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ENVIRONMENTAL SCIENCES LTD.

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Lynn Kriwoken,
Chair, Technical Advisory Committee
Elk Valley Water Quality Plan
B.C. Ministry of Environment
PO Box 9362 Stn Prov Govt
Victoria, BC V8W 9M2

Dear Lynn:

Further to the discussions that were convened during the April 2-4, 2014 meeting of the Technical Advisory Committee (TAC) in Cranbrook, B.C., I am pleased to submit the following recommendations related to the development of the Elk Valley Water Quality Plan (EVWQP). These recommendations apply to the following topic areas:

- Selenium Loadings to Lake Koocanusa;
- Lake Koocanusa Monitoring Program Results;
- Approach to Evaluating and Managing Water Quality in Lake Koocanusa;
- Approach to Evaluating Effects on Human Health;
- Evaluation of Interactive and Cumulative Effects of Multiple Stressors;
- Approach to Development of a Regional Aquatic Effects Monitoring Program;
- Approach to the Evaluation of Benthic Invertebrate Community Structure;
- Ecological Effects Matrices for Selenium, Cadmium, Nitrate, and Sulphate;
- Approach to the Application of Covers Within the Elk Valley Water Quality Plan; and,
- Additional Advice.

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**Donald D. MacDonald**
*Aquatic Biologist*
*Pacific Environmental Research Centre*
#24 - 4800 Island Hwy N.
Nanaimo, British Columbia
V9T 1W6
Tel (250) 729-9625
Fax (250) 729-9628

# 1.0 Selenium Loadings to Lake Koocanusa

A part of the TAC-5 presentations, David Naftz (USGS) provided estimates of selenium loadings to Lake Koocanusa under current conditions and after commissioning of the active wastewater treatment plant on Line Creek. This analysis provided TAC members with an independent evaluation of the potential efficacy of wastewater treatment in terms of reducing loadings of selenium to the lake. The unique perspective that such analyses provide may be helpful for communicating with the public in a way that inspires confidence in the information that is presented. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

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

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

# 2.0 Lake Koocanusa Monitoring Program Results

During TAC-5, Teck provided an overview of the results of environmental monitoring that was conducted in Lake Koocanusa in 2013 and that is planned for 2014. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: Conduct 28-d to 56-d laboratory bioaccumulation tests with environmental media obtained from Lake Koocanusa. Such tests should be conducted by exposing oligochaete worms *(Lumbriculus variegatus*) to sediment samples obtained from Lake Koocanusa. The overlying water used in the exposures should be near-bottom water from Lake Koocanusa collected from the same locations as the sediment samples.

***Rationale***: Information on the levels of selenium (and other bioaccumulative chemicals of potential concern [COPCs] e.g., Hg) in benthic invertebrates from Lake Koocanusa is required to evaluate the bioavailability of selenium that is released to the lake and to confirm water/sediment bioaccumulation factors (BAFs) calculated using data from elsewhere in the watershed.

**Advice**: Conduct a study to evaluate the effects on peamouth chub associated with accumulation of selenium in ovarian tissues. Such a study should be conducted in a manner that is consistent with the studies that have been conducted to evaluate the effects on westslope cutthroat trout and mountain whitefish associated with accumulation of selenium in ovarian tissues.

***Rationale***: Based on the data presented by Teck, it appears that peamouth chub collected in Lake Koocanusa have 10 to 15 µg/kg DW of selenium in their ovaries. This level appears to be lower than effects thresholds for westslope cutthroat trout or more sensitive fish species. However, effects studies have been conducted on only a limited number of species that occur within the watershed. Therefore, it is prudent to evaluate the sensitivity of this species to selenium accumulation in its tissues.

**Advice**: Water quality monitoring in Lake Koocanusa should include monthly sampling of all water quality variables, including conventional variables, nutrients, major ions, and metals. In addition, at least two 5-in-30 day sampling events (i.e., collect and analyze five water samples within a 30-d period, with samples collected at roughly seven day intervals) should be conducted each year. The 5-in-30 day sampling events should be conducted during the ascending and descending limbs of the hydrograph.

***Rationale***: Teck has evaluated the available water chemistry data for Lake Koocanusa and has concluded that there is not enough temporal variability to justify collection of surface water samples more frequently than monthly. However, no data have been collected to evaluate short-term temporal variability in conventional variables, nutrients, major ions, or metals (total or dissolved). Such data are required to evaluate attainment of B.C. water quality guidelines (WQGs; i.e., long-term guidelines). Therefore, it is essential that five surface water samples be collected during a 30-d period during both the ascending and descending limbs of the hydrograph to evaluate attainment of WQGs in Lake Koocanusa.

# 3.0 Approach to Evaluating and Managing Water Quality Conditions in Lake Koocanusa

During TAC-5, Teck presented an approach for evaluating and managing water quality conditions in Lake Koocanusa. The plan involved monitoring and evaluating water quality in the lake, developing a plan to meet WQGs in the lake, conducting ongoing monitoring and assessment in the lake, and establishing a linkage with the adaptive management plan. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: Establish short-term targets for cadmium, nitrate, selenium, and sulphate that are consistent with existing levels of these constituents in Lake Koocanusa south of the mouth of the Elk River (i.e., LK2). That is, establish short-term water quality targets that stabilize the concentrations of these COPCs.

***Rationale***: The Terms of Reference (ToR) for the EVWQP indicate that the "Plan will immediately establish short-term concentration targets and time-frames to stabilize water quality concentrations for selenium, cadmium, nitrate, and sulphate for stabilization." Therefore, the short-term targets for these constituents should be no higher than existing levels in the lake. The levels of selenium in the lake should never be allowed to reach the maximum concentration target of 2 µg/L in Lake Koocanusa south of the mouth of the Elk River (LK2).

**Advice**: Develop a conceptual site model (CSM) for Lake Koocanusa that describes the sources and releases of COPCs, the other stressors in the lake, the environmental transport and fate of COPCs, the ecological and human health effects of COPCs, the potentially-complete exposure pathways, and the ecological receptors and human populations potentially at risk due to exposure to COPCs. Utilize the CSM to identify assessment endpoints for Lake Koocanusa (e.g., survival, growth, and reproduction of benthic fish species), to develop effects hypotheses (i.e., how are the effects on ecological receptors or human health associated with exposure to COPCs likely to be expressed), and to select the measurement endpoints that will provide the most relevant information on the status of the assessment endpoints. The effects hypotheses should include hypotheses regarding the effects of individual COPCs, the effects of COPC mixtures, and the effects of multiple stressors (i.e., interactive and cumulative effects hypotheses; e.g., COPCs, water level alterations, etc.).

