Objectives at the BMC Minerals Kudz Ze Kayah Project

Minnow Environmental Inc. (Minnow) is pleased to provide a brief summary of the application of Biotic Ligand Models (BLMs) to evaluate the potential use of the Water-Effect Ratio Procedure (WERP) to derive Site-Specific Water Quality Objectives (SSWQO) for copper, lead and zinc at the BMC Minerals Kudz Ze Kayah Project.

Project Background

The BMC Minerals Kudz Ze Kayah Project is located in Yukon Territory, approximately 110 kilometers southeast of the community of Ross River. The project lies primarily within the Geona Creek watershed (Figure 1). Geona Creek flows to Finlayson Creek, which in turn is a tributary to the Finlayson River, and ultimately the Frances, Liard and MacKenzie rivers. An initial environmental evaluation of the project by a previous owner indicated that water quality of Geona and Finlayson creeks would potentially be impacted by mine water discharge, particularly based on concentrations of copper, selenium, zinc, ammonia and nitrite (Cominco 1996). It is expected that this mine water will be treated prior to discharge during the operational period. The evaluation reported herein can contribute to the design criteria for water treatment.

Technical Background

Briefly, the WERP is one of several procedures that can be used to develop SSWQOs according to protocols established by the Canadian Council of Ministers of the Environment (CCME 2003). The WERP can be a suitable means of SSWQO derivation in situations where site water

KUDZ ZE KAYAH PROJECT

FIGURE 1

WATER QUALITY
MONITORING STATIONS

FEBRUARY 2017

Legend:
- ▲ Surface Water Quality Stations
- ▬ Robert Campbell Highway
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Contour (40m interval)
- Watercourse
- Waterbody
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Claims

ALEXCO ENVIRONMENTAL GROUP

minnow environmental inc.
A Trinity Consultants Company

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(Last edited by: amatiashevska; 02/02/2017/13.57 PM)

Map labels: ROBERT CAMPBELL HIGHWAY, FINLAYSON LAKE, KZ-26, FINLAYSON CREEK, EAST CREEK, KZ-16, KZ-15, KZ-17, GEONA CREEK, KZ-9 AND SEEP, FINLAYSON CREEK, KZ-7, KZ-2, FAULT CREEK, SOUTH CREEK, KZ-13, NORTH, RIVER, WOLVERINE LAKE

characteristics enhance or ameliorate toxicity such that toxicity testing demonstrates a different response in the test organisms exposed to site water relative to test water used to formulate the generic guideline. The WER is calculated as the ratio of the effect concentration of a given analyte in site water relative to the effect concentration in reconstituted laboratory water. The WER can then be applied to the generic water quality guideline (by multiplying the guideline by the WER) to develop a SSWQO (CCME 2003).

In order to implement the WERP, site water sampled at various times throughout the year (to capture the range of observed water chemistry) must be tested for toxicity using multiple test organisms, along with laboratory water that is matched for hardness and alkalinity with the site water. This testing may include water from more than one site, and can be an expensive undertaking especially when multiple contaminants are being assessed. In order to avoid wasting resources on cases where a meaningful WER is not likely, Biotic Ligand Modelling (BLM) can be used to examine whether application of the WERP is warranted (i.e., to determine whether a meaningful WER would be expected). Biotic Ligand Models account for key water quality characteristics that influence the bioavailability and toxicity of metals (e.g., DiToro et al. 2001; Niyogi and Wood 2004; De Schamphelaere and Janssen 2004; USEPA 2007; Peters et al. 2011; Erickson 2013). The models treat organisms as "biotic ligands" that are in competition for metal binding (and uptake) with other ligands (such as dissolved organic matter), and also account for competition between metals and major ions for both abiotic and biotic ligands. BLMs can predict the fraction of free bioavailable metal in a given water as well as no-effect and/or effect concentrations. These predicted no-effect or effect concentrations can then be used to calculate estimated WERs by dividing the site water no-effect or effect concentration by the equivalent laboratory water result.

Approach

Based on an assessment of baseline water quality data from the Kudz Ze Kayah Project (e.g. Cominco 1996), it is anticipated that SSWQOs may need to be developed for several metals and metalloids including copper, lead and zinc. Three water quality monitoring stations in the Kudz Ze Kayah Project receiving environment were identified for evaluation of the potential utility of the WERP: KZ-17 (the mouth of Geona Creek), KZ-15 (Finlayson Creek downstream of Geona Creek), and KZ-26 (Finlayson Creek near the mouth), with station KZ-26 being furthest downstream of the Kudz Ze Kayah Project site (Figure 1). The objective of this report is to use BLMs to predict WERs for each metal, and based on the predicted WERs, to evaluate whether proceeding with the WERP to derive SSWQOs is advisable.

Methods

Three BLMs were applied in this assessment: 1) the Windward BLM (USEPA 2007; Windward 2015); 2) the Bio-Met bioavailability tool (ECHA 2008; Bio-Met 2013); and 3) the PNEC.pro BLM (Verschoor et al. 2012; Deltares 2013). Each model requires different inputs with varying validated input ranges as outlined in Table 1, and provide differing outputs as discussed below.

The Windward BLM has been adopted by the USEPA (2007) and provides Ambient Water Quality Criteria, both acute and chronic, that define copper concentrations below which adverse effects would not be expected under the specific water quality that co-occurs with the copper. The model produces a Final Acute Value (FAV) - a concentration of copper that is an estimate of the 5th percentile of a Species Sensitivity Distribution (SSD) represented by average LC50s and EC50s (lethal concentration and effect concentration to 50% of the population, respectively) of the tested genera. The FAV is then used to calculate a Criterion Maximum Concentration (CMC; acute water quality criterion) by dividing the FAV by 2 and a Criterion Continuous Concentration (CCC; chronic water quality criterion) by dividing the FAV by an Acute-Chronic Ratio (ACR). For lead, the Windward BLM software tool uses an acute toxicity endpoint (LA50) to predict effect concentrations for the test organisms rainbow trout, fathead minnow, *Daphnia magna*, and *Ceriodaphnia dubia*. The LA50 represents the lethal accumulation of a metal on a biologically sensitive receptor (biotic ligand) that results in 50% mortality during an acute exposure, and the associated total dissolved concentration of the metal that will result in 50% mortality of the exposed population (LC50) is calculated. For zinc, the Windward BLM output includes both acute and chronic HC5 values. The HC5 is a 5th percentile Hazard Concentration which is calculated from a Species Sensitivity Distribution (SSD) constructed from BLM-normalized data. The Windward BLM incorporates earlier equilibrium models, CHESS (chemical equilibrium of soils and solutions) and WHAM (Windermere Humic Aqueous Model) which include modelling of chemical and electrostatic interactions of organic molecules.

PNEC.pro is a simplified chronic BLM with dissolved organic carbon (DOC) being the only required input, and pH, calcium, magnesium and sodium designated as optional input parameters which help increase the accuracy of the prediction (Verschoor et al. 2012). The PNEC.pro software uses linear equations to simplify biotic ligand modelling for the user, and calculates Predicted No Effect Concentrations (PNECs; 5th percentile Hazard Concentrations) for both copper and zinc by assuming that binding to the biotic ligand has a proportional relationship with metal toxicological effects (Verschoor et al. 2012). These linear equations are based on a large toxicological dataset and a wide variety of water chemistry conditions, and are validated against full biotic ligand models.

Similar to the PNEC.pro BLM, the Bio-Met bioavailability tool is a chronic BLM that is a simplification of a "full" chronic BLM developed by the European Chemicals Agency (ECHA 2008).

Table 1: Biotic Ligand Model input data requirements, and validated upper and lower bounds for specified analytes.

Biotic Ligand Model		Analyte	Requirement	Unit	Lower Bound	Upper Bound
Windward		Dissolved Organic Carbon	Required	mg/L	0.05	29.7
		Humic Acid	Required	%	10	60
		pH	Required	pH	4.9	9.2
		Calcium	Required	mg/L	0.204	120
		Magnesium	Required	mg/L	0.024	51.9
		Sodium	Required	mg/L	0.16	237
		Potassium	Required	mg/L	0.039	156
		Sulphate	Required	mg/L	0.096	278
		Chloride	Required	mg/L	0.32	280
		Alkalinity	Required	as $CaCO_3$ mg/L	1.99	360
		Sulphide	Required	mg/L	0.001	0.006
		Temperature	Required	^{o}C	10	25
PNEC-pro		Dissolved Organic Carbon	Required	mg/L	n/a	n/a
		pH	Optional	pH	5.5	8.8
		Calcium	Optional	mg/L	n/a	n/a
		Magnesium	Optional	mg/L	n/a	n/a
		Sodium	Optional	mg/L	n/a	n/a
Bio-Met	Copper	Dissolved Organic Carbon	Required	mg/L	n/a	n/a
		pH	Required	pH	6.0	8.5
		Calcium	Required	mg/L	3.1	93
	Nickel	Dissolved Organic Carbon	Required	mg/L	n/a	n/a
		pH	Required	pH	6.5	8.7
		Calcium	Required	mg/L	2.0	88
	Zinc	Dissolved Organic Carbon	Required	mg/L	n/a	n/a
		pH	Required	pH	6.0	8.0
		Calcium	Required	mg/L	5.0	160

n/a - not applicable

The Bio-Met tool uses pH, DOC and calcium to calculate "local Environmental Quality Standards" (EQS) for copper and zinc under co-occurring pH and concentrations of DOC and calcium. The EQS is a 5th percentile Hazard Concentration (HC5; similar to a PNEC determined using the PNEC.pro BLM), and is calculated from a SSD according to European Union Water Framework Directive (WFD) methodology (European Communities 2011). The model is based on a database of more than 20,000 simulations of chronic toxicity relationships developed under a variety of water quality conditions, to which the input data are compared, and the EQS is then derived.

The three BLMs (Windward, PNEC.pro and Bio-Met) were used to predict chronic no-effect concentrations for copper and zinc for each sampling event at each of the three water quality monitoring stations (KZ-15, KZ-17, and KZ-26). The Windward BLM is the only model which can be applied to lead, and therefore was used to predict acute effect concentrations for lead (the only prediction currently available in the model) for each sampling event at each site. DOC is required input data for all three BLMs (Table 1). Therefore, only data containing DOC measurements could be used in the BLMs, limiting the useable data to sampling events between April and December 2015 (Table 2). Caution should therefore be applied in deriving conclusions from the limited data. Water quality data were unavailable for humic acid and sulphide, both of which are input parameters for the Windward BLM. A humic acid content of 10% was therefore assumed and the lower bound of the prescribed range for sulphide in the Windward BLM was applied (Table 2; as recommended by Windward [2015]). In addition, all recorded temperature data were equal to or below the lower bound for temperature for which the Windward BLM is validated (10°C; Table 1), therefore all temperatures were adjusted to this lower data limit for the analysis (Table 2).

WERs were calculated for each data point by comparing the site-specific BLM result to the result for USEPA standard reconstituted water (USEPA 2007; Table 2). The USEPA standard reconstituted water is presented for different levels of hardness (USEPA 2007), therefore site water from each sampling event was paired with USEPA standard water of appropriate hardness (Table 3). These pairings were used for WER calculation, with site water BLM predicted no-effect (or effect) concentrations divided by the equivalent USEPA standard reconstituted water no-effect (or effect) concentrations for the appropriate hardness water. A WER of greater than 2 was considered necessary for the WERP to be considered a potentially useful technique for deriving SSWQO.

Results

Copper

The utility of the WERP for copper was evaluated using all three BLMs. However, results of the PNEC.pro BLM were often outside of the validated range of the model (Table 4) and were not used further. WERs calculated from the Bio-Met and the Windward BLM results indicated that

Table 2: Input data for Windward, PNEC.pro, and Bio-Met Biotic Ligand Models for Kudz Ze Kayah site water monitoring stations KZ-15, KZ-17 and KZ-26 [1], and for USEPA laboratory reconstituted water (USEPA 2007).

Station / Sample Name	Station/Sample Description	Sampling Date	Hardness	Dissolved Organic Carbon (DOC)	pH (lab) [2]	Calcium (dissolved)	Magnesium (dissolved)	Sodium (dissolved)	Potassium (dissolved)	Sulphate (dissolved)	Chloride	Alkalinity (total) [2]	Sulphide [3]	Temperature (field) [4]	Humic Acid Content [5]
			mg/L as CaCO3	mg/L	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	°C	%
USEPA	Moderately hard	n/a	80-100	0.50	7.6	14.0	12.0	26.3	2.09	81.5	1.91	65	0.001	10	10
	Hard	n/a	160-180	0.50	7.8	27.9	24.0	52.6	4.19	163	3.81	115	0.001	10	10
	Very hard	n/a	280-320	0.50	8.2	55.8	48.0	105	8.39	326	7.62	235	0.001	10	10
KZ-15	Finlayson Creek downstream of Geona Creek	29-Apr-15	270	0.9	8.4	78.7	17.9	1.58	1.74	35.0	<0.50	224	0.001	10	10
		11-May-15	73	14.9	7.7	22.2	4.3	0.48	2.07	<0.50	0.98	59	0.001	10	10
		22-Jun-15	141	2.3	8.2	46.6	6.1	0.84	1.15	19.5	<0.50	102	0.001	10	10
		28-Jul-15	156	0.9	8.1	48.3	8.7	1.06	1.31	23.1	<0.50	125	0.001	10	10
		22-Aug-15	140	1.4	8.1	43.5	7.6	0.95	1.15	24.4	<0.50	115	0.001	10	10
		9-Sep-15	146	1.7	8.2	46.0	7.4	0.92	1.25	23.9	<0.50	114	0.001	10	10
		11-Sep-15	148	1.8	8.1	46.7	7.5	0.95	1.32	25.3	1.70	112	0.001	10	10
		14-Oct-15	175	1.1	8.2	54.1	9.7	1.00	1.15	29.3	0.55	146	0.001	10	10
		19-Nov-15	212	1.2	8.4	62.9	13.3	1.23	1.37	33.1	<0.50	181	0.001	10	10
		2-Dec-15	224	1.6	8.1	65.1	14.9	1.31	1.35	31.9	0.59	193	0.001	10	10
KZ-17	Mouth of Geona Creek	29-Apr-15	263	1.6	8.3	76.2	17.7	2.54	1.88	32.1	<0.50	214	0.001	10	10
		11-May-15	69	15.6	7.3	20.9	4.1	0.45	2.24	<0.50	1.20	54	0.001	10	10
		22-Jun-15	149	2.9	8.1	46.2	8.2	0.89	1.20	25.8	<0.50	118	0.001	10	10
		28-Jul-15	184	1.8	8.1	55.4	11.0	1.20	1.51	26.7	<0.50	143	0.001	10	10
		22-Aug-15	169	1.7	8.0	51.1	10.0	1.06	1.32	31.2	<0.50	137	0.001	10	10
		9-Sep-15	161	2.2	8.3	50.2	8.8	0.88	1.23	31.4	0.61	136	0.001	10	10
		14-Oct-15	193	1.3	8.3	58.4	11.4	1.01	1.23	31.7	0.60	161	0.001	10	10
		19-Nov-15	212	1.6	8.3	62.2	13.8	1.23	1.40	34.7	0.66	177	0.001	10	10
		2-Dec-15	223	1.9	8.1	65.6	14.5	1.22	1.35	31.6	0.61	187	0.001	10	10
KZ-26	Finlayson Creek near mouth	29-Apr-15	311	1.8	8.4	82.0	25.9	2.31	1.85	47.6	<0.50	252	0.001	10	10
		11-May-15	109	13.9	7.9	28.7	9.1	0.82	1.86	13.3	1.00	86	0.001	10	10
		23-Jun-15	182	5.6	7.9	49.8	13.9	1.30	1.37	27.8	0.97	146	0.001	10	10
		29-Jul-15	222	3.3	8.2	58.9	18.2	1.49	1.41	32.3	0.55	176	0.001	10	10
		22-Aug-15	179	9.1	8.1	47.7	14.5	1.20	0.94	29.9	<0.50	145	0.001	10	10
		8-Sep-15	196	5.6	8.3	52.9	15.6	1.22	1.18	31.1	0.88	158	0.001	10	10
		15-Oct-15	226	4.1	8.3	59.3	18.8	1.47	1.35	36.9	0.73	195	0.001	10	10
		18-Nov-15	268	2.3	8.3	71.4	21.7	1.78	1.63	40.9	<0.50	213	0.001	10	10
		1-Dec-15	263	1.6	8.2	69.1	21.9	1.77	1.48	39.5	0.59	222	0.001	10	10

[1] Only sampling dates from monitoring stations with reported concentrations of DOC are displayed.

[2] pH and alkalinity values displayed for laboratory reconstituted water are the middle of the range reported for these parameters for different USEPA reconstituted water types (USEPA 2007)

[3] Sulphide data were not reported for collected water samples or USEPA laboratory water; therefore lower bound of the prescribed range for sulphide in the Windward BLM (Windward 2015) was used for each sample.

[4] All reported sampling temperatures were at or below the lower bound for temperature within the Windward BLM software. The lower bound (10°C) was therefore used for each sample, including the USEPA labortory water.

[5] Humic Acid Content was not reported for collected water samples or USEPA laboratory water, therefore the lower bound of Humic Acid Content within the Windward BLM software (10%) was used.

n/a = not applicable

Table 3: Input water hardness data for Windward, PNEC.pro, and Bio-Met Biotic Ligand Models for the Kudz Ze Kayah Project water monitoring stations KZ-15, KZ-17 and KZ-26 [1], and for USEPA laboratory reconstituted water (USEPA 2007).

Station / Sample Name	Station/Sample Description	Sampling Date	Measured Hardness	USEPA Hardness Range	Allocated Site-water Hardness [1]
			mg/L as $CaCO_3$	mg/L as $CaCO_3$	
USEPA	Moderately hard	n/a	n/a	80-100	Moderately hard
	Hard	n/a	n/a	160-180	Hard
	Very hard	n/a	n/a	280-320	Very hard
KZ-15	Finlayson Creek downstream of Geona Creek	29-Apr-15	270	n/a	Very hard
		11-May-15	73	n/a	Moderately hard
		22-Jun-15	141	n/a	Hard
		28-Jul-15	156	n/a	Hard
		22-Aug-15	140	n/a	Hard
		9-Sep-15	146	n/a	Hard
		11-Sep-15	148	n/a	Hard
		14-Oct-15	175	n/a	Hard
		19-Nov-15	212	n/a	Hard
		2-Dec-15	224	n/a	Hard
KZ-17	Mouth of Geona Creek	29-Apr-15	263	n/a	Very hard
		11-May-15	69	n/a	Moderately hard
		22-Jun-15	149	n/a	Hard
		28-Jul-15	184	n/a	Hard
		22-Aug-15	169	n/a	Hard
		9-Sep-15	161	n/a	Hard
		14-Oct-15	193	n/a	Hard
		19-Nov-15	212	n/a	Hard
		2-Dec-15	223	n/a	Hard
KZ-26	Finlayson Creek near mouth	29-Apr-15	311	n/a	Very hard
		11-May-15	109	n/a	Moderately hard
		23-Jun-15	182	n/a	Hard
		29-Jul-15	222	n/a	Hard
		22-Aug-15	179	n/a	Hard
		8-Sep-15	196	n/a	Hard
		15-Oct-15	226	n/a	Hard
		18-Nov-15	268	n/a	Very hard
		1-Dec-15	263	n/a	Very hard

[1] The USEPA hardness range for laboratory reconstituted water closest to the measured hardness of each sample was selected.

n/a = not applicable

Table 4: Calculation of the Water Effect Ratio (WER) using Windward, PNEC.pro, and Bio-Met Biotic Ligand Model derived chronic copper no-effect concentrations for sitewater compared to USEPA standard reconstituted water.

Station / Sample Name	Station/Sample Description	Sampling Date	Hardness Value	Hardness Range	Hardness Category	Dissolved Organic Carbon (DOC) mg/L	pH (lab) pH units	Copper (Total) µg/L	Copper (Dissolved) µg/L	CCME (Total) µg/L	USEPA (Dissolved) µg/L	Final Acute Value (FAV), µg/L	CMC (CMC=FAV/2), µg/L	CCC (CCC=FAV/ACR), µg/L	WER	PNEC [3] µg/L	WER	EQS [4] µg/L	WER
USEPA	Moderately hard	n/a	n/a	80-100	Moderately hard	0.50	7.6	n/a	n/a	n/a	1.5	4.9	2.5	1.5	n/a	12.2	n/a	2.5	n/a
	Hard	n/a	n/a	160-180	Hard	0.50	7.8	n/a	n/a	n/a	2.4	7.6	3.8	2.4	n/a	7.7	n/a	1.7	n/a
	Very hard	n/a	n/a	280-320	Very hard	0.50	8.2	n/a	n/a	n/a	4.9	15.7	7.8	4.9	n/a	OD	n/a	1.0	n/a
KZ-15	Finlayson Creek downstream of Geona Creek	29-Apr-15	270	n/a	Very hard	0.85	8.4	0.27	0.22	4.0	6.5	21.0	10.5	6.5	1.3	OD	-	1.0	1.0
		11-May-15	72.9	n/a	Moderately hard	14.9	7.7	3.42	1.75	2.0	41.4	133	66.6	41.4	27.0	49.3	4.0	74.7	30.4
		22-Jun-15	141	n/a	Hard	2.26	8.2	0.53	0.49	3.2	10.8	34.6	17.3	10.8	4.6	5.7	0.7	4.8	2.9
		28-Jul-15	156	n/a	Hard	0.93	8.1	0.43	0.35	3.5	4.4	14.1	7.0	4.4	1.9	2.3	0.3	1.9	1.1
		22-Aug-15	140	n/a	Hard	1.40	8.1	0.72	0.47	3.2	6.1	19.6	9.8	6.1	2.6	4.9	0.6	3.9	2.4
		9-Sep-15	146	n/a	Hard	1.70	8.2	0.44	0.54	3.3	8.1	26.2	13.1	8.1	3.5	4.4	0.6	3.3	2.0
		11-Sep-15	148	n/a	Hard	1.80	8.1	0.42	0.54	3.3	7.9	25.5	12.8	7.9	3.4	5.1	0.7	3.9	2.4
		14-Oct-15	175	n/a	Hard	1.06	8.2	0.42	0.26	3.8	5.7	18.2	9.1	5.7	2.4	0.5	0.1	1.6	1.0
		19-Nov-15	212	n/a	Hard	1.22	8.4	0.33	0.25	4.0	8.1	25.9	13.0	8.1	3.4	OD	-	1.3	0.8
		2-Dec-15	224	n/a	Hard	1.55	8.1	0.28	0.23	4.0	7.7	24.8	12.4	7.7	3.3	0.2	0.02	3.1	1.9
KZ-17	Mouth of Geona Creek	29-Apr-15	263	n/a	Very hard	1.59	8.3	0.27	0.23	4.0	9.9	31.8	15.9	9.9	2.0	OD	-	2.3	2.3
		11-May-15	69.1	n/a	Moderately hard	15.6	7.3	4.67	1.84	2.0	25.8	83.2	41.6	25.8	16.8	54.2	4.4	73.3	29.8
		22-Jun-15	149	n/a	Hard	2.91	8.1	0.64	0.51	3.3	12.6	40.5	20.2	12.6	5.4	8.3	1.1	8.4	5.1
		28-Jul-15	184	n/a	Hard	1.82	8.1	0.49	0.41	4.0	8.4	27.0	13.5	8.4	3.6	3.2	0.4	3.9	2.4
		22-Aug-15	169	n/a	Hard	1.70	8.0	0.52	0.57	3.7	7.5	24.3	12.1	7.5	3.2	4.0	0.5	3.9	2.4
		9-Sep-15	161	n/a	Hard	2.20	8.3	0.66	0.43	3.6	11.4	36.6	18.3	11.4	4.8	4.3	0.6	3.8	2.3
		14-Oct-15	193	n/a	Hard	1.34	8.3	0.45	0.24	4.0	7.5	24.0	12.0	7.5	3.2	OD	-	1.8	1.1
		19-Nov-15	212	n/a	Hard	1.58	8.3	0.43	0.28	4.0	9.0	29.0	14.5	9.0	3.8	OD	-	2.3	1.4
		2-Dec-15	223	n/a	Hard	1.87	8.1	0.33	0.23	4.0	9.2	29.7	14.8	9.2	3.9	0.9	0.1	3.1	1.9
KZ-26	Finlayson Creek near mouth	29-Apr-15	311	n/a	Very hard	1.84	8.4	0.31	0.33	4.0	13.1	42.1	21.0	13.1	2.7	OD	-	1.9	1.9
		11-May-15	109	n/a	Moderately hard	13.9	7.9	1.63	0.99	2.5	49.9	161	80.4	49.9	32.5	43.6	3.6	41.3	16.8
		23-Jun-15	182	n/a	Hard	5.64	7.9	1.62	0.85	4.0	21.8	70.2	35.1	21.8	9.3	16.0	2.1	20.9	12.6
		29-Jul-15	222	n/a	Hard	3.32	8.2	0.68	0.57	4.0	18.1	58.4	29.2	18.1	7.7	5.4	0.7	4.8	2.9
		22-Aug-15	179	n/a	Hard	9.10	8.1	1.83	1.09	3.9	42.1	135	67.7	42.1	17.9	24.6	3.2	26.3	15.9
		8-Sep-15	196	n/a	Hard	5.60	8.3	0.90	0.77	4.0	30.9	99.6	49.8	30.9	13.2	12.6	1.6	12.3	7.4
		15-Oct-15	226	n/a	Hard	4.12	8.3	0.59	0.42	4.0	24.0	77.2	38.6	24.0	10.2	6.9	0.9	6.6	4.0
		18-Nov-15	268	n/a	Very hard	2.30	8.3	0.49	0.44	4.0	14.3	46.0	23.0	14.3	2.9	OD	-	3.1	3.1
		1-Dec-15	263	n/a	Very hard	1.64	8.2	0.34	0.35	4.0	9.5	30.7	15.3	9.5	2.0	OD	-	2.3	2.3

☐ WER ≥ 2.0.

