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Chair, Technical Advisory Committee
Elk Valley Water Quality Plan
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Dear Lynn:

Further to the discussions that were convened during the July 8 to 10, 2014 meeting of the Technical Advisory Committee (TAC-7) in Vancouver, B.C. While a great deal of progress has been made on the development of the Elk Valley Water Quality Plan (EVWQP), a number of key issues remain unresolved, including:

- The initial implementation of the EVWQP relies on active water treatment (AWT) to achieve targets. Although there is a monitoring and adaptive management framework, there are no specific triggers for incorporating passive and semi-passive treatment options into the EVWQP or other planning processes. This deficiency makes it uncertain if or how reliance on AWT will be reduced or eliminated;
- The targets that were established under the EVWQP are being treated as pollute-up-to values. That is, the goal of stabilising and reducing concentrations of contaminants in receiving waters is not reflected consistently in the EVWQP. This is particularly an issue for selenium, sulphate, and cadmium;
- There is no plan to meet the targets in the tributaries. Therefore, permits will still need to authorize pollution in the tributaries (i.e., discharge levels will result in exceedances of WQGs or targets);
- The adaptive management plan is conceptual only. The framework does not describe detailed assessment endpoints, measurement endpoints, triggers, or associated management actions. This is a major limitation of the EVWQP because it results in a high level of uncertainty about how management decisions will be taken in the future;

- The plan does not describe a robust monitoring program to assess effects through routine monitoring [e.g., using a before-after, control-impact (BACI) approach for benthic invertebrates] and supporting studies. Therefore, there is substantial uncertainty about what monitoring will be done and, importantly, how the monitoring programs will be designed to support effects assessment;
- Interactive and cumulative effects have still not been adequately assessed in the plan. In addition, a clear plan for assessing such effects in the future is not included in the EVWQP; and,
- Lake Koocanusa has still not been adequately addressed in the EVWQP. This is of fundamental importance to virtually all stakeholders and governments.

In addition, I am pleased to submit the following specific recommendations related to development of the Elk Valley Water Quality Plan (EVWQP; June 30, 2014 Version). These recommendations apply to the following topic areas:

- Aquatic Environment Synthesis Report (Annex K1; 2014);
- Regulatory Context (Chapter 2 of the EVWQP);
- Consultation and Technical Advice (Chapter 3 of the EVWQP);
- Current Baseline Conditions (Chapter 4 of the EVWQP);
- Assessment and Protection of Human Health and Groundwater (Chapter 5 of the EVWQP);
- Management Options (Chapter 6 of the EVWQP);
- Calcite Management (Chapter 7 of the EVWQP);
- Water Quality Targets and Implementation Plan(Chapter 8 of the EVWQP);
- Social and Economic Considerations (Chapter 9 of the EVWQP);
- Monitoring (Chapter 10 of the EVWQP); and,
- Adaptive Management (Chapter 11 of the EVWQP).

1.0 Aquatic Environment Synthesis Report (Annex K1; 2014)

A part of the TAC-6 meeting, the results of the evaluations of existing conditions in the Elk River Watershed and Lake Koocanusa were presented. Based on a review of the information that was presented, the following advice is reiterated:

Advice: There is a role for independent analysis of environmental data and information related to the Elk Valley and Lake Koocanusa. Therefore, it is recommended that an independent environmental monitoring agency be established to provide guidance and oversight related to the collection, analysis, interpretation, and reporting of data collected within the Elk Valley.

Rationale: A great deal of data and information has been collected on environmental conditions in the Elk Valley in recent years. In the future, implementation of the Regional Aquatic Effects Monitoring Program (AEMP) and various mine-related AEMPs will result in collection of additional data and information. To ensure that such data collection is focused and relevant, that the resultant information is evaluated using appropriate methods and procedures, and that the dissemination of such data and information is timely and accurate, an independent environmental monitoring agency needs to be established in the Elk Valley.

Advice: Reorganize the Synthesis Report to present the relevant information on existing conditions in the watershed on a receptor-by-receptor basis.

Rationale: The Terms of Reference of the EVWQP indicate that the plan will use the best available science to evaluate the impacts and cumulative effects of point and non-point sources of waste on water quality, aquatic biota, and human consumers. Currently, the Synthesis Report includes sections on a variety of topics (i.e., water quality, sediment quality, calcite, tissues chemistry), but does not provide a basis for evaluating effects or cumulative effects arising from single or multiple stressors. To do so, the report would be structured in a manner that is more consistent with the conceptual site model(s), whereby multiple lines-of-evidence would be used to evaluate the effects and potential effects for each receptor group. For example, the evaluation of effects on benthic invertebrates under current conditions should rely on data on surface water chemistry, surface water toxicity, sediment chemistry, sediment toxicity, benthic invertebrate community structure, stream-bed substrate composition, and calcite index.

Advice: Evaluate environmental quality conditions for all water bodies within the study area, including mine works, when considering bioaccumulative substances (such as selenium).

Rationale: For toxic substances, it is reasonable to exclude mine works from the evaluation of current conditions. However, bioaccumulative contaminants have the potential to cause adverse effects on ecological receptors within the mine works when those areas represent an attractive nuisance for wildlife (e.g., Clode Pond). Therefore, the effects of bioaccumulative chemicals of potential concern (COPCs) need to be evaluated within such areas as part of the overall assessment of existing environmental conditions in the Elk Valley.

1.1 Surface Water Quality

The evaluation of existing surface water quality data is presented in Section 3.1 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Develop a table that identifies all of the potentially mining-influenced tributaries to the Elk and Fording Rivers (i.e., by management unit; MU) and identifies the water quality sampling stations on each tributary. This table should also include sampling stations on the Elk River and the Fording River. The analyte groups that were measured at each station should also be identified (i.e., conventional variables, major ions, nutrients, metals, PAHs, others).

Rationale: The maps 3.1-2 to 3.1-7 provide useful information on the locations of surface water sampling stations within the study area. However, the reader also needs to understand the spatial extent of sampling stations relative to coal-mining activities. Accordingly, there is a need to provide a more complete understanding of the extent to which mining-influenced tributaries have been sampled. Such a table will provide a basis for identifying all the water bodies that have been influenced by mining activities in the Elk Valley.

Advice: Include a table of the water quality guidelines (WQGs) that were used to screen surface-water chemistry data from the Elk Valley in the main body of the report.

Rationale: The first step of the evaluation of existing surface water chemistry data involves screening against WQGs. The reader needs to know what WQGs were used in the screening process.

Advice: Prior to initiating screening of the existing water quality data, the underlying surface-water chemistry data need to be evaluated to determine if minimum data requirements are met. To complete this step, minimum data requirements need to be established. Such minimum data requirements need to consider spatial coverage within the MU (i.e., all mining-influenced tributary and mainstem reaches need to have been sampled), temporal coverage (i.e., were the results of at least two 5-in-30 day sampling events available for each mining-influenced tributary and mainstem reach), and minimum number of samples per sampling location and analyte (e.g., at least 10 samples should be available for a location before using the results to screen out an analyte).

Rationale: One of the key tenets of screening-level assessments is to avoid screening out analytes prematurely. To avoid doing so, it is important to ensure that enough data are available to provide a fulsome evaluation of water quality conditions. Establishment of minimum data requirements provides a transparent basis for ensuring that screening does not result in inappropriate elimination of analytes.

Advice: Provide clear rationale for identifying primary and secondary chemicals of interest (CoIs) for each MU. In addition, describe the underlying rationale for the methods that were selected for identifying primary and secondary CoIs.

Rationale: In the second step of the surface-water evaluation process, median concentrations of CoIs were calculated and used to classify the CoIs into two categories, primary and secondary. The rationale for doing so is not provided in the draft document. Moreover, this step in the process is unnecessary and may result in screening out CoIs that should be included in the assessment of existing conditions in the Elk River watershed.

Advice: In addition to reporting the frequency of exceedance of WQGs, calculate and report maximum hazard quotients based on a comparison of measured COPC concentrations to each of the selected WQGs for each sampling station in each MU. The results of this analysis need to be tabulated and presented in the text of the main report for all analytes.

Rationale: Most of the underlying surface water chemistry data used in the evaluation of existing water quality conditions were obtained from grab samples collected on a monthly or less frequent basis. Therefore, all of these results (with the exception of samples collected as part of a 5-in-30 day sampling event) should be considered to represent mean monthly concentrations of the CoIs in surface water and should be compared to long-term WQGs. Hence, exceedance of a long-term WQG in one or more surface water samples represents a condition that could adversely affect aquatic organisms. This analysis will provide relevant information on current water quality conditions.

Advice: Present the results of the analysis of reference water quality conditions in the main text of the report. This analysis needs to include a description of the criteria that were used to identify candidate reference stations and to evaluate the adequacy of candidate reference stations. In addition, the reference concentrations that were calculated for all analytes should be tabulated and presented in the main report.

Rationale: In the third step of the evaluation of surface-water chemistry data, the surface-water chemistry data from the study area are compared to reference concentrations of CoIs. However, examination of the information presented at TAC-6 indicates that reference concentrations are not reported for most analytes in surface water. In addition, it appears that inappropriate procedures have been used to calculate reference concentrations. For example, reference concentrations of 18 NTU and 40 mg/L were reported for turbidity and TSS, respectively. This is inappropriate because both analytes exhibit substantial temporal (i.e., high flow vs. low flow) and spatial (i.e., tributary vs. mainstem) variability (See Table 3.1-1). Therefore, it is inappropriate to calculate a single reference concentration for these variables. In addition, the reference concentrations presented in Table 3.1-3 appear to have been unduly affected by apparent outliers or data from inappropriate reference stations (e.g., selenium, copper, uranium, phenanthrene, pyrene). Selection of inappropriate reference concentrations has the potential to influence the results of the screen.

Advice: Establish reference concentrations using data on the measured concentrations of CoIs in surface water only.

Rationale: The available data on the concentrations of CoIs at reference stations includes both measured concentrations and non-detect results. Because high non-detect results have the potential to bias high the estimates of reference concentrations, it is essential to either eliminate non-detect data from the analysis prior to calculating reference concentrations or screen non-detect data for reference stations against WQGs prior to calculating reference concentrations (i.e., non-detect data with detection limits greater than WQGs should not be used to establish reference concentrations).

Advice: Eliminate the evaluation of the frequency of exceedance of reference concentration (i.e., 10% of concentrations need to be greater than the reference concentration for a CoI to be carried forward) from the CoI refinement process.

Rationale: The frequency of exceedance criterion has the potential to result in elimination of numerous CoIs that should be evaluated in the detailed evaluation. For example, ammonia in all MUs, cadmium in MU-3, zinc in MU-3 and 4, cobalt, and uranium in MU-1. However, this approach completely ignores the magnitude of exceedance of the reference concentration.

Advice: Conduct a sensitivity analysis by calculating flow-weighted average concentrations to represent reference conditions for the Elk River downstream of the confluence of the Fording River (represented by the average of GH_ER2 and FR_UFR1) and the Elk River downstream of the confluence of Michel Creek (represented by the average of GH_ER2, FR_UFR1, and CM_MC1). If applicable, incorporate the flow-weighted average concentrations into the background comparison analysis.

Rationale: Background surface water concentrations estimated by taking the arithmetic mean of the background concentrations from multiple upstream locations may be over- or under-estimated depending on the differences in the flow conditions of each of the streams being incorporated in the average. Therefore the flow-weighted average concentrations may provide a better estimate of background conditions for stations that are influenced by multiple streams.

Advice: Re-evaluate the list of CoIs that require detailed evaluation after revising the procedures for refining the CoI list, as described in Section 3.1.2 of the Synthesis Report.

Rationale: The procedures that are described for CoI refinement (Section 3.1.2 of the Synthesis Report) are not appropriate. Application of these procedures will result in screening out a number of CoIs for various MUs and/or altogether. As the analysis of current water quality conditions needs to be robust and defensible, it is essential that the CoI refinement steps be repeated using more appropriate procedures.

Advice: Any CoI that exceeds a WQG in two or more surface water samples from an MU needs to be evaluated in the detailed evaluation of water quality conditions. In addition, any analyte for which WQGs are not available or for which insufficient data are available to characterize concentrations in all mining-influenced tributaries and all mainstem stations need to be evaluated in the detailed evaluation. The total number of samples for which data exist for each analyte in each MU needs to be reported. In addition, tables that provide summary statistics for each analyte in each MU and for each analyte in the reference samples need to be included in the Synthesis Report (i.e., n, number samples with detected concentrations, minimum, maximum, mean, geomean, and 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th} percentiles).

Rationale: The procedures that are described in Section 3.2.1 for refining the list of CoIs appears to have the potential for inappropriate elimination of certain substances that could be adversely affecting water quality conditions in the study area. In addition, the results of the screening steps are not fully presented in the Synthesis Report (i.e., results are presented only for those analytes that exceeded WQGs or reference concentrations). Summary statistics are required to provide additional perspective on the screening-level analysis of the underlying water quality data.

Advice: Evaluate the potential effects of cadmium using hardness-based WQGs, including the draft BC WQG that was recently released by BCMOE.

Rationale: The Toxicology Work Group (TWG) provided a number of recommendations regarding the evaluation of cadmium in the EVWQP. More specifically, the TWG recognized the inherent uncertainty in the application of a biotic ligand model (BLM) for cadmium because:

1. No numerical WQGs have been established in Canada using the BLM;
2. No numerical WQC have been established in the United States using the BLM; and,
3. No site-specific toxicity testing has been conducted to evaluate the applicability of the BLM for cadmium in the Elk Valley.

Accordingly, it was agreed that evaluations of the potential effects of cadmium on aquatic organisms would be evaluated using hardness-normalized WQGs and the BLM for cadmium. Hence, the Synthesis Report needs to be revised to include an evaluation of the effects of cadmium using the hardness-normalized WQGs.

Advice: The detailed evaluations of water quality conditions should be revised to report both the frequency of exceedance of the site-specific toxicity thresholds and the magnitude of exceedance of the site-specific toxicity thresholds. The results for tributary stations and for mainstem stations should be reported separately.

Rationale: The evaluations of existing water quality conditions presented in Section 3.1.3 of the Synthesis Report are focused on determination of the number of stations within each MU that have exceedances (i.e., maximum and median concentrations) of the site-specific toxicity thresholds. While these results may provide relevant information for evaluating water quality conditions, they provide no information on the frequency or magnitude of exceedance of the selected toxicity thresholds. Because effects on aquatic organisms are likely to be influenced by both the frequency and magnitude of exceedance of the selected toxicity thresholds, the frequency and magnitude of exceedance of the toxicity thresholds need to be reported for each analyte at each station, then summed for all tributaries within an MU.

Advice: Evaluate the potential effects of zinc on aquatic organisms using hardness-based WQGs.

Rationale: To date, there has been no discussion among the members of the TWG or the Technical Advisory Committee (TAC) regarding the application of a BLM to evaluate the effects of zinc on aquatic organisms. There is inherent uncertainty in the application of a BLM for zinc because:

1. No numerical WQGs have been established in Canada using a BLM for zinc;
2. No numerical WQC have been established in the United States using the BLM for zinc; and,
3. No site-specific toxicity testing has been conducted to evaluate the applicability of the BLM for zinc in the Elk Valley.

Accordingly, evaluations of the potential effects of zinc on aquatic organisms should be evaluated using hardness-normalized WQGs for zinc. Hence, the Synthesis Report needs to be revised to include an evaluation of the effects of zinc using the hardness-normalized WQGs.

Advice: Revise the Section of the Synthesis Report on toxicity tests (i.e., Section 3.1.4) to provide additional information on the toxicity tests that were conducted, on the number of samples that were tested, and on the limitations of the toxicity testing program.

Rationale: The toxicity testing programs that were conducted in 2013 provide relevant information for evaluating current water quality conditions within the study area. However, the description of the toxicity testing that was done is insufficient to enable the reader to fully understand the work that was done or its implications. For example, while the species tested are identified in the text, the duration of exposure and endpoints measured are not. Therefore, this section of the report needs to be revised to provide more information on the studies that were conducted and the associated results.

Advice: Revise Section 3.1.5.1 of the Synthesis Report to provide additional information on the sampling locations that are discussed, the magnitude of the exceedances of WQGs, and the forms of phosphorus that were evaluated.

Rationale: Section 3.1.5.1 of the Synthesis Report describes the results of the evaluation of phosphorus in MU-6. Concentrations of phosphorus in the lake downstream of the Elk River are compared to the levels that were measured at an upstream location. However, the upstream station is not identified and it could be the lake station that is potentially influenced by phosphorus loadings from the Elk River. Therefore, comparisons should explicitly describe concentrations that were measured at Wardner. Currently, the discussion focuses on median concentrations at each station. However, it is also important to discuss ranges and distributions of phosphorus data when comparing stations. Furthermore, the current discussion does not describe the phosphorus species that was measured. Therefore, the discussion should describe the species that was measured (TP, TDP, OP) and discuss the limitations of the data for evaluating biologically-available phosphorus in the lake.

Advice: The discussion of selenium concentrations in Lake Koocanusa (Section 3.1.5.2) needs to be revised to reflect the limitations of the data relative to comparison to the B.C. WQG for water and to reference concentrations. Because only monthly water quality data are available, each measurement should be compared to the WQG to evaluate attainment with WQGs. In addition, selenium concentrations in the lake should not be compared to the 95th percentile of reference locations. Rather, concentrations in the lake should be compared to data from the site at Wardner (minimum, maximum, mean, distributions).

Rationale: The long-term WQG for selenium in water is 2 µ/L. Attainment of the WQG is evaluated using the results of five surface water samples collected within a 30-d period. The WQG is not intended to be compared to a median concentration at any station or for multiple stations. Such comparisons provide a biased evaluation of water quality conditions in the lake.

Advice: The conclusion that no constituents were classified as COPCs in Lake Koocanusa must be revised based on a more objective evaluation of water quality conditions in the lake.

Rationale: The evaluation of water quality conditions in Lake Koocanusa was based on inappropriate statistical analysis of the data prior to comparison to WQGs. Because water samples collected on a monthly basis must be considered to represent average conditions for the month, the data for each monthly surface-water sampling result must be compared to the corresponding long-term WQG. In addition, the evaluation of water quality conditions in the lake relied on inappropriate comparisons of in-lake concentrations to pooled reference stations from the Elk River watershed and Lake Koocanusa. Because the Kootenay River and the Elk River represent the primary sources of surface water to the lake, data from the Elk River at the mouth and each sampling station in the lake must be compared to the data that were collected at Wardner. This will provide a more accurate evaluation of the influence of contaminant loadings from the Elk River on water quality conditions in Lake Koocanusa.

1.2 Sediment Quality

The evaluation of existing sediment quality data is presented in Section 3.2 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Conduct a broad survey of sediment chemistry within the study area using sampling methods that facilitate sediment sampling across a range of streambed substrate types (i.e., fine sediment, gravel, and cobbles, etc.).

Rationale: The available sediment chemistry data for the Elk River watershed were generated using sediment samples collected primarily in depositional areas within the study area. While this information is relevant for assessing sediment quality conditions in the watershed, it does not provide information on many mine-influenced areas that have different stream-bed substrate types (e.g., gravel, cobbles, etc.). Nevertheless, benthic invertebrates are exposed to fine sediment that accumulates in coarser stream-bed substrates. Hence, there is a need to characterize sediment quality conditions in many areas that were not sampled in 2011 and 2013, due to the focus on sampling obviously depositional habitats. It is important to note that sampling of fine sediment in stream-bed substrates that include coarser materials requires different methods than those that are applied in depositional habitats. More specifically, MacNeil corers, freeze-core sampling, modified Besser samplers, and/or alternative methods, combined with sieving to < 2.00 mm, is required to obtain fine sediment for chemical analysis from coarser-grained substrates.

Advice: Develop and present a table that summarizes the sediment chemistry data for reference stations. This analysis needs to include a description of the criteria that were used to identify candidate reference stations and to evaluate the adequacy of candidate reference stations. In addition, the reference concentrations that were calculated for all analytes should be tabulated and presented in the main report.

Rationale: The comparison of data from mining-influenced areas to reference area concentration data is a key step in the COPC identification process for sediments (i.e., as described in Section 3.2.2 of the Synthesis Report). However, the data that were used to calculate reference area concentrations were not presented in the main body of the Synthesis Report. For this reason, a summary of the reference area concentration data needs to be presented (i.e., minimum, mean, SD, maximum, 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). Because inclusion of inappropriate reference stations can influence the reference area concentrations that are calculated, the selection criteria for reference stations needs to be fully described.

Advice: The reference area data should be screened (i.e., to remove samples with non-detected concentrations above the benchmarks) before they are used to estimate reference area concentrations for the various COPCs.

Rationale: Based on the information presented in Table 3.2.4, most of the measurements of PAH concentrations in sediments from reference areas were less than the detection limit (<DL). Treatment of these <DL results can substantially influence the reference area concentrations that are estimated from the underlying data. Because a <DL should not be used to determine if a SQG has been exceeded unless the DL is lower than the SQG, <DL measurements with DLs that are greater than the interim sediment quality guideline (ISQG) should be eliminated from the data set prior to data analysis. After DL screening, the remaining data in the data set should be evaluated using an appropriate outlier analysis. Outliers should be removed from the data set prior to data analysis. Following screening, the remaining data should

be evaluated to determine if sufficient data are available to calculate a reference area concentration (i.e., minimum of 10 samples).

Advice: Re-evaluate the COPCs following implementation of a more robust approach to the estimation of reference area concentrations.

Rationale: Based on a review of the information presented in Section 3.2.2, a number of COPCs have been screened out of the assessment as a result of selecting inappropriate reference area concentrations (e.g., 1.78 mg/kg DW for phenanthrene). Therefore, the COPC refinement step needs to be repeated after more appropriate reference area concentrations have been estimated.

Advice: In Section 3.2.2.4, explicitly acknowledge the limitations of the toxicity test results in terms of evaluating the effects of sediment-associated COPCs on benthic invertebrates. In addition, the description of the toxicity testing results presented in Section 3.2.2.4 does not agree with Table 3.2.7 (i.e., text refers to testing at multiple stations per location, while the table does not). This discrepancy needs to be corrected.

Rationale: Two toxicity tests were utilized to evaluate the toxicity of Elk Valley sediments to benthic invertebrates. In total, six sediment samples were tested, including two reference area samples, one mine workings sample, and three mining influenced samples. This represents an extremely limited data set for characterizing sediment toxicity in the study area. In addition, the two toxicity tests that were selected were of short duration and measured a limited number of endpoints. Therefore, the results of the toxicity testing conducted to date do not provide a basis for characterizing sediment toxicity in the study area.

Advice: Conduct long-term toxicity tests with midge (life-cycle) and amphipods (42-d) to evaluate sediment toxicity in future sediment quality assessments.

Rationale: Benthic invertebrates are continuously exposed to sediment-associated contaminants throughout their life cycles. Such exposure to sediment-associated COPCs can adversely affect the survival, growth, biomass, and reproduction of benthic invertebrates. Accordingly, long-term toxicity tests that evaluate survival, growth, biomass, and reproduction need to be conducted to provide a basis for assessing effects on these receptors.

Advice: Revise the summary of the Elk River watershed evaluation of sediment quality conditions to provide a more balanced assessment of current conditions.

Rationale: The text of Section 3.2.2.5 indicates that sediment quality conditions are generally acceptable throughout most of the study area. This conclusion is not supported by the existing data and information for several reasons. First, the available sediment chemistry data indicate that COPC concentrations consistently exceed ISQGs and frequently exceed probable effect levels (PELs; i.e., Cadmium, Nickel, fluorene, naphthalene, and phenanthrene). Hence, the concentrations of COPCs are frequently sufficient to adversely affect the survival, growth, biomass, and/or reproduction of benthic invertebrates. The magnitude of exceedance of the SQGs also needs to be considered in this evaluation (i.e., in addition to the frequency of exceedance). Second, limited short-term sediment toxicity data showed that the survival of benthic invertebrates was impaired in at least one exposure area. In addition, the toxicity tests did not evaluate effects in long-term exposures or effects on reproduction, rendering them of limited value for assessing sediment quality conditions. Third, the benthic invertebrate community structure data were not considered in the sediment quality assessment. Even with the insensitive methods that were used in the benthic invertebrate community structure analysis, impairment of the benthic invertebrate community was demonstrated at numerous locations throughout the Elk Valley. As benthic invertebrate communities are likely responding to multiple stressors, including sediment quality conditions, such data should have been used in the sediment quality assessment.

Advice: Describe the effects of stream-bed substrate composition on benthic invertebrates and fish in the Elk Valley.

Rationale: The section of the report on sediment quality focuses on sediment chemistry and sediment toxicity. However, stream-bed substrate composition represents a key factor influencing egg-to-fry survival rates for salmonid fishes. In addition, stream-bed substrate composition can affect benthic invertebrate community structure and the abundance of benthic invertebrates. Therefore, there is a need to characterize existing conditions in the Elk Valley and describe the effects of sedimentation on these receptors.

Advice: Revise Section 3.2.3 of the Synthesis Report to explicitly describe the limitations of the existing data for evaluating sediment quality conditions in Lake Koocanusa.

