Appendix 22-B

Addendum to HHERA: Supplementary Assessment of Selenium Bioaccumulation Risk to Fish

AECOM

AECOM Canada Ltd.
415 Gorge Road East
Suite 200
Victoria, BC V8T 2W1
Canada

T: 250.475.6355
F: 250.475.6388
aecom.com

May 31 2023

Our Reference
60590462

Karyn Lewis
Manager Regulatory Affairs
Crown Mountain Coking Coal Project

Addendum to HHERA: Supplementary Assessment of Selenium Bioaccumulation Risk to Fish

Dear Ms. Lewis

Subsequent to the submission of the Crown Mountain Environmental Impact Statement documents to the Impact Assessment Agency of Canada (IAAC), a specific information request relative to the Human and Ecological Health and the Fish and Fish Habitat Assessment chapters and the assessment of bioaccumulative substances was received. AECOM provided additional analysis of the potential for bioaccumulative effects to fish health in a written response provided February 3, 2023. Subsequent to this, the IAAC requested additional information specifically related to selenium bioaccumulation and the toxicological benchmarks used in the Detailed Environmental Risk Assessment (AECOM, 2021).

Specifically, the IAAC requested that AECOM provide information related to the following:

1. *The EIS Guidelines state that the aquatic ecosystem includes the following fish species: westslope cutthroat trout, bull trout, burbot, and mountain whitefish. Provide the information requested for each species, or provide a justification with a clear scientific rationale as to why one species may be used as a proxy for another, taking into account the potential unique characteristics of the different life stages of each species. The Agency further notes that the EVWQP derives from a provincial order. No federal departments were signatories to the plan nor do they participate in its Technical Advisory Committee. Any information that originated as part of that process needs to be stated in the EIS including supporting rationale since federal departments are likely unaware of that information.*
2. *The Agency requires details on the model equations, inputs, assumptions and validation used in the bioaccumulation model in order to conduct a technical review of the information presented by the Proponent.*

This technical letter report provides additional information relative to each of these identified items and will form an addendum to the Detailed Quantitative Environmental Risk Assessment, prepared by AECOM Canada Ltd. for NWP Coal Canada Ltd. (dated November 2021).

1. Selenium Bioaccumulation Model

Uptake of aqueous selenium by microbes and algae result in an increase in selenium concentrations from parts per billion (ug/L) to parts per million (mg/kg, expressed on a dry weight basis) in organic matter at the base of the food web. Once taken up into particulate organic matter, selenium is available for transfer to primary consumers such as aquatic invertebrates. Higher trophic level taxa, such as fish and birds, accumulate selenium from their aquatic diets and transfer this selenium to their offspring during egg provisioning. The overall outcome of the process described above is that tissue concentrations at all trophic levels in the aquatic food-web are related to aqueous selenium concentration, although not in a fixed proportion, and that the bioaccumulation of selenium can be described as a function of the concentration of selenium at each successive trophic level.

The Elk Valley selenium bioaccumulation model considered various modelling approaches available, but ultimately a multi-step framework as suggested by Orr et al. (2012), whereby each successive step in the bioaccumulation process (i.e. water-to-periphyton, periphyton-to-invertebrates, and invertebrates-to-fish eggs) is modelled independently was selected as the preferred approach. The following presents a detailed summary of the steps used to derive the Elk Valley Selenium Bioaccumulation Model, as presented in the Teck (2014) Area-Based Management Plan[1] .

1.1 Data Compilation

The bioaccumulation models presented in the Elk Valley Water Quality Plan are based on empirical measurements of selenium concentration in water, periphyton, aquatic invertebrates, and fish eggs compiled from 21 biological sampling programs conducted in the Elk Valley over approximately two decades. Compiled data were evaluated for their reliability and relevance for use in deriving selenium bioaccumulation models, and tissue selenium concentrations were then paired with aqueous selenium concentrations and between adjacent trophic levels (i.e. invertebrate data were paired with periphyton data, and vertebrate data (fish eggs) were paired with invertebrate data). Tables of paired data used to develop the bioaccumulation models are included in Annex E of the Elk Valley Area Based Management Plan.

1.2 Model Derivation

The multi-step model was derived as a series of component equations describing the bioaccumulation of selenium from water to periphyton, from periphyton to invertebrates, and from invertebrates to fish egg. For each of these component equations analyses were carried out to guide selection of appropriate data, selection of appropriate model structure, and evaluate model performance.

