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ATTENTION: Lesley Shelley

Review of Potential for Metals from the Proposed Seabridge Gold KSM Mine to be to Cause Sub-Lethal, Toxic Effects to Salmonids in the Unuk River Watershed

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On behalf of Rescan Environmental Services Ltd. (Rescan), Biowest Research Consultants (Biowest), has conducted a review of the potential for metals from the Seabridge Gold's Proposed KSM Mine to impact salmonids in the Unuk River watershed. As part of this review, we have reviewed the following documents:

- Sub-lethal metal toxicity concerns for Unuk watershed salmonids from Seabridge Gold's proposed KSM mine. Prepared by Michael H.H. Price for Skeena Wild Conservation Trust. March 8, 2014. (Price, 2014).
- KSM Project Environmental Assessment, Chapters 14 (Surface Water Quality) and 15 (Fish and Aquatic Habitat). Available on-line at http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_home_322.html. (KSM Project Environmental Impact Assessment [EIA]).
- Memorandum: Response to BC MoE Comments # 52, 136, 137, 138, 234, 246, 247, 302 and 303 and Gitanyow Hereditary Chief's Comment #224 on the Application/EIS (Seabridge Gold). Prepared by Rescan Environmental Services Ltd. December 19, 2013. (Rescan, 2013).

This review specifically pertains to the conclusions presented by Price (2014) regarding the potential for seven metals from the proposed KSM Mine to adversely impact salmonids.

This letter provides a review of the approach used by Rescan to assess the potential for the Project to result in the degradation of surface water quality in the Unuk Watershed, and reviews the information and conclusions presented by Price (2014) in the context of current methods for the assessment of potential impacts to aquatic life, including salmonids.

We have considered the baseline and predicted surface water quality presented in the Project EIA and in Rescan, 2013, as well as Rescan's approach for identifying contaminants of potential concern (COPCs), and calculating hazard quotients for the COPCs, presented in Rescan (2013). We generally conclude that Rescan has appropriately used the BC Ministry of Environment (BC MOE) surface water quality guidelines and current, standard risk assessment approaches, as recommended by the BC MoE, the Canadian Council for Ministers of the Environment (the

CCME) and Environment Canada, in their assessment. It is our opinion that they have relied on the best available science and methods to predict potential impacts to aquatic receptors, including salmonids, in the Unuk River watershed.

Although Price (2014) does not comment on the approach used by Rescan in their assessment to estimate the potential impact of surface water quality degradation on aquatic life, and specifically salmonids, the author disputes the conclusions of the Project EIA with respect to the potential for the proposed KSM Mine to adversely impact salmonids in the Unuk River Watershed.

Based on our review of Chapter 15 of the the Project EIA we understand that the Unuk River is a large river with a diverse fish community. The Unuk River provides habitat for resident rainbow and cutthroat trout, Dolly Varden, bull trout and mountain whitefish, and is used as a spawning route for Pacific salmon, anadromous steelhead, and cutthroat trout. A number of sub-watersheds, including Sulphurets Creek, were assessed as part of the Project baseline assessment. The Project Environmental Assessment reports that during electrofishing, gillnetting and minnow trapping conducted as part of the baseline assessment during 2008 to 2012, that small numbers of Dolly Varden were observed below the approximate 200 m cascade in Sulphurets Creek (located approximately 500 m upstream of the confluence with the Unuk River), but no fish species were present above the cascade or in Sulpurets Lake.

The baseline and predicted surface water quality presented in Chapter 14 of the Project indicated that due to naturally occurring acid rock drainage, total and dissolved metal concentrations in Mitchell and Sulphurets creeks were frequently higher than BC water quality guidelines for the protection of freshwater aquatic life, with dissolved aluminum, total cadmium, total chromium, total cobalt, total copper, total iron, total lead, total selenium, and total zinc measured at concentrations exceeding the guideline.

This letter provides a review of the approach used by Rescan to screen for COPCs and to assess the potential for the Project to result in a degradation of surface water quality in the Unuk River Watershed, and reviews the information and conclusions presented by Price (2014) in the context of current methods for the assessment of potential impacts to aquatic life, including salmonids.

EIA Chemical Screening

In the Project EIA, Rescan used the BC Water Quality (BCWQ) guidelines to screen for chemicals of potential concern (COPCs) in surface water. These guidelines are derived based on the best available science, and considering all components of the aquatic ecosystem (e.g., algae, macrophytes, invertebrates, fish). This approach is consistent with risk assessment methods prescribed by various regulatory agencies, including the BC MoE, the CCME and Environment Canada.

As presented in Section 14.7.3.2 of the Project EIA (Potential Residual Effects due to Effluent Quality), the receiving environment water quality in Sulphurets Creek and the Unuk River were evaluated by the following:

- Through a comparison of the predicted surface water concentrations to the BCWQ guidelines; or,
- For parameters where baseline concentrations exceeded the BCWQ guidelines, a comparison of the predicted concentrations to mean and maximum baseline concentrations.