***Rationale***: A CSM 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 and COPC mixtures, 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 the reader with a basis for evaluating the adequacy of the data and information that are assembled to evaluate effects in the lake, now and in the future. The CSM must consider such stressors as flow regulations, reservoir drawdown, COPC concentrations, suspended sediments, deposited sediments, and others.

**Advice**: Long-term targets for Lake Koocanusa should include targets for surface-water chemistry, whole-sediment chemistry, invertebrate-tissue chemistry, and fish-tissue chemistry.

***Rationale***: The COPCs that were named in the ToR for the EVWQP include substances that partition into surface water (i.e., cadmium, selenium, nitrate and sulphate), substances that partition into sediments (i.e., cadmium), and substances that partition into biological tissues (selenium and, to a lesser extent, cadmium). Therefore, long-term targets need to be established for all of these media types to ensure that the aquatic ecosystem and associated uses are adequately protected.

**Advice**: The long-term targets that are ultimately selected for Lake Koocanusa should ensure that the concentrations of COPCs in each media type meet the following criteria:

1. Degradation of water quality conditions in the lake should be minimized (i.e., water quality targets established to protect water uses should not be considered to be pollute-up-to levels. All reasonable efforts should be taken to minimize loadings of COPCs to the lake);
2. At minimum, all water uses should be protected at all times throughout the lake;
3. British Columbia WQGs or Montana State water quality standards (whichever is lower) should be selected as long-term targets for all substances, except when existing levels are already below such WQGs. In such cases, existing levels should be adopted as short-term targets. Long-term targets should be established at lower levels to further reduce loadings to the lake; and,
4. The assimilative capacity of the lake should be shared equitably between British Columbia and Montana. Hence, long-term targets should be set at

levels that provide British Columbia and Montana with flexibility to accommodate water users within their jurisdiction.

***Rationale***: The ToR is clear that short-term targets are required to stabilize water quality conditions at the Order stations. Therefore, further degradation of water quality conditions in the lake should not occur. In the long-term, water management in the lake should focus on protecting existing and future water uses in British Columbia and in Montana. Fair and equitable water use requires that the assimilative capacity of the lake be evaluated and shared equally between the two jurisdictions.

**Advice**: Potential effects on the trophic status of Lake Koocanusa should be fully considered when setting long-term targets for nitrate. Long-term target setting for nitrate should consider inputs of nitrogen from upstream sources, inputs of all forms of nitrogen from the Elk River, existing and future sources of phosphorus, and the forms of phosphorus that occur in the lake and could occur in the lake in the future.

***Rationale***: To date, evaluations of the effects of nitrate have focused on development of toxicity thresholds for aquatic organisms. However, releases of nitrate (and other nitrogen species) have the potential to stimulate algal growth and alter the trophic status of receiving waters. Therefore, the potential for eutrophication needs to be considered and evaluated when setting long-term targets for nitrate.

**Advice**: Water quality objectives should be developed for phosphorus in the Elk River and in Lake Koocanusa. Such WQOs should be established at levels that prevent further degradation of the lake and minimize the potential for changes in the trophic status of the lake.

***Rationale***: Mine-associated active wastewater treatment facilities have the potential to release phosphorus into receiving waters in the Elk Valley. In addition, there are numerous other potential sources of phosphorus in the Elk River Valley and elsewhere in the Kootenay River System. As the Elk River and/or Lake Koocanusa are likely to be phosphorus limited under current conditions, it is essential to ensure that discharges of phosphorus from Elk Valley coal mines, in combination with discharges of phosphorus from other sources, do not result in changes in the trophic status of the river or the lake.

# 4.0 Approach to Evaluating Effects on Human Health

The approach for evaluating effects on human health associated with exposure to COPCs consists of two steps, including:

- Step 1: Baseline evaluation (i.e., which is equivalent to screening-level human health risk assessment); and,
- Step 2: Potential effects assessment (i.e., which involves identification of exposure pathways, evaluation of the factors affecting exposure pathways, derivation of pathway-specific benchmarks, evaluation of exposure, and characterization of potential effects).

Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: Develop a CSM that describes the sources and releases of COPCs, identifies the COPCs that are relevant for assessing effects on human health (i.e., based on the results of the baseline assessment), the environmental transport and fate of COPCs, the potential effects of COPCs on human health, the potentially-complete exposure pathways, and the human populations potentially at risk due to exposure to COPCs. Utilize the CSM to identify assessment endpoints for human health, to develop effects hypotheses (i.e., how are the effects on human health associated with exposure to COPCs likely to be expressed), and to select the measurement endpoints that will provide the most relevant information on the status of the assessment endpoints. The effects hypotheses should include hypotheses regarding the effects of individual COPCs and the effects of COPC mixtures (as relevant for human health assessment).

***Rationale***: A CSM 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 and COPC mixtures, identifying potentially complete exposure pathways, identifying human populations potentially at risk, and developing effects hypotheses that link the stressors and human populations. In turn, the CSM supports identification of the measurement endpoints that are most appropriate for evaluating effects on human health. This information will provide the reader with a basis for evaluating the adequacy of the data and information that are assembled to evaluate effects on human health, now and in the future.

**Advice**: Explicitly identify data gaps and data quality issues in the results of the baseline assessment and the potential effects assessment. Clearly describe how data quality issues have been addressed and how censored data have been treated in the analyses.

***Rationale***: The information needed to conduct a comprehensive (i.e., valley-wide) assessment of effects on human health associated with exposure to COPCs is likely not available. For this reason, it is important to fully identify data requirements and identify gaps in the existing data set. This will facilitate the evaluation of uncertainty in the assessment and help to focus subsequent data collection efforts. In addition, it is important to describe how data quality issues have been addressed in the uncertainty section. Finally, treatment of censored data has the potential to influence the results of the assessment. Therefore, it is essential to fully describe all of the underlying assumptions and treatment methods related to censored data.