The primary statistical tools for model development were ordinary least squares (OLS) regression and mixed effects models. Following the initial fit of the log-linear form of the regression models, residuals were inspected to determine whether an alternative model form may be warranted. In cases where residuals exhibited an apparent structured pattern an alternative model was evaluated. Where an alternative model was determined to be warranted, the preferred alternative was a piecewise model. Because selenium is physiologically regulated it has been hypothesized that organisms are capable of maintaining homeostasis over a range of environmental or dietary selenium concentrations. However, when exposure concentrations increase past a certain threshold, the organism’s capacity to maintain homeostasis may be overwhelmed. This would produce a bioaccumulation model whereby the slope of the model would be relatively shallow up to a break point, at which point the slope would increase.

Goodness of fit and reliability of derived models were assessed based on inspection of model diagnostic plots. Final models were evaluated to assess sensitivity to decisions made during model development, including data selection and selection of modelling techniques and model forms.

1.2.1 Water-to-Periphyton

The component equation describing water to periphyton was derived based on 126 paired observations included in the dataset with an even distribution across aqueous selenium concentrations ranging from 0.1 to 328 ug/L. The dataset included 66 samples collected from lotic habitats and 60 samples collected from lentic habitats.

Analysis of covariance (ANCOVA) identified no statistically significant effect of habitat type on the slope (p=0.82) or intercept (p=0.26) of the relationship between periphyton selenium concentration and aqueous selenium concentration. Visual observation indicated a similar pattern of selenium uptake for the two habitats. Therefore, lentic and lotic periphyton data were combined into a single model.

Model diagnostics of the log-linear model identified that an alternative model was warranted. The final model for periphyton was a piecewise fit model based on the combined lentic and lotic datasets (Figure 1). The bioaccumulation models presented in Golder (2014) are considered representative of the bioaccumulative behaviour of selenium in the Fish and Fish Habitat local study area (LSA) and regional study area (RSA).

---

[1] The Elk Valley Area Based Management Plan and associated documentation is available from: Area Based Management Plan - Province of British Columbia (gov.bc.ca)

The fitted model relating periphyton selenium concentration ([Se]peri; mg/kg dw) to aqueous selenium concentration ([Se]aq; ug/L) is:

$$\log_{10}[Se]_{peri} = 0.220 + 0.125 \times \log_{10}[Se]_{aq} \quad for\ [Se]_{aq} < 10.5\ \mu g/L$$

$$\log_{10}[Se]_{peri} = -0.163 + 0.501 \times \log_{10}[Se]_{aq} \quad for\ [Se]_{aq} \geq 10.5\ \mu g/L$$

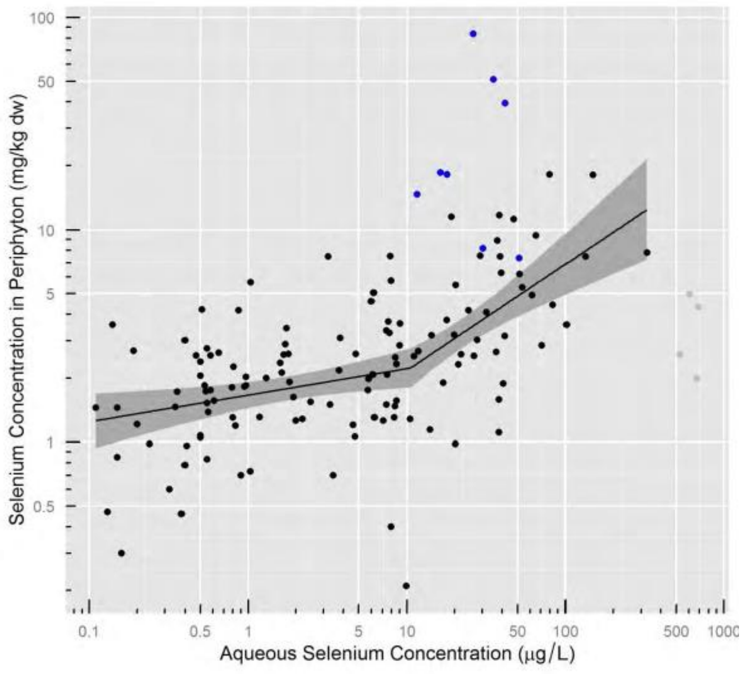

Figure 1: Final Periphyton Model (Line) and Confidence Interval (Shaded)[2]. Reproduced from Teck, 2014.

1.2.2 Periphyton to Invertebrates

The component equation describing bioaccumulation from periphyton to aquatic invertebrates was derived based on 134 data pairs representing 134 distinct periphyton selenium concentrations ranging from <0.1 to 65.3 mg/kg dw, although the majority were between 0.2 and 20 mg/kg dw. The dataset included 71 samples collected from lotic habitats and 63 samples collected from lentic habitats.

