Sabina
GOLD & SILVER CORP.

BACK RIVER PROJECT
Responses to Technical Comments on the Hydrodynamic Model for Water Licence (2AM-BRP1831) Amendment

March 12, 2021

BACK RIVER PROJECT

Responses to Water Licence Amendment Hydrodynamic TCs

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1. Responses to Comments

1.1 RESPONSE TO KITIKMEOT INUIT ASSOCIATION

KIA-WLA-TC-01: Divergence from FEIS predicted impacts to Goose Lake

Detailed Review Comment

In the Modification Package Version 2 under Section 2.3.3 Sabina writes, *"Water management and discharge will also continue to occur in the same manner as outlined in the FEIS, and discharge to the environment will only occur during Closure and in compliance with pre-established discharge criteria as previously assessed and permitted." In Section 3.1.6 Sabina states, "In alignment with original Project design, discharge to the environment will only occur on Project Closure. At that time, discharge will be provisional on attainment of the Site-Specific Water Quality Objectives and established Water Licence criteria. No changes to these requirements are being proposed as a part of this modification. As a result, residual effects to Freshwater Water or Sediment Quality remain as predicted in the FEIS. These effects are anticipated to be negligible in nature and the significance rankings of the overall residual effect aspects remain unchanged from those predicted in the FEIS."*

These statements indicate that the modifications to the Back River project will not change the impacts to the receiving environment; anticipated effects of the proposed changes to the project will continue to be negligible in nature and in line with the magnitude of effects assessed in the FEIS.

In Section 4.5.4.3.3 of the FEIS Volume 6, Sabina writes, *"For the Closure phase, results indicate that predicted arsenic concentrations remain below the CCME guideline in the main basin of the lake. However, small, localized areas in the western and southern parts of the lake are predicted to have arsenic concentrations above the CCME guideline but at or below the site specific WQO for Goose Lake (0.01 mg/L) … Predicted arsenic concentrations at the known Lake Trout Spawning Habitat area and the Fish Overwintering Habitat area are predicted to remain below the CCME guideline for the protection of freshwater aquatic life (0.005 mg/L)."*

"For the 'worst-case' year, predicted arsenic concentrations are greater than the CCME guideline throughout [Goose Lake] during all seasons and at all depths. However, predicted concentrations remain below the WQO (0.01 mg/L) for the main basin of the lake."

"Overall, Goose Lake is predicted to have arsenic concentrations close to or below the CCME guideline for the protection of freshwater aquatic life (0.005 mg/L) for the long-term (Figure 4.5-1)."

The predicted effects of surface contact water discharged to the freshwater environment outlined in the FEIS included consideration of all areas of Goose Lake and found arsenic concentrations were to remain below the Site-Specific Water Quality Objective (SSWQO) during discharge and that concentrations would remain below the CCME guideline for the long-term. These predictions were used to predict a low magnitude effect on Goose Lake water quality with no residual effects. Similar predictions were made for the other significant parameter of concern, copper:

In Section 4.5.4.3.8 Copper of the FEIS, Sabina writes, *"Copper concentrations were predicted to be greater than the CCME water quality guideline for copper in soft waters (0.002 mg/L) in the Llama OF and Goose IF SE tributaries during the Closure and early Post-Closure phases (Tables 4.5-7, 4.5-8, and*

4.5-10). However, as copper is naturally abundant in Goose Lake and its tributaries, a site-specific WQO was developed of 0.0042 mg/L.

No predicted copper concentrations were greater than the site-specific water quality objective of 0.0042 mg/L. Although some predicted copper concentrations in Goose Lake tributaries were greater than the generic CCME water quality guideline (0.002 mg/L), the predicted copper concentrations were expected to be within the natural variation in the receiving environment. Therefore, the magnitude of the residual effects from copper on water quality was concluded to be low. The duration of the residual effects of copper, based on the quantitative modelling results, was short term, because the long-term median concentrations of copper in the Post-Closure Phase were close to baseline concentrations and less than the site-specific water quality objective and the generic CCME water quality guideline."

Section 5.1 of the Hydrodynamic and Water Quality Modelling of Goose Lake highlights that the "*Time periods when maximum monthly concentrations for water quality constituents are predicted to be above chronic water quality benchmarks (Table 1) at the outlet of Goose Lake are:*

- *The modelled operational, closure, and post-closure periods: aluminum and copper*
- *The modelled closure and the post-closure periods: nitrate, nitrite, arsenic, chromium, and iron."*

As depicted in Figures 1 of Attachment 1 of the Hydrodynamic and Water Quality Modelling of Goose Lake technical memorandum, concentrations of nitrite, aluminum, arsenic, copper and iron do not recede below their respective guidelines or objectives during the 25 years of mine life modeled. This suggests that despite the entirety of Goose Lake being considered as part of the mixing zone, these parameters remained elevated and could potentially impact aquatic biota further downstream.

In the FEIS, increases to receiving environment concentrations of arsenic, aluminum, copper, and other parameters of concern were considered low in magnitude, medium term in duration and reversible. The updated hydrodynamic model suggests that concentrations of these parameters of concern will be higher than previously anticipated and lasting longer in duration. This represents a significant divergence from the FEIS conclusions.

Recommendation/Request:

We recommend Sabina propose and implement mitigations for impacts to water quality such that the significance evaluations presented in the FEIS are maintained. We highlight predicted residual elevated concentrations of nitrate, nitrite, aluminum, arsenic, copper and iron in the freshwater environment presented in the hydrodynamic modelling for Goose Lake as a significant concern, and recommend mitigations focus on that list of parameters at minimum.

