

Appendix 2

Review Comments and Short Responses

Review Comments From Golder Associates

1. Additional climatic parameters will be necessary for effectively modeling groundwater transport at the Kiggavik site. We suggest that additional climatic parameters, such as precipitation, evaporation, seasonal temperature trends and permafrost conditions also be examined. The University of Victoria's Canadian Institute for Climate Studies provides a good interface for modeling climatic trends in Canada until the 2080s. A number of models and emission scenarios are available and results are obtainable at localized scales. We suggest that a specific climate model and emission scenario (or a select few climate models and scenarios) be established so that environmental conditions are well defined and additional information and data can be acquired when necessary. This will not only aid in modeling groundwater transport but will also make the data presented in this report applicable to a wider range of modeling efforts that involve climatic and/or hydrological components.

Response: Additional parameters added in Appendix. Section 5.6. Using computer models is discussed in Section 2.2, no further modelling undertaken but Appendix 1 created to detail parameters.

2. Provide Kiggavik site-specific data, particularly for short-term predictions. The report does not always indicate the specific scale or location at which the data are applicable. Climate change is a spatially variable occurrence and predictions vary considerably with respect to regional characteristics. For example, high latitudes are particularly susceptible to the effects of climate change; the Arctic is expected to undergo preferential warming (Kattsov et al., 2005). It is therefore necessary that data are specific to the Kiggavik site. Regional data are provided for the models available through the Canadian Institute for Climate Studies website.

Response: Climate is now specified to Baker Lake region, Systems remain global. Appendix 1 specifies spatial scale where possible.

3. Although the report provides a summary of the major climate forcing mechanisms and the scales at which they operate, it fails to indicate the relative influence of each mechanism. This information will help indicate the sensitivity of the proposed model and how different greenhouse gas scenarios may affect the results.

Response: The climate forcing mechanisms are global scale. Sensitivity is not described as the resolution of the models and the temperature record are too coarse to detect changes reliably.

4. The report indicates a cooling trend over the next 50 years. However, we have run 12 global circulation models under a variety of Intergovernmental Panel on Climate Change (IPCC) derived emission scenarios for the Kiggavik site. The mean, 1st quartile, 3rd quartile, minimum and maximum temperature values for the 61 experiments are indicated in Figure 1. All models present a significant and consistent warming trend over the next 50 years. We therefore suggest the short term climatic trends in this report be further examined.

Response: Cooling over the next 50 years is now broadly anticipated by many groups due to the reduction in solar radiation and the strong negative Arctic Oscillation. The model data has deviated from the real temperatures experienced.

5. It is necessary to provide original sources and cross references in the report. This information will help confirm credibility and allow supplementary data to be obtained when necessary.

Response: Although not all references are referenced within the text a larger proportion have been cross referenced.

Review Comments from Sennes

1. The primary weakness of the report, in my opinion, is that the report does not focus in on the climate in the vicinity of the Kiggavik mine and reaches no specific conclusions relative to the long-term effects on mine tailings storage.

Response: The scenario has been refined to the Baker Lake area, but it should not be refined too much as there is too much uncertainty (Section 5.6). No comment is made on the tailings as that was not part of the initial requirement. Was requested only to define the future climate for modelling purposes on ground freezing.

2. In short, what the report states is that the effects of greenhouse gases on climate forcing will be limited to the next 500 years, after which everything goes back to normal and the primary influences on climate change are the same ones that have been operating on the earth's climate in the past 10,000 years. There is reason to question this fundamental assumption in the report.

Response: This part is correctly understood. A future energy scenario is added to the document in Section 2.2. In addition the return to CO₂ in balance with earth temperature is discussed. CO₂ logarithmic relationship with CO₂ is discussed. The cyclical nature of the drivers for climate change must be considered and are not adequately dealt with in the IPCC models – this is also discussed.

3. However, the underlying premise for this projection of future climate assumes that once the effect of current climate warming due to greenhouse gases is over in the next 500 years, the Arctic ice cap will reform and that everything returns to the same state that it was in after the last ice age.

Response: This part is not correctly understood. A return to ice age conditions will start at some point between now and a time of 50000 years into the future. The decline into an ice age is a slow saw tooth process with both warm and cool periods. The scenario that has been developed clearly shows that after the cooling in the near future there will be warming and then a long period with variable warming and cooling. This is anticipated to be similar to the period 5000YBP in Appendix 1.

4. As for the long-term climate projection present in SRK's Figure 4.7, the projection is remarkably stable over the next 50,000 years. The past 10,000 years have exhibited an unusually stable climate relative to what has happened in previous interglacial periods, and the SRK report projects that the future climate will remain stable for another 50,000 years. This does not seem credible in view of the evidence from ice cores and ocean sediment data used to reconstruct climate change over the past 800,000 years. Therefore, while I credit SRK for having pulled together a good summary of the climate change cycles that may influence our climate over the next 10,000 years, I am sceptical about their application of those cycles to project the potential changes in the 1,000-10,000 year and longer time frame.

Response: The interglacials are typically 10000 years and we are currently at a point where we are roughly 10000 years from the last glacial period. This interglacial is however anticipated to last for 10000 to 30000 years as originally indicated in Section 5.3.1. There may well be small cold and warm periods during this time, but Berger et al (2008) who focussed on this point think this is likely to be a very long interglacial. As the whole area of knowledge is still under development the Berger et al paper was considered to be one of the likely options as they could demonstrate a causal link with solar radiation and therefore it fits with the base assumption in this report that the main climate driver is the sun.

5. It seems to me that this is perhaps the most critical issue for the near term climate change scenario presented by SRK. What happens to the Kiggavik tailings storage if the permafrost is lost in the next 1,000 years?

Response: The point is accepted but the original briefing was to provide possible climate parameters that could be used for modelling the freeze operation at Kiggavik. No requirement was made for describing the tailings as part of this report.

Review Comments from AREVA

1. We would like your report to incorporate a reference to the Arctic Ensemble Scenarios (<http://yukon.cccsn.ca/?page=ensemblescenarios>) and the proposed temperature change at Baker Lake for the 2011- 2100 period.

Response: The Arctic ensembles have been included. Baker Lake data and Ensemble data are plotted and presented along with a description of the data and an extraction of the rate changes expected. To ensure this data is in context I have also added a section comparing IPCC predictions against observed records for Baker Lake for the past 25 years where these are available. Section 5.6.

2. It would be also appropriate to include reference to The Nunavut Climate Change Strategy 2003.

Response: This has been added and the guiding principles and climate change map have been included in the text. It also refers to an earlier section where the Nunavut people's perception of climate change is reported. Section 5.6.

3. Please make sure that the conclusion of your report (including Figure 70) includes the climate change scenario we have been using to estimate permafrost degradation and tailings thermal behavior; that is a 5 degree rise over 100 years from a mean annual surface temperature of -7 °C to -2 °C.

Response: The trend line has been added to the final graph. Section 5.6.