ANCOVA identified no statistically significant effect of habitat type on the slope (p=0.26) or intercept (p=0.90) of the relationship between periphyton selenium concentration and aqueous selenium concentration. Visual observation indicated a similar pattern of selenium uptake for the two habitats. Therefore, lentic and lotic periphyton data were combined into a single model.

OLS regression was used to fit a statistically significant log-linear model to the combined lentic and lotic invertebrate dataset. Evaluation of the model residuals identified no apparent residual structure.

---

[2] Blue dots in Figure 1 represent periphyton data from specific locations (i.e., Clode Pond, Goddard Marsh and a portion of the Fording River Oxbow) that were identified, through discussion with the Technical Working Group, to reflect a distinct pattern of selenium bioaccumulation into the base of the food chain that is not reflected in the remainder of the available lentic and lotic periphyton dataset. These data were not included in the current bioaccumulation model, as per TWG recommendation, because the models were developed to describe the prevailing selenium bioaccumulation pattern that occurs in the majority of aquatic habitats in the Elk Valley.

The final model for invertebrates was a log-linear fit to the combined lentic and lotic dataset (Figure 2). The fitted model relating aquatic invertebrate tissue selenium concentration ([Se]inv; mg/kg dw) to periphyton tissue selenium concentration ([Se]peri; mg/kg dw) is:

$$\log_{10}[Se]_{inv} = 0.658 + 0.456 \times \log_{10}[Se]_{peri}$$

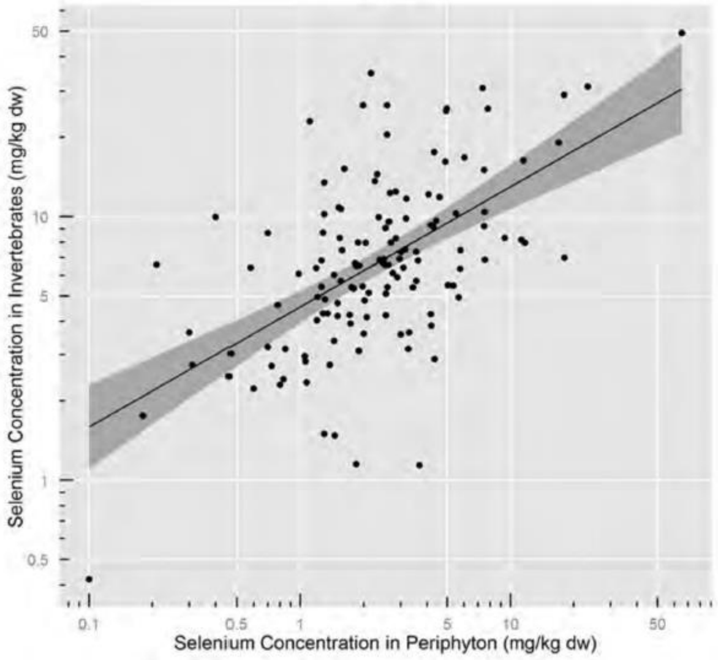

Figure 2: Final Invertebrate Model (Line) and Confidence Interval (Shaded). Reproduced from Teck, 2014.

1.2.3 Invertebrates to Fish (WCT) Eggs

Fish species with sufficient data for potential model development were Westslope Cutthroat Trout (WCT) and longnose sucker. ANCOVA identified a statistically significant effect of species on the slope ($p=0.02$) and intercept ($p=0.01$) of the relationship between egg selenium concentration and invertebrate selenium concentration. Visual comparison indicated that a generally similar pattern of bioaccumulation exists between the two species, with longnose sucker generally exhibiting lower concentrations of egg selenium at a given invertebrate selenium concentration. Therefore, the fish bioaccumulation component model was derived using data for WCT.

The component equation describing bioaccumulation from aquatic invertebrates to Westslope cutthroat trout eggs was derived based on 176 data pairs, representing 33 sampling events with invertebrate selenium concentrations ranging from 3.1 to 49.2 mg/kg dw. There was a gap in the distribution of invertebrate selenium with relatively few observations between 10 and 30 mg/kg dw. The dataset included 98 samples collected from lotic habitats and 88 samples collected from lentic habitats.

