Summary Table

Category	#	Description of "Technical Advice" from Mtg	Rationale
Ecological Effects Assessment / Lake Koocanusa *Work Package #2b: Preliminary Results of the Assessment of Ecological Effects*	**B4-1**	In addition to modeling and monitoring the concentration of selenium, cadmium, nitrate, sulfate and other contaminants of concern entering Lake Koocanusa, modeled and measured monthly/annual loads entering Lake Koocanusa are also needed to begin to understand current and potential environmental impacts. Load modeling results for selected monitoring sites on the Elk and Fording Rivers will be distributed (by Montana USGS) at the April TAC meeting in the context of initial treatment capacities, selenium concentration, mine expansion, and variations in mean annual discharge.	Lake Koocanusa is a large lentic system that is currently receiving contaminant loadings from mining in the Elk and Fording River Valleys. It is possible that these contaminant loadings will continue during and after coal mining operations have ceased. Initial empirical watershed modeling results have indicated that selenium concentrations, for example, in Lake Koocanusa will not exceed 2ug/L. Little is known about the biogeochemical cycling of selenium in Lake Koocanusa and it is possible that this system may act as a selenium sink that could increase selenium uptake in biota beyond acceptable levels. Although detailed biogeochemical studies of selenium and other contaminants of concern in Lake Koocanusa are considered to be beyond the scope of the current Elk Valley Water Quality Plan, detailed information on the measured and modeled contaminant loads entering this system on monthly and annual time steps are needed to begin to understand present and long-term impacts from mining and the potential interactions between contaminant concentration/loading, reservoir volume, persistence of contaminant sinks, variability in timing of reservoir inputs, and evolving contaminant treatment capacities. In addition, trends in contaminant loads entering Lake Koocanusa will be a more meaningful metric of short- and long-term remediation success in the Elk and Fording Rivers, than simply concentration.
	B4-2	A Working Group should be established immediately to define the scope of the assessment that needs to be conducted on Lake Koocanusa. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The TAC has recommended that impacts in Lake Koocanusa be evaluated, under current conditions and under future conditions, under the EVWQP. However, a work package describing the approach that will be used to assess impacts in Lake Koocanusa will not be presented to the TAC until April, 2014. This timing will not provide the members of the TAC sufficient time to provide meaningful input on the approach. Therefore, a Working Group should be established immediately to guide the development of an approach for assessing impacts in Lake Koocanusa.
	B4-3	At a minimum the scope of the assessment of effects in Lake Koocanusa needs to include the following:	An assessment of current conditions in Lake Koocanusa is required to establish baseline conditions in the lake and to support the evaluation of future permit applications for development projects

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		1. Evaluation of ambient water quality conditions throughout the lake (including evaluation of existing water-chemistry data, surface-water toxicity data, periphyton, zooplankton, and trophic status information, and other related data and information); 2. Evaluation of ambient sediment quality conditions throughout the lake (including evaluation of existing sediment-chemistry data, sediment-toxicity data, and benthic invertebrate community structure data); 3. Evaluation of existing invertebrate-tissue chemistry, fish-tissue chemistry, and bird-egg chemistry data; 4. Evaluation of current loadings of COPCs to the lake from all sources; 5. Evaluation of the factors that are currently limiting primary productivity within the lake; and, Identification of long-term monitoring and assessment needs for confirming that loadings of COPCs to the lake are being reduced, that a water quality objective of 2 µg/L for selenium is protective of aquatic organisms and aquatic-dependent wildlife, and that inputs of nutrients are not adversely affecting the trophic status of the lake. *For additional context refer to MacDonald letter (dated February 18, 2014)*	(i.e., coal mine expansion and other developments). The results of such an assessment and future monitoring are also needed to ensure that international waters, species at risk, and First Nations interests are adequately protected.
Selenium Ecological Effects Assessment	**B4-4**	Include bull trout and white sturgeon in the Selenium Effects Assessment and overall effects monitoring for population-level impacts as well as bio-accumulation in individual fish.	Bull trout and white sturgeon are of particular cultural, historical and substance importance. Bull trout are listed as "threatened' under the U.S. Endangered Species Act (U.S. ESA) due to impaired spawning and recruitment across their range and Koocanusa Reservoir is designated as bull trout "critical habitat". White Sturgeon are listed as "endangered" under the U.S. ESA, in the Kootenai River below Libby Dam. The fact that selenium concentrations have risen for the past eight years at Creston, B.C., after the flow of the Kootenai River returns to Canada, is clear evidence of significant effect outside the regional study area.
Work Package #2b: Preliminary Results of the Assessment of	**B4-5**	Include a safety factor in the proposed benchmarks for fish and birds. Consider a more conservative (lower) value for the EC10.	An EC10 of 25 mg/kg dry weight for Westslope cutthroat is not sufficiently protective of aquatic life. A benchmark associated with 10% population lethality is a significant impact for listed species such as bull trout and Westslope cutthroat trout. Management of listed species in the U.S/MT is for EC_0 (zero take of individual