[1] See Table A.1 for derivation of hardness-dependent CCME (Canadian Council of Ministers of the Environment) and USEPA (United States Environmental Protection Agency) Water Quality Guidelines. The Windward Biotic Ligand Model for copper calculates the USEPA copper Ambient Water Quality Criteria, therefore the CCC shown is the USEPA chronic criteria for copper.

[2] CMC = Criterion Maximum Concentration; CCC = Criterion Continuous Concentration; ACR = Acute-Chronic Ratio.

[3] PNEC is the Probable No-effect Concentration.

[4] EQS is the Environmental Quality Standard, and is considered to be equivalent to a site-specific PNEC.

OD - Out of Domain (result is outside of the validated range of the model). Water Effect Ratios could not be calculated for samples with an Out of Domain result.

n/a - not applicable.

the WERP may be a useful technique for deriving a SSWQO (i.e., WER > 2). Calculated WERs from both models were greater than 2 in more than half the sampling events at each sampling station (Table 4), and showed similar spatial and temporal trends. Spatial analysis of the WERs focussed on the Windward BLM, since this has been adopted by the USEPA for prediction of Ambient Water Quality Criteria (Figure 2), while temporal analysis considered WERs from the Bio-Met and Windward BLMs. Mean predicted WERs from the Windward BLM were highest at the furthest downstream monitoring station (KZ-26; mean = 10.9), with a lower 95% confidence limit of 3.5 at this station. Mean WERs at the upstream stations (KZ-15 and KZ-17) were lower, with 95% confidence intervals spanning a WER value of 1.0 (i.e., no ratio) at station KZ-15, indicating high variability in the predicted WERs from this monitoring location (Figure 2). Regression analysis of WER results from both the Windward and Bio-Met BLMs indicated that predicted WERs were highly dependent on DOC concentrations (r^2 = 0.899, p<0.001; Figure 3) with maximum WERs predicted in all three BLMs when DOC concentrations were highest (May 2015; Table 4). Evaluation of the relationship between water pH and predicted WERs yielded a weaker significant relationship (r^2 = 0.463, p<0.001; Figure A.1); however this is likely due to the co-occurrence of high DOC concentrations with relatively lower pH (Table 4). Due to the dependence of predicted WERs on DOC concentrations, the WERP should only be considered for development of a copper SSWQO in situations where DOC concentrations are high enough to result in a WER greater than 2 (i.e., there is no predicted benefit when DOC is low). As such, the WERP may be of use when DOC concentrations are greater than approximately 1.3 mg/L (as determined by regression analysis; Figure 3) but the WERP is unlikely to yield a SSWQO higher than the generic guideline at lower DOC concentrations.

Overall, the WERP has the potential to yield a beneficial SSWQO only under certain circumstances (DOC concentrations greater than approximately 1.3 mg/L) which, across all monitoring stations, appear to consistently occur only in the spring. In order to accommodate the observed temporal variability in predicted WERs (due to variability in DOC concentrations), the use of a season-specific or DOC threshold-based SSWQO should be considered. This approach could allow for a higher SSWQO at times of the year when DOC is elevated.

Lead

The Windward BLM was used to predict the utility of the WERP for lead based on acute toxicity predictions for four test organisms. Calculated WERs were highest for *Ceriodaphnia dubia* with the WER for the majority of sampling events greater than 2, and lowest for fathead minnow with fewer than half of the calculated WERs greater than 2 at stations KZ-15 or KZ-17 (Table 5). Spatial analysis of WERs considered only fathead minnow results, as these are the most conservative (Figure 2), while temporal analysis considered WERs for all four test organisms. As observed for copper, mean predicted WERs were highest at the furthest downstream monitoring
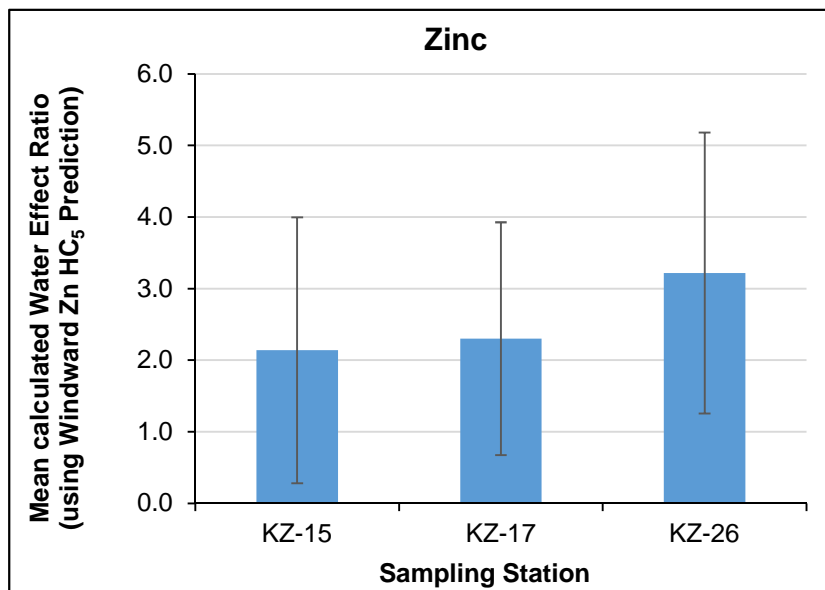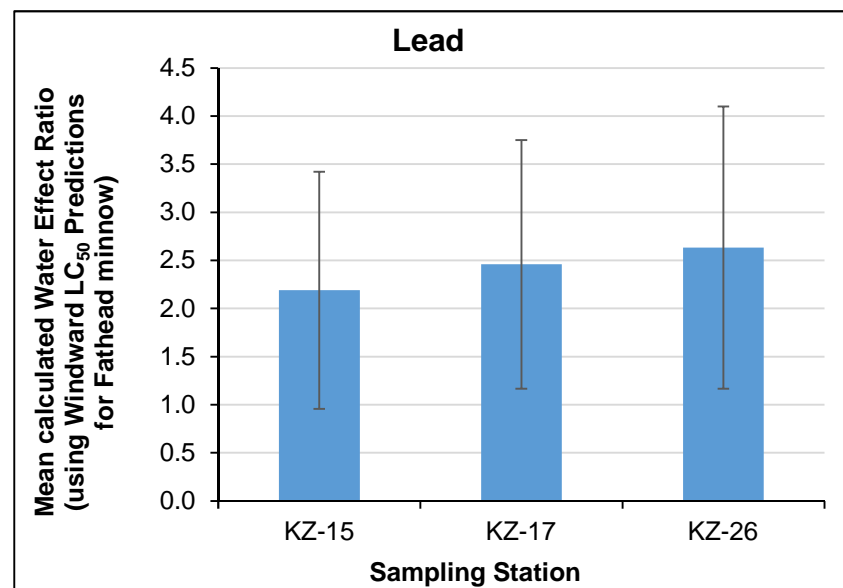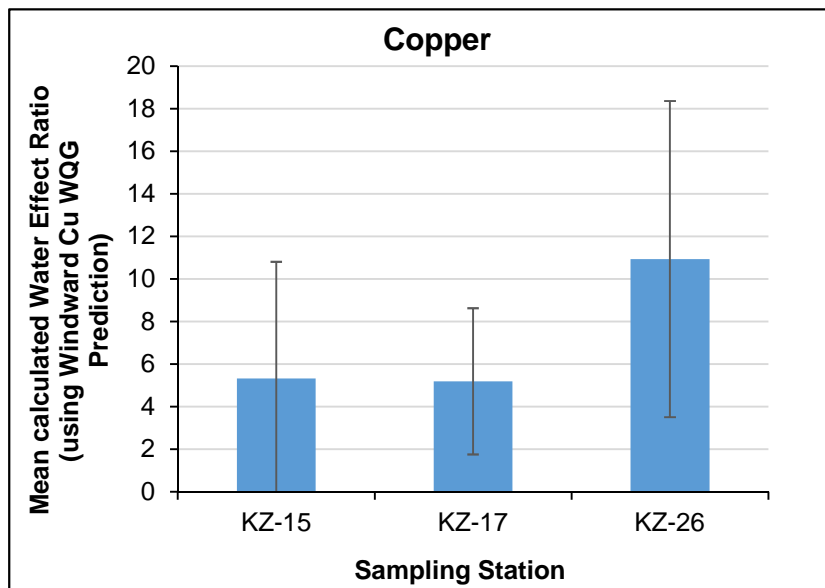
Figure 2: Mean predicted Water Effect Ratios calculated using select Biotic Ligand Model tools for Copper, Lead, and Zinc, for water quality data from monitoring stations KZ-15, KZ-17, and KZ-26 at the Kudz Ze Kayah Project, Yukon. Error bars represent 95% confidence intervals.
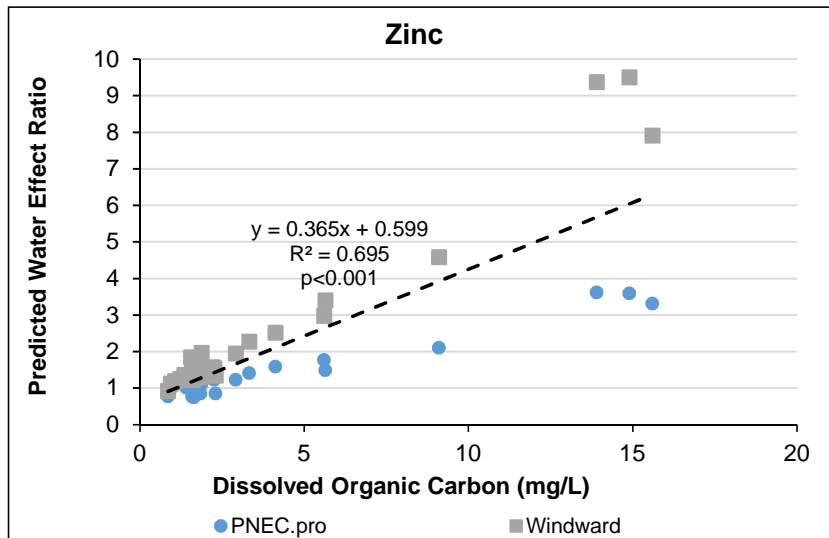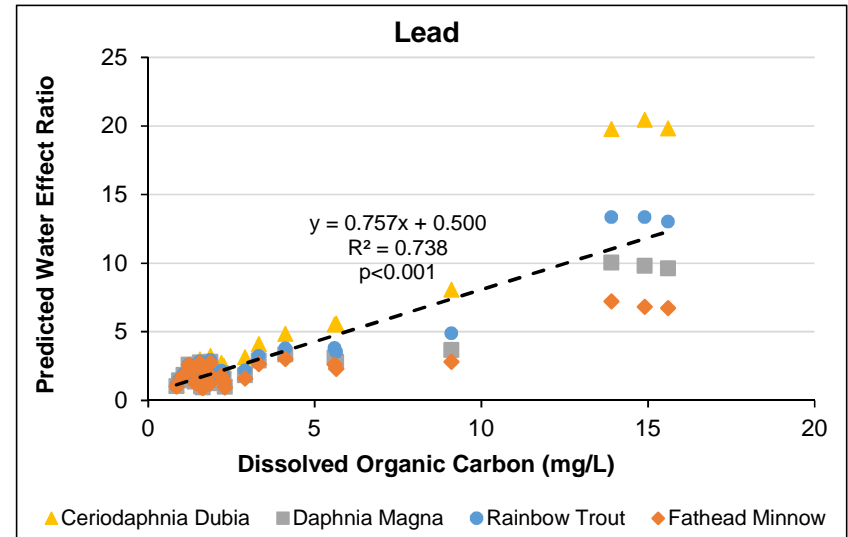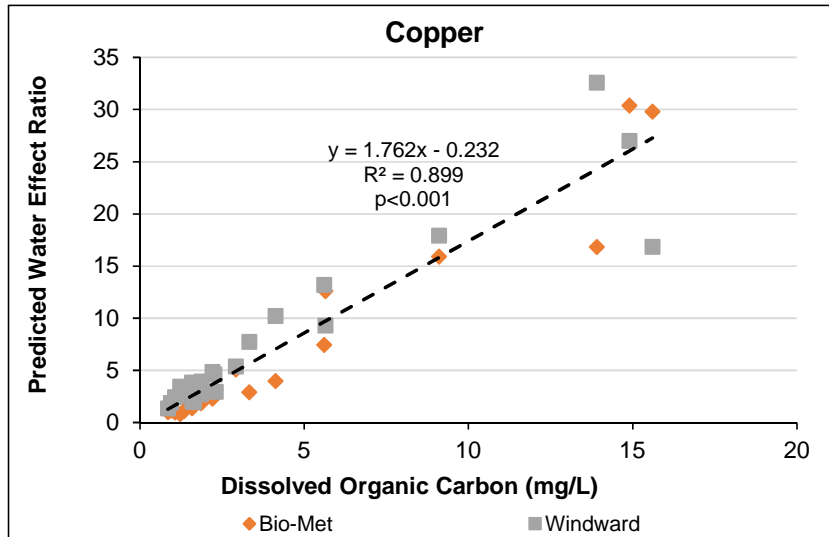
Figure 3: Linear Regression analysis of predicted Water-Effect Ratios relative to measured Dissolved Organic Carbon (mg/L) concentrations in water from monitoring stations KZ-15, KZ-17, and KZ-26 [1] at the Kudz Ze Kayah Project, Yukon.

[1] Linear regression was based on predicted WER results from all three BLM models (Windward, PNEC.pro and Bio-Met) for lead. Regression of predicted WERs for copper included only results from the Windward and Bio-Met BLMs, and for zinc included only results from the Windward and PNEC.pro BLMs due to input data or results outside the validated range of the model.

Table 5: Calculation of the Water Effect Ratio (WER) using Windward Biotic Ligand Model derived acute lead effect concentrations for site water compared to US EPA standard reconstituted water.

Station / Sample Name	Station/Sample Description	Sampling Date	Hardness Value	Hardness Range	Hardness Category	Water Quality Data — Dissolved Organic Carbon (DOC)	pH (lab)	Lead (Total)	Lead (Dissolved)	Water Quality Guidelines[1] — CCME (Total)	USEPA (Dissolved)	Windward Output — Rainbow Trout	Fathead Minnow	Daphnia Magna	Ceriodaphnia Dubia	WER — Rainbow Trout	Fathead Minnow	Daphnia Magna	Ceriodaphnia Dubia
						mg/L	pH Units	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L				
USEPA	Moderately hard	n/a	n/a	80-100	Moderately hard	0.50	7.6	n/a	n/a	n/a	n/a	169	505	285	62	n/a	n/a	n/a	n/a
	Hard	n/a	n/a	160-180	Hard	0.50	7.8	n/a	n/a	n/a	n/a	401	1,429	748	118	n/a	n/a	n/a	n/a
	Very hard	n/a	n/a	280-320	Very hard	0.50	8.2	n/a	n/a	n/a	n/a	1,336	5,217	2,633	330	n/a	n/a	n/a	n/a
KZ-15	Finlayson Creek downstream of Geona Creek	29-Apr-15	270	n/a	Very hard	0.85	8.4	0.010	<0.005	7.0	7.3	1,408	5,335	2,724	366	1.1	1.0	1.0	1.1
		11-May-15	72.9	n/a	Moderately hard	14.9	7.7	0.939	0.017	2.1	1.8	2,251	3,449	2,800	1,259	13.3	6.8	9.8	20.4
		22-Jun-15	141	n/a	Hard	2.26	8.2	0.056	0.009	4.9	3.7	736	1,986	1,176	298	1.8	1.4	1.6	2.5
		28-Jul-15	156	n/a	Hard	0.93	8.1	0.023	<0.005	5.6	4.1	602	2,040	1,090	190	1.5	1.4	1.5	1.6
		22-Aug-15	140	n/a	Hard	1.40	8.1	<0.05	<0.005	4.9	3.6	601	1,836	1,027	217	1.5	1.3	1.4	1.8
		9-Sep-15	146	n/a	Hard	1.70	8.2	0.021	0.005	5.2	3.8	676	1,999	1,134	250	1.7	1.4	1.5	2.1
		11-Sep-15	148	n/a	Hard	1.80	8.1	0.014	0.009	5.2	3.8	685	1,986	1,137	261	1.7	1.4	1.5	2.2
		14-Oct-15	175	n/a	Hard	1.06	8.2	0.080	<0.005	6.5	4.6	759	2,618	1,389	233	1.9	1.8	1.9	2.0
		19-Nov-15	212	n/a	Hard	1.22	8.4	2.23	<0.005	7.0	5.6	1,045	3,703	1,943	304	2.6	2.6	2.6	2.6
		2-Dec-15	224	n/a	Hard	1.55	8.1	0.020	<0.005	7.0	6.0	1,134	3,907	2,072	352	2.8	2.7	2.8	3.0
KZ-17	Mouth of Geona Creek	29-Apr-15	263	n/a	Very hard	1.59	8.3	0.025	<0.005	7.0	7.1	1,426	5,061	2,653	419	1.1	1.0	1.0	1.3
		11-May-15	69.1	n/a	Moderately hard	15.6	7.3	1.560	0.023	2.0	1.7	2,196	3,397	2,744	1,220	13.0	6.7	9.6	19.8
		22-Jun-15	149	n/a	Hard	2.91	8.1	0.103	0.008	5.3	3.9	878	2,285	1,376	369	2.2	1.6	1.8	3.1
		28-Jul-15	184	n/a	Hard	1.82	8.1	0.032	<0.005	7.0	4.9	874	2,735	1,512	308	2.2	1.9	2.0	2.6
		22-Aug-15	169	n/a	Hard	1.70	8.0	0.020	<0.005	6.2	4.4	785	2,438	1,353	279	2.0	1.7	1.8	2.4
		9-Sep-15	161	n/a	Hard	2.20	8.3	0.058	0.009	5.8	4.2	870	2,565	1,458	321	2.2	1.8	1.9	2.7
		14-Oct-15	193	n/a	Hard	1.34	8.3	0.092	<0.005	7.0	5.1	911	3,105	1,655	284	2.3	2.2	2.2	2.4
		19-Nov-15	212	n/a	Hard	1.58	8.3	0.115	<0.005	7.0	5.6	1,060	3,597	1,921	332	2.6	2.5	2.6	2.8
		2-Dec-15	223	n/a	Hard	1.87	8.1	0.036	<0.005	7.0	6.0	1,170	3,901	2,098	380	2.9	2.7	2.8	3.2
KZ-26	Finlayson Creek near mouth	29-Apr-15	311	n/a	Very hard	1.84	8.4	0.011	<0.005	7.0	8.4	1,761	6,312	3,296	505	1.3	1.2	1.3	1.5
		11-May-15	109	n/a	Moderately hard	13.9	7.9	0.237	0.009	3.6	2.8	2,254	3,645	2,864	1,216	13.4	7.2	10.0	19.8
		23-Jun-15	182	n/a	Hard	5.64	7.9	0.221	0.011	7.0	4.8	1,422	3,297	2,103	658	3.5	2.3	2.8	5.6
		29-Jul-15	222	n/a	Hard	3.32	8.2	0.027	<0.005	7.0	5.9	1,299	3,798	2,167	483	3.2	2.7	2.9	4.1
		22-Aug-15	179	n/a	Hard	9.10	8.1	0.241	0.008	6.7	4.7	1,957	4,016	2,740	949	4.9	2.8	3.7	8.0
		8-Sep-15	196	n/a	Hard	5.60	8.3	0.058	0.006	7.0	5.2	1,526	3,749	2,328	651	3.8	2.6	3.1	5.5
		15-Oct-15	226	n/a	Hard	4.12	8.3	<0.05	0.006	7.0	6.0	1,515	4,333	2,499	571	3.8	3.0	3.3	4.8
		18-Nov-15	268	n/a	Very hard	2.30	8.3	0.013	0.014	7.0	7.2	1,465	4,907	2,636	465	1.1	0.9	1.0	1.4
		1-Dec-15	263	n/a	Very hard	1.64	8.2	<0.005	<0.005	7.0	7.1	1,347	4,734	2,492	401	1.0	0.9	0.9	1.2

WER ≥ 2.0.

[1] See Table A.1 for derivation of hardness-dependent CCME (Canadian Council of Ministers of the Environment) and USEPA (United States Environmental Protection Agency) Water Quality Guidelines.

n/a - not applicable.

station KZ-26 (mean = 2.6; Figure 2) although the observed difference among means was small. The WERs predicted for all four of the test organisms also varied temporally, with maximum WERs predicted when DOC concentrations were highest (May 2015; Table 5). Regression analysis of DOC concentrations and the predicted WERs demonstrated a significant relationship between the two variables, with 74% of the variance in the predicted WERs explained by DOC concentrations (r^2 = 0.738, p<0.001; Figure 3). A weaker significant positive relationship also existed between water pH and predicted WERs but is likely due to the co-occurrence of high DOC concentrations with low pH results discussed above. Based on analysis of the limited data available, the development of SSWQO using the WERP for the upstream stations KZ-15 and KZ-17 would likely only be beneficial during the spring (May) when DOC concentrations are high. Concentrations of DOC were higher throughout the year at the downstream monitoring station (KZ-26), and as such the WERP could potentially be applied to a greater portion of the year (e.g., May to October based on 2015 data). Consideration should be given to the development of a season-specific or DOC threshold-based SSWQO similar to the approach discussed above for copper. Based on the linear equation developed between DOC and predicted WERs for lead (Figure 3), there appears to be potential for development of SSWQO when DOC is in excess of approximately 2.0 mg/L, but it is unlikely that a meaningful WER would result at DOC concentrations below this.

Zinc

All three BLM tools were used to assess the potential utility of the WERP for zinc. Input pH data exceeded the validated range for the Bio-Met BLM (Tables 1 and 6) and the Bio-Met BLM results were not used further. WER predictions yielded by the PNEC.pro and Windward BLMs were low (< 2) for the majority of sampling events at stations KZ-15 and KZ-17 (Table 6). Spatial analysis of WERs focussed on the Windward BLM, due to the inclusion of a greater number of parameters in this model (Figure 2), while temporal analysis considered WERs from the Windward and PNEC.pro BLMs. Mean predicted WERs were higher at monitoring station KZ-26 (mean = 3.2) relative to the upstream stations KZ-15 and KZ-17 (mean < 2.3), with both upstream monitoring stations having lower confidence limits of the mean below 1.0 (Figure 2). Similar to the trends observed for copper and lead, maximum predicted WERs in all models coincided with highest DOC concentrations in May 2015. Significant relationships existed between both DOC concentrations and the predicted WERs (r^2 = 0.695, p<0.001; Figure 3), and between pH and the predicted WERs (Figure A.1), the latter of which was weaker and likely due to the co-occurrence of high DOC and low pH results as discussed above. Based on the linear equation developed for the relationship between DOC concentrations and the predicted WERs (based on all BLM results), WERs greater than 2 are likely to occur when DOC concentrations exceed approximately 3.8 mg/L. Therefore, due to the low predicted WERs observed at stations KZ-15 and KZ-17 and the dependence of predicted WERs on water DOC concentrations, use of the WERP should be

Table 6: Calculation of the Water Effect Ratio (WER) using Windward, PNEC.pro, and Bio-Met Biotic Ligand Model derived chronic zinc no-effect concentrations for sitewater compared to USEPA standard reconstituted water.