Model diagnostics of the log-linear model identified that an alternative model was warranted. The final model for WCT eggs was a piecewise mixed effects model using the combined lentic and lotic datasets (Figure 3). The fitted model relating WCT egg selenium concentration ([Se]egg; mg/kg dw) to aquatic invertebrate tissue concentration ([Se]inv; ug/L) is:

$$\log_{10}[Se]_{egg} = 1.02 + 0.026 \times \log_{10}[Se]_{inv} \quad for\ [Se]_{inv} < 6.8\, mg/kg\ dw$$

$$\log_{10}[Se]_{egg} = 0.126 + 1.10 \times \log_{10}[Se]_{inv} \quad for\ [Se]_{inv} \geq 6.8\, mg/kg\ dw$$

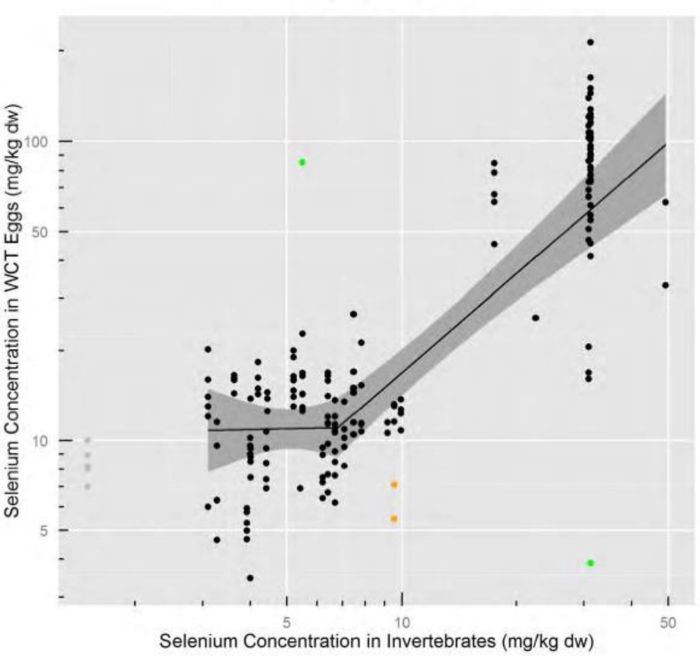

Figure 3: Final Westslope Cutthroat Trout Model (Line) and Confidence Interval (Shaded), reproduced from Teck (2014).

2. Selenium Toxicity Benchmarks

Selenium is a naturally occurring chemical element that is also an essential micronutrient. Trace amounts of selenium are required for normal cellular function in almost all animals. However, excessive amounts of selenium can also have toxic effects, with selenium being one of the most toxic of the biologically essential elements (Chapman et al. 2010). Egg-laying vertebrates have a lower tolerance than do mammals, and the transition from levels of selenium that are biologically essential to those that are toxic occurs across a relatively narrow range of exposure concentrations (Chapman et al. 2009, 2010). The most well-documented, overt, and severe toxic effects of selenium in fish are reproductive teratogenesis and larval mortality (US EPA, 2016). Egg-laying vertebrates appear to be the most sensitive taxa, with toxicity resulting from maternal transfer to eggs. As such, it is desirable to consider fish egg selenium benchmarks for the assessment of potential effects to fish health.

2.1 Aqueous Selenium Benchmarks Included in the HHERA

Potential reproductive effects to fish were assessed in the HHERA based on aqueous selenium benchmarks derived as part of the benchmark definition in support of the Area Based Management Plan (Teck, 2014). The benchmark considered in the HHERA was based on a 10% total reproductive effects level, for the most sensitive species tested. The aqueous benchmarks were derived by determining the aqueous concentration at which modelled dietary selenium concentrations reach the dietary benchmarks associated with a 10% reproductive effect. This is considered appropriate as the majority of selenium exposure is associated with dietary intake, and reproductive effects are associated with fish egg selenium concentration established during egg provisioning.

For WCT, the most restrictive effects curve was calculated using the two-step bioaccumulation model (Teck, 2014), resulting in a modelled Level 1 (10%) reproductive effect level at an aqueous selenium concentration of 70 ug/L. The 95% upper prediction limit (UPL95) of potential effect at this aqueous selenium concentration was 13%. For brown trout, the most sensitive species tested, the most restrictive effects curve was also established using the two-step model. The calculated aqueous selenium concentration required to predict a 10% reproductive effect was 19 ug/L, with a UPL95 of 14%.

This value (19 ug/L) was carried forward as the aqueous selenium benchmark protective of fish reproductive health in the HHERA, as it is anticipated to be protective of not only WCT, but other sensitive fish species in the LSA. The use of the most sensitive species in risk assessment is a well established and conservative practice and is considered to be protective of the ecological endpoint being assessed for most (95%), if not all species present.