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Ecological Effects			species) and a separate permitting process is required for mortality impacts to listed species.
	B4-6	An safety/uncertainty factor should be applied to the toxicity values being used deriving water-based benchmarks from the Se modelling efforts	1) Whether the multi-step or single (BAF) model of selenium accumulation is part of the final determinations of target levels, both approaches have high levels of uncertainty. For example, each step in the multi-step approach had about 70% unattributed variance (r2 ~30%), which would introduce with confidence bounds around the final numbers. 2) The dose-response curve for Se in reproductive tissues is very steep. Moving from almost no effect to reproductive failure occurs over a narrow range of concentrations. The selected end-point is an EC10, which is not "no effect". Given the uncertainties in the model estimates and the consequences of underestimating the resulting tissue selenium burden (i.e: overestimating a safe target for Se in water), the tissue benchmark for deriving a water concentration should be less than the 25 mg/kg EC10 proposed for WCT.
	B4-7	[Assessment Methodology] To determine the population effects on a species, suggest first looking at: 1) effect levels and endpoints for COCs separately for main stem, lentic and tributaries; then 2) COCs in combination for main stem, lentic, and tributary; Then combine information from main stem, lentic, and tributary to estimate effects on population.	It is important to look at the effects from the COCs on the receptor (by themselves and in combination) for main stem, lentic and tributaries before combining water types since effects may be different for each area based on differences in COC concentrations.
	B4-8	[Assessment Methodology] More rationale is needed for determining potential effects to populations when assessing the effects within each habitat.	Critical factors would include levels of effects, endpoints, life history of the organism, indirect effect, food web dynamics, other stressors etc.
	B4-9	[Main Report] Clarify what the UPLs actually represent. Periphyton or invertebrates are composite samples. UPLs are supposed to be prediction limits reflecting <u>individual</u> values, but in many cases, the data are composite sample representing averages and so it is not clear what a UPL actually represents.	For example. Consider the equations for Step3 from invertebrates to eggs. Does the UPL represent the [Se] in individual eggs? The range of mean [Se] among fish? This has implications when these UPL are used. The legend says it is the 90th percentile of the modelled values, but what does a 90th percentile of composite averages really mean? This needs to be carefully specified. For

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			example, are the modelled concentrations for eggs in fish that of individual eggs? For birds are they for individual eggs?
	B4-10	[Appendix C] For future reports and analyses clarify what the "individual" is that is being modelled.	The term "individual" is used throughout the report however it is unclear what is being modelled. The models predict average concentrations for many individuals. The authors claim that UPL are for individuals (e.g. individual eggs in fish? The mean concentration of eggs within a fish? For individual birds? The mean concentration for a clutch of eggs?). This needs to be clarified. Prediction intervals for composite samples cannot be interpreted as representing individuals, and therefore they have no clear meaning.
	B4-11	[Appendix C] The multi-step model fails to predict the [Se] in fish when the [Se water] > 10. The authors note that a similar problem occurred for periphyton. The model does fit for lotic environments at low [Se]. Need to investigate the reasons for model failure and improve the model before using it. Compare the results of the multi-step model to the one-step model.	The multi-step model overestimates [Se in WCT] at low [Se water] and underestimates [Se in WCT] at higher [Se water] concentrations (i.e. at concentrations higher than 10).
	B4-12	[Appendix D] In future reports and analyses, use the correct terms when referring to endpoints.	ECx should not be used to refer to all effects and endpoints as suggested. A 20% effect on growth (IC20) is a very different endpoint than a LC20 (concentration that would be lethal to 20% of the organisms tested).
	B4-13	[Appendix D] In the development of ecological effects benchmarks, we recommended the use of the preference of endpoints provided in the BC and CCME protocol.	The authors are not using the order of preference provided in the BC and CCME protocols. This could have an impact on the conservatism of the proposed ecological effects benchmarks.
	B4-14	[Appendix D] For ranking and choosing studies which are used in developing ecological effects benchmarks, use the ranks (primary, secondary, unacceptable) provided by the updated BC MOE Se WQG (2014) authored by Beatty and Russo.	The authors of Appendix D are ranking studies incorrectly and are not consistent with the BC and CCME protocols. Studies that are ranked primary in this report were ranked unacceptable by the Ministry. The Ministry has already ranked the Se literature according to BC and CCME protocols.
	B4-15	[Appendix D] For ecological effects benchmarks use guidelines identified in BC MOE Se WQG (2014) for the no-effects benchmarks.	The updated Se WQG identifies thresholds for: - selenium toxicity on fish and birds; - egg/ovary toxicity thresholds; - and whole body toxicity thresholds for reproductive and non-reproductive endpoints in fish.

<table>
<tr><th colspan="4">Summary Table</th></tr>
<tr><th>Category</th><th>#</th><th>Description of "Technical Advice" from Mtg</th><th>Rationale</th></tr>
<tr><td></td><td></td><td></td><td>The BC MoE (2014) Se WQGs represent values that are protective and should be used as the no-effects benchmarks.</td></tr>
<tr><td></td><td>B4-16</td><td>[Appendix D]
Suggest including the BC MOE whole-body Se toxicity threshold of 4 µg/g (dw) for a protective ecological effects benchmark to protect reproductive and non-reproductive end points in fish.</td><td>This threshold was determined to be protective based on a review of the whole-body Se toxicity thresholds for reproductive (adult) and non-reproductive (juvenile) endpoints in fish. Beatty and Russo concluded in the BC MOE 2014 WQG update that there was sufficient toxicity data available to develop a juvenile fish toxicity threshold based on whole-body Se.</td></tr>
<tr><td></td><td>B4-17</td><td>[Appendix D]
Provide rationale on why dietary benchmarks are restricted to juvenile birds - See Ohlendorf and Heinz 2011 (dietary endpoints relate to reduced hatchability). Suggest dietary benchmarks cover all life stages of birds and preferentially use egg Se in birds as the benchmark.</td><td>There are published studies for Se toxicity on juvenile birds; however hatchability (reproductive effect) is thought to be a more sensitive endpoint than juvenile bird endpoints (Ohlendorf 2003). Also see Wayland et al. 2007. There are some dietary studies available that could be used to develop a dietary benchmark. Ohlendorf (2003) suggested dietary thresholds for Se (based on mallard data) of: EC10 = 4.87 (3.56-5.74), EC20=5.86, and EC50= 8.05 mg/Kg. Ohlendorf and Heinz (2011) suggest that there is an elevated probability of reproductive impairment in sensitive bird species at dietary concentrations of Se is >5.0 mg/kg (dw). The Utah Department of Environmental Quality Released a Fact Sheet with Recommended Guidelines for a Water Quality Standard for Selenium in the Great Salt Lake. The recommended Se water quality standard to prevent impairment for aquatic life lies within the ranges of:
- 3.6 to 5.7 mg Se/kg for bird diet items
- 6.4 to 16 mg Se/kg for bird eggs (see below – taken from http://www.deq.utah.gov/workgroups/gsl_wqsc/docs/2008/May/GSL_FACTSHEET_0520008_ProtectionLevelSelenium_Final.pdf