Rationale: Sediment chemistry was the only line of evidence used to evaluate sediment quality conditions in Lake Koocanusa. Based on the information presented in Table 3.2.8, the conclusion that sediments in the lake pose negligible potential for harm to aquatic biota is based on comparison of total metal concentrations in sediments to SQGs. The number of samples evaluated is not identified. In addition, the magnitude of the exceedances of SQGs is not described. Furthermore, no data are presented on the concentrations of PAHs in lake sediments. Importantly, no sediment toxicity, benthic invertebrate community structure, or sediment bioaccumulation data were presented for the lake. Therefore, the conclusion that was reached regarding sediment quality conditions in the lake is, at best, only very poorly supported by relevant and appropriate data. At worst, this conclusion is misleading and potentially wrong. At minimum, this section of the document must be revised to explicitly recognize the limitations in the available data and information.

1.3 Calcite

The evaluation of existing calcite data is presented in Section 3.3 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Use concretion status (CI_C) as a primary metric for the evaluating effects of calcite on benthic invertebrates and fish.

Rationale: The calcite index currently includes two metrics that are combined in the calculation. One of the metrics provides information on the presence/absence of calcite. The second metric provides information on embeddedness of the streambed substrate. The second metric (i.e., concretion status) is likely to be more biologically relevant than the first metric. Therefore, the concretion status alone (and other metrics) should be used to evaluate the potential effects of calcite on fish and invertebrates.

Advice: Evaluations of the effects of calcite formation on stream-resident biota should include robust monitoring of habitat quality variables (including physical and chemical variables; e.g., intra-gravel DO, velocity, etc.) and biological effects (e.g., benthic invertebrate community structure and abundance; salmonid egg-to-fry survival rates; etc.).

Rationale: To date, calcite monitoring has focused on determining the distribution and spatial extent of calcite formation. As such, no data have been generated on the effects of calcite on ecological receptors. This is a major limitation relative to evaluating the effects of calcite on benthic invertebrates, fish, and other aquatic organisms. This data gap also makes it difficult to evaluate the interactive effects of multiple stressors or the cumulative effects of anthropogenic activities.

1.4 Periphyton

The evaluation of existing periphyton data is presented in Section 3.4 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Compile the available periphyton community structure data on a broad taxonomic basis, including green algae (Chlorophyta), blue-green algae (Cyanophyta), flagellate chrysophytes (Xanthophyceae and Chrysophyceae), diatoms (Bacillariophyceae), and other algae.

Rationale: The existing periphyton community structure data appear to be limited value due to difficulties that the labs experience while sorting samples and identifying species. While these difficulties appear to limit the value of the benthic invertebrate community structure data, a more simplistic analysis may yield more useful results. For this reason, the existing data should be re-analysed to determine the relative abundance of major periphyton taxa.

1.5 Benthic Invertebrates

The evaluation of existing benthic invertebrate data is presented in Section 3.5 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Detailed advice related to the collection and interpretation of benthic invertebrate samples was provided by KNC following TAC-5. It is not clear that this advice was considered during preparation of the Aquatic Synthesis Report. Therefore, the benthic invertebrate section of the report should be revised to incorporate the advice that was provided previously.

Rationale: There are numerous limitations to the underlying benthic invertebrate community structure data that were reported in the Aquatic Synthesis Report. In addition, the data analyses that were conducted are not at all transparent and do not appear to provide a sensitive basis for evaluating effects on benthic invertebrate communities within the study area.

Advice: Present the tabulated results of the benthic invertebrate community structure assessment in the main body of the report. Present the results separately for the two years of sampling.

Rationale: The description of the results of the benthic invertebrate community structure assessment does not appear to be supported by a tabulated summary of the available data. The text references Table 3.4-5; however, that table does not appear in the list of tables or in the tables themselves. Therefore, the description of community structure and health (Section 3.5.2) is not supported by data or the results of data analyses.

Advice: In the tabulated results of the benthic community structure data, identify unaffected reference stations and reference stations that may have been affected by logging, road construction, or other anthropogenic activities.

Rationale: A reference envelope-type approach has been used to evaluate the benthic invertebrate community structure data that have been collected within the study area. The underlying assumption of this type of analysis is that benthic communities at reference locations represent conditions in areas that have not been adversely affected by mining or other human activities. However, benthic communities are known to respond to a number of stressors, including fine sediment that is mobilized by various activities within a watershed. Inclusion of “reference stations” that have been affected by non-mining-related activities expands the size of the reference envelope and decreases the power to detect mining-related effects. Therefore, it is essential that only appropriate reference sites are used to define reference conditions within the Elk Valley.

1.6 Fish Tissue

The evaluation of existing fish tissue data is presented in Section 3.6 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Present the dietary toxicity reference values (TRVs) for fish and aquatic-dependent birds in the main text of the Aquatic Synthesis Report.

Rationale: The text of the report provided hazard quotients (HQs) that were calculated for fish or aquatic-dependent birds, using the selected dietary TRVs for fish and birds. However, these TRVs do not appear to be presented in the text of the report. Therefore, the TRVs that were selected for use in the screening-level assessment must be identified, along with the underlying rationale for their selection.

Advice: For the evaluation of Se fish tissue concentrations, change the "comparison to reference areas" to "comparison with non-mine influenced water bodies" with a disclaimer (i.e., footnote) stating that these sites have not been evaluated to determine if they are appropriate reference areas in terms of hydrological and biogeochemical similarity.

Rationale: The concentrations of selenium in fish tissues from reference areas have been calculated and used in the tissue screening evaluation. While information on reference tissue concentrations can be relevant in assessments of fish tissue quality, there is substantial uncertainty in the estimates of reference concentrations of selenium in the Elk Valley (i.e., because fish are mobile and fish collected in reference areas may have been exposed to selenium in mine-affected areas. Therefore, comparison to reference selenium concentrations could inappropriately result in screening out species or areas that may be a concern from the standpoint of selenium bioaccumulation (Appendix 1).

Advice: Provide the additional rationale for selecting large-scale suckers (LSU) as sentinel species for evaluating mining-related effects on fish.

Rationale: Although some rationale is provided for selecting LSU as a sentinel species, no information was provided on their potential to bioaccumulate selenium or to be responsive to other stressors associated with mining activities. Before selecting sentinel species, it is helpful to develop effects hypotheses. Such hypotheses are essential for identifying measurement endpoints (i.e., indicators and metrics) that can be used to evaluate mining-related effects. Currently, this type of linkage to the conceptual site model is missing from this section of the Aquatic Synthesis Report.

1.7 Amphibians

The evaluation of existing amphibian tissue data is presented in Section 3.7 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Present the dietary TRVs for amphibians in the text of the Aquatic Synthesis Report.

Rationale: The text of the report provided HQs that were calculated for amphibians, using the selected dietary TRVs for fish. However, these TRVs do not appear to be presented in the text of the report. Therefore, the TRVs that were selected for use in the screening-level assessment must be identified, along with the underlying rationale for their selection.

Advice: For the evaluation of Se egg-mass concentrations, change "comparison to reference areas" to "comparison with non-mine influenced water bodies" with a disclaimer (i.e., footnote) stating that these sites have not been evaluated to determine if they are appropriate reference areas in terms of hydrological and biogeochemical similarity.

Rationale: The concentrations of selenium in eggs from reference areas have been calculated and used in the tissue screening evaluation. While information on reference tissue concentrations can be relevant in assessments of tissue quality, there is substantial uncertainty in the estimates of reference concentrations of selenium in the Elk Valley.

1.8 Evaluation of Environmental Quality

The evaluation of environmental quality is presented in Section 4 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Describe the data that were considered in the evaluation of environmental quality in the context of the CSM (i.e., describe the data that were used to evaluate effects on each receptor group).

Rationale: The text of the report generally describes the data that were used to evaluate environmental quality in the Elk Valley. However, this description is not linked to the CSM for the site or effects hypotheses. Therefore, the data that are directly relevant to each receptor group need to be identified and used to evaluate effects on that receptor group (e.g., surface-water chemistry data and periphyton community data are relevant for evaluating effects on periphyton). The evaluation of environmental quality is not useful for evaluating current conditions in the abstract.

Advice: Provide a more complete description of the water quality index (WQI) that was developed for use in the Elk Valley. Provide the rationale for altering the water quality classification system that was developed by the CCME (2001).

Rationale: It appears that the site-specific WQI includes the site-specific water quality benchmarks that were developed during the EVWQP process. However, different water quality benchmarks were developed for each receptor group. Therefore, it would seem to be appropriate to develop a separate WQI for each of the receptor groups that are considered in the evaluation. It is not clear, from the description of the WQI provided, that multiple WQIs were developed and used in the assessment. Therefore more information is needed to fully describe the WQI and the rationale for its use in the assessment.

Advice: Eliminate the description of the approach for interpreting overall environmental quality by area within management units.

Rationale: The approach to evaluating overall environmental quality by area within management units is not appropriate. To be useful, this evaluation needs to be conducted first on a receptor-by-receptor basis, where individual and then multiple stressors are evaluated. Subsequently, the results that were generated for each receptor group for the tributaries, for the off-channel habitats, and for the mainstem reaches within each MU can be discussed collectively. Finally, the results for all receptor groups can be discussed collectively. The current approach is not consistent with the CSM and does not provide a basis for evaluating effects hypotheses.

Advice: Eliminate the watershed report card until such time that it can be properly developed (i.e., in a manner consistent with the CSM and effects hypotheses) and validated.

Rationale: The evaluation of overall environmental quality was summarized in the draft watershed report cards that were presented at TAC-6. Each of the indicators of environmental quality used in the evaluation has a number of limitations that make it inappropriate for use at this time. For example, the WQI is not sufficiently described and is inconsistent with the CCME (2001) WQI. The calcite index is not linked to biological effects; so, the classifications that were selected are arbitrary. The benthic invertebrate community structure analysis is strongly affected by the selection of reference station and the treatment/analysis of associated data. The benchmarks for calculating the metrics for assessing selenium in tissues are incompletely described. Collectively, these limitations render the various metrics of uncertain value for characterizing environmental quality conditions in the Elk Valley. Moreover, insufficient and inappropriate rationale has been provided on how the various metrics have been considered together to develop an overall rank for a sampling station. Importantly, key mining-related stressors that could substantially affect ecological receptors have not been evaluated in the report card [e.g., stream-bed substrate quality, TSS, changes in streamflow, exposure to groundwater during surface water recharge (i.e., during base flow periods), etc.]. Therefore, the integration of multiple data types and associated report card are not reliable tools for evaluating existing environmental conditions in the Elk Valley.

1.9 Recommendations for Future Studies and Monitoring

The recommendations for future studies and monitoring is presented in Section 5 of the Aquatic Environment Synthesis Report. Based on a review of the information that was presented, the following advice (and associated rationale) is provided:

Advice: Revise the section of the report that indicates that there are no data gaps.

Rationale: Although a substantial amount of information has been collected to support the evaluation of current conditions in the Elk Valley, it is incorrect to indicate that there are no major data gaps. Some of the key data gaps include (but are not limited to):

1. Distribution of freshwater mussels within the Elk River watershed, Lake Koocanusa, and appropriately selected reference areas;
2. Effects of contaminants associated with mining-activities on the survival, growth, and reproduction of freshwater mussels;

3. Effects of calcite formation and presence on the distribution and abundance of freshwater mussels;
4. Levels of selenium in the tissues of burbot in Lake Koocanusa;
5. Bioaccumulation of selenium in aquatic plants, aquatic invertebrates, and fish in Lake Koocanusa;
6. Effects of egg/ovary selenium on the reproduction of peamouth chub, burbot, and bulltrout;
7. Effects of nitrate on the survival, growth, and reproduction of mayflies;
8. Effects of multiple stressors and nutrient addition on periphyton abundance and community structure (i.e., at the highest taxonomic levels);
9. The effects of multiple stressors on the benthic invertebrate abundance and community structure;
10. The sensitivity of the CABIN-Reference Envelope Approach to benthic invertebrate community structure assessment; and,
11. Critical levels of aquatic plant nutrients in Lake Koocanusa.

Therefore, the report needs to be revised to identify key data gaps that need to be addressed by future monitoring and supporting studies.

2.0 Regulatory Context

Regulatory context is described in Chapter 2 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Describe the regulatory context of the EVWQP, including its relationship to federal and provincial legislation, regulations, and policies, to other plans relevant to the Elk Valley, and to future permitting of Teck-lead and other development projects in the Elk Valley.

Rationale: The Terms of Reference for the EVWQP indicate that the Plan will outline the current regulatory context applicable to selenium, cadmium, nitrate, and sulphate in water and calcite formation in the Designated Area. While this chapter provides a description of the provincial and federal environmental legislation that are relevant to managing the environment in B.C., this chapter should fully describe the regulatory context of the EVWQP. The text in Chapter 2 provides little information on the regulatory context for the EVWQP.

Advice: The EVWQP should be reviewed and revised at least every five years to provide a current and relevant plan for permitting new projects and amending permits for existing projects.

Rationale: The Terms of Reference for the EVWQP indicate that the Plan will propose for periodic BCMOE review and approval of amendments to the Plan. Given the timing of the proposed mitigation actions, it is reasonable to expect that the EVWQP will need to be updated at least every five years. This is important because there are numerous data gaps and uncertainties that need to be addressed during implementation of the Plan. The results of monitoring, special studies, and mitigation research and development are likely to influence both the water quality targets that have been established under the Plan and the mitigation that is selected to address water quality concerns. The Plan needs to be updated to reflect the new information and to inform permitting of new and existing projects.

3.0 Consultation and Technical Advice

The processes undertaken by Teck on consultation and the incorporation of technical advice are described in Chapter 3 of the EVWQP. No advice is provided on this chapter of the EVWQP.

4.0 Current Baseline Conditions

The baseline data that were used to evaluate current conditions in the Elk Valley are described in Chapter 4 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Develop a single, consolidated CSM that includes both physical and chemical stressors.

Rationale: The current baseline conditions chapter of the EVWQP describes a CSM for the designated area. However, this CSM does not include physical stressors. This makes it difficult to develop hypotheses regarding the interactive effects of multiple stressors or the cumulative effects of multiple anthropogenic activities. Therefore, a single, consolidated CSM that includes both physical and chemical stressors needs to be developed.

Advice: Include a table in Chapter 4 that provides a means of identifying the data used to evaluate current baseline conditions. This table needs to describe the data available for media type for each of the tributaries and mainstem by management unit.

Rationale: Presentation of the information in this way provides a broad perspective on the data that were used to facilitate a cursory characterization of current baseline conditions and supports subsequent identification of data gaps.

Advice: Include a table of the guidelines that were used to screen surface-water chemistry data from the Elk Valley in the main body of the report.

Rationale: The first step of the evaluation of existing surface water chemistry data involves screening against WQGs. The reader needs to know what WQGs were used in the screening process.

Advice: In addition to reporting the frequency of exceedance, calculate and report the maximum hazard quotients based on a comparison of measured CoI concentrations to each of the selected WQGs for each sampling station in each MU. The results of this analysis need to be tabulated and presented in the text of the main report for all analytes.

Rationale: Most of the underlying surface water chemistry data used in the evaluation of existing water quality conditions were obtained from grab samples collected on a monthly or less frequent basis. Therefore, all of these results (with the exception of samples collected as part of a 5-in-30 day sampling event) should be considered to represent mean monthly concentrations of the CoIs in surface water and should be compared to long-term WQGs. Hence, exceedance of a long-term WQGs in one or more surface water samples represents a condition that could adversely affect aquatic organisms. This analysis will provide relevant information on current water quality conditions.

Advice: Remove samples with high non-detect results from the data set prior to conducting COPC screen.

Rationale: High non-detect values (i.e., samples with non-detect concentrations that are higher than the respective screening threshold) should be excluded prior to identifying COPCs to reduce the probability of falsely identifying COPCs.

Advice: Revise Sections 4.3 and 4.4 of the EVWQP (i.e., Existing Data and Evaluation of Environmental Quality) based on the advice that was provided on the Aquatic Synthesis Report.

Rationale: Detailed advice was provided to facilitate revision of the Aquatic Synthesis Report. This advice demonstrated that the data and approaches used to evaluate the existing status of surface water quality, sediment quality, periphyton communities, benthic invertebrate communities, fish communities, amphibian communities, and avian communities had limitations that needed to be addressed. As Sections 4.3 and 4.4 of the EVWQP are based, in large measure, on the Aquatic Synthesis Report, there is a need to revise this chapter of the Plan accordingly.

Advice: Explicitly identify data gaps and uncertainties in Chapter 4 of the EVWQP.

Rationale: Data gaps and uncertainties associated with the evaluation of existing environmental conditions in the Elk Valley need to be explicitly identified to maintain transparency in the EVWQP process.

5.0 Assessment of Protection of Human Health and Groundwater

The results of the assessment for protection of human health and groundwater are described in Chapter 6 of the EVWQP. More detailed information on the assessment is presented in Elk Valley Water Quality Plan: Draft Human Health Evaluation of Current Baseline Conditions (Environ 2014). Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Provide a clear and consistent rationale for the selection of guidelines and TRVs used in the human health evaluation.

Rationale: It is essential that the rationale for the selection of guidelines and TRVs is cleared documented in the evaluation. In addition, the procedures that were used to derive guidelines or TRVs need to be described to provide transparency in the evaluation process.

Advice: Present the complete results of the screen that was conducted for surface water, sediments, and fish tissues.

Rationale: The current evaluation presents the screening results for only those substances that exceeded the selected guidelines. The evaluation would be strengthened by including tabulated summaries for all media types that include all measured COPCs, maximum concentrations, the selected guideline, and associated HQ. Substances for which no guidelines are available should be included in the tabulated summaries to ensure that uncertain COPCs are consistently identified. In addition, substances that could have been released into the environment (i.e., as identified using the CSM for human health), but were not measured, need to be included in the summary and identified as uncertain COPCs. This approach will provide greater transparency in the assessment.

Advice: Re-evaluate the risks to human health associated with exposure to bromide in surface water.

Rationale: The results of the evaluation indicated that the maximum concentration of dissolved bromide in surface water exceeded the guideline for total bromide. This result should have resulted in identification of bromide as a constituent of concern that required more detailed evaluation (i.e., if dissolved bromide exceeded a guideline, then total bromide would also exceed the guideline). Therefore, the effects of bromide on human health need to be re-evaluated. If no human-health based guideline is available for bromide, this CoI needs to be identified as an uncertain COPC and brought forward into the risk assessment.

Advice: Evaluate the significance of indirect pathways for those COPCs that tend to accumulate or biomagnify in the environment.

Rationale: The assumption that secondary or indirect exposure pathways are all minor and do not need to be evaluated may flawed. For substances that tend to accumulate or biomagnify in the environment, uptake by wildlife and consumption of game meat could provide an important source of exposure. Similarly, uptake by riparian plants and subsequent consumption of these plants could result in significant exposure to substances that accumulate in plants. Therefore, these secondary pathways need to be evaluated. If insufficient data are available to conduct a comprehensive spatial evaluation for certain COPCs, then this must be identified as a data gap that needs to be addressed. Information on traditional land use practices by KNC members and associated traditional ecological knowledge should be used to inform the evaluation of secondary exposure pathways.

Advice: Check the accuracy of all of the calculations used to evaluate potential effects on human health under baseline conditions.

Rationale: As presented, at least some of the calculations used in the evaluation are not reproducible. Therefore, the underlying equations, benchmarks, and exposure point concentrations should all be checked to assure their accuracy (see Appendix 2 for more information).

Advice: Include toddler as a receptor in the evaluation of potential effects on human health under baseline conditions.

Rationale: According to Health Canada (2010) guidance, toddlers would normally be considered to be the critical receptor for threshold chemicals at a site where all age classes are present. Therefore, toddlers need to be included the evaluation of potential effects on human health under baseline conditions.

Advice: The effects of TDS should be evaluated relative to human health and potability of drinking water supplies.

Rationale: Total dissolved solids (TDS) has the potential to adversely affect drinking water supplies. Therefore, TDS needs to be addressed in the assessment of protection of human health and groundwater.

Advice: Explicitly identify data gaps and discuss uncertainties associated with the human health assessment (i.e., present this important information as a bulleted list in the Chapter 6 and in the accompanying report).

Rationale: Information on data gaps and uncertainties is essential for understanding how much confidence can be placed in the results of the human health risk assessment. In addition, this information is needed to support the design of monitoring programs to address data gaps and/or supporting studies to address uncertainties.

Additional comments on the assessment of protection of human health and groundwater draft and on the associated human health evaluation of current conditions are provided in Appendix 2.

6.0 Management Options

The management options that were considered and ultimately selected for application are described in Chapter 6 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Validate the water quality model to confirm that it provides an accurate basis for predicting COPC concentrations in Lake Koocanusa, using data on COPC levels in the tributaries and other source areas.

Rationale: The evaluation of management options was, in part, based on water quality modeling that provided a basis for "if this-then that" evaluations of various scenarios. Therefore, the water quality model plays a fundamental role in the evaluation and selection of mitigation options in the EVWQP. Therefore, the accuracy of the model as it relates to model predictions in Lake Koocanusa is a key uncertainty in the EVWQP process. To reduce this uncertainty, the concentrations of COPCs in surface water in Lake Koocanusa that are predicted using the model should be compared to actual measurements of surface water quality in Lake Koocanusa as more data become available. This needs to be conducted annually as new data are generated. This type of water quality model validation is also needed for the riverine components of the watershed and associated tributaries.

Appendix 3 and 4 provide additional comments on the management options proposed by Teck.

7.0 Calcite Management

Background information, monitoring and assessment methods, monitoring results, narrative objectives and targets, treatment technology options, and adaptive management related to calcite are described in Chapter 7 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: A conceptual site model has been presented that links calcite formation to effects on ecological receptors. Use the CSM to develop environmental effects hypotheses, interactive effects hypotheses, and cumulative effects hypotheses that explicitly consider the potential effects of calcite and other stressors on aquatic receptors.

Rationale: Calcite represents an important physical stressor for ecological receptors utilizing habitats in tributaries and, to a lesser extent, mainstem areas. Development of a CSM provides a systematic basis for formulating environmental effects hypotheses, interactive effects hypotheses, and cumulative effects hypotheses that explicitly consider the potential effects of calcite and other stressors on aquatic receptors. Such hypotheses are needed to guide monitoring and assessment activities relative to calcite in the future.

Advice: For the purposes of describing current conditions, classify streams into three categories using the calcite monitoring data that were collected in 2013 (Appendix 5), including:

1. ***Unaffected Streams* -** These streams have calcite levels consistent with those observed in reference streams. Such streams have CIC values and CIP values less than or equal to the upper limit of background, as defined by the 95^{th} percentiles calculated for reference sites. The 95^{th} percentile value for CIC is 0.05, while the 95^{th} percentile value for CIP is 0.345 (see Appendix 5).

2. ***Moderate-Affected Streams* -** These streams have calcite levels that are intermediate between unaffected streams and highly affected streams (i.e., CIP of 0.35 to <0.75 or CIC of >0.05 to <0.5);

3. ***Highly-Affected Streams* -** These streams have at least 75% of the pebbles showing evidence of calcite formation (i.e., CIP 0.75) or at least 25% of the streambed showing evidence of concretion (i.e., CIC 0.5).

Rationale: A calcite index (CI) as developed to provide a basis for classifying streams in the Elk Valley based on the presence of calcite (CIP) and the degree of concretion of the streambed (CIC), where CI = CIP + CIC. The three classifications that were developed included a low CI range (0 to 0.99), a mid-CI range (1.0 to 1.99), and an upper CI range (2.00 to 3.00). While these range of CI values provide one means of classifying streams relative to calcite content, an alternate classification system that considers the potential effects may be more appropriate in the near-term. The unaffected classification identified above defines the reference envelope using the indicators incorporated into the CI. The highly-affected streams would be expected to have substantial reductions in benthic invertebrate productivity and/or reduced egg-to-fry survival rates for salmonids (i.e., with a high incidence of calcite or substantial concretion of streambed substrates).

Advice: Provide a definition of "receiving environment" or rename the term to something more accurate.

Rationale: In this chapter of the EVWQP, the term receiving environment refers to portions of the streams downstream of constructed works, such as settling ponds, culverts, and similar structures. This term should be replaced with a term that more accurately describes these mine works.

Appendix 3 provides additional comments on the calcite monitoring plan that was developed by Teck.

8.0 Water Quality Targets and Implementation Plan

The short-term, medium-term, and long-term water quality targets and the associated initial implementation plan are described in Chapter 8 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Adopt the draft B.C. WQG for dissolved cadmium as the long-term water quality target for cadmium.

Rationale: The Toxicology Working Group evaluated a number of options for selecting benchmarks for cadmium for the protection of aquatic life. Toxicity-based targets that are equivalent to the B.C. WQGs offer a higher level of protection relative to WQGs established by the CCME. Ultimately, it was recommended by KNC and BCMOE that the draft BC WQGs for dissolved cadmium be selected for use in evaluating current conditions in the Elk Valley and for establishing a long-term target for cadmium.

Advice: The B.C. WQGs and site-specific benchmarks for cadmium, nitrate, selenium, and sulphate should not be regarded as "pollute up to numbers." Rather, all reasonable and practical mitigation measures should be taken to minimize loadings of these substances to receiving waters.