2.2 Fish Egg Selenium Benchmarks

As part of the current additional assessment, AECOM have also considered fish egg tissue benchmarks protective of fish populations. When a fish's dietary selenium concentration becomes elevated above background levels, an elevated level of selenium is transferred into eggs, primarily the yolk, resulting in the exposure of developing embryos and fry to selenium (Janz et al. 2010). Consequently, one of the most sensitive indicators of selenium toxicity is deformity or mortality in embryo-larval stages of fish development and egg selenium concentrations represent the most toxicologically relevant exposure for reproductive effects (Janz et al. 2010). Fish egg selenium concentrations protective of sensitive fish populations have been derived by others in the past and are described below.

2.2.1 DeForest et al. (2011)

The authors[3] derived a fish egg selenium tissue benchmark with a focus on Canadian species following Canadian Council of Ministers of the Environment (CCME) benchmark derivation protocols, employing a species sensitivity distribution (SSD) approach, following the collection and assessment of input data quality. DeForest (2011) includes toxicity thresholds based on egg selenium concentration for 12 freshwater species. Endpoints included in the toxicity studies include hatchability, swim-up, alevin mortality, larval deformities, and edema. SSDs were developed based on species mean toxicity thresholds. The SSD was established using the best-fitting distribution to the log-transformed selenium toxicity threshold data. The CCME approach suggests that where adequate data is available, as is the case here, that the 5th percentile of the SSD be identified as the tissue benchmark. DeForest et al. (2011) calculate a fish egg selenium concentration benchmark of 20 mg/kg dw based on the CCME SSD approach.

2.2.2 Elk Valley Water Quality Plan (Golder, 2014)

Fish egg selenium toxicity studies were also used to develop a fish egg tissue benchmark protective of fish populations as part of the development of the Elk Valley Water Quality Plan[1]. The derived egg selenium concentration benchmarks were based on compiled toxicity data from 15 primary studies and an additional 11 secondary studies. The compiled dataset includes 14 species and presents selenium concentration and corresponding effect level for the embryo-larval survival, presence of deformity, and edema endpoints. The range of selenium concentration, and associated effects endpoints are presented in Figure 4. The EVWQP derived a Level-1 (i.e. <10% effects level) egg selenium concentration benchmark of 18 mg/kg dw, which is equal to the lowest EC_{10} or LOEC values reported in all primary studies, and for all but one of the secondary studies.

The secondary study, reported to have a lower EC10 for edema, was limited to testing only the control and high exposure ([Se]aq = 10 ug/L) scenario[4]. The magnitude of response for edema at the 10 ug/L treatment was high (100%); however, the variance of response within the treatment group was >100%, resulting in a high degree of uncertainty. As a follow-up study, Bluegill sunfish were exposed to control water, 2.5 ug /L selenium treatment, and 10 ug/L selenium treatment for a period of 35 weeks prior to spawning, with each treatment conducted in duplicate[5]. Ovary selenium concentrations were 5.1 and 5.2 mg/kg dw in control streams, 12.1 and 22.4 mg/kg dw in 2.5 µg/L streams and 54 and 84 mg/kg dw in 10 µg/L streams. Larval edema was elevated in fry originating from the 2.5 µg/L treatment, although magnitude of effect was only 2.8% compared with the control. The LOEC for edema and lordosis was 22.4 mg/kg dw, which is in closer agreement to other studies that reported edema endpoint data.

---

[3] DeForest, D.k., G. Gilron, S. A. Armstrong, and E. L. Robertson. 2011. Species Sensitivity Distribution Evaluation for Selenium in Fish Eggs: Considerations for Development of a Canadian Tissue-Based Guideline. Integr. Environ. Assess. Manag. 8(1): 6–12

[4] Hermanutz, R.O. 1992. Malformation of the fathead minnow (*Pimephales promelas*) in an ecosystem with elevated selenium concentrations. Bull. Environ. Contam. Toxicol. 49(2):290-294.

[5] Hermanutz, R.O., K.N. Allen, N.E. Detenbeck and C.E. Stephan. 1996. Exposure to bluegill (Lepomis macrochirus) to selenium in outdoor experimental streams. U.S. EPA Report. Mid-Continent Ecology Division. Duluth, MN