<table>
<tr><th>Diet Selenium (mg /kg)</th><th>Reduction in Hatchability</th><th>Egg Selenium (mg/kg)</th><th>Reduction in Hatchability</th></tr>
<tr><td>3.6</td><td>3%</td><td>6.4</td><td>2%</td></tr>
<tr><td>4.9</td><td>10%</td><td>12</td><td>10%</td></tr>
<tr><td>5.7</td><td>18%</td><td>16</td><td>21%</td></tr>
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	B4-18	[Appendix D] Suggest that the dietary benchmarks that protect fish and birds also need to be considered when developing benchmarks for invertebrates.	The BC MoE Se WQG (2014) has an interim dietary guideline of 4 µg/g (dw) for fish and birds which applies to invertebrate tissue. Exceeding this benchmark could result in effects to birds and fish that consume invertebrates. This should be factored into how we review the ecological effects of invertebrate benchmarks. (See the literature for dietary endpoints that were not considered for juvenile fish effects in RBT – Goettle and Davies 1978, Hilton et al. 1980, Hilton and Hodson 1983).
	B4-19	[Appendix D] Suggest that additional toxicity testing for amphibians resident to the Elk Valley is needed to improve the amphibian benchmarks proposed.	There is uncertainty in how protective the benchmarks proposed for Amphibians are, since they are based on African clawed frogs and Cope's gray tree frogs. No studies were available for species found in the Elk Valley.
	B4-20	Evaluate the performance of non-linear models for estimating K_d in lotic and lentic habitats. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The linear model that was presented does not appear to adequately describe the relationship between selenium concentrations in water and selenium concentrations in periphyton. Therefore, alternative models should be developed and evaluated to determine if they explain more of the variability in the underlying data.
	B4-21	Review the underlying data that were used to develop the selenium bioaccumulation model and identify the pairs of water chemistry and periphyton-tissue chemistry data that inspire the highest confidence that the concentrations of selenium in water represent the exposure concentration for the periphyton (i.e., for sampling locations that have the lowest variability in water quality conditions based on samples collected at multiple times throughout the year). *For additional context refer to MacDonald letter (dated February 18, 2014)*	The selenium bioaccumulation model is based on paired measurements of water chemistry and periphyton-tissue chemistry. While the periphyton-tissue chemistry data reflect integration of exposure to selenium over some extended period of time (i.e., weeks to months), the water chemistry data typically represent a point estimate of selenium concentrations (i.e., at time that the sample was collected). This disconnect between exposure concentration and tissue concentration may expolain some of the high variability in the K_d estimates.
	B4-22	Design and implement controlled-laboratory (bioaccumulation tests) and controlled-field studies (artificial stream systems) using site water to confirm or refine the water-to-periphyton model that was developed for use in bioaccumulation modelling. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The K_d model that was developed explains only 30% of the variability in the underlying matching water chemistry and periphyton-tissue chemistry data. Hence, there is substantial uncertainty in the resultant model predictions. Conducting focussed laboratory and/or mesocosm studies would increase confidence in the Kd model and the decisions that are taken based, in part, on the selenium bioaccumulation modelling.

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	B4-23	As part of an uncertainty analysis, describe the influence of abiotic and biotic factors (i.e., selenium speciation, influence from other contaminants, dietary preferences, temperature, habitat type, species sensitivity, life-stage, food web structure and large foraging distances) on the developed bioaccumulation model. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Bioaccumulation is influenced by many abiotic and biotic factors that include the amount and form of selenium present, influence of other elements and compounds both natural or introduced from human activities (co-contaminants), dietary preferences, temperature, habitat type, species-specific sensitivity, life stage, and area-specific food web structure (Stewart et al. 2010). These factors make selenium bioaccumulation inherently difficult to understand, as well as to accurately quantify and predict site-specifically, particularly for species that forage over long distances within a watershed (e.g., WCT). Many of these factors, which could result in significant model error and misinterpretation, have not been addressed by the authors. The variability in both the periphyton and benthic invertebrate data is high. This high degree of variability is reflected in the weak model relationships (very low r2 values and high residual variance) seen in the lentic (r2 = 0.35) and lotic (r2 = 0.28) periphyton models, as well as the pooled invertebrate (r2 = 0.33), the pooled amphibian (r2 = 0.36), and spotted sandpiper (r2 = 0.30) models. The data variability is in part the result of the multiple factors that influence selenium exposure and accumulation characteristics in biota, which the authors suggest are not incorporated into the model. However, the authors may not have accounted for the possible error associated with the use of data from 16 different studies conducted over several decades.
	B4-24	As part of the documentation developed with the bioaccumulation model, provide a description of alternative selenium bioaccumulation models in the scientific literature along with the rationale for choosing the multi-step modelling approach. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The authors do not mention the existence of other selenium accumulation models describing the relationship between selenium exposure and resulting tissue selenium in receptor organisms. There are more complex bi-phasic models that describe a hormetic response to selenium exposure (Beckon et al. 2008, Harding 2008). Harding (2008) suggested that bird selenium data collected in the Elk Valley best fit a hormetic model. A fuller range of possible models could be compared by the authors to determine if another approach might be more robust in describing selenium bioaccumulation in the Elk Valley.