**Advice**: Evaluate the representativeness and completeness of the groundwater chemistry data that have been collected to support the evaluation of effects on human health. This evaluation should include:

1. Mapping of the spatial distribution of groundwater aquifers in the Elk Valley, including shallow-water and deep-water aquifers (including a description of each aquifer);
2. Mapping of the distribution of soil types within the Elk Valley;
3. Geographic distribution of sampled wells compared to the geographic distribution of targeted drinking water wells;
4. Listing of communities in the Elk Valley and description of drinking water sources;
5. Number of wells sampled compared to the number of wells that were targeted for sampling;
6. Depth of each drinking water well that was sampled (i.e., to determine if shallow or deep groundwater was sampled); and,
7. Proximity of each drinking water well from the Fording River, Elk River, or mining-affected tributary (i.e., to determine if the water that was sampled likely represents surface water infiltration or groundwater).

For each groundwater source, the uses of the groundwater should be identified (i.e., drinking water, irrigation, livestock watering, etc.).

***Rationale***: A groundwater sampling program was undertaken by Teck to provide the information needed to evaluate human exposure to COPCs in drinking water. This sampling program resulted in collection of groundwater chemistry data for about a third of the groundwater wells that were initially targeted for sampling. Because the resultant groundwater chemistry data represent essential information for assessing potential effects on human health, it is critical to determine if they provide a reasonable basis for assessing potential effects on human health. The importance of other pathways (e.g., consumption of garden vegetables, consumption of livestock) may become apparent when the uses of groundwater beyond drinking water sources are considered.

**Advice**: Include all of the available data on the concentrations of COPCs in wildlife tissues and plant tissues in the human health effects assessment.

***Rationale***: Ktunuxa Nation members utilize a broad range of plant and animal species as part of the traditional lifestyles that are practiced within the Elk Valley. It is important to fully understand the types and quantities of traditional foods that are consumed by members in order to adequately evaluate exposure to COPCs. In addition, it is important to utilize all of the available data and information on the levels of COPCs in traditional food to support estimation of potential effects and to identify data gaps. It is also important to understand other traditional uses of plants and animals that could result in exposure to COPCs (e.g., use of reeds and other plants in basket weaving, use of kidney, liver, and other organs from wildlife species, etc.)

**Advice**: Conduct a robust evaluation of the adequacy of the available data for assessing baseline exposure to COPCs in reference areas. This evaluation should include the development of *a priori* criteria for identifying suitable reference areas, an assessment of the extent to which the selected reference areas satisfy the reference area selection criteria, and an assessment of the adequacy of the available data. The assessment of human health effects should include an explanation of why the selected reference areas are appropriate for evaluating incremental exposure throughout the entire watershed. The implications of selection of alternative reference areas should also be discussed.

***Rationale***: Data on the levels of COPCs in environmental media from selected reference areas will be complied to support the baseline evaluation of human health effects. Concentrations of COPCs in reference areas will be compared to data on the levels of COPCs in various management units to identify the COPCs that are carried forward into the effects assessment. Application of inappropriate reference areas could lead to dropping COPCs that should be carried forward into the effects assessment. Therefore, it is important to ensure that reference areas are appropriately selected and meet relevant selection criteria.

**Advice**: In conducting the human health effects assessment, it should be assumed that fishing could resume in the Upper Fording River at some time in the future.

***Rationale***: Currently, the westslope cutthroat trout fishery in the Upper Fording River is closed. However, it is possible that this fishery could be reopened at some time in the future. If this is the case, consumption of fish from the Upper Fording River could result in increased exposure to bioaccumulative COPCs.

**Advice**: Consider using alternative daily fish intake rates for Ktunuxa Nation members who reside within the Elk Valley (e.g., Tobacco Plains).

***Rationale***: The KNC traditional use survey provides important information on consumption rates of fish and other traditional foods. However, the survey did not provide sufficient information on fish consumption rates for Ktunuxa Nation members who reside within the Elk Valley. These members may have higher fish consumption rates than members residing outside the Elk Valley (i.e., due to proximity to the lake and availability of fish in the area).

# 5.0 Evaluation of Interactive and Cumulative Effects of Multiple Stressors

There are a variety of stressors that could adversely affect ecological receptors in the Elk Valley, including the COPCs identified in the Order, other chemical stressors, physical stressors, and biological stressors. The effects on ecological stressors are a function of exposure to all of the stressors that are present within the study area and the response of the organisms that are exposed to those stressors. To date, an approach to estimating the interactive and/or cumulative effects of multiple stressors in a quantitative manner has not been presented to the TAC. The following advice is provided in response to a request from Teck to provide a description of an approach that could be used to evaluate the interactive and cumulative effects of multiple stressors within the study area.

**Advice**: The following step-wise approach is recommended to facilitate evaluation of the effects of multiple stressors of key ecological receptors in the Elk Valley:

- Develop a CSM for each area under consideration (note: the CSMs for tributaries, the Fording River, the Elk River, and Lake Koocanusa are likely to have unique elements. Accordingly, separate CSMs should be developed for each ecosystem type. Because management units can include multiple ecosystem types, development of MU-wide CSMs only is not recommended);

- Identify the stressors that are present in each ecosystem type, including Order-related stressors (i.e., cadmium, selenium, nitrate, sulfate, and calcite), other mining-related stressors (e.g., total dissolved solids [TDS], total suspended solids [TSS], dissolved oxygen [DO], water temperature, streambed substrate composition, flow alteration, etc.), and other stressors (e.g., disease organisms, non-native species, reservoir drawdown, etc.);

- Screen stressors to identify the stressor-pathway combinations that have the greatest potential for adverse effects (rationale for eliminating stressors from further evaluation needs to be provided);

- Evaluate the effects of individual stressors to identify the receptors and endpoints that are most likely to be adversely affected by exposure to stressors (e.g., selenium is likely to affect the survival of the embryos of egg-laying vertebrates). The effects matrices that have been developed for the four Order COPCs provide a basis for estimating the magnitude of effects of individual stressors. Tools like the Stress Index Model (Newcombe and MacDonald 1991; MacDonald and Newcombe 1993; Newcombe and Jensen 1996; Newcombe 1997) or Fredle Index Model (MacDonald and McDonald 1987; Caux *et al.* 1997) provide a basis for evaluating the magnitude of effects for other stressors (e.g., for TSS, deposited sediment). In some cases, the magnitude of effects will need to be estimated using best professional judgement if quantitative tools are not available;

