Zajdlik & Associates Inc.

Memo

To: R. Walbourne, P. Green

From: B Zajdlik

CC: [Click **here** and type name]

Date: 15/04/2015

Re: Viability of the Minewater Management Plan

After review of relevant documents and discussions with Dominion Diamond Ekati Corporation with respect to the proposed Jay Pipe Project the viability of the minewater management plan warrants further discussion. The topics are presented as information requests and appear in no particular order. Responses were provided in Dominion Diamond Mine Ekati Corporation EA1314-01 Jay Project, Dominion Diamond Corporation Developer's, Assessment Report – Responses to Information Requests. April 2015. This document is referred to herein as DDEC (2015).

1. Viability of Minewater Management Plan

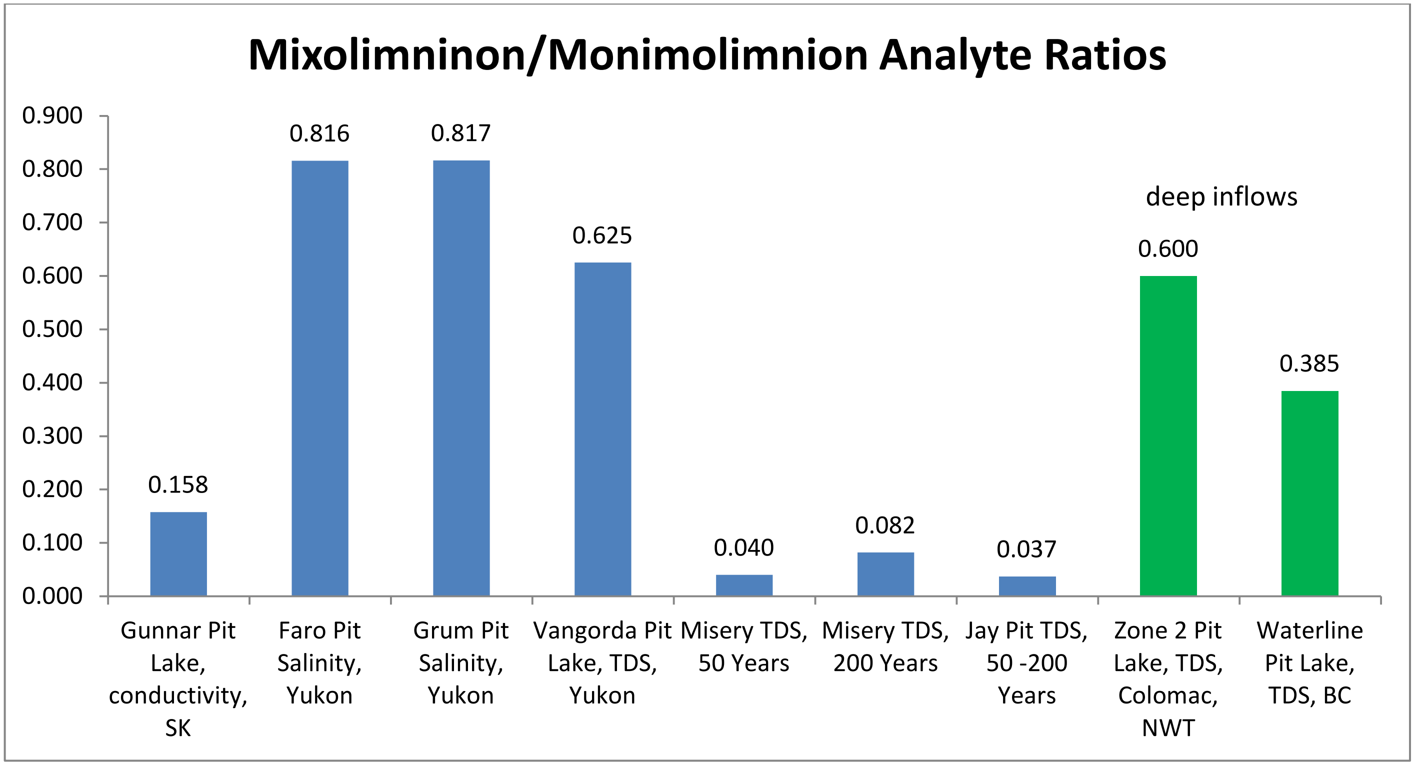
The viability of the minewater management plan is contingent upon perpetual stratification in several pits. The Jay Pit minewater management plan uses modelling and also cites Boehrer and Schultze 2006; Castendyk and Webster-Brown 2007a; Castendyk and Eary 2009 as evidence of "isolating poor quality water (e.g., acidic water, high TDS water) under meromictic conditions in a pit lake (that) has been successfully applied at other mine sites". Please provide a table listing applicable case studies and the congruence between these studies and the Misery, Jay and Lynx pits where perpetual stratification is predicted.

1.1. Response: Information Request Number: DAR-GNWT-IR-62 (DDEC, 2015)

The IR response provides a group of case studies considered suitable based on similarity of climate. The data are presented below.