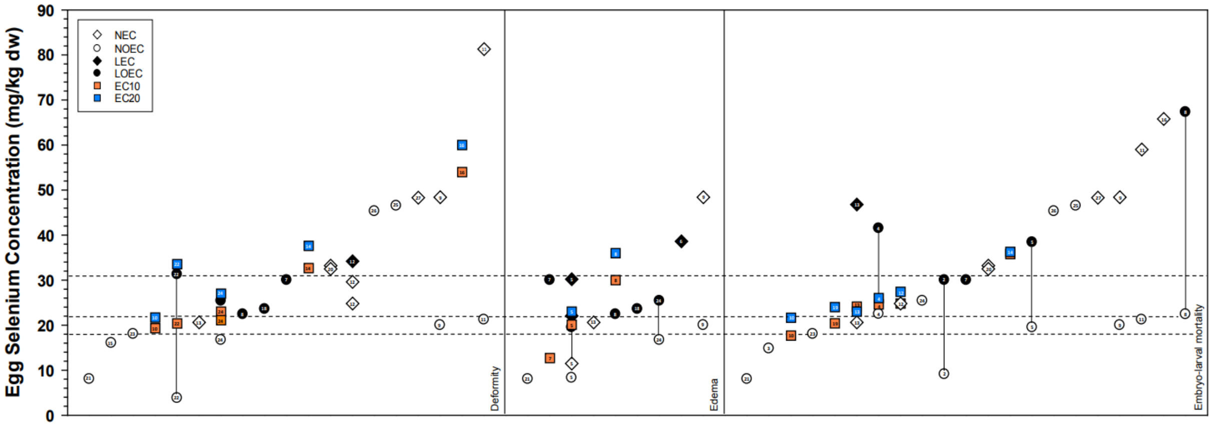

Figure 4: Egg selenium Concentration and corresponding Effect on Fish Reproduction[6] (Reproduced from Teck, 2014; Annex E)

2.2.3 US EPA 2016 Aquatic Life Ambient Water Quality Criteria for Selenium – Freshwater 2016

More recently the US EPA[7] has conducted a review of available fish egg selenium toxicity data and established a fish egg selenium benchmark protective of fish populations. The toxicity studies relevant to the derivation of the fish tissue selenium criterion elements involve (a) extended duration dietary exposure, and (b) measurement of total selenium in the tissue of the target organism. Selenium accumulation in the eggs of the exposed adult female prior to spawning has been shown to yield the most robust relationship (statistically significant) with occurrence of deformities and reduced survival of the offspring. Chronic toxicity studies (both laboratory and field studies) were screened to ensure they contained the relevant chronic exposure conditions of selenium to aquatic organisms (i.e., dietary, or dietary and waterborne selenium exposure), measurement of chronic effects, and measurement of selenium in tissue(s). The criterion derivation uses only those studies in which test organisms were exposed to selenium in their diet, because such studies most closely replicate real-world exposures (diet and/or diet plus water).

Egg-ovary Species Mean Chronic Values (SMCVs) were calculated from the chronic values (EC10s and occasionally NOECs) obtained from the relevant toxicity tests (Table 1). Genus Mean Chronic Values (GMCVs) were calculated from the SMCVs and then rank-ordered from least to most sensitive (Table 1). The egg-ovary Final Chronic Value (FCV) was calculated from regression analysis of the four most sensitive GMCVs, in this case extrapolating to the 5th percentile of the distribution represented by the tested genera. The four lowest egg-ovary Genus Mean Chronic Values (GMCVs) are all based solely on EC$_{10}$ endpoints and are considered adequately protective. The FCV directly serves as the fish tissue egg-ovary criterion concentration element without further adjustment because the underlying EC10s represent a low level of effect

Based on the available data, expressed as EC10 values, US EPA calculated an egg-ovary benchmark of 15.1 (mg Se/kg dw), based primarily on 17 reproductive studies representing 10 fish genera. This value is lower than the GMCV for White sturgeon, a federally listed species.

---

[6] Effects are separated for deformity, edema, and embryo-larval mortality; Dashed lines indicate effect Level 1 (<10%), Level 2 (<20%), and Level 3 (>25% - to 50%) benchmark concentrations for sensitive fish species; Vertical solid lines represent bounded no-observed effects concentration (NOEC) and Lowest Observed Effects Concentration (LOEC) values

[7] US EPA. 2016. 2021 Revision to: Aquatic Life Ambient Water Quality Criteria for Selenium – Freshwater 2016. EPA 822-R-21-006. August 2021.