Sabina Response:

Sabina agrees with KIA's recommendation. The current version of hydrodynamic modelling was developed in accordance with Part E, Item 15 of the Type A Water Licence (2AM-BRP1831), which required Sabina to provide a hydrodynamic model following conclusion of the environmental assessment. The current modelling results for Goose Lake have been used as an initial tool for the purposes of project planning and to provide an initial outline of potential risks to water quality downstream of the lake outlet.

These current model outputs provide Sabina with the foundation on which to:

- undertake further engineering refinement;

- investigate potential mitigation alternatives (i.e., treatment, adaptive management refinements in existing management plans);
- consider and incorporate further monitoring data;
- modify existing management systems;
- address excessive conservatisms in the model; and
- define proposed effluent criteria and/or if needed, SSWQO's.

All of which will allow Sabina to update the hydrodynamic and water quality model to specifically address regulatory concerns related to the receiving environment in Goose Lake, as well as define realistic/appropriate mixing zones for each of the discharges prior to their release to the receiving environment.

Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

KIA-WLA-TC-02: Change in discharge period to include two years of the operational period.

Detailed Review Comment

In the Modification Package Version 2 under Section 2.3.3 Sabina writes, *"Water management and discharge will also continue to occur in the same manner as outlined in the FEIS, and discharge to the environment will only occur during Closure and in compliance with pre-established discharge criteria as previously assessed and permitted".*

In Section 1.0 of the Hydrodynamic and Water Quality Modelling of Goose Lake, Sabina states, *"The Project is a proposed open pit and underground gold mine with an estimated 28-year life from mobilization to post-closure. Water associated with mine-affected discharges to the receiving environment (Goose Lake) are not planned to occur until Year 11 of the operational period."*

The change in discharge timelines should be clearly communicated.

Recommendation/Request:

Please clarify within the application that discharges to the environment are now planned during the operation project phase representing a departure from FEIS predictions. We further request a discussion of any potential implications this change may have on interactions with the receiving environment.

Sabina Response:

Sabina confirms that water associated with mine-affected discharges to the receiving environment (Goose Lake) are not planned to occur until Year 11 of the operational period, and that Section 2.3.3 of the Modification Package was an error.

KIA-WLA-TC-03: Water quality predictions and defining the mixing zone

Detailed Review Comment

In the Technical memorandum Hydrodynamic and Water Quality Modelling of Goose Lake Section 1.2 Sabina indicates that, *"The main objective of this study was to predict water quality constituent concentrations at the outlet of Goose Lake and identify constituents of potential concern."*

In Section 6.1.5 of the Back River Project Water Management Plan Sabina states, *"This updated Hydrodynamic model will be utilized to verify the Water and Load Balance model, determine treatment options required to meet CCME guidelines, and to establish potential associated regulated mixing zones within the receiving environment."*

At the IR stage, KIA requested the updated hydrodynamic model predict water quality at the edge of a regulated mixing zone to assist reviewers in understanding the extent water quality will exceed applicable water quality objectives guidelines within Goose Lake. By modeling a single point (the outlet), the extent of impacts within Goose Lake cannot be assessed. Furthermore, Goose Lake is fish bearing and water quality within it should be maintained at or below CCME WQOs or SSWQOs as applicable for the protection of aquatic life in that waterbody beyond a 100 m mixing zone. As part of Sabina's water management objectives as outline in Section 7.2 of the Back River Project Water Management Plan, they are committed to, *"Collecting and treating contact water as required to meet SSWQOs in the receiving environment."* Therefore, as part of this commitment to meeting SSWQOs in the receiving environment a discussion surrounding treatment options should be provided.

In section 4.0 Model Uncertainties and Limitations Sabina states, "*The water balance model is based on average climate conditions (SRK 2020) as such no climate variations are included in the hydrodynamic model, (i.e., wet or dry years).*" Water quantity plays an important role in determining the concentration of water quality parameters in the receiving environment. Completing a sensitivity analysis by altering precipitation scenarios (i.e., wet vs dry year scenarios) will help the reviewer evaluate the size of the mixing zone and the extant of mine impact on the receiving environment.

In Section 6.1 of the Back River project Water Management Plan Sabina states, *"The Water and Load Balance model for the Project was developed using the GoldSim© software package (version 12.1.3) (GoldSim Technology Group 2019). The model was run on a daily time step and runs from Year -2 to Year 47. This run length was chosen as it allows the model to run until steady state conditions are reached in pits and downstream receptors."*

In Section 2.2 of the Technical memorandum Hydrodynamic and Water Quality Modelling of Goose Lake Sabina states, *"Two modelling periods were used in the Goose Lake Model… Forecast Periods: Project mining Year 11 to 25 (SRK 2020, Appendix A). This period includes the final two years of operation, eight years of closure, and five years of post-closure (as discharge quality is expected to improve after closure). This specific timeframe was used in the modelling as this is the period that site contact water will be discharged to Goose Lake. The model forecast simulation was initialized in fall of Year 10 of operations prior to lake freeze-up to accommodate a warm-up period."*

The figures contained in attachment 1 of the hydrodynamic model depict concentrations of nitrate, nitrite, aluminum, arsenic, copper and iron all exceed either their CWQGs or SSWQOs. Concentrations of nitrite, aluminum, arsenic, copper and iron do not recede below their respective guidelines or objectives during the 25 years of mine life modeled. This suggests that despite the entirety of Goose Lake being used as the mixing zone these parameters remained elevated and could potentially impact aquatic biota further downstream. The point in time at which these parameter concentrations return to background concentrations or below CWQGs or SSWQOs remains unknown suggesting the time frame of modeling

should be extended to understand when concentrations of these key parameters no longer pose a threat to aquatic biota. As noted by Sabina earlier 47 years of modeling were required to reach steady-state conditions.

