

## Johnson, Bill H (DNR)

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**From:** David Blaha <[REDACTED]>  
**Sent:** Tuesday, April 24, 2012 4:49 AM  
**To:** Carlson, Erik (DNR)  
**Cc:** Houston Kempton ([REDACTED]) Al Trippel  
**Subject:** Co-variance question

Erik  
Here are our thoughts on the co-variance question. this reflects discussions with Fred Marinelli, Mike Olson, and Jim Finley.  
Let me know if any questions

### **Issue Statement**

Several of the constituents in waste rock would be expected to behave similarly in response to changes in pH (i.e., concentrations should all move up or down depending on changes in pH). The Mine Site model as currently designed does not model pH so there is at least the potential that at least some these constituents may not behave as would be expected. The question is how big a problem this is and whether the model needs to be adjusted to reflect the expected behaviour.

### **Discussion**

The model does address co-variance between many constituents that leach from the waste rock because it calculates the release of many metals in proportion to sulfide S concentration in the rock (see Table 1-24 in the Water Modeling Work Plan for the Mine Site). We would expect all the solutes whose release is proportional to the sulfide S concentration should thus increase together in proportion to the concentration of sulfide S, and these solutes thus all co-vary to each other.

### **Recommendation:**

There are several options for patching up the model to alter this, but we did not identify model changes that would clearly improve the approach. To site one example of chasing our tails, consider that the model starts by calculating release rates for arsenic and nickel in proportion to sulfide S, then adds random uncertainty to release of each solute. If we then force a covariance to exist between nickel and arsenic onto model results, we are, in part, removing the probabilistic uncertainty that we had just put in. As a result, we believe the best approach is to use the GoldSim model as it is currently configured, then test the results in the evaluation stage to see if it captures the expected co-variance.

In the Model Evaluation exercise, ERM will check to see whether the solutes of concern whose releases are related to sulfide S concentration do in fact vary together in the model realizations. We can do this by just comparing solute concentrations in leachate from the waste rock in each realization. But because many of the processes in the model could obscure this correlation (e.g., the release of arsenic and nickel from the waste rock could be strongly correlated, but this effect may not be visible after the concentration of one of them is reduced by a concentration cap), we will need to be careful to compare values before secondary effects may alter the concentrations. One option would be to set up a simulation with artificially high water flush rates, so that concentrations of all solutes are below the concentration cap. In this case, concentrations of solutes in leachate from waste rock would be proportional to their release rates, and the covariance in release rates built into the model input for Cat1 rock should be reflected in the solute concentrations predicted by the model for Cat1 rock leachate.

For three of the elements - nickel, aluminum, and iron--solute release are calculated by 2 methods (see last 3 entries in Table 1-24 in the Water Modeling Work Plan for the Mine Site). The model apparently averages the release by these 2 methods for each realization. The model evaluation should check to determine which method is dominating the solute release rates.

Finally, there are a few constituents whose release rates are not linked to S concentrations, but which are expected to covary with sulfide S. These are zinc, whose release is set as a proportion of magnesium release, and cadmium, whose release is set as a proportion of zinc release. ERM's Model Evaluation Plan will assess whether predicted concentrations of zinc and cadmium do in fact trend together with the other metals as expected.

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