Table 1: Ranked Genus Mean Chronic Values for Fish Reproductive Effects Measured as Egg or Ovary Concentration

Rank	**GMCV** (mg Se/kg dw)	**Species**	**SMCV** (mg Se/kg dw)
8	56.2	Dolly Varden, *Salvelinus malma*	56.2
7	34**	Northern pike, *Esox lucius*	34
6	27	Desert pupfish, *Cyprinodon macularius*	27
5	26.3	Largemouth bass, *Micropterus salmoides*	26.3
4	25.3	Cutthroat trout, *Oncorhynchus clarkia*	26.2
		Rainbow Trout, *Oncorhynchus mykiss*	24.5
3	21	Brown trout, *Salmo trutta*	21.0
2	20.6	Bluegill sunfish, *Lepomis macrochirus*	20.6
1	15.6	White sturgeon, *Acipenser transmontanus*	15.6

*Notes: Table reproduced from US EPA (2016); GMCV = Genus Mean Chronic Value, SMCV = Species Mean Chronic Value; ** The northern pike SMCV is an EC24 based on larval deformities. The EC10 is less than 34 mg/kg dw.*

2.2.4 Fish-egg Selenium Benchmark Carried Forward

AECOM have carried forward the US EPA fish egg selenium benchmark of 15.1 (mg/kg dw) for further assessment of potential bioaccumulative impacts of selenium. According to fish inventories presented in Chapter 12 of the EIS documents, fish bearing reaches within the Fish and Fish Habitat LSA are populated by WCT, Bull Trout, Mountain Whitefish, and Eastern Brook Trout. The US EPA derived fish egg selenium benchmark is considered protective of the fish species present in the Fish and Fish Habitat LSA based on the following rationale:

1. The US EPA fish-egg selenium benchmark directly considers cutthroat trout in its derivation. The *Oncorhynchus* GMCV of 25.3 (mg/kg dw) is similar to the EC_{10} for WCT included in the Deforest et al. (2012) SSD derived value.
2. The US EPA benchmark considers a GMCV for the *Salvelinus* genus. The *Salvelinus* genus includes the bull trout (*Salvelinus confluentus*) and the eastern brook trout (*Salvelinus fontinalis*), an introduced species not native to freshwaters west of the Rockies.
3. The freshwater whitefish genus, which includes Mountain whitefish (*Prosopium williamsoni*) is not directly considered in the US EPA derivation, however a secondary study included in the benchmark derivation for the EVWQP assessed potential effects to mountain whitefish. This study identified a no effect concentration (NEC) of 32.5 (mg/kg dw) for the larval deformity endpoint, and 33.2 (mg/kg dw) for survival, however there is some uncertainty in this value as a result of the study not including a control group.
4. Selenium is an important physiologically regulated micronutrient has been shown to have a very steep species sensitivity distribution, with many species exhibiting a threshold of effects occurring around the 20 (mg/kg dw) concentrations range.

3. Assessment of Potential Risks to Fish

Potential risk to fish populations in the LSA as a result of selenium bioaccumulation has been assessed herein by calculating predicted fish egg selenium concentration ($[Se]_{egg}$; mg/kg dw) using the three-step bioaccumulation model and predicted aqueous selenium concentrations from the Crown Mountain Water Quality Model for the median (P50) and 95th percentile (P95) source term input scenarios, assuming the Waste Rock Dump (WRD) layering approach is successful at reducing oxidation of pyrite, thereby reducing release of sulphate, acidity, and associated trace elements including selenium.

To assess potential for bioaccumulative impacts of selenium to fish populations, AECOM have calculated predicted fish egg selenium concentrations based on the calculated maximum 30 day rolling average from the SRK Consulting Inc. (2021) Water Quality Model, using the three-step bioaccumulation model detailed above. The SRK model predicts surface water quality at model nodes described in Table 2, for the entire 34-year Project lifecycle, including construction, operation, closure, and post closure phases. Using the maximum predicted 30-day rolling average value as the chronic surface water concentration, this represents a conservative “worst-case” scenario on which to base the current assessment.

Predicted concentration of total selenium in water ([Se]aq; ug/L), and the associated predicted concentration of selenium in fish egg ([Se]egg; mg/kg dw), based on the three-step bioaccumulation model, are presented in Table 2. Predicted fish egg selenium concentrations have been compared to the US EPA (2016) benchmark of 15.1 mg/kg dw. Based on this assessment, the following conclusions can be drawn.