Rationale: Ecological receptors utilizing aquatic and riparian habitats in the Elk Valley have the potential to be exposed to a variety of physical and chemical stressors. The effects of some, but not all, of these stressors have been evaluated in the EVWQP. These evaluations have resulted in the adoption of WQGs for certain COPCs (i.e., sulphate) and development of site-specific benchmarks for other COPCs (i.e., cadmium, nitrate, and selenium). These benchmarks have been established at EC_{10} levels for specific receptors and do not include application of uncertainty factors. The effects of various other stressors, such as calcite, TSS, intragravel dissolved oxygen, deposited sediment, water temperature, etc., have not been quantitatively evaluated. In addition, the interactive effects of multiple stressors and the cumulative effects of multiple anthropogenic activities have not been quantitatively evaluated. Therefore, there is still a substantial amount of residual uncertainty about the level of protection that the WQGs and site-specific benchmarks provide, when interactive and cumulative effects are considered. Accordingly, all reasonable and practical mitigation measures should be taken to minimize loadings of these substances to receiving waters (i.e., to ensure that concentrations of these COPCs are maintained at the lowest practical levels).

Advice: Provide a definition of “maximum average monthly concentration”, and change “average” to “mean”. In the definition, provide additional information that describes that the monthly concentrations frequently or usually consist of one sample collected per month.

Rationale: The metrics used in the EVWQP should be clearly defined, including the methods used for calculating the metrics.

Advice: Add “interim” to the Level 1 and Level 2 nitrate benchmarks.

Rationale: The TWG recommended that the site-specific toxicity testing results for *Ceriodaphnia dubia* be used to support the development of interim targets for the Elk Valley. However, additional long-term toxicity tests conducted with the amphipod, midge, and rainbow trout, and toxicity tests conducted with amphipods were also recommended to be completed and the results incorporated into the target derivation process.

Advice: Clarify that the target of 40 µg/L for selenium in Lower Fording River (MU 2) is not a Level 1 benchmark. In addition, clearly outline the rationale that the 12% effect size is still protective, but has a lower margin of safety. Also, provide more information in this paragraph on why the Level 1 benchmark is not achievable.

Rationale: This clarification would improve the technical clarity and transparency of the EVWQP.

Advice: Sulphate concentrations are predicted to continue to rise and are predicted to eventually exceed the WQG at certain locations in the Elk Valley. Provide rationale for not addressing these issues in the EVWQP and explain what future work will be done to determine if water quality treatment for sulphate is necessary.

Rationale: All reasonable and practical mitigation measures should be taken to minimize loadings of the order constituents to receiving waters (i.e., to ensure that concentrations of these COPCs are maintained at the lowest practical levels). However, no measures have been proposed to address increasing concentrations of sulphate. This needs to be corrected in the EVWQP.

Advice: Adopting BC MoE tissue guidelines as long-term benchmarks and targets for the EVWQP is the most appropriate approach to protect aquatic organisms against the effects of selenium. Adoption of BC MoE WQGs for selenium in for other media (water, sediment, dietary) could also be helpful in an adaptive management framework to protect unimpacted areas and serve as long-term assessment goals in impacted areas of the Elk Valley where mitigative measures are undertaken (also see Appendix 6 and 7).

Rationale: The B.C. WQGs are more conservative than the proposed water quality targets, account for multiple sources of uncertainty, and are aligned with recommended Se toxicity thresholds, criteria and benchmarks published by other regulatory jurisdictions. Although dietary tissue benchmarks for juvenile fish and birds is not recommended (because diet is not a direct measure of toxicity), if dietary benchmarks are adopted they should be consistent with BC's WQG. The implementation of dietary benchmarks should be part of an adaptive management framework to provide an early alert in management units where new mining activities may pose a risk to sensitive organisms.

Advice: A comprehensive quantitative assessment of cumulative impacts from coal mining to aquatic life should be conducted for the Elk Valley that incorporates additional studies on a wider range of resident fish, bird and amphibian species.

Rationale: The assessment of interactive effects in the EVWQP is qualitative and too subjective. There is also a lack of quantitative information on the cumulative effects on a wide range of species exposed to effluents and habitat disturbance from coal mining.

Additional comments on the water quality targets and the initial implementation plan are provided in Appendix 6 and 7.

9.0 Social and Economic Considerations

The social and economic considerations associated with the EVWQP are described in Chapter 9. No advice is offered on this chapter of the EVWQP.

10.0 Monitoring

Chapter 10 of the EVWQP describes the elements of the monitoring program that will be conducted during implementation of the Plan. The EVWQP describes three types of monitoring activities that will be conducted in the Elk Valley, including water monitoring (i.e., including routine monitoring conducted under EMA permits and monitoring conducted synoptically with biological monitoring), biological monitoring [including baseline monitoring, aquatic effects monitoring associated with individual projects (AEMP), and regional aquatic effects monitoring (RAEMP)], and special supporting studies. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Develop a monitoring framework for the Elk Valley that will provide the data and information needed to thoroughly evaluate the effects of mining activities on the aquatic ecosystem. The steps involved in this process should include:

1. Develop a single conceptual site model (CSM) that describes sources and releases of contaminants, identifies physical and chemical stressors of potential concern, describes environmental transport and fate processes, describes the expected ecological effects of physical and chemical stressors (based on literature-based information and other

studies), identifies potentially-complete exposure pathways, identifies receptors potentially at risk.

2. Use the CSM to develop hypotheses regarding the effects of individual stressors, the interactive effects of multiple stressors, and the cumulative effects of stressors associated with multiple human activities.

3. Identify assessment endpoints (e.g., survival, growth, and reproduction of fish) that need to be evaluated using the results of monitoring programs.

4. Identify measurement endpoints (e.g., egg-to-fry survival of cutthroat trout) that will provide a basis for evaluating the status of each assessment endpoint.

5. Design monitoring programs to guide the collection of data for each measurement endpoint, including spatial and temporal considerations.

Rationale: The monitoring chapter of the EVWQP currently includes descriptions of the monitoring requirements identified in the Terms of Reference for monitoring objectives for the EVWQP, and for monitoring objectives for the RAEMP. However, the monitoring that is described does not appear to have been informed by a consolidated CSM or focused on providing the information needed to test an ecological effects hypothesis. This represents a major limitation of the design of the monitoring programs that are described in this chapter of the EVWQP. This limitation can be effectively addressed by following and documenting a systematic data quality objectives process, as described above (see USEPA 2000; 2006; MacDonald *et al.* 2009a; 2009b; 2009c; 2009d; 2009e; 2009f; MacDonald *et al.* 2009g; Zajdik *et al.* 2009; Clark *et al.* 2010).

Advice: Revise the EVWQP to identify a monitoring framework that includes three types of monitoring programs (rather than media types and special studies), including:

1. Surveillance network monitoring programs (i.e., which are also referred to as Mine Site Monitoring Programs) that are conducted to provide data and information on the status and trends of environmental conditions within mine works, including effluent quality monitoring, seepage monitoring, on-site groundwater monitoring, etc. (as required under EMA permitting);

2. Local AEMPs (LAEMPs) that are conducted in the immediate vicinity of individual projects to provide data and information of the effects of mining activities on the aquatic environment and aquatic-dependent wildlife. Typically, such AEMPs would be expected to include surface water monitoring, sediment quality monitoring, biological monitoring, etc. (as required under EMA permitting).

3. RAEMP that is conducted throughout the Elk River watershed and Lake Koocanusa to provide data and information on the effects of mining activities on the aquatic environment and aquatic-dependent wildlife. The RAEMP will need to include a number of program elements including surface water monitoring, sediment quality monitoring, biological monitoring, and special studies.

Advice: Clearly identify all of the goals of the RAEMP.

Rationale: Whitfield (1988) described the goals and data collection designs for water quality monitoring. More specifically, Whitfield (1988) identified five reasons for conducting water quality monitoring, including:

1. Assessment of the status and trends in environmental conditions;
2. Evaluation of compliance (i.e., attainment) with water quality objectives or standards;
3. Estimation of mass transport;
4. Assessment of environmental effects and impacts; and,
5. General surveillance.

As monitoring programs need to be specifically designed to achieve each of these monitoring goals, it is essential to clearly define monitoring goals prior to designing the RAEMP. Based on discussions convened among the members of the Monitoring Working Group, it is apparent that the RAEMP has the following goals:

1. Assessment of the status and trends in environmental conditions (Data and information generated from status and trends monitoring will inform the adaptive management program);
2. Evaluation of attainment of short-term, medium-term, and long-term water quality targets (and associated triggers) for cadmium, nitrate, selenium, and sulphate (Data and information generated from

targets attainment monitoring will inform the adaptive management program);

3. Evaluation of the narrative targets that have been established for calcite (Data and information generated from targets attainment monitoring will inform the adaptive management program); and,
4. Assessment of environmental effects of activities associated with coal mining in the Elk Valley (Data and information generated from environmental effects monitoring will inform the adaptive management program);
5. Assessment of the cumulative environmental effects associated with coal mining and other anthropogenic activities in the Elk Valley, including climate change (Data and information generated from cumulative effects monitoring will inform the adaptive management program); and,
6. Validation of key tools that were developed to support the EVWQP, including water quality models, bioaccumulation models, and site-specific benchmarks for water and other environmental media (Data and information generated during validation of key tools will inform refinement of the EVWQP and the adaptive management program).

These goals need to be incorporated into the monitoring chapter of the EVWQP.

Advice: As part of the LAEMP and RAEMP, develop selection criteria, identify candidate reference areas (referred to control stations in the design of BACI-type monitoring programs), and evaluate the appropriateness of those reference areas (in terms of hydrological and biogeochemical similarity) that will be included in the environmental effects and cumulative effects monitoring elements of the RAEMP.

Rationale: A BACI-based monitoring program design should be used in the RAEMP to evaluate the environmental effects associated with coal mining activities and the cumulative effects associated with all anthropogenic activities. This type of monitoring necessitates identification and evaluation of candidate reference stations that are potentially appropriate for used in the RAEMP. To ensure that the selection of reference stations is conducted in a transparent and appropriate manner, it is necessary to establish selection criteria on an *a priori* basis. Such selection criteria should include:

1. The reference station should be located in the sample body of water as the effluent discharge (Environment Canada 2004; e.g., The

reference stations for Michel Creek should be located within the Michel Creek drainage basin). If a suitable reference station is not available within the same water body, then the reference stations should be located in the nearest comparable drainage basin (Environment Canada 2004);

2. The characteristics of riparian areas adjacent to reference stations should be similar to those at the mining-influenced stations prior to the implementation of mining activities;
3. The stream order, streambed substrate types, hydrological characteristics of reference stations should be similar to those at the mining-influenced stations prior to the implementation of mining activities;
4. Water quality characteristics at reference stations should be similar to those at the mining-influenced stations prior to the implementation of mining activities (i.e., based on baseline monitoring activities). When baseline data are not available, water quality characteristics at reference stations should be similar to those in the nearest comparable drainage basin;
5. Sediment quality characteristics at reference stations should be similar to those at the mining-influenced stations prior to the implementation of mining activities (i.e., based on baseline monitoring activities). When baseline data are not available, sediment quality characteristics at reference stations should be similar to those in the nearest comparable drainage basin;
6. Tissue chemistry at reference stations should be similar to those at the mining-influenced stations prior to the implementation of mining activities (i.e., based on baseline monitoring activities) and clearly not affected by exposure to discharges from mine sites (i.e., for mobile species). When baseline data are not available, tissue chemistry at reference stations should be similar to those in the nearest comparable drainage basin that has clearly not been affected by exposure to discharges from mine sites (i.e., for mobile species); and,
7. Surface water toxicity and sediment toxicity at reference stations should be within the range defined for acceptable negative control samples used in laboratory toxicity tests (as defined in Environment Canada, USEPA, and/or ASTM standard methods).

Advice: Include an additional monitoring station in Lake Koocanusa downstream of Sand Creek and outside the potential influence of discharges from the Elk River (i.e., located upstream of the existing monitoring station that is located upstream of the Elk Arm of Lake Koocanusa).

Rationale: The purpose of this monitoring station is to provide a reference station in the lake that is far enough upstream that it is unlikely to be influenced by discharges from the Elk River and far enough into the lake that fine sediment from the Kootenay River has largely settled out of the water column.

Advice: Expand the RAEMP to include ongoing groundwater monitoring, both in the immediate vicinity of mining activities and in downstream areas.

Rationale: Groundwater resources have a number of uses in the Elk Valley, including drinking water supplies, irrigation, and livestock watering. In addition, groundwater recharge may represent an important component of the streamflow of the tributaries, the Fording River, and or the Elk River at certain times of the year. Therefore, it is important to characterize groundwater quality and quantity in the Elk Valley in the immediate vicinity of mining activities and in downstream areas. Teck initiated groundwater sampling activities in 2013. These results, in conjunction with the CSM, should be used to design an ongoing groundwater monitoring program for the Elk Valley.

Advice: Conduct a gradient-based sediment toxicity testing program within the Elk Valley and Lake Koocanusa as a supporting study under the RAEMP.

Rationale: To date, only limited sediment toxicity data have been collected within the Elk Valley, including short-term toxicity tests with amphipods (14-d tests with *Hyalella azteca*) and midge (10-d tests with *Chironomus dilutus*). This is not sufficient to evaluate toxicity to benthic invertebrates in longer-term exposure or to evaluate reproductive effects. Implementation of this program should involve the collection of fine sediment (i.e., <2.00 mm) at near-field, mid-field, and far-field stations located throughout the study area (including Lake Koocanusa) to establish baseline conditions. By sampling along a potential concentration gradient, it may be possible to develop concentration-response relationships and site-specific sediment toxicity thresholds for selected COPCs.

Advice: Evaluate the distribution and abundance of freshwater mussels within the Elk River watershed, Lake Koocanusa, and appropriately selected reference areas as a supporting study under the RAEMP.

Rationale: Freshwater mussels represent key components of aquatic communities. To date, no information has been presented on the distribution or abundance of freshwater mussels in the Elk River, tributaries to the Elk River, or Lake Koocanusa. As freshwater mussels are known to be sensitive to a variety of physical, chemical, and biological stressors, including those that are associated with mining activities, it is essential to obtain information on the distribution and abundance of freshwater mussels in mining-influenced and appropriately selected reference areas.

Advice: Evaluate the effects of selected contaminants (i.e., cadmium, selenium, nitrate, and sulphate) associated with mining-activities on the survival, growth, and reproduction of freshwater mussels (in water-only exposures) as a supporting study under the RAEMP.

Rationale: A series of toxicity tests have been conducted to evaluate the toxicity of nitrate and sulphate to aquatic plants, aquatic invertebrates, and fish. The results of these toxicity tests have provided the data and information needed to derive site-specific water quality benchmarks for these water quality variables. However, no toxicity testing has been conducted to evaluate the toxicity of these COPCs or other water quality variables on freshwater mussels. For this reason, it is appropriate to design and implement a toxicity testing program to determine if the water quality benchmarks that have been developed for the protection of other aquatic species would also be protective of freshwater mussels.

Advice: Evaluate the effects of calcite formation and presence on the distribution and abundance of freshwater mussels as a supporting study under the RAEMP.

Rationale: Calcite formation has the potential to alter the quality of streambed substrates and, hence, decrease their suitability for inhabitation by freshwater invertebrates and their use by fish for spawning and incubation. A study is currently being designed to evaluate the effects of calcite formation and presence on benthic macroinvertebrates. However, such a study is unlikely to be designed to assess effects on freshwater mussels. For this reason, the scope of the proposed study should be expanded to ensure that freshwater mussels are identified and enumerated at all of the mining-influenced and reference stations that are examined. Survey methods relevant to freshwater mussels will need to be employed to ensure that relevant data are generated on the effects of calcite formation and presence on the distribution and abundance of freshwater mussels (e.g., Smith *et al.* 2003; Angelo *et al.* 2007).

Advice: Evaluate the effects of egg/ovary selenium on the reproduction of peamouth chub, burbot, and bull trout as a supporting study under the RAEMP. In addition, the effects of egg/ovary selenium on the reproduction of mountain whitefish should be re-evaluated using a broader range of tissue concentrations than was obtained in the Nautilus Environmental (2012) study, including inclusion of control fish.

Rationale: Data on the toxicity of tissue-associated selenium are available for a number of freshwater fish species. However, matching tissue chemistry and reproductive success data are not available for several key species that utilize habitats in Lake Koocanusa, including peamouth chub, burbot, and bull trout. This data gap makes it difficult to determine if the long-term target for selenium in water is likely to be protective of all fish species that utilize habitats in Lake Koocanusa. Generation of concentration-response data for these additional fish species will provide greater certainty that the targets, based on toxicity to brown trout, are protective of peamouth chub, burbot, and bull trout. Re-evaluation of the toxicity of selenium to mountain whitefish will provide improved confidence that the targets that are set for selenium will also protect mountain whitefish.

Advice: Evaluate the levels of selenium in the tissues of burbot and bull trout in Lake Koocanusa as a supporting study under the RAEMP.

Rationale: To date, no data have been reported on the levels of selenium in the tissues of burbot collected in the Canadian portion of Lake Koocanusa. Because these species are utilized by KNC members and others as an important food source, it is important to document the levels of selenium in the tissues of these species. Whenever possible, non-lethal sampling methods (e.g., muscle plugs) should be used to obtain tissue samples. In addition, sampling opportunities may exist when KNC members are harvesting these species.

Advice: Evaluate the accuracy of the selected bioaccumulation models (i.e., water to invertebrate tissues) by refining estimates of exposure point concentrations of selenium (i.e., concentrations in water based on weekly or more frequent measurements conducted during key seasons) and tissue concentrations of selenium (i.e., by collecting multiple replicate data at exposure stations) as a supporting study under the RAEMP.

Rationale: Currently, there is considerable uncertainty in the estimates of exposure for the matching surface-water chemistry and tissue chemistry data that have been used to develop the bioaccumulation models. That is, it is not clear that surface-water chemistry data collected on the same date that a tissue sample is collected (or an annual average calculated from monthly samples) represents the relevant exposure concentration for evaluating bioaccumulation. Therefore, a more focused study needs to be conducted to better define the relationship between exposure and tissue concentrations in benthic invertebrates. Consideration should be given to using multiplate samplers to collect periphyton and invertebrates for tissue analysis and to high-frequency samplers for collecting surface-water samples.

Advice: Evaluate the bioaccumulation of selenium in the tissues of aquatic plants, aquatic invertebrates, and fish in Lake Koocanusa as a supporting study under the RAEMP.

Rationale: Synoptically-collected water chemistry and tissue chemistry data have been collected from lentic and lotic habitats within the Elk River watershed to support bioaccumulation modelling of selenium. Comparable data have not been collected in Lake Koocanusa. Therefore, a study should be designed and implemented to collect exposure and tissue chemistry data to determine if the Elk Valley bioaccumulation model(s) provides a basis for accurately predicting bioaccumulation in Lake Koocanusa. All three major ecosystem (plants, invertebrates, and fish) need to be addressed in this study.

Advice: Evaluate the effects of multiple stressors and nutrient addition on periphyton abundance and community structure (i.e., at the highest taxonomic levels) throughout the Elk Valley as a supporting study under the RAEMP.

Rationale: A variety of physical (e.g., fine sediment, flow, calcite formation), chemical (e.g., sulphate, N:P ratios, etc.), and biological stressors (e.g., grazing) can influence the abundance and community structure of periphyton in Elk Valley streams and rivers. To date, no information has been presented on the effects of multiple stressors on periphyton abundance and community structure in tributary streams or in the Elk and Fording rivers. Therefore, a study is needed to evaluate the effects of multiple stressors on primary productivity in lotic habitats within the Elk watershed.

Advice: Design and implement a supporting study to evaluate the relative sensitivity of the CABIN-based sampling methods, replicate Serber-based sampling methods, and multiplate sampling methods for evaluating the effects of water quality and other stressors on benthic invertebrate community structure, abundance, and biomass.

Rationale: A CABIN-based approach has been used to evaluate the effects of mining activities on benthic invertebrates within the Study Area. This method provides a standard approach to biological monitoring and assessment that can be used across Canada to evaluate aquatic ecosystem health. However, the approach was not designed to support hypothesis testing or to provide a quantitative impact assessment tool. Borisko *et al.* (2007) reported that such rapid bioassessment tools are coarse and are unlikely to detect subtle impacts to the benthic community. This is because such methods that lack replication have insufficient statistical power to detect subtle differences (Kerans *et al.* 1992). Rapid bioassessment methods are better suited to the detection of major impacts or gross impairment (Kilgour *et al.* 2005). As benthic invertebrate sampling in the Elk Valley should be designed to detect subtle, as well as gross, impacts, a study needs to be designed and implemented for the sensitivity of various sampling methods and levels of replication for detecting mining-related effects in Elk Valley streams. See Beatty *et al.* (2006) for further information on the design of such a study.

Advice: Evaluate the effects of multiple stressors on the benthic invertebrate abundance and community structure in streams and rivers within the Elk Valley. Monitoring should be conducted annually at core stations and every three years at all of the other stations as a supporting study under the RAEMP.

Rationale: A variety of physical (e.g., fine sediment, flow, calcite formation), chemical (e.g., sulphate, nitrate, cadmium, etc.), and biological stressors (e.g., predation) can influence the abundance and community structure of benthic invertebrates in Elk Valley streams and rivers. Monitoring of benthic invertebrate communities to date has utilized a general biomonitoring approach (i.e., a CABIN-based reference envelope monitoring program). While such monitoring provides information on the status of the benthic invertebrate community, this type of monitoring is not sufficiently sensitive to detect subtle effects on benthic invertebrates exposed to multiple stressors. Accordingly, a before-after/control-impact (BACI) design needs to be used to evaluate the effects of mining activities on the benthic community. For streams that are already affected by discharges from a mine, a control-impact (CI) design will need to be applied. For all new mines, a BACI-type design should be utilized. To support the design of ongoing BACI and CI monitoring and to calibrate the data that have been collected to date using the CABIN-based approach, a number of core monitoring stations should be sampled in 2014 using the CABIN sampling protocol, a CI-based replicate-sampling protocol (using Surber samplers; 10 replicates/station), and multi-plate sampler (e.g., Hester-Dendy samplers for mainstem locations; for example, see Letovsky *et al.* 2012). The resultant data should be used to identify the minimum number of replicate samples that need to be collected at each station to detect subtle effects on the benthic invertebrate community using the BACI- and/or CI-based sampling designs.

Advice: Determine critical levels of aquatic plant nutrients (ammonia, nitrite, nitrate, phosphorus) in Lake Koocanusa as a supporting study under the RAEMP.

Rationale: The water quality targets for nitrate are based on the toxicity of nitrate to aquatic invertebrates and fish. However, nitrate is an important aquatic plant nutrient that can contribute to changes in the trophic status of receiving waters. As there are already numerous sources of phosphorus in the Elk Valley and active water treatment plants could represent additional sources of phosphorus, it is important to determine the levels of nitrate (as well as ammonia and nitrite) that would protect against eutrophication in Lake Koocanusa. It is likely that *in-situ* limnocorral-based investigations would provide one of the most means of establishing nutrient-based WQOs for nitrate in Lake Koocanusa.

Advice: Develop a site-specific WQO (benchmark) for phosphorus (i.e., total phosphorus (TP), total dissolved phosphorus (TDP), and/or orthophosphate phosphorus (OP) in Lake Koocanusa; i.e., using limnocorrals) as a supporting study under the RAEMP.

Rationale: Section 3.1.5.1 of the Synthesis Report describes the results of the evaluation of current phosphorus levels in Lake Koocanusa. These results indicate that about one-third of the samples from MU-6 had phosphorus concentrations above the selected WQG. This is a concern because operation of active water treatment plants (AWTPs) in the Elk Valley is likely to result in releases of additional phosphorus into receiving waters. Therefore, loadings of phosphorus to Lake Koocanusa are likely to increase in the coming years. Considering the loadings of nitrogen to the lake that are already occurring, increases in phosphorus loadings have the potential to increase the frequency and/or magnitude of algal blooms in the lake and/or alteration of the trophic status of the lake. Site-specific WQOs for phosphorus would provide critical information for managing releases of nutrients to the lake.

Advice: Evaluate the bioaccumulation of selenium in amphibian species from the Elk Valley as a supporting study under the RAEMP.

Rationale: While there is a considerable amount of data available to evaluate linkages between concentrations of selenium in surface water and the concentrations of selenium in benthic invertebrate tissues, there is uncertainty in the relationship between dietary selenium levels and egg selenium concentrations in amphibians. Therefore, a laboratory study should be conducted to evaluate bioaccumulation in a surrogate species (i.e., by feeding leopard frogs invertebrates with different concentrations of selenium). This study should be linked to the effects study described below.

Advice: Evaluate the effects of selenium bioaccumulation on the reproductive success of amphibians in a laboratory study (i.e., using leopard frogs) as a supporting study under the RAEMP.

Rationale: There is still considerable uncertainty regarding the effects of selenium on the reproductive success of amphibians in the Elk Valley. For this reason, toxicity testing with a surrogate species should be conducted to evaluate the effects of selenium bioaccumulation on reproductive success (i.e., from egg to metamorphosis).

Advice: In the Conceptual Site Model Table, express the “Effect” column as assessment endpoints and include all of the measurement endpoints.

Rationale: Presenting the table in this way makes a clear connection between the RAEMP and the adaptive management triggers that will be developed during implementation.