Rescan calculated hazard quotients (HQs) for COPCs as a ratio of the predicted concentrations for the COPCs to the BCWQ guidelines or baseline concentrations; the HQs were used to screen for potential residual effects.

Rescan (2013) indicates that predicted mean and maximum selenium concentrations exceed mean and maximum baseline concentrations during high-flow and low-flow months of the Operation, Closure, and Post-closure Project phases in Sulphurets Creek (Site SC3) and in the Unuk River (Sites UR1 and UR2); the predicted selenium concentrations were in excess of the BCWQ guideline at in Sulphurets Creek (Site SC3) and in the Unuk River (Site UR1 only). The Project EIA and Rescan (2013) indicates that extensive mitigation for management of selenium is included in the Project design, including the construction of a Selenium Treatment Plant, and that selenium concentrations will be monitored through the Aquatic Effects Monitoring Plan, which allows for adaptive management if effects on aquatic life are identified.

As outlined above, the BCWQ guidelines were in the COPC screening and in the calculation of HQs for many of the Project COPCs. A summary of the BC MoE protocol on the derivation of the BC Water Quality Guidelines is provided here as a means of demonstrating that these guidelines are scientifically defensible, robust, and protective of effects, including sub-lethal effects, to salmonids.

BC Water Quality Guidelines

The BCWQ guidelines are derived based on a review of the scientific literature and results from toxicity tests, as well as consideration of guidelines from other jurisdictions and conditions specific to British Columbia (BC MoE, 2012). Although the available toxicity literature provides useful information on the effects of toxicants on various life forms, as suggested by Price (2014), the information has limitations, as it is based on laboratory tests that only approximate natural/field conditions and do not account for organism exposure to mixtures or indirect effects through food-web (i.e., diet) exposures. To compensate for these uncertainties, uncertainty factors are applied to the lowest available effects data (e.g., ECx) to derive guidelines (BC MoE, 2012), thereby providing greater certainty that the guidelines are protective. The level of uncertainty factor (typically between 2 and 10) to be applied is determined based on the completeness of the aquatic toxicological database (as per BC MoE minimum data requirements for guideline derivation [BC MoE, 2012]) for the toxicant and the scientific soundness of the available data.

The minimum data requirements to be considered a sufficient aquatic toxicity database for a full (or approved) BC Water Quality guideline for freshwater aquatic life include the following (from BC MoE, 2012):

Fish

- For long-term average guidelines: at least 3 long-term studies on 3 or more freshwater species resident in B.C., including at least 2 cold-water species (e.g., trout).
- For short-term maximum guidelines: at least 3 short-term studies on 3 or more freshwater species resident in B.C., including at least 2 cold-water species.

Invertebrates

- For long-term average guidelines: at least 2 long-term (partial or full life-cycle) studies on 2 or more invertebrate species from different classes, 1 of which includes a planktonic species resident in B.C. (e.g., daphnid).
- For short-term maximum guidelines: at least 2 short-term studies on 2 or more invertebrate species from different classes, 1 of which includes a planktonic species resident in B.C.

Plants

- At least 1 study on a freshwater vascular plant or freshwater algal species resident in B.C.
- For highly phytotoxic substances, 3 short-term and/or long-term studies on freshwater plant or algal species.

Amphibians

- When available, toxicity studies using amphibians should be included.

The preferred endpoints to derive a long-term (i.e., chronic) average guideline are endpoints representing a low-effects threshold for a species from a critical study. The endpoints for the available data are ranked, with the preference for endpoints including the following (listed in order of preference):

- ECx/ICx representing a low-effects threshold;
- EC15-25/IC15-25;
- LOEC;
- MATC;
- EC26-49/IC26-49;
- non-lethal EC50/IC50; and,
- LC50.

As indicated, sub-lethal endpoints are preferred, and mortality endpoints only considered when sub-lethal endpoints are not available.

When the above minimum data requirements are met, the data are evaluated to ensure they meet acceptable standards, including for test conditions/design, test concentrations,

temperature, hardness, pH, experimental design and a description of the statistics used in evaluating the data (BC MoE, 2012). Based on this evaluation, the available data is classified as primary, secondary or unacceptable for use.

Acute (short-term maximum) guidelines are derived based on the lowest reliable EC_{50} or LC_{50} from a short-term toxicity test, and chronic (long-term average) guidelines are derived using the ECx/ICx representing a low-effects threshold from a reliable long-term exposure study. The BC MoE (2012) recommends that preference be given to sensitive native BC species, when data is available (BC MoE, 2012). As indicated, these values are then multiplied by an appropriate uncertainty factor to derive a acute and chronic guidelines. Regression based toxicity estimates (i.e. ECx) are preferred to hypothesis based toxicity values (i.e. NOEC and LOEC) for water quality guidelines development (BC MoE, 2012).