Recommendation/Request:

1. As several parameters of concern do not meet CWGQs or SSWQOs at the outlet of Goose Lake, Sabina is again requested to define the extent of the mixing zone(s) for each inflow into Goose Lake under a) increased and decreased precipitation scenarios (i.e., wet vs dry year scenarios), b) increased warming conditions (i.e., a thickening of the active layer), c) under ice to determine the effect of cryo-concentration on water quality within Goose Lake. Note the under-ice scenario should assume 100% solute exclusion.

2. Provide a discussion on treatment options to be utilized to meet CCME guidelines or SSWQOs as applicable at the edge of a defined mixing zone. Note that the regulated mixing zone should be 100 m from where surface contact water flowing from the site enters the receiving environment.

3. Extend the timeframe of the modelling to include the point at which parameters of concern (nitrate, nitrite, aluminum, arsenic, copper and iron) return to concentrations below their respective CWQGs or SSWQOs.

Sabina Response:

Part 1)
Sabina acknowledges that water quality within Goose Lake and in the vicinity of the discharges needs to be further evaluated through updated modelling to facilitate an assessment of potential effects to aquatic life within the lake. The next model update will incorporate updated site-based inputs and include climate sensitivity scenarios (e.g., dry/wet climatic/meteorology conditions), which will allow further investigations of water quality concentrations at various locations within the lake, with particular focus on defining mixing zones.

a,b,c) Using overly conservative model scenarios (e.g., more extreme/less frequent events) for mixing zone developments (i.e., defining the distance from the discharge point where relevant CCME guidelines and SSWQOs must be met) could potentially result in a larger proposed mixing zone (larger area of the lake where relevant guidelines are not met), which is not the goal of the mixing zone assessment. As part of the mixing zone assessment, upper bound model predictions (e.g., 95th or 99th percentiles of concentrations in the predicted time series over the simulation period, which will also include ice-cover season) will be used to estimate the upper range of predicted concentrations in the lake and determine the locations where relevant CCME guidelines and SSWQOs will be met. Using these upper bound model predictions will result in a reasonably conservative estimate of the mixing zone. It should be noted that discharge during ice-covered conditions is not anticipated, however, predicted concentrations during ice-cover season will be considered in the mixing zone development. The current model considers a range of meteorological conditions (i.e., air temperature, wind speed and direction, relative humidity, barometric pressure, and short-wave radiation) covering 12 years of climate data over the lake; however, it is acknowledged that precipitation and inflow values are currently only representative of average climate conditions (Section 2.4.2 of the hydrodynamic modelling report).

c) The model does account for cryo-concentration (100% salt rejection) and as explained above predicted concentrations over the entire simulations period (including ice cover season) will be used for mixing zone developments.

Part 2)
The next model update will incorporate mitigations and changes to water management plan, and results of the updated model will be used to propose mixing zones. Should future modeling that accounts for these mitigations and updated source term inputs show that constituents of potential concern (CoPCs) remain higher than SSWQOs and/or guidelines at the edge of the mixing zone, Sabina will evaluate treatment options including considering the development of new SSWQOs.

Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

Part 3)
The next model update will include longer simulation period into post-closure, with an aim to illustrate achieving steady state conditions.

KIA-WLA-TC-04: Model warm up period

Detailed Review Comment

In Section 2.2 Sabina states, *"In both modelling periods, a warm-up period was included to provide sufficient time for the model to reach dynamic equilibrium before simulation results were used for comparison against measured data or for future predictions." Further in the report in Section 2.4.5 Sabina states, "Initial conditions on the first day of forecast period (September 15, Year 10; before lake freeze-up) within Goose Lake were defined using the median value reported in Golder 2019 (Appendix 2D, Table 2D-16). Temperature and chemistry were assumed constant throughout the domain for initialization purposes."*

A proportionately larger flush of arsenic is anticipated at the beginning of the discharge period. If the beginning of the modelling period is artificially held constant and/or is not provided for review or compared against measured or for future predictions large fluxes in parameters of concern, which may be acutely toxic to biota, could be missed.

Recommendation/Request:

Please clarify what is considered a "warm up period", the "domain", and why parameters of concern were artificially held constant throughout the domain and indicate how large fluxes in parameters of concern due to discharge initiation will be modeled and where this data can be found for review.

Sabina Response:

A warm-up period was included to provide sufficient time for the model to reach dynamic equilibrium before simulation results were used for comparison against measured data or for future predictions. For example, the Forecast Period starts from Year 11 of operations; instead of starting the model on the first day of Year 11, the model was initiated a few months earlier (i.e., September 15, Year 10 at 00:00 hour) to allow the model to reach dynamic equilibrium. This does not mean inflows to the lake or chemistry of the inflows were modified or held constant. An initial condition for Goose Lake (domain), is required for the model on this start date; this refers to the lake water quality conditions assigned to the lake in the model on the first day of simulation (i.e., in-lake water quality parameter concentrations on the start date of the model and not to inflows rates/chemistries to the lake). There are no mine related inflows to the Goose Lake before Year 11, as such, the initial model conditions in the lake on September 15, Year 10 were assigned the median values/concentrations from all existing monitored data for the month of September for Goose Lake as reported in Golder 2019 (Appendix 2D, Table 2D-16).