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	B4-25	Document how the uncertainty and variability observed in each step of the bioaccumulation model is carried forward through the linked equations and how this uncertainty and variability is described in the final equation. In addition, an evaluation of the models should be conducted by plotting the predicted versus observed concentrations, along with a line of unity. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The authors acknowledge that the challenge in multi-step modelling is to account for uncertainty and variability across the multiple linked equations. However, it is unclear how, or if, this was accomplished. The weak r2 values and high residual variance of these models leaves some doubt that they are "acceptable" fits of the data. The authors have not fully explained their decisions to accept these models as "reasonably representative" in light of these weaknesses. It is unclear how all the variability in these models has been accounted for. Additionally, there is no verification of the models (comparison plots of predicted versus observed concentrations).
	B4-26	Document the details of uncertainty in matching the samples from 16 different studies used in the bioaccumulation modelling. The documentation should include: • Detailed description of uncertainty due to sample collection (timing, location, methods); • Detailed description of uncertainty regarding sample analysis (composite versus individual); and, • Describe other sources of uncertainty *For additional context refer to MacDonald letter (dated February 18, 2014)*	The reliability of this type of modelling is dependent on accurate, concurrently collected data from key locations and during relevant time periods for all model compartments. In this multi-step model, the data pairings were developed from 16 studies conducted over several decades. However, the authors did not provide sufficient details to fully evaluate how disparate the data pairs might be with respect to sample location, collection method used, and the date and timing of sampling relative to critical periods of selenium sequestration by target organisms. Since much of this detailed information was not provided, the studies cited were quickly reviewed to gain some appreciation of these important aspects. Some data pairs were not collected at the same locations, but no details were provided regarding the actual distance between sample locations and the effect this might have on the accuracy of the model. As well, timing of sample collection was slightly different in each study. As mentioned above, the number of samples used to calculate a mean and/or the number of replicates in a composite value was variable. Based on examination of Table C.1.1, periphyton data collected in the fall of one year was paired with mean water quality from the year prior to or in other cases the year after periphyton sampling occurred. While synoptic water quality values may have been closer in time to periphyton sampling, at least one data pair was two years apart and did not

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			match (lentic periphyton and lotic water). Since aqueous selenium is taken up by primary producers very quickly upon exposure, many of these pairs are unlikely to reflect water quality conditions that were relevant to periphyton selenium uptake. An additional concern is the timing of the periphyton and invertebrate samples relative to measurement of selenium in target organisms (e.g., were invertebrate samples collected in summer or fall paired with WCT tissue samples taken in spring?) Similar problems exist with the periphyton:invertebrate model. Periphyton data reported in Minnow et al. (2011) were collected "throughout the year" (May, June, July and August 2009), while aquatic invertebrates samples were collected in spring, summer or both spring and summer. The time of year that periphyton or invertebrate samples were collected (spring, fall, or throughout the year) could affect the assemblage observed and, hence, the resulting selenium concentrations, since there is a high degree of variability in species-specific selenium accumulation. Golder states that amphibian selenium data were comprised of individual sample results. However, in several studies examined (e.g., Minnow 2006; Minnow et al. 2007, Minnow et al. 2011) amphibian selenium values reflect analysis of 50-150 eggs from an egg mass, not individual eggs. The review also revealed that the historical data from the multiple studies used were generated using several different collection methods. For example, the periphyton data reported in Minnow et al. 2011 (15 data points) resulted from three different methods. In lentic areas, introduced substrates (plates) left for six weeks were sampled, "epipelon" was either scraped from rocks or lifted from pond sediment using a syringe, whereas in lotic areas "epilithon" was collected by scraping cobbles and boulders. In October 2001, EVS (2005) collected periphyton by scraping rocks and invertebrates were collected using a Surber sampler (mesh size not reported). In September 1996, McDonald and Strosher (1998)

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			collected periphyton using either forceps to pull algal mats or a utility blade to scrape algae from rocks, and obtained aquatic invertebrates using a Hess sampler (mesh size not reported). Some periphyton and invertebrate data represent a single composite value while others are the geometric mean of replicate samples. It is very possible that these differing approaches could alter the representativeness of the sample, introducing variability and greater uncertainty in model predictions. Minnow et al. (2007 collected benthic invertebrates using either a petite ponar dredge (lentic areas) or a kick net (lentic and lotic areas). Orr et al. (2012) noted that combining data across multiple studies may have contributed in part to the lower r2 values reported in three lotic trophic transfer models. Since many of the same studies in Orr et al. (2012) were also used here, this could be a significant source of uncertainty in these models.
	B4-27	Conduct a sensitivity analysis to determine the effects of pooling multiple species (i.e., in the case of the amphibians). *For additional context refer to MacDonald letter (dated February 18, 2014)*	Pooling data for two amphibian species is not a conservative approach given that the two species may have very different selenium bioaccumulation characteristics and toxicity thresholds. By pooling data for these species into one model, relating model predictions to potential selenium effects could be incorrect. Similarly, pooling bird and fish data seems counterintuitive and results in loss of valuable information to predict species-specific responses.
Cadmium Ecological Effects Assessment	**B4-28**	Recommend providing details about BLM modifications required to predict chronic toxicity endpoints	The BLM is designed to predict acute toxicity in site-specific water. The well-established acute BLM would need to be modified in order to predict chronic toxicity endpoints. The details — specifically, the scientific rationale--for these modifications are necessary to evaluate their appropriateness in establishing WQOs.
	B4-29	Rationale for excluding studies needs more detail. Firm *a priori* rationale for selecting or rejecting any given published result needs to be applied objectively to the entire literature.	
Work Package #2b: Preliminary Results of the	**B4-30**	Provide science-based rationale about how the acute BLM was modified to accommodate chronic endpoints.	More rationale is needed in order to evaluate the proposed BLM-based benchmark.
	B4-31	Recommend incorporating seasonal variation in MLE.	The MLE appears to be fit ignoring seasonal variations, so changes in the sampling plan (e.g. shifting to/away from areas of high