When the above minimum data requirements are not met, interim guidelines may be derived. Of the seven metals referenced by Price (2014) [aluminum, cadmium, copper, lead, nickel, silver and zinc], all but cadmium and nickel have approved (full) chronic (30-day mean) and acute (short-term maximum) BCWQ guidelines for freshwater aquatic life, indicating that the aquatic toxicity database was sufficient to allow for the derivation of full guidelines.

Although BC has yet to derive an approved guideline for cadmium, a working (or interim) water quality guideline for freshwater aquatic life is available and has been referenced in the Project Environmental Assessment. This guideline is considered to be conservative and protective. This is evidenced by the Canadian Council for Ministers of the Environment (CCME) revised Aquatic Life environmental quality guideline published in 2014. The BC working water quality guideline is hardness dependent, and represented as a range of 0.01 (at hardness of 30 mg/L) to 0.06 µg/L (at hardness of 210 mg/L); the CCME (2014) long-term guideline for cadmium is of 0.09 µg/L at hardness of 50 mg/L, with the equation $CWQG = 10^{[0.83(\log[\text{hardness}]) - 2.46]}$ provided for calculation of a site-specific hardness between 17 and 280 mg/L.

Similar to cadmium, although no approved BCWQ guideline is available for nickel, a working guideline for freshwater aquatic life is available and has been used in the Project Environmental Assessment. The reference provided for the working guideline for nickel is the CCME Canadian Environmental Quality Guidelines (2005). A review of the CCME guidelines indicates that no further updates to the guideline have been made. As such, the working guideline is considered to be the most appropriate Canadian guideline for use in the evaluation of surface water quality associated with the Project.

Review of Price (2014) Assessment

Price (2014) has conducted a literature review to evaluate the potential for seven metals aluminum, cadmium, copper, lead, nickel, silver and zinc to adversely impact salmonids in the area of the TMF. It is unclear why these seven metals were selected; review of the

Project Environmental Assessment indicates that only selenium was identified as a COPC with the potential for residual effects in Sulphurets Creek. Furthermore, the evaluation presented does not appear to acknowledge or understand the various stages of hazard evaluation; the COPC screening presented by Rescan (2013) has generally been conducted according to provincial and national methods/guidance. The use of the BCWQ guidelines and baseline conditions in the screening process are recommended and acceptable approaches, and because the seven metals identified by Price were not carried forward as final COPCs for the Project, no further evaluation of potential impacts is warranted.

A review of Price (2014) indicates an apparent lack of understanding regarding the importance of baseline water quality in determining the potential for impacts to salmonids. Although baseline conditions are mentioned in the early sections of the document, the conclusions regarding potential impacts to salmonids do not discuss baseline conditions, which are crucial in this evaluation. We also note that Price's (2014) comparison of baseline water quality to predicted water quality compares measured dissolved metals concentrations representative of the overall watersheds to predicted total metals concentrations representative of individual 'sites'. This comparison represents a worst-case scenario; the evaluation compares the lower measured dissolved metals baseline concentrations to the maximum predicted total surface water concentrations (represented by Scenario 4: Upper Case). By nature, models such as that used in the prediction of water quality for the Project are inherently conservative, and thus, the comparison of the two worst-case scenarios (low dissolved metals baseline concentrations to maximum total metals predicted concentrations), is unrealistic and will over-estimate potential impacts to water quality above baseline. We acknowledge that some level of conservatism is required based on the various unknowns at this stage in the Project, however, introducing an unrealistic level of conservatism into the assessment will result in conclusions that are fraught with uncertainty, to the point that they become meaningless.

The evaluation provided by Price summarizes a portion of the available literature on the sub-lethal toxicity of these metals, with the conclusions largely based on behavioral endpoints. Behavioral endpoints are inherently subjective and have the potential for observer bias. Because of this, less weight is put on behavioral endpoints compared to other endpoints that can be directly measured, and it is not common to derive a water quality guideline based on a behavioral endpoint. This is evidenced by guidance provided by the BC MoE (2012), which indicates the following regarding endpoints considered in the derivation of the BC Water Quality Guidelines:

> *"Endpoints should be demonstrated to be ecologically relevant toxic endpoints. These generally include but are not exclusive to reproduction, growth, development and survival of young and adults. Other endpoints (e.g., behaviour, deformities etc.) will be evaluated on a case-by-case basis."*

Furthermore, Price (2014) does not appear to acknowledge the water treatment proposed for the Mine Site. Chapter 14 of the Project EIA discusses the Mine Site Water Treatment Plant (WTP); water collected at the WSF will be pumped to the Mine Site WTP located downstream. The Mine Site WTP will use a conventional HDS lime water treatment process, and water quality for effluent from the WTP was predicted using a pilot-scale testing program of the HDS process. The results of the pilot test indicates that concentrations of metals were greatly (in many cases by 90%) decreased, with concentrations of all metals predicted to be below baseline concentrations.