Station / Sample Name	Station/Sample Description	Sampling Date	Hardness Value	Hardness Range	Hardness Category	Water Quality Data Dissolved Organic Carbon (mg/L)	pH (lab) (pH units)	Zinc (Total) (µg/L)	Zinc (Dissolved) (µg/L)	Water Quality Guidelines [1] CCME (Total) (µg/L)	USEPA (Dissolved) (µg/L)	Windward Output Zn Chronic HC$_5$ [2] (µg/L)	WER	PNEC.pro Output PNEC Output [3] (µg/L)	WER	Bio-Met Output EQS [4] (µg/L)	WER
USEPA	Moderately hard	n/a	n/a	80-100	Moderately hard	0.50	7.6	n/a	n/a	n/a	n/a	22.7	n/a	8.0	n/a	11.9	n/a
	Hard	n/a	n/a	160-180	Hard	0.50	7.8	n/a	n/a	n/a	n/a	35.0	n/a	11.2	n/a	11.9	n/a
	Very hard	n/a	n/a	280-320	Very hard	0.50	8.2	n/a	n/a	n/a	n/a	52.2	n/a	17.5	n/a	11.9	n/a
KZ-15	Finlayson Creek downstream of Geona Creek	29-Apr-15	270	n/a	Very hard	0.85	8.4	3.22	2.91	30	274	47.9	0.9	13.4	0.8	14.5	1.2
		11-May-15	72.9	n/a	Moderately hard	14.9	7.7	22.9	5.66	30	90	216	9.5	28.8	3.6	68.2	5.7
		22-Jun-15	141	n/a	Hard	2.26	8.2	2.88	2.55	30	158	53.9	1.5	13.7	1.2	18.3	1.5
		28-Jul-15	156	n/a	Hard	0.93	8.1	2.08	1.25	30	172	39.2	1.1	10.9	1.0	11.9	1.0
		22-Aug-15	140	n/a	Hard	1.40	8.1	3.50	1.29	30	157	43.9	1.3	11.3	1.0	15.3	1.3
		9-Sep-15	146	n/a	Hard	1.70	8.2	2.81	2.27	30	163	46.4	1.3	12.7	1.1	15.3	1.3
		11-Sep-15	148	n/a	Hard	1.80	8.1	2.47	1.99	30	165	50.7	1.4	12.1	1.1	15.3	1.3
		14-Oct-15	175	n/a	Hard	1.06	8.2	4.17	1.93	30	190	41.6	1.2	12.1	1.1	13.1	1.1
		19-Nov-15	212	n/a	Hard	1.22	8.4	5.76	3.90	30	223	43.5	1.2	14.0	1.3	15.9	1.3
		2-Dec-15	224	n/a	Hard	1.55	8.1	4.35	2.26	30	234	64.3	1.8	11.8	1.1	18.0	1.5
KZ-17	Mouth of Geona Creek	29-Apr-15	263	n/a	Very hard	1.59	8.3	5.86	5.32	30	268	63.3	1.2	13.5	0.8	18.0	1.5
		11-May-15	69.1	n/a	Moderately hard	15.6	7.3	42.7	7.49	30	86	179	7.9	26.5	3.3	60.8	5.1
		22-Jun-15	149	n/a	Hard	2.91	8.1	5.45	2.89	30	166	68.0	1.9	13.7	1.2	22.7	1.9
		28-Jul-15	184	n/a	Hard	1.82	8.1	3.45	2.18	30	198	58.5	1.7	12.1	1.1	15.3	1.3
		22-Aug-15	169	n/a	Hard	1.70	8.0	4.10	2.80	30	184	54.4	1.6	11.7	1.1	15.3	1.3
		9-Sep-15	161	n/a	Hard	2.20	8.3	7.54	4.26	30	177	54.7	1.6	14.1	1.3	18.3	1.5
		14-Oct-15	193	n/a	Hard	1.34	8.3	9.89	4.50	30	206	47.6	1.4	12.8	1.1	15.9	1.3
		19-Nov-15	212	n/a	Hard	1.58	8.3	8.20	6.06	30	223	53.9	1.5	13.3	1.2	18.0	1.5
		2-Dec-15	223	n/a	Hard	1.87	8.1	7.24	3.75	30	233	68.5	2.0	12.3	1.1	18.0	1.5
KZ-26	Finlayson Creek near mouth	29-Apr-15	311	n/a	Very hard	1.84	8.4	0.41	0.29	30	309	67.5	1.3	14.8	0.8	18.0	1.5
		11-May-15	109	n/a	Moderately hard	13.9	7.9	4.40	1.27	30	127	213	9.4	29.0	3.6	72.7	6.1
		23-Jun-15	182	n/a	Hard	5.64	7.9	2.40	0.31	30	196	119	3.4	16.6	1.5	38.5	3.2
		29-Jul-15	222	n/a	Hard	3.32	8.2	0.86	0.35	30	232	79.2	2.3	15.8	1.4	24.8	2.1
		22-Aug-15	179	n/a	Hard	9.10	8.1	3.80	0.74	30	193	160	4.6	23.5	2.1	52.3	4.4
		8-Sep-15	196	n/a	Hard	5.60	8.3	1.77	0.81	30	209	104	3.0	19.7	1.8	38.5	3.2
		15-Oct-15	226	n/a	Hard	4.12	8.3	1.10	0.35	30	236	87.8	2.5	17.7	1.6	30.6	2.6
		18-Nov-15	268	n/a	Very hard	2.30	8.3	0.77	0.60	30	272	69.8	1.3	14.9	0.9	20.8	1.7
		1-Dec-15	263	n/a	Very hard	1.64	8.2	0.28	0.23	30	268	65.7	1.3	12.9	0.7	18.0	1.5

☐ WER ≥ 2.0.

[1] See Table A.1 for derivation of hardness-dependent CCME (Canadian Council of Ministers of the Environment) and USEPA (United States Environmental Protection Agency) Water Quality Guidelines.

[2] Chronic HC$_5$ is the chronic hazardous concentration to 5% of the exposed population.

[3] PNEC is the Probable No-effect Concentration.

[4] EQS is the Environmental Quality Standard, and is considered to be equivalent to a site-specific PNEC. The majority of pH values were outside the validated EQS calculation range for zinc (pH >8) and should be interpreted with caution.

n/a - not applicable.

considered for the development of a season-specific of DOC threshold-based SSWQO. This approach could allow for development of a higher SSWQO in the spring when WERs are predicted to be higher (> 2) due to elevated DOC concentrations (above approximately 3.8 mg/L).

Summary

Application of BLMs to predict WERs for copper, lead and zinc using limited available data suggests that use of the WERP to develop SSWQOs for these metals is only likely to be beneficial if season-specific or DOC-based SSWQOs are considered. Higher DOC concentrations in the spring and downstream (at station KZ-26) relative to upstream may support SSWQOs greater than guidelines, but would only be applicable under specific conditions. Such SSWQOs could potentially be useful to the project in evaluating water management options such as seasonal discharge.
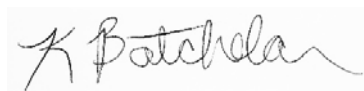
We trust that this brief letter report meets your requirements and expectations. If you have any questions or would like to discuss any aspect of this report, please do not hesitate to let us know.

Sincerely,
Minnow Environmental Inc.

Pierre Stecko, M.Sc., EP, RPBio   Katharina Batchelar, M.Sc.
Senior Aquatic Scientist & Principal   Aquatic Scientist

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APPENDIX A

SUPPORTING DATA AND ANALYSES
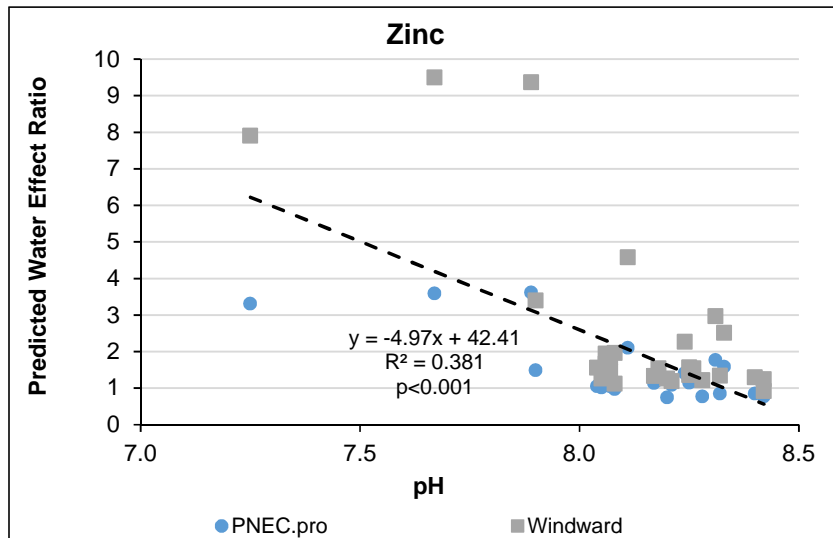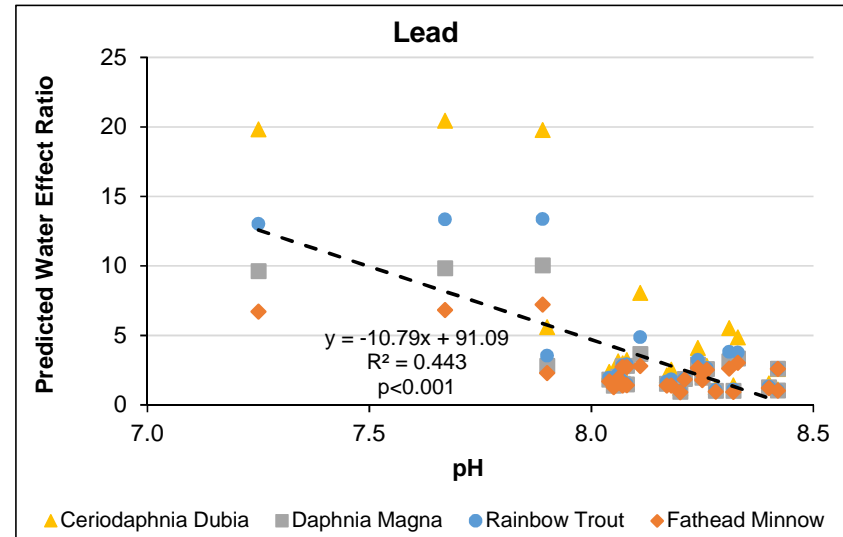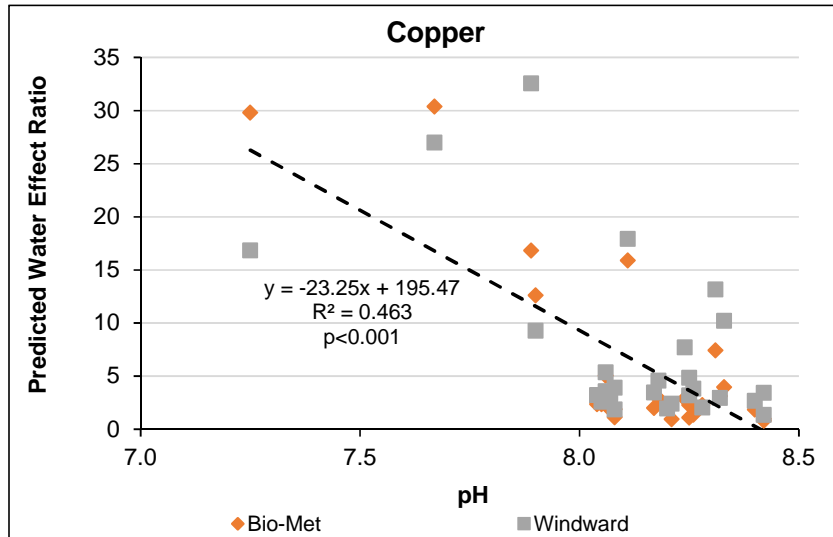
Figure A.1: Predicted Water-Effect Ratios relative to measured pH concentrations in water from monitoring stations KZ-15, KZ-17, and KZ-26 [1] at the Kudz Ze Kayah Project, Yukon.

[1] Linear regression was based on predicted WER results from all three BLM models (Windward, PNEC.pro and Bio-Met) for lead. Regression of predicted WERs for copper included only results from the Windward and Bio-Met BLMs, and for zinc included only results from the Windward and PNEC.pro BLMs due to input data or results outside the validated range of the model.

Table A.1: Explanation of hardness-dependent water quality guidelines.

Guideline Source		Parameter	Units	Guideline Description
Canadian Council for Ministers of the Environment	CCME (2015)[a]	Copper	µg/L	Guideline is hardness-dependent. Below 82 µg/L hardness, guideline is 2 µg/L; between 82 and 180 mg/L hardness, the equation ($0.2 \times e^{(0.8545[\ln(hardness)]-1.465)}$) is used; above 180 mg/L hardness, guideline is 4 µg/L.
		Lead	µg/L	Guideline is hardness-dependent. Below 60 mg/L hardness, guideline is 1 µg/L; between 60 and 180 mg/L hardness, the equation ($e^{(1.273\ln(mean\ hardness)-4.704)}$); above 180 mg/L hardness, guideline is 7 µg/L.
		Zinc	µg/L	Guideline is 30 µg/L.
United States Environmental Protection Agency	US EPA (2015)[b]	Copper	µg/L	Freshwater guideline is calculated using the Biotic Ligand Model, and is expressed in terms of dissolved metal in the water column. The Criterion Continuous Concentration (CCC) for dissolved copper in freshwater was used, calculated using the Windward BLM.
		Lead	µg/L	Guideline is hardness-dependent. The equation ($[e^{(1.273[\ln(hardness)]-4.705)}]*[1.462-(\ln(hardness)*(0.146)])$) is used to calculate Criterion Continuous Concentration (CCC) for dissolved concentrations in freshwater.
		Zinc	µg/L	Guideline is hardness-dependent. The equation ($[e^{(0.8473[\ln(hardness)]+0.884)}]*[0.986]$) is used to calculate Criterion Continuous Concentration (CCC) for dissolved concentrations in freshwater.

[a] CCME (Canadian Council for Ministers of the Environment). 2014. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Accessed at http://st-ts.ccme.ca/, January 2016.

[b] USEPA (United States Environmental Protection Agency). 2015. National Recommended Water Quality Criteria - Aquatic Life Criteria Table.
  Accessed at http://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

APPENDIX C.
BMC Minerals Kudz Ze Kayah Project Site-Specific Water Quality Objective Recalculation Procedure for Copper, Lead and Zinc (Minnow Environmental Inc.)

February 5, 2016

Mr. Scott Keesey
Senior Environmental Manager
Alexco Environmental Group
#3 Calcite Business Centre
151 Industrial Rd.,
Whitehorse, Yukon
Y1A 2V3

Dear Mr. Keesey,

**Re: BMC Minerals Kudz Ze Kayah Project Site-Specific Water Quality Objective
         Recalculation Procedure for Copper, Lead and Zinc**

Minnow Environmental Inc. (Minnow) is pleased to provide a brief letter report examining the potential application of the Recalculation Procedure (RCP) to deriving site-specific water quality objectives (SSWQO) for copper, lead and zinc at the BMC Minerals Kudz Ze Kayah Project.

Project Background

The BMC Minerals Kudz Ze Kayah Project is located in Yukon Territory, approximately 110 kilometers southeast of the community of Ross River. The project lies primarily within the Geona Creek watershed (Figure 1). Geona Creek flows to Finlayson Creek, which in turn is a tributary to the Finlayson River, and ultimately the Frances, Liard and MacKenzie rivers. An initial environmental evaluation of the project by a previous owner indicated that water quality of Geona and Finlayson creeks would potentially be impacted by mine water discharge, particularly based on concentrations of copper, selenium, zinc, ammonia and nitrite (Cominco 1996). It is expected that this mine water will be treated prior to discharge during the operational period. The evaluation reported herein can contribute to the design criteria for water treatment.

Technical Background

The Recalculation Procedure (RCP) is one of several accepted approaches for deriving SSWQOs (e.g., CCME 2003). Briefly, the RCP involves the acquisition of an up-to-date toxicological database that includes the data used to derive a generic guideline for a particular parameter. The database is then examined relative to a species list for the area to which the SSWQO will be applied. Data for species that are not resident in the area are identified and are removed from the database. An SSWQO is derived using the same methodology that was originally used to derive the generic guideline, but only considers the reduced data set. If it can be demonstrated that the sensitive species that influenced the derivation of the generic guideline do not occur locally, the recalculation will likely result in a new, higher SSWQO. Conversely, if the most

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 1

WATER QUALITY
MONITORING STATIONS

FEBRUARY 2017

Legend:
▲ Surface Water Quality Stations
━━ Robert Campbell Highway
═══ Tote Road/Proposed Access Road
─── Proposed Mine Road
─── Contour (40m interval)
─── Watercourse
▨ Waterbody
▓ Location of Proposed Mine Infrastructure
▨ BMC Minerals (No.1) Ltd. Claims

ALEXCO ENVIRONMENTAL GROUP

minnow environmental inc.
A Trinity Consultants Company

D:\Project\AllProjects\Kudz_Ze_Kayah\Maps\01_WaterQuality\01-Surface\Specific\Minnow\SWQ_Minnow_20161212.mxd
(Last edited by: amatiashevska; 02/02/2017/13.57 PM)

sensitive species are resident in the watershed, then this method would not be expected to result in any difference. In practice, as long as appropriate datasets can be acquired and biological assemblages have been well characterized, it can generally be quickly determined whether or not the approach is likely to result in any difference from the generic guideline.

Methods

<u>Toxicological Data</u>

Toxicological datasets were acquired for copper, lead and zinc to assess species sensitivity. Initial requests for data were submitted to Environment Canada. Environment Canada provided data for zinc and provided further assistance through referral to alternate data sources. Ultimately, toxicological data for copper were collected from the European Union Risk Assessment Report for copper (EURAR 2008). This database evaluated chronic exposure only, and the literature is inclusive up to 2004. Fewer toxicological data were available for lead, so available chronic toxicity reports were compiled to evaluate the range in toxicity for common species (Besser et al. 2005; Borgmann et al. 2005; Brix et al. 2012; Esbaugh et al. 2012; Grosell et al. 2006; Mager et al. 2010; Mager et al. 2011a; Mager et al. 2011b; Wang et al. 2010). These data were considered sufficient for a preliminary examination of the potential for recalculation. Additional data are potentially available through the International Lead Association, but would only be retrieved if the initial assessment is promising. Lastly, toxicological data for zinc were collected from the draft Canadian Water Quality Guideline for the Protection of Aquatic Life for zinc (CCME 2016), and contained a complete literature review up to 2012 for both acute and chronic exposure.

For each metal, toxicity tests (acute and chronic separately when available) were ordered from most to least sensitive based on the species/endpoint effect concentration. The endpoint duration and developmental stage used varied by report due to differences in the optimal conditions required for each species, but overall the lower the measured effect in the endpoint, the more sensitive that species was. Once ordered, the top ten most sensitive species for copper (Table 1), lead (Table 2), zinc (Tables 3 and 4) were selected and reported for initial evaluation. For zinc, only studies used in the CWQG species sensitivity distribution (SSD; CCME 2016) were considered for this report. In the SSD selection process, when more than one study examined the same species, the most sensitive report was selected for inclusion, and if all parameters were the same then the geometric mean was calculated and used in the SSD. This approach was applied for copper and zinc for the current report, where applicable.

<u>Site Biological Data</u>

Site biological data were acquired from the three sources: the Initial Environmental Evaluation report (Cominco 1996), the Kudz Ze Kayah Project – Aquatic Ecosystems and Resources Baseline Report (Alexco 2015), and the 2014 Kudz Ze Kayah Environmental Monitoring Report (Laberge and Can-Nic-a-Nick 2015). The Kudz Ze Kayah Project – Aquatic Ecosystems and Resources Baseline Report (Alexco 2015) report provides data from available baseline environmental studies on fisheries and other aquatic resources in support of the Kudz Ze Kayah

project development, as well as includes results from additional studies conducted by Alexco Environmental Group Inc. in 2015.

Fish distribution surveys were primarily conducted in Geona Creek, Finlayson Creek, East Creek, South Creek as well as the North Lakes/River system (Figure 1). Three sites on Finlayson Creek were monitored biennially since 2002 under Water Licence QZ97-026. The sites were:

- KZ-16: Upstream of confluence with Geona Creek, at tote road (reference site).
- KZ-15: 100 m downstream of confluence with Geona Creek.
- KZ-26: Just above the confluence with Finlayson River, at Robert Campbell Highway.

In the project area, the primary fish species captured and identified were Arctic grayling (*Thymallus arcticus*), Burbot (*Lota lota*) and Slimy sculpin (*Cottus cognatus*) (Alexco 2015, Laberge and Can-Nic-a-Nick 2015, Cominco 1996 ; Appendix Table A.1), however it is known that salmonid species other than Arctic grayling are present in the project area (i.e. Lake trout (*Salvelinus namaycush*), Mountain whitefish (*Prosopium williamsoni*); Cominco 1996) although few were captured in any of the surveys (Cominco 1996).

Benthic invertebrate surveys were primarily conducted at Geona Creek, Finlayson Creek, North River and East Creek during baseline studies in September 1995, and under the water licence in 2000, 2004, 2006, 2008, 2010, 2012 and 2014 (KZ-9, KZ-15, KZ-16, KZ-21, KZ-26, KZ-27; Laberge and Can-Nic-A-Nic 2015). Additional benthic invertebrate community sampling was conducted in September 2015 in order to fill in baseline information gaps on Geona Creek (KZ-2, KZ-7, KZ-17; Alexco 2015; Appendix Table A.3). While these data were used to assess the presence and absence of sensitive species within the project area, it is notable that it is difficult to confidently conclude that sensitive species are not present due to the limited spatial coverage and focus on riffle habitat only.

Although periphyton communities were surveyed in 2015 (Alexco 2015), no site biological data exists for aquatic plants. It may be appropriate to augment the baseline data for algae and plants because algae appear to be sensitive to zinc exposure.

RCP Utility Evaluation

Examination of the chronic toxicological dataset for copper (Table 1) indicates that the three most copper sensitive species are cladocerans (small crustaceans commonly known as water fleas). The particular sensitivity of cladocerans has been well characterized (e.g., USEPA 2007). Cladocerans have been documented in the invertebrate data set (Appendix Table A.2). It is also notable that a total of eight of the ten most chronically copper sensitive species-endpoint combinations are for species that are present in the study area (or reasonable surrogate species are present).

Examination of the chronic toxicological dataset for lead (Table 2) indicates that the two most lead sensitive species: *Lymnaea stagnalus* (a pond snail) and the cladoceran *Ceriodaphnia dubia* are present in the study area (or reasonable surrogate species are present). It is also

Table 1: Top ten most sensitive species/endpoints to chronic copper exposure [1]

Rank	Species latin name	Species common name	Life stage	Exposure duration	Endpoint	Observed effect	Measured no effect concentration (µg/L)
1	*Oncorhynchus mykiss*	Rainbow trout	fry (0.12 g; 2.6 cm)	60 d	NOEC	growth	2.2
2	*Ceriodaphnia dubia*	Scud	neonates (< 8 h)	7 d	NOEC	mortality	4
3	*Daphnia pulex*	Water flea	neonates (< 24 h)	42 d	NOEC	mortality	4
4	*Pimephales promelas*	Fathead minnow	embryo-larval	32 d	NOEC	growth	4.8
5	*Juga plicifera*	Snail	mature	30 d	NOEC	mortality	6
6	*Salvelinus fontinalis*	Brook trout	fry	30 d	NOEC	Growth	7
7	*Campeloma decisum*	Snail	11 to 27 mm snail	42 d	NOEC	mortality	8
8	*Brachionus calyciflorus*	Rotifer	neonates (< 2 h)	2 d	NOEC	reproduction	8.2
9	*Clistoronia magnifica*	Caddisfly	larvae 1st generation	240 d	NOEC	Life cycle	8.3
10	*Gammarus pulex*	Amphipod	mixed sizes (1.5-14 mm)	100 d	NOEC	population response	11

[1] data source: European Union Risk Assessment Report (EURAR 2008), European Copper Institute.

    denotes a species or genus confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

    denotes a reasonable surrogate species is confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

    denotes uncertainty of presence/absence of species or surrogate species in the area.

    absence of colour indicates genus unlikely to occur in the region or distribution unknown

Table 2: Sensitivity ranked toxicity data for chronic exposure to lead [1]

Rank	Species latin name	Species common name	Life stage	Exposure duration	Endpoint	Observed effect	Measured effect concentration (µg/L)
1	*Lymnaea stagnalis*	pond snail	7-10 d	14-d	EC10	Growth	0.9
2	*Ceriodaphnia dubia*	cladoceran	Neonates	7-d	EC10	Reproduction	1.0
3	*Philodina rapida*	rotifer	Adults	4-d	EC10	Population growth	2.4
4	*Hyalella azteca*	amphipod	1.2-1.3 mm (mixed age)	42-d	EC25	Reproduction	2.8
5	*Lampsilis siliquoidea*	fatmucket mussel	Juveniles	28-d	EC10	Length	6.4
6	*Oncorhynchus mykiss*	rainbow trout	Embryo	62-d	EC10	Weight	7.0
7	*Pimephales promelas*	fathead minnow	Larvae (8-d)	21-d	LOEC	Fecundity	31
8	*Chironomus dilutus*	midge	Larvae (8-d)	27-d	MATC	Survival	233
9	*Micropterus dolomieui*	smallmouth bass	Fingerlings	90-d	NOEC	Growth	308

[1] confidential data source

☐ (blue) denotes a species or genus confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (green) denotes a reasonable surrogate species is confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (orange) denotes uncertainty of presence/absence of species or surrogate species in the area.