11.0 Adaptive Management

The adaptive management framework, research and development programs, other management plans, changing circumstances, public reporting, and review and approval of amendments to the Plan are described in Chapter 11 of the EVWQP. Advice (and associated rationale) on this chapter of the EVWQP include:

Advice: Establish an independent environmental monitoring agency to provide guidance and oversight related to the collection, analysis, interpretation, and reporting of data collected within the Elk Valley.

Rationale: The rationale for this recommendation is provided earlier in this document. However, the recommendation is repeated here because establishment of such an independent environmental monitoring agency is also directly relevant to the adaptive management element of the EVWQP.

Advice: Develop a stand-alone adaptive management plan that provides specific information on the adaptive management triggers and associated management actions, in addition to the chapter of the EVWQP that addresses adaptive management.

Rationale: An adaptive management plan represents an essential element of the overall adaptive management framework that will be applied in the Elk Valley. While the chapter of the EVWQP that addresses adaptive management and plan implementation provides important information on the proposed adaptive management framework, a stand-alone adaptive management plan will be more amenable to periodic update and refinement as new data and information becomes available. Therefore, it is more likely that a stand-alone AMP can be consistently used to guide future management decisions than the EVWQP itself. The stand-alone AMP should be revised, at minimum, every three years.

Advice: Define the objectives for the adaptive management component of the EVWQP.

Rationale: A definition of adaptive management is provided in the EVWQP. However, clearly defined objectives for the adaptive management component of the EVWQP are not provided. Such objectives are required to inform the development of a responsive adaptive management framework.

Advice: Clarify the timeline and process for trigger development and reporting. Ensure consistency between Chapter 10 and Chapter 11 of the EVWQP.

Rationale: Clarifying this information improves the technical clarity of the document and facilitates evaluation of the adaptive management framework.

Advice: Provide an overview of the CSM for the site and the associated environmental effects, interactive effects, and cumulative effects hypotheses in the adaptive management chapter of the EVWQP.

Rationale: Adaptive management provides a systematic process for learning during implementation of the EVWQP to confirm that the objectives are being met and to adjust management actions if required. To be effective, the adaptive management component of the plan must be linked to key indicators of environmental quality conditions and informed by the results of focussed environmental monitoring programs. The CSM and associated effects hypotheses identify the assessment endpoints that are likely to be affected by stressors associated with coal mining activities and/or other anthropogenic activities. In addition, the CSM and associated effects hypotheses inform the selection of measurement endpoints (i.e., environmental variables) that will be used to evaluate the status of the assessment endpoints.

Advice: Identify the assessment endpoints (i.e., indicators of environmental quality conditions) and measurement endpoints (i.e., metrics) that will be used to inform management decisions under the EVWQP.

Rationale: The EVWQP currently identifies the monitoring components (e.g., water quality monitoring at order stations, periphyton monitoring, ambient sub-lethal toxicity tests, groundwater monitoring, and human health assessment) that will be considered in the adaptive management plan. However, these components are not sufficiently specific to provide a basis for explicitly identifying the assessment endpoints (e.g., survival, growth, and reproduction of westslope cutthroat trout) and measurement endpoints (e.g., concentrations of selenium in cutthroat trout eggs/ovaries) that will be used to support management decisions in the Elk Valley. Therefore, assessment endpoint and measurement endpoints need to be explicitly identified in the adaptive management framework.

Advice: Identify the targets (if relevant) and triggers for action in the adaptive management framework.

Rationale: Triggers for use in adaptive management are identified in the EVWQP, including trends and concentrations compared to predictions, targets, and timeframes, chlorophyll-a trends and guidelines, critical effects sizes, trends and drinking water guidelines, and changes in health risk results. However, these triggers are not sufficiently specific to guide decision making under the EVWQP. Therefore, the triggers for action need to be identified in the EVWQP (e.g., If a the target of selenium in cutthroat trout is the EC10 for cutthroat trout, then a trigger needs to be set below the target value that provides sufficient time to implement management actions to ensure that the target is not exceeded).

Advice: Identify the management actions that will be taken if one or more of the triggers for action are exceeded during the implementation phase of the EVWQP.

Rationale: The EVWQP currently includes an adaptive management decision flow chart that generally describes how the triggers would be used within the adaptive management framework. However, this information is not sufficiently specific to determine what actions would be taken if a trigger is exceeded during Plan implementation. Therefore, the adaptive management plan must identify the specific actions that would be taken for each of the triggers that are included in the AMP. This lack of specificity represents a key uncertainty that needs to be addressed because, without further information, there is no way of knowing what actions would be taken when targets are exceeded.

Advice: Identify the metrics and associated triggers that would lead to implementation of passive mitigation measures, semi-passive mitigation measures, and cover installation under the EVWQP.

Rationale: The EVWQP currently identifies research and development as part of the overall adaptive management framework for the Elk Valley. However, clear linkages between environmental monitoring and the implementation of alternative mitigation options are not provided in the Plan. Therefore, it is not possible to determine what metrics or triggers will be used to facilitate incorporation of new technologies or alternative existing technologies into the Plan.

Here's hoping that this supplemental advice is useful to you and the rest of the Technical Advisory Committee.

Sincerely,

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Principal, MacDonald Environmental Sciences Ltd.
Canadian Director, Sustainable Fisheries Foundation

J.Sinclair, Msc., RPBio.
MESL

Attachments:

Appendix 1 – Summary Statistics for Selenium for Reference Evaluations (MESL)
Appendix 2 – Comments on Human Health Assessment: Claire McCauley (Intrinsik Environmental Sciences Inc.)
Appendix 3 – Comments on Management Options, Calcite Management, and R&D Summary: Andre Sobolewski (Clear Coast Consulting Inc.)
Appendix 4 – Comments on Management Options: Rina Freed (Source Environmental Associates Inc.)
Appendix 5 – Evaluation of the Calcite Index (Sinclair and MacDonald 2014)
Appendix 6 – Comments on Water Quality Targets: Julia Beatty (Beatty Environmental Consulting)
Appendix 7 – Recommended Water Quality Targets for Selenium for Lake Koocanusa (MESL)

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Appendices

Appendix 1.1. Distribution of the concentration of selenium (µg/L dry weight) in fish tissue (whole-body) collected in mine-exposed and reference waterbodies in the Elk Valley and surrounding region.

Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	Percentiles 5th	10th	25th	50th	75th	90th	95th
Mine-Exposed Areas													
MU 1													
Westslope cutthroat trout	35	18.2	13.7	22.9	5.9	51.5	6.56	6.89	8.17	11.4	23.8	42.4	46.5
MU 2													
Mountain whitefish	5	10.2	1.6	12.2	8.2	12.4	8.46	8.72	9.5	9.8	11.1	11.9	12.1
Westslope cutthroat trout	11	8.51	1.58	9.57	7.3	12.3	7.43	7.56	7.65	7.9	8.4	10.8	11.6
MU 3													
Longnose dace	3	6.74	0	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74	6.74
Longnose sucker	14	5.78	3.16	7.61	2.16	11.7	2.34	2.51	3.09	4.78	8.43	9.97	10.8
MU 4													
Brook Trout	20	5.35	1.83	6.21	2.78	8.95	2.91	3.67	4.05	5.09	6.17	8.25	8.76
Longnose sucker	22	36	17.3	43.6	9.2	80.5	12.6	16.1	21.3	37	46.7	54.1	57.1
Mountain whitefish	10	9.64	1.24	10.5	7.5	12	7.9	8.31	8.95	9.8	9.98	10.7	11.4
Westslope cutthroat trout	14	5.2	0.829	5.68	3.8	7	3.93	4.15	4.8	5.2	5.65	5.94	6.35
MU 5													
Brook trout	8	13.5	7.48	19.7	6.9	29.9	7.06	7.22	8.73	11.4	15.2	20.9	25.4
Longnose sucker	15	6.78	3.92	8.95	2.16	12.7	2.16	2.27	2.83	7.12	10.6	11	11.6
Mountain whitefish	15	12.8	4.35	15.3	7.7	20.9	7.92	8.13	9.6	11.9	16	19.2	20.4
Westslope cutthroat trout	15	6.86	1.81	7.87	4.5	11	4.64	4.7	5.1	7.61	7.96	8.05	8.95
MU 6													
Kokanee	10	2.36	0.236	2.53	1.85	2.7	1.99	2.14	2.28	2.4	2.47	2.59	2.65
Largescale sucker	10	2.36	0.32	2.59	1.91	2.9	2	2.08	2.13	2.3	2.48	2.86	2.88
Mountain whitefish	10	6.46	3.7	9.11	2.05	15.9	3.19	4.33	4.72	5.51	7.03	8.81	12.4
Peamouth chub	10	2.31	0.555	2.7	1.51	3.25	1.61	1.72	1.85	2.31	2.59	2.99	3.12
Westslope cutthroat trout	10	5.45	1.43	6.47	2.77	7.67	3.37	3.97	4.82	5.5	6.43	7.01	7.34
Mine Works													
MU 1													
Westslope cutthroat trout	6	57.3	12.6	70.5	41.4	74.8	42.4	43.4	47.7	58.4	64.5	70	72.4
MU 4													
Westslope cutthroat trout	1	21.1	N/A	N/A	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1

Appendix 1.1. Distribution of the concentration of selenium (µg/L dry weight) in fish tissue (whole-body) collected in mine-exposed and reference waterbodies in the Elk Valley and surrounding region.

Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	Percentiles 5th	10th	25th	50th	75th	90th	95th
Reference Areas													
Longnose sucker	17	4.08	1.44	4.82	2.26	8.4	2.74	2.88	3.15	3.76	4.58	5.52	6.24
Mountain whitefish	5	6.6	1.06	7.92	5.4	8.1	5.48	5.56	5.8	6.7	7	7.66	7.88
Sculpin	80	5.24	2	5.69	1.8	11.5	2.48	2.79	3.8	5.1	6.3	7.6	9.11
Westslope cutthroat trout	20	5.84	1.98	6.77	3.3	12.1	3.49	4.04	4.57	5.55	6.5	7.19	9.06
United States													
Kokanee	10	2.61	0.264	2.8	2.33	3.19	2.37	2.41	2.44	2.53	2.75	2.9	3.05
Peamouth chub	10	3.38	0.535	3.76	2.36	4.15	2.53	2.7	3.13	3.54	3.7	3.81	3.98

N/A = not applicable; UCL = upper confidence limit of the mean

Appendix 1.2. Distribution of the concentration of selenium (µg/L dry weight) in fish tissue (muscle) collected in mine-exposed and reference waterbodies in the Elk Valley and surrounding region.

							Percentiles						
Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	5th	10th	25th	50th	75th	90th	95th
Mine-Exposed Areas													
MU 1													
Westslope cutthroat trout	108	13.8	11.3	15.9	3.03	56.3	4.9	6.47	8.14	9.68	13.5	34.8	41.1
MU 2													
Bull trout	9	4.12	0.52	4.52	3.14	4.77	3.33	3.52	3.96	4.14	4.41	4.71	4.74
Mountain whitefish	30	6.09	1.68	6.72	3.7	11.1	4.18	4.5	4.96	6.02	6.4	7.95	9.69
Westslope cutthroat trout	47	9.07	3.14	10	3.23	19.5	6.46	6.75	7.13	8	9.9	13.3	15.8
MU 3													
Mountain whitefish	5	8.24	3.8	13	4.12	14.3	4.59	5.06	6.48	7.47	8.84	12.1	13.2
MU 4													
Bull trout	6	4.5	0.792	5.33	3.46	5.69	3.58	3.7	4.02	4.5	4.88	5.3	5.5
Longnose sucker	5	53.4	22.5	81.4	15	71	23	31	54.9	58.3	68	69.8	70.4
Mountain whitefish	27	5.14	1.42	5.7	3.39	10	3.66	3.77	4.21	4.69	5.88	6.68	6.94
Westslope cutthroat trout	126	8.22	10.9	10.1	0.91	105	2.28	2.95	4.27	5.7	8.19	13	17.9
MU 5													
Bull trout	7	5.02	1.44	6.35	3.28	6.83	3.36	3.43	3.88	4.85	6.19	6.76	6.79
Longnose sucker	5	11.4	2.72	14.8	7.65	14.2	8.04	8.43	9.61	12.1	13.4	13.9	14
Mountain whitefish	42	5.87	2	6.49	2.79	13	3.64	3.84	4.79	5.35	6.46	8.16	10.1
Westslope cutthroat trout	83	6.99	2.68	7.58	3.71	27.4	4.28	4.6	5.8	6.9	7.75	8.4	8.58
MU 6													
Bull trout	39	1.73	0.254	1.81	1.1	2.33	1.37	1.4	1.6	1.7	1.9	2	2
Kokanee	67	1.91	0.373	2	1.3	2.82	1.5	1.5	1.6	1.9	2.08	2.58	2.69
Longnose sucker	28	3.47	0.754	3.76	2.5	5.1	2.5	2.5	3	3.2	4.2	4.4	4.85
Mountain whitefish	10	3.01	0.818	3.6	2	4.56	2	2	2.67	2.88	3.33	4.11	4.33
Northern pikeminnow	57	1.7	0.719	1.89	1	3.71	1	1.06	1.2	1.4	1.9	2.85	3.23
Peamouth chub	57	2.89	0.836	3.12	1.7	5.3	1.79	1.89	2.18	2.8	3.4	4.2	4.28
Rainbow trout	8	2.06	0.622	2.58	1.5	3.09	1.5	1.5	1.58	1.8	2.6	2.76	2.93
Westslope cutthroat trout	11	4.26	0.882	4.86	3.29	5.62	3.29	3.29	3.41	4.22	4.99	5.32	5.47

Appendix 1.2. Distribution of the concentration of selenium (µg/L dry weight) in fish tissue (muscle) collected in mine-exposed and reference waterbodies in the Elk Valley and surrounding region.

Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	Percentiles 5th	10th	25th	50th	75th	90th	95th
Mine Works													
MU1													
Westslope cutthroat trout	85	37.8	20.1	42.1	3	92.4	7.21	10.1	19.4	40	50.4	61.7	70.8
MU4													
Westslope cutthroat trout	1	24.3	NA	NA	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3
Reference Areas													
Bull trout	16	2.17	1.14	2.78	0.9	4.05	1.05	1.1	1.17	1.6	3.34	3.68	3.8
Longnose sucker	17	1.94	1.03	2.47	0.9	4.09	1.06	1.16	1.3	1.4	1.9	3.71	3.83
Lake trout	17	1.5	0.232	1.62	1.2	2	1.2	1.26	1.3	1.5	1.6	1.78	1.92
Lake whitefish	20	1.46	0.214	1.56	1	1.8	1.19	1.2	1.37	1.4	1.63	1.71	1.8
Mountain whitefish	80	3.63	1.17	3.89	1.3	7.2	1.5	1.86	2.88	3.84	4.4	4.9	5
Northern pikeminnow	11	1.18	0.841	1.75	0.8	3.7	0.8	0.8	0.85	1	1	1.1	2.4
Peamouth chub	21	1.5	0.268	1.62	1	2	1	1.2	1.3	1.5	1.7	1.8	1.9
Westslope cutthroat trout	284	4.31	1.86	4.53	1	12	1.54	2.37	3.2	4	5.02	6.67	8.13
United States													
Burbot	56	3.97	1.67	4.42	0.719	8.14	1.32	1.65	2.68	3.93	5.05	6.1	6.61
Bull trout	53	2.33	0.75	2.54	0.1	3.95	1.4	1.6	1.8	2.28	2.78	3.37	3.75
Kokanee	50	1.92	0.287	2	1.3	2.42	1.5	1.5	1.7	1.96	2.13	2.29	2.38
Longnose sucker	46	4.89	1.35	5.29	1.52	6.82	2.58	3.05	3.75	5.12	5.98	6.38	6.55
Mountain whitefish	2	2.45	0.636	8.17	2	2.9	2.04	2.09	2.22	2.45	2.68	2.81	2.86
Northern pikeminnow	47	1.6	0.373	1.71	1	2.43	1.03	1.16	1.3	1.6	1.88	2.09	2.28
Peamouth chub	61	3.54	1.45	3.91	1.7	8.37	1.9	2.3	2.66	3.04	4.2	5.35	6.69
Rainbow trout	15	2.5	0.677	2.88	1.5	4.14	1.57	1.7	2.04	2.46	2.8	3.13	3.47
Westslope cutthroat trout	2	3.74	3.28	33.2	1.42	6.06	1.65	1.88	2.58	3.74	4.9	5.6	5.83

N/A = not applicable; UCL = upper confidence limit of the mean

Appendix 1.3. Distribution of the concentration of selenium (µg/L dry weight) in fish reproductive tissue (ovaries and gonads) collected in mine-exposed and reference and surrounding region.

Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	Percentiles 5th	10th	25th	50th	75th	90th	95th
Mine-Exposed Areas													
MU1													
Westslope cutthroat trout (Ovaries)	46	25.6	23.4	32.6	6	85.3	9.4	10.5	12.5	14.4	24.2	65.7	80.7
MU2													
Bull trout (Ovaries)	5	14.5	2.69	17.8	12.5	19	12.5	12.6	12.7	13.4	14.9	17.4	18.2
Mountain whitefish (Ovaries)	30	31.8	7.39	34.6	20.3	50.5	21.5	22.3	27	29.9	36.2	41.3	43.6
Westslope cutthroat trout (Ovaries)	28	15.1	3.44	16.4	10.5	26.5	10.9	11.4	13.6	14.5	16.1	19.3	20.8
MU3													
Longnose sucker (Ovaries)	20	8.11	3.2	9.61	3.49	15.6	3.6	4.55	6.03	8.02	9.46	11.6	14.6
MU4													
Longnose sucker (Ovaries)	27	41.3	14.3	47	13.3	76.6	18.8	27.3	33.2	38	49.7	55.9	62.4
Mountain whitefish (Ovaries)	30	35.8	10.1	39.6	18.9	58.6	21.3	22.8	27.6	36.6	42.1	48.9	49.4
Westslope cutthroat trout (Ovaries)	20	8.74	2.57	9.94	3.45	13.2	5.37	6.11	7.05	8.98	10.3	12.1	13
MU5													
Mountain whitefish (Gonads)	8	36.1	6.05	41.1	29.6	45.5	29.9	30.2	31.4	34.4	40.8	43.2	44.3
Bull trout (Ovaries)	1	16.5	NA	NA	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Brook trout (Ovaries)	1	21.1	NA	NA	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1	21.1
Longnose sucker (Ovaries)	6	11.7	3.33	15.1	7.41	16	7.61	7.82	9.02	12.2	13.6	14.9	15.4
Mountain whitefish (Ovaries)	33	35.5	10.3	39.2	21.6	68.4	23.4	25.7	28.4	33.5	40	48	54.6
Westslope cutthroat trout (Ovaries)	15	12.4	2.93	14	8.2	18.3	8.4	8.89	10.4	11.3	14.3	15.7	16.8
MU6													
Kokanee (Gonads)	37	4.04	0.795	4.3	2.9	5.61	3	3.1	3.4	3.87	4.58	5.22	5.55
Longnose sucker (Gonads)	4	4.82	0.896	6.25	4	5.6	4.01	4.03	4.07	4.85	5.6	5.6	5.6
Northern Pikeminnow (Gonads)	18	3.62	0.984	4.11	2.5	5.9	2.67	2.7	2.82	3.5	4.08	5.08	5.56
Peamouth chub (Gonads)	20	7.31	2.08	8.28	4	11.6	4.66	4.97	5.8	7.2	8.22	10.8	11.1
Kokanee (Ovaries)	9	3.6	0.508	3.99	2.78	4.61	2.96	3.15	3.24	3.66	3.75	4.01	4.31
Largescale sucker (Ovaries)	1	3.87	NA	NA	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87
Mountain whitefish (Ovaries)	7	16.8	6.04	22.4	8.94	24.4	10.2	11.4	13.2	13.8	22	24.2	24.3
Westslope cutthroat trout (Ovaries)	6	11	3.77	15	6.69	16.5	6.94	7.19	8.2	10.6	13.4	15.3	15.9

Appendix 1.3. Distribution of the concentration of selenium (µg/L dry weight) in fish reproductive tissue (ovaries and gonads) collected in mine-exposed and reference and surrounding region.

Waterbody Category / Management Unit / Species	n	Mean	Standard Deviation	95% UCL	Minimum	Maximum	Percentiles 5th	10th	25th	50th	75th	90th	95th
Mine Works													
MU1													
Westslope cutthroat trout (Ovaries)	79	78.1	43.6	87.9	3.88	213	13.3	17.6	46.2	82.3	106	123	146
MU4													
Westslope cutthroat trout (Ovaries)	1	25.7	N/A	25.7	25.7	25.7	25.7	25.7	25.7	25.7	25.7	25.7	25.7
Reference Areas													
Mountain whitefish (Gonads)	8	28.9	5.82	33.8	20.8	36.3	21.3	21.7	24.9	29	34.1	34.8	35.6
Northern Pikeminnow (Gonads)	11	2.58	0.98	3.24	0.8	5	1.55	2.3	2.3	2.5	2.6	3.1	4.05
Peamouth chub (Gonads)	9	7.27	2.68	9.33	2.9	10.9	3.54	4.18	5.2	7.4	8.8	10.6	10.7
Longnose sucker (Ovaries)	8	5.03	0.565	5.5	4.21	5.74	4.22	4.22	4.76	5.07	5.42	5.61	5.68
Mountain whitefish (Ovaries)	30	24.2	7.71	27.1	6.81	41.6	15	15.8	19.2	23.1	29	32.9	37.6
Westslope cutthroat trout (Ovaries)	72	8.92	4.39	9.95	2	16.9	2.9	3.74	5.47	8.1	12.6	15.6	16.1
United States													
Kokanee (Gonads)	31	3.68	0.566	3.89	2.9	5.07	3	3.1	3.29	3.6	3.92	4.4	4.8
Longnose sucker (Gonads)	5	5.23	1.2	6.72	4	6.87	4.02	4.04	4.1	5.6	5.6	6.36	6.62
Northern Pikeminnow (Gonads)	42	3.8	1.18	4.17	2.44	8.08	2.58	2.7	2.82	3.5	4.35	5.31	5.88
Peamouth chub (Gonads)	51	8.42	3.01	9.26	4	21.7	5.19	5.7	6.68	7.7	9.36	12	12.4
Rainbow trout (Gonads)	2	4.72	0.0849	5.48	4.66	4.78	4.67	4.67	4.69	4.72	4.75	4.77	4.77
Westslope cutthroat trout (Gonads)	1	10.4	NA	NA	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Kokanee (Ovaries)	9	3.93	0.597	4.39	3.31	4.8	3.36	3.41	3.51	3.54	4.48	4.74	4.77
Peamouth chub (Ovaries)	10	7.81	2.23	9.41	5	11.3	5.29	5.58	5.84	7.5	9.58	10.3	10.8

N/A = not applicable; UCL = upper confidence limit of the mean

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June 26th, 2014

Attention: Mr. Don MacDonald
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#24-4800 Island Highway N.
Nanaimo, BC V9T 1W6

Sent via email: mesl@shaw.ca

Dear Don:

Subject: Review of the Elk Valley Water Quality Plan: Draft Human Health Evaluation of Current Baseline Conditions

As requested, Intrinsik Environmental Sciences Inc. (Intrinsik) has reviewed the ENVIRON International Corporation (Environ) report entitled "Elk Valley Water Quality Plan: Draft Human Health Evaluation of Current Baseline Conditions" dated May, 2014. In addition to the key areas of focus identified in your e-mail (of June 13th, 2014), the review also provides, where appropriate, commentary on other aspects of the Draft Human Health Evaluation.

While the approach undertaken in the completion of the risk assessment for the Human Health Evaluation of Current Baseline Conditions was consistent in style with currently accepted practice, the lack of a clear and transparent methodology would prevent an equally trained professional from being able to recreate the assessment with the information provided in the evaluation. Many of the key considerations identified in our 10 April 2014 review of the March 2014 Human Health Evaluation Work Plan are still valid (see Attachment A). This summary document reviews the key concerns and identifies, in both the baseline characterization and the risk assessment, where the lack of additional information or inconsistencies call the conclusion of not identifying any health risks associated with current water quality conditions into question.

Key considerations for the Ktunaxa First Nation and the Ktunaxa Nation Council (KNC) identified in the review include:

- There is a lack of a clear and consistent rationale in the selection of guidelines and in the application of the stated hierarchy of the guidelines to the interpretation of the data.
- There is a need for the provision of a clear rationale regarding the screening protocols.
- As presented many of the equations in Section 5.2 are not reproducible; benchmark selection and calculation of benchmark quantities require re-evaluation to ensure accuracy.
- The omission of the toddler as a receptor in the assessment. Health Canada (2010a) identifies that "… for threshold chemicals at a site where all age classes

are present, the toddler would normally be considered the critical receptor". The toddler life stage is not included in the assessment.

- While, in the assessment of environmental guidelines, a hazard quotient (HQ) of 0.2 is used to be consistent with British Columbia Ministry of the Environment (BCMoE) and Health Canada risk management levels, the risk assessment uses a HQ of 1.0 for the evaluation of risks associated with exposure to potential receptors. Rationale for the discrepancy should be provided.
- The lack of incorporation of the Traditional Ecological knowledge (TEK) information and the traditional land use practices (including hunting, trapping fishing and harvesting) of the KNC in the assessment of potential exposure.
- The similarity of consumption characteristics for traditional foods for those KNC members living on reserve in the Cranbrook area and those for KNC members living in the Elk Valley area; as the Ktunaxa Diet Study did not have any respondents from the Elk Valley area.
- The indirect or secondary exposure pathways (consumption of harvested game or riparian plants) are screened out due to the lack of calculated risks associated with exposure to surface water and sediment; however there is no discussion regarding the potential biomagnification of contaminants in the food chain.

