Gartner Lee Limited memorandum

to: Valerie Chort
copy: Bud McAlpine, Vic Enns, Eric Soprovich, Ron Nicholson, John Chapman
from: Eric Denholm
date: December 8, 2003
re: **Anvil Range 2003 Tailings Investigation – Revised Geochemical Test Program**

This memo describes a revised geochemical test program that is proposed as part of the 2003 Investigation of the Rose Creek Tailings Facility (the "2003 Program"). The revisions are intended to capture the comments raised during a teleconference on this topic that was held on November 26 and that included Eric Denholm, Bud McAlpine, Eric Soprovich and Ron Nicholson.

Overview of the 2003 Program

As stated in the approved work plan dated July 11, 2003 and as confirmed on the November 26 teleconference, the specific objectives of the 2003 Program are to:

1. Calculate the stored and available contaminant loads within the tailings mass *(including provision of a detailed description of the methodology used, per Nov 26 teleconference)*;
2. More confidently delineate the areal extent of contaminants in the aquifer, focussing on areas of predominantly sandy tailings; and
3. Calculate changes in contaminant concentrations over time at the Cross Valley Dam within a timeframe of the next 5, 10, 25 and 50 years.

These objectives were proposed to be achieved by the following activities:

1. drilling to bedrock at nine locations using a sonic drill rig;
2. installation of multilevel piezometer "bundles" in each drillhole and collection of groundwater samples;
3. stratigraphic logging of soil "cores" and collection of samples of tailings and aquifer soils;
4. geochemical and physical testing of samples; and
5. analysis of data.

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The first three of these five activities have been completed and this memo proposes a means of completing activity number 4.

Specific Objectives of the 2003 Geochemical Test Program

There have been two substantive geochemical investigations of the Rose Creek tailings: 1988 and 2001. The 2001 program was designed specifically to follow up on the earlier work by repeating sampling locations and parameters. The combined 1988 and 2001 geochemical test programs provide total metal content, ABA analyses, shake flask tests (2001 only), grain size determinations, permeability testing and metal sorption tests. Both programs provide paste pH, paste conductivity and some moisture contents through the unsaturated tailings in each impoundment.

In addition to the 1988 and 2001 field investigations, Environment Canada provided a preliminary estimate of the mass of soluble zinc contained in the tailings, based on the 2001 test data, and has also provided several technical analyses of tailings oxidation and contaminant transport.

Given the data and analyses that have already been completed as recently as 2001, the specific requirements of the 2003 geochemical test program are focussed not on obtaining a general understanding of the state of oxidation of the tailings but, rather, on gathering data specific to:

1. verification of the estimated masses of total and soluble zinc (and other metals) in the tailings;
2. additional quantification of the zinc/metal attenuation potential along contaminant flowpaths; and
3. additional quantification of soil permeability for calculation of travel times and groundwater flow rates.

These 3 specific objectives are proposed to be achieved by conducting shake flask, sorption and grain size tests on select samples from the tailings and the native aquifer.

Sample Preparation

The soil samples collected during the 2003 drilling program have been stored, since collection, in sealed plastic bags in a freezer at the Gartner Lee Limited office in Whitehorse. The samples that are selected for analysis will be shipped to the laboratory (planned in Vancouver) by the quickest means possible in coolers packed with ice packs in order to minimize the opportunity for oxidation en-route.

The 2001 investigations included a comparison of field pH, wet rinse pH in the lab and dry rinse pH in the lab (i.e., after purposely drying the sample). This comparison found that there had been a consistent decrease in pH during transportation but that there had also been a consistent decrease in pH during drying of the samples at the lab and, therefore, the drying procedure was discontinued.

For the 2003 test program, the samples will not be dried at the lab but, rather, the test procedures will be undertaken with the samples "as received". A rinse pH will be requested of the lab, however, to provide an indication of any general decrease in pH that may have occurred during transportation.

Total Metal Content

The existing database regarding total metal content of the tailings is considered to be extensive, drawing not only from the environmental characterizations but also from additional metallurgical testing conducted during mine operations by the mine owners. Further, the collection of total metal content data is not considered to be an essential contributor to the interpretation of shake flask or other tests proposed for this program.