Keeping temperature and chemistry constant throughout the domain for initialization purposes, means that for the first day of the simulation period (i.e., initial conditions in the model used for 00:00, September 15, Year 10) the whole lake possesses the same temperature and chemistry. The model then predicts temperature and chemistry in the lake starting the second time step (i.e., 01:00 September 15, Year 10).

Fluxes in all modelled parameters, including parameters of concern, will not be modified and are input to the model exactly as provided by the water and load balance model. These mine-affected inflows/fluxes are active in Year 11.

KIA-WLA-TC-05: Water quality inputs into the hydrodynamic model

Detailed Review Comment

Sabina indicates that, *"Water quality data required for the Goose Lake Model included chemistry and temperature data for inflows to the lake:*

- *For the calibration period: TDS and water temperature…*
- *During the calibration period TDS concentrations of inflows from local watersheds (natural tributaries of Goose Lake basin) were represented by the median TDS concentrations (values reported as "calculated TDS", calculated from major ions as per APHA 2012) reported in the Aquatic Baseline Synthesis Report (Golder 2019), except for PN-04 where average monthly concentrations were used (given the variability)"*

The concentration of several metals (arsenic and copper) is of particular interest for the hydrodynamic model of Goose Lake. Therefore, it would be prudent to include these metals as part of the calibration period to ensure predicted concentrations of these metals are consistent with measured concentrations. Clarification is also required what is meant by median TDS concentrations. Does this refer to the monthly median, annual median, median over the entire monitoring period or another averaging period?

A more conservative approach such as using the 75th percentile would be more prudent.

Recommendation/Request:

We recommend that parameters of concern, such as arsenic and copper, be specifically assessed during the calibration period of the hydrodynamic model to provide confidence in the accuracy of predicted metal concentrations within the forecast portion of the model.

We also request Sabina apply a more conservative value for TDS concentrations at PN04 during the calibration period for inflows from local watersheds; the 75th percentile or higher of seasonal values is recommended.

Sabina Response:

Part a)
Please note:

- Having a reasonable calibration for the transport module indicates that the model tracks the movement of water and dissolved constituents (represented by TDS) reasonably well throughout the vertical and lateral extents of the lake. TDS is considered an appropriate calibration parameter for the water quality model and calibrating additional conservatively modelled dissolved parameters is not considered to add any value.
- Water quality constituents (including metals) are modelled conservatively in the water column, which means that they would not undergo chemical reactions (e.g., precipitation), biological uptake or transformations, or physical processes (e.g., settling). Overall, this assumption would result in concentrations of metals being overestimated by the model.
- As presented in Golder 2016, the hydrodynamic model developed for Snap Lake in the Northwest Territories, simulated metals in two way: 1) applying a conservative assumption (no mechanism that reduces the load and therefore concentration in water column was applied); and 2) applying a settling rate to metals. As presented in Appendix A of Golder (2016), results of both approaches are compared to monitored data which shows the majority of metals using first approach were overestimated in Snap Lake because of the modelled conservatism.

Part b)
Please note:

- The sentence below presented in the hydrodynamic WQ modelling report indicates that instead of using the median concentration/value of all monitored data in 2012 and 2013 (regardless of the month they are collected in) and applying that single concentration/value to inflows throughout the year for PN04 inflows, monthly concentrations/values were calculated using the average of monthly monitored data collected at this location. This therefore provided specific monthly derived concentrations/values for PN04 inflow (rather than a single value applied to all months).

  > *"During the calibration period TDS concentrations of inflows from local watersheds (natural tributaries of Goose Lake basin) were represented by the median TDS concentrations (values reported as "calculated TDS", calculated from major ions as per APHA 2012) reported in the Aquatic Baseline Synthesis Report (Golder 2019), except for PN-04 where average monthly concentrations were used (given the variability observed in the measured data)"*

- The use of the 75th percentile TDS concentration for model calibration is not advised as this would compromise the integrity of the calibration. Specifically, applying higher (upper bound values) TDS concentrations to the inflows during the calibration period will result in an underestimation of TDS concentrations in the lake during the Forecast Period.
- The monthly average of monitored data for TDS used in the model inputs for PN04 was compared to the 75th percentile concentration; the difference between the "monthly average" and "75th percentile of monthly data" is less than 2%.

References:

Golder (Golder Associates Ltd.). 2016. Predictions of Total Dissolved Solids, Major Ions, Nutrients, and Total Metals and Metalloids Concentrations in Snap Lake, 2016 – 2020. Submitted to De Beers Canada Inc. April 2016. URL:http://registry.mvlwb.ca/Documents/MV2011L2-0004/MV2011L2-0004%20-%20De%20Beers%20Snap%20Lake%20Mine%20-%20Extended%20Care%20and%20Maintenance%20Plan%20V1%20-%20C%20and%20M%20Plan%20-%20Apr20-16.pdf

KIA-WLA-TC-06: Model calibration

Detailed Review Comment

In Section 2.4.5 Sabina states, *"During the calibration period TDS concentrations of inflows from local watersheds (natural tributaries of Goose Lake basin) were represented by the median TDS concentrations (values reported as "calculated TDS", calculated from major ions as per APHA 2012) reported in the Aquatic Baseline Synthesis Report (Golder 2019), except for PN-04 where average monthly concentrations were used (given the variability observed in the measured data) (Table 5)."*