1. Water quality in Grave Creek upstream of the confluence with Harmer Creek is not impacted by contact or process water as a result of the proposed project. Aqueous selenium concentrations presented in Table 2 are equal to the 50th percentile and 95th percentile background concentrations used as source terms in the SRK (2021) Water Quality Model.
2. SRK (2021) concluded that predicted concentrations of selenium in the Elk River after the confluence with Michel Creek (EV_ER1) are not distinguishable from baseline conditions in the 50th percentile or 95th percentile source term scenarios, suggesting there is no measurable change in water quality in the Elk River downstream of Michel Creek as a result of the Project.
3. Water quality nodes impacted by discharge from Harmer Creek exhibit an elevated predicted concentration of selenium in fish eggs.
    a. None of the predicted fish egg concentrations of selenium in Grave Creek after the confluence with Harmer Creek exceed the fish egg concentration benchmark of 15.1 mg/kg dw.
    b. Predicted fish egg concentrations in Harmer Creek (upstream of the confluence with Grave Creek and impacted solely by activities at Teck’s Elkview Operation) are predicted to marginally exceed the US EPA egg selenium benchmark of 15.1 (mg/kg dw) but are below the egg selenium benchmark of 18 (mg/kg dw) derived in support of the Area Based Management Plan.
4. Aqueous concentrations of selenium in Alexander Creek are predicted to increase by ~125%. Predicted concentrations of selenium in fish eggs for Alexander Creek under baseline conditions (10.95 mg/kg dw) are calculated from an aqueous selenium concentration at WQM Node AC-4, which is an upstream reference located prior to the confluence with West Alexander Creek.
    a. Concentrations of selenium in fish eggs at AC-3 (located immediately after the confluence with West Alexander Creek), are predicted to increase from 10.95 to 10.96 (mg/kg dw) under the 50th percentile source term scenario, and from 10.96 to 10.98 (mg/kg dw) under the 95th percentile source term model scenario.
    b. Predicted concentration of selenium in fish eggs at WQM Nodes along Alexander Creek show a very slight increase as a result of the Project interaction; however, predicted concentrations are below the identified tissue-based toxicity reference value of 15.1 mg/kg dw protective of fish

populations. Potential effects to fish reproduction in Alexander Creek are considered to be negligible.

Table 2: Predicted Concentrations of Selenium in Surface Water ($[Se]_{aq}$; ug/L) and Fish Eggs ($[Se]_{egg}$; mg/kg dw) at Water Quality Model Nodes.

WQM Node	Description	$[Se]_{aq}$		$[Se]_{egg}$	
		P50	P95	P50	P95
GC-1	Grave Creek upstream of confluence with Elk River. Surface water influenced by discharge from Harmer Creek not associated with proposed project interaction.	17.79	24.09	12.08	13.04
GC-2	Grave Creek downstream of confluence with Harmer Creek. Surface water quality influenced by discharge from Harmer Creek not associated with proposed project interaction.	22.21	29.98	12.78	13.78
GC-3	Grave Creek upstream of confluence with Harmer Creek.	0.85	1.52	10.95	10.96
GC-4	Harmer Creek upstream of confluence with Grave Creek. Surface water quality not influenced by proposed project.	35.35	47.50	14.36	**15.47**
GC-5	Grave Creek, downstream of GCR withdrawal location.	0.85	1.52	10.95	10.96
GC-6	Grave Creek upstream of GCR withdrawal location	0.85	1.51	10.95	10.96
GC-7	Grave Creek downstream of Clean Coal Transfer Area	0.87	1.55	10.96	10.96
GC-8	Grave Creek downstream of Coal Handling Process Plant	0.85	1.51	10.95	10.96
AC-1	Alexander Creek upstream of Highway 3	1.19	2.21	10.96	10.97
AC-2	Alexander Creek mid-reach (between Highway 3 and Alexander/West Alexander Creek confluence)	1.24	2.31	10.96	10.97
AC-3	Alexander Creek downstream of confluence with West Alexander Creek	1.57	2.99	10.96	10.98
AC-4	Alexander Creek upstream of confluence with West Alexander Creek	0.85	1.51	10.95	10.96
AC-6	West Alexander Creek downstream of Main Sediment Pond Outlet.	4.79	9.56	10.98	10.99
EV_ER1	Confluence of Elk River and Michel Creek upstream of Sparwood	8.44	8.79	10.99	10.99

*Notes:**Bold** values indicate exceedance of 15.1 (mg/kg dw), the most stringent fish egg concentration benchmark identified.*

4. Closure

The bioaccumulation models used in the current supplemental assessment are considered to provide a reasonably accurate estimate of selenium uptake for the range of aquatic habitats present in the LSA, particularly where measurable changes to water quality are predicted. The fish egg selenium concentration benchmarks used are considered to be sufficiently protective of fish species in the local study area and have been derived following scientifically defensible methods.

This supplemental assessment of potential risks to fish health as a result of selenium bioaccumulation identified a negligible incremental risk due to Project interaction with surface water for both the 50th percentile and conservative 95th percentile source term scenarios used in the SRK (2021) Water Quality Model.

It is our hope that this supplemental assessment provides the necessary information to satisfy the IAAC's concerns.

Yours sincerely,

<Original signed by>

Mike Sanborn, M.Sc., R.P.Bio.
Senior Risk Assessment Specialist
AECOM Canada Ltd.
T: 250-389-3424
M: 250-634-4924
E: mike.sanborn@aecom.com