☐ (white) absence of colour indicates genus unlikely to occur in the region or distribution unknown

notable that a total of four of nine species-endpoint combinations in the available database are for species that are present in the study area (or reasonable surrogate species are present).
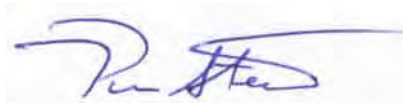
Examination of the acute and chronic toxicological datasets for zinc (Tables 3 and 4) indicate that the green algae *Pseudokirchneriella subcapitata* is particularly sensitive to zinc. *P. subcapitata* is a ubiquitous green alga commonly used in toxicity testing (e.g., Environment Canada 2007). Due to the overall ubiquity of *P. subcapitata* and apparent sensitivity of other green algae (e.g., *Chlorella pyrenoidosa* and *C. vulgaris*; Table 3 and 4), the presence of green algae at the site (Appendix Table A.3) suggests zinc sensitivity. It is also notable that a total of nine of the ten most acutely zinc sensitive species-endpoint combinations and six of ten of the most chronically zinc sensitive species-endpoint combinations are for species that are present in the study area (or reasonable surrogate species are present).

Summary

Evaluation of the potential application of the RCP to derive SSWQOs for copper, lead and zinc in Geona and Finlayson creeks suggests that the approach would not yield SSWQOs that differ meaningfully from generic guidelines. This is due to the presence of sensitive species such as arctic grayling (family Salmonidae), water fleas of the crustacean order Cladocera, and green algae which are among the most sensitive organisms to copper, lead and zinc.

We trust that this brief letter report meets your requirements and expectations. If you have any questions or would like to discuss any aspect of this report, please do not hesitate to let us know.

Sincerely,
Minnow Environmental Inc.

Pierre Stecko, M.Sc., EP, RPBio   Jennifer Ings, PhD.
Senior Aquatic Scientist & Principal   Aquatic Scientist

Table 3: Top ten most sensitive species/endpoints to acute zinc exposure [1]

Rank	Species latin name	Species common name	Life stage	Exposure duration	Endpoint	Observed effect	Measured effect concentration (µg/L)
1	*Pseudokirchneriella subcapitata*	Green algae	Not reported	24 h	EC50	Growth	15
2	*Chlorella pyrenoidosa*	Green algae	Not reported	24 h	EC50	Growth	57
3	*Oncorhynchus mykiss* [a]	Rainbow trout	Juvenile	5 d	LC50	Mortality	61
4	*Daphnia magna*	Water flea	Juvenile	96 h	LC50	Mortality	68
5	*Ceriodaphnia reticulata*	Water flea	Less than 4h	48 h	LC50	Mortality	76
6	*Oncorhynchus tshawytscha*	Chinook salmon	Juvenile	96 h	LC50	Mortality	84
7	*Salvelinus confluentus* [a]	Bull trout	Juvenile	5 d	LC50	Mortality	89
8	*Daphnia pulex*	Water flea	Less than 24hrs	48 h	LC50	Mortality	107
9	*Ceriodaphnia dubia* [a]	Cladocerans	Less than 48h old	48 h	EC50	Immobility	108
10	*Lampsilis rafinesqueana*	Neosho mucket	Juvenile	48 h	EC50	Survival	134

[1] data source: (Draft Canadian Water Quality Guideline for the Protection of Aquatic Life

[a] Measured effect concentration presented as a geometric mean

☐ (blue) denotes a species or genus confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (green) denotes a reasonable surrogate species is confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (orange) denotes uncertainty of presence/absence of species or surrogate species in the area.

☐ absence of colour indicates genus unlikely to occur in the region or distribution unknown

Table 4: Top ten most sensitive species/endpoints to chronic zinc exposure [1]

Rank	Species latin name	Species common name	Life stage	Exposure duration	Endpoint	Observed effect	Measured effect concentration (µg/L)
1	*Pseudokirchneriella subcapitata*	Green algae	Exponential growth phase	72 h	EC20	growth inhibition	10
2	*Epeorus latifolium*	Mayfly	Larva	4 weeks	EC10	emergence	14.4
3	*Ceriodaphnia dubia*	Water flea	Neonate	7 d	MATC	Reproduction	18.1
4	*Chlorella vulgaris*	Green algae	Exponential growth phase	72 h	EC50	biomass	34
5	*Jordanella floridae*	flagfish	Larva	100 d	MATC	Growth	36
6	*Hydra viridissima*	Green hydra	Not reported	7 d	EC10	Population growth inhibition	52.23
7	*Lampsilis siliquoidea*	Fatmucket	Juvenile	28 d	IC10	Length	55
8	*Oncorhynchus tshawytscha*	Chinook salmon	Fry	200 h	LC10	Mortality	68
9	*Brachionus havanaensis*	Rotifer	adults and juveniles	18 d	EC10	Population growth inhibition	78.2
10	*Pimephales promelas*	Fathead minnow	Larva	7 d	IC10	Growth	83.9

[1] data source: (Draft Canadian Water Quality Guideline for the Protection of Aquatic Life

☐ (blue)   denotes a species or genus confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (green)   denotes a reasonable surrogate species is confirmed to be present (based on Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996)

☐ (orange)   denotes uncertainty of presence/absence of species or surrogate species in the area.

☐ (white)   absence of colour indicates genus unlikely to occur in the region or distribution unknown

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APPENDIX A

BIOLOGICAL DATA

Table A.1: Fish Species in Kudz Ze Kayah Project Vicinity[1] (Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996).

Family	Subfamily	Genus/Species	Common Name
Salmonidae			
	Salmoninae		
		Salvelinus namaycush	Lake trout
	Coregoninae		
		Prosopium williamsoni	Mountain whitefish
	Thaymallinae		
		Thymallus arcticus	Arctic grayling
Gadidae			
		Lota lota	Burbot
Cottidae			
		Cottus cognatus	Slimy sculpin

[1] Fish samples collected from locations at or near KZ-2, KZ-7, KZ-9, KZ-15, KZ16, KZ-21, KZ-26.

Table A.2: Benthic Invertebrate Species in Kudz Ze Kayah Project Vicinity[1] (Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996).

Phylum:	Subphylum	Class	Order	Family	Subfamily	Tribe	Genus/Species
Arthropoda							
	Hexapoda						
		Insecta					
			Ephemeroptera				
				Ameletidae			
							Ameletus
				Baetidae			
							Acentrella parvula
							Acentrella turbida
							Baetis
							Baetis bicaudatus
							Baetis tricaudatus group
				Ephemerellidae			
							Attenella sp.
							Drunella doddsii
							Drunella grandis group
							Drunella sp.
							Drunella spinifera
							Ephemerella
							Ephemerella velmae
				Heptageniidae			
							Cinygmula sp.
							Epeorus deceptivus
							Epeorus longimanus
							Epeorus
							Ironodes sp.
							Rhithrogena
			Plecoptera				
				Capniidae			
				Chloroperlidae			
							Haploperla sp.
							Paraperla sp.
							Suwallia
							Sweltsa sp.
				Leuctridae			
							Perlomyia sp.
				Nemouridae			
							Zapada
							Zapada cinctipes
							Zapada columbiana
							Zapada frigida
							Zapada oregonensis group
				Perlodidae			
				Taeniopterygidae			
							Taenionema
			Trichoptera				
				Brachycentridae			
							Brachycentrus americanus
							Brachycentrus occidentalis
							Micrasema
							Micrasema gelidum
				Glossosomatidae			
							Glossosoma
				Hydropsychidae			
							Parapsyche sp.
				Hydroptilidae			
							Oxyethira sp.
				Limnephilidae			
							Ecclisomyia sp.
				Rhyacophilidae			
							Rhyacophila
							Rhyacophila brunnea/vemna group
							Rhyacophila hyalinata group
							Rhyacophila vofixa group
				Uenoidae			
							Oligophlebodes
			Coleoptera				
				Elmidae			
							Heterlimnius sp.
			Diptera				
				Ceratopogonidae			
							Probezzia
				Chironomidae			
					Chironominae		
						Tanytarsini	
							Micropsectra
							Rheotanytarsus
							Stempellina sp.
							Tanytarsus
					Diamesinae		
						Diamesini	
							Diamesa
							Pagastia
							Potthastia longimana group
							Pseudodiamesa sp.

[1] Benthic invertebrate samples collected from KZ-2, KZ-7, KZ-9, KZ-15, KZ-16, KZ-17, KZ-21, KZ-26, KZ-27.

Table A.2: Benthic Invertebrate Species in Kudz Ze Kayah Project Vicinity[1] (Alexco 2015; Laberge and Can-Nic-a-Nic 2015; Cominco 1996).

Phylum:	Subphylum	Class	Order	Family	Subfamily	Tribe	Genus/Species
					Orthocladiinae		
							Brillia sp.
							Corynoneura
							Cricotopus
							Eukiefferiella
							Eukiefferiella claripennis group
							Eukiefferiella devonica group
							Heleniella sp.
							Hydrobaenus
							Krenosmittia sp.
							Orthocladius
							Parakiefferiella
							Rheocricotopus
							Thienemanniella
							Tvetenia
							Tvetenia bavarica group
							Tvetenia tshernovskii
						Corynoneurini	
							Corynoneura
							Thienemanniella
					Tanypodinae		
						Pentaneuriini	
							Thienemannimyia group
					Podonominae		
						Boreochlini	
							Boreochlus sp.
					Tanypodinae		
						Pentaneurini	
							Thienemannimyia group
				Empididae			
							Chelifera/ Metachela
							Clinocera sp.
							Oreogeton sp.
				Psychodidae			
							Pericoma/Telmatoscopus sp.
				Simuliidae			
							Helodon sp.
							Prosimulium
							Simulium
				Tipulidae			
							Antocha sp.
							Dicranota
							Gonomyodes sp.
	Chelicerata						
		Arachnida					
			Trombidiformes				
				Aturidae			
							Aturus
				Feltriidae			
							Feltria sp.
				Hygrobatidae			
							Atractides
							Hygrobates
				Lebertiidae			
							Lebertia
				Sperchontidae			
							Sperchon
							Sperchonopsis sp.
			Oribatei				
				Oribatidae			
							Oribatida
	Crustacea						
		Ostracoda					
		Branchiopoda					
			Cladocera				
		Maxillipoda					
		Copepoda					
Mullusca		Bivalvia					
		Gastropoda					
			Basommatophora				
				Planorbidae			*Gyraulus*
Annelida							
	Clitellata						
		Oligochaeta					
			Lumbriculida				
				Lumbriculidae			
			Tubificida				
				Enchytraeidae			
							Enchytraeus
Nematoda							
Platyhelminthes							
		Turbellaria					
Cnidaria							
		Hydrozoa					
			Anthoathecatae				
				Hydridae			
							Hydra

[1] Benthic invertebrate samples collected from KZ-2, KZ-7, KZ-9, KZ-15, KZ-16, KZ-17, KZ-21, KZ-26, KZ-27.

Table A.3: Periphyton Species in Kudz Ze Kayah Project Vicinity[1] (Alexco 2015).

Genus/Species	Genus/Species
Achnanthes flexella	Gomphonema clevei
Achnanthes hauckiana	Gomphonema gracile
Achnanthes lanceolata	Gomphonema olivaceum
Achnanthes linearis	Gomphonema subclavatum
Achnanthes minutissima	Gomphonema tenellum
Amphipleura pellucida	Hannaea arcus
Amphora ovalis	Melosira italica
Amphora perpusilla	Melosira varians
Anomoeoneis vitrea	Meridion circulare
Caloneis ventricosa	Navicula anglica
Caloneis ventricosa minuta	Navicula cryptocephala
Chlamydomonas sp.	Navicula cryptocephala veneta
Cocconeis placentula	Navicula gregaria
Cymbella affinis	Navicula minuscula
Cymbella cesatii	Navicula mutica
Cymbella cymbiformes	Navicula pupula
Cymbella lunata	Navicula radiosa
Cymbella microcephala	Navicula sp.
Cymbella minuta	Nitzschia acicularis
Cymbella sinuata	Nitzschia amphibia
Cymbella tumida	Nitzschia capitellata
Denticula elegans	Nitzschia constricta
Diatoma hiemale mesodon	Nitzschia dissipata
Diatoma tenue	Nitzschia frustulum
Diatoma tenue elongatum	Nitzschia palea
Diatoma vulgare	Nitzschia paleacea
Didymosphenia geminata	Oscillatoria sp.
Epithemia turgida	Pinnularia sp.
Eunotia pectinalis	Rhoicosphenia curvata
Fragilaria capucina mesolepta	Rhopalodia gibba
Fragilaria construens	Synedra radians
Fragilaria construens venter	Synedra rumpens
Fragilaria leptostauron	Synedra ulna
Fragilaria pinnata	Tabellaria fenestrata
Fragilaria vaucheria	Tabellaria flocculosa
Frustulia rhomboides	Ulothrix sp.
Gomphonema angustatum	

[1] Periphyton samples were collected from KZ-2, KZ-7, KZ- 9, KZ-13, KZ-15, KZ-16, KZ-17, KZ-21, KZ-22, KZ-26.

APPENDIX D.

Kudz Ze Kayah Project Water Quality Data for KZ-13, KZ-15, KZ-9 and KZ-26
(Alexco Environmental Group Inc.)