- Develop an interactive effects matrix (see Table 1) to help document the effects of individual stressors and to identify potential interactive effects. Utilize the interactive effects matrix to identify interactions among effects and to determine how effects should be summed to estimate cumulative effects. The following advice is offered to facilitate cumulative effects assessment:

    1. For stressors that affect the same receptor-endpoint pairs (e.g., cadmium, nitrate, and TSS all have the potential to influence the survival of fish fry), assume that the interactive effects are additive. While synergism or antagonism is possible, it is unlikely that the data necessary to evaluate effects beyond simple additivity are readily available. Therefore, the magnitude of the effects on each endpoint can be estimated by summing the effects that were estimated for individual stressors;
    2. For stressors that affect multiple endpoints within a species, the interactive effects should be qualitatively evaluated initially (i.e., to determine if effects on each life stage are likely to combine to affect the population of the species). Then, additivity should be assumed to estimate the range of

effects that could be observed. For example, if a 30% reduction in egg-to-fry survival is estimated for a fish species and a 20% reduction in growth is estimated for the same species (which could translate into a 20% reduction in biomass; i.e., productivity), the effect on the biomass of the species could be up to 50%. This would translate into a 50% loss in the ecological services that are provided by that species. While it is understood that some density-dependencies could influence this result, it is unlikely that such factors can be quantified at this time; and,

3. For receptors that are likely to be affected by multiple receptors, the combined effects of those stressors should be assumed to be additive (i.e., in the absence of information to demonstrate otherwise). For example, the productivity of westslope cutthroat trout could be adversely affected by exposure to selenium (i.e., through reproductive effects and growth effects). In addition, the productivity of westslope cutthroat trout could be adversely affected by reductions in the abundance of benthic invertebrates. These types of effects are interactive and cumulative because they all have the potential to influence the biomass of trout produced within an area of interest.

***Rationale***: The approach to effects assessment in the Elk Valley has focused on evaluating the effects of the individual stressors that were identified in the Order. While this is a key part of the overall effects assessment process, the effects on ecological receptors will be underestimated if the interactive and/or cumulative effects of multiple stressors are not evaluated in a quantitative manner. Therefore, it is essential that the interactive and cumulative effects of multiple stressors be quantitatively evaluated to support the development of the EVWQP.

## 6.0 Approach to Development of a Regional Aquatic Effects Monitoring Program

Teck has been conducting aquatic effects monitoring in the vicinity of each of the various mines in the Elk Valley. In addition, monitoring has been conducted throughout the regional study area to provide data and information for evaluating effects under existing conditions and to inform the design of a Regional Aquatic Effects Monitoring Program (RAEMP). Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: Develop a CSM for the entire study area that describes the sources and releases of COPCs, the other stressors in the ecosystem, the environmental transport and fate of COPCs, the ecological effects of COPCs, the potentially-complete exposure pathways, and the ecological receptors potentially at risk due to exposure to COPCs.

***Rationale***: A CSM 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 and COPC mixtures, identifying potentially complete exposure pathways, identifying ecological receptors, and developing effects hypotheses that link the stressors and receptors.

**Advice**: Utilize the CSM to identify assessment endpoints for the Fording River and associated floodplain, the Elk River and associated floodplain, Lake Koocanusa, and the tributaries. Assessment endpoints must be selected based on the ecosystems, communities, and species that occur, have historically occurred, or could potentially occur at the site. The following factors need to be considered during the selection of assessment endpoints:

- The COPCs that occur in environmental media and their concentrations;
- The mechanisms of toxicity of the COPCs to various groups of organisms;
- The ecologically-relevant receptor groups that are potentially sensitive or highly exposed to the contaminant, based upon their natural history attributes; and,
- The presence of potentially complete exposure pathways.

Thus, the fate, transport, and mechanisms of ecotoxicity for each COPC or group of COPCs must be considered to determine which receptors are likely to be most at risk. This information must include an understanding of how the adverse effects of the contaminant could be expressed (e.g., reproductive effects in fish) and how the form of the chemical in the environment could influence its bioavailability and toxicity.

***Rationale***: The CSM represents an essential tool for identifying the relationships between stressors and receptors within the regional study area and, hence, for identifying the assessment endpoints that need to be evaluated in the RAEMP. Selection of appropriate assessment endpoints will help to guide the development of the RAEMP. The assessment endpoints should be stated in terms of key attributes of the receptor groups that are potentially affected by mining-related activities (e.g., survival, growth, and reproduction of benthic fish species).

**Advice**: Develop a series of effects hypotheses that describe how the effects on ecological receptors are likely to be affected by exposure to COPCs, COPC mixtures, and/or other stressors. It is anticipated that three types of effects hypotheses will be developed. The effects hypotheses should include hypotheses regarding the effects of individual COPCs, the effects of COPC mixtures, and the effects of multiple stressors (i.e., interactive and cumulative effects hypotheses).

***Rationale***: Evaluation of the effects of individual COPCs represents one of the analyses that needs to be conducted to determine effects under current conditions and to evaluate the potential benefits associated with various management scenarios. However, it is also important to evaluate the interactive effects of multiple mine-related stressors and the cumulative effects of mine-related stressors and other stressors.

**Advice**: Based on the effects hypotheses that were developed using the various CSMs, identify the measurement endpoints that are most appropriate for evaluating effects in the tributaries, in the Fording River and associated floodplain, in the Elk River and associate floodplain, and in Lake Koocanusa. Develop a table for each type of habitat (e.g., tributary stream; off-channel wetland) that provides a comprehensive listing of:

- Receptor groups (e.g., benthic invertebrates);
- Assessment endpoints (survival, growth, and reproduction on benthic invertebrates);
- Focal species (EPT taxa [Ephemeroptera, Plecoptera, Trichoptera]);
- Effects hypotheses (exposure to toxic substances in waters will adversely affect the abundance of sensitive benthic invertebrate species in tributary streams);
- Measurement endpoints (abundance and diversity of EPT taxa as measured using standardized kick-net sampling procedures; see Field Sampling Plan and Quality Assurance Project Plan for additional information);
- Monitoring variables (identification and counts of individual EPT taxa in kick-net samples); and,
- Data interpretation approach (e.g., comparison to reference envelope developed using data on the abundance and diversity of EPT taxa collected in appropriately selected reference areas).

