7 February 2014

Mr Kevin O'Reilly
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Dear Mr O'Reilly:

Thank you for the opportunity to review the thermal modelling of the proposed waste rock pile for the Pigeon Pit at the Ekati mine. I have read the documents you directed me to, namely Dominion Diamond's *Ekati Diamond Mine Waste Rock and Ore Storage Management Plan, Pigeon Amendment, December 2013*, and EBA A Tetra Tech Company's report entitled *Pigeon Pit Waste Rock Storage Area Design, Ekati Diamond Mine, NT*. I have no expertise in geochemistry, but I am familiar with geothermal modelling in permafrost terrain. The following comments, therefore, concern the latter report.

I have no doubt that the temperature in the rock pile will drop below 0 °C over the next 10 years, as projected by the thermal modelling. The reason is that I have been assured that the other waste rock piles at Ekati are in this state. However, I have two questions regarding the calibration of the model and one regarding the climate change modelling which I believe will be of interest to the Board in its consideration of the proposed design.

1. Calibration of the model.

   On p. 7 of the EBA report in Table 6, a series of measured and predicted ground temperatures are presented that purport to demonstrate that the model has been well calibrated. The two series are indeed close. However, it is not clear where measured temperatures were obtained, nor is it clear what the nature of the temperatures provided is. In this case, calibration involves running some simulations with the model and checking the temperature data provided by the model against field measurements. If these are close, the model is considered well calibrated. If they are apart, then adjustments are required to various values that are used in the model, such as the thermal conductivities of the materials.

   On p. 4-5, the EBA report states that "borehole data was adopted from the nearby Pigeon Pit site investigation completed by EBA in August 2012. ….. The overburden thickness at OP-01 was 7.5 m, which consisted of 2 m of thawed till, 1 m of ice-rich frozen till, and 4.5 m of frozen till. …" If this is the material that is used for calibration of the model, then it is not clear how the upper 2 m of thawed till can return a temperature of -1.8 °C at 1.7 m depth, as reported in Table 6.

If the calibration temperatures are simply from a reading collected on one day (23 June 2013), then further data should be requested by the Board regarding calibration, because they are not as representative of annual conditions as should be required, especially in the uppermost 8-10 m of the model. In particular, the Board might consider requesting the mean annual temperature predicted by the thermal model at various depths and the actual mean annual field temperatures as measured at the site.

Furthermore, the model should, at calibration predict the active-layer depth (thaw depth) accurately. Since the temperatures presented for calibration are all below 0 °C, it is not possible to verify this condition.

Therefore, the Board may wish to be reassured that the calibration is suitable for the purposes of long-term modelling.

A second calibration issue concerns the nature of heat flow in the waste rock pile. The description of the GEOTHERM software indicates that all heat transfer in the model is simulated as conduction. Given that the waste rock will be piled with a significant porosity, the extent of air convection, especially on the sides of the pile should be addressed. In winter, and in the main body of the pile, convection may tend to cool the pile more efficiently than conduction, but at the edges of the pile there may be more heating in summer. As far as I can see, this topic has not been considered in the design. The till cap will assist in reducing convection, but active-layer development within this cap will not be simulated correctly beneath the 1 m of waste rock cover if convection is ignored. The effects may not be serious at this stage, but may increase over time with climate warming. I suggest that the Board request clarification on this point from EBA.

2. Climate change.

The report suggests on p. 6 that the "Balanced emission scenario" (A1B) used in the thermal analyses is a "reasonably conservative case". The Board may wish to consider that over the last 8 years there has been considerable awareness in Canada of emissions and emissions targets, but the emissions rate has not decreased, and worldwide the trend is the same. We are now have a CO_2 concentration of 400 ppm in our atmosphere, and it is rising at 2 ppm per year. In 25 years we shall be at 450 ppm, the level at which models suggest very serious environmental feedbacks, probably irreversible, will begin. We have already begun to see the feedback operate on Arctic ice cover. If we had begun to reduce our emissions, globally, I would accept that AIB is a reasonable scenario. We have not, and so I conclude that it is unacceptably optimistic. I believe the Board should request examination of the thermal regime of the proposed waste rock pile under more realistic, i.e. a more rapid emissions scenario, A2.

The reason is straightforward. In the results presented, particularly in Table 9 on p. 9, the model projects that the active layer in the pile will increase in thickness. The increase is steady, and there is no suggestion that the thicknesses presented have reached equilibrium. If climate change were to be more rapid that simulated by A1B, then the active layer may, indeed penetrate the till cover.

The Board may wish to consider whether permafrost is sustainable in the waste rock after climate change. Under the A2 scenario, both active layer thicknesses and rock pile temperatures will be higher. It is not clear what they will be at equilibrium under warmer climate conditions. It will be of interest to the Board to know whether, following changes in climate, permafrost remains sustainable in the waste rock. If conditions are expected to change sufficiently for permafrost degradation in a significant portion of the pile within the next 100 years, then the quality of the runoff from the pile may deteriorate. Therefore, the Board may ask for further assessment of climate change impacts on the thermal regime, and the time scale over which significant thawing of the pile is anticipated.

Yours sincerely

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