In Section 3.0 Sabina states, *"The hydrodynamic and transport modules of MIKE3 FM were calibrated to match measured and predicted thermal and transport behaviour in Goose Lake. The Goose Lake Model was calibrated to measured temperature and TDS concentrations (values reported as "measured TDS") in 2012 and 2013 (Golder 2019) by comparing measured and predicted values."*

Finally, in Section 3.2 Sabina states, *"Predicted TDS profiles at GLTL are compared with the measured data on Figure 7. During both open-water and ice-cover seasons, the predicted TDS profile follows the measured profile pattern. As discussed in Section 2.5.4, TDS concentrations of inflows to the lake were based on "lab calculated" values, while the in-lake concentrations (used to compare to predicted results) were based on "field measured" values. The difference between the two TDS values could cause a minor difference in the reported values. Thus, calibration was considered adequate if the observed and predicted TDS followed the same pattern, while recognizing that the absolute values would not be expected to match."*

TDS inputs should be consistent for all aspects of the model. If measured TDS concentrations are not available for all water quality stations than calculated TDS concentrations should be used consistently for model inputs, model calibration and model forecasting to allow for a more consistent evaluation of model prediction accuracy.

In Section 3.0 Sabina states, *"Within the temperature formulation, the minimum temperature was set to 0°C instead of the default value of -2.1°C to prevent freshwater temperatures dropping below 0°C."* Full rationale for this change and its implications to modelling outputs were not provided.

Recommendation/Request:

We recommend Sabina,

1. Use a consistent measurement approach for TDS inputs into the hydrodynamic model. We specifically recommend the use of calculated TDS given measured TDS is not available for all stations throughout the period of record.

2. Provide an explanation of the implications of altering the temperature formula of the hydrodynamic model.

Sabina Response:

Part 1)
Sabina agrees with KIA's comment; as additional data are collected; they will be incorporated into future iterations of the model. The dataset used to calibrate the model was limited to the available data (field measured TDS values for in-lake concentrations and lab calculated TDS values for inflows to the lake). In the future monitoring programs, calculated TDS value will be collected/analyzed and will be used in the future model updates.

Part 2)

The DHI MIKE model was originally developed for oceans; thus, the range for water temperature in the model includes sub-zero temperatures (i.e., applicable to the natural temperature range of saline waters). The minimum temperature in the model for Goose Lake was changed to zero degree Celsius because Goose Lake is a fresh waterbody and water temperature is not expected to go below freezing (confirmed by under ice monitored data).

1.2 RESPONSE TO CROWN-INDIGNOUS RELATIONS AND NORTHERN AFFAIRS CANADA

CIRNA-WLA-HydroD-01: Hydrodynamic Model Review

Detailed Review Comment

In summary, the model is still preliminary because of uncertainties in the inputs. CIRNAC would request that the next version of this model addresses such issues as:

1. Ability to reproduce vertical physical structure of the lake temperature;

2. Whether cryo-concentrated water is outflowing, if so, when and how much;

3. Mixing zone near inflows rather than using the whole lake.

Recommendation/Request:

- The performance of the model in simulating vertical temperature variability (stratification) must be improved for acceptable validation. No model results that depend on the vertical distribution of dissolved material can be relied upon without a reasonable match to observed temperature stratification.
- The timing of modelled Goose Lake outflows should be presented against observed data, and the goals of the modelling study clarified. In-lake and outflowing concentrations should be reported separately if the environmental or regulatory concerns are separate.
- The report should discuss the fate of water with cryo-concentrated dissolved solids. Is there any mechanism for this water to leave Goose Lake with elevated concentration, or does it in fact mix and dilute with meltwater before outflow? Similarly, is there any mechanism during summer stratification for inflows to transit quickly to the lake outlet with reduced mixing?
- The performance, capabilities and opportunities for improving the results of the model should be further discussed during the upcoming Technical Meetings.

Sabina Response:

Part a)
Sabina agrees with CIRNAC's recommendation. Water quality conditions, including temperature, within Goose Lake are currently being monitored and will continue to be monitored throughout the life of mine. These monitoring data will be used to validate existing model projections or, if required, update and refine hydrodynamic model assumptions and performance to allow updated projections to be developed and addressed (e.g., for regulatory purposes, account for mine plan modifications).

As listed in Section 4.0 of the report, MIKE3 does not include a comprehensive ice module, and modules used in this study do not account for the sediment-water and ice-water heat exchange. As such, this model does not facilitate the mild inverse temperature stratification observed and expected during ice-cover conditions. It should be noted, however, that despite this limitation, chemical stratification expected under ice, or during other low-energy conditions, can still be adequately simulated through refinement of vertical mixing coefficients. Monitoring data collected to date do not yet suggest that vertical stratification of temperature or chemistry during the open water season occurs; however, further work remains to examine the sensitivity of model results at the lake outlet and throughout the lake to variable vertical mixing coefficients. The stratification effect of density differences between mine affected discharges and lake water will therefore be established in the next iteration of the model to replicate the potential for chemical stratification during summer and ice cover conditions.