***Rationale***: The CSM supports identification of the measurement endpoints that are most appropriate for evaluating effects on each ecological receptor group. This information will provide the reader with a basis for evaluating the adequacy of the data and information that are assembled to evaluate effects in the lake, now and in the future. The CSM must consider all such potential stressors within the habitat type under consideration.

**Advice**: Include estimates of periphyton biomass and composition of the periphyton community (i.e., percent diatoms, percent blue-greens) in the RAEMP. Periphyton community structure is likely to be a less relevant metric.

***Rationale***: The periphyton monitoring data collected to date indicates that measures of periphyton community composition are too variable to provide useful information for evaluating the effects of mining activities.

**Advice**: Conduct a laboratory study to evaluate the effects on amphibians associated with accumulation of selenium in their tissues. Such a study should be conducted by exposing oligochaetes to various concentrations of selenium in water and feeding the Se-dosed oligochaetes (i.e., with multiple exposure levels) to leopard frogs prior to spawning. Effects on reproduction should be evaluated.

***Rationale:*** Insufficient information is currently available to identify toxicity thresholds of selenium for amphibians. By conducting a feeding study, it should be possible to generate the data needed to identify the concentrations of selenium in frog eggs that are associated with adverse effects on reproduction.

**Advice**: Monitor the levels of fine sediment in streambed substrates within mining-affected tributaries and appropriately selected reference tributaries. Sampling of stream-bed substrates should be conducted using freeze-coring or McNeil coring techniques. Substrates collected in this manner can also be used to evaluate sediment chemistry within the tributaries.

***Rationale***: Mining-related activities can result in mobilization of fine sediment and subsequent deposition in stream-bed substrates. In turn, changes in stream-bed substrate composition can result in impairment of the benthic invertebrate community and/or reduced egg-to-fry survival for fish. Monitoring of stream-bed substrate quality will provide valuable information on the effects of mining on the quality of stream habitats.

**Advice**: Ongoing surface-water toxicity testing should be included as an integral element of the LAEMPs and the RAEMP. A suite of toxicity tests on sensitive species that include sub-lethal endpoints and long-term exposure should be identified for inclusion in the AEMPs. Monitoring stations should be located 100 m downstream of the final point of control for discharges to the tributaries, the Fording River, and the Elk River. Additional monitoring locations should be added if toxicity is observed immediately outside the initial dilution zones for the various wastewater discharges and uncontrolled releases.

***Rationale***: Exposure to surface water in the tributaries, in the Fording River, and in the Elk River has the potential to cause adverse effects on fish and other aquatic organisms. While biological monitoring conducted in the field will provide some of the data and information needed to evaluate mining-related effects on aquatic organisms, controlled laboratory studies are also needed to provide additional information on the toxicity of surface waters within the study area. For this reason, a suite of toxicity tests should be used to evaluate surface water toxicity within the study area.

# 7.0 Approach to the Evaluation of Benthic Invertebrate Community Structure

In 2012, Teck conducted a survey to evaluate benthic invertebrate community structure (BICS) in the Elk Valley. The survey involved collection of benthic invertebrate samples at a number of mining-affected stations in the Elk Valley and at a number of reference stations in southeast British Columbia and Alberta. The reference station data were evaluated in two ways to facilitate interpretation of the data from the study area. Following data analysis, stations form the study area were designated as adversely affected, potentially adversely affected, or not adversely affected. These results are intended to be used to evaluate effects on the benthic invertebrate community under baseline conditions. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: A Before-After-Control-Impact (BACI) approach should be used preferentially to evaluate the effects of mining activities on BICS. For all mining-affected areas that have data collected upstream and within or downstream of affected areas, compare the results of BICS analyses directly.

***Rationale***: A reference envelope approach was developed to support an evaluation of BICS data collected within the Elk Valley. While it is not unreasonable to utilize a reference envelope approach (using appropriately selected reference stations for each ecosystem type; i.e., tributary stream, small river, and river), the approach that has been used to evaluate the data collected in 2012 does not appear to provide a sensitive basis for evaluating mining related effects. That is, the analysis appears to be confounded by the selection of reference stations and the application of the reference station data for developing the reference envelope.

A more direct way of evaluating effects is to compare data collected upstream and downstream of the mining activities, at reference and test stations, and/or before and after the mining activities were initiated (i.e., using a BACI-type approach). Currently, data collected within a single stream (e.g., Michel Creek) are compared to data from up to three different groups of reference stations.

**Advice**: The methods used in 2012 should be revised to facilitate more quantitative evaluation of BICS in the Elk Valley.

***Rationale***: The approach that was used to evaluate BICS focussed on four primary benthic community metrics, including family richness, EPT proportion, Ephemeroptera proportion, and Chironomidae proportion. In addition, nonmetric multidimensional scaling (NMDS) ordination of benthic invertebrate community data facilitated identification of two axes (Axis 1 and Axis 2) that were also used to evaluate effects on the benthic community. While the descriptions of the methods are not sufficient to fully evaluate the methods that were used, it appears that the BICS analyses are primarily based on proportional, rather than absolute, metrics. This is a major limitation of the sampling and analysis methods.

Based on the results of studies conducted in the vicinity of other mine sites, the absolute abundance (rather than relative abundance) of benthic invertebrates, the absolute abundance of sub-groups (e.g., EPT taxa, mayflies, stoneflies, caddisflies, midge), and the absolute abundance of various functional groups (e.g., scrapers, shredders, collectors, predators) provide important and unique information on the effects of anthropogenic activities on the benthic community (e.g., Clements *et al.* 2000; Maret *et al.* 2003). Therefore, information on abundance of benthic organisms is essential for evaluating effects on one of the important ecological services that the benthic community performs in stream systems (i.e., providing food to fish and other organisms). Relative proportion of EPT taxa or other proportional metrics can provide information on the structure of the community, but not on the functioning of that community.