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Assessment of Ecological Effects			concentration that occur seasonally) could lead to estimates of the distribution which may not be applicable to real life.
	B4-32	Total cadmium should be used rather than dissolved for comparisons to guidelines.	The BC working water quality guideline for cadmium as well as the CCME water quality guideline for cadmium is for total cadmium, not dissolved cadmium.
	B4-33	How will concentrations of Cd in sediments be factored into the evaluation of potential ecological effects for Cd?	How do sediment concentrations compare with the BC working sediment quality guidelines which are based on the CCME sediment quality guidelines for cadmium?
	B4-34	Design and implement a field study to evaluate the composition (i.e., type) of dissolved organic carbon (e.g., humic substances, polysaccharides, low-molecular weight acids, and high-molecular weight acids) that occurs in the Fording River, Elk River, and tributaries during high flow and low flow conditions. *For additional context refer to MacDonald letter (dated February 18, 2014)*	To support the development of a BLM for cadmium, unmeasured levels of DOC in the water used in laboratory toxicity tests reflected in the cadmium toxicity data set were estimated using a variety of methods. The potential influence of the addition of food to toxicity testing chambers on DOC concentrations was not considered in these estimates of DOC concentrations however. This creates uncertainty in the BLM because DOC may have been underestimated. One argument for not considering feed-related DOC is that such carbon may not be as reactive as the DOC in waters from the Elk Valley. Thus far, no information has been presented on the composition of DOC in Elk Valley receiving waters during various times of the year. The recommended study will provide the information needed to determine the percentage of Elk Valley DOC that is likely to be reactive.
	B4-35	Design and implement a laboratory toxicity study to validate the application of the BLM for predicting the chronic toxicity of cadmium to fish and aquatic invertebrates. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The BLM that was developed for cadmium is based on laboratory toxicity and associated water chemistry data. However, much of the data on water quality conditions was estimated because major ion and/or DOC concentrations were not reported by the original investigators. Therefore, there is substantial uncertainty regarding the reliability of the BLM for predicting toxicity within the Elk River, Fording River, and associated tributaries. This uncertainty can be resolved by validating the applicability of the BLM with well-designed laboratory toxicity studies conducted using site water.
	B4-36	The comparison of water quality conditions to normalized effect values should be conducted using both the BLM and hardness-normalized effect values.	Studies conducted on the utility of the BLM in predicting toxicity of cadmium to aquatic organisms during chronic exposure have not shown that the BLM can accurately predict toxicity during chronic exposures. The use of the hardness-normalization procedure has

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		For additional context refer to MacDonald letter (dated February 18, 2014)	been used in the development of promulgated water-quality guidelines in British Columbia and elsewhere in Canada. Therefore, the effects assessment should include an evaluation conducted using hardness-normalized effect values.
	B4-37	Conduct a sensitivity analysis by using the individual toxicity test results (i.e., rather than grouping the effect and endpoint values from multiple studies) in the effects assessment. *For additional context refer to MacDonald letter (dated February 18, 2014)*	A conservative approach would be to use methods consistent with the derivation of water quality guidelines in British Columbia (Meays 2012). In that guidance document, studies are classified as primary or secondary based on study and/or data quality. The results of individual studies are used to identify the lowest effect value from a primary study to serves as the basis for the water quality guideline.
	B4-38	The units used in the text, tables, and figures should be consistent within the document; both µg/L and mg/L are used when reporting cadmium toxicity data. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The use of consistent units improves readability and minimizes interpretation errors.
	B4-39	Update Tables 6 and 14 in the document to state that effects are expected below the CCME water quality guideline. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Figures 18 and 22 show that BLM and/or hardness-normalized effects data fall below the CCME water quality guideline (represented as the orange dotted line). These tables should be updated to state that effects are expected to occur below the CCME WQGs.
Nitrate/ Sulphate Ecological Effects Assessment *Work Package #2b: Preliminary*	**B4-40**	Consideration should be given to the potential increase in phosphorus availability with increasing sulphate concentrations.	Pg 8. It is mentioned that Elk and Fording are primarily phosphorus limited based on existing N:P ratios. Several peer-reviewed studies identify the potential of eutrophication associated with sulphate. Increasing sulphate concentrations have the potential to lead to rising P mobilization rates (see Zak et al. 2006), Curtis 1989, Lamers et al. 1998; Lamers et al. 2002; Smolders et al. 2003; Smolders et al. 2006; Van der Welle et al. 2007; Smolders et al. 2010)
	B4-41	When setting targets, consideration should be given to other water uses such as livestock watering guidelines and human health guidelines, to ensure targets are protective of all water uses.	Ruminant livestock (cattle, sheep, goats) are sensitive to sulphate. High levels of sulphate can be highly toxic and can be linked to polioencephalomalacia (central nervous system disease in ruminants characterised by blindness, ataxia, recumbancy and seizures).

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Results of the Assessment			A draft update to the CCME livestock watering guideline suggests a sulphate guideline for livestock watering of 500 mg/L for beef and 250 mg/L for dairy cattle. Drinking water guidelines for human health are: • Sulphate: 500 mg/L • Nitrate: 10 mg/L
	B4-42	When quoting reliability of effect estimates (EC10), look into how the effects data were calculated (i.e., look into the design of the toxicity experiment and how the data were analyzed) before concluding that there are no significant differences between lower effects sizes and the control or reference treatment.	Reliability of lower effect estimates (e.g. EC5, EC10) is dependent on what concentrations are tested as well as sufficient sample size to detect effects. The authors suggest that "lower effect sizes are often not significantly different relative to the control or reference treatment" however, it depends on how the effects are calculated (usually you would adjust for effects that occur under controls, however in some cases this may not be done).
	B4-43	Clarify if values for nitrate are (as N)?	It is unclear if nitrate is being reported (as N).
	B4-44	For future reports and as part of the analyses conducted for the development of targets, please note that Table 5-4 in the nitrate/sulphate document contains errors and that values and endpoints mentioned are incorrect.	Examples: The table cites the PESC study for early life stage rainbow trout however, Kennedy re-ran the experiments resulting in more reliable estimates. For amphibians the table cites a 21-d IC20 whereas it is actually an LC25 endpoint. There are several other errors in the table.
	B4-45	Please provide a rationale why the most sensitive receptor group to nitrate (which was crustaceans at 3.3 mg/L) was not presented instead of the 5-13 mg/L values presented in the report.	Section 6.1 Nitrate – authors suggest that chronic toxicity ranges from 5 – 13 mg/L N however, Table 5-3 cites low-effects in the Upper Elk R experiment to *C. dubia* at 3.3 mg/L N.
	B4-46	Provide rationale for the following conclusions: "measureable effects to sensitive organisms are expected at high concentrations but are "unlikely to translate to population-level effects".	Effect levels and endpoints need to be identified as different endpoints could have different implications (e.g. growth endpoint vs. death). Also to determine the effects on a population you would need to account for life histories of organisms, indirect effects, food-web dynamics and what other potential effects are (e.g. other stressors, response to other substances).
	B4-47	Recommend providing details about how ion ratios represented those expected for the Elk or Fording River receiving environments during "mixture" toxicity testing.	Ionic ratios are known to be important TMFs. Consequently, details about how the toxicity test exposure waters were reflective of the receiving environments is important in order to properly interpret test results.

