Alistair MacDonald

From: Adrian Brown [abrown@abch2o.com]

Sent: August 29, 2007 9:53 PM

To: Alistair MacDonald

Cc: 'Catherine Mallet'; 'Lionel Marcinkoski'; 'Lindsay Cymbalist'; 'Michael Palmer'; 'Nathan Richea'; 'Teresa Joudrie'; 'Kathleen Racher'; 'Lorraine Seale'

Subject: Tamerlane Ventures: Ammonia Evaluation Information

To: Alistair MacDonald, Mackenzie Valley ~~Land and Water~~ Board
EIR

Alistair:

Please find for submission the attached information relating to ammonia concentration evaluation for mines utilizing emulsion/ANFO mixes as the blasting agent. The information has been extracted from "Diavik Diamond Mine Ammonia Management Plan Review Panel Report, prepared by the Weh'eezhii Land and Water Board Ammonia Management Plan Expert Panel, dated February 9, 2007. This document is available on the WLWB website at http://www.mvlwb.com/pdf/pre2000water/N7L2-1645/Report/AmmMgmt/AMP/AMP-ExpertPanelReport-Feb07.pdf

The above study also provides a template for the evaluation of the concentration of ammonia in a mine discharge stream, using source concentraions of ammonia, and the water balance for the project. This evaluation applied to the Diavik site is available on the WLWB website at http://www.mvlwb.com/pdf/pre2000water/N7L2-1645/Report/AmmMgmt/AMP/AMP-Expert-AmmoniaModel7.zip. The file contains the computational framework for evaluation of the quality of any conservative constituent of a discharge water stream of a mining project.

Respectfully submitted

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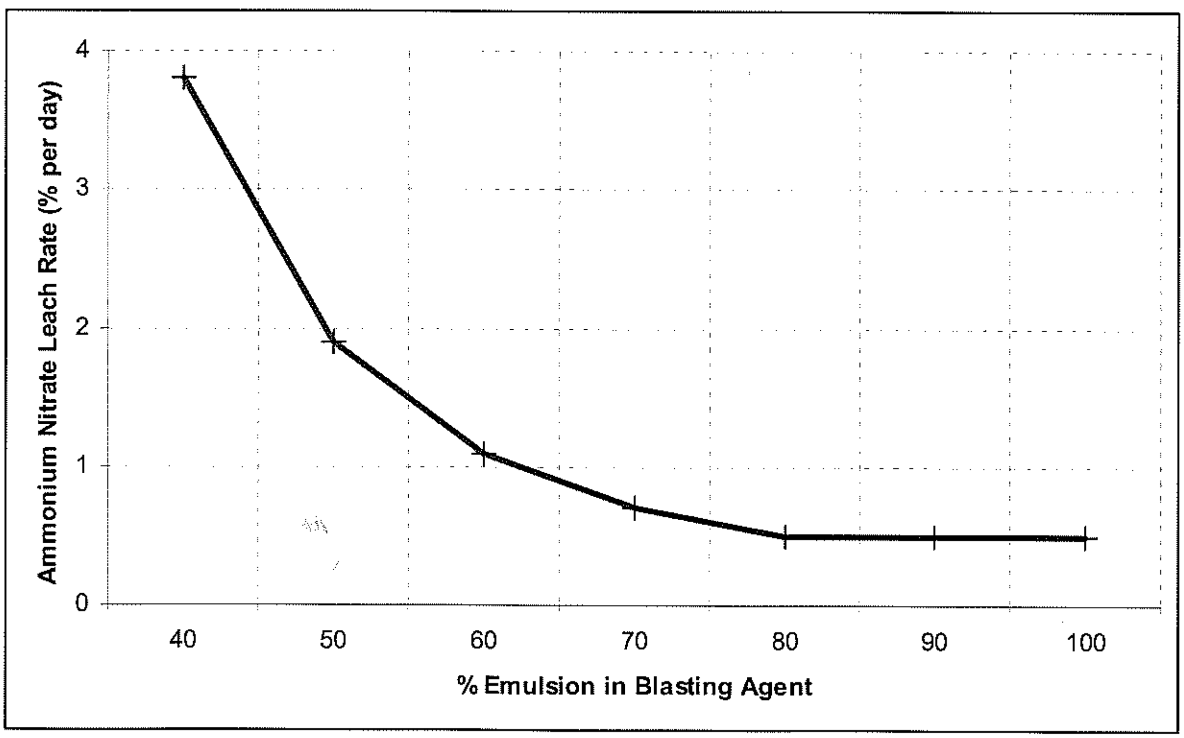
Memorandum