**Advice**: The methods used in 2012 should be revised to facilitate statistical differences in BICS among stations located upstream and downstream of mining activities in the Elk Valley.

***Rationale***: The 2012 benthic sampling program was designed to collect a single benthic invertebrate sample at each sampling location. As such, the design did not facilitate evaluation of within station variability in BICS metrics or permit statistical evaluation of the resultant data to assess mining-related impacts using upstream-downstream comparisons. This is a major limitation of the sampling program design. Therefore, it is recommended that alternative sampling methods be adopted to facilitate more transparent statistical analysis of the resultant data.

**Advice**: Re-evaluate the reference areas that were initially selected to support evaluation of the effects of coal mining on BICS using more relevant selection criteria. More specifically, reference areas should meet the following selection criteria:

- Land use activities in the vicinity of and upstream of candidate reference stations should be limited in scope and magnitude, such that they would be expected to have little or no influence on BICS metrics;
- Physical characteristics of candidate reference stations should be similar to those in the study area (i.e., stream order, gradient, stream flow, water temperature); and,
- Chemical characteristics of candidate reference stations should not be affected by mining activities or other local anthropogenic activities (water or sediment chemistry could be affected by long-range transport of atmospheric contaminants).

While it may be tempting to use stream-bed substrate composition, particle size distribution, TSS, percent canopy cover, and other habitat factors in the reference site selection process, it is essential to understand that mining activities can and do influence these variables. Therefore, selection of reference stations to match all habitat characteristics of study area stations may result in an underestimate of mining-related effects because mining activities affect stream habitat characteristics. Detailed statistical summaries of the physical and chemical data that have been compiled for reference and test stations will provide a basis for understanding the adequacy of selected reference stations.

***Rationale***: The reference areas that were selected to support the evaluation of BICS appear to include stations that have been influenced by forest management and/or other activities. Such areas are not directly relevant for evaluating the actual effects mining-related activities on BICS. Rather, such areas provide a basis for evaluating the incremental effects of mining activities on benthic communities, beyond those that are associated with forest management or other anthropogenic activities. This approach to effects assessment underestimates the effects of mining on the benthic community.

**Advice**: Evaluate multi-plate samplers (e.g., Hester-Dendy Samplers) for assessing effects on benthic invertebrates associated with changes in water quality conditions.

This approach should be used in conjunction with other approaches to BICS evaluation (i.e., kick sampling).

***Rationale***: Habitat characteristics is a factor that can influence the result of BICS evaluations. Multi-plate samplers provide a basis for assessing effects of water quality changes on benthic invertebrates without having to account for habitat alteration or other factors. Hence, the resultant data may have less noise, which may increase sensitivity in the determination of mining-related effects. Therefore, a pilot study should be designed and implemented to determine if multi-plate samples can be used as part of the LAEMPs and/or RAEMP. Because mining activities can affect benthic habitat characteristics and such characteristics can influence the benthic community, monitoring results generated using multi-plate samplers alone could underestimate mining-related effects on the benthic community. Therefore, other approaches to BICS evaluation need to be identified, described, and implemented.

**Advice**: Evaluate the implications of relying on specific indicators (e.g., total EPT abundance, abundance of mayflies, abundance of caddisflies, abundance of stoneflies, relative abundance of EPT taxa) and fewer indicators to designate sampling stations as impaired or not impaired.

***Rationale***: Using the approach applied in the 2012, each of the BICS metrics measured for a station from the study area was compared to a reference envelope to determine if the station was significantly different from reference conditions. A station was designated as impaired if at least five metrics were significantly different from reference conditions. This appears to be an insensitive method for evaluating the effects of mining on BICS. Accordingly, a sensitivity analysis should be conducted to determine the implications of using sensitive indicators of effects (e.g., abundance of EPT taxa) to designated stations as impaired or not impaired. In addition, the implications of designating stations as impaired if fewer metrics indicate impairment should be investigated.

**Advice:** The criteria for selecting monitoring stations for inclusion in the Reference Envelope (for the reference criteria approach; RCA) should be provided to the TAC (see information request to Carla Fraser). In addition, summary statistics for each of the habitat variables and water quality variables used in evaluating candidate reference stations and assigning them to groups should be developed and provided to the TAC (see Table 2 in Maret *et al.* 2003 as an example). Such summary statistics should be developed for each group of reference stations and each group of test stations that were linked to the reference group. Summary statistics should include mean, median, standard deviation, range and 5$^{th}$, 10$^{th}$, 24$^{th}$, 50$^{th}$ 75$^{th}$, 90$^{th}$, and 95$^{th}$ percentiles. After review of the material, a sensitivity analysis should be conducted based on any recommendations of the TAC.

***Rationale:*** The effects assessment for the benthic invertebrate community data is not transparent. The underlying information on the reference sites and the appropriateness of those sites for use in the effects assessment needs to be reviewed in detail. While the underlying data on the water quality and habitat variables for each of the sites has been provided in the AEMP, the criteria used to determine if a reference site was appropriate for use (i.e., selection criteria) was not provided. This information is required to adequately review the approach used by Minnow (2014) in the effects assessment.

**Advice:** The RCA and subsequent comparison to reference conditions is not transparent and does not appear to be a sensitive method for evaluating the effects to benthic invertebrates in the Elk Valley. Determine the minimum effects size for each BICS metric that was used in the effects assessment (i.e., how much does a metric have to differ from the mean of the reference group before a sample is designated as impaired for that endpoint?).

***Rationale:*** To determine if stations are unaffected by mining activities, or whether additional investigation was needed to determine if a particular mine-exposed site is affected by mining activities, Minnow (2014) selected twelve community metrics (i.e, six of the community endpoints, including: family richness; proportion of EPT taxa; proportion of Chironomidae taxa, and the non-metric multidimensional scaling [NMDS] axes 1 and 2 predicted by both the BEAST and ANNA models). Non-central *F*-tests were then used to test each of the mine-exposed sites to determine if the difference between the mean metric (e.g., family richness) in the reference group and the metric at the mine-exposed location were statistically different ($p < 0.1$). In addition, information provided from the non-central *F*-test was used to determine if the mine-exposed stations were statistically similar (equivalence test) to the reference condition ($p \geq 0.9$). In a preliminary analysis of the proposed reference envelope used in the effects assessment, it was determined that for at least one of the reference stations, it was inconclusive from the equivalence test whether the station represented the mean reference condition for five of the twelve benthic community endpoints (i.e., there is a large amount of variability within the reference sites). Using this information, Minnow (2014) developed criteria to evaluate each of the mine-exposed sites. A mine-exposed site was determined to be unaffected if:

- None of the benthic community metrics were statistically different from the reference condition ($p < 0.1$); **and**,

- It was concluded that seven or more of the benthic community metrics were similar to the reference condition using equivalence test ( $p \geq 0.9$; i.e., less than or equal to five of the metrics with $p < 0.9$.