Summary Table			
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	B4-48	Explain the potential uncertainties in the exposure concentrations that were developed from water chemistry measurements conducted at the beginning and end of each toxicity test. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Measurements of concentrations of COPCs in water at the beginning and end of toxicity tests provide reasonable estimates of exposure conditions during static toxicity tests. However, such measurements may be inadequate for estimating exposure concentrations for static-renewal or flow-through toxicity tests (i.e., because stock solutions may be remade at various times during the test and there is potential for errors during stock solution preparation). Therefore, some discussion of the potential errors and the procedures that were applied to ensure that exposure concentrations remained consistent during the toxicity tests would be helpful.
	B4-49	Conduct an evaluation of the effects on aquatic organisms associated with exposure to major anions and cations (i.e., total dissolved solids; TDS). *For additional context refer to MacDonald letter (dated February 18, 2014)*	The Terms of Reference of the EVWQP indicate that the plan will address the cumulative effects of point and non-point sources of waste on water, aquatic biota, and human consumers, using best available science. Before cumulative effects can be evaluated, the effects of individual stressors need to be determined. To date, little or no information has been compiled on the effects on aquatic organisms associated with exposure to elevated levels of major ions (relative to pre-mining levels; with the exception of sulphate and nitrate). Yet, exposure to elevated levels of major ions (as measured by total dissolved solids, hardness, alkalinity, specific conductance, concentrations of individual ions) has the potential to influence the abundance of individual taxa and/or the diversity/species composition of aquatic communities. Therefore, the effects of major ions on aquatic organisms needs to be evaluated.
	B4-50	The effects matrix that was developed to interpret water chemistry data for nitrate and sulphate requires additional support from the primary literature. More specifically, a comprehensive review of the literature that links the magnitude of effects observed in laboratory toxicity tests to responses of aquatic organisms in the field needs to be conducted. The results of such a literature review needs to be compiled and used to support the interpretations of toxicity test results presented in the effects matrix (i.e., >IC50 - greater potential for population level effects, etc.). Similarly, the matrix that combines the evaluations conducted with literature-based	Our experience is not consistent with the interpretation of toxicity test results presented in the effects matrix. In contrast to the interpretation presented therein, we have observed adverse effects in the field when COPC concentrations exceed an IC20 level. Above an IC50, adverse effects on populations of sensitive species are expected to occur. Therefore, the interpretive framework presented in the effects matrix needs to be supported by empirical data before it can be applied.

Summary Table			
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		toxicity thresholds and site-specific toxicity thresholds requires further information to support the interpretation of the results and the associated conclusions (see slides 28 and 30 in presentation). This comment also applies to the assessments of selenium and cadmium. *For additional context refer to MacDonald letter (dated February 18, 2014)*	
	B4-51	The potential effects of nitrate enrichment on the trophic status of Elk Valley tributaries, the Fording River, the Elk River, and Lake Koocanusa need to be evaluated. This evaluation needs to consider current conditions of both nitrogen and phosphorus and the potential for additional releases of phosphorus into receiving waters from various municipal, agricultural, and industrial sources. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The evaluation of the effects of nitrate have, thus far, consisted of a toxicological evaluation for aquatic organisms. However, releases of nitrate into surface waters can also result in eutrophication, if nitrogen is a limiting nutrient for aquatic plant growth. It is essential that both the toxicological and eutrophication-related effects of nitrate are assessed in the EVWQP.
Representative Management Scenarios *WP #5: Management Scenarios*	**B4-52**	The planning horizon for the EVWQP (i.e., 20 years) is too short to support the identification of the most appropriate long-term solutions to the water quality issues that are evident in the Elk Valley. While 12 to 20 years is an appropriate timeframe for meeting the long-term targets that need to be developed under the EVWQP, planning activities must also consider a longer timeframe (i.e., 140 years and beyond) to ensure that appropriate decisions are made. *For additional context refer to MacDonald letter (dated February 18, 2014)*	One limitation of the approach that is being taken for evaluating the applicability of various management options in the EVWQP is the overall planning horizon. Utilization of a short-term planning horizon during development of the EVWQP creates a bias against mitigation measures that may be appropriate for implementation over a longer time period and those that may result in water quality improvements beyond the 20-year planning horizon. This bias is likely to result in selection of active water treatment in perpetuity to address ongoing water quality issues. Because the potential value of bituminous geomembrane (BGM) covers cannot be demonstrated within a 20-year planning horizon, progressive reclamation activities are likely to proceed with the placement of vegetated covers that may not provide substantial improvements in water quality conditions. A longer planning horizon is required to recognize the potential value of BGM covers and other technologies that required longer timeframes to achieve benefits.
	B4-53	Adopt placement of BGM covers as best management practice for progressive reclamation at coal-mining operations in the Elk Valley. Doing so will require adoption of the reasonable assumption that BGM covers will reduce infiltration into waste rock storage facilities and that reduced	In the absence of data demonstrating that the BGM covers provide an effective basis for reducing the loadings of selenium and other COPCs into receiving waters, progressive reclamation activities will proceed with the placement of vegetated covers over waste rock