Therefore, no additional analyses for total metal content are proposed for this program. Because of the numerous samples collected and held in storage, total metal analyses could be conducted as a follow up test program if the results of the tests proposed herein suggest that this would be beneficial.

Shake Flask Testing

The approach to these tests is to add to the database initiated in 2001 by collecting data at new locations, with specific consideration to areas thought to be predominantly coarser tailings. In 2001, 10 to 12 shake flask tests spanning the entire tailings profile were conducted for locations P01-10, P01-09, P01-08, P01-07, P01-05 and A7 (note that location A7 is a 2001 drill location in the northern extent of the Original Impoundment that was found to be dry and no monitoring well was installed). This approach is considered to remain valid and 8 to 12 shake flask tests spanning the entire tailings profile are proposed for each of the eight new (2003) drill locations in tailings. Locations P03-01, P03-03, P03-06 and P03-07 are specifically located in areas thought to be predominantly coarser tailings.

Samples for the 2003 test program will be selected to be representative of the stratigraphy observed through the tailings profile, both the saturated and unsaturated zones and of the paste pH/paste conductivity values through the tailings profile.

The 2001 shake flask testing utilized a 3:1 mixing ratio for a 24-hour mixing period. The 2001 investigation included some (12 of 74 samples) duplicate testing at a 20:1 mixing ratio and found that the 3:1 ratio may have been solubility constraining for some highly oxidized samples and that this may have affected the absolute concentrations of metals leached in some samples. Given the observations drawn for the 2001 program and the current standards in conducting shake flask tests, the 2003 tests will be conducted at a mixing ratio of 20:1 with a minor number of duplicates at a ratio of 3:1. This is not considered to substantially constrain the ability to combine and compare data across the two data sets.

Sorption Testing

Sorption tests were conducted in both 1988 and 2001 on samples of soil from the native aquifer. The results of these tests were highly sensitive to the mixing ratio and the trends in results were considered, in 2001, to be contrary to general expectations. It was recommended, in 2001, that further testing be conducted before the results were used. The following methodology was used for the 2001 tests:

The analytical procedure used for the sorption testing was developed according to guidelines from USEPA publication 530-SW-87-006 (USEPA, April 1992). A simple synthetic solution was prepared in the laboratory based upon the characteristics of the groundwater sample collected on September 10, 2001 from well P01-10A. The characteristics of the synthetic solution were intended to be representative of sulphate and zinc levels that are currently entering the native sediments from the overlying tailings at this location. The synthetic solution had a pH of 8.64, which was in close agreement with the pH value of 8.52 measured in well P01-10A. Sorption testing was conducted at a temperature of 6 (+/-2) ^{O}C consistent with the temperature of the groundwater measured during the installation of well P01-10A. Eight soil/solution mixtures were prepared with liquid to solids ratios ranging from 1:4 to 1:500. The mixtures were agitated for a period of 72 hours and then analyzed.

The test methodology is proposed to be amended for the 2003 test program in order to better represent the site specific conditions and to provide information more focussed on the specific needs of the project. The approach to the 2003 test program will be to limit the number of samples tested and to run each sample at a constant mix ratio of 1:4 liquid to solids, or as low as practical, but at a number of solution concentrations to provide a detailed sorption curve ("K_d"). This is considered to be important because the values for K_d can vary according to solution concentration. The approach will also plan to utilize groundwater drawn from the Anvil Range site in place of a synthetic solution fabricated in the laboratory. This is considered important in order to capture any interactions between compounds present in the groundwater and, particularly, the interactions between ferrous iron and zinc, which may effectively "compete" for soil sorption sites.

Two samples representative of the sand and gravel unit in the upper aquifer underlying the tailings will be selected for testing. A composite sample that would combine samples from various areas of the aquifer was considered but is not proposed, in this case, as there is no clear benefit to adopting the composite sample approach. Further, the large number of samples collected during the 2003 drill program provides the opportunity to conduct additional tests in the future, if desired.