The thresholds used to determine whether a mine-exposed site requires additional investigation (i.e., more than five endpoints showing deviation from the reference condition) is not a sensitive measure of effect considering the variability observed in the reference condition and the suitability, or lack thereof, of the selected reference stations. The inherent variability in the benthic invertebrate community data at the reference stations is large and spread across multiple benthic invertebrate metrics. This makes it difficult to discern real effects related to mining operations in the Elk Valley. In addition, no information on the relative abundance (i.e., productivity) at the test sites compared to the reference sites were conducted due to the limitations of the CABIN approach. This is a major deficiency in the effects assessment as other researchers (e.g., Hauer and Sexton 2013) have found differences between mine-exposed (i.e., test sites) and upstream reference sites in the Elk Basin.

**Advice:** Develop a single reference envelope for each BICS metric that captures 95% of the variability in the underlying data for the selected reference stations. In recognition of the effects hypotheses that are develop, a statistical approach should be applied that recognizes that differences from reference conditions need to be evaluated using a one-tailed test (i.e., calculate $5^{th}$ or $95^{th}$ percentiles for the reference data for each metric, depending on the direction of change expected in response to exposure to mining-related stressors).

***Rationale:*** The methods that were used in the 2012 AEMP document to identify stations that differ from reference conditions are not transparent. There is a need to establish a clearly defined numerical reference envelope for each BICS matrix or multiple numerical reference envelopes if there are several groups of reference stations. To do so, the approach needs to change from one of multiple hypotheses testing to clearly defining the reference envelope that data from the test stations can be compared to.

**Advice:** Conduct the evaluation of effects on BICS using a single reference envelope approach.

***Rationale:*** Currently, two separate procedures are used to define reference conditions within the Elk Valley, including the BEAST and ANNA models. In the 2012 AEMP document, both models are presented and used because they purportedly provide independent lines-of-evidence for evaluating effects on BICS. This is not correct. The data underlying both models are the same and, hence, the evaluations are not independent. Therefore, one method needs to be selected and used in the assessment of BICS. Application of both models unnecessarily complicates the analysis and interpretation of the results.

**Advice:** The revised analysis conducted to determine if BICS is adversely affected at sites affected by mining operations (i.e., by comparing the selected community metrics to the range of observed values at the reference sites; presented in Table 5.3) should include all evaluated test sites, regardless of whether they were classified as unaffected in the previous analysis. Furthermore, the test sites should be compared to the distribution of metric values (i.e., $5^{th}$ to $95^{th}$ percentiles) for the appropriate reference group (indicated by the BEAST and ANNA models), rather than to the pooled data for all reference stations.

***Rationale:*** By comparing the test sites to the pooled for all reference groups in this analysis, the sensitivity of the BICS analysis is greatly reduced. The variability in the community structure data due to differences in habitat variables by definition, inflates the distribution (or observed) responses at the reference sites. A more appropriate analysis would be to use the distributions of metric values that are calculated for each of the stratified reference groups (from the BEAST and ANNA models) to evaluate the data from comparable test sites.

**Advice:** The concentrations of Order (and other) contaminants in benthic invertebrate tissues should be compared to tissue residue benchmarks to evaluate effects benthic invertebrates at the mine-exposed stations.

***Rationale:*** The evaluation of the invertebrate tissue chemistry data was limited to the comparison of concentrations measured in invertebrates at the mine-exposed stations to the upper limit observed in the reference stations. A more fulsome evaluation should be conducted by comparing the invertebrate tissue concentrations to tissue residue benchmarks (as available) as well as to the reference stations.

# 8.0 Ecological Effects Matrices for Selenium, Cadmium, Nitrate, and Sulphate

As part of TAC-5, Teck provided an update on the ecological effects matrices that are being developed for selenium, cadmium, nitrate, and sulphate. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: The dose-response relationship for chinook salmon should be used to evaluate effects on fish associated with dietary exposure to selenium.

***Rationale***: For other receptor groups and for selenium in fish tissues, effects will be estimated using concentration-response relationships. A similar approach can be applied for the dietary exposure route in fish by applying the dietary dose-response relationship that has been developed for chinook salmon.

**Advice**: Identify effects thresholds for nitrate and sulphate in the tributaries to the Elk and Fording rivers.

***Rationale***: Effects thresholds for nitrate and sulphate were presented for the Elk and Fording rivers. However, no effects thresholds for these COPCs were presented for the tributaries. As effects associated with exposure to these COPCs also need to be evaluated in the tributaries, it is necessary to identify effects thresholds that apply to the tributaries.

**Advice**: For those variables for which the effects thresholds are hardness dependent, the effects thresholds should be established using the 5$^{th}$ percentile hardness value for the receiving water under consideration.

***Rationale***: The effects thresholds presented for nitrate and sulphate were calculated using the median water hardness for each of the receiving water bodies.

**Advice**: The term "ecologically-protective values" should not be used in the EVWQP. Rather, the terms Level 1 and Level 2 Thresholds should be used.

***Rationale***: The Level 1 and Level 2 Thresholds that have been proposed for use in the EVWQP do not represent no effects levels. Rather, they are effects thresholds that were developed using various types of toxicity data. No information is currently available that demonstrates that such effects thresholds are protective of the environment when present alone or in combinations with other stressors.

Therefore, it would be misleading to refer to these effects thresholds as "ecologically-protective values"

**Advice**: Evaluate the toxicity of mixtures of major ions (e.g., as indicated by TDS, or conductivity) to fish and other aquatic life.