Summary Table

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		infiltration into these facilities will reduce loadings of selenium and other COPCs to receiving waters. Subsequent research should be focussed on evaluating the efficacy of BGM covers over the longer term. *For additional context refer to MacDonald letter (dated February 18, 2014)*	storage facilities. Once such covers have been placed, it is virtually certain that the waste rock management facilities will not be retrofitted with BGM covers. Hence, the opportunity to control releases of COPCs at the source will be largely lost. As a result, long-term water quality issues will likely need to rely upon active wastewater treatment in perpetuity. This option is unlikely to be favored by KNC members. Adopting BGM covers as a best management practice would ensure that opportunities for placement of BGM covers are not lost and that this technology can be fully evaluated within the next 20 to 40 years.
	B4-54	Identify opportunities for large-scale trials to evaluate the effectiveness of BGM covers in the Elk Valley. *For additional context refer to MacDonald letter (dated February 18, 2014)*	There are a number of waste rock storage facilities that are currently available for covering and that can be resloped to 3:1 (e.g., Brownie Dump). These facilities should be evaluated to identify at least two that are sufficiently similar to support evaluation of the effectiveness of vegetated vs. BGM covers. Such trials should be initiated in the near term (within the next 10 years) to provide the information necessary to confirm or reject the use of BGM covers as a best management practice for progressive and final reclamation.
	B4-55	Evaluate the potential applications and effectiveness of in situ bioreactors (i.e., located within or immediately down gradient of waste rock storage facilities) in the Elk Valley. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Fluidized-bed reactors have been demonstrated to facilitate removal of selenium from wastewaters in the Elk Valley. While large-scale wastewater treatment systems utilizing this technology are likely to provide near-term solutions to the water quality issues that are evident in the Elk Valley, there may be opportunities to control releases of selenium at or near the source through the application of in-situ bioreactors (such as those that have been designed by Microbial Technologies Inc. and/or Envirogen Technologies).
	B4-56	Further detail is needed on how the representative scenarios will be crafted, and more importantly how the "decision surface" will be quantified. At this point it is unclear whether both economics and water quality benefits be considered (without bounds) or whether management options will be constrained *a priori* based on some pre-determined criteria? These up-front decisions are very important to prevent surprises at the end. Additionally, in finding an "optimal solution", it is important note that a reasonable amount	At this point it is unclear how the representative scenarios will be framed, what will be considered (i.e., economics, water-quality, etc.) or what will be presented to the TAC to show that a reasonable range of possible management solutions was considered. For example, often in a two-dimension or multi-objective decision problem (i.e., where both economics and water quality benefits are at stake) a suitable approach would be to

Summary Table			
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		of options must be considered to satisfy the TAC that sufficient rigor has been incorporated (i.e., water treatment, diversions, and both geomembrane and natural covers). Please specify how many different combinations of options will be considered.	evaluate a wide enough range of model runs (and corresponding economic analysis) so the pareto frontier (and a "knee") are apparent. By defining the shape of the non-inferior solutions, and describing the relative trade-off between water quality and economics accordingly, suitable decisions (or negotiations) can then be conducted.
	B4-57	[Water Treatment] The EVWQP should provide a discussion of water treatment plant waste, including volumes, characterization, potential water quality and aquatic effects issues, and possible disposal plans. A work plan should be included that outlines information to be collected including information to assess the long term stability and risk mitigation for these materials in the valley.	Active treatment of mine water will produce very large volumes of secondary waste that will require proper handling and long term disposal. Currently little is known about these materials or how to manage them effectively in the long term, which may have significant implications (cost, operations, environmental). A plan to address how and when this information will be obtained should be incorporated into the EVWQP.
Water Quality Planning Model *WP #6b: Results of Water Quality Planning Model*	**B4-58**	Model the effectiveness of BGM covers over a period of at least 200 years. This modelling effort should include a range of assumptions regarding the effectiveness of BGM covers in reducing loadings of COPCs to receiving waters from waste rock storage facilities (e.g., 35%, 50%, 65%, and 80% load reductions). *For additional context refer to MacDonald letter (dated February 18, 2014)*	Modelling water quality conditions over a 20-year period necessarily results in a bias against the use of BGM covers to mitigate water quality effects. While active wastewater treatment represents a necessary short-term solution for addressing key water quality issues (i.e., selenium and nitrate) in the Elk Valley, active wastewater treatment in perpetuity is not a preferred long-term solution. Therefore, it is essential to evaluate the potential efficacy of alternative mitigation measures that may provide substantial benefits over the long term. It is likely the BGM covers will provide such long-term benefits, but long-term modelling will be required to evaluate those benefits.
Ecological Effects Assessment for Tributaries	**B4-59**	Rationale is required for how Management Units were derived.	It is not clear how management units were derived. Management units should be ecologically relevant.
	B4-60	Consider modifying Management Unit 4. Consider splitting the management unit into: 1) above current and future mine influence; and 2) below current and future mine influence.	
	B4-61	Provide a table summarizing the available information on the tributaries monitored under the AEMP including: - water quality; - loadings; - whether it is fish bearing or not fish bearing; and	This will help to identify if there are any data gaps.

Summary Table			
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		- biological data.	
	B4-62	Develop a conceptual site model for the tributaries that describes the linkages between all of the potential stressors within the tributaries and all of the ecological receptors that utilize habitats within the tributaries. A similar conceptual site model needs to be developed for mainstream areas that explicitly recognizes the role that tributaries play in the maintenance of healthy and productive fish communities (i.e., providing spawning habitat, rearing habitat, exporting invertebrates to the mainstem, etc.). *For additional context refer to MacDonald letter (dated February 18, 2014)*	A conceptual site model provides a basis for describing the scope of the study area, identifying physical and chemical stressors, evaluating the transport and fate of COPCs, evaluating the effects of the various COPCs, COPC mixtures, and other stressors identifying potentially complete exposure pathways, identifying ecological receptors, and developing effects hypotheses that link the stressors and receptors. In turn, the CSM supports identification of the measurement endpoints that are most appropriate for evaluating effects on each ecological receptor group. This information will provide a basis for evaluating the adequacy of the data and information that are assembled to evaluate effects in the tributaries, both now and in the future. The CSM must consider such stressors as flow reductions, calcite formation, COPC concentrations, suspended sediments, deposited sediment, and others (e.g., blasting proximal for waterbodies, diversions, etc.).
	B4-63	Provide additional information on the methods that will be used to predict the concentrations of COPCs and the magnitude of other stressors in the future. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Information on future water quality conditions and the presence of other stressors is required to evaluate the potential effectiveness of the EVWQP for mitigating effects in the mining-affected tributaries within the Elk Valley. However, little information was provided on the methods that will be used to predict future conditions within each of the tributaries that could be affected by the proposed mitigation measures. Therefore, more information is required on the procedures that will be used for predicting future conditions.
	B4-64	In addition to evaluating the effects of individual stressors present within the tributaries, the cumulative effects of multiple stressors (including long-term climate change) need to be assessed. Such an evaluation needs to be directed by the development of effects hypotheses (i.e., that emerge from the CSM development process). *For additional context refer to MacDonald letter (dated February 18, 2014)*	Ecological receptors utilizing habitats within the tributaries have the potential to be adversely affected by a number of stressors, including changes in streamflows, changes in water quality conditions, formation of calcite, climate change, and others. While stressor-by-stressor evaluations of effects can provide useful insights into the factors that are causing effects in the tributaries, the effects assessment will be incomplete and underpredictive of effects if a cumulative effects assessment is not conducted. Therefore, the approach to incorporating tributaries into the