Station Name	Description	Sample Date	pH (field) pH units	pH (lab) pH units	Temperature (field) C	Hardness (from total) mg/L	Hardness (from dissolved) mg/L	Aluminum (Al), total mg/L	Ammonia (N) mg/L	Antimony (Sb), total mg/L	Arsenic (As), total mg/L	Cadmium (Cd), total mg/L	Chloride mg/L	Copper (Cu), total mg/L	Cyanide, total mg/L	Cyanide, Weak Acid Dissociable mg/L	Fluoride mg/L	Iron (Fe), total mg/L	Lead (Pb), total mg/L	Manganese (Mn), total mg/L	Mercury (Hg), total mg/L	Molybdenum (Mo), total mg/L	Nickel (Ni), total mg/L	Nitrate (N) mg/L	Nitrite (N) mg/L	Selenium (Se), total mg/L	Silver (Ag), total mg/L	Sulphate, dissolved mg/L	Thallium (Tl), total mg/L	Uranium (U), total mg/L	Zinc (Zn), total mg/L	Aluminum (Al), dissolved mg/L	Antimony (Sb), dissolved mg/L
CCME Guidelines - Protection of Aquatic Life			6.5-9.0	6.5-9.0				*	0.197		0.0050	*	120	*	0.0050		0.12	0.30	*		0.000026	0.073	*	3		0.001	0.00025		0.0008	0.015	0.03		
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals			6.5-9.0	6.5-9.0					0.197				120		0.0050		0.12	0.30	*		0.000026	0.073	*	3		0.001	0.00025		0.0008	0.015	0.03	*	
BC-MOE - Maximum Guidelines for Aquatic Life			6.5-9.0	6.5-9.0						0.0090				*	0.0050		1.000	*	*					0.002					*		*	*
KZ-13	South Creek near mouth	31-Aug-94		7.9		252	229	3.25			0.0069			0.022				9.43	0.258							0.0009		41.3			0.07	0.01	
KZ-13	South Creek near mouth	2-Dec-94		7.3		69.2	71.1		0.011										0.049				0.11				10.3					
KZ-13	South Creek near mouth	7-Apr-95		8		98.9	98.9	0.021	0.007		2.50E-05	5.00E-06		0.0004	0.0005	0.0005		0.15	0.0003	0.045	5.00E-06	0.0002	0.0005	0.15	0.0025	0.00016	5.00E-06	12.1			0.008	0.008	
KZ-13	South Creek near mouth	8-May-95		7		47.7	46.5	0.44	0.008		0.0004	0.0004		0.0021	0.0005	0.0005		0.085	5.00E-06	0.079	5.00E-06	0.0002	0.002	0.03	0.0025	2.50E-05	5.00E-06	5			0.008	0.07	
KZ-13	South Creek near mouth	11-Jun-95		7.1		47	46.5	0.15	0.0025		0.002	0.00002		0.001	0.0005	0.0005		0.25	0.0003	0.02		0.0002	0.0005	0.04	0.0025	2.50E-05	5.00E-06	6.6			0.019	0.026	
KZ-13	South Creek near mouth	23-Jul-95		7.4		61.1	61.1	0.036	0.0025		2.50E-05	0.00001		0.0006	0.0005	0.0005		0.091	0.0003	0.02	5.00E-06	0.0011	0.0005	0.01	0.0025	0.00035	5.00E-06	10.3			0.004	0.009	
KZ-13	South Creek near mouth	15-Aug-95		7.4		54.9	51.9	0.028	0.0025		2.50E-05	0.00001		0.0008		0.0005		0.082	0.0001	0.022	5.00E-06	0.0006	0.0005	0.05	0.0025	0.0001	5.00E-06	7			0.003	0.003	
KZ-13	South Creek near mouth	22-Aug-95		7.6		66.9	69.8	0.11	0.0025		0.0001	0.00003		0.0009	0.0005	0.0005		0.23	0.0002	0.039	5.00E-06	0.0002	0.001	0.01	0.0025	2.50E-05	5.00E-06	7.6			0.005	0.01	
KZ-13	South Creek near mouth	30-Aug-95		7		61.1	61.1	0.026	0.0025		0.00011	5.00E-06		0.0005	0.0005	0.0005		0.083	0.0001	0.021	5.00E-06	0.0005	0.0005	0.03	0.0025	0.0006	5.00E-06	5.9			0.004	0.009	
KZ-13	South Creek near mouth	6-Sep-95		7.4		63.6	64	0.034	0.007		2.50E-05			0.0005	0.0005	0.0005		0.09	0.0002	0.019	5.00E-06	0.0006	0.001	0.05	0.0025	2.50E-05	5.00E-06	7.5			0.004	0.011	
KZ-13	South Creek near mouth	13-Sep-95		7		69.8	66.9	0.037	0.0025		0.0001	0.00002		0.0008	0.0005	0.0005		0.1	0.0002	0.023	5.00E-06	0.0005	0.0005	0.06	0.0025	0.0009	5.00E-06	7.8			0.003	0.011	
KZ-13	South Creek near mouth	30-Apr-15	7.55	8.24	-0.1	113	111	0.0969	0.0074	2.50E-05	0.000291	0.0000359	1.2	0.00082	0.0005	0.00025	0.064	0.258	0.000196	0.0748	1.00E-06	0.000953	0.00065	0.0935	0.001	0.000236	0.0000128	13.7	0.0000051	0.00259	0.0038	0.00495	0.000046
KZ-13	South Creek near mouth	12-May-15	7.96	7.53	0.4	36.1	35.6	0.666	0.0063	2.50E-05	0.000639	0.000109	0.85	0.0026	0.00119	0.00116	0.033	1.34	0.00106	0.196	0.0000025	0.000545	0.00223	0.035		0.000133	0.000019	0.25	0.0000128	0.000844	0.0114	0.0341	1.00E-05
KZ-13	South Creek near mouth	13-May-15																															
KZ-13	South Creek near mouth	24-Jun-15	7.84	7.86	8.1	60.8	61.4	0.0293	0.0083	2.50E-05	0.000226	0.000197	0.73	0.00084		0.00025	0.043	0.0664	2.50E-05	0.016	1.00E-06	0.000548	0.00063	0.0175	0.001	0.000138	0.0000258	10.2	0.0000049	0.00041	0.0028	0.00784	0.000027
KZ-13	South Creek near mouth	29-Jul-15	7.96	7.78	10.3	70.8	70.5	0.0567	0.0102	0.000033	0.000276	0.0000275	0.25	0.000575	0.00061	0.0007	0.043	0.141	0.0000698	0.0455	1.00E-06	0.000595	0.0006	0.0198	0.001	0.000152	2.50E-06	11.6	0.0000023	0.00568	0.00353	0.00715	0.000028
KZ-13	South Creek near mouth	23-Aug-15	7.69	7.83	6.8	64.1	64.7	0.016	0.0025	2.50E-05	0.000236	0.000031	0.25	0.00103	0.0056		0.044	0.0697	2.50E-05	0.0197	1.00E-06	0.000496	0.00042	0.0378	0.001	0.000123	2.50E-06	14.2	0.000002	0.000456	0.0045	0.00683	0.000024
KZ-13	South Creek near mouth	11-Sep-15	7.92	8.02	5.3	68.7	70.9	0.0262	0.0025	0.000023	0.000206	0.000031	0.25	0.000561	0.0008		0.044	0.0704	0.000045	0.0158	1.00E-06	0.000488	0.000423	0.0246	0.001	0.000135	2.50E-06	12.4	1.00E-06	0.00054	0.00436	0.00873	0.000029
KZ-13	South Creek near mouth	14-Oct-15	7.75	7.89	1.5	76	73.4	0.0273	0.0134	0.00003	0.000185	0.000483	0.53	0.000483	0.0025	0.00025	0.039	0.0779	0.000047	0.0233	1.00E-06	0.000611	0.000395	0.0581	0.001	0.000198	2.50E-06	13.6	0.0000046	0.00592	0.00316	0.00592	0.000021
KZ-13	South Creek near mouth	6-Nov-15	7.79	8.07	-2	83.4	78.4	0.0347	0.025	0.000036	0.000218	0.000041	0.25	0.000521	0.00057	0.00025	0.044	0.103	0.000085	0.0376	1.00E-06	0.000676	0.00043	0.0793	0.001	0.000251	2.50E-06	16	1.00E-06	0.00804	0.00421	0.022	0.00003
KZ-13	South Creek near mouth	2-Dec-15	7.78	8.05	0.4	89.8	87.6	0.0273	0.0025	0.000034	0.000229	0.000034	0.25	0.0005	0.00025	0.00025	0.039	0.132	0.000052	0.042	1.00E-06	0.000633	0.000398	0.0855	0.001	0.000296	2.50E-06	15.4	1.00E-06	0.00107	0.00377	0.00487	0.00003
KZ-13	South Creek near mouth	21-Jan-16	7.6	7.99	0	88.8	89.4	0.0149	0.009	1.00E-05	0.00188	0.000045	0.57	0.000347	0.00063	0.0072	0.045	0.171	0.000042	0.0824	1.00E-06	0.000737	0.000362	0.154	0.001	0.000297	2.50E-06	13.8	1.00E-06	0.000861	0.00388	0.00357	1.00E-05
KZ-13	South Creek near mouth	8-Feb-16	7.51	7.99	0	84.9	87	0.0228	0.0066	1.00E-05	0.000307	0.000043	0.25	0.00633	0.00065		0.047	0.357	0.000101	0.115	1.00E-06	0.000696	0.000408	0.159	0.001	0.000304	2.50E-06	13.5	1.00E-06	0.000733	0.00509	0.00279	1.00E-05
KZ-13	South Creek near mouth	21-Mar-16	6.82	7.83	0.9	91.8	88.4	0.0136	0.051	1.00E-05	0.000193	0.00027	0.25	0.000269	0.00054	0.0025	0.044	0.221	0.000023	0.0945	1.00E-06	0.000755	0.000345	0.151	0.001	0.000328	2.50E-06	14.6	0.000002	0.000783	0.00255	0.00485	1.00E-05
KZ-13	South Creek near mouth	20-Apr-16	7.56	8.07	0.2	91	116	0.0072	0.0124	2.50E-05	0.000151	0.000021	0.25	0.0056	0.0025	0.0025	0.053	0.0823	2.50E-05	0.0246	1.00E-06	0.000664	0.00037	0.0808	0.001	0.000252	2.50E-06	14.5	1.00E-06	0.00154	0.0018	0.00688	0.000032
KZ-13	South Creek near mouth	16-May-16	7.53	7.99	2.4	56.5	59.4	0.02	0.0025	2.50E-05	0.00015	0.000015	0.54	0.00083	0.0053	0.0025	0.044	0.0758	2.50E-05	0.0136	1.00E-06	0.0005	0.00044	0.0344	0.001	0.000158	2.50E-06	8.17	1.00E-06	0.000402	0.0022	0.0108	0.00002
KZ-13	South Creek near mouth	14-Jun-16	7.99	7.98	9.7	61.5	61.5	0.081	0.0073	0.000055	0.000252	0.000039	0.54	0.000779	0.00107	0.0065	0.042	0.206	0.000204	0.0398	1.00E-06	0.000547	0.000519	0.0404	0.001	0.000142	0.000006	11.4	1.00E-06	0.000457	0.00502	0.00827	0.00002
KZ-13	South Creek near mouth	26-Jul-16	7.49	7.98	8.6	71.2	72.6	0.0343	0.024	0.000028	0.00026	0.000033	0.25	0.00088	0.0025	0.0055	0.043	0.119	0.000065	0.0382	1.00E-06	0.00057	0.00049	0.0287	0.001	0.000147	5.00E-06	12.8	0.000003	0.000605	0.0038	0.00754	0.000032
KZ-13	South Creek near mouth	28-Aug-16	7.75	7.95	6.1	68	64	0.0261	0.03	0.000023	0.000231	0.000034	0.72	0.000596	0.0025	0.0025	0.042	0.0877	0.000056	0.0175	1.00E-06	0.000462	0.000498	0.0452	0.001	0.000143	2.50E-06	11.5	0.000002	0.00049	0.00461	0.00879	0.000028
KZ-13	South Creek near mouth	6-Sep-16	7.62	7.96	7	60.6	63.4	0.0251	0.012	0.000026	0.000199	0.0003	0.25	0.000583	0.00071	0.0073	0.046	0.0675	0.000038	0.0144	1.00E-06	0.000448	0.000462	0.0412	0.001	0.000142	2.50E-06	12.8	0.000002	0.000494	0.0049	0.00853	0.000027
KZ-13	South Creek near mouth	3-Oct-16	7.7	7.66	1.1	70.9	69	0.0182	0.01	0.000028	0.000207	0.00003	0.25	0.000525	0.0025		0.046	0.0747	0.000058	0.0187	1.00E-06	0.000552	0.000164	0.0618	0.001	0.000164	2.50E-06	13.8	1.00E-06	0.000606	0.00425	0.00789	0.00003
Average			7.67	7.73	3.5	76.7	76.4	0.1854	0.0093	0.000026	0.000495	0.0000291	0.46	0.001747	0.00049	0.00049	0.044	0.4935	0.0001426	0.0508	0.0000022	0.000556	0.000644	0.0616	0.0015	0.00019	0.0000053	11.85	0.0000025	0.000786	0.00716	0.0117	0.000024
Count			19	30	19	30	30	29	29	19	29	28	19	29	27	28	19	29	28	30	27	28	28	29	27	29	28	30	19	19	29	29	19
Minimum			6.82	7	-2	36.1	35.6	0.0072	0.0025	0.00001	0.000025	0.000005	0.25	0.000269	0.00025	0.00025	0.033	0.0664	0.000023	0.0136	0.000001	0.0002	0.000345	0.01	0.001	0.000025	0.0000025	0.25	0.000001	0.000402	0.0018	0.00279	0.00001
Maximum			7.99	8.24	10.3	252	229	3.25	0.051	0.000055	0.0069	0.000109	1.2	0.022	0.00119	0.00116	0.064	9.43	0.00106	0.258	0.000005	0.0011	0.00223	0.159	0.0025	0.0009	0.0000258	41.3	0.0000128	0.00259	0.07	0.07	0.000046
Geometric Mean			7.67	7.72	2.1	71.7	71.7	0.0439	0.0063	0.000024	0.000193	0.0000241	0.4	0.000866	0.00043	0.00044	0.044	0.1461	0.0000846	0.0357	0.0000017	0.000513	0.000562	0.0478	0.0014	0.000139	0.0000041	9.9	0.0000018	0.000692	0.00473	0.00874	0.000022
Count <DL			0	0	0	0	0	0	0	11	9	4	2	10	18	18	0	0	5	0	26	4	6	2	27	4	24	1	10	0	0	0	4
Standard Deviation			0.26	0.36	3.9	37	33.9	0.6057	0.0103	0.0001	0.001282	0.0000192	0.27	0.004061	0.00025	0.00021	0.006	1.7348	0.0002012	0.0552	0.0000018	0.000205	0.000453	0.0446	0.0007	0.000165	0.0000054	6.64	0.0000028	0.000515	0.01253	0.01309	0.000009
1st Quartile			7.55	7.43	0.3	61.1	61.4	0.0228	0.0025	0.000024	0.00015	0.0000199	0.25	0.000521	0.00025	0.00025	0.042	0.082	0.0000443	0.0198	0.000001	0.000494	0.000422	0.03	0.001	0.000123	0.0000025	7.89	0.000001	0.000492	0.00353	0.00683	0.00002
Median			7.7	7.88	1.5	69	69.4	0.028	0.007	0.000025	0.000207	0.0000288	0.25	0.000779	0.0005	0.0005	0.044	0.1	0.0000674	0.0311	0.000001	0.00055	0.0005	0.0452	0.001	0.000147	0.0000038	11.85	0.000001	0.000606	0.004	0.00827	0.000027
3rd Quartile			7.81	7.99	6.9	84.5	84.8	0.0567	0.0102	0.000029	0.00026	0.0000345	0.57	0.0009	0.0055	0.00057	0.045	0.206	0.0002	0.0481	0.000005	0.000641	0.000607	0.0808	0.0025	0.000251	0.000005	13.78	0.0000027	0.000824	0.005	0.01	0.00003
95th Percentile			7.963	8.07	9.76	106.655	113.75	0.5756	0.0276	0.0000379	0.0014556	0.0000423	0.88	0.004838	0.000989	0.0007265	0.0541	9.468	0.0003	0.15955	0.0000058	0.0008837	0.00165	0.1528	0.0025	0.0003412	0.0000168	15.73	5.87E-06	0.001645	0.01596	0.03086	0.0000334
Mean + 2 Standard Deviation			8.19	8.45	11.3	150.7	144.2	1.3968	0.0299	0.000046	0.003059	0.0000675	1.00	0.009869	0.00099	0.00091	0.056	3.9631	0.000545	0.1612	0.0000058	0.000966	0.00155	0.1508	0.0029	0.00052	0.0000161	25.13	0.0000081	0.001816	0.03222	0.03788	0.000042
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	3-Dec-94		7.9		213	214		0.011									0.02				0.19				27.5					
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	5-Apr-95		7.9		271	285	0.007	0.0025		0.00024	0.00002		0.0002	0.0005	0.0005		0.035	0.0005	0.016	5.00E-06	0.0002	0.0005	0.2	0.0025	0.0011		32			0.008	0.011	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	8-May-95		7.3		89.7	29.8	0.1	0.006		0.0006	0.00002		0.002	0.0005	0.0005		0.34	5.00E-05	0.047		0.0002	0.002	0.03	0.0025	0.0003	5.00E-06	9.8			0.055	0.016	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-Jun-95		7.6		108	92.6	0.017	0.0025		0.0003	0.00002		0.001	0.0005	0.0005		0.059	0.0005	0.01		0.0002	0.0005	0.03	0.0025	2.50E-05	5.00E-06	15.8			0.005	0.01	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Jul-95		7.8		158	162	0.009	0.0025		2.50E-05	0.00001		0.0004	0.0005	0.0005		0.029	0.0002	0.0057	5.00E-06	0.0002	0.0005	0.01	0.0025	0.00033	5.00E-06	24.8			0.004	0.007	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	15-Aug-95		7.8		148	148	0.003	0.0025		0.00009	0.00001		0.0018		0.0005		0.042	5.00E-05	0.011	5.00E-06	0.0004	0.002	0.01	0.0025	0.0001	5.00E-06	25.5			0.004	0.003	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Aug-95		7.7		158	152	0.02	0.0025		0.0007	0.00002		0.0009	0.0005	0.0005		0.077	0.0001	0.019	5.00E-06	0.0002	0.001	0.03	0.0025	0.00047	5.00E-06	19.7			0.006	0.01	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	30-Aug-95		7.7		148	138	0.01	0.0025		0.00015	5.00E-06		0.0004	0.0005	0.0005		0.052	5.00E-05	0.015	5.00E-06	0.0002	0.001	0.01	0.0025	0.0005	5.00E-06	24.1			0.004	0.003	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	6-Sep-95		8		150	144	0.009	0.005		0.00011	0.00001		0.0004	0.0005	0.0005		0.044	5.00E-05	0.013		0.0002	0.0005	0.05	0.0025	0.0006	5.00E-06	23.8			0.003	0.01	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-Sep-95		7.9		155	162	0.011	0.0025		0.00026	0.0006		0.0008	0.0005	0.0005		0.04	0.0001	0.011	5.00E-06	0.0005	0.0011	0.05	0.0025	0.00011	5.00E-06	21.1			0.004	0.003	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Aug-02				132	143	0.01	0.0025									0.131		0.035				0.01	0.0025			21.3			0.0025	0.01	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Aug-04		8.2		179	185	0.035	0.02		0.0005	0.00007		0.001				0.186	0.00025	0.082				0.01	0.0025	0.0005		22.7	0.00216		0.005	0.002	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	24-Aug-06	8.1	8.1	7.2	140	140	0.007	0.006		0.0005	0.00002		0.0005				0.029	0.00025	0.008	5.00E-06		0.0005	0.04	0.0025	0.0005		18.6	0.001		0.0025	0.001	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	14-Aug-08	8.3	8.3	9.6	177	168	0.008	0.0025		0.0003	0.00002		0.0006				0.012	0.0002	0.003	1.00E-05		0.0005	0.06	0.0025	0.0006		22	0.0017		0.0025	0.015	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Aug-10	8.0	8.3	9.7	180	189	0.01	0.025		0.0004	0.00002		0.0003				0.066	0.0001	0.02	1.00E-05	0.001	0.0005	0.02	0.0025	0.0005		29	0.0023		0.0025	0.0015	
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	16-Aug-12	8.0	8.18	7.8	147	144	0.0183	0.006	0.000041	0.000462	0.0000674		0.000576				0.0931	0.0006	0.0272		0.000721	0.000483	0.032	0.0025	0.000687	2.50E-06	21.5	1.00E-06	0.00143	0.00202	0.00674	0.000033
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	21-Aug-14	7.79	8.22	8.5	163	163	0.00363	0.023	0.000038	0.000414	0.000022		0.000434				0.0418	0.000011	0.0146	1.00E-06	0.00108	0.000501	0.032	0.0025	0.000534	2.50E-06	25.8	1.00E-06	0.00216	0.00216	0.00212	0.00003
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	29-Apr-15	7.63	8.42	-0.1	255	270	0.00204	0.0199	0.000025	0.000371	0.0000329	0.25	0.000265	0.00025	0.00025	0.12	0.0357	0.0000102	0.0334	1.00E-06	0.00132	0.000946	0.164	0.001	0.0013	2.50E-06	35	0.0000085	0.00461	0.00322	0.00064	0.000037
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-May-15	7.71	7.67	-0.2	70.1	72.9	0.356	0.0025	2.50E-05	0.00318	0.000261	0.98	0.00342	0.00146	0.00137	0.042	2.07	0.000939	0.338	0.0000044	0.000667	0.00314	0.01		0.000283	0.0000238	0.25	0.0000085	0.000685	0.0229	0.0502	0.000027
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	12-May-15																															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-May-15																															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Jun-15	7.86	8.18	8.6	120	141	0.0163	0.0025	0.000033	0.0004	0.0000287	0.25	0.000531	0.00064	0.00055	0.073	0.104	0.0000561	0.0279	1.00E-06	0.000677	0.00044	0.0093	0.001	0.000434	2.50E-06	19.5	1.00E-06	0.00114	0.00288	0.00307	0.000037
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Jun-15																															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	28-Jul-15	7.94	8.08	10.1	157	156	0.0169	0.0025	0.000038	0.000433	0.0000229	0.25	0.000425	0.0005	0.00069	0.074	0.0917	0.0000233	0.023	1.00E-06	0.000854	0.000483	0.0153	0.001	0.00047	2.50E-06	23.1	1.00E-06	0.00171	0.00208	0.00168	0.000033
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Aug-15	7.81	8.05	7.7	141	140	0.0057	0.0059	2.50E-05	0.00038	0.000026	0.25	0.00072	0.00025	0.0025	0.065	0.0607	2.50E-05	0.0177	1.00E-06	0.000698	0.00043	0.0229	0.001	0.000474	2.50E-06	24.4	1.00E-06	0.00132	0.0035	0.00175	0.000031
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	9-Sep-15	8.19	8.17	6.2	140	146	0.00465	0.0025	0.000027	0.000398	0.00003	0.25	0.00044	0.00074	0.00062	0.064	0.0633	0.000021	0.0193	1.00E-06	0.000683	0.000385	0.0429	0.001	0.000657	2.50E-06	23.9	1.00E-06	0.00144	0.00281	0.00806	0.000028