1. Overview

In order to meet the requirements set out in Ministerial Order No. M113 ("the Order") issued April 15, 2013 by the BC Ministry of Environment (MoE), the Elk Valley Water Quality Plan: Draft Human Health Evaluation of Current Baseline Conditions was developed in part to protect human health and groundwater in the Elk Valley recognizing the heavy dependence of the Elk Valley regional economy on mining and related activities. The basis of the water quality plan is to meet short, medium and long term environmental quality targets. This is to be accomplished through the adoption and implementation of various operational management scenarios and evaluation of potential causal relationships between water quality concentrations of the constituents of potential concern (COPC) and effects on human health and aquatic ecosystem health, both of which were identified as key values. The four COPC specifically identified in the Order are cadmium (Cd), selenium (Se), nitrate (NO_3^-) and sulphate (SO_4^{2-}); however, the assessment also included additional available environmental analytical parameters including metal constituents.

The approach used in the assessment incorporated two phases: (i) the evaluation of baseline water quality conditions from the perspective of human health (in accordance with Section 3.4 of the Terms of Reference (TOR) established in response to the Order); and, (ii) the assessment of potential human health impacts (in accordance with Section 3.8 of the TOR). In the first phase (baseline evaluation), the last three years of environmental quality data (surface water, fish tissue, groundwater, and sediment) collected from within the six established management units (MU) were evaluated and compared to guidelines identified to be protective of human health.

Overall, the report would benefit from a more transparent guideline selection process. It is recommended that the guidelines from each of the agencies considered be presented in a format that allows for easy reference and comparison. The assessment can then clearly indicate which guidelines are being adopted based on a general policy decision and which are being used based on the individual merits of the chemical guideline.

The report should provide a clear and transparent chemical screening section that provides actual screening tables (i.e., tables containing all chemicals, their associated maximums and a comparison to applicable guidelines). The report currently provides only the results of the chemical screening process.

The development and presentation of 'pathway-specific benchmarks' should be revisited. It is difficult to recreate the health-based benchmarks presented in the report with the data provided. The use of the standardized equations developed by CCME (2006) during the development of soil quality standards should be considered in the analysis. It is unclear why different hierarchies were applied to select 'health-based' guidelines and toxicological reference values (TRVs) in the development of the pathway-specific benchmarks. There are many instances where TRVs from the US EPA IRIS were selected over the latest Health Canada information.

The assessment is predicated on the assumption that if the primary exposure pathways (e.g., direct contact with sediments) do not pose a potential human health risk, neither does the secondary exposure pathways. The potential for certain chemical substances and/or metals present in sediment to accumulate and/or bio-magnify as they progress through the food chain has not been discussed. It is possible, for some chemical compounds and/or metals, that health-based sediment benchmarks protective of consumption of fish (i.e., an indirect/secondary exposure pathway) maybe more restrictive (i.e., lower) than benchmarks protective of direct contact with sediment (i.e., direct ingestion and dermal contact).

The risk assessment presents a 'more detailed analysis' constituting a discussion of hazards and incremental lifetime cancer risks (ILCRs) for those chemicals that exceeded the previously developed health-based pathway-specific benchmarks. The analysis involved quantifying human health hazards (expressed as HQ values) and ILCRs for specific chemicals and environmental media. If there are constituents in specific environmental media that exceed a health-based pathway-specific benchmark, it would stand to reason that a more detailed human health risk assessment focussing on these specific constituents and environmental media would be required to more fully understand the potential health risks.

The addition of a discussion regarding the uncertainties in the data and the receptor characterization parameters for both exposure and toxicity should be considered. The discussion of uncertainty is an important component of any health risk assessment document.

2. Data Quality Evaluation

The data quality evaluation section (Section 3 in the Evaluation) discusses the datasets used in the baseline analysis, the chemical constituents considered and the breadth of monitoring data available. The summary statistics are included in this section. The data summarized here formed the basis for the current baseline screening. The collection and analysis of site characterization data are an integral component of the chemical screening process and they have the potential to impact the outcome of the health risk assessment. The database contained constituent concentrations from previously undertaken analytical work associated with environmental assessments for Teck's operations in each of the six MUs, and data from the Montana Department of Environmental Quality.

Specific data evaluation criteria were not presented. Substitution methods were used for non-detect (ND) values (ND = detection level (DL)) in the calculation of the mean and summary statistics. There was neither discussion as to how different DL were evaluated across data for the same media nor indication as to the protocol for the identification of outliers and qualifications for their exclusion (if at all) from the data set.

The available constituent data were presented in Table 6; however, it is unclear if complete datasets were included as iron was not identified as being analyzed in groundwater samples. The available data followed from the evaluation of the primary pathways as identified in Figure 10; thus, riparian plants and game meat tissues were not included in the assessment.

The MUs are large areas based on geophysical boundaries across which environmental media are unlikely to have a narrow range of constituent concentrations. It may be more appropriate to sub-classify MU areas into smaller regions which may have more modal constituent concentrations.

3. Current Baseline Assessment

The review of the Current Baseline Assessment (Section 4 in the Evaluation) focussed on determining whether the methods and data used to identify constituents of potential concern in the environmental media were appropriate. The evaluation of baseline water quality conditions from the perspective of human health was required in accordance with Section 3.4 of the TOR established in response to the Ministerial Order. The comparison to guidelines was assessed for relevancy and comments are included herein. The lack of an uncertainty analysis was identified. Specific comments regarding the assessment of the current baseline are included below.

Section 4.1 Guidelines for Baseline Assessment

- Page 35. The report indicates that the hierarchy applied when selecting regulatory human health-based guidelines was recommended by “BCMoE and the Teck consultant team”. This methodology or rationale used to develop the hierarchy should be included in the assessment. Applying a blanket hierarchical approach alone may not capture the latest science and/or state of knowledge as it applies to a specific health-based guideline. (For example Health Canada (2012a) reports a maximum acceptable concentration (MAC) for lead in drinking water of 0.01 mg/L. The drinking water guideline for lead applied in the current assessment (as reported in Table 12, page 39), is the BC Water Quality Guideline (BCWQG) (BCMoE 2006) of 0.05 mg/L).
- Page 35. The report indicates that the “human health protective guidelines based on the most intensive possible contact or exposure pathway were used.” It is then indicated that health-based regulatory guidelines protective of incidental soil ingestion under a residential setting are “generally more protective” than guidelines based on “periodic recreational contact with sediments”. The report should specifically reference these health-based regulatory sediment guidelines (protective of direct contact with sediment).
- Page 35. Table 11 does not clearly communicate the ranking of each regulatory source for each environmental media of interest. The hierarchy used to select human health-based guidelines is not clearly laid out in Section 4.1. The inclusion of a series of ranked lists from each regulatory agency (including full

citations) for each environmental media of interest would be beneficial in this section of the report.

Section 4.1.1 – Guidelines for Surface Water and Groundwater

- Table 12, Page 39. The discussion prior to Table 12 makes a number of references to several different Health Canada, BCMoE and US EPA documents; complete references for these sources should be included.
- Table 12, Page 39. Not all drinking water guidelines presented in Table 12 are predicated on the protection of human health. Some guidelines (e.g., iron, manganese, sodium, etc.) are based on aesthetics (e.g., taste, staining, smell, etc.) and/or best available technology. The inclusion of the general endpoint of each drinking water guideline should be included in Table 12 and then used in the screening of the COPC.

Section 4.1.2 – Guidelines for Sediment

- Given the lack of regulatory endorsed human health-based sediment guidelines protective of direct contact pathways, the application of soil guidelines protective of incidental soil ingestion is warranted. However, the general statement (page 40) indicating that "… incidental ingestion of soil is expected to be greater than incidental ingestion of sediment during recreational activities" should be substantiated. Intrinsik (2011) indicated that it was recognized that incidental ingestion of sediment may be elevated relative to ingestion of soil as a result of higher moisture content and adherence; however, appropriate sediment-specific ingestion rates have not been identified in the scientific literature.
- Page 40. The last paragraph indicates that a number of chemicals were lacking <u>sediment guidelines</u>; however, the previous discussion established that no regulatory health-based sediment guidelines were identified for any of the constituents of potential concern and as a result, health-based soil guidelines were used as surrogates. It is unclear (based on this last paragraph) whether health-based <u>soil guidelines</u> for these inorganic elements (bismuth, calcium, magnesium, phosphorous, potassium, sulfur and titanium) and organic compounds (acenaphthylene and benzo(g,h,i)perylene) currently exist.
- It should be made explicitly clear (where appropriate) that the values presented in Table 13 are health-based soil guidelines that are being applied to sediment concentrations.
- Table 13. The report indicates that guidelines for sediment (soil) ingestion through recreational contact were selected based on the following hierarchy: (1) BCMoE Contaminated Sites Regulation (CSR), (2) Canadian Council of Ministers of the Environment (CCME) guidelines, and (3) United State Environmental Protection Agency (US EPA) Regional Screening Levels (RSL). Table 13 indicates that a US EPA Region 3 (R3) RSL value for total chromium (in soil) of <u>10,286 mg/kg</u> was applied as the "sediment guideline" despite CCME reporting a total chromium human health soil quality guideline (protective of soil ingestion) of <u>220 mg/kg</u>. It appears that the US EPA R3 (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/ressoil_sl_table_run_MAY2014.pdf) does not provide a RSL value for total chromium. A footnote at the bottom of Table 13 indicates that total chromium values were derived based on a "1:6 ratio of hexavalent chromium to trivalent chromium", suggesting that this was derived

by ENVIRON. If the assessment is to use this value, the report should clearly present how this 'health-based guideline' was derived and why it should supersede that of CCME.

- Page 40. Second last paragraph. The report indicates that "…values are based on a cancer risk of 1 in 1,000,000 or an HQ of 0.1, but have been modified in the screening table to be consistent with BCMoE and Health Canada risk management levels (i.e., HQ=0.2 and cancer risk=1 in 100,000)." Prior to this paragraph it was stated that the hierarchy selected was BCMoE CSRs, CCME and US EPA RSLs. Health Canada may have a target ILCR value of 1 in 100,000 as it applies to PQRA and DQRAs; however, it should be clearly noted that the CCME derive health-based soil guidelines using a target risk of 1 in 1,000,000, not 1 in 100,000 as evident in the derivation of the arsenic soil standard. If the assessment has applied a CCME soil guideline for a carcinogenic substance (e.g., arsenic), the target risk should be confirmed and adjusted as necessary.
- Table 13. Although it was indicated that BCMoE health-based soil quality guidelines would be selected over CCME and US EPA R3 RSLs, it is worth noting that the CCME copper soil quality guideline protective of incidental soil ingestion (1,100 mg/kg) is approximately 15 fold lower than the value presented in Table 13 (15,000 mg/kg) from BCMoE. From the report, it is unclear why such large differences between the health-based soil guidelines for the same chemical exist (e.g., a 46 and 15 fold difference observed in reported guideline value for total chromium and copper, respectively). Given the observations made through verification of total chromium and copper, the provision of a clear and concise description of the exposure pathways, general assumptions (e.g., target risk values) and methods used by each of the three regulatory authorities (i.e., BCMoE, CCME and US EPA) to derive their respective health-based soil guidelines may be appropriate. Table 13 could present the inclusion of health-based direct contact guidelines in soil for each chemical from each of the three selected regulatory agencies in conjunction with the rationale as to which guideline was selected on a chemical-by-chemical basis.

Section 4.1.3 – Guideline for Fish Tissue

- The discussion concerning the proportion of total arsenic that is inorganic in fish tissue is appropriate and appears to be well documented; however, this discussion may be better suited in the effects assessment as opposed to the discussion concerning the derivation/origin of fish tissue guidelines. The guidelines for fish tissue as it pertains to arsenic are specific to inorganic arsenic and, therefore, no adjustment to the actual guideline is required. The adjustment (to accommodate for the inorganic proportion in fish tissue) should occur on the exposure (or concentration) side of the assessment and, therefore the discussion would be better suited elsewhere.
- The US EPA guidelines are based on TRVs that may be different from those used in Canada and in the rest of the assessment. As the US EPA values were adopted in the assessment it should be transparent as to which health based TRV are the basis of the guideline. It should also be transparent as to how changes in TRV values used in the US EPA values will be integrated into the Plan to ensure that all guidelines remain relevant.
- The full reference provided in the report (US EPA 2013) indicates that the guidelines were last up-dated in November of 2013; however, the provided reference is associated with fish tissue guidelines updated in May of 2014. This

observation may in part provide an explanation to the observation discussed below.
http://www.epa.gov/reg3hwmd/risk/human/pdf/MAY_2014_FISH_THQ01_watermark.pdf

- It is unclear how the fish tissue guidelines originating from the US EPA R3 RSL were modified to produce the values presented in Table 14. As an example, the fish tissue guideline for aluminum reported in Table 14 is 280 mg/kg wet weight. Based on the discussion provided prior to Table 14, the guideline value for aluminum (of 280 mg/kg) was based on a target HQ of 0.2. Upon examination of the US EPA R3 RSL table (as cited above), a tissue guideline for aluminum of 150 mg/kg is reported. Transposing from a target HQ of 0.1 to 0.2 should result in an exact doubling of the US EPA R3 tissue guideline based on the equation presented by the US EPA R3. This discrepancy was observed for most other compounds listed in Table 14.

  http://www.epa.gov/reg3hwmd/risk/human/rbconcentration_table/usersguide.htm
- It is unclear what toxicological endpoint (i.e., non-cancer versus cancer) was used when selecting fish tissue guidelines from the US EPA R3 table as guidelines protective of both non-cancer and cancer effects exist for inorganic arsenic. All guideline tables (including Table 14) in the report would benefit from providing guidelines protective of both cancer and non-cancer endpoints as appropriate.
- The assessment needs to indicate how the fish tissue guideline for total chromium was derived. The US EPA R3 provides non-cancer guidelines for both chromium (III) and chromium (VI) in addition to a cancer-based guideline for chromium (VI). It is unclear from the information provided in the footnote, exactly how a total chromium guideline was developed.

Section 4.2.1 – Surface Water Results

- Rather than providing tabular summaries of maximum surface water concentrations and corresponding guidelines for only those chemicals that exceeded their respective guidelines (i.e., the end result of the screening exercise), additional clarity and understanding would be facilitated in this section of the assessment if complete chemical screening tables were presented. A complete screening table would include (at a minimum) a list of all chemicals analyzed in surface water (forty-four (44) inorganic and nine (9) organic chemicals), their associated maximum concentrations and the corresponding health-based guideline.
- Table 17. The footnote indicates that with the exception of aluminum, all guidelines (applied to surface water concentrations) were based on total concentrations as opposed to the dissolved phase concentration. Given this information, it is unclear why for some compounds the dissolved phase concentrations are compared to guidelines (based on total concentrations) when total concentrations exist. A discussion of the applicability of the aluminum guideline (dissolved phase) to the total aluminum concentration as reported should be included.

Section 4.2.2 – Sediment Results

- Parallel to previous comments, the inclusion of a complete screening table in this section providing a list of all chemicals analyzed in sediment (33 inorganic and

17 organic compounds), their associated maximum concentrations and the corresponding health-based soil guideline would be beneficial.

Section 4.2.3 – Fish Tissue Results

- Complete screening tables should be provided as previously indicated for other environmental media.
- It is unclear based on the information presented in Tables 22 and 23 whether the arsenic concentrations reported in fish represent total or inorganic arsenic. If these data represent inorganic concentrations, a footnote indicating that inorganic arsenic concentrations in fish tissue were approximated should be provided.

Section 4.2.4 – Groundwater Results

- A complete screening table should be provided as previously indicated for other all other environmental media.

4. Effects Assessment

The review of the Effects Assessment, (Section 5 in the Evaluation) completed in accordance with Section 3.8 of the TOR established in response to the Ministerial Order, required the assessment of potential human health impacts associated with the findings of the baseline assessment and in consideration of the potential cumulative effects. The review evaluated whether the methods and the TRVs used in the effects assessment were appropriate and considered whether the exposure was adequately characterized for each population segment and whether the calculated exposure point concentrations (EPC) were appropriate. The hazard quotient values, the multiple exposure pathways and the risk assessment conclusions were also evaluated.

The review of the effects assessment focused on the methods and inputs used to develop ‘pathway-specific benchmarks’ and their associated application. Specific areas of interest included, but were not limited to, the selection of receptors; exposure factors; development and application of exposure point concentrations; toxicological reference value selection; and the adequacy of recognizing the impact of uncertainties.

Section 5.1.1 – Surface Water

- Page 63, par 3. The discussion concerning bromide in surface water appears to indicate that the maximum (dissolved phase) bromide surface water concentration exceeded a guideline expressed as total bromide in surface water; however, because the guideline is based on total (as opposed to dissolved) this exceedance was not considered a reliable indicator. This rationale appears flawed. Presumably the dissolved phase concentration will either be equal to or less than the total concentration. As a result, the fact that the maximum measured dissolved phase bromide concentration exceeds the total bromide guideline is a reasonable indicator that the total bromide concentration in surface water (if measured) would also exceed the guideline. This discussion/rationale may also apply to several other constituents of concern and should be reviewed.

Section 5.2.1 – Calculation of Pathway-specific Benchmarks

- The discussion provided in Section 5.2 identifies both primary and secondary exposure pathways as illustrated in the CSM (Figure 10). The report indicates that: "If exposure concentrations do not exceed primary pathway-specific benchmarks, then it is reasonable to assume that exposures via secondary pathways will not result in hazards or risks exceeding management thresholds. For example, if the primary pathway-specific benchmark for direct ingestion of surface water". It should be recognized that this assumption only holds true if the routes of exposure are the same between the primary and secondary exposure pathways. It is also possible that chemical compounds and/or metals that tend to accumulate and/or biomagnify, although not a concern to human health via direct contact (e.g., direct soil ingestion, drinking water consumption), could present a potential human health risk via indirect exposure pathways (e.g., deposition onto soil, uptake by wildlife and consumption of game meat; deposition onto soil and uptake by riparian traditional vegetation consumed by KNC members) once they make their way through the food-chain.
- The equation presented on page 62 should be reviewed; when the calculation is completed the units do not match those presented when applying intake or contact rates from soil. The general methods and equations employed by the CCME (2006) during the derivation of Soil Quality Guidelines (SQGs) for the protection of Human Health should be considered. Intrinsik (2011) also presented equations (consistent with CCME 2006) as applied to sediments.
- The terminology used to describe the terms ADER (average daily exposure rate) and the LADER (lifetime average daily exposure rate) should be reviewed as these two terms should not refer to chemical-specific exposures rates but rather intake rate factors (e.g., soil intake rate (kg/d), dermal contact rate (kg/d) or a soil inhalation rate). Again, a review of the CCME (2006) methods used to derive SQGs and/or Intrinsik (2011) would be beneficial.
- The equation presented on Page 62 should be reviewed. The term representing the relative absorption factor (ABS_{GI}) appears to be incorrectly placed on the numerator (as opposed to the denominator) of the equation. The description of ABS_{GI} term should be reviewed as it representative of a relative dermal absorption factor (ABS_d), not a gastrointestinal absorption faction. The ABS_d values (presented in Table 31 and taken from Health Canada (2010b)) represent relative ABS_d and, therefore, should not be adjusted by the oral absorption factor. It is noted that the equation expressing the dermal contact rate with sediments (page 69) incorporates the relative dermal absorption factor (ABS_d) and, therefore, no adjustment for ABS_d is required in the equation presented on page 62. The report would benefit from indicating (below the equation on page 62) that the dermal contact rate ($ADER_d$) has been adjusted for by the relative dermal absorption factor (ABS_{GI}). A review of the CCME methods used to derive SQGs would be beneficial.
- The equation presented on page 63 expressing the 'cancer benchmark' should be reviewed. It is unclear why the dermal contact pathway (inclusive of a relative dermal bioavailability factor) would not also be included. Inorganic arsenic was assessed via non-cancer and cancer endpoints; as such the effects-based guidelines/standards protective of the dermal exposure pathway would be based, in part, on the oral cancer slope factor for inorganic arsenic.
- It appears as through the hierarchy used to select TRVs during the derivation of pathway-specific human health-based guidelines (Section 5.2.1, Table 26) is

different from that used to select health-based guidelines used in Section 4.1. In many instance (e.g., manganese, nickel, zinc, etc.) TRVs from the US EPA Integrated Risk Information System (IRIS) were selected over TRVs established by Health Canada (2010b). Given the previous development of a hierarchy for the selection of health-based guidelines presented in Section 4.1 (BCMoE Water Quality Guidelines (WQG), Health Canada, BCMoE CSR, CCME and US EPA), it is unclear why TRVs from IRIS (US EPA) were selected over those from Health Canada. The hierarchy should be made consistent or a review of the individual TRVs developed by each regulatory entity should be conducted to ascertain the most scientifically defensible and appropriate TRV.

- Given the recent regulatory movement concerning lead toxicity (both in the United States and Canada), further discussion including citeable regulatory sources concerning the current regulatory status of lead TRVs should be provided as well as indicating how the lead TRV used in the assessment was derived.
- The equation presented on page 65 expressing the average daily water intake rate is consistent with Health Canada (2012b); however, in the development of effects-based 'potable standards or guidelines' the assumption that a receptor consumes all of his/her daily water intake rate from a single source is often considered standard practice and, therefore, partitioning drinking water rates on a daily or weekly basis is not be considered conservative in the context of developing generic drinking water standards/guidelines.
- Table 31. For a number of chemicals presented in Table 31 (page, 74) the value of zero (0) has been assigned to the relative dermal absorption factor (ABS_d). These data should be reviewed. It is suspected that Health Canada lacks absorption values for these metals and, therefore, either a default value of 1.0 should be applied or a rationale to apply a generic ABS_d less than one should be provided.

Section 5.2.1.3 – Incidental Ingestion of and Dermal Contact with Sediment while Swimming

- The assessment indicates that sediment intake rates were those provided by Intrinsik (2011). Intrinsik (2011) presented two (2) different sediment ingestion rates for the toddler. This assessment should provide the rationale used to select the lower sediment ingestion rate (of 20 mg/d) for the toddler over the higher contact rate scenario (of 80 mg/d) as presented in Table 29.

Section 5.2.1.4 – Consumption of Fish

- Page 72. The application of exposure frequency as it applies to fish and potable water intake rates (as previously mention) should not occur. Intake rates (used to predict chronic exposures) should represent an approximation of daily intake over prolonged periods of time and, therefore, will inherently include frequency data. As a result, these intake rates (i.e., fish and drinking water rates) should not be further adjusted by exposure frequency (i.e., days per week and/or weeks year). It is noted that all exposure frequency factors apply 52 weeks/yr and 7 days/week; however, the elimination of these two terms would help simplify (L)ADER equations and prevent future adjustments to the exposure frequency terms.

- On page 72, the report indicates that "…for arsenic in fish tissue, the exposure rate was adjusted by a factor of 10%". As previously indicated, the rationale for the use of 10% appears to be well documented and justified; however, the report provides no discussion as to how the adjustment to the intake rate was made. To accommodate for the inorganic fraction in fish tissue, the adjustment should occur on the exposure (or concentration) side of the assessment (i.e., adjustment of the exposure point concentrations (EPC)). The pathway-specific benchmark should be specific to the form of arsenic upon which the TRV used to develop the benchmark was based.
- Table 30. It is unclear how the fish consumption rates were calculated and which specific factors from Richardson (1997) were used in the assessment. Health Canada (2007) provides details regarding portion sizes and consumption rates for the life stages and should be considered in the assessment.

Section 5.2.2 – Exposure Point Concentrations

- The derivation of an EPC such as upper 95 percent upper confidence limit on the arithmetic mean (95 UCLM) concentration, as calculated using the US EPA software package ProUCL is typically considered an appropriate approach within the context of conducting a detailed human health risk assessment. However, caution should be exercised particularly when dealing with very large exposure units, such as the MU described in this assessment. A key underlying premise of utilizing the 95 UCLM to represent an EPC within a given exposure unit is the assumption that human receptors will tend to move, over time, in a random fashion throughout the exposure unit and hence come into contact with an estimate of the average (or mean) concentration within that exposure unit. When dealing with large (or community wide sites), the movement of receptors throughout the exposure unit (e.g., a city, town, etc.) is not random. As a result, geographic location of environmental media considerations relative to where receptors spend the majority of their time needs to be a significant consideration when dealing with wide area sites.

5.2.3.1 – Surface Water Benchmark Screening Results

- Table 32. It is unclear why "pathways-specific benchmarks" were developed for compounds that already have regulatory drinking water guidelines. Given that an attempt was made to employ regulatory methods, exposure factors and TRVs during the development of the "pathway-specific benchmarks", it is unclear what is be gained by "re-developing" existing standards/guidelines. In the case of arsenic, it is clear that relevant health-based drinking water standards (based on the most sensitive endpoint, cancer) exist. It is therefore, unclear why this report has developed its own drinking water guidelines (or pathway-specific benchmarks) despite valid regulatory guidelines being already in place. It is understandable that a pathway-specific benchmark may need to be developed in cases where a human-health based regulatory guideline does not exist for a particular chemical or environmental media.