***Rationale***: Coal-mining activities result in releases of wastewater with elevated levels of major ions into receiving water systems, including calcium, sodium, potassium, nitrate, sulphate, carbonates, and chloride. While increases in water hardness can mitigate the toxicity of certain COPCs (e.g., cadmium), high levels of major ions, either alone or in combination, can be toxic to aquatic organisms. The potential for toxicity associated with exposure to elevated levels of nitrate and sulphate is being addressed in the EVWQP. However, the potential toxicity of mixtures of major ions has not been addressed. This is important as surface waters in the Elk Valley are known to contain elevated concentrations of major ions and combinations of major ions are likely to be more toxic than any one major ion alone. Accordingly, the toxicity of mixtures of major ions needs to be evaluated to support development of the EVWQP.

## 9.0 Approach to the Application of Covers Within the Elk Valley Water Quality Plan

As part of TAC-5, Teck presented the approach to covers that would be included in the Elk Valley Water Quality Plan. Based on a review of the information that was presented, the following advice (and associated rationale) is offered:

**Advice**: Adopt BGM covers as a best management practice (BMP) for reclaiming all waste rock management facilities in the Elk Valley.

***Rationale***: Based on the information that was presented at TAC-5, it appears that BGM covers are likely to provide an effective means of reducing infiltration of precipitation into waste rock piles and, hence, for reducing loadings of COPCs to receiving waters. While it is understood that the benefits of such covers may not be realized for some time into the future, it is apparent that such covers will reduce reliance on active wastewater treatment facilities and reduce long-term liabilities for Teck. Therefore, BGM covers should be adopted as a BMP for reclamation and closure planning and implementation. The results of the ongoing R&D program will likely provide a basis for refining BMPs in the future.

**Advice**: Identify opportunities to accelerate research on the effectiveness of BGM covers and other technologies (e.g., *in-situ* semi-passive treatment systems) in terms of reducing COPC loadings and achieving other benefits by conducting large-scale pilot programs in the Elk Valley.

***Rationale***: There is an urgent need to better understand the effectiveness of BGM covers and other technologies in terms of reducing COPC loadings to surface waters and groundwater. By identifying areas that can be used now to conduct large-scale trials of BGM covers and/or other technologies, it may be possible to generate the data and information needed to optimize these systems and reduce reliance on active wastewater treatment systems. Such areas should include those that are available for closure now or in the near future and those areas that are available for temporary closure (i.e., placement of additional materials may be anticipated at some time in the future, trial covers could be placed now to accelerate the generation of research results).

## 10.0 Additional Advice

A substantial amount of information was presented at TAC-5. Based on the information that was presented, specific advice was developed related to each of the topic areas that were addressed. The following provides additional advice that emerged from consideration of how the various types of information will contribute to the development of the EVWQP:

**Advice**: Include specific triggers for action in the EVWQP. Such action triggers need to be based on the results of monitoring of environmental media in the Elk Valley, identify the management actions that will be taken if the triggers are exceeded, and describe the schedule for implementing each management action. Triggers need to be established for each of the water bodies that are being affected by mining-related activities.

***Rationale:*** Adaptive management has been identified as a central element of the overall EVWQP. To be effective, adaptive management must include effective monitoring of environmental conditions in the study area, a clearly-defined framework for interpreting monitoring program results, clearly-defined triggers for action, and specific management actions and time frames for implementation of those management actions. In this way, management responses to changes in environmental conditions are defined on an *a priori* basis and schedules for implementing those responses are defined.

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

Sincerely,

D.D. MacDonald, RPBio., CFP, Principal
Director, Pacific Environmental Research Centre
Canadian Director, Sustainable Fisheries Foundation

Jesse Sinclair, R.P.Bio
Senior Biologist

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**Table 1. Matrix for Evaluating Interactive Effects and Cumulative Effects within the Regional Study Area - Kilmarnock Creek**

| | | | **Stressor (Estimate of Proportion of Population Affected)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Receptor** | **Life Stage** | **Endpoints Affected** | **Cd** | **Se** | **NO3** | **SO4** | **Calcite** | **Total Order Stressors** | **Water Hardness** | **TSS** | **Deposited Sediment** | **Water Temperature** | **Total - All Stressors** |
| Aquatic Plants | | | | | | | | | | | | | |
| - Periphyton | All | Growth | | | | | | | | | | | |
| - Bryophytes | All | Growth | | | | | | | | | | | |
| - Macrophytes | All | Growth | | | | | | | | | | | |
| Benthic Invertebrates | | | | | | | | | | | | | |
| - Stoneflies | All | S,G,R | | | | | | | | | | | |
| - Caddisflies | All | S,G,R | | | | | | | | | | | |
| - Mayflies | All | S,G,R | | | | | | | | | | | |
| - Combined EPT Taxa | All | S,G,R | 0.15 | 0 | 0.15 | 0 | 0.35 | **0.65** | | | | | |
| Fish | | | | | | | | | | | | | |
| - Westslope CT | Egg-Fry | S | 0.08 | 0.31 | 0.1 | 0 | 0.05 | **0.54** | | | | | |
| | Fry - SA | G | | | | | | | | | | | |
| | SA-Adult | G | | | | | | | | | | | |
| - Mountain White | Egg-Fry | S | | | | | | | | | | | |
| | Fry - SA | G | | | | | | | | | | | |
| | SA-Adult | G | | | | | | | | | | | |
| Amphibians | Egg-Tadpole | | | | | | | | | | | | |
| Birds | | | | | | | | | | | | | |
| - Red-Winged BB | Egg-Hatch | | | | | | | | | | | | |
| | Hatch-Fledge | | | | | | | | | | | | |
| | Fledge-SA | | | | | | | | | | | | |
| - Spotted SP | Egg-Hatch | | | | | | | | | | | | |
| | Hatch-Fledge | | | | | | | | | | | | |
| | Fledge-SA | | | | | | | | | | | | |

Note: CSM will identify stressors, receptors, and life stages that need to be included in the table.
Note: The simplest assumption is that the effects of multiple stressors on a receptor are additive
Note: TSS effects can be evaluated using the Stress Index Model.
Note: Deposited sediment can be evaluated using geometric mean diameter or Fredle Index.
Note: Other Stressors are a few examples only.