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			EVWQP needs to include a multiple stressor analysis within a cumulative effects framework.
	B4-65	Clearly describe the nature (type), magnitude, and spatial extent of effects in each mining-affected tributary under current conditions and under future management scenarios. *For additional context refer to MacDonald letter (dated February 18, 2014)*	Information on the effects within the tributaries under current conditions and under the proposed future management scenarios is required to understand the trade-offs that may need to be considered to balance economic, social, and environmental interests. By clearly documenting effects in each tributary under current conditions and describing how the proposed management scenarios will alter those conditions, the implications of the various management scenarios can be better understood.
Approach for Calcite Management ***WP#4: Calcite***	**B4-66**	The calcite monitoring program should be able to determine not only the precipitation patterns of calcite within streams that occurs during late summer, but also the seasonal dissolution that might occur during freshet.	Determination/monitoring of seasonal precipitation/dissolution might be an important aspect of the calcite effects assessment, especially if remobilization of trace elements such as Cd is occurring.
	B4-67	The narrative objective that was proposed for addressing calcite formation needs to be revised to focus on managing the problem, rather than understanding the problem. The following narrative objective is recommended for inclusion in the EVWQP: "Manage mine related calcite formation such that stream-bed substrates within the Elk River, the Fording River, and associated tributaries support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish (i.e., comparable to those present in appropriately selected reference areas)." *For additional context refer to MacDonald letter (dated February 18, 2014)*	The Terms of Reference for the EVWQP indicate that narrative objectives need to be articulated to guide calcite management. The narrative objective proposed at the fourth TAC meeting does not meet this requirement.
	B4-68	Develop medium-term and long-term targets for calcite. As no targets have been proposed to date, the following targets are recommended for inclusion in the EVWQP: 1. Short-term goals: Within three years, survey all streams in the Elk Valley that are affected by coal mining-related activities; map the spatial extent and magnitude (i.e., low, moderate, and high) of calcite formation in all streams; evaluate the effects of calcite formation through the implementation of well-designed field studies that include appropriate effects metrics; complete and document laboratory and field investigations conducted to identify and evaluate candidate	The Terms of Reference for the EVWQP indicate that medium-term and long-term targets and timeframes need to be established to reduce the rate and control the formation of calcite and manage impacted streams. Therefore, such targets need to be included in the EVWQP.

Summary Table			
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		calcite management approaches and systems; identify the most effective approaches to managing calcite formation for each type of source area and receiving water stream; and, complete a preliminary calcite management plan. 2. Medium-term target: Within 10 years, reduce the spatial extent of moderate and high levels of calcite by 50% relative to 2013/2014 levels. 3. Long-term target: Within 20 years, reduce the spatial extent of moderate and high levels of calcite by 80% relative to 2013/2014 levels. *For additional context refer to MacDonald letter (dated February 18, 2014)*	
	B4-69	Conduct a comprehensive review of the scientific literature to identify candidate approaches to evaluating stream-bed substrate quality. The results of this literature search should be used to identify assessment endpoints (e.g., survival and growth of aquatic plants; survival, growth, and reproduction of benthic invertebrates; survival, growth, and reproduction of fish) for evaluating the effects of calcite formation. In addition, these results should be used to identify the measurement endpoints (e.g., abundance of benthic invertebrates and individual taxa; diversity of the benthic invertebrate community, intragravel dissolved oxygen levels, etc.) for evaluating the effects of calcite formation on fish and other aquatic organisms. *For additional context refer to MacDonald letter (dated February 18, 2014)*	The Terms of Reference of the EVWQP indicate that the plan will address the impact of calcite formation. However, methods for evaluating the effects of calcite formation on fish and other aquatic organisms have not been described. Therefore, a literature search should be conducted to support identification and evaluation of candidate impact assessment methods for calcite.
	B4-70	Revise the calcite monitoring program to include metrics that facilitate evaluation of effects on fish and other aquatic organisms associated with calcite formation in receiving waters. A before-after-control-impact approach should be used to evaluate the effects of calcite formation and associated management strategies to control calcite formation. The steps involved in the design of such a monitoring program should include: 1. Develop a conceptual model for calcite formation in receiving waters; 2. Identify all receiving waters in the Elk Valley with water quality conditions and/or mining activities potentially sufficient to promote calcite formation;	

Summary Table			
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		3. Classify receiving waters prone to calcite formation based on physical-chemical characteristics and habitat types; 4. Identify appropriate reference areas for type of receiving water that was identified within the mining-affected areas; 5. Identify the assessment endpoints and measurement endpoints that will be incorporated into the monitoring program; 6. Identify a number of representative reaches of each type of receiving water within mining-influenced and reference areas that will be used to support intensive effects monitoring; 7. Describe the type and frequency of sampling and analysis that will be conducted within each reach; 8. Describe the type and frequency of monitoring that will be conducted on other stream reaches to further evaluate the nature, extent, and magnitude of calcite formation; and, 9. Describe the procedures that will be used to evaluate the resultant data and determine the effects of calcite formation on aquatic organisms. *For additional context refer to MacDonald letter (dated February 18, 2014)*	

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