Section 5.3 – Pathway-Specific Risk Analysis

- Section 5.3 quantifies human health hazards, expressed as hazard quotient (HQ) values, for nitrate in surface water and four (4) metals (aluminum, arsenic, cobalt and selenium) in fish. Incremental lifetime cancer risks (ILCRs) resulting from exposure to inorganic arsenic are also presented. Although the assessment addresses the general methods used to derive HQ values, the input data including EPC, TRVs and intake rates used to derive the HQ estimates in Tables 38 through 40 are not provided and, therefore, estimates cannot easily be reproduced.

- According to Section 5.3, a '…more detailed risk analyses were needed…' due to a number of constituents present in surface water and fish exceeding the previously developed health-based 'pathway-specific benchmarks'. As a result, Section 5.3 presents HQ values and ILCRs for these specific constituents in surface water (nitrate) and fish (aluminum, arsenic, cobalt and selenium). It is not clear (based on the information provided) how a constituent could exceed a non-cancer health-based pathway-specific benchmark (target risk of 0.2) but yet have a HQ of 0.2. For example, Table 39 presents a HQ value of 0.2 for cobalt as a result of consuming fish in MU1. However, Table 36 presents a health-based pathway-specific benchmark (non-cancer target risk of 0.2) for cobalt in fish of 0.086 mg/kg. The corresponding reported 95 UCLM cobalt fish concentration (Table 36) is 0.104. It would be beneficial if in addition to explicitly indicating the input data used to generate forward facing risk calculations the explanation also included a discussion as to why this exercise constitutes a 'more detailed risk analyses' over the previous development of health-based pathway-specific benchmarks. If there are constituents in specific environmental media that exceed health-based pathway-specific benchmarks, it would stand to reason that a more detailed human health risk assessment focussing on these specific constituents and media would be required to more fully characterize potential health risks.
- The relevance of using an approximation of the average surface water concentration from each MU as a potable drinking water source over an entire lifetime (i.e., in the case of inorganic arsenic) has little relevance. A discussion of background concentrations of arsenic in surface water and potable drinking water sources throughout the Province relative to the levels observed within each MU would provide more practical information.
- The selenium exposure through diet as obtained from the Health Canada Total Diet Study considered an exposure of 2.2 µg/kg bw/day for all ages, this value increases to 5.7 µg/kg bw/day for the toddler life stage (Health Canada 2011). The re-evaluation of the toddler as the most sensitive life stage should be considered for the threshold COPC.
- It is unclear in Table 41 whether the media concentrations presented are representative of total or inorganic arsenic.
- While pathway-specific screening against benchmark values was conducted for each exposure medium and benchmark values were derived for the primary exposure pathways, clarification as to the selection of guideline values and the calculation of benchmarks will reduce the uncertainty inherent in these calculations.
- The outcome of screening for the primary pathways concluded that from the baseline data for surface water, arsenic and nitrate exceeded the pathway-specific benchmark and for sediment and groundwater, no primary pathway specific benchmarks were exceeded.
- It was concluded that as other pathways would pose a risk orders of magnitude lower than those for the drinking water pathway, benchmarks for the secondary pathways were not required to be developed.

In order to for the KNC to have greater confidence in the assessment and its conclusions additional details and clarity in guideline selection, TRV hierarchy, benchmark calculation, exposure assessment and risk calculation using the most sensitive receptor should be required. The specific inclusion of qualitative or semi-quantitative details regarding the potential for exposure through secondary pathways based on the traditional practices of the community should be requested.

Intrinsik would like to take this opportunity to thank you for the opportunity to work with the KNC in this review. Should you have any questions or concerns or require clarification regarding the review of the documents or the assessment, please do not hesitate to contact either Claire McAuley or Bart Koppe at (403) 237-0275.

Yours sincerely,
Intrinsik Environmental Sciences Inc.

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Memo

To: Don MacDonald

From: André Sobolewski

Date: July 11, 2014

Re: Elk Valley Water Quality Plan review

I reviewed three documents related to the Elk Valley Water Quality Plan:

- Chapter 4 – Management Options
- Chapter 5 – Calcite Management
- Teck R&D Summary

There is some overlap between these documents, particularly the discussion of water management options and the description of related R&D activities. In this review, I will comment more extensively about activities in the R&D program than those mentioned in Chapter 4, since this is a better context to discuss them.

Below are my thoughts and recommendation for each of these three documents.

Management Options

The Management Options chapter presents a few, limited options for managing nitrate and selenium. Essentially, Teck proposes to manage contaminated water by diverting clean water away from reactive waste rock and by constructing and operating treatment plants to reduce contaminant concentrations and loads to acceptable levels.

Although it is acknowledged that covers will eventually be required to reclaim the waste, this scenario is not fully elaborated and remains vague. However, the latter scenario is of great interest to many stakeholders and it needs to be more fully developed. Will Teck rely on water treatment plants for several decades or will they be phased out for covers and low maintenance/passive treatment systems? Does Teck want to defer a decision on covers until it has completed its R&D program and define in-pile treatment options?

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Despite many unknowns, Teck needs to more thoroughly define management options associated with closure, when waste rock piles can be covered or otherwise modified to control or mitigate contaminant release.

Calcite Management

A 2012 report by Vast Resource Solutions[1] indicated that the problem of calcite deposition on stream beds is significant: they report that 20% of streams that were surveyed are affected. This is substantially more than was reported in the 2013 survey and is presented in this document. The large extent of the Vast Resource survey, which covered six existing or planned operations, indicates that the problem of calcite deposition is serious.

This problem has also been reported elsewhere, but there are no effective solutions known to mitigate the impact of calcite deposition. Therefore, the research activities and iterative approach proposed by Teck to manage calcite deposition is reasonable.

The calcite index (CI) developed to monitor calcite deposition is simple and practical. Teck's decision to set a CI of 2 to designate significant damage is arguably too high, since the 2012 survey indicated that significant deposition occurred at lower CI values. This threshold value should be refined in light of more comprehensive monitoring results. Until then, a lower CI threshold value of 1.5 is recommended.

The decision-making framework (Figure 9) is sound, but should comprise three sets of targets:

- A short-term objective (1-5 years) to develop, field-test and validate mitigation measures and treatment processes
- A mid-term objective (5-10 years) to remediate impacted streams with CI >1.5 by reducing the CI to below 0.5. This is a more protective approach that is commensurate with the severity of the problem.
- A long-term objective (>15 years) bring the CI <0.5 in all mine-exposed streams.

Several treatment methods were described that could be used to control calcite.

Alkalinity reduction (or acid addition) can easily be implemented in-stream (i.e., crib containing elemental sulphur or other acid-generating material) and should be evaluated. As indicated, it will be important to account for the increased anion concentrations (i.e., increased in-stream sulphate concentrations) generated by this process. Another concern that needs to be evaluated before implementing this approach is that calcite dissolution could release contaminants of interest (e.g., cadmium).

[1] Hlushak, D. 2013. Calcite Monitoring Program – 2012 Field Assessment (Elk Valley). Prepared for Teck Coal Ltd. Prepared by VAST Resource Solutions, Cranbrook, BC. 19 pp + 3 appds.

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Constructed cascades and trickling filters require an elevation difference that would naturally work to mitigate calcite formation (via CO_2 off-gassing). Their use would only be feasible at elevation, where seepage or groundwater daylights into a stream.

Treatment in ponds, in combination with addition of anti-scalants or PCC, is promising because it is easily implemented and can control precipitates effectively. However, ponds can only be constructed near valley bottoms, which limits their applicability.

The adaptive management approach recommended by Teck will succeed only if the progress of their work is reviewed and evaluated within a set timeframe. Teck should define an acceptable review process and cycle for this work.

R&D Summary

Teck's R&D program is divided into two programs that address the key research needs for the Elk Valley coal mines:

- Development of Active Water Treatment for the immediate need to reduce contaminant loads, and,
- Development of Source Control measures for the long-term control of contaminant release.

The Active Water Treatment component is not really a research program: it is the process normally used to evaluate and select water treatment systems at any mine site. In contrast, the Source Control R&D is a genuine research program, with the potential to develop new processes for the control of contaminants leached from waste rock.

The list of active treatment systems being evaluated is comprehensive and comprises all the major processes known to remove nitrate, selenium and sulphate. The supporting studies on management of residuals are necessary and appropriate.

A small portion of the Water Treatment program examines passive treatment systems, such as bioreactors and flooded pits. The level of effort for these projects is dwarfed by the level of effort committed to the development of treatment plants. This is appropriate for the immediate needs of present operations, but it is disproportionally low in relation to the potential contributions of passive systems to contaminant removal. After treatment plants have been built and put in operation, Teck should shift its focus to research passive treatment systems that could remove significant contaminant loads. These might include hybrid bioreactors (with periodic needs for operators, mechanical implements, or reagents), novel Permeable Reactive Barriers, or other systems that are suited to the climate and topography of this region.

At most mines, source control measures would include flooding reactive waste rock or covering it with an impervious, engineered soil layer. It is believed that neither of these

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methods will be available to deal with the legacy of waste rock at Teck's BC coal mines. Saturated pit backfill will address only a small portion of the waste rock. Covering waste rock piles is not likely possible because there is not enough cover material (till, clay) available, unless creative means of acquiring material from other sources (e.g., dredged material disposal projects, etc.) are developed. This type of creative thinking needs to start immediately.

Two key observations give hope that other source control measures may prevent selenium leaching:

- Some piles of waste rock release less selenium than expected, suggesting that it is being attenuated; and,
- Selenium in groundwater below coarse coal rejects (CCR) pond was observed to be attenuated at a number of coal mines in BC.

Broadly, these effects are believed to result from the partial reduction of selenate to selenite and its adsorption to iron oxides and other constituents in the waste rock. It is also possible that microbial processes transform selenium anions to their insoluble, elemental form. The research activities of the Waste Rock Pile Design and CI (contaminants of interest) Management project are designed to provide a fundamental understanding of these processes. As such, these studies are vital to improve the future design of waste rock piles to minimize the release of contaminants. Ideally, and the ultimate goal of this research, features of piles that retain selenium can be identified and replicated in the design of future waste rock piles.

The study is broken down into different components: pile instrumentation, biogeochemical and hydrological investigations. Each component seems to be well thought out and is designed to provide useful, complementary information.

Nominally, the processes that attenuate selenium are similar to those operating in passive treatment systems, albeit on a larger scale. Therefore, the information obtained from this study will be useful for the design of passive treatment systems, as well as for the design of waste rock piles.

While this research can potentially inform the design of future waste rock piles, it will be difficult to "retrofit" existing piles. Without conventional covers or possibility to submerge waste rock, there are few measures available to control or mitigate contaminants released within these piles. Reactive structures like Permeable Reactive Barriers (PRBs) may be constructed in these piles, and their design will be informed by the above studies, as well as studies of saturated fills. If these approaches cannot be implemented, Teck will have to rely on continual, long-term water treatment, either active or passive.

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The R&D program briefly describes groundwater studies that were undertaken at the West Line Creek dump. These studies need to be expanded at other sites to improve our understanding of the relation between fluctuating groundwater levels and selenium release. If such interactions account for significant selenium loads, they will not be curtailed by covers installed on these dumps.

The finding that rock drains do not release selenium brings some relief because the prospect of installing covers on them is very daunting.

The watershed water balance model developed for Teck will be an important management tool. However, a glaring omission in the model – and more broadly, in the R&D program – is the lack of research on factors that affect selenium ecotoxicity and environmental fate. There is no mention of investigation of Trophic Transfer Factors in different segments of the watershed or of loss factors in receiving water bodies. Studies of the Great Salt Lake[2] have demonstrated that a substantial proportion of the selenium load it receives is lost by volatilization, which affects the final Water Quality Objective for this lake.

A key element of the water balance model will be to relate watershed-wide target nitrate or selenium levels to discharge criteria for individual treatment plants. This is a critical aspect of the permitting process, as it links the performance of individual plants and management measures with valley-wide targets for these contaminants. Given this regulatory function, the model must make robust predictions, since a "recalibration" or "update" to the model would mean a change in the permit for these treatment plants.

The nitrate control study is interesting and strongly supported. Since there is evidence that residual nitrate in waste rock can potentiate selenium release (or prevent its attenuation), even a small decrease in the nitrate loss factor could result in a significant decrease in mass loadings into the Elk Valley River. This may be beneficial both financially for the company and safeguard the ecological health of the system.

[2] Ohlendorf, Harry M.; DenBleyker, Jeff; Moellmer, William O.; and Miller, Theron (2009) "Development of a site-specific standard for selenium in open waters of Great Salt Lake, Utah," *Natural Resources and Environmental Issues*: Vol. 15, Article 4. Available at: http://digitalcommons.usu.edu/nrei/vol15/iss1/4

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TECHNICAL MEMORANDUM

Date: July 10, 2014

To: Don MacDonald, MacDonald Environmental Sciences Ltd.

From: Rina Freed, Ph.D., P.Eng., Source Environmental Associates Inc.

Subject: Elk Valley Water Quality Plan Review – Management Options

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Source Environmental Associates Inc. (SEA) has reviewed the Draft Elk Valley Water Quality Plan and background information. Review comments are provided on the Management Options Chapter dated June 30, 2014 and the Initial Implementation Plan Chapter dated May 2014. For this review, SEA has attempted to answer a number of key questions including:

1. Has a reasonable evaluation of management options been conducted and should additional management options be considered?
2. For waste rock resulting from future mining expansions, which management options are appropriate?
3. Are there additional mitigations options that should be implemented in the near term?
4. Is the schedule for implementing treatment mitigation appropriate?
5. Has sufficient site characterization been conducted and are the collection efficiencies appropriately designed?

1 Has a reasonable evaluation of management options been conducted and should additional management options be considered?

Insufficient information is provided to justify the selection of the limited options discussed in the Management Chapter, namely active water treatment with clean water diversion and consideration of waste rock covers. Additional management options for addressing existing waste rock liabilities should be considered. The practical strategies identified by Teck are a good starting place but they are not discussed. The current draft outlines the plan to operate active water treatment plants.

Supporting Information: The following information provides the rationale for the above statement:

- In the Draft Management Options Chapter, a list of practical strategies for mine design is shown in Figure 6-3 and a summarize follows:
    - Reduce water volumes to treat: covers, minimize footprints
    - Place rock underwater: submerge rock fills – passive or enhanced
    - Divert contaminated water to passive treatment areas: direct water to backfilled pits, reactive barrier walls, etc
    - Within dump treatment: textural discontinuity, enhanced biological/ existing process

  Many of these practical strategies for waste rock management are not included in the evaluation of options and should be discussed in more detail. The evaluation of options provided only outlines the plan to commission operational active water treatment plants.

- For example, while Teck places emphasis on the option of passive treatment using saturated fills, these are not included in the options evaluated. These saturated fills refer to water-filled pits backfilled with waste rock that can be used as treatment flow-through cells. It is not clear why this option was not included in the review of management options given the high degree of optimism indicated.

- Alternative cover materials are not discussed and should be considered in more detail for addressing loadings (selenium, etc) from existing waste rock. For example, materials on hand or readily available such as coarse coal rejects, municipal WWTP sludge or pulp mill treatment plant sludge may be cost effective options for use as a cover material. Bare rock and graded rock are not typically considered cover alternatives. The discussion of the waste rock cover designs should include discussion of various surface treatments in more detail. Overall, the level of effort for waste rock covers is not adequate to assess the merits of this management option.

- Financial comparisons are typically provided within an evaluation of management options and no such costing is provided. To improve transparency associated with the evaluation of management options, financial comparison are important. It is possible that full disclosure of the estimated costs cannot be provided, however a cost comparison could be made available on a relative basis.

Overall SEA feels that little justification of the selected option is provided and active water treatment alone may not be the best management strategy for the existing waste rock liability in the near term. SEA does support the inclusion of active water treatment, but not as a standalone measure for the evaluation of management options.

2 For waste rock resulting from future mining expansions, which management options are appropriate?

The EVWQP needs to differentiate between legacy waste rock and newly generated waste rock. Active water treatment is not an appropriate management assumption for newly developed waste rock. Appropriate management strategies involve source control such as submerging the waste rock in saturated facilities. Significantly more work is needed to justify inclusion of active water treatment as a management strategy for newly generated waste rock. As a contingency plan, active water treatment is appropriate for future expansion projects.

Supporting Information: The following information provides the rationale for the above statement:

- The existing waste rock liabilities in the Elk Valley are already enormous and causing environmental problems. As Teck proposes to expand operations and add to the inventory of waste rock, a new approach is needed. Experience from other mine operations and closure planning shows that once active water treatment is started, it is rare, if ever, turned off.

- Legacy waste rock inherently has fewer management options than waste rock associated with a new development. While SEA acknowledges that active water treatment will be a large part of the management of legacy waste rock, SEA feels it is inappropriate for Teck to plan for active water treatment for the enormous amount of additional waste rock planned for the Elk Valley. However, Teck is not attempting to differentiate between existing and newly generated waste rock in terms of evaluating management options and implementing treatment mitigations.

- One alternative that should be evaluated in more detail is submergence of waste rock as a management alternative. This option is analogous to co-disposal of potentially acid generating (PAG) waste rock within tailings dams. From the research results completed, it is clear that saturated waste rock spoils are not problematic and unsaturated waste rock spoils are the key problem. Stand-alone waste rock facilities could be developed to mitigate released selenium and other substances. It is clear from a review of the progress to date that a suboxic environment would significantly reduce selenium leaching.

- For new waste rock, SEA feels it is appropriate for Teck to deal with the liabilities as they occur and not increasing the closure securities required long-term. It is understood that the topography is challenging for submerging waste rock; however, detailed feasibility studies should be conducted. With all the existing impacted areas in the Elk Valley, it may be possible to saturate new waste rock in lower lying areas.

SEA feels it's not a viable option to add to the already overwhelming problems associated with management of unsaturated waste rock spoils. Teck should address the existing waste rock liabilities before planning for future expansion projects.

3 Are there additional mitigations options that should be implemented in the near term?

To address the existing waste rock liabilities, additional mitigation options should be implemented in the near term. Teck needs to attempt to implement control measures that do not encourage long-term treatment as the closure plan. Teck promotes the use of saturated fills as a passive treatment strategy. Teck should commit to developing and evaluating a large-scale saturated-fill treatment system as a part of the EVWQP. This management option appears to be cost effective and technically feasible in the near term. For proposed expansion projects, Teck should design saturated waste rock management facilities or equivalent source control strategies as part of its commitment to improved mine design.

Supporting Information: The following information provides the rationale for the above statement:

- The draft EVWQP strongly supports the use of saturated fills as a passive treatment option that is both cost effective and very promising. Without a large scale trial, the technology will never be proven and Teck needs to be a leader in this area of research and development.

- Teck should be investing more effort and resources into R&D for mine waste mitigation planning to avoid the need for additional long-term active water treatment. The best chance to avoid long-term treatment is upfront design of waste rock facilities. Because the disturbance area is already so large, it may be possible to use the disturbed areas to deposit new waste rock. Large scale flooding of waste rock has not been discussed in detail and should be evaluated.

Effective research and development involves risks and an attitude of acceptance of some failures.

4 Is the schedule for implementing treatment appropriate?

A clearer decision making framework for the timing and capacity of treatment systems is required. Sequential implementation of AWTFs and/or passive treatment systems acts to slow down the achievement of water quality improvements and load reduction. A best management practice approach should be adopted for planning purposes. Treatment for discharges identified as priorities for load reductions should be built as rapidly as possible.

Supporting Information: The following information provides the rationale for the above statement:

- While Teck propose to implement water treatment sequentially, SEA feels a more rapid implementation approach is appropriate and possible. In the Water Quality Targets and Implementation Chapter, the following statement is provided: "Two-year spacing of AWTFs allows an efficient construction team, and implement the most efficient technologies available[1]." The initial valley-wide selenium management plan (Feb 2013) called for building treatment plants on a yearly basis. The rationale for planning to build AWTFs every 1-2 years at Fording River Operations (FRO), Greenhills Operations (GHO) and Elk Valley Operations (EVO) is not clearly described. Teck's proposal for sequential implementation of treatment appears to unnecessarily delay mitigation of degraded water quality. Therefore, the rationale for the mitigation plan needs to be better described.

- The schedule for implementing treatment systems should be clearly rationalized. For example, Teck claims that meeting their proposed "level" 1 Se benchmark at FR5 is not technically achievable. However, a clear justification for this statement is not provided. It appears that Teck has a financial plan for building and running AWTPs that does not fit with meeting the proposed "level" 1 Se benchmark at FR5; however, that financial plan is not disclosed. In addition, the planning framework for implementing treatment systems is overly complicated and should be simplified.

- It is not appropriate for Teck to propose delaying treatment for high selenium and other contaminant loadings based on the justification of needing to meet the targets proposed by Teck (e.g., 40 ug/L of Se at Fording River, FR5 and 57 ug/L Se at FR4). Such high long-term water quality targets are clearly controversial. Teck should demonstrate that it is doing all it can to change direction, especially in the Fording River. SEA is of the opinion that Teck will not convince regulators and stakeholders that it is doing enough to protect the environment, given the nature and extent of the problem. Therefore, SEA believes that a best management practice approach is more likely to succeed for treatment planning.

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[1] EVWQP, Chapter on the Water Quality Targets and Implementation, Table X1: Planning basis, rationale and adaptive management considerations", May 2014, page 41

5 Has sufficient site characterization been conducted and are the collection efficiencies appropriately protective?

The collection efficiency for water treatment in the EVWQP is estimated to be 70% for many sites with seepage through waste rock, and SEA feels that this collection efficiency is not adequately protective. Additional mitigation strategies should be evaluated to improve collection efficiency. To effectively plan for improved seepage collection efficiency in the EVWQP, additional site characterization is required.

Supporting Information: The following information provides the rationale for the above statement:

- The basis for the 70% collection efficiency assumption in the EVWQP is not provided and detailed characterization has either not been completed or not reported. SEA notes that for the Line Creek Operations, Phase II Application, Teck stated seepage collection efficiencies could be as high as 99.3%. Higher seepage collection efficiencies could be proposed in the EVWQP.

- Additional details are required to describe the groundwater mitigation strategies to maximize collection of contaminated seepage. Improved mitigation strategies should be evaluated such as hydraulic drains. These drains consist of large diameter pipes that are perforated on the upper side and are installed along creek banks to protect receiving environments. For example, a drain capture installation acts as a pump and treat system at Nyrstar Myra Falls Operating Mine, where groundwater seepage from unsaturated waste rock is a large source of contaminant loadings to receiving surface waters. Traditional seepage capture wells can also collect groundwater seepage for water treatment and reactive barriers are appropriate for passive treatment of seepage.

- Drilling in waste rock and groundwater site characterization is very limited for most of Teck's Operations with the exception of LCO2. Additional drilling and site characterization is required in waste rock to define the source area concentrations. Site characterization should also address the issue of how much loading is attributed to direct precipitation on the waste rock versus groundwater flow through waste rock from upslope. The mechanism of source loadings at each site should be characterized in detail with tracer tests or other indicative field based studies.

Evaluation of the Calcite Index

J. A. Sinclair and D. D. MacDonald

July 4, 2014

1.0 Background Information

Chapter 7 of the Elk Valley Water Quality Plan (EVWQP) provides a description of studies that have been conducted to date on the formation (presence, abundance, and concretion) of calcite in mine-affected (i.e., exposed) and unaffected (i.e., reference) streams in the Elk Valley. In addition, Chapter 7 of the EVWQP provides medium- and long-term targets that are proposed for calcite formation in the valley and actions to meet the stated targets.

In 2013, 122 stream reaches that are currently mine-affected or will be mine-affected (i.e., proposed) were surveyed (Table A4.1) to standardize the methodology for data collection, document the extent and degree of calcite deposition, determine rates of calcite deposition, and classify stream reaches for prioritizing mitigation activities. In addition, 11 stream reaches in reference areas were also surveyed to assess the distribution of natural calcite deposition (Table A4.1). In general, the mine-affected (i.e., exposed) stream reaches showed elevated calcite index scores for all three index components [calcite presence (CI_P), calcite concretion (CI_C), and overall calcite index (CI; Figure A4.1)].

The CI is calculated as the sum of the CI_P, which can range from 0 (no calcite observed) to 1 (100% of the stream bed covered in calcite), and the CI_C, which can range from 0 (no concretion) to 2 (fully concreted). While low (CI = 0.00 to 0.99), mid (CI = 1.0 to 1.99), and upper (CI = 2.0 to 3.0) calcite index ranges were proposed by Teck to classify each of the assessed streams, these ranges are not derived from the results of monitoring and assessment activities that were conducted to evaluate environmental effects hypotheses, interactive effects hypotheses, and cumulative effects hypotheses that explicitly consider the potential effects of calcite on aquatic receptors. Given that calcite represents an important physical stressor for ecological receptors utilizing habitats in tributaries and, to a lesser extent, mainstream areas, the near-term classification of streams should consider the potential effects on aquatic receptors.