Tailings porewater will be drawn from the mine site specifically for the purpose of this test program. The water is proposed to be drawn from well P03-01-9, as representative of strongly contaminated water. Field pH and conductivity will be recorded to ensure that the water as sampled appears to be similar to the fall 2003 samples. The contingency sampling well will be P03-03-9. The sample collection method will be focussed on minimizing oxygen entry into the sample water during sampling and transport. This will involve the use of specialized sample collection apparatus and methods, as

appropriate and practical. Further, the laboratory methods will also be focussed on minimizing oxygen entry into the sample water. This will also involve specialized procedures such as nitrogen purging of oxygen, as appropriate and practical.

Each sample will undergo a 72-hour test at five solution concentrations. The solutions will be based on dilutions, with distilled water, of the sample water drawn from the mine site and will span a range from low concentrations (approximately 0.10 mg/L total zinc) to the undiluted mine sample water.

Grain Size Testing

As part of the 2001 investigation, 1 or 2 grain size analyses were conducted for each of 6 drill locations in the tailings impoundments, including 3 samples of native soils. The grain size determinations varied tremendously among the sample set as a whole and at each location as is expected for mine tailings deposited from various surface spigot locations. For example, the % passing the #200 screen (a common reference size) varied among the tailings samples from 10% (coarser) to 98% (finer). The % passing the # 200 screen for the 3 samples of native soils varied from 10% to 42%.

It is proposed that grain size analyses (including hydrometer analyses) be performed on select samples of the sand and gravel unit in the upper portion of the aquifer. This soil unit is recommended because it is considered to be the most relevant in regards to the transport of contaminants through the aquifer. Six samples will be analysed, with the recognition that additional samples could be analysed in future follow up tests.

In addition to the above, it is understood that grain size testing of select samples of tailings will be undertaken as part of a separate project being conducted by SRK and this information would then also be available for further characterization of the tailings.

Permeability Testing

Permeability tests were conducted in 2001 on three tailings samples and one native soil sample.

Further permeability testing is not proposed as part of the 2003 program as it is not considered to be essential to achieving the objectives of the program.

Summary of Proposed Tests and Sample Selection

The table below summarizes the tests described above and lists the specific samples that are proposed for selection. The sample depths, logged classifications and field chemistry data can be obtained from the draft drill logs that have been previously circulated.

Test	P03-01	P03-02	P03-03	P03-04	P03-05	P03-06	P03-07	P03-08
Shake Flask	AS2	AS1	AS1	AS1	AS1	AS1	AS1	AS2
	BS2	AS2	AS2	AS2	AS2	AS3	BS1	BS1
	BS3	BS1	AS3	BS1	BS1	BS2	CS1	BS3
	CS1	CS1	BS2	BS3	BS3	BS3	CS3	BS4
	CS2	CS2	CS1	CS2	CS1	CS1	DS2	CS3
	CS4	CS3	CS3	CS4	CS4	CS2	DS4	DS2
	DS2	DS2	DS2	DS3	DS2	CS4	ES1	FS1
	DS4	DS4	ES1	ES1	ES1	DS2	ES2	FS3
	-	ES2	ES4	ES2	ES4	DS4	FS1	FS4
	-	ES3	FS2	ES4	FS2	ES1	FS3	-
	-	-	-	-	GS1	ES3	GS1	-
	-	-	-	-	GS4	-	GS2	-
Sorption	-	-	-	-	HS3	FS2	-	-
Grain Size	ES2	ES6		FS2	HS4	ES4		HS4

Closing

We feel that this letter captures the comments of the November 26 teleconference and recommend that the geochemical test program proceed on the basis of this letter. We will endeavour to keep all parties informed of the progress and results as they are received and, in this way, any minor modifications to the program can be incorporated on an ongoing basis. We will proceed with assembling the samples listed herein and will verify that the review group (per the copy list herein) is satisfied with that sample.

Sincerely,
GARTNER LEE LIMITED

(via email)

Eric Denholm
Senior Mining Consultant