Station Name	Description	Sample Date	pH (field) pH units	pH (lab) pH units	Temperature (field) C	Hardness (from total) mg/L	Hardness (from dissolved) mg/L	Aluminum (Al), total mg/L	Ammonia (N) mg/L	Antimony (Sb), total mg/L	Arsenic (As), total mg/L	Cadmium (Cd), total mg/L	Chloride mg/L	Copper (Cu), total mg/L	Cyanide, total mg/L	Cyanide, Weak Acid Dissociable mg/L	Fluoride mg/L	Iron (Fe), total mg/L	Lead (Pb), total mg/L	Manganese (Mn), total mg/L	Mercury (Hg), total mg/L	Molybdenum (Mo), total mg/L	Nickel (Ni), total mg/L	Nitrate (N) mg/L	Nitrite (N) mg/L	Selenium (Se), total mg/L	Silver (Ag), total mg/L	Sulphate, dissolved mg/L	Thallium (Tl), total mg/L	Uranium (U), total mg/L	Zinc (Zn), total mg/L	Aluminum (Al), dissolved mg/L	Antimony (Sb), dissolved mg/L
CCME Guidelines - Protection of Aquatic Life			6.5-9.0	6.5-9.0				*	0.197		0.0050	*	120	*	0.0050	0.12	0.30	*			0.000026	0.073	*	3		0.001	0.00025		0.0008	0.015	0.03		
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals			6.5-9.0	6.5-9.0					0.197				120		0.0050	0.12								3									
BC-MOE - Maximum Guidelines for Aquatic Life									0.0090					*	0.0050		1.000	*	*				*				0.002			*		*	*
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-Sep-15	8.03	8.07	7.2	143	148	0.00335	0.0093	0.000029	0.000408	0.000026	1.7	0.00042	0.00074	0.00074	0.067	0.0581	0.000014	0.0153	1.00E-06	0.000691	0.000401	0.0299	0.001	0.000701	2.50E-06	25.3	1.00E-06	0.00148	0.00247	0.00354	0.000032
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	14-Oct-15	7.76	8.21	0.8	178	175	0.0283	0.0101	0.000025	0.000561	0.000038	0.55	0.000417	0.00025	0.00025	0.069	0.141	0.0008	0.0335	1.00E-06	0.000851	0.000474	0.135	0.001	0.00117	2.50E-06	29.3	1.00E-06	0.00234	0.00417	0.00128	0.00003
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Nov-15	7.7	8.42	0	219	212	0.0103	0.0089	0.000041	0.000547	0.000038	0.25	0.000331	0.00025	0.00025	0.093	0.112	0.00223	0.0473	1.00E-06	0.000998	0.000064	0.188	0.001	0.0013	0.000021	33.1	1.00E-06	0.00312	0.00576	0.00411	0.000032
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	2-Dec-15	7.29	8.07	0.1	236	224	0.0103	0.0084	0.000033	0.000505	0.000038	0.59	0.000279	0.00025	0.00025	0.078	0.0764	0.00002	0.032	1.00E-06	0.00107	0.00065	0.194	0.001	0.00134	2.50E-06	31.9	1.00E-06	0.0036	0.00435	0.00051	0.000031
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Jan-16	7.18	8.19	0	271	282	0.00305	0.0358	0.000026	0.000531	0.000049	0.82	0.000305	0.0005	0.0005	0.1	0.0858	0.000031	0.0468	1.00E-06	0.00132	0.00183	0.209	0.001	0.00156	2.50E-06	36.7	1.00E-06	0.00498	0.00622	0.00185	0.000025
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	9-Feb-16	7.35	8.16	0	259	259	0.00964	0.0117	0.00003	0.000793	0.000054	0.55	0.000355	0.00025	0.00025	0.1	0.175	0.000091	0.0559	1.00E-06	0.00134	0.001	0.216	0.001	0.00135	2.50E-06	37.3	1.00E-06	0.00495	0.00755	0.00083	0.000027
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Mar-16	7.23	8.02	1	266	263	0.00909	0.0058	0.000044	0.00563	0.000044	0.52	0.000246	0.0005	0.0005	0.1	0.105	0.000033	0.0434	1.00E-06	0.0014	0.000942	0.217	0.001	0.00142	2.50E-06	36.5	1.00E-06	0.00514	0.00485	0.00261	0.000031
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Apr-16	7.81	8.17	0.5	238	286	0.005	0.0065	2.50E-05	0.000554	0.000036	0.62	0.00043	0.00025	0.00025	0.11	0.071	2.50E-05	0.0234	1.00E-06	0.00148	0.0086	0.145	0.001	0.00115	2.50E-06	34	1.00E-06	0.00477	0.0038	0.00124	0.000033
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	4-May-16	7.43	8.12	0.9	169	170	0.0125	0.0025	2.50E-05	0.000554	0.000031	1.1	0.00072	0.00025	0.00025	0.092	0.146	0.000062	0.0218	1.00E-06	0.00101	0.00075	0.0883	0.001	0.000742	2.50E-06	22.3	1.00E-06	0.00255	0.0034	0.00294	0.000033
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	15-May-16	7.85	8.18	3.9	121	118	0.0158	0.0025	2.50E-05	0.000398	0.000027	0.54	0.00098	0.0055	0.0053	0.074	0.108	2.50E-05	0.015	1.00E-06	0.000654	0.0058	0.0533	0.001	0.000434	2.50E-06	15.8	0.000003	0.00134	0.0018	0.0032	0.000023
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-Jun-16	8.01	8.09	9.3	131	132	0.0055	0.015	2.50E-05	0.000408	0.000019	0.74	0.0007	0.0068	0.0053	0.075	0.0554	2.50E-05	0.0107	1.00E-06	0.000842	0.0038	0.0123	0.001	0.000485	5.00E-06	22.5	1.00E-06	0.00132	0.002	0.0164	0.000039
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	26-Jul-16	7.84	8.2	8.5	137	135	0.00423	0.03	0.0003	0.000338	0.0002	0.25	0.000501	0.0069	0.0069		0.0411	0.000016	0.0153	1.00E-06	0.000756	0.000364	0.0119	0.001	0.000389	2.50E-06	23.2	1.00E-06	0.00121	0.00165	0.00172	0.00003
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	27-Aug-16	7.91	8.05	4.9	109	108	0.0271	0.11	0.00003	0.000473	0.000036	0.96	0.0011	0.00025	0.00025	0.052	0.126	0.000324	0.0251	1.00E-06	0.000474	0.000614	0.0221	0.001	0.000335	2.50E-06	22.6	1.00E-06	0.000713	0.00341	0.00556	0.000031
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	7-Sep-16	7.86	8.13	4.9	140	141	0.0265	0.015	0.000031	0.000473	0.000038	0.7	0.000657	0.00067	0.00069	0.06	0.149	0.00011	0.036	1.00E-06	0.000607	0.000573	0.0722	0.001	0.000643	2.50E-06	26.6	1.00E-06	0.00124	0.00496	0.00199	0.000032
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	1-Oct-16	7.86	8.25	-0.1	174	178	0.0118	0.099	0.000033	0.000481	0.000038	0.59	0.000432	0.0054	0.0084	0.078	0.0844	0.000049	0.0292	1.00E-06	0.000928	0.000485	0.164	0.001	0.00131	2.50E-06	32.1	0.000003	0.0022	0.00563	0.00156	0.00003
Average			7.78	8.05	4.5	168.2	168.8	0.0233	0.014	0.00003	0.000494	0.000058	0.61	0.000694	0.00049	0.0005	0.079	0.1415	0.0001856	0.0334	0.0000027	0.000733	0.000485	0.0746	0.0017	0.000661	0.0000045	24.75	0.0000015	0.002319	0.00572	0.00571	0.000031
Count			26	37	26	38	38	37	38	23	36	36	21	36	30	30	21	37	36	38	32	34	34	38	36	36	31	38	23	27	37	37	23
Minimum			7.18	7.3	-0.2	70.1	29.8	0.00204	0.0025	0.000025	0.000025	0.000025	0.25	0.0002	0.00025	0.00025	0.012	0.0000102	0.003	0.000001	0.0002	0.000364	0.0093	0.001	0.000025	0.0000025	13.3	0.000001	0.000685	0.00165	0.0005	0.000023
Maximum			8.3	8.42	10.1	271	286	0.356	0.11	0.000041	0.00318	0.00081	1.7	0.00342	0.00146	0.00137	0.12	2.07	0.00223	0.338	0.00001	0.00148	0.00314	0.217	0.0025	0.00156	0.0000238	37.3	0.0000085	0.00514	0.055	0.0502	0.000039
Geometric Mean			7.77	8.04	2.8	160.7	157.5	0.01088	0.007	0.00003	0.000387	0.0000308	0.51	0.000557	0.00044	0.0005	0.076	0.0789	0.0000696	0.0222	0.0000018	0.000614	0.000652	0.0429	0.0015	0.000475	0.0000035	21.79	0.0000012	0.001958	0.00398	0.00327	0.000031
Count <DL			0	0	0	0	0	2	16	6	3	1	7	0	19	18	0	0	11	0	31	8	8	6	36	3	29	1	20	0	4	5	0
Standard Deviation			0.29	0.23	4	51.5	58.4	0.05858	0.0233	0.000005	0.000488	0.0001353	0.37	0.000611	0.00025	0.00024	0.02	0.3314	0.0003968	0.0532	0.0000026	0.000385	0.0006	0.0743	0.0008	0.000445	0.0000049	7.45	0.0000016	0.001419	0.00903	0.00855	0.000004
1st Quartile			7.65	7.9	0.2	140	140.2	0.0057	0.0025	0.000025	0.000363	0.0002	0.25	0.0004	0.00025	0.00025	0.066	0.044	0.000025	0.015	0.000001	0.00048	0.000483	0.0165	0.001	0.000376	0.0000025	21.62	0.000001	0.00132	0.0025	0.00168	0.00003
Median			7.82	8.1	4.9	156	154	0.01	0.006	0.00003	0.000423	0.0000283	0.55	0.00047	0.0005	0.0005	0.074	0.0764	0.000531	0.0209	0.000001	0.000695	0.0005	0.036	0.001	0.0005	0.0000025	24	0.000001	0.00171	0.0038	0.003	0.000031
3rd Quartile			7.99	8.19	8.3	179.8	188	0.0169	0.0142	0.00003	0.000535	0.000038	0.74	0.00074	0.0006	0.006	0.093	0.112	0.0001325	0.0335	0.000001	0.000999	0.000833	0.1425	0.0025	0.001112	0.0000025	29.23	0.000001	0.002835	0.005	0.007	0.000033
95th Percentile			8.1675	8.324	9.675	266.75	282.45	0.048	0.04528	0.0000407	0.00072325	0.00011775	1.1	0.00185	0.00074	0.000795	0.11	0.2168	0.00060975	0.059815	0.00000725	0.001361	0.002	0.21005	0.0025	0.0013675	0.000013	36.53	0.000003	0.004971	0.01098	0.0152	0.000037
Mean + 2 Standard Deviation			8.36	8.51	12.5	271.2	285.6	0.14046	0.0606	0.00004	0.00147	0.0003286	1.35	0.001916	0.00099	0.00098	0.119	0.8043	0.0009792	0.1398	0.0000079	0.001503	0.001975	0.2232	0.0033	0.001551	0.0000143	39.65	0.0000047	0.005157	0.02378	0.02281	0.000039
KZ-26	Finlayson Creek at Robert Campbell Highway	5-Apr-95		8.2		310	310	0.011	0.0025		0.00034	0.0001		0.0003	0.0005	0.0005		0.031	0.0008	0.05	5.00E-06	0.0002	0.0005	0.26		0.0092	5.00E-06	42.8		0.0005	0.007		
KZ-26	Finlayson Creek at Robert Campbell Highway	8-May-95		7.6		126	29.7	0.11	0.007		0.0028	5.00E-06		0.002	0.0005	0.0005		1	5.00E-05	0.094	5.00E-06	0.0002	0.003	0.03	0.0025	0.0002	5.00E-06	16.3		0.0005	0.053	0.003	
KZ-26	Finlayson Creek at Robert Campbell Highway	11-Jun-95		8		157	136	0.11	0.0025		0.0008	0.00004		0.0019	0.0005	0.0005		0.29	0.0007	0.015	5.00E-06	0.0002	0.002	0.01	0.0025	2.50E-05	0.00063	19.1		0.009	0.015		
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Jul-95		8.1		226	217	0.011	0.0025		2.50E-05	5.00E-06		0.0006	0.0005	0.0005		0.032	0.0002	0.0037	5.00E-06	0.0002	0.005	0.04	0.0025	0.00037	5.00E-06	31.6		0.0005	0.006		
KZ-26	Finlayson Creek at Robert Campbell Highway	15-Aug-95		8.1		220	199	0.1	0.0025		0.00032	5.00E-06		0.0011	0.0005	0.0005		0.21	0.0004	0.0053	5.00E-06	0.0002	0.003	0.05		0.0001	0.00001	33.8		0.002	0.003		
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-95		8		220	222	0.11	0.0025		0.0004	0.00008		0.0016	0.0005	0.0005		0.27	0.0002	0.0077	5.00E-06	0.0002	0.001	0.01		0.0066	5.00E-06	30.8		0.003	0.008		
KZ-26	Finlayson Creek at Robert Campbell Highway	30-Aug-95		7.9		203	197	0.18	0.0025		0.00051	5.00E-06		0.0016	0.001	0.0005		0.47	0.0002	0.014	5.00E-06	0.0002	0.003	0.03		0.0007	5.00E-06	27.8		0.009	0.006		
KZ-26	Finlayson Creek at Robert Campbell Highway	6-Sep-95		8.2		197	194	0.047	0.009		0.00026	5.00E-06		0.0011	0.0005	0.0005		0.16	0.0002	0.0088	5.00E-06	0.0002	0.002	0.01		0.0006	5.00E-06	25.2		0.004	0.017		
KZ-26	Finlayson Creek at Robert Campbell Highway	13-Sep-95		8		217	212	0.022	0.036		0.00035	0.00001		0.001	0.0005	0.0005		0.098	5.00E-05	0.0041	5.00E-06	0.0002	0.005	0.03		0.0014	5.00E-06	30.9		0.002	0.023		
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Aug-02				183	197	0.03	0.0025									0.158		0.014				0.01	0.0025			26.5		0.0025	0.02		
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Aug-04		8.4		241	245	0.003	0.02		0.0005	0.00001		0.0006				0.01	0.00025	0.003				0.01	0.0025	0.0005		29.9		0.00229	0.0025	0.0005	
KZ-26	Finlayson Creek at Robert Campbell Highway	24-Aug-06	8.3	8.3	7.1	210	210	0.009	0.0025		0.0005	0.00001		0.0007				0.12	0.00025	0.009	5.00E-06			0.01	0.0025	0.0005		29		0.0018	0.0025	0.002	
KZ-26	Finlayson Creek at Robert Campbell Highway	14-Aug-08	8.5	8.3	9.5	233	222	0.01	0.0025		0.0008	0.00002		0.0006				0.09	0.0001	0.007	1.00E-06			0.01	0.0025	0.0005		30		0.0024	0.0025	0.004	
KZ-26	Finlayson Creek at Robert Campbell Highway	18-Aug-10	8.4	8.47	10.2	219	246	0.006	0.08		0.0004	5.00E-06		0.0005				0.021	0.0001	0.003	1.00E-05	0.001	0.0005	0.01	0.0025	0.0004		36		0.0022	0.0025	0.0015	
KZ-26	Finlayson Creek at Robert Campbell Highway	16-Aug-12	8.3	8.27	9.6	189	193	0.0307	0.011	0.000096	0.00128	0.00018		0.000693				0.174	0.000051	0.016		0.00104	0.00138	0.01	0.0025	0.000603	2.50E-06	28.7	1.00E-06	0.00195	0.0011	0.00603	0.000097
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-14	8.23	8.31	9.4	230	213	0.00532	0.019	0.000067	0.000659	0.0001		0.000476				0.0572	0.000008	0.00339	0.0000035	0.00114	0.0007	0.025	0.0025	0.000465	2.50E-06	29.8	1.00E-06	0.00231	0.00063	0.00104	0.000067
KZ-26	Finlayson Creek at Robert Campbell Highway	29-Apr-15	8.43	8.4	0.1	302	311	0.00243	0.0119	0.000063	0.000654	0.0000122	0.25	0.000314	0.00051	0.00025	0.13	0.094	0.0000105	0.00498	1.00E-06	0.00115	0.00082	0.201	0.001	0.000866	2.50E-06	47.6	1.00E-06	0.00376	0.00041	0.00061	0.000055
KZ-26	Finlayson Creek at Robert Campbell Highway	11-May-15	7.54	7.89	-0.3	107	109	0.144	0.0078	0.000068	0.00208	0.000058	1	0.00163	0.00108	0.00114	0.057	0.994	0.000237	0.0942	0.000003	0.000651	0.00239	0.01		0.000206		13.3	0.0000112	0.00937	0.0044	0.00908	0.00005
KZ-26	Finlayson Creek at Robert Campbell Highway	14-May-15																															
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Jun-15	8.18	7.9	7	178	182	0.101	0.0086	0.00014	0.00119	0.000031	0.97	0.00162	0.00025	0.00025	0.11	0.309	0.000221	0.0174	1.00E-06	0.00115	0.00183	0.0057	0.001	0.000426	0.0000133	27.8	0.0000043	0.00188	0.0024	0.00352	0.000101
KZ-26	Finlayson Creek at Robert Campbell Highway	29-Jul-15	8.24	8.24	8.4	213	222	0.0129	0.013	0.000098	0.00106	0.0000149	0.55	0.000675	0.0006	0.00067	0.12	0.134	0.0000272	0.0104	1.00E-06	0.00121	0.00146	0.0079	0.001	0.000484	2.50E-06	32.3	1.00E-06	0.00237	0.00086	0.00196	0.000094
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-15	8.05	8.11	5.8	176	179	0.141	0.0054	0.000156	0.00149	0.000019	0.25	0.00183	0.00025	0.00025	0.092	0.477	0.000241	0.0394	1.00E-06	0.000947	0.00249	0.0168	0.0026	0.000455	2.50E-06	29.9	0.000003	0.00163	0.0038	0.00764	0.000138
KZ-26	Finlayson Creek at Robert Campbell Highway	8-Sep-15	8.24	8.31	4	200	196	0.0201	0.0025	0.000102	0.00114	0.000019	0.88	0.000902	0.0099	0.0095	0.1	0.18	0.000058	0.0245	1.00E-06	0.000912	0.00165	0.009	0.001	0.000593	2.50E-06	31.1	1.00E-06	0.00204	0.00177	0.00583	0.000102
KZ-26	Finlayson Creek at Robert Campbell Highway	11-Sep-15																															
KZ-26	Finlayson Creek at Robert Campbell Highway	15-Oct-15	8.18	8.33	0.7	223	226	0.0107	0.0114	0.000076	0.000932	0.000011	0.73	0.00059	0.00025	0.00025	0.11	0.102	2.50E-05	0.00764	1.00E-06	0.00109	0.00094	0.0565	0.001	0.000689	2.50E-06	36.9	1.00E-06	0.00267	0.0011	0.00109	0.00007
KZ-26	Finlayson Creek at Robert Campbell Highway	18-Nov-15	8.45	8.32	0	258	268	0.00537	0.0025	0.000067	0.000509	0.00001	0.25	0.00049	0.00025	0.00025	0.12	0.0425	0.000013	0.00487	1.00E-06	0.000944	0.00744	0.101	0.001	0.000912	2.50E-06	40.9	1.00E-06	0.00289	0.00077	0.00677	0.000073
KZ-26	Finlayson Creek at Robert Campbell Highway	1-Dec-15	7.81	8.2	0	273	263	0.0008	0.0084	0.000064	0.000559	0.000005	0.59	0.000341	0.0051	0.00025	0.1	0.0166	2.50E-05	0.000649	1.00E-06	0.00109	0.000672	0.157	0.001	0.00116	2.50E-06	39.5	1.00E-06	0.00325	0.0028	0.0076	0.00006
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Jan-16																															
KZ-26	Finlayson Creek at Robert Campbell Highway	8-Feb-16	7.92	8.35	0	294	300	0.042	0.0099	0.000074	0.00193	0.000049	0.75	0.00107	0.00025	0.00025	0.11	0.57	0.000443	0.104	1.00E-06	0.000963	0.00157	0.252	0.001	0.000874	2.50E-06	46.1	1.00E-06	0.00355	0.00421	0.00072	0.000048
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Mar-16	7.77	8.29	-0.1	376	306	0.00821	0.0394	0.00006	0.000498	0.000011	0.55	0.000339	0.00025	0.0006	0.11	0.0694	0.000021	0.0071	1.00E-06	0.00104	0.000698	0.272	0.001	0.00133	2.50E-06	44.5	1.00E-06	0.00376	0.00053	0.0026	0.000066
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Apr-16	7.82	8.35	1.2	246	288	0.0078	0.0025	0.000067	0.00104	0.000011	0.52	0.00059	0.0052	0.0052	0.12	0.198	2.50E-05	0.0125	1.00E-06	0.00114	0.00114	0.115	0.001	0.000649	2.50E-06	39.8	1.00E-06	0.00309	0.005	0.00186	0.000064
KZ-26	Finlayson Creek at Robert Campbell Highway	3-May-16	7.87	8.23	2.0	207	204	0.0139	0.01	0.000081	0.00129	0.000021	1.2	0.00083	0.0007	0.0062	0.12	0.27	2.50E-05	0.0161	1.00E-06	0.00126	0.00128	0.0538	0.001	0.000535	2.50E-06	30.5	1.00E-06	0.00263	0.0012	0.0015	0.000084
KZ-26	Finlayson Creek at Robert Campbell Highway	14-May-16	8.17	8.48	7.9	215	225	0.0064	0.0025	0.000078	0.000725	0.000011	1.2	0.00067	0.0005	0.0005	0.14	0.0937	2.50E-05	0.00556	1.00E-06	0.00105	0.00089	0.028	0.001	0.000543	2.50E-06	37	1.00E-06	0.00245	0.005	0.00104	0.000045
KZ-26	Finlayson Creek at Robert Campbell Highway	13-Jun-16	8.08	8.29	7	201	202	0.0081	0.019	0.000067	0.000743	0.000013	0.8	0.0007	0.0073	0.0006	0.12	0.0687	2.50E-05	0.00667	1.00E-06	0.00104	0.0008	0.0303	0.0022	0.000496	5.00E-06	30.9	1.00E-06	0.00205	0.005	0.00085	0.000074
KZ-26	Finlayson Creek at Robert Campbell Highway	25-Jul-16	7.85	8.27	8.5	210	201	0.0793	0.028	0.000139	0.00159	0.000025	0.25	0.00141	0.00055	0.00025	0.11	0.309	0.000153	0.0219	1.00E-06	0.00104	0.00211	0.0166	0.001	0.000489	5.00E-06	36.4	0.000002	0.0019	0.0017	0.00576	0.000139
KZ-26	Finlayson Creek at Robert Campbell Highway	26-Aug-16	8.2	8.29	8.8	194	202	0.193	0.011	0.000125	0.00211	0.000041	0.96	0.00182	0.00025	0.00025	0.099	0.692	0.000338	0.0555	1.00E-06	0.000982	0.0025	0.0124	0.001	0.000401	5.00E-06	31.9	1.00E-06	0.00179	0.0045	0.00304	0.000091
KZ-26	Finlayson Creek at Robert Campbell Highway	6-Sep-16	7.89	8.25	5.6	186	194	0.0817	0.018	0.000103	0.00127	0.000024	1.1	0.00109	0.00083	0.0083	0.11	0.339	0.000199	0.0367	1.00E-06	0.000912	0.00179	0.0375	0.001	0.000569	5.00E-06	32.4	1.00E-06	0.00182	0.00252	0.00341	0.000092
KZ-26	Finlayson Creek at Robert Campbell Highway	30-Sep-16	8.06	8.36	0.2	199	210	0.036	0.17	0.000077	0.00107	0.000022	0.59	0.0084	0.0065	0.0079	0.11	0.229	0.000069	0.0255	0.0000023	0.000982	0.00121	0.0812	0.001	0.000846	5.00E-06	36.5	1.00E-06	0.00229	0.0019	0.00193	0.000071
Average			8.1	8.21	4.7	218	215.2	0.04885	0.0168	0.00009	0.00093	0.00002	0.71	0.000958	0.00052	0.0005	0.109	0.2394	0.0001682	0.020216	0.0000029	0.000799	0.001424	0.0577	0.0018	0.000532	0.0000257	32.4	0.0000016	0.002388	0.00375	0.00523	0.000082
Count			24	34	24	35	35	35	35	21	34	34	19	34	28	28	19	35	34	35	30	32	32	35	33	34	30	35	25	35	35	35	21
Minimum			7.54	7.6	-0.3	107	29.7	0.0008	0.0025	0.00006	0.000025	0.000005	0.25	0.0003	0.00025	0.00025	0.057	0.01	0.0000025	0.000649	0.000001	0.0002	0.0005	0.0057	0.001	0.000025	0.0000025	13.3	0.000001	0.000937	0.00028	0.0005	0.000048
Maximum			8.5	8.48	10.2	376	311	0.193	0.17	0.000159	0.0028	0.0008	1.2	0.002	0.00108	0.00114	0.14	1	0.0008	0.104	0.00001	0.00126	0.003	0.272	0.0026	0.00133	0.00063	47.6	0.0000043	0.00376	0.053	0.023	0.000139
Geometric Mean			8.1	8.2	2.8	213	204	0.02215	0.008	0.000086	0.000723	0.0000147	0.63	0.000829	0.00047	0.00045	0.107	0.1423	0.0000816	0.010937	0.000002	0.000647	0.001209	0.0286	0.0016	0.000411	0.0000047	31.4	0.0000014	0.00229	0.00174	0.00319	0.000079

Station Name	Description	Sample Date	pH (field)	pH (lab)	Temperature (field)	Hardness (from total)	Hardness (from dissolved)	Aluminum (Al), total	Ammonia (N)	Antimony (Sb), total	Arsenic (As), total	Cadmium (Cd), total	Chloride	Copper (Cu), total	Cyanide, total	Cyanide, Weak Acid Dissociable	Fluoride	Iron (Fe), total	Lead (Pb), total	Manganese (Mn), total	Mercury (Hg), total	Molybdenum (Mo), total	Nickel (Ni), total	Nitrate (N)	Nitrite (N)	Selenium (Se), total	Silver (Ag), total	Sulphate, dissolved	Thallium (Tl), total	Uranium (U), total	Zinc (Zn), total	Aluminum (Al), dissolved	Antimony (Sb), dissolved
			pH units	pH units	C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CCME Guidelines - Protection of Aquatic Life			6.5-9.0	6.5-9.0				*	0.197		0.0050	*	120	*	0.0050	0.12	0.30	*			0.000026	0.073	*	3		0.001	0.00025		0.0008	0.015	0.03		*
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals			6.5-9.0	6.5-9.0					0.197				120		0.0050	0.12							3									
BC-MOE - Maximum Guidelines for Aquatic Life			6.5-9.0	6.5-9.0							0.0090			*	0.0050		1.000	*		*						0.002					*	*	
Count <DL			0	0	0	0	0	0	13	0	3	6	4	0	16	18	0	0	12	0	27	9	5	10	31	3	25	0	14	0	10	4	0
Standard Deviation			0.25	0.19	4	50	55.3	0.05569	0.0306	0.000031	0.000614	0.0000173	0.32	0.000515	0.00024	0.00023	0.018	0.2494	0.0001899	0.026698	0.0000026	0.000395	0.000806	0.0771	0.0008	0.000305	0.0001142	7.5	0.000001	0.00069	0.00882	0.00558	0.000025
1st Quartile			7.88	8.1	0.2	196	196.5	0.00815	0.0025	0.000067	0.0005	0.00001	0.55	0.0006	0.00025	0.00025		0.0797	0.000025	0.00514	0.000001	0.0002	0.000733	0.01	0.0025	0.0004	0.0000025	29.4	0.000001	0.0019	0.0007	0.0015	0.000066
Median			8.18	8.27	5.8	213	210	0.0201	0.0086	0.000077	0.000772	0.0000126	0.73	0.000765	0.0005	0.0005	0.11	0.16	0.0001	0.009	0.000001	0.000982	0.001245	0.028	0.0022	0.0005	0.0000038	31.1	0.000001	0.00229	0.002	0.00304	0.000074
3rd Quartile			8.26	8.32	8.4	232	235.5	0.09085	0.0155	0.000102	0.00125	0.0000242	0.96	0.001332		0.0006	0.12	0.2995	0.000233	0.01965	0.000005	0.001075	0.002	0.0552	0.0025	0.000664	0.000005	36.7		0.00267	0.00276	0.064	0.000094
95th Percentile			8.447	8.4245	9.585	304.4	307.2	0.1548	0.05158	0.000156	0.0020905	5.215E-05	1.2	0.0018545	0.0009965	0.000908	0.131	0.7826	0.00053295	0.09406	7.75E-06	0.001177	0.003	0.2544	0.0025	0.001004	0.000016985	44.98	0.000003	0.003718	0.009	0.0179	0.000138
Mean + 2 Standard Deviation			8.6	8.59	12.7	318	325.8	0.16023	0.078	0.000152	0.002158	0.0000546	1.35	0.001988	0.001	0.00096	0.145	0.7382	0.000548	0.073612	0.0000081	0.001589	0.003036	0.2119	0.0034	0.001142	0.0002541	47.4	0.0000036	0.003768	0.02139	0.01639	0.000132
KZ-9	Lower Geona Creek	18-Jul-94		7.6		109		0.03						0.001				0.26	0.026							0.00025		21.8			0.005		
KZ-9	Lower Geona Creek	31-Aug-94		7.5		161	160	0.03						0.001				0.51	0.057							0.0005		20.9			0.005	0.01	
KZ-9	Lower Geona Creek	3-Dec-94		7.3		190	196		0.025								0.096							0.18				28.4					
KZ-9	Lower Geona Creek	5-Apr-95		7.6		214	209	0.012	0.018		0.00026	0.00002		0.0004	0.0005	0.0005		0.59	0.0001	0.15	5.00E-06	0.0002	0.001	0.2	0.0025	0.0011	5.00E-06	23.9			0.013	0.012	
KZ-9	Lower Geona Creek	11-Jun-95		7.7		118	115	0.023	0.0025		0.0006	0.00003		0.001	0.0005	0.0005		0.17	0.0005	0.026	5.00E-06	0.0002	0.0005	0.01	0.0025	2.50E-05	5.00E-06	18.9			0.007	0.014	
KZ-9	Lower Geona Creek	22-Aug-95		8		165	164	0.045	0.0025		0.0009	0.00004		0.0006	0.0005	0.0005		0.42	0.0002	0.1	5.00E-06	0.0002	0.0005	0.04	0.0025	2.50E-05	5.00E-06	20.5			0.009	0.012	
KZ-9	Lower Geona Creek	13-Sep-95		7.9			170		0.0025						0.0005	0.0005								0.04	0.0025			25.7				0.03	
KZ-9	Lower Geona Creek	23-Aug-02				147	157	0.02	0.0025									0.279		0.062				0.01	0.0025			25.3			0.006	0.01	
KZ-9	Lower Geona Creek	19-Aug-04		8.2		196	203	0.01	0.022		0.001	0.00004		0.0005				0.213	0.00025	0.087				0.03	0.0025	0.0005		22.7		0.00201	0.0025	0.002	
KZ-9	Lower Geona Creek	24-Aug-06	8	8	5.2	180	180	0.007	0.0025		0.0005	0.00003		0.0004				0.081	0.00025	0.021	5.00E-06			0.02	0.0025	0.0005		24.8			0.0025	0.001	
KZ-9	Lower Geona Creek	14-Aug-08	8.3	8.1	7.5	188	171	0.025	0.0025		0.0004	0.001		0.0007				0.373	0.0019	0.055	1.00E-05	0.0005	0.0005	0.05	0.0025	0.0006		23			0.009	0.007	
KZ-9	Lower Geona Creek	19-Aug-10	7.4	8.02	8.6	154	179	0.008	0.12		0.0002			0.0004				0.564	0.0001	0.081	1.00E-05	0.0005	0.0005	0.02	0.0025	0.0004		26			0.006	0.0015	
KZ-9	Lower Geona Creek	16-Aug-12	7.5	8.01	6.4	130	145	0.0197	0.0051	0.000064	0.000236	0.000058		0.000605				0.311	0.000068	0.0497		0.00049	0.000391	0.028	0.0025	0.000647	2.50E-06	25.5	1.00E-06	0.000668	0.0109	0.00556	0.00006
KZ-9	Lower Geona Creek	21-Aug-14	7.97	8.16	7.1	172	167	0.0218	0.019	0.000051	0.00108	0.000057		0.000503				0.307	0.00007	0.0926	1.00E-06	0.0014	0.00058	0.033	0.0025	0.000673	2.50E-06	25.2	1.00E-06	0.00169	0.00771	0.002	0.00005
KZ-9	Lower Geona Creek	30-Apr-15	8	7.73	-0.2	208	216	0.0117	0.0241	0.00003	0.000387	0.0000637	0.25	0.000369	0.0025	0.0025	0.097	0.486	0.000112	0.15	1.00E-06	0.000078	0.00156	0.116	0.0023	0.00104	2.50E-06	29.4	1.00E-06	0.00156	0.00905	0.00345	0.000056
KZ-9	Lower Geona Creek	11-May-15	7.59	7.52	-0.2	54	50.5	0.689	0.01	0.000058	0.00192	0.000378	1	0.00469	0.00151	0.00146	0.032	5.2	0.00247	0.234	0.0000033	0.000435	0.00271	0.01		0.000303	0.0000284	0.25	0.0000125	0.000359	0.0479	0.0556	0.000037
KZ-9	Lower Geona Creek	13-May-15																															
KZ-9	Lower Geona Creek	23-Jun-15	7.48	8.1	12	186	134	0.0626	0.0085	0.00006	0.000455	0.000084	0.72	0.00105	0.0025	0.0025	0.057	0.866	0.000482	0.0434	1.00E-06	0.000471	0.000481	0.0115	0.001	0.000973	0.0000107	25.8	1.00E-06	0.000624	0.0137	0.00228	0.000063
KZ-9	Lower Geona Creek	24-Jun-15																															
KZ-9	Lower Geona Creek	29-Jul-15	7.52	7.9	9	159	156	0.026	0.01	0.000063	0.000303	0.0000703	0.25	0.000542	0.00025	0.00068	0.066	0.431	0.0000966	0.0549	1.00E-06	0.000563	0.000475	0.034	0.001	0.00064	2.50E-06	28.2	1.00E-06	0.000989	0.0098	0.00165	0.000066
KZ-9	Lower Geona Creek	23-Aug-15	7.46	7.95	6.6	144	146	0.0142	0.0025	0.000063	0.000279	0.000069	0.25	0.00096	0.0025	0.00025	0.066	0.266	0.000067	0.0405	1.00E-06	0.000576	0.00036	0.0387	0.002	0.0069	2.50E-06	31	0.000002	0.000861	0.0103	0.00178	0.000057
KZ-9	Lower Geona Creek	10-Sep-15	7.6	8.13	5.7	169	167	0.0346	0.0025	0.00007	0.000427	0.000105	0.25	0.000879	0.00071	0.00077	0.059	0.466	0.000227	0.0431	1.00E-06	0.00054	0.00132	0.0453	0.001	0.000967	2.50E-06	33.8	0.000002	0.00123	0.0202	0.00452	0.000061
KZ-9	Lower Geona Creek	15-Oct-15	7.31	8.05	0	181	176	0.0227	0.0185	0.000052	0.000357	0.000092	0.56	0.000514	0.00025	0.00053	0.064	0.548	0.000165	0.0609	1.00E-06	0.000661	0.000656	0.139	0.001	0.00144	2.50E-06	32.2	1.00E-06	0.00144	0.0186	0.00121	0.000044
KZ-9	Lower Geona Creek	20-Nov-15	8.71	8.15	0	186	192	0.0194	0.0194	0.000043	0.000377	0.000097	0.52	0.000359	0.00025	0.00025	0.079	1.11	0.000078	0.0888	1.00E-06	0.000623	0.000414	0.171	0.001	0.00126	2.50E-06	34.2	1.00E-06	0.00148	0.0212	0.00286	0.000039
KZ-9	Lower Geona Creek	2-Dec-15	7.05	7.75	0	199	186	0.0226	0.0234	0.000041	0.00037	0.000082	0.25	0.000341	0.00025	0.00025	0.068	1.18	0.00006	0.0898	1.00E-06	0.000641	0.000415	0.175	0.001	0.00124	2.50E-06	31.5	1.00E-06	0.00164	0.02	0.001	0.000036
KZ-9	Lower Geona Creek	20-Jan-16	7.21	8	0	228	219	0.00854	0.0339	0.000025	0.000416	0.000074	0.98	0.000263	0.00055	0.00065	0.088	1.54	0.000056	0.127	1.00E-06	0.000703	0.00051	0.199	0.001	0.00129	2.50E-06	34.1	1.00E-06	0.00178	0.0171	0.00202	0.000024
KZ-9	Lower Geona Creek	9-Feb-16	7.01	7.9	0	214	203	0.0193	0.0172	0.000032	0.000682	0.000085	0.87	0.000381	0.00025	0.00025	0.086	2.81	0.000196	0.135	1.00E-06	0.000739	0.000552	0.191	0.001	0.00116	2.50E-06	34.1	1.00E-06	0.00183	0.017	0.0008	0.000024
KZ-9	Lower Geona Creek	20-Mar-16	6.97	8.14	0.8	239	250	0.00272	0.0025	0.000032	0.000117		0.55	0.000069	0.00025	0.00025	0.061	0.0028	0.000033	0.00198	1.00E-06	0.00145	0.000102	0.507	0.001	0.00307	2.50E-06	41.7	1.00E-06	0.00313	0.00171	0.00315	0.00002
KZ-9	Lower Geona Creek	20-Apr-16	7.31	8.04	0.7	153	188	0.0225	0.0188	2.50E-05	0.000304	0.000073	1.1	0.00061	0.0051	0.00025	0.069	0.476	0.00012	0.0852	1.00E-06	0.000564	0.0005	0.123	0.001	0.000695	2.50E-06	26.4	1.00E-06	0.00122	0.0101	0.00267	0.000035
KZ-9	Lower Geona Creek	4-May-16	7.31	7.84	2.6	121	116	0.0422	0.0171	2.50E-05	0.00038	0.000076	1.1	0.00124	0.00066	0.00025	0.065	0.527	0.000283	0.0573	1.00E-06	0.000571	0.0007	0.0571	0.001	0.000627	2.50E-06	16.6	0.000002	0.000851	0.0134	0.0051	0.000046
KZ-9	Lower Geona Creek	19-May-16	7.33	8.16	4	105	122	0.175	0.021	0.000054	0.000483		0.53	0.00174	0.00057	0.00025	0.07	0.671	0.000585	0.0402	1.00E-06	0.000415	0.00083	0.0355	0.001	0.000529	5.00E-06	22.1	0.000003	0.000635	0.0157	0.00437	0.000058
KZ-9	Lower Geona Creek	14-Jun-16	7.1	8.07	7.9	132	127	0.0291	0.022	0.000063	0.000267	0.000056	0.25	0.000677	0.00107	0.00144	0.056	0.328	0.000159	0.0379	1.00E-06	0.000497	0.000361	0.0274	0.001	0.000611	0.000007	29.5	1.00E-06	0.000802	0.0114	0.00114	0.000053
KZ-9	Lower Geona Creek	27-Jul-16	7.19	8.22	8.4	145	147	0.0139	0.035	0.000064	0.000256	0.000062	0.54	0.000078		0.0025	0.05	0.287	0.000076	0.0414	1.00E-06	0.000517	0.00035	0.0274	0.001	0.000615	0.000006	33.3	0.000002	0.000778	0.0106	0.00092	0.000054
KZ-9	Lower Geona Creek	27-Aug-16	7.79	8.05	6.8	123	128	0.216	0.1	0.000117	0.000925	0.000145	0.71	0.00291	0.00025	0.00025	0.054	0.804	0.000233	0.0487	1.00E-06	0.000438	0.00089	0.0197	0.0023	0.000655	0.000017	30.3	0.000006	0.000657	0.0343	0.00581	0.00007
KZ-9	Lower Geona Creek	7-Sep-16	7.52	7.97	5.8	150	157	0.0357	0.036	0.000051	0.000268	0.000104	0.77	0.00108		0.0007	0.062	0.265	0.000229	0.029	1.00E-06	0.000496	0.000489	0.0902	0.001	0.00104	2.50E-06	35.7	0.000006	0.000657	0.026	0.00321	0.000054
KZ-9	Lower Geona Creek	4-Oct-16	7.5	7.95	-0.1	172	162	0.0405	0.017	0.00004	0.000371	0.000155	0.92	0.000789	0.00025	0.00025	0.067	0.583	0.000266	0.06	1.00E-06	0.000572	0.000504	0.173	0.001	0.00138	2.50E-06	33.3	1.00E-06	0.00134	0.0332	0.00227	0.000053
Average			7.49	7.93	4.2	163	165.4	0.05499	0.0207	0.000051	0.000501	0.0001143	0.62	0.000882	0.00047	0.0049	0.066	0.7164	0.0003975	0.07189	0.0000023	0.000581	0.000639	0.0882	0.0017	0.000821	0.0000051	26.94	0.0000021	0.001245	0.0139	0.00668	0.000049
Count			25	33	25	33	33	32	32	22	29	29	20	31	24	24	20	32	29	33	27	27	27	32	30	31	25	34	22	26	32	32	22
Minimum			6.97	7.3	-0.2	54	50.5	0.00272	0.0025	0.00002	0.000117	0.00001	0.25	0.000069	0.00025	0.00025	0.032	0.0028	0.000033	0.00198	0.000001	0.0002	0.000102	0.01	0.001	0.000025	0.000002	16.6	0.000001	0.000359	0.00171	0.0008	0.00002
Maximum			8.71	8.22	12	239	250	0.689	0.12	0.000117	0.00192	0.001	1.1	0.00469	0.00151	0.00146	0.097	5.2	0.00247	0.234	0.00001	0.00145	0.00271	0.507	0.0025	0.00307	0.0000284	41.7	0.0000125	0.00313	0.0479	0.0556	0.00007
Geometric Mean			7.48	7.93	3	158	160.1	0.02532	0.0117	0.000046	0.000418	0.0000758	0.54	0.00066	0.0004	0.00041	0.064	0.4227	0.0001891	0.05686	0.0000016	0.000526	0.000544	0.0504	0.0015	0.000612	0.0000038	23.69	0.0000015	0.001123	0.01082	0.00361	0.000046
Count <DL			0	0	0	0	0	0	2	9	1	0	6	2	16	16	0	0	3	0	26	5	4	4	27	5	21	1	14	0	4	3	0
Standard Deviation			0.41	0.23	3.8	39	37.8	0.12392	0.0257	0.000021	0.000367	0.0001822	0.31	0.000881	0.00031	0.0034	0.014	0.9694	0.0006542	0.04678	0.0000026	0.000281	0.000476	0.1019	0.0007	0.000561	0.0000059	7.26	0.0000026	0.000584	0.01014	0.01065	0.000014
1st Quartile			7.21	7.84	0	144	146	0.01413	0.0025	0.000034	0.000279	0.000056	0.25	0.0004	0.00025	0.00025	0.058	0.285	0.000078	0.0414	0.000001	0.000481	0.000445	0.0255	0.001	0.000514	0.0000025	23.23	0.000001	0.000814	0.00753	0.00176	0.000037
Median			7.46	8	5.2	165	167	0.02265	0.0176	0.000051	0.00038	0.000073	0.56	0.00061	0.00038	0.0038	0.065	0.471	0.000165	0.0573	0.000001	0.00054	0.0005	0.0393	0.001	0.000655	0.0000025	26.2	0.000001	0.001225	0.01075	0.003	0.000053
3rd Quartile			7.59	8.1	7.1	188	188	0.03488	0.0223	0.000063	0.0005	0.000092	0.88	0.00056		0.00056	0.069	0.6102	0.000266	0.0898	0.0000022	0.000632	0.000661	0.147	0.0025	0.00107	0.0000025	32.03	0.000001	0.001545	0.01748	0.00611	0.00006
95th Percentile			8.24	8.176	8.92	219.6	217.2	0.19345	0.0648	0.0000697	0.001048	0.0002888	1.1	0.002325	0.001016	0.0013395	0.08845	2.1115	0.002158	0.15	0.0000085	0.0012017	0.001224	0.19945	0.0025	0.00141	0.0001574	34.725	0.00000585	0.001965	0.033695	0.0212	0.0000659
Mean + 2 Standard Deviation			8.31	8.39	11.8	241	241	0.30283	0.0721	0.000093	0.001235	0.0004787	1.24	0.002644	0.00109	0.00117	0.094	2.6552	0.0017059	0.16545	0.0000075	0.001143	0.001591	0.292	0.0031	0.001943	0.0000169	41.46	0.0000073	0.002413	0.03418	0.02798	0.000077