2.0 Recommendations for Classifying Streams in the Elk Valley

An alternate classification system that considers the potential affects to aquatic receptors is recommended for application in the near-term in the Elk Valley. The classification system was derived using information collected from the reference stream reaches and effects hypotheses that stream bed conditions that show evidence of concretion in greater than 25% of the stream bed or have the potential for concretion (i.e., more than 75% of the streambed showing evidence of calcite; Figure A4.2) have the potential to cause adverse effects to aquatic receptors. Therefore, in the near term, it is recommended that the following alternate classification system be applied:

- ***Unaffected Streams*** **-** These streams have calcite levels consistent with those observed in reference streams. Such streams have CI_P values and CI_C values less than or equal to the maximum score in reference streams. The maximum CI_P value from a reference stream reach reported from the 2013 study was 0.48. The maximum CI_C value from a reference stream reach reported from the 2013 study was 0.08 (Figure A4.2);

- ***Moderately-Affected Streams*** **–** These streams have calcite levels that are intermediate between unaffected streams and highly affected streams (i.e.1, CI_P of > 0.48 to < 0.75 or CI_C of > 0.08 to < 0.5; Figure A4.2); and,

- ***Highly-Affected Streams*** **–** These streams have at least 75% of the pebbles showing evidence of calcite formation (i.e., $CI_P \geq 0.75$) or at least 25% of the streambed showing evidence of concretion (i.e., $CI_C \geq 0.5$; Figure A4.2).

Jesse Sinclair, Senior Biologist
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Don MacDonald, President,
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Table A4.1. Calcite Indices for the streams surveyed in 2013 in the Elk Valley.

Management Unit/Stream Type/ Stream Name	Nearest Operation	Calcite Presence Score (CI_P)	Calcite Concretion Score (CI_C)	Calcite Index (CI)
Management Unit 1				
Reference				
Chauncey Creek R1	N/A	0.00	0.00	0.00
Fording River R12	N/A	0.00	0.00	0.00
Exposed				
Cataract Creek R1	GHO	1.00	2.00	3.00
Cataract Creek R2	GHO	1.00	0.89	1.89
Cataract Creek R3	GHO	1.00	2.00	3.00
Clode Outlet R1	FRO	0.00	0.00	0.00
Dry Creek - EVO R1	EVO	0.85	1.38	2.23
Dry Creek - EVO R2	EVO	0.85	1.38	2.23
Dry Creek - EVO R3	EVO	0.85	1.35	2.20
Dry Creek - EVO R4	EVO	0.75	0.68	1.42
Eagle Pond Outlet R1	FRO	1.00	0.90	1.90
Fish Pond Creek R1	FRO	0.00	0.00	0.00
Fording River R10	FRO	0.00	0.00	0.00
Fording River R11	FRO	0.00	0.00	0.00
Fording River R5	GHO	0.32	0.0	0.32
Fording River R6	GHO	0.68	0.06	0.74
Fording River R7	GHO	0.40	0.03	0.43
Fording River R8	GHO	0.30	0.01	0.31
Fording River R9	GHO	0.00	0.00	0.00
Gardine Creek R1	GHO	0.29	0.00	0.29
Grassy Creek R1	FRO	0.00	0.00	0.00
Greenhills Creek R1	GHO	0.35	0.01	0.35
Greenhills Creek R2	GHO	0.60	0.00	0.6
Greenhills Creek R3	GHO	0.83	0.47	1.3
Greenhills Creek R4	GHO	0.79	0.83	1.62
Henretta Creek R1	FRO	0.00	0.00	0.00
Henretta Creek R2	FRO	0.00	0.00	0.00
Henretta Creek R3	FRO	0.00	0.00	0.00
Kilmamock Creek R1	FRO	0.83	1.33	2.16
Lake Mountain Creek R1	FRO	0.00	0.00	0.00
Lake Mountain Creek R2	FRO	0.00	0.00	0.00
Lake Mountain Creek R3	FRO	0.00	0.00	0.00
Lake Mountain Creek R4	FRO	0.00	0.00	0.00
Porter Creek R1	GHO	0.78	0.14	0.92
Porter Creek R2	GHO	0.05	0.06	0.11
Porter Creek R3	GHO	0.97	1.8	2.78
Smith Ponds Outlet R1	FRO	0.89	1.72	2.61
South Pond Seep R1	FRO	0.00	0.00	0.00
Swift Creek R1	GHO	0.87	1.71	2.58
Swift Creek R2	GHO	0.00	0.00	0.00
Proposed				
Dry Creek - LCO R1	LCO	0.00	0.00	0.00
Dry Creek - LCO R2	LCO	0.00	0.00	0.00
Management Unit 2				
Reference				
Grace Creek R1	N/A	0.29	0.02	0.31
Grace Creek R2	N/A	0.15	0.01	0.15
Line Creek R7	N/A	0.00	0.00	0.00
South Line Creek R2	N/A	0.00	0.00	0.00
Exposed				
Contingency Pond Outlet R1	LCO	0.93	0.00	0.93
Contingency Pond Seep R1	LCO	0.92	0.00	0.92
Fording River R1	LCO	0.00	0.00	0.00
Fording River R2	LCO	0.00	0.00	0.00

Table A4.1. Calcite Indices for the streams surveyed in 2013 in the Elk Valley.

Management Unit/Stream Type/ Stream Name	Nearest Operation	Calcite Presence Score (CI_P)	Calcite Concretion Score (CI_C)	Calcite Index (CI)
Management Unit 2				
Exposed (cont'd)				
Fording River R3	LCO	0.00	0.00	0.00
Line Creek R1	LCO	0.27	0.00	0.27
Line Creek R2	LCO	0.00	0.00	0.00
Line Creek R3	LCO	0.00	0.00	0.00
Line Creek R4	LCO	0.4	0.00	0.4
Management Unit 3				
Reference				
Elk River R15	N/A	0.00	0.00	0.00
Exposed				
Elk River R11	LCO	0.00	0.00	0.00
Elk River R12	GHO	0.00	0.00	0.00
Leask Creek R1	GHO	0.03	0.00	0.03
Leask Creek R2	GHO	0.13	0.00	0.13
Mickelson Creek R1	GHO	0.01	0.00	0.01
Mickelson Creek R2	GHO	0.05	0.00	0.05
North Thompson Creek R1	GHO	0.74	0.50	1.24
North Wolfram Creek R1	GHO	0.45	0.25	0.70
South Wolfram Creek R1	GHO	0.97	1.00	1.97
Thompson Creek R1	GHO	0.00	0.00	0.00
Thompson Creek R2	GHO	0.07	0.01	0.08
Thompson Creek R3	GHO	0.00	0.00	0.00
Wolfram Creek R2	GHO	0.25	0.02	0.27
Wolfram Creek R3	GHO	1.00	1.93	2.93
Management Unit 4				
Reference				
Alexander Creek R3	N/A	0.40	0.08	0.48
Andy Good Creek R1	N/A	0.00	0.00	0.00
Grave Creek R3	N/A	0.00	0.00	0.00
Michel Creek R5	N/A	0.00	0.00	0.00
Exposed				
Aqueduct Creek R1	EVO	0.00	0.00	0.00
Aqueduct Creek R2	EVO	0.00	0.00	0.00
Aqueduct Creek R3	EVO	0.00	0.00	0.00
Balmer Creek R1	EVO	0.00	0.00	0.00
Bodie Creek R1	EVO	0.00	0.00	0.00
Bodie Creek R2	EVO	0.06	0.00	0.06
Bodie Creek R3	EVO	0.65	0.51	1.16
CCR Seep R1	EVO	0.00	0.00	0.00
Corbin Creek R1	CMO	0.97	0.99	1.95
Corbin Creek R2	CMO	0.98	1.74	2.72
Elk River R10	LCO	0.00	0.00	0.00
Elk River R9	EVO	0.00	0.00	0.00
Erickson Creek R1	EVO	0.99	1.30	2.29
Erickson Creek R2	EVO	0.88	0.90	1.78
Erickson Creek R3	EVO	0.96	1.40	2.36
Erickson Creek R4	EVO	0.53	0.09	0.62
Feltham Creek R1	EVO	0.00	0.00	0.00
Fennelon Creek R1	EVO	0.00	0.00	0.00
Gate Creek R1	EVO	0.05	0.00	0.05
Gate Creek R2	EVO	0.13	0.02	0.15
Goddard Creek R1	EVO	0.00	0.00	0.00
Goddard Creek R2	EVO	0.00	0.00	0.00
Goddard Creek R3	EVO	0.00	0.00	0.00
Grave Creek R1	EVO	0.54	0.00	0.54

Table A4.1. Calcite Indices for the streams surveyed in 2013 in the Elk Valley.

Management Unit/Stream Type/ Stream Name	Nearest Operation	Calcite Presence Score (CI_P)	Calcite Concretion Score (CI_C)	Calcite Index (CI)
Management Unit 4				
Exposed (cont'd)				
Grave Creek R2	EVO	0.23	0.00	0.23
Harmer Creek R1	EVO	0.58	0.00	0.58
Harmer Creek R2	EVO	0.17	0.00	0.17
Harmer Creek R3	EVO	0.15	0.00	0.15
Harmer Creek R4	EVO	0.16	0.01	0.17
Harmer Creek R5	EVO	0.19	0.00	0.19
Harmer Dump Seep R1	EVO	0.49	0.03	0.52
Lagoon C Seep R1	EVO	0.39	0.00	0.39
Lindsay Creek R1	EVO	0.19	0.00	0.19
Michel Creek R1	EVO	0.31	0.00	0.31
Michel Creek R2	EVO	0.05	0.00	0.05
Michel Creek R3	NA	0.00	0.00	0.00
Michel Creek R4	CMO	0.00	0.00	0.00
Milligan Creek R1	EVO	0.00	0.00	0.00
Milligan Creek R2	EVO	0.00	0.00	0.00
Otto Creek R1	EVO	0.30	0.00	0.30
Otto Creek R2	EVO	0.03	0.00	0.03
Otto Creek R3	EVO	0.01	0.01	0.02
Pengelly Creek R1	CMO	0.09	0.00	0.09
Pit Rd 12 Seep R1	EVO	0.00	0.00	0.00
Qualteri Creek R1	EVO	0.00	0.00	0.00
Sawmill Creek R1	EVO	0.00	0.00	0.00
Sawmill Creek R2	EVO	0.38	0.00	0.38
Sixmile Creek R1	EVO	0.80	0.00	0.80
Sixmile Creek R2	EVO	0.00	0.00	0.00
South Pit R1	EVO	0.00	0.00	0.00
South Pit R2	EVO	0.02	0.01	0.03
Spring Creek R1	EVO	0.20	0.00	0.20
Thresher Creek R1	EVO	0.00	0.00	0.00
Unnamed South of Sawmill Creek R1	EVO	0.00	0.00	0.00
Proposed				
Dry Creek - LCO R3	LCO	0.00	0.00	0.00
Dry Creek - LCO R4	LCO	0.00	0.00	0.00
Dry Creek - LCO R5	LCO	0.00	0.00	0.00
Dry Creek - LCO R6	LCO	0.00	0.00	0.00
Management Unit 5				
Exposed				
Elk River R8	N/A	0.40	0.00	0.40

N/A = Not applicable.

Table A4.2. Summary statistics of the calcite scores and calcite indices for the reference and mine-exposed streams surveyed in 2013 in the Elk Valley.

Stream Type / Score	n	Mean	Standard Deviation	95% UCL	Min	Max	Percentile 5th	10th	25th	50th	75th	90th	95th
Reference													
Calcite Presence Score (CI_P)	11	0.08	0.14	0.17	0.00	0.40	0	0	0	0	0.075	0.29	0.345
Calcite Concretion Score (CI_C)	11	0.010	0.024	0.026	0.00	0.080	0	0	0	0	0.0050	0.020	0.050
Calcite Index (CI)	11	0.09	0.16	0.20	0.00	0.48	0	0	0	0	0.075	0.31	0.395
Exposed													
Calcite Presence Score (CI_P)	116	0.30	0.37	0.36	0.00	1.0	0	0	0	0.065	0.59	0.93	0.98
Calcite Concretion Score (CI_C)	116	0.25	0.54	0.35	0.00	2.0	0	0	0	0	0.030	1.3	1.7
Calcite Index (CI)	116	0.55	0.86	0.71	0.00	3.0	0	0	0	0.085	0.64	2.2	2.6
Proposed													
Calcite Presence Score (CI_P)	6	0.00	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calcite Concretion Score (CI_C)	6	0.00	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calcite Index (CI)	6	0.00	N/A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

n = number of samples; 95% UCL = 95% upper confidence limit of the mean; Min = Minimum; Max = Maximum; N/A = Not applicable.

Figure A4.1. Distribution of calcite scores for reference and mine−exposed streams from surveys conducted in 2013 in the Elk Valley.

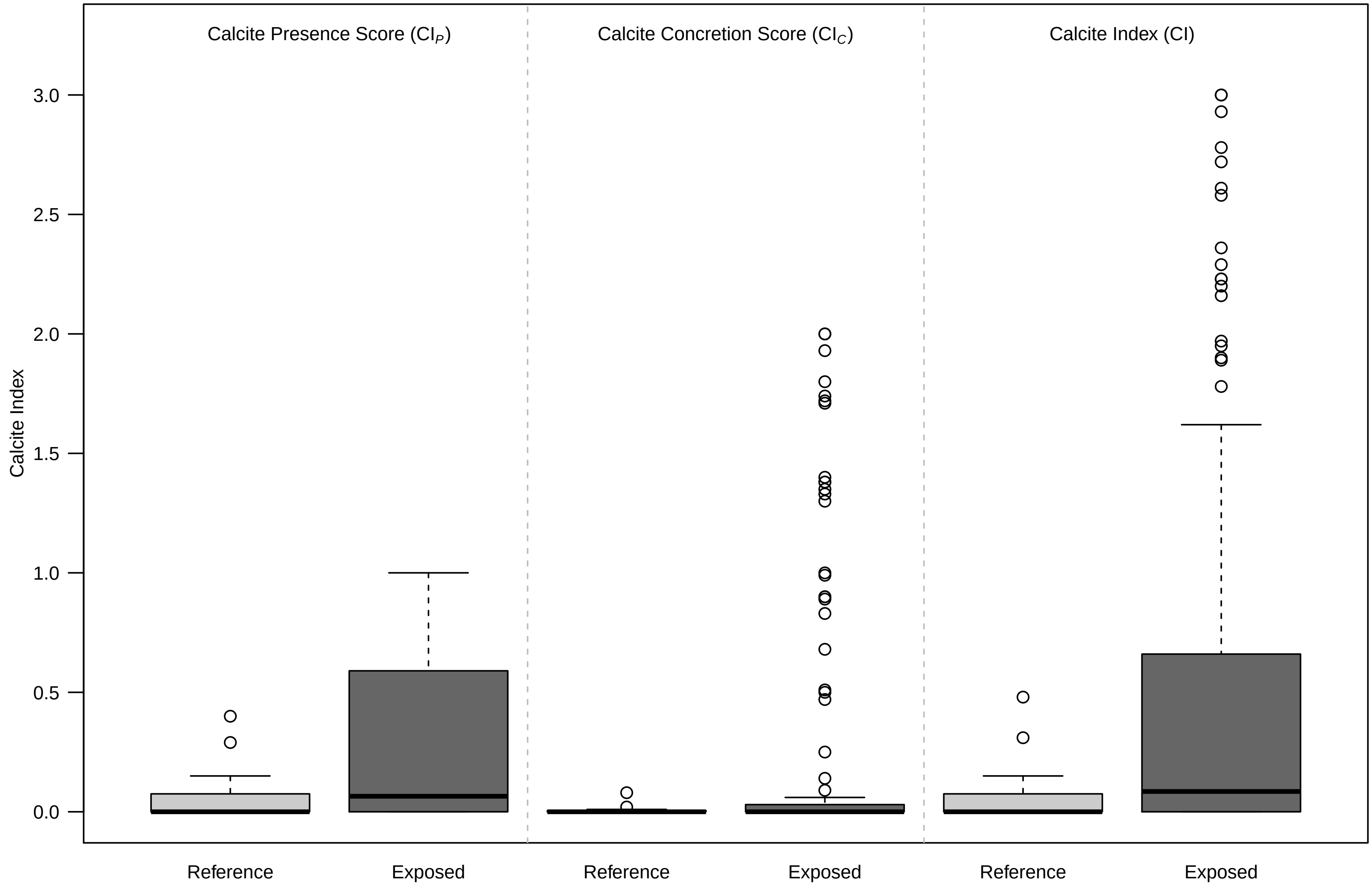
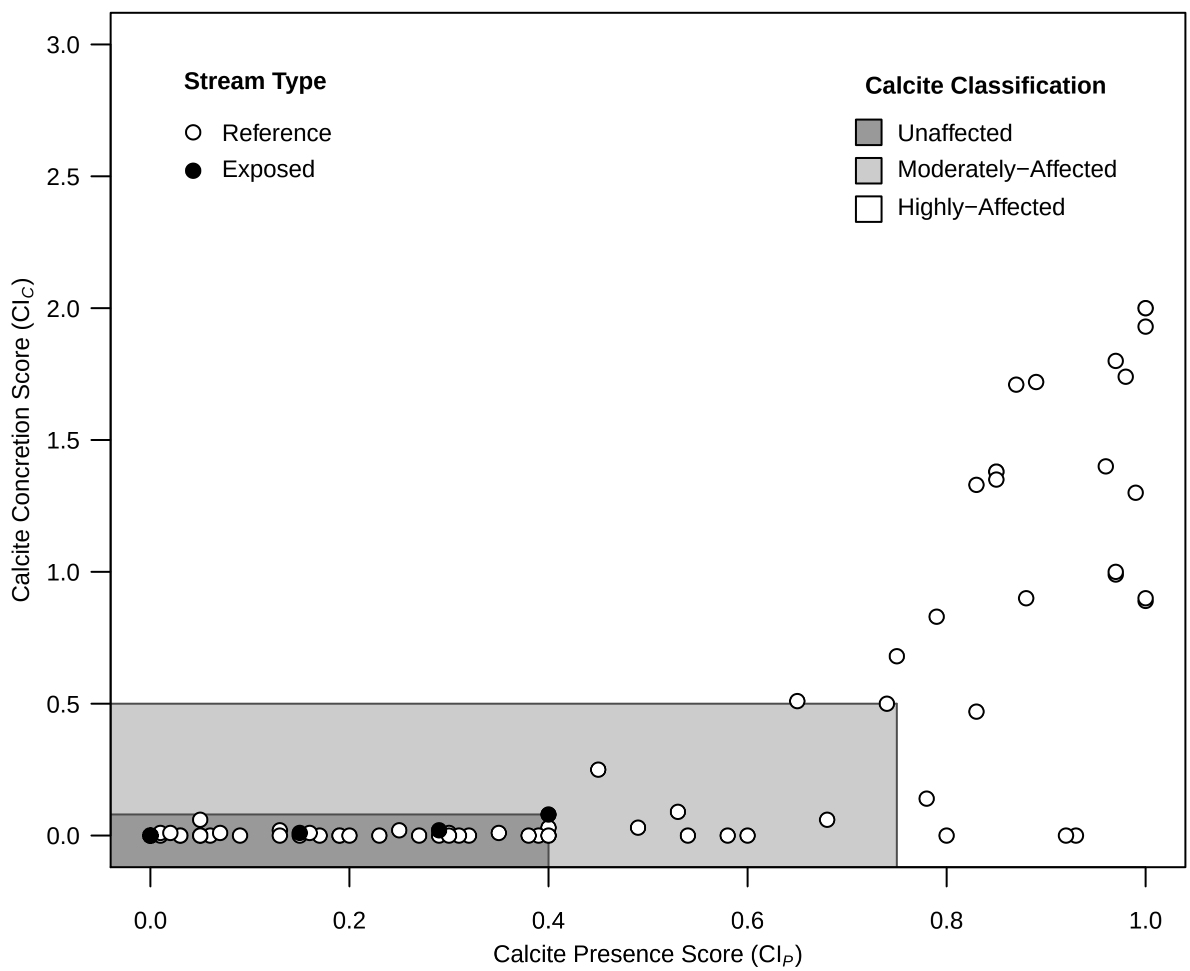


Figure A4.2. Relationship between calcite presence scores and calcite concretion scores for reference and mine−exposed streams from surveys conducted in 2013 in the Elk Valley.



June 24th 2014

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Subject: Elk Valley Water Quality Plan Review – Selenium Water Quality Benchmarks

Thank you for the opportunity to review the Elk Valley Water Quality Plan related to selenium water quality benchmarks. During my review, I have attempted to answer a number of key questions related to the benchmarks including:

1. Does the framework for developing WQ Benchmarks and WQ Targets provide a basis for protecting aquatic life that is consistent with the level of protection that is provided by the WQGs?
2. Are the critical effects sizes selected for WQ benchmark derivation consistent with the best available science?
3. Are the benchmarks for selenium in tissues appropriate?
4. Are there fundamental flaws in the suite of bioaccumulation models that were used to establish WQ benchmarks?
5. Would WQ targets based on tissue concentrations rather than water concentrations result in thresholds that are less uncertain and more protective?
6. Are there other ways to establish site-specific benchmarks for selenium that have lower uncertainty than those proposed by Teck?

In addition, I have provided a number of recommendations to address uncertainties related to the selenium water quality benchmarks.

1.0 Does the framework for developing WQ Benchmarks and WQ Targets provide a basis for protecting aquatic life that is consistent with the level of protection that is provided by the WQGs?

The Golder framework does not provide a level of protection for all sensitive aquatic life that is consistent with BC's WQGs. The basis for the Golder framework is a highly variable data set that was used to develop linked models with multiple uncertainties and non-conservative assumptions. This results in benchmarks and targets that are many times greater than BC MoE WQGs and not adequately protective.

Supporting Information: The following information is provided to provide the rationale for the above statement:

- WQG derivation and the method Golder used for benchmark derivation are very different processes. The BC MoE protocol for deriving WQGs follows a standard, rigorous and more conservative process aimed at adequately protecting all sensitive organisms over the long term. Golder developed benchmarks and targets based on non-conservative assumptions and statistical models which have a high degree of uncertainty due to many sources of variability and error across multiple linked equations;

- To account for the uncertainties associated with variability, potential error in data reporting and inconsistencies or unknowns in toxicological responses across species, the BC MoE guidelines incorporate uncertainty factors. Golder has incorporated no uncertainty factors in the benchmarks and targets to address the uncertainties;
- The decision criteria used by Golder to evaluate and classify studies was applied inconsistently and was contrary to that used by BC MoE and CCME. For example, Golder's review excluded studies that contain valuable information on juvenile Se toxicity (Hilton et al. 1980 and 1982; Hodson et al. 1980; Hilton and Hodson 1983; Hicks et al. 1984; Hunn et al. 1987; Miller et al. 2007). By excluding water-only exposure studies as Golder did, the information forming the foundation for selection of appropriate benchmarks is incomplete and increases uncertainty;
- BC MoE standard practice is to develop WQGs based on individual-level effect concentrations to account for the uncertainties in accurately identifying population-level critical effect concentrations. Golder's use of *population-level* critical effect sizes are not adequately conservative and this approach will put sensitive species at greater risk (see comments on CES);
- The pooling of lotic and lentic data to develop the trophic transfer models for periphyton and invertebrates is not supported by the data itself (slopes of the lotic and lentic Se relationships are different) and is not consistent with the common scientific understanding of Se accumulation (i.e., the rate of uptake of Se in lentic environments is much greater than lotic);
- Pooling Se data for more than one species of amphibian, bird and fish in the trophic transfer models is not supported by the data:
    - all models highly variable and relationships are weak (low r^2 values),
    - small sample numbers in some cases (western toad),
    - bird Se intercepts significantly different suggesting different toxicokinetics,
    - one invertebrate Se concentration paired with many fish egg Se concentrations, underscoring that these are not really paired data.
- Combining species data in modelling Se bioaccumulation is contrary to common scientific knowledge of the variability of species-specific differences in Se bioaccumulation, adding error and greater uncertainty to model predictions;
- There remains an incomplete understanding of Se bioaccumulation and sensitivity of Se toxicity for a broad range of species of fish, birds and amphibians resulting in use of a limited number of surrogate species, some of which may not the most sensitive (e.g., mallards versus coots and spotted sandpiper); and,
- Golder conducted an assessment of "interactive effects" from a mixture of contaminants, but the method used for integrating the full suite of cumulative effects (e.g., multiple stressors (habitat loss), impacts from Se in groundwater, climate change related flow changes (more intense extremes) was qualitative, was not verified using real data and therefore is incomplete and unproven, leaving a great deal of uncertainty in predictions.

2.0 Are the critical effects sizes selected for WQ benchmark derivation consistent with the best available science?

Selection of an appropriate critical effect size (CES) should be commensurate with the available science, detailed knowledge of differences in Se bioaccumulation within the study area, and habitat use of those areas by all species at risk. In addition, evaluation and incorporation of the inherent uncertainty associated with the statistical approach must be included to adequately protect sensitive species. Golder has not adequately addressed the various sources of uncertainty related to CESs which translate into Se benchmarks and targets that are likely to put sensitive aquatic organisms at risk.