In addition to the above, we have the following comments specific to the individual metals evaluated by Price (2014):

- Price (2014) indicates that the predicted concentrations of aluminum in Sulphurets Creek and Unuk River, during all stages of mine development, are known to have sub-lethal effects on salmonids at low pH (pH ~ 5). The Project EIA indicates that following treatment (i.e., the Mine Site WTP), that the pH of the effluent will the circumneutral. The conclusions reached by Price (2014) regarding the potential for sub-lethal toxicity to salmonids exposed to aluminum in the Unuk River Watershed are therefore considered irrelevant, as acidic conditions required to elicit the sub-lethal effects reported by Price (2014) are not anticipated.
- As discussed above, the CCME has recently published a revised aquatic life environmental quality guideline for cadmium; the revised CCME guideline is based on a current literature review, and has been derived using a species sensitivity distribution approach, thereby ensuring protection of the most sensitive species. It is noted that CCME (2014) reports rainbow trout (*Oncorhynchus mykiss*) to be the most sensitive fish species, and has used the available toxicity data for this species in the derivation of the guideline. The CCME (2014) long-term guideline for cadmium is of 0.09 µg/L at hardness of 50 mg/L, compared to the BCWQ for cadmium at a hardness of 50 mg/L of 0.02 µg/L. Given the increase in the revised CCME guideline based on the current scientific literature and approaches for guideline derivation, Rescan's use of the BCWQ guideline for cadmium in their assessment is considered to be conservative.
- Price (2014) indicates that predicted maximum concentrations of nickel in Unuk River during all phases of the Project will have a negative effect on salmonids. This conclusion again seems to be based on a single reference, Giattina et al. (1982) and reported avoidance behaviors in fish exposed to nickel. It is noted that the worst-case (Scenario 4: Upper Case) mean concentration of > 17 µg/L referenced by Price is well below the BCWQ guideline for nickel of 65 µg/L (based on a maximum hardness of 60 to 120 mg/L). As discussed in earlier sections of this review, use of this worst-case scenario is considered overly conservative, and is likely to over predict potential impacts. As such, and given that the concentration is less than half of the applicable BCWQ guideline, the potential for impacts to salmonids is considered to be low.

The seven metals discussed by Price (2014) are less the BCWQ guidelines and/or the baseline concentrations and therefore are not COPCs. On this basis, these seven metals do not require further consideration.

Conclusions

The COPC screening approach used by Rescan has followed standard risk assessment approaches, as recommended by the BC MoE, the CCME and Environment Canada. The seven metals evaluated by Price (2014) were not identified as COPCs based on concentrations less than the BCWQ or less than baseline concentrations, and therefore, no further evaluation was required. Furthermore, the Price (2014) review does not acknowledge the water treatment proposed for the Mine Site, which will reportedly result in a significant reduction of metals concentrations.

It is our opinion that Rescan has relied on the best available science and methods to predict the potential for discharge from the Mine Site to affect aquatic life, including salmonids, in the Unuk River Watershed.

REFERENCES

BC MOE (British Columbia Ministry of Environment). (2013). Guidance for the Derivation and Application of Water Quality Objectives in British Columbia. Water Protection and Sustainability Branch Environmental Sustainability and Strategic Policy Division.

BC MOE. (British Columbia Ministry of Environment). (2012). Derivation of Water Quality Guidelines to Protect Aquatic Life in British Columbia.

CCME (Canadian Council of Ministers of the Environment). (1999). A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life.

CCME (Canadian Council of Ministers of the Environment). (2014). Canadian Water Quality Guidelines for the Protection of Aquatic Life. Cadmium.

GENERAL LIMITATIONS AND CONFIDENTIALITY

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This report has been prepared based on the Seabridge Statement of Work and the literature identified during the review. Dr. Chris Kennedy expresses no warranty with respect to the accuracy of the data reported in the literature.

The evaluation and conclusions reported herein do not preclude the identification of additional literature pertinent to the metals discussed in this report. If new literature/studies become available, modifications to the findings, conclusions and recommendations in this report may be necessary.

Where information obtained from reference sources is included in the report, no attempt to verify the reference material was made. Dr. Chris Kennedy expresses no warranty with respect to the toxicity data presented in various references or the validity of the toxicity studies on which it was based. Scientific models employed in the evaluations were selected based on accepted scientific methodologies and practices in common use at the time and are subject to the uncertainties on which they are based.

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