Station Name	Description	Sample Date	Antimony (Sb), dissolved mg/L	Arsenic (As), dissolved mg/L	Cadmium (Cd), dissolved mg/L	Copper (Cu), dissolved mg/L	Iron (Fe), dissolved mg/L	Lead (Pb), dissolved mg/L	Manganese (Mn), dissolved mg/L	Mercury (Hg), dissolved mg/L	Molybdenum (Mo), dissolved mg/L	Nickel (Ni), dissolved mg/L	Selenium (Se), dissolved mg/L	Silver (Ag), dissolved mg/L	Thallium (Tl), dissolved mg/L	Uranium (U), dissolved mg/L	Zinc (Zn), dissolved mg/L
CCME Guidelines - Protection of Aquatic Life																	
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals				0.0050	*	*	0.30	*		0.000026	0.073	*	0.0010	0.00025	0.00080	0.015	0.030
BC-MOE - Maximum Guidelines for Aquatic Life					*	*	0.35	*									*
KZ-13	South Creek near mouth	31-Aug-94		0.0016		0.0005	0.694		0.051				0.00025				0.001
KZ-13	South Creek near mouth	2-Dec-94							0.021								
KZ-13	South Creek near mouth	7-Apr-95		2.50E-05	0.00001	0.0004	0.069	0.0014	0.038	5.00E-06	0.0002	0.0005	0.00015	5.00E-06			
KZ-13	South Creek near mouth	8-May-95		0.0002	0.00002		0.29	0.0004	0.046	5.00E-06	0.0002		2.50E-05	5.00E-06			
KZ-13	South Creek near mouth	11-Jun-95		0.0001	0.00001	0.0007	0.047	0.0002	0.0067		0.0006	0.0005	2.50E-05	5.00E-06			0.003
KZ-13	South Creek near mouth	23-Jul-95		2.50E-05	5.00E-06	0.0006	0.034	0.0002	0.016	5.00E-06	0.0008	0.0005	0.00032	5.00E-06			0.004
KZ-13	South Creek near mouth	15-Aug-95		2.50E-05	5.00E-06	0.0004	0.03	5.00E-05	0.013	5.00E-06	0.0006	0.0005	0.0001	5.00E-06			0.003
KZ-13	South Creek near mouth	22-Aug-95		0.00011	0.00001	0.0006	0.049	5.00E-05	0.013	5.00E-06	0.0002	0.0005	2.50E-05	5.00E-06			0.003
KZ-13	South Creek near mouth	30-Aug-95		0.00009	5.00E-06	0.0005	0.028	5.00E-05	0.013	5.00E-06	0.0004		0.00005	5.00E-06			0.002
KZ-13	South Creek near mouth	6-Sep-95		2.50E-05	5.00E-06	0.0005	0.32	5.00E-05	0.012	5.00E-06	0.0004	0.0005	2.50E-05	5.00E-06			0.002
KZ-13	South Creek near mouth	13-Sep-95		0.0006	0.00002	0.0007	0.035	0.0003	0.013	5.00E-06	0.0004	0.0005	0.00015	5.00E-06			0.002
KZ-13	South Creek near mouth	30-Apr-15		0.000219	0.00001	0.000327	0.0271	0.0000051	0.0108	1.00E-06	0.000939	0.000427	0.000237	2.50E-06	1.00E-06	0.00244	0.00099
KZ-13	South Creek near mouth	12-May-15		0.000253	0.0000107	0.00086	0.0961	0.0000161	0.000376	0.0000023	0.000403	0.000779	0.000106	2.50E-06	0.0000023	0.00033	0.0012
KZ-13	South Creek near mouth	13-May-15															
KZ-13	South Creek near mouth	24-Jun-15		0.000193	0.0000121	0.000775	0.0247	0.000006	0.00601	1.00E-06	0.000527	0.000466	0.000124	2.50E-06	1.00E-06	0.000396	0.00158
KZ-13	South Creek near mouth	29-Jul-15		0.000249	0.0000175	0.000435	0.0311	2.50E-06	0.0168	1.00E-06	0.000566	0.000492	0.000138	2.50E-06	0.0000024	0.000565	0.00179
KZ-13	South Creek near mouth	23-Aug-15		0.000193	0.000014	0.000474	0.0198	2.50E-06	0.00842	1.00E-06	0.000491	0.000392	0.000138	2.50E-06	1.00E-06	0.000403	0.00233
KZ-13	South Creek near mouth	11-Sep-15		0.000196	0.000024	0.000484	0.0187	0.000006	0.00609	1.00E-06	0.000485	0.000412	0.000153	2.50E-06	1.00E-06	0.000521	0.00297
KZ-13	South Creek near mouth	14-Oct-15		0.000162	0.000015	0.000436	0.0186	2.50E-06	0.00972	1.00E-06	0.000566	0.000341	0.000176	2.50E-06	1.00E-06	0.000649	0.00203
KZ-13	South Creek near mouth	6-Nov-15		0.000172	0.000022	0.000571	0.0291	0.000046	0.0226	1.00E-06	0.000714	0.000358	0.000248	2.50E-06	0.000002	0.000781	0.00261
KZ-13	South Creek near mouth	2-Dec-15		0.000156	0.000015	0.000385	0.0417	2.50E-06	0.0226	1.00E-06	0.000664	0.000351	0.000306	2.50E-06	1.00E-06	0.000939	0.00142
KZ-13	South Creek near mouth	21-Jan-16		0.000123	0.000027	0.000272	0.0305	0.000005	0.0575	1.00E-06	0.000755	0.000291	0.000277	2.50E-06	1.00E-06	0.000788	0.00243
KZ-13	South Creek near mouth	8-Feb-16		0.000132	0.000026	0.000282	0.0373	0.000012	0.0636	1.00E-06	0.000765	0.000308	0.000311	2.50E-06	1.00E-06	0.000684	0.00298
KZ-13	South Creek near mouth	21-Mar-16		0.000122	0.00002	0.000238	0.0411	0.000006	0.08	1.00E-06	0.000763	0.000318	0.000308	2.50E-06	0.000002	0.000784	0.00197
KZ-13	South Creek near mouth	20-Apr-16		0.000196	0.00002	0.000439	0.0677	0.000006	0.0298	1.00E-06	0.00077	0.000455	0.000274	2.50E-06	1.00E-06	0.002	0.00183
KZ-13	South Creek near mouth	16-May-16		0.000155	0.000012	0.000634	0.0369	0.000007	0.00559	1.00E-06	0.000499	0.000451	0.000123	0.000005	0.000004	0.000355	0.00165
KZ-13	South Creek near mouth	14-Jun-16		0.000161	0.000013	0.000423	0.0123	2.50E-06	0.00136	1.00E-06	0.000528	0.000336	0.000115	0.000005	0.000003	0.000418	0.00137
KZ-13	South Creek near mouth	26-Jul-16		0.000226	0.000008	0.000472	0.0171	2.50E-06	0.000187	1.00E-06	0.000549	0.000358	0.00012	2.50E-06	0.000002	0.000593	0.00096
KZ-13	South Creek near mouth	28-Aug-16		0.000202	0.000015	0.000558	0.0215	0.000019	0.00566	1.00E-06	0.000463	0.000439	0.000128	2.50E-06	1.00E-06	0.000473	0.00315
KZ-13	South Creek near mouth	6-Sep-16		0.00016	0.000019	0.000537	0.0153	0.000005	0.00269	1.00E-06	0.000457	0.000438	0.000131	2.50E-06	0.000002	0.000478	0.00309
KZ-13	South Creek near mouth	3-Oct-16		0.000188	0.000021	0.000455	0.0195	0.000005	0.00288	1.00E-06	0.000544	0.00039	0.000148	2.50E-06	0.000002	0.000604	0.00277
Average				0.000197	0.0000147	0.000498	0.0759	0.0001021	0.019846	0.0000022	0.000545	0.000435	0.000161	0.0000035	0.0000017	0.000747	0.00219
Count				29	28	28	29	28	30	27	28	28	29	28	19	19	27
Minimum				0.000025	0.000005	0.000238	0.0123	0.0000025	0.000187	0.000001	0.0002	0.000291	0.000025	0.0000025	0.000001	0.00033	0.00096
Maximum				0.0016	0.000027	0.00086	0.694	0.0014	0.08	0.000005	0.000939	0.000779	0.00032	0.000005	0.000004	0.00244	0.004
Geometric Mean				0.000133	0.0000131	0.000477	0.0399	0.0000164	0.010464	0.0000017	0.000509	0.000425	0.000128	0.0000033	0.0000015	0.000636	0.00204
Count <DL				4	4	1	0	10	0	26	3	7	5	26	10	0	1
Standard Deviation				0.000278	0.0000065	0.000147	0.139	0.0002729	0.020583	0.0000018	0.000185	0.000099	0.000093	0.0000012	0.0000009	0.00055	0.0008
1st Quartile				0.00011	0.00001	0.000417	0.0215	0.000005	0.00603	0.000001	0.000443	0.000358	0.000115	0.0000025	0.000001	0.000446	0.00162
Median				0.000161	0.0000145	0.000479	0.0311	0.0000065	0.013	0.000001	0.000536	0.000438	0.000138	0.0000025	0.000001	0.000593	0.002
3rd Quartile				0.000196	0.00002	0.000578	0.047	0.00005	0.0226	0.000005	0.000677	0.0005	0.000248	0.000005	0.000002	0.000782	0.00298
95th Percentile				0.0002514	0.0000253	0.00074875	0.308	0.000365	0.060855	0.000005	0.0007895	0.0005	0.0003098	0.000005	0.0000031	0.002044	0.003132
Mean + 2 Standard Deviation				0.000753	0.0000277	0.000792	0.3539	0.0006479	0.061012	0.0000058	0.000915	0.000633	0.000347	0.0000059	0.0000035	0.001847	0.00379
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	3-Dec-94							0.013								
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	5-Apr-95		2.50E-05	0.00003	0.0003	0.018	0.0007	0.0063	5.00E-06	0.0002	0.001	0.00027				0.009
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	8-May-95		0.0012	5.00E-06	0.0019	0.0007	5.00E-05	0.0002		0.0002	0.0005	0.0003	5.00E-06			0.002
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-Jun-95		0.0002	0.00001	0.001	0.026	0.0002	0.0027	5.00E-06	0.0002	0.0005	2.50E-05	5.00E-06			0.005
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Jul-95		2.50E-05	5.00E-06	0.0005	0.024	0.0002	0.0059	5.00E-06	0.0002	0.0005	0.0003	5.00E-06			0.004
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	15-Aug-95		2.50E-05	5.00E-06	0.0005	0.007	5.00E-05	0.0077	5.00E-06	0.0002	0.0005	0.0001	5.00E-06			0.005
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Aug-95		0.0004	5.00E-05	0.0005	0.011	0.0001	0.0081	5.00E-06	0.0002	0.0005	0.00045	5.00E-06			0.005
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	30-Aug-95		0.00013	5.00E-06	0.0004	0.009	5.00E-05	0.0078	5.00E-06	0.0002	0.0005	0.00005	5.00E-06			0.001
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	6-Sep-95		0.00009	0.00001	0.0005	0.031	5.00E-05	0.0085		0.0002	0.001	0.00005	5.00E-06			0.002
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-Sep-95		0.00023	0.00006	0.0007	0.018	0.0001	0.01	5.00E-06	0.0004	0.0005	0.00011	5.00E-06			0.004
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Aug-02					0.023		0.017								0.0025
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Aug-04		0.0005	0.00003	0.0006	0.023	0.00025	0.018				0.0005			0.00164	0.0025
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	24-Aug-06		0.0005	0.00001	0.0006	0.0025	0.00025	0.005	5.00E-06			0.0005			0.0011	0.0025
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	14-Aug-08		0.0004	0.00301	0.001	0.015	0.0004	0.003	1.00E-05	0.0005	0.0005	0.0007			0.0017	0.008
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Aug-10		0.0004	0.00002	0.0004	0.01	0.0001	0.012	1.00E-05	0.001	0.0005	0.0006			0.0027	0.0025
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	16-Aug-12		0.00043	0.000025	0.000434	0.0272	0.000008	0.0194		0.000859	0.000411	0.000636	2.50E-06	1.00E-06	0.00146	0.00146
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	21-Aug-14		0.000362	0.000018	0.000304	0.0179	0.000009	0.012	0.0000038	0.000993	0.000458	0.000529	2.50E-06	1.00E-06	0.00207	0.00192
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	29-Apr-15		0.000359	0.0000305	0.000218	0.0037	2.50E-06	0.0138	1.00E-06	0.00127	0.00109	0.00127	2.50E-06	0.000007	0.00471	0.00291
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-May-15		0.000437	0.0000584	0.00175	0.145	0.0000173	0.0119	0.0000038	0.000432	0.00146	0.000252	2.50E-06	1.00E-06	0.000521	0.00566
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	12-May-15															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-May-15															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Jun-15		0.000363	0.000017	0.000494	0.0156	0.0000091	0.00741	1.00E-06	0.000714	0.000405	0.000465	2.50E-06	1.00E-06	0.00116	0.00255
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	23-Jun-15															
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	28-Jul-15		0.000386	0.0000209	0.000353	0.0127	2.50E-06	0.0119	1.00E-06	0.000839	0.000424	0.000481	2.50E-06	1.00E-06	0.00174	0.00125
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	22-Aug-15		0.000349	0.000018	0.000469	0.0174	2.50E-06	0.0117	1.00E-06	0.000758	0.000524	0.000507	2.50E-06	1.00E-06	0.00138	0.00129
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	9-Sep-15		0.000359	0.000022	0.000536	0.0201	0.000005	0.012	1.00E-06	0.000672	0.000447	0.000602	2.50E-06	1.00E-06	0.00142	0.00227