AdrianBrown

Date:	August 29, 2007
From:	Adrian Brown, Adrian Brown Consultants
To:	Alastair MacDonald, Mackenzie Valley Land and Water Board
Subject:	**Dissolution Rate of ANFO-Based Blasting Emulsions**

The leaching rate of bulk emulsions increases with ANFO (Ammonium Nitrate/Fuel Oil) content in the blend as shown in Figure A1-1 (Orica Mining Services, undated communication), using data from laboratory experiments. The emulsion was contained in cylindrical sieves immersed in a large volume of stirred water. The conditions are not exactly comparable to emulsion attacked by water while loaded in a borehole, but should show similar behaviour. One may note from this data that moving from 65% emulsion/35% ANFO to 80% emulsion/20% ANFO approximately halves the ammonium nitrate leaching rate; moving to 100% emulsion would give little, if any, additional improvement. The composition of the emulsion tested was not exactly the same as that used at Diavik, but the latter should exhibit similar behaviour.

Figure A1-1: Leaching Rate of Doped Bulk Emulsion



Memorandum

Source: Matts, Brown, and Koren, 2007, Section 2.2.3

Memorandum

REFERENCE

Matts, T., Brown, A., and Koren, D., 2007. *Diavik Diamond Mine Ammonia Management Plan Review Panel Report*. Report prepared for the Wek'eezhii Land and Water Board by the WLWB Ammonia Management Plan Expert Panel, February 9, 2007. Copy of report available on WLWB website at http://www.mvlwb.com/pdf/pre2000water/N7L2-1645/Report/AmmMgmt/AMP/AMP-ExpertPanelReport-Feb07.pdf

1. INTRODUCTION

The WLWB ammonia simulation model has been prepared to determine the lowest practical concentration of ammonia in discharge to Lac de Gras from the Diavik project.

2. METHOD

The model simulates the non-production portion of the water management system at Diavik. This system collects water containing ammonia from the mining areas, discharges the combined flow into the North Inlet, and then passes North Inlet water through the (phosphate and TSS) Water Treatment Plant to discharge in Lac de Gras.

The water management system that contributes to the discharge into Lac de Gras is shown in Figure A-1. The principal components of the system that are considered in the ammonia model are as follows:

1. A154 Surface Mine. This mine uses ammonium nitrate based blasting agents, and has inflow from groundwater that mobilizes the ammonium nitrate residue to the water management system.
2. A418 Surface Mine. This mine is currently being prepared for development by construction of a levee around the mine area and pumping lake water to the North Inlet for sediment removal and discharge. Subsequently, the
3. A154/A418 Underground Mine. This mine complex is being developed to exploit the lower portions of the A154 and A418 kimberlite pipes from underground. Ammonium nitrate based explosives will be predominantly used in this complex. Water inflow to these mines will rapidly dewater the surface mines from above, and the (large) total flow will be directed to the North Inlet.
4. A21 Surface Mine. The A21 kimberlite is currently being evaluated by underground exploration. If developed, extraction will be by surface mining, followed by underground extraction. The water from this mine will be directed either to the North Inlet system, or to the Processed Kimberlite Containment (PKC) system, from which there is normally no discharge to Lac de Gras.

The model operates by considering the mass flux of ammonia through the North Inlet on a monthly basis. It computes the ammonia discharged to the North Inlet by these components, computes the amount of ammonia lost during residence in Lac de Gras, and computes the amount of ammonia lost by discharge through the WTP to Lac de Gras. It then computes the concentration of ammonia in the North Inlet at the end of the month by dividing the remaining ammonia into the remaining water volume in the North Inlet.