It should be noted that the ice module limitation is not expected to significantly affect the model's ability to simulate future water quality conditions because:

- mine-affected inflows to Goose Lake do not generally occur during the ice-cover season
- adjustments to the vertical mixing coefficients (for temperature and salinity) via sensitivity testing will be undertaken to examine the potential for short-circuiting of effluent from the discharge points to the lake outlet

Part b, c)
Water quality concentrations throughout Goose Lake and at the lake outlet will be separately presented in the updated modelling report and results for the lake outflow will be only presented when there is an active discharge from the lake. The presence of ice cover at the lake outlet suggests that the potential for cryo-concentrated water leaving the lake is unlikely until substantial melting of lake ice has occurred; any initial flows through the outlet at the onset of spring melt are expected to predominantly be ice melt flow. Short-circuiting of elevated mine affected inflows due to temperature stratification in the lake (once observed through additional monitoring data) is also considered unlikely because higher density mine-affected inflows relative to lake water would conceivably result in a negatively rather than positively buoyant plume; that is, mine-affected flows would migrate to the lower portion of the lake. Nevertheless, these considerations will be examined in closer detail during the next model update and if necessary, modifications to the model can be made to replicate observed chemical stratification.

Part d)
Sabina acknowledges that water quality within Goose Lake and in the vicinity of the discharges needs to be further evaluated to facilitate an assessment of potential effects to aquatic life within the lake. The current version of hydrodynamic modelling was developed in accordance with Part E, Item 15 of the Type A Water Licence (2AM-BRP1831), which required Sabina to provide a hydrodynamic model following conclusion of the environmental assessment. The current modelling results have been used as an initial tool for the purposes of project planning and to provide an initial outline of potential risks to water quality downstream of the lake outlet.

The next model update will incorporate updated site-based inputs and include reasonable and applicable climate sensitivity scenarios, which will allow further investigations of water quality concentrations at various locations within the lake, with particular focus on defining mixing zones.

Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

1.3 RESPONSE TO ENVIRONMENT AND CLIMATE CHANGE CANADA

ECCC-WLA-HydroD-01: Predictions at the Outlet of Goose Lake

Detailed Review Comment

The main objective of the Hydrodynamic and Water Quality Modelling was to predict water quality concentrations at the outlet of Goose Lake (PN03) and identify constituents of potential concern as a result of mine discharges and water withdrawals. This approach identified several parameters that are predicted to exceed CCME water quality guidelines and/or site specific water quality objectives at the outlet of Goose Lake for nitrate, nitrite, aluminum, arsenic, copper, chromium and iron during the various stages of mine life. ECCC notes that the outlet of Goose Lake (PN03) is approximately 4 km from the discharge at

PN04 and approximately 2 km from the discharge at PN05. To have water quality guideline exceedances occur at this distance from the discharges indicates there would be a high degree of alteration to water quality within the entirety of Goose Lake, indicating the potential for effects to aquatic life within the lake. No rationale is provided for why modelling was completed at the outlet of Goose Lake rather than within Goose Lake, in the vicinity of the discharges. The Proponent has not provided any modelling within the two potential mixing zones from the discharges and has not provided any discussion on the potential impacts to aquatic life in Goose Lake. Modelling should be completed at the edge of the mixing zones associated with PN04 and PN05. Mixing zones should be minimized to the extent possible, and guidelines (CCME and site-specific) should be met at the edge of the mixing zone.

Recommendation/Request:

ECCC recommends the Proponent:

- Provide a rationale for the selection of PN03 to assess potential impacts to water quality in the model, rather than locations in the immediate vicinity of the discharges.
- Provide a discussion of the potential impacts to aquatic life within Goose Lake given the modelling predictions, and predicted exceedances at the outlet of Goose Lake at PN03.
- Provide a discussion on the extent of the mixing zones from PN04 and PN05 and provide modelled concentrations at the edge of the proposed mixing zones.

Sabina Response:

Part a, b, c)

Sabina acknowledges that water quality within Goose Lake and in the vicinity of the discharges needs to be evaluated to facilitate an assessment of potential effects to aquatic life within the lake. The current version of hydrodynamic modelling was developed in accordance with Part E, Item 15 of the Type A Water Licence (2AM-BRP1831), which required Sabina to provide a hydrodynamic model following conclusion of the environmental assessment. The current modelling results have been used as an initial tool for the purposes of project planning and to provide an initial outline of potential risks to water quality downstream of the lake outlet (hence the emphasis of modelled WQ at PN03). The PN03 provides an understanding of the full assimilative capacity and mixing potential of the lake.

The next model update will incorporate updated site-based inputs and include climate sensitivity scenarios, which will allow further investigations of water quality concentrations at various locations within the lake, with particular focus on defining mixing zones.

Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

ECCC-WLA-HydroD-02: Model Calibration

Detailed Review Comment

Section 3.0 of the Hydrodynamic and Water Quality Model provides a discussion of the calibration process for the model. This process was completed using measured temperature and total dissolved solids (TDS) concentrations from 2012 and 2013 to match measured and predicted thermal and transport behavior in Goose Lake. The overall conclusion of this calibration is that the model performs adequately as a predictive tool for water quality forecasts in Goose Lake. However, ECCC notes that, based on Figures 4 and 8, calibration was based on only 4 samples over two years at monitoring stations GLWB, GLCB, and GLTL, and on only one sample over two years at GLSE. The Proponent has not provided any discussion related to the minimal data that was used in calibration of the model, how this might impact the outcomes of the model, or whether additional model calibration with more data is required.