Station Name	Description	Sample Date	Arsenic (As), dissolved mg/L	Cadmium (Cd), dissolved mg/L	Copper (Cu), dissolved mg/L	Iron (Fe), dissolved mg/L	Lead (Pb), dissolved mg/L	Manganese (Mn), dissolved mg/L	Mercury (Hg), dissolved mg/L	Molybdenum (Mo), dissolved mg/L	Nickel (Ni), dissolved mg/L	Selenium (Se), dissolved mg/L	Silver (Ag), dissolved mg/L	Thallium (Tl), dissolved mg/L	Uranium (U), dissolved mg/L	Zinc (Zn), dissolved mg/L
CCME Guidelines - Protection of Aquatic Life																
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals			0.0050	*	*	0.30	*		0.000026	0.073	*	0.0010	0.00025	0.00080	0.015	0.030
BC-MOE - Maximum Guidelines for Aquatic Life				*	*	0.35	*									*
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	11-Sep-15	0.00035	0.000021	0.00054	0.011	0.000009	0.0103	1.00E-06	0.000697	0.000403	0.000598	2.50E-06	1.00E-06	0.00144	0.00199
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	14-Oct-15	0.000367	0.000022	0.000255	0.0092	2.50E-06	0.0129	1.00E-06	0.000836	0.000378	0.000984	2.50E-06	1.00E-06	0.00229	0.00193
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	19-Nov-15	0.000344	0.000029	0.000253	0.0076	2.50E-06	0.0221	1.00E-06	0.00104	0.000589	0.00122	2.50E-06	1.00E-06	0.00321	0.0039
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	2-Dec-15	0.000412	0.000022	0.000226	0.0102	2.50E-06	0.0191	1.00E-06	0.00116	0.0006	0.00155	2.50E-06	1.00E-06	0.00352	0.00226
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Jan-16	0.000392	0.000042	0.00025	0.0035	2.50E-06	0.0306	1.00E-06	0.00143	0.000824	0.00151	2.50E-06	1.00E-06	0.00512	0.0056
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	9-Feb-16	0.000308	0.000035	0.000186	0.0031	2.50E-06	0.0301	1.00E-06	0.00141	0.000859	0.00134	2.50E-06	1.00E-06	0.00476	0.00518
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Mar-16	0.000341	0.000034	0.000241	0.0028	0.000006	0.028	1.00E-06	0.00145	0.000863	0.00143	2.50E-06	1.00E-06	0.0051	0.00423
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	20-Apr-16	0.0005	0.000031	0.000311	0.0165	2.50E-06	0.0185	1.00E-06	0.00157	0.000899	0.00119	2.50E-06	1.00E-06	0.00549	0.00329
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	4-May-16	0.00041	0.000019	0.000492	0.0401	0.000012	0.00842	1.00E-06	0.0109	0.000676	0.000765	2.50E-06	1.00E-06	0.00272	0.00212
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	15-May-16	0.000261	0.000013	0.000705	0.0156	2.50E-06	0.00385	1.00E-06	0.000652	0.000552	0.000403	0.000006	1.00E-06	0.00128	0.00095
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	13-Jun-16	0.000336	0.0000131	0.000465	0.0138	2.50E-06	0.00688	1.00E-06	0.000826	0.000363	0.000539	2.50E-06	1.00E-06	0.00141	0.00116
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	26-Jul-16	0.000288	0.000014	0.000424	0.0077	2.50E-06	0.00559	1.00E-06	0.000702	0.000358	0.000359	2.50E-06	1.00E-06	0.00114	5.00E-05
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	27-Aug-16	0.000316	0.000021	0.000962	0.0208	0.000034	0.00608	1.00E-06	0.000496	0.000512	0.000346	2.50E-06	1.00E-06	0.000682	0.00176
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	7-Sep-16	0.000337	0.000016	0.000474	0.0097	0.000005	0.00834	1.00E-06	0.000603	0.000386	0.000597	2.50E-06	1.00E-06	0.00125	0.00222
KZ-15	Finlayson Creek 100 m d/s confluence with Geona Cr	1-Oct-16	0.000458	0.000022	0.000345	0.0127	2.50E-06	0.016	1.00E-06	0.000944	0.000409	0.00151	2.50E-06	1.00E-06	0.00222	0.00213
Average			0.00035	0.0001059	0.000544	0.0179	0.0000735	0.0119	0.0000027	0.000734	0.0006	0.00064	0.0000033	0.0000013	0.002342	0.00306
Count			36	36	36	37	36	38	32	34	34	36	31	23	27	37
Minimum			0.000025	0.000005	0.000186	0.0007	0.0000025	0.0002	0.000001	0.0002	0.000358	0.000025	0.0000025	0.000001	0.000521	0.00005
Maximum			0.0012	0.00301	0.0019	0.145	0.0007	0.0306	0.00001	0.00157	0.00146	0.00155	0.000006	0.000007	0.00549	0.009
Geometric Mean			0.00028	0.0000219	0.000463	0.012	0.0000153	0.00934	0.0000019	0.000599	0.00056	0.000453	0.0000031	0.0000011	0.001947	0.00241
Count <DL			5	5	0	1	20	0	30	9	9	3	30	22	0	5
Standard Deviation			0.000194	0.000498	0.000377	0.0232	0.0001417	0.0073	0.0000026	0.000415	0.000253	0.000453	0.0000012	0.0000013	0.001487	0.00194
1st Quartile			0.000303	0.0000138	0.000309	0.009	0.0000025	0.00701	0.000001	0.000408	0.00043	0.000334	0.0000025	0.000001	0.00133	0.00193
Median			0.000359	0.000021	0.000472	0.0138	0.000009	0.011	0.000001	0.000708	0.0005	0.000518	0.0000025	0.000001	0.0017	0.0025
3rd Quartile			0.000403	0.0000301	0.000555	0.0201	0.0000625	0.01545	0.000005	0.000998	0.000657	0.00082	0.0000025	0.000001	0.002965	0.004
95th Percentile			0.0005	0.0000588	0.0011875	0.03282	0.0002875	0.028315	0.00000725	0.001437	0.0010315	0.00151	0.000005	0.000001	0.005114	0.006128
Mean + 2 Standard Deviation			0.000738	0.0011019	0.001298	0.0643	0.0003569	0.0265	0.0000079	0.001564	0.001106	0.001546	0.0000057	0.0000039	0.005316	0.00694
KZ-26	Finlayson Creek at Robert Campbell Highway	5-Apr-95	0.00022	5.00E-06	0.0004	0.0025	0.0011	0.002	5.00E-06	0.0002	0.0005	0.00086	5.00E-06			0.003
KZ-26	Finlayson Creek at Robert Campbell Highway	8-May-95	0.0002	5.00E-06	0.001	0.0025	5.00E-05	0.0001		0.0009	0.001	0.0002	5.00E-06			0.0005
KZ-26	Finlayson Creek at Robert Campbell Highway	11-Jun-95	0.0005	5.00E-06	0.002	0.05	0.0002	0.0024	5.00E-06	0.0002	0.001	2.50E-05	0.00004			0.002
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Jul-95	2.50E-05	5.00E-06	0.0005	0.011	0.0001	0.0028	5.00E-06	0.0002	0.0005	0.00032	0.00001			0.002
KZ-26	Finlayson Creek at Robert Campbell Highway	15-Aug-95	2.50E-05	5.00E-06	0.0007	0.007	5.00E-05	0.0018	5.00E-06	0.0002	0.0005	0.0001	5.00E-06			0.003
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-95	0.00033	5.00E-06	0.0011	0.01	5.00E-05	0.0023	5.00E-06	0.0002	0.0005	0.00015	5.00E-06			0.0005
KZ-26	Finlayson Creek at Robert Campbell Highway	30-Aug-95	0.00017	5.00E-06	0.0006	0.024	5.00E-05	0.0037	5.00E-06	0.0002	0.001	0.00007	5.00E-06			0.002
KZ-26	Finlayson Creek at Robert Campbell Highway	6-Sep-95	0.00017	5.00E-06	0.0008	0.036	5.00E-05	0.0046		0.0002	0.001	0.00006	0.00001			0.002
KZ-26	Finlayson Creek at Robert Campbell Highway	13-Sep-95	0.00031	0.00003	0.0012	0.036	0.0001	0.0034	5.00E-06	0.0002	0.0005	0.00014	5.00E-06			0.001
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Aug-02				0.041		0.006								0.0025
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Aug-04	0.0005	5.00E-06	0.0005	0.0025	0.00025	0.002				0.0005			0.00065	0.0025
KZ-26	Finlayson Creek at Robert Campbell Highway	24-Aug-06	0.0005	0.00002	0.0006	0.06	0.00025	0.005	5.00E-06			0.0005			0.0019	0.0025
KZ-26	Finlayson Creek at Robert Campbell Highway	14-Aug-08	0.0009	0.00003	0.0005	0.035	0.0001	0.004	1.00E-05		0.001	0.0005			0.0024	0.0025
KZ-26	Finlayson Creek at Robert Campbell Highway	18-Aug-10	0.0006	0.00001	0.0005	0.009	0.0001	0.003	1.00E-05	0.001	0.0005	0.0005			0.0028	0.0025
KZ-26	Finlayson Creek at Robert Campbell Highway	16-Aug-12	0.000845	0.000011	0.000662	0.0634	0.000007	0.00704		0.0011	0.00123	0.000354	2.50E-06	1.00E-06	0.00191	0.00051
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-14	0.000613	0.000008	0.000454	0.0224	2.50E-06	0.00211	0.0000039	0.00112	0.000711	0.000439	2.50E-06	1.00E-06	0.00234	0.00025
KZ-26	Finlayson Creek at Robert Campbell Highway	29-Apr-15	0.000533	0.0000119	0.000334	0.0109	2.50E-06	0.00176	1.00E-06	0.00114	0.000807	0.000862	2.50E-06	1.00E-06	0.00391	0.00029
KZ-26	Finlayson Creek at Robert Campbell Highway	11-May-15	0.000775	0.0000228	0.000987	0.161	0.0000087	0.00733	0.0000029	0.000568	0.00178	0.000226	2.50E-06	1.00E-06	0.000907	0.00127
KZ-26	Finlayson Creek at Robert Campbell Highway	14-May-15														
KZ-26	Finlayson Creek at Robert Campbell Highway	23-Jun-15	0.000799	0.0000118	0.000845	0.0405	0.0000112	0.00212	1.00E-06	0.0011	0.00123	0.000449	2.50E-06	1.00E-06	0.00182	0.00031
KZ-26	Finlayson Creek at Robert Campbell Highway	29-Jul-15	0.000836	0.0000085	0.000565	0.0357	2.50E-06	0.00285	1.00E-06	0.0012	0.00135	0.000511	2.50E-06	1.00E-06	0.00233	0.00035
KZ-26	Finlayson Creek at Robert Campbell Highway	22-Aug-15	0.000952	0.000012	0.00109	0.0657	0.000008	0.00811	1.00E-06	0.000959	0.00184	0.0047	2.50E-06	1.00E-06	0.00171	0.00074
KZ-26	Finlayson Creek at Robert Campbell Highway	8-Sep-15	0.00084	0.000011	0.000771	0.0538	0.000006	0.00985	1.00E-06	0.000913	0.00141	0.000547	2.50E-06	1.00E-06	0.00202	0.00081
KZ-26	Finlayson Creek at Robert Campbell Highway	11-Sep-15														
KZ-26	Finlayson Creek at Robert Campbell Highway	15-Oct-15	0.000725	0.000011	0.000423	0.0241	0.000006	0.00552	1.00E-06	0.00105	0.000909	0.000806	2.50E-06	1.00E-06	0.00267	0.00035
KZ-26	Finlayson Creek at Robert Campbell Highway	18-Nov-15	0.000413	0.000008	0.000442	0.0068	0.000014	0.00152	1.00E-06	0.000968	0.000792	0.000919	2.50E-06	1.00E-06	0.00303	0.0006
KZ-26	Finlayson Creek at Robert Campbell Highway	1-Dec-15	0.000514	0.000005	0.000353	0.0128	2.50E-06	0.000557	1.00E-06	0.00103	0.000663	0.00107	2.50E-06	1.00E-06	0.00307	0.00023
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Jan-16														
KZ-26	Finlayson Creek at Robert Campbell Highway	8-Feb-16	0.000426	0.000009	0.000331	0.0034	2.50E-06	0.0019	1.00E-06	0.00105	0.000688	0.000891	2.50E-06	1.00E-06	0.00363	0.00062
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Mar-16	0.000411	0.000008	0.000332	0.0027	2.50E-06	0.0013	1.00E-06	0.00115	0.000621	0.000957	2.50E-06	1.00E-06	0.00404	0.00033
KZ-26	Finlayson Creek at Robert Campbell Highway	19-Apr-16	0.00086	0.000014	0.000525	0.0866	2.50E-06	0.00822	1.00E-06	0.00118	0.00124	0.000664	2.50E-06	1.00E-06	0.00354	0.00059
KZ-26	Finlayson Creek at Robert Campbell Highway	3-May-16	0.000883	0.000006	0.000519	0.0607	2.50E-06	0.00113	1.00E-06	0.00121	0.00113	0.000589	2.50E-06	1.00E-06	0.0025	0.00025
KZ-26	Finlayson Creek at Robert Campbell Highway	14-May-16	0.000662	0.000006	0.000538	0.0217	2.50E-06	0.00164	1.00E-06	0.00124	0.000876	0.000549	2.50E-06	1.00E-06	0.00281	0.00027
KZ-26	Finlayson Creek at Robert Campbell Highway	13-Jun-16	0.000582	0.0000061	0.00053	0.0124	2.50E-06	0.00141	1.00E-06	0.00106	0.000716	0.000539	2.50E-06	1.00E-06	0.00224	0.0003
KZ-26	Finlayson Creek at Robert Campbell Highway	25-Jul-16	0.000931	0.00001	0.000977	0.0509	0.000012	0.00862	1.00E-06	0.00102	0.00168	0.000442	2.50E-06	1.00E-06	0.00182	0.00053
KZ-26	Finlayson Creek at Robert Campbell Highway	26-Aug-16	0.000863	0.000008	0.000711	0.0335	0.000006	0.000673	1.00E-06	0.00102	0.00119	0.000388	2.50E-06	1.00E-06	0.00194	0.00034
KZ-26	Finlayson Creek at Robert Campbell Highway	6-Sep-16	0.000889	0.000009	0.000721	0.0331	0.000009	0.00372	1.00E-06	0.000887	0.00125	0.000543	2.50E-06	1.00E-06	0.00186	0.00057
KZ-26	Finlayson Creek at Robert Campbell Highway	30-Sep-16	0.000907	0.000008	0.000438	0.0363	2.50E-06	0.0119	1.00E-06	0.00105	0.000974	0.000968	2.50E-06	1.00E-06	0.00233	0.0006
Average			0.000577	0.00001	0.000675	0.0333	0.0000755	0.003782	0.0000028	0.000829	0.000956	0.000503	0.0000048	0.000001	0.002407	0.0011
Count			34	34	34	35	34	35	30	32	32	34	30	21	25	35
Minimum			0.000025	0.000005	0.000331	0.0025	0.0000025	0.0001	0.000001	0.0002	0.0005	0.000025	0.0000025	0.000001	0.00065	0.00023
Maximum			0.000952	0.00003	0.002	0.161	0.0011	0.0119	0.00001	0.00124	0.00184	0.00107	0.00004	0.000001	0.00404	0.003
Geometric Mean			0.000458	0.0000086	0.000615	0.0206	0.0000153	0.002707	0.0000019	0.000682	0.000883	0.000387	0.0000035	0.000001	0.002244	0.00076

Station Name	Description	Sample Date	Arsenic (As), dissolved	Cadmium (Cd), dissolved	Copper (Cu), dissolved	Iron (Fe), dissolved	Lead (Pb), dissolved	Manganese (Mn), dissolved	Mercury (Hg), dissolved	Molybdenum (Mo), dissolved	Nickel (Ni), dissolved	Selenium (Se), dissolved	Silver (Ag), dissolved	Thallium (Tl), dissolved	Uranium (U), dissolved	Zinc (Zn), dissolved
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CCME Guidelines - Protection of Aquatic Life																
CCME Guidelines - Protection of Aquatic Life vs. Dissolved Metals			0.0050	*	*	0.30	*		0.000026	0.073	*	0.0010	0.00025	0.00080	0.015	0.030
BC-MOE - Maximum Guidelines for Aquatic Life				*	*	0.35	*									*
Count <DL			4	9	0	3	20	1	28	8	7	3	27	21	0	7
Standard Deviation			0.000278	0.0000065	0.000336	0.0313	0.0001934	0.002922	0.0000026	0.000388	0.000388	0.000288	0.000007	0	0.000833	0.00094
1st Quartile			0.000412	0.000005	0.000465	0.0105	0.0000025	0.00178	0.000001	0.000476	0.000652	0.000329	0.0000025	0.000001	0.0019	0.00035
Median			0.000591	0.000008	0.000551	0.0331	0.0000088	0.0028	0.000001	0.00101	0.000942	0.0005	0.0000025	0.000001	0.00233	0.0006
3rd Quartile			0.000839	0.000011	0.000793	0.0455	0.00005	0.00526	0.000005	0.0011	0.00123	0.000645	0.0000025	0.000001	0.00281	0.002
95th Percentile			0.0009154	0.00002532	0.001135	0.07197	0.00025	0.008989	7.75E-06	0.0012045	0.001725	0.00096085	0.00001	0.000001	0.003854	0.00265
Mean + 2 Standard Deviation			0.001133	0.000023	0.001347	0.0959	0.0004623	0.009626	0.000008	0.001605	0.001732	0.001079	0.0000188	0.000001	0.004073	0.00298
KZ-9	Lower Geona Creek	18-Jul-94														
KZ-9	Lower Geona Creek	31-Aug-94		0.0005		0.16		0.05				0.00025				0.004
KZ-9	Lower Geona Creek	3-Dec-94						0.098								
KZ-9	Lower Geona Creek	5-Apr-95	0.00013	0.00002	0.0004	0.11	0.0005	0.14	5.00E-06	0.0002	0.001	0.001	5.00E-06			0.011
KZ-9	Lower Geona Creek	11-Jun-95	0.0004	0.00002	0.0009	0.092	0.0002	0.019	5.00E-06	0.0004	0.0005	2.50E-05	5.00E-06			0.018
KZ-9	Lower Geona Creek	22-Aug-95	0.0006	5.00E-06	0.0005	0.054	0.0001	0.058	5.00E-06	0.0005	0.0005	2.50E-05	5.00E-06			0.005
KZ-9	Lower Geona Creek	13-Sep-95	0.00065	0.0005	0.0024	0.53	0.0026	0.11	5.00E-06	0.0009	0.004	0.00013	5.00E-06			0.014
KZ-9	Lower Geona Creek	23-Aug-02				0.067		0.048								0.0025
KZ-9	Lower Geona Creek	19-Aug-04	0.0005	0.00002	0.0004	0.009	0.00025	0.076				0.0005			0.00035	0.0025
KZ-9	Lower Geona Creek	24-Aug-06	0.0005	0.00002	0.0004	0.026	0.00025	0.011	5.00E-06			0.0005			0.0016	0.005
KZ-9	Lower Geona Creek	14-Aug-08	0.0003	0.00007	0.0004	0.102	0.0001	0.031	1.00E-05	0.0005	0.0005	0.0007			0.0012	0.006
KZ-9	Lower Geona Creek	19-Aug-10	0.0003	0.00003	0.0004	0.229	0.0001	0.09	1.00E-05	0.0005	0.0005	0.0004			0.0011	0.0025
KZ-9	Lower Geona Creek	16-Aug-12	0.000222	0.000044	0.000581	0.186	0.000018	0.0483		0.000463	0.000318	0.000479	2.50E-06	1.00E-06	0.000642	0.00966
KZ-9	Lower Geona Creek	21-Aug-14	0.000756	0.000031	0.000306	0.0852	0.000006	0.0581	0.0000042	0.00142	0.00042	0.000647	0.000006	1.00E-06	0.00169	0.00263
KZ-9	Lower Geona Creek	30-Apr-15	0.000288	0.0000606	0.000398	0.0889	0.0000067	0.147	1.00E-06	0.000699	0.00068	0.00106	2.50E-06	1.00E-06	0.00165	0.00891
KZ-9	Lower Geona Creek	11-May-15	0.000308	0.0000685	0.00171	0.289	0.0000565	0.0436	0.0000034	0.000273	0.00101	0.000218	2.50E-06	1.00E-06	0.000185	0.0134
KZ-9	Lower Geona Creek	13-May-15														
KZ-9	Lower Geona Creek	23-Jun-15	0.000208	0.0000341	0.00066	0.0646	0.0000067	0.0183	1.00E-06	0.000511	0.000355	0.000576	2.50E-06	1.00E-06	0.000707	0.00561
KZ-9	Lower Geona Creek	24-Jun-15														
KZ-9	Lower Geona Creek	29-Jul-15	0.000212	0.0000399	0.000382	0.0855	2.50E-06	0.0409	1.00E-06	0.000589	0.000332	0.000625	2.50E-06	1.00E-06	0.000964	0.00646
KZ-9	Lower Geona Creek	23-Aug-15	0.00021	0.000043	0.000574	0.101	0.000007	0.0337	1.00E-06	0.000568	0.000514	0.000686	2.50E-06	1.00E-06	0.000908	0.00705
KZ-9	Lower Geona Creek	10-Sep-15	0.000218	0.000071	0.000574	0.101	0.000017	0.0264	1.00E-06	0.000527	0.00035	0.000876	2.50E-06	1.00E-06	0.00118	0.0129
KZ-9	Lower Geona Creek	15-Oct-15	0.000185	0.000071	0.000308	0.0735	0.000006	0.0471	1.00E-06	0.000641	0.000309	0.00126	2.50E-06	1.00E-06	0.00138	0.0139
KZ-9	Lower Geona Creek	20-Nov-15	0.000158	0.000061	0.000241	0.0672	2.50E-06	0.0839	1.00E-06	0.00062	0.000364	0.00119	2.50E-06	1.00E-06	0.00152	0.0182
KZ-9	Lower Geona Creek	2-Dec-15	0.000181	0.000054	0.000222	0.111	2.50E-06	0.0797	1.00E-06	0.000661	0.000373	0.00134	2.50E-06	1.00E-06	0.00157	0.0132
KZ-9	Lower Geona Creek	20-Jan-16	0.000184	0.000054	0.000189	0.0148	2.50E-06	0.115	1.00E-06	0.000722	0.000455	0.00119	2.50E-06	1.00E-06	0.00177	0.0133
KZ-9	Lower Geona Creek	9-Feb-16	0.000171	0.000052	0.00017	0.0153	2.50E-06	0.119	1.00E-06	0.000706	0.000501	0.00104	2.50E-06	1.00E-06	0.00168	0.0122
KZ-9	Lower Geona Creek	20-Mar-16	0.000109	0.000033	0.000068	0.0005	0.000006	0.00146	1.00E-06	0.00149	0.000081	0.00326	2.50E-06	1.00E-06	0.00303	0.00086
KZ-9	Lower Geona Creek	20-Apr-16	0.000285	0.000072	0.000488	0.206	0.000032	0.0917	1.00E-06	0.000674	0.000533	0.000943	2.50E-06	1.00E-06	0.00153	0.0103
KZ-9	Lower Geona Creek	4-May-16	0.000309	0.000054	0.000805	0.238	0.000085	0.0456	1.00E-06	0.000516	0.000514	0.000649	2.50E-06	1.00E-06	0.000799	0.00973
KZ-9	Lower Geona Creek	19-May-16	0.000219	0.000036	0.000644	0.113	0.000048	0.0173	1.00E-06	0.000533	0.00034	0.000626	2.50E-06	1.00E-06	0.000729	0.00565
KZ-9	Lower Geona Creek	14-Jun-16	0.000164	0.000036	0.00048	0.0625	0.000023	0.0157	1.00E-06	0.000476	0.000262	0.000557	2.50E-06	0.000002	0.000714	0.00699
KZ-9	Lower Geona Creek	27-Jul-16	0.000197	0.000046	0.000499	0.071	0.000006	0.0266	1.00E-06	0.000521	0.000299	0.000622	2.50E-06	0.000002	0.00076	0.00624
KZ-9	Lower Geona Creek	27-Aug-16	0.00025	0.000063	0.00141	0.0475	0.000153	0.0153	1.00E-06	0.000443	0.000435	0.000638	2.50E-06	0.000002	0.000661	0.0126
KZ-9	Lower Geona Creek	7-Sep-16	0.00017	0.000079	0.00074	0.062	0.000043	0.0149	1.00E-06	0.0005	0.000346	0.00097	2.50E-06	0.000002	0.00109	0.0166
KZ-9	Lower Geona Creek	4-Oct-16	0.000155	0.000095	0.000394	0.0666	0.000012	0.0313	1.00E-06	0.000631	0.000323	0.00133	0.000005	0.000003	0.00151	0.0211
Average			0.000285	0.0000628	0.000585	0.1103	0.0001548	0.05612	0.0000026	0.000614	0.000576	0.000784	0.0000031	0.0000013	0.001189	0.00931
Count			30	30	31	32	30	33	28	28	28	31	26	22	26	32
Minimum			0.000109	0.000005	0.000068	0.0005	0.0000025	0.00146	0.000001	0.0002	0.000081	0.000025	0.0000025	0.000001	0.000185	0.00086
Maximum			0.000756	0.0005	0.0024	0.53	0.0026	0.147	0.00001	0.00149	0.004	0.00326	0.000006	0.000003	0.00303	0.0211
Geometric Mean			0.000251	0.0000453	0.000465	0.0701	0.0000259	0.04088	0.0000017	0.000568	0.000444	0.000564	0.000003	0.0000012	0.00104	0.00756
Count <DL			2	1	1	1	9	0	26	3	4	5	24	17	0	3
Standard Deviation			0.000162	0.0000852	0.000474	0.1029	0.0004744	0.03957	0.0000027	0.000275	0.000699	0.000588	0.0000012	0.0000006	0.000585	0.00527
1st Quartile			0.000182	0.0000333	0.000388	0.0624	0.000006	0.0264	0.000001	0.0005	0.000338	0.0005	0.0000025	0.000001	0.000737	0.00546
Median			0.000218	0.000049	0.00048	0.0854	0.0000205	0.0471	0.000001	0.00053	0.000428	0.000647	0.0000025	0.000001	0.00114	0.00928
3rd Quartile			0.000306	0.0000671	0.000612	0.1115	0.0001	0.0839	0.0000044	0.000664	0.000504	0.00102	0.0000025	0.000001	0.00156	0.01323
95th Percentile			0.0006275	0.0000878	0.00156	0.26095	0.0003875	0.1274	8.25E-06	0.001238	0.0010065	0.001335	0.000005	0.000002	0.00175	0.01809
Mean + 2 Standard Deviation			0.000609	0.0002332	0.001533	0.3161	0.0011036	0.13526	0.000008	0.001164	0.001974	0.00196	0.0000055	0.0000025	0.002359	0.01985