Supporting Information: The following information is provided to provide the rationale for the above statement:

- Selecting a critical effect size for *populations* is contrary to BC MoE's policy that *individuals* should be protected.
- In Section 7.2.2.1 (Critical Effect Size), Golder quotes several authors (Suter et al. 1995; US EPA 1999, 2013; Mebane 2010; BC MoE 2014a) who suggest a 20% population-level effect concentration as a reasonable CES. However, both Suter et al. (1995) and Mebane (2010) caution against the use of population-based critical effect levels where multiple stressors are present. Since aquatic organisms within the Elk Valley are exposed to multiple stressors (habitat loss from calcite and progressive mine development, multiple contaminants and climate change), use of population-level critical effect sizes is not appropriate;
- Golder cited Van Kirk and Hill (2007) who stated that population-level effects on cutthroat trout may only become evident when individual-level mortality exceed 40-60%. However, these authors made other important statements about the model limitations and conclusions that Golder did not mention;
- Van Kirk and Hill (2007) stated that their model underestimated Se effects since it only included pre-winter juvenile growth and survival. Their model did not include effects of Se on juvenile survival in spring, summer and winter, nor the movement of fish in and out of lentic areas (variable exposure), toxic responses from other contaminants, and effects of other stressors (e.g., habitat loss). These are all additional effects that fish in the Elk Valley are potentially exposed to, so model results should be viewed with caution;
- The Van Kirk and Hill (2007) model predicted that when whole-body Se tissue concentrations were greater than 7.0 – 10.0 µg/g Se (dw) the density-dependent compensation was exceeded and population-level effects increased substantially with only small increases in tissue Se concentration;
- The tipping point for increased population-level effects may be related to the very steep dose-response curve for Se (i.e., once the Se effect threshold EC10 is exceeded, effects increase dramatically with only minor increases in Se exposure concentrations). This aspect of Se toxicity results in greater uncertainty in benchmarks based on population-level critical effect sizes;

- Van Kirk and Hill (2007) also stated that environmental variability significantly affects individual-level toxicity by increasing the negative response to contaminants (i.e., population size reductions greater than might be expected);
- Based on the model predictions, Van Kirk and Hill (2007) recommended that Se body burdens should not exceed 7.0 µg/g (dw) to protect juvenile cutthroat trout. In recognition of lower Se effect thresholds that have been published, the authors suggested a more conservative maximum allowable Se body burden of 5.5 µg/g Se (low end of the 95% CI) to account for model uncertainties. This population-level effect threshold is only marginally higher than the BC WQG for whole-body Se of 4.0 µg/g;
- Gledhill and Van Kirk (2011) modeled long-term Se effects on populations of bluegill sunfish (*Lepomis macrochirus*). They concluded that populations with smaller equilibrium size appear to be more vulnerable to the negative effects of environmental variability, which may result in population extinctions at much lower Se concentrations than predicted. Equilibrium population size of fish species in the Elk Valley may be another important factor that should be considered in selecting an appropriately protective CES;
- The model developed by Golder only applies to two species and may have very limited applicability across other species with unknown sensitivities to Se toxicity;
- The literature suggests a higher degree of caution should be exercised when implementing population model outputs in circumstances where other environmental factors can impart effects (Barnthouse et al. 1990; Suter et al. 1995; Suter and Barnthouse 2000; Mebane 2010)
- Closer examination of the literature is necessary to develop a fuller appreciation of the limitations of population-level modeling and the reliance of model outputs for management; and,
- Since Se bioaccumulation is not always predictable and many knowledge gaps exist, a conservative approach to derivation of CES (10%) at the individual level would be more appropriate under these circumstances and much less uncertain. Where uncertainty in the critical effect size remains, application of an uncertainty factor should be considered.

3.0 Are the benchmarks for selenium in tissues appropriate?

The consensus of current scientific opinion is that tissue benchmarks are the most direct measure of Se effects. However, the tissue benchmarks proposed by Golder are not appropriate.

Supporting Information: The following information is provided to provide the rationale for the above statement:

3.1 Fish Reproductive Benchmarks

While the egg Se tissue benchmark targets an appropriate tissue type, the reproductive benchmarks for fish proposed by Golder are high, relative to the uncertainties associated with the studies used and therefore put resident fish species at risk.

Evaluation:

- Benchmarks for reproductive effects in fish were average EC10s for WCT and brown trout and did not consider variability in response and the possibility that more sensitive species or life stages might be at greater risk;
- The selection of fish reproductive benchmarks did not take into consideration uncertainty in the dose-response relationship;
- It is unclear if the implications of the very steep Se dose-response curve were fully accounted for. Once the average EC10 concentrations are exceeded, individual-level effects are dramatically more pronounced with only small increments of Se;
- The WCT benchmark did not consider differences in Se accumulation and response in the smaller size (≤ 200mm) fish which comprise half the WCT population; and,
- The sensitivity to co-contaminants and habitat disturbances (cumulative effects) that exacerbate the toxic effects of Se have not been adequately determined or incorporated into the Se benchmarks.

3.2 Dietary (Juvenile Fish and Birds) Benchmarks

Many uncertainties exist with establishing a dietary benchmark for juvenile fish and birds which should preclude its use as a benchmark.

Evaluation:

- Many authors state that dietary Se is an indirect means of evaluating the effect of Se on fish and birds since exposures and the observed responses can be highly variable (Malloy et al. 1999; US EPA 2004; DeForest and Adams 2011). Internal tissue Se concentrations (liver, muscle, whole-body in the case of fish) are a more direct measure of toxic effect and are the preferable tissue types for benchmark derivation;
- Concentrations of Se in invertebrates are *highly variable* since Se bioaccumulation rates are area- and species-specific, increasing the difficulty of using dietary Se for detecting and managing effects;
- Characterizing the diet of juvenile fish and birds varies from location to location depending on season, species, age of organism and range of foraging, so linking dietary Se to effects are at best very difficult;
- The toxicity of Se specific to juvenile fish and birds is not as well researched and of the few publications that do exist some present conflicting information (i.e., no certainty in toxicity endpoints);
- In the development of juvenile benchmarks for fish, only dietary exposure routes were considered and the other potential source of exposure waterborne Se, was ignored (see comments above on studies excluded from Golder's benchmark literature review). The assumption that water-only Se exposures are unimportant is incorrect;
- The juvenile bird Se benchmark was derived using research for only one species (mallard duckling), which may have limited relevance given that other species are thought to be more sensitive to Se (i.e., coots and spotted sandpiper);

- There are few studies on juvenile fish that are conducted under controlled conditions which provide toxicity information for combined aqueous and dietary Se exposures at environmentally relevant concentrations to understand the extent and interactions of the two important exposure pathways;
- If dietary benchmarks are to be implemented for juvenile fish and birds, they should be aligned with lower, more conservative recommended dietary effect thresholds published by other experts and regulatory agencies;
- The lowest dietary thresholds for fish and birds are between 3 and 5 µg/g Se (dw) (BC MoE 2014). A panel of Se experts recommended 5 µg/g Se (dw) as a dietary trigger for invertebrate Se (Canton et al. 2008);
- A compelling argument for a lower dietary benchmark is found in an Elk Valley study on spotted sandpiper (Harding et al. 2005) which showed a significant decrease in hatchability at two exposed sites with mean dietary Se concentrations of 4.7 and 10.2 µg/g Se (dw). This is a reproductive effect but these birds are clearly highly sensitive. The lowest of these dietary exposure concentrations at which effects were apparent should be cause for added conservatism;
- Wayland et al. (2007) evaluated the dietary risks of Se to American dippers and Harlequin ducks downstream of a coal mine. A dietary Se exposure of 6.4 µg/g (dw) was associated with a 20% reduction in hatchability, suggesting that Golder's dietary benchmark of 15 for juvenile birds is double that found these authors; and,
- Ohlendorf (2007) reviewed several studies on mallards and recommended a dietary threshold for deformity and hatchability of 4.4 µg/g (95% CI, 3.8 – 4.8 µg/g). Although this is a reproductive dietary threshold, not specific to juveniles, it demonstrates the birds are highly sensitive to dietary Se.

3.3 Bird Reproductive Benchmarks

The reproductive bird egg tissue benchmark of 12 µg/g Se (dw) is not sufficiently conservative to protect sensitive bird species.

Evaluation:

- There is very little information to suggest that bird benchmarks will adequately protect against the risks of Se toxicity to other sensitive wildlife (amphibians, reptiles), so some consideration of this should be incorporated into the bird Se benchmarks selected;
- There is a general lack of Se toxicity information (toxicokinetics and toxicodynamics) for a broad range of birds species, so using a toxicity benchmark based on studies for only one species (mallard) is unlikely to protect the most sensitive of bird species that reside in the Elk Valley (e.g., coots and sandpiper);
- Although there is general agreement that bird egg Se is the appropriate measure for a reproductive bird benchmark, there is disagreement on whether the general egg Se toxicity effect concentration should be 12 µg/g (dw) or should be a more conservative 6 µg/g (dw).

- Based on the uncertainties related to derivation and application of a non-conservative bird benchmark in the range of 12 µg/g, BC MoE (2014) adopted a more conservative guideline of 6 µg/g, which was consistent with recommendations from Skorupa (1998) and Seiler et al. (2003) and aligned with trigger values adopted by the State of Utah that were indentified in Footnote 14 for the Great Salt Lake;
- A compelling line of evidence for a lower egg Se benchmark can be found in an Elk Valley bird study by Harding et al (2005). These authors found a that spotted sandpiper at exposed sites had a significant 15% reduction in hatchability at a mean egg Se concentration of 7.3 µg/g (dw);

3.4 Invertebrate Growth and Reproduction Benchmark

There is far too much variability in reported invertebrate Se toxicity and far too few reliable studies to suggest a benchmark that will protect invertebrates. This should be removed from the list of benchmarks.

Evaluation:

- See the discussion presented on this in the BC MoE's technical report (2014) in Sections 7.4.3.3 and 8.4.3.1.

4.0 Are there fundamental flaws in the suite of bioaccumulation models that were used to establish WQ benchmarks?

The bioaccumulation models developed by Golder have many uncertainties which translate into water quality benchmarks that are extremely under protective which raises serious concerns about the usefulness of these models.

Supporting Information: The following information is provided to provide the rationale for the above statement:

- The model includes a patch-work of Se data collected over 15 years, sometimes employing very different collection methods which increases the data variability and uncertainty of the final model equations;
- Annual average water Se concentrations were paired with Se tissue data collected once or twice at a similar sites and similar years. The lack of truly paired water and tissue data imparts great uncertainty to the model predictions;
- Average water Se data used in the model should address seasonal variability and seasonally important Se exposure periods (i.e., 30-day Se concentrations in the month up to spawning or egg laying in fish and birds);
- There is weak evidence to support pooling lotic and lentic periphyton models due to the high variability (reflected as weak r^2 values in the water to periphyton Se, and water to invertebrate Se relationships), different slopes and the small number of sample sizes in lentic areas. Common scientific knowledge about the differences in Se accumulation

dynamics in lotic and lentic areas would preclude combining these models due to the high data variability and resulting uncertainty in related model outputs.

- Combining species-specific bioaccumulation data for fish and birds models is contrary to our scientific understanding of the variability and species-specific differences in Se uptake and response;
- The water to invertebrate model represents average Se concentrations for several taxa. However, invertebrate Se concentrations among invertebrate taxa are *highly variable* due to area- (lotic versus lentic), season- and species-specific differences. This adds uncertainty to the model predictions;
- The model assumes steady-state equilibrium in Se concentrations in environmental compartments, but Se concentrations in water are increasing 10% annually (Orr et al. 2006 and 2012). This violates the model assumption of steady-state [Se] and could result in model predictions underestimating real conditions;
- Was all fish data included in the model or was the data set censored? In previous versions of the model, 23 fish egg tissue Se data points considered outliers by Golder, were removed from the analysis. Golder suggested these fish, although caught in lotic waters (Nautilus 2009), reflected lentic bioaccumulation conditions. These lotic data should be included in the model since they reflect the range of Se exposure related to WCT movement between lotic and lentic environments;
- Comparison of actual and predicted values shows the WCT BAF model (Golder 2010) under-predicted Se, particularly as Se concentrations increase, which increases the uncertainty of the water Se benchmarks and targets. Is this still the case?;
- The parabolic nature of the 95% confidence intervals for all models suggests higher uncertainty as Se increases;
- Incorporating an assumption that Se bioaccumulation in fish be based on the proportion of lentic:lotic areas in the watershed is overly simplistic. McPhail (2007) and Hagen (1993) suggest that adult WCT prefer slow moving water (velocities < 0.01 m/s) and sloughs (standing water) disproportionately, likely because they are more productive. WCT also appear to use groundwater fed pools to overwinter (McPhail 2007). A more realistic approach to estimating fish habitat use of lentic versus lotic environments is necessary based on a full examination of existing literature;
- The impacts of groundwater Se contamination on surface water are a component that has not been researched nor factored into the bioaccumulation models. This aspect could be important in understanding Se exposure, for example to over-wintering WCT adults and juveniles (see above);
- In previous iterations of the model (Golder 2010), bioaccumulation predictions were for average size (350 mm) WCT. However, the model showed that at the same water concentrations, small size (200 mm) fish accumulated more Se than larger ones. At the time, the BAF model predicted that at 2 µg/L water Se, 11 % of small size fish would have egg Se concentrations above 20 µg/g dw; at 5, 10 and 30 µg/L Se in water, those percentages increased to 23, 36 and 62 % of fish over the toxicity threshold, respectively. This demonstrates the high risk of reproductive effects at water concentrations above 2 µg/L. Since approximately half of the WCT population are in the ≤ 200 mm size (A. deBruyn, pers. comm. Feb 26, 2013), the benchmarks of 43 and 17

µg/L are very likely to result in significant reproductive impairment and severe reductions in WCT populations.

5.0 Would WQ targets based on tissue concentrations rather than water concentrations result in thresholds that are less uncertain and more protective?

Conservative tissue-based targets would be more scientifically defensible and provide a greater level of protection because they are a far more direct measure of Se effects and therefore carry much greater certainty.

Supporting Information: The following information is provided to provide the rationale for the above statement:

- The BC MoE incorporated tissue Se guidelines since the consensus of scientific opinion suggested that internal tissue Se concentrations were the most direct measure of Se effects in an organism. Recently, the states of Utah and Kentucky, and the US EPA have all chosen to make tissue-based criteria (egg Se in birds and/or fish, and whole-body Se in fish) the primary measure of the criteria. This is also consistent with existing scientific opinion regarding the measurement of Se effects. BC MoE Se tissue guidelines are lower than the critical effect sizes used by Golder to estimate water column benchmarks.
- Both BC MoE (2014) and the US EPA's (2014) recently released draft Se criteria have included water column guidelines or criteria for lotic and lentic waters but in both cases these are included as secondary values. The water column benchmarks proposed by Golder are <u>many</u> times higher than WQGs published by BC MoE, CCME and the recently released draft US EPA (2014) water criteria, which leaves serious doubts that the Golder benchmarks are going to protect sensitive aquatic life.

6. Are there other ways to establish site-specific benchmarks for selenium that have lower uncertainty than those proposed by Teck?

Adoption of BC's WQGs for Se is the most appropriate approach because the guidelines incorporated such a review, were tailored specifically for BC and much of the data from the Elk Valley were used to rationalise the guidelines. A review of regulatory guidelines and criteria for Se would result in tissue- and/or water-based benchmarks would prove to be more scientifically defensible, conservative and ensure a higher degree of protection.

Supporting Information: The following information is provided to provide the rationale for the above statement:

- BC MoE (2014) compared the Se WQGs with a general linear bioaccumulation model for water to WCT egg Se in lentic environments (r^2 = 0.75) that had been developed by Golder (2010). Using the average egg EC10 for WCT larval survival (21 µg/g) the model equation generated a water Se concentration of 2.2 µg/L. This comparison suggested that the WQG of 2.0 µg/L was not overly conservative and the maximum water Se concentration to ensure protection of lentic fish over the long term might be closer to 1 µg/L (hence the alert concentration water quality guideline for sensitive environments);

- The US EPA (2014) conducted a similar review and trophic-level analysis of data collected across the US and derived an updated set of Se criteria. They recommended a primary tissue-based chronic criterion for Se in fish egg/ovary which recognizes the current scientific consensus regarding the appropriateness of a tissue-base value. For ease of implementation, they also recommended muscle and whole-body tissue Se criteria, and 30-day average water criteria for lentic and lotic systems. Note: These criteria are derived differently than BC's WQGs so are expected to protect 95% of sensitive aquatic organisms.

7.0 Recommendations

The following advice and rationale are provided to address uncertainties related to the selenium water quality benchmarks.

Advice: Adopt BC MoE's tissue Se guidelines as long-term benchmarks and targets for the EVWQP is the most appropriate approach to protect aquatic organisms. Adoption of BC MoE's Se WQGs for other media (water, sediment, dietary) could be helpful in an adaptive management framework to protect unimpacted areas and serve as long-term assessment goals in impacted areas of the Elk Valley where mitigative measures are undertaken.

Rationale:

- WQGs are far more conservative, account for multiple sources of uncertainty and are aligned with recommended Se toxicity thresholds, criteria and benchmarks published by other regulatory jurisdictions.
- Although dietary tissue benchmarks for juvenile fish and birds is not recommended (because diet is not a direct measure of toxicity), if dietary benchmarks are adopted they should be consistent with BC's WQG. The implementation of dietary benchmarks should be part of an adaptive management framework to provide an early alert in management units where new mining activities may pose a risk to sensitive organisms.

Advice: The impacts of coal mining on groundwater and the groundwater-surface water interface should be investigated and that assessment incorporated into the overall assessment, management and mitigation of impacts to the Elk Valley.

Rationale:

- This is one large unknown and deficiency in the overall monitoring and mitigation plan.

Advice: A comprehensive quantitative assessment of cumulative impacts from coal mining to aquatic life should be developed for the Elk Valley that incorporates additional studies on a wider range of resident fish, bird and amphibian species.

Rationale:

- The assessment of interactive effects is qualitative and too subjective. There is a lack of quantitative information on the cumulative effects on a wide range of species exposed to effluents and habitat disturbance from coal mining.

Here's hoping that this supplemental advice is useful to you and the rest of the Technical Advisory Committee.

Sincerely,

Julia Beatty, R.P.Bio., P.Ag.
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Elk Valley Water Quality Plan:
Recommended Water Quality Targets for Selenium for Lake Koocanusa

1.0 Introduction

Ministerial Order Number M113 requires Teck Coal Limited (Teck) to develop an area-based management plan for the Elk Valley, British Columbia, (i.e., Elk Valley Water Quality Plan; EVWQP). The plan is intended to describe environmental management objectives and associated management actions that will:

- Protect aquatic ecosystem health;
- Manage the bioaccumulation of selenium, cadmium, nitrate, and sulphate in the receiving environment (including fish tissue);
- Protect human health; and,
- Protect groundwater.

To achieve these environmental management objectives, Teck needs to immediately establish short-term concentration targets and time-frames that result in the stabilization of water quality concentrations for four chemicals of potential concern (COPCs), including selenium, cadmium, nitrate, and sulphate. In addition, Teck needs to establish long-term concentration targets and time-frames for selenium, cadmium, nitrate, and sulphate that consider, at a minimum:

- Current concentrations of these COPCs;
- Current and emerging economically-achievable treatment technologies;
- Sustainable balancing of environmental, economic, and social costs and benefits;
- Current and emerging science regarding the fate and effects of these COPCs; and,
- Site-specific water quality objectives for these COPCs, as well as narrative objectives to guide calcite management.

The Ministerial Order also indicates that the long-term concentration targets for selenium will include a concentration target for selenium of 2 µg/L in Lake Koocanusa south of the mouth of the Elk River (LK2). While such a target for selenium in water may be consistent with the B.C. water quality guidelines for selenium (Beatty and Russo 2012), there is considerable uncertainty regarding the level of protection that the concentration target of 2 µg/L affords aquatic organisms, human consumers and aquatic-dependent wildlife utilizing habitats within and in the vicinity of Lake Koocanusa. This memorandum was prepared to provide recommendations for establishing interim targets for selenium in Lake Koocanusa and a strategy for their refinement as the necessary data and information become available.

2.0 Background of the Establishment of Targets for Selenium in Lake Koocanusa

There are a number of factors that need to be considered during the establishment of targets for selenium in Lake Koocanusa. For example, the Ministerial Order indicates that the EVWQP must include a concentration target for total selenium of 2 µg/L [which is the B.C. water quality guideline (WQG) for selenium in water. The WQG is a long-term guideline; attainment of the WQG is evaluated using the results of five sampling events conducted within a 30-day period, with water samples collected roughly every seven days; Beatty and Russo (2012)]. While the WQG for selenium in water is intended to be broadly protective of aquatic organisms and aquatic-dependent wildlife in the province, B.C. Ministry of the Environment (BCMOE) recognized that very sensitive environments and/or species may be at risk when selenium levels are below the WQG in water (Beatty and Russo 2012). For this reason, an Alert Concentration of 1 µg/L was also established under the B.C. WQGs. If the Alert Concentration is exceeded in water, then a series of actions should be triggered as part of an adaptive management approach to evaluate and, if necessary, mitigate the bioaccumulation and adverse effects of selenium. Such actions may include generating further information on food web selenium bioaccumulation, evaluation of potential risks to sensitive organisms associated with exposure to selenium, and/or mitigation to reduce releases of selenium into the receiving environment. Average concentrations of selenium in Lake Koocanusa have already exceeded the Alert Concentration and are trending towards the WQG for selenium in water (absent of future mitigation measures). The B.C. WQGs also include a guideline of 4.0 mg/kg DW for benthic invertebrate tissues, fish whole body, and fish muscle (interim) and a guideline of 11.0 mg/kg DW for fish eggs/ovaries.

Recently, the USEPA (2014) released draft aquatic life ambient water quality criteria (WQC) for selenium - freshwater. These criteria, which are currently under peer review, indicate that monthly average selenium concentrations should remain below 1.3 µg/L in lentic systems to avoid adverse effects on aquatic organisms. The draft WQC also include tissue residue values that should not be exceeded to protect aquatic life, including criteria of 15.2 mg/kg dry weight (DW) for selenium in fish eggs or ovaries, 8.2 mg/kg DW for selenium in fish whole body, and 11.8 mg/kg for fish muscle (skinless, boneless filet). The criterion for selenium in fish eggs and ovaries overrides the criteria for fish whole body, fish muscle, or water when such data are available. Such criteria provide additional perspective for target setting in Lake Koocanusa.

3.0 Development of Water Quality Targets and Targets for Fish and Invertebrate Tissues

Monthly average concentrations of selenium in surface water within Lake Koocanusa are currently on the order of 1.1 to 1.3 µg/L (Reference). Based on the language contained in the Ministerial Order and the Terms of Reference for the EVWQP, it would seem reasonable to establish short-term water quality targets for selenium in Lake Koocanusa that are consistent with current levels of selenium in the lake (i.e., 1.1 to 1.3 µg/L to stabilize water quality concentrations for selenium). However, in recognition of the time that is required to implement the proposed mitigation options, KNC and others can support the concept of establishing an ***interim short-term water quality target of 2 µg/L***, provided that the following conditions are met:

- The interim short-term water quality targets (including fish and invertebrate tissue targets) remain in effect for a period of no more than 8 years (i.e., until December 31, 2022);
- An interim short-term target of 4.0 mg/kg DW be established for benthic invertebrate tissues in Lake Koocanusa, which represents the mean concentration of a least three composite benthic invertebrate tissue samples collected near the edge of the initial dilution zone defined as the point measured from the mouth of Elk River that coincides with 10% of the volume of Lake Koocanusa;
- An interim short-term target of 7.0 mg/kg DW be established for fish whole-body tissues in Lake Koocanusa (based on mean whole-body concentrations in Westslope cutthroat trout in Lake Koocanusa), which represents the mean concentration of at least five tissues samples collected near the edge of the initial dilution zone defined as the point measured from the mouth of Elk River that coincides with 1% of the volume of Lake Koocanusa;
- An interim short-term target of 5.0 mg/kg DW be established for fish muscle tissues in Lake Koocanusa (based on mean muscle concentrations in Westslope cutthroat trout in Lake Koocanusa), which represents the mean concentration of at least five tissues samples collected near the edge of the initial dilution zone defined as the point measured from the mouth of Elk River that coincides with 1% of the volume of Lake Koocanusa;

- An interim short-term target of 15.2 mg/kg DW be established for fish eggs/ovaries in Lake Koocanusa, which represents the mean concentration of a least five samples collected near the edge of the initial dilution zone defined as the point measured from the mouth of Elk River that coincides with 1% of the volume of Lake Koocanusa;
- A Lake Koocanusa-specific bioaccumulation model be developed using robust data and information on the exposure of aquatic organisms (i.e., periphyton, zooplankton/benthic invertebrates, fish) to water-borne selenium and on the concentrations of selenium in ecosystem components; and,
- Additional studies be conducted to evaluate the effects of selenium bioaccumulation (i.e., accumulation in ovaries and eggs) on peamouth chub, burbot, and bull trout.

The long-term objectives for water-borne and tissue associated selenium shall not exceed the short-term interim targets defined above. The long-term targets will be revised after three years (i.e., by December 31, 2017), once the results of site-specific studies for Lake Koocanusa once they are completed. Such revised targets for selenium in Lake Koocanusa have been included in the EMA permits for each of the operating coal mines in the Elk Valley.

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