Recommendation/Request:

ECCC recommends the Proponent:

a) Provide a discussion on why such a small dataset was used to calibrate the model and how this might impact the outcomes and uncertainty in the modelled results

b) If the use of minimal calibration data has impacted the calibration process and outcomes of the model, provide a discussion on how the model will be further calibrated; this discussion should also include consideration of how the model calibration may affect outputs of the model in future iterations.

Sabina Response:

Part a)
The water quality and temperature dataset used to calibrate the model was limited to available data for four locations in Goose lake collected in 2012 and 2013; however, these data are considered appropriate and adequate for this initial version of the model because they represent the spatial extent of a relatively small lake and include open water and ice cover seasons. As additional data are collected, they will be incorporated into future iterations of the model. Please refer to the summary below and Figure 1 in the report to see where these locations are (in different morphological areas of the lake):

- GLWB is located in the narrow/shallow part of the lake (<2m deep) which becomes temporarily hydrodynamically disconnected from the main body of the lake during ice-cover periods. GLWB is located in the Goose Lake neck which captures all the inflows from upstream of the lake entering at PN04.
- GLCB and GLSE are located within the deeper portions of the lake (>5 m deep) which remains connected to the main body of the lake throughout the year. GLCB is located in Goose Lake central basin and captures inflows from all upstream sources; and GLSE is located in Goose Lake south basin, which captures inflows from southern parts of the watershed.
- GLTL is located at the outlet of the lake (>5 m deep), a small area that also becomes hydrodynamically disconnected from the main body of the lake during the ice-cover period. GLTL located in Goose Lake tail, representing quality of water before it discharges downstream.

Part b)
Please note that:

- The current hydrodynamic model likely overestimates the water quality conditions that we are expecting in Goose Lake. This conservatism makes sure potential changes to lake water quality are not underestimated. A reasonable level of potential uncertainty is addressed by applying conservative assumptions to model inputs and parameters to minimize the likelihood that future predictions will be under-estimated (i.e., modelling water quality constituents as conservative constituents in the water column, meaning that they do not undergo chemical, biological or physical reductive processes that would remove mass from the system, besides via advective outflow). Another level of conservatism was added in tabular results by presenting extreme values (i.e., maximum concentrations) which is capturing a wider range of potential concentrations.
- Water quality, including temperature, within Goose Lake are currently being monitored and will continue to be monitored throughout the life of mine. As necessary, these monitoring data will be used to update and refine the hydrodynamic model (e.g., for regulatory purposes, accounting for mine plan modifications). Monitoring data will be compared to model predictions to confirm that they remain valid.
- As part of adaptive management, the model will continually be used as a tool to incorporate updated site inputs and/or mine plan options to identify water quality outcomes in Goose Lake. Where inputs/mine plan options are incorporated into the model and problematic water quality is encountered, Sabina will be notified, and these will be adjusted iteratively to identify the best outcome for Goose lake water quality.
- In the next iteration of modelling, a sensitivity analysis within the range of what could reasonably be expected will be conducted to evaluate the sensitivity of model predictions to reasonable changes to model setup and input parameters.
- Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

ECCC-WLA-HydroD-03: Uncertainty and Limitations

Detailed Review Comment

The report identifies a number of uncertainties related to the modelling, including that the model has only been based on average conditions and no climate variations have been used (i.e. wet or dry years). ECCC acknowledges that this is an early model iteration, and that the timing of the releases are not until predicted to occur until Year 11. However, as additional data becomes available and the model is further refined, additional sensitivity scenarios, including climate variations should be completed in order to reduce model uncertainty.

Recommendation/Request:

ECCC recommends that future model iterations include relevant sensitivity scenarios, including climate variations, to reduce uncertainty.

Sabina Response:

A sensitivity analysis will be conducted in the next iteration of the hydrodynamic modelling to assess dry/wet climatic/meteorology conditions. It should be noted that:

- As presented in Section 2.4.2 of the hydrodynamic modelling report, the current model considered a range of meteorological conditions (i.e., air temperature, wind speed and direction, relative humidity, barometric pressure, and short-wave radiation) covering 12 years of climate data over the lake; however, it is acknowledged that precipitation and inflow values are currently only representative of average climate conditions.

ECCC-WLA-HydroD-04: Comparison of Model Results to Background Concentrations

Detailed Review Comment

In the analysis of the predicted potential effects to Goose Lake the Proponent compares the modelled concentrations at PN03 to site-specific water quality objectives and the Canadian Council of Ministers of the Environment (CCME) guidelines, but not to the natural background concentrations of Goose Lake. Given the results of the modelling, there is the potential for extensive alteration to Goose Lake water quality. Comparison of predicted water quality to background water quality would provide additional context to the predicted potential changes to water quality in Goose Lake.

Recommendation/Request:

ECCC recommends the Proponent provide comparison of modelled water quality in Goose Lake to natural background concentrations, including for those parameters for which there are no guidelines, in order to better detect any changes from observed background water quality conditions in Goose Lake.

Sabina Response:

The objective of conducting three-dimensional modelling of Goose Lake is to identify the fate, and potential environmental risk of, parameters identified as being of potential concern in the water quality screening assessment. Sabina is concerned that increasing the total number of modelled parameters to include those that have been previously shown to meet regulated water quality criteria at the point of discharge, or even others without applicable regulatory criteria, is likely to increase already lengthy simulation times.

In the next iteration of the model, predicted concentrations within Goose Lake will be compared against background concentrations for all constituents with chronic aquatic life guideline or site-specific water quality objective, if feasible. Future modelling scope will be limited to the constituents with water quality guidelines, for the purpose of assessing mixing zones and effects to aquatic life.