3. CALIBRATION

The model is calibrated against the performance of the water management system for the period 2003 through 2006. The calibration is used to develop three parameters that fit the ammonia concentration at discharge to the ammonia used in mining:

1. Ammonia Loss Rate. This annual parameter is computed from the relationship between the actual ammonium nitrate used in blasting to the ammonia that is discharged from the mining system. The loss rate has been computed for the last four years, and is presented in Table A-1. The loss rate has increased over the life of the A154 Surface Mine, and is currently standing at an annual average loss rate of 2.3% of ammonium nitrate used in blasting. This value has not been significantly reduced by recent variation in emulsion/ANFO mixture from 65/35 to 80/20, suggesting that the loss rate is not strongly dependent on blasting agent solubility. The increase in loss rate has been related to the water inflow to the mine, as shown in Table A-1.
2. Ammonia Rate Factor. This parameter is developed to produce the observed significant variability in ammonia loss from month to month. The causes for the variability from month to month are not well known, but they do occur. The monthly Ammonia Rate Factor that best reproduces the variability of the discharged ammonia concentration is presented in Table A-2, using data collected from the A154 Surface Mine. Note that the rate factor has been selected to produce the magnitude of the variations observed in ammonia discharge, not necessarily the month of the year in which they have occurred historically.

3. North Inlet Ammonia Destruction. This parameter is computed from the observed behavior of the system to date to reflect the monthly amount of ammonia that is destroyed (likely converted to nitrate and nitrogen) in the North Inlet. The ammonia destruction is presented in Table A-3, and represents the average of the ammonia destruction computed by subtracting the ammonia input to the lake from the change in ammonia inventory in the lake on a monthly basis. A one month time lag is observed between ammonia input at the west end of the inlet, and ammonia concentration change at the lake discharge at the east end of the inlet, and this is accommodated by lagging the comparision by one month. The ammonia destruction is strongly temporal, approaching zero in the winter when the North Inlet is ice covered, and over 2 tons per month in summer, when the lake is (presumably) warmer and more agitated and oxygenated.

4. SIMULATION

Forward simulation is performed by applying a mining schedule, ammonium nitrate use schedule, dewatering flow schedule, ammonium nitrate loss schedule, and any ammonia removal schedules resulting from mitigation measures to the calibrated model. The model then simulates the expected future ammonium concentrations in the North Inlet discharge, and the upper confidence limit for those concentrations.

The model is used to simulate a range of outcomes, as follows:

1. Base Case. This case involves performance of the project as proposed by DDMI, with mining, ammonium nitrate use, dewatering, and water management unchanged. Ammonium nitrate dissolution performance is maintained at the current level, and no ammonia mitigation measures are included. This constitutes the "no action" case, against which the benefits of taking ammonia mitigation actions are evaluated.

2. Mitigation Cases. These cases evaluate the ammonia concentration at discharge upon adoption of a suite of practical ammonia mitigation measures, including improved blasting measures, modified water management practices, and treatment options. The results are evaluate the improvement in ammonia discharge performance.

5. EVALUATION OF EFFLUENT QUALITY CRITERIA

Effluent Quality Criteria are set for the project by determining the effluent quality that can more probably than not be achieved on every monitoring period in the project life.

The EQC for 30-day sampling is set by the following process:

1. The expected monthly average ammonia discharge concentrations are determined by simulation.

2. The relationship between the upper confidence limit of the peak monthly concentration and the average monthly concentration is determined using the four years of actual data. The 99.9923% upper confidence limit is used, representing the confidence required to meet the required more probable than not condition for any day in the project.

3. The peak concentration estimate for each month of the operation is determined by applying the peak relationship to each simulated month.

4. The maximum discharge concentration for any month in the project is selected as the EQC.

The EQC for 1-day grab sampling is set by the following process:

1. The relationship between the upper confidence limit of the peak daily concentration and the monthly concentration is determined using the four years of actual data. The 99.9923% upper confidence limit is also used.

2. The upper concentration limit for grab samples taken in any month is determined by applying the relationship between UCL peak daily concentration and monthly concentration to each simulated UCL estimate of monthly concentration, computed as described above.

3. The maximum discharge concentration for any day in the project is selected as the EQC for grab samples.