Site, Region	Meromictic Water Body	Monimo-limnion	Mixo-limnion	Mixolimnion /Monimolimnion Analyte Ratios	Comment
Gunnar Pit Lake, SK	Gunnar Pit Lake, conductivity, SK	1900	300	0.158	Uses conductivity, which can be challenging to measure especially if analyte ratios vary substantively.
Faro Mine, Yukon	Faro Pit Salinity, Yukon	1250	1020	0.816	
Faro Mine, Yukon	Grum Pit Salinity, Yukon	900	735	0.817	(mixolimnion is median of range provided)
Faro Mine, Yukon	Vangorda Pit Lake, TDS, Yukon	2000	1250	0.625	(mixolimnion is median of range provided, assumed typographic error in IR response)
Ekati, NWT	Misery TDS, 50 Years	5500	220	0.040	50 years, Figure 8G2.4-5, Predicted TDS profiles over 200 - year Period after Closure of Misery Pit
Ekati, NWT	Misery TDS, 200 Years	5500	450	0.082	200 years, Figure 8G2.4-5, Predicted TDS profiles over 200 - year Period after Closure of Misery Pit
Jay Pipe, NWT	Jay Pit TDS, 50 - 200 Years	2700	100	0.037	50 Years Figure 8G2.4-6 Predicted TDS profiles over 200-year Period after Closure of Jay Pit m = metres; mg/L = milligrams per litre.
Colomac, NWT	Zone 2 Pit Lake, TDS, Colomac, NWT	1000	600	0.600	subject to deep inflows " From IR: As described in the response to DAR-IEMA-IR-17, deep inflows are not expected to be an issue in either Jay or Misery pit lake."
Equity Silver Mine, BC	Waterline Pit Lake, TDS, BC	2000	770	0.385	
Equity Silver Mine, BC	Maine Zone Pit				excluded due to stirring

The data are plotted below.


Mixolimninon/Monimolimnion Analyte Ratios
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.158
0.816
0.817
0.625
0.040
0.082
0.037
deep inflows
0.600
0.385
Gunnar Pit Lake, conductivity, SK
Faro Pit Salinity, Yukon
Grum Pit Salinity, Yukon
Vangorda Pit Lake, TDS, Yukon
Misery TDS, 50 Years
Misery TDS, 200 Years
Jay Pit TDS, 50 -200 Years
Zone 2 Pit Lake, TDS, Colomac, NWT
Waterline Pit Lake, TDS, BC

The figure shows that the mixolimnion / monimolimnion analyte ratios are an order of magnitude lower than in the selected case studies. Given the reliance of the mine water management plan on perpetual stratification the reasons for the marked difference between predicted and measured ratios should be discussed.

The recommended discussion should also include a sensitivity analysis, particularly for the Jay Pit Lake which is intended to support aquatic life and is predicted to remain stratified in perpetuity. Sensitivity analysis is recommended by Castendyk and Brown (2007b) to explore uncertainties in predictions.

One source of uncertainty is the effect of salt exclusion particularly if the concentrations in the mixolimnion are under predicted. This is because salt exclusion can affect meromixis both positively and negatively (Pieters and Lawrence, 2014). The extent of the salt exclusion effect is a function of the chemoclime gradient, surface area to volume ratio of mixolimnion, etc. Although the W2 model used to predict pit stratification "can model formation of ice cover, it does not include salt exclusion" (DDEC 2014 DAR Appendix 8G) so the extent of the effect, particularly if the chemocline gradient is weaker than expected, is not known. It is not clear without modifying the model, how this uncertainty would be addressed.

Another source of uncertainty is the composition of groundwater at depth as discussed in section 5. This is because ground water inflows that are hyposaline relative to the monimolimnion can reduce stability (Pieters and Lawrence, 2014). Note that the importance of this depends upon the unknown degree of difference between the expected and observed groundwater flows but may be mitigated due to the expected net positive flow out of the Jay and Misery pits.

There is a non-zero risk that seismic activity will destabilize the stratification due to an internal seich. Internal seiching and some mixing were detected at the Waterline pit-lake despite being 1,600km from the epicentre (Pieters and Lawrence, 2014.). Seismicity is discussed in the DAR (Appendix 3B, section 3.5). The risk of seismicity in destabilizing the perpetual stratification predicted for Jay Pit Lake should be estimated. This is of lesser consequence for the Misery Pit lake which is 1) not intended to support fish and 2) is predicted to become fully mixed within 3000 years (DAR Appendix 8G, Figure 8G2.4-7).

1.2. References

Boehrer B, and M. Schultze. 2006. On the relevance of meromixis in mine pit lakes. 7th International Conference on Acid Rock Drainage (ICARD), March 26-30, 2006, St. Louis, Missouri, R.I. Barnhisel (ed.) American Society of Mining and Reclamation (ASMR), Lexington.

Castendyk, D.N. and J.G. Webster-Brown . 2007a. Sensitivity analyses in pit lake prediction, Martha Mine, New Zealand: Relationship between turnover and input water density. Chem. Geol. 244: 42-55.

Castendyk, D.N. and J.G. Webster-Brown. 2007b. Sensitivity analyses in pit lake prediction, Martha Mine, New Zealand 12: Geochemistry, water–rock reactions, and surface adsorption. Chemical Geology, Volume 244: 56.

Castendyk DN, Eary LE (eds). 2009. Mine Pit Lakes: Characteristics, predictive modelling and sustainability, Vol. 3. Management Technologies for Metal Mining Influenced Waters. Society for Mining, Metallurgy and Exploration Inc. (SME). Littleton, CO, USA.

Pieters, R. and G.A. Lawrence. 2014. Physical processes and meromixis in pit lakes subject to ice cover Can. J. Civ. Eng. 41:569–578.