It should be noted that full suite of water quality constituents has been and will be monitored as part of aquatic effects monitoring program and will be screened against background/baseline conditions in the lake as part of the annual reporting for this program.

ECCC-WLA-HydroD-05: Chromium Water Quality Guideline Exceedances at PN03

Detailed Review Comment

Section 5.1 (Model Results) of the Hydrodynamic and Water Quality Model notes that concentrations of several parameters are predicted to exceed chronic water quality benchmarks, including chromium. However, ECCC notes that the concentrations of chromium provided in Table 8 do not indicate any exceedances of the guidelines, nor do the figures provided in Attachment 1.

Recommendation/Request:

ECCC recommends the Proponent provide further clarification on the potential for exceedances of chromium water quality benchmarks at PN03.

Sabina Response:

We thank ECCC for this observation. Chromium has been listed by mistake. As shown in tabular and graphical results, chromium concentrations are predicted to remain below surface water quality guidelines over the simulation period.

ECCC-WLA-HydroD-06: Predicted Water Quality in Goose Lake

Detailed Review Comment

The hydrodynamic and water quality model predicts exceedances of water quality benchmarks for aluminum and copper during operations, closure, and post-closure, as well as guideline exceedances for nitrate, nitrite, arsenic, and iron during closure and post-closure. The analysis completed during previous Regulatory processes did not predict exceedances of the same subset of parameters, and there is currently very little information provided on potential mitigations that may be applied in order to reduce the extent of effects from the Project in Goose Lake.

Based on the discharge approach proposed by the Proponent, water is held through the majority of operations and discharged later in mine life (Year 11 of operations). The results of the Hydrodynamic modelling indicates that this approach appears to lead to exceedances of water quality guidelines in Goose Lake to occur during the closure and post-closure phases of the project, rather than operations. The modelling completed to date includes predictions through 5 years post-closure, but even at the end of the modelled period there

are still predicted water quality guideline exceedances for nitrite, aluminum, arsenic, copper, and iron. Based on this modelling, it is unclear when (i.e., at what point in time post closure) water quality guidelines will be met, as the time-period currently modelled does not depict normalizing or decreasing concentrations for all parameters. Modelling should be extended to capture a sufficient post-closure time-frame where water quality concentrations in Goose Lake are consistently decreasing and are below guidelines. In addition, as described in ECCC Comment 1, modelling should be completed at a minimized mixing zone such that overall impacts to Goose Lake are reduced, rather than at the outlet of Goose Lake. Given the predicted guideline exceedances late into post-closure, additional years of post-closure monitoring may be required.

The Proponent provided several potential approaches to manage concentrations such that guidelines are met, but does not propose a specific path forward to ensure that effects due to discharges will be minimized to the extent possible. The Proponent refers to the fact that discharge will not occur until Year 11 of operations and therefore there will be time to fine tune the model and develop management strategies if the guideline exceedances persist. ECCC acknowledges there is time to refine the model until proposed discharge at Year 11, and that measured data will provide valuable information on the actual site conditions. However, the current results of the model must be acknowledged and a path forward to manage water quality should be developed.

Recommendation/Request:

ECCC recommends the Proponent:

- Identify realistic and feasible options for management of site water quality such that impacts to the water quality of Goose Lake are minimized.
- Provide updated predictions that indicate when in post-closure water quality is expected to meet guidelines at PN03, and the edge of mixing zones associated with PN04 and PN05.
- Provide a timeline of proposed model updates associated with the Project to further refine the model predictions.
- Discuss potential changes required to post-closure monitoring based on the hydrodynamic model results and predicted exceedances of guidelines during post-closure.

Sabina Response:

Part a)
Sabina agrees with ECCCs recommendations. The current version of hydrodynamic modelling was developed in accordance with Part E, Item 15 of the Type A Water Licence (2AM-BRP1831), which required Sabina to provide a hydrodynamic model following conclusion of the environmental assessment. The current modelling results for Goose Lake have been used as an initial tool for the purposes of project planning and to provide an initial outline of potential risks to water quality downstream of the lake outlet.

These current model outputs provide Sabina with the foundation on which to:

- undertake further engineering refinement;
- investigate potential mitigation alternatives (i.e., treatment, adaptive management refinements in existing management plans);
- consider and incorporate further monitoring data;
- modify existing management systems;
- address excessive conservatisms in the model; and
- define proposed effluent criteria and/or if needed, SSWQO's.

All of which will allow Sabina to update the hydrodynamic and water quality model to specifically address regulatory concerns related to the receiving environment in Goose Lake, as well as define realistic/appropriate mixing zones for each of the discharges prior to their release to the receiving environment.

Part b)
Please see response to ECCC-WLA-HydroD-01.

Part c)
Sabina commits to provide the next update to the hydrodynamic model ninety (90) days following approval of the licence, including mixing zone design. The updates are to take into account commitments made with respect to the submissions received during the technical review of the Application, as well as final submission and issues raised during the Public Hearing process. In addition, Sabina will incorporate mitigations and changes to water management and updated site-based inputs, where applicable.

Part d)
Potential changes required to post-closure monitoring based on the hydrodynamic model results and predicted exceedances of guidelines during post-closure will be identified once updated modelling is completed and mixing zones are defined. Where applicable, general monitoring requirements, the Aquatic Effects Management Plan (AEMP) and Interim Closure and Reclamation Plan (ICRP) may be updated to reflect these future potential changes.