Additional interpretive information for Ruth/Morningstar Mines (1/27/2009)

Peter, per our conversation, I have prepared some additional interpretive information on the following four issues to help support a judgment regarding the adequacy of the risk assessment and overall interpretation of the analytical data collected in 2008. I will have additional more detailed information coming on item 4, but wanted to let you see what I have so far. The issues are:

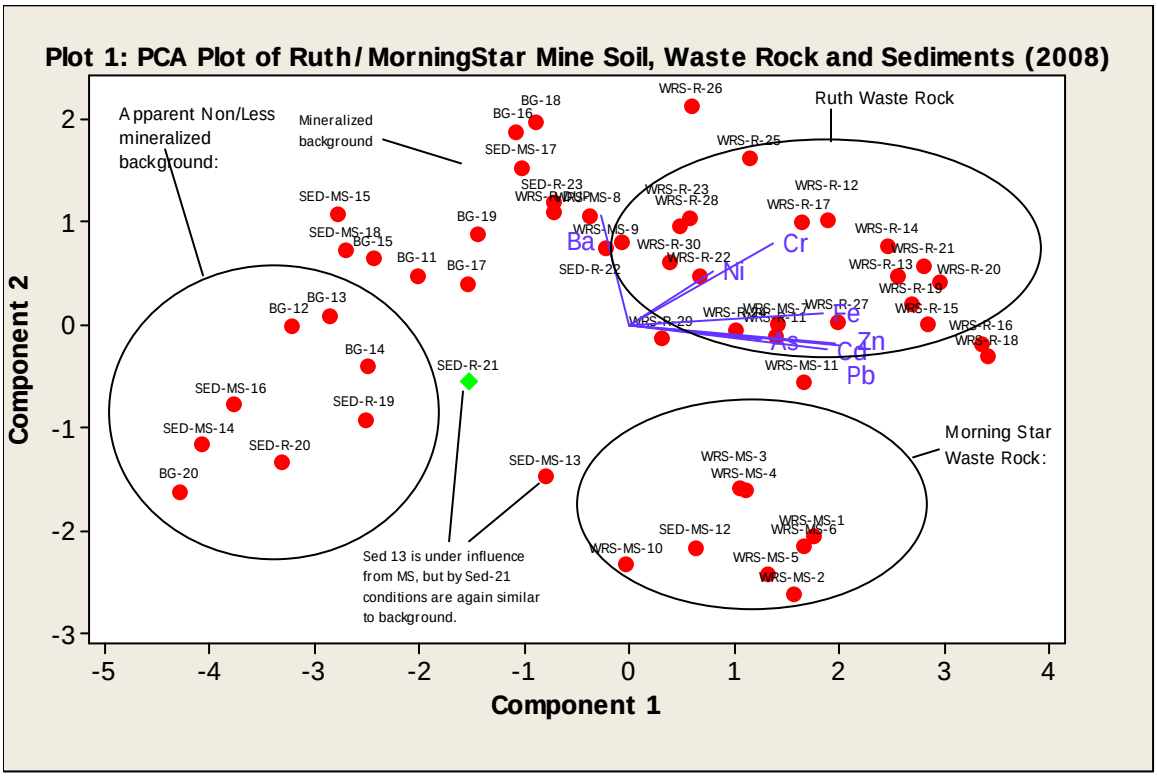
1) Relative source contribution of the 2008 sediment, soil/waste rock and water samples;
2) Interpretation of the Arsenic and Lead risk assessment results;
3) Interpretation of Oregons "Hotspot" Rule;
4) Benthic Community Structure In Battle Ax Creek.

Source Attribution

The purpose of this evaluation was to create a means of visualizing the relative similarity or dissimilarity of 2008 collected samples on the basis of the variation in relative analyte concentrations. Without going into the full details, the approach requires addressing any non-detected values, followed by log-transformation of the data to put results on a similar scale and then performing principle components analysis (PCA) on the transformed data. Scores or coefficients associated with each of the two primary components are assigned to each sample and plotted in two dimensional space. However, the plots are 2-D representations on the multivariate relationships between samples, accounting for all metals analyzed. The plots are simply interpreted based on linear distance between sample points. Points closer to each other are more similar, and further apart are more different. In this way a sample can be determined to be relatively more similar or different from a known source sample. Finally, the blue lines are known as loadings, and show which original variables (in this case metals) contribute to the location where a sample plots. For example, if a lead loading line points toward a group of samples, then lead is a significant contributor to why those samples plotted in a particular region.

Soil and water samples were analyzed separately and the plots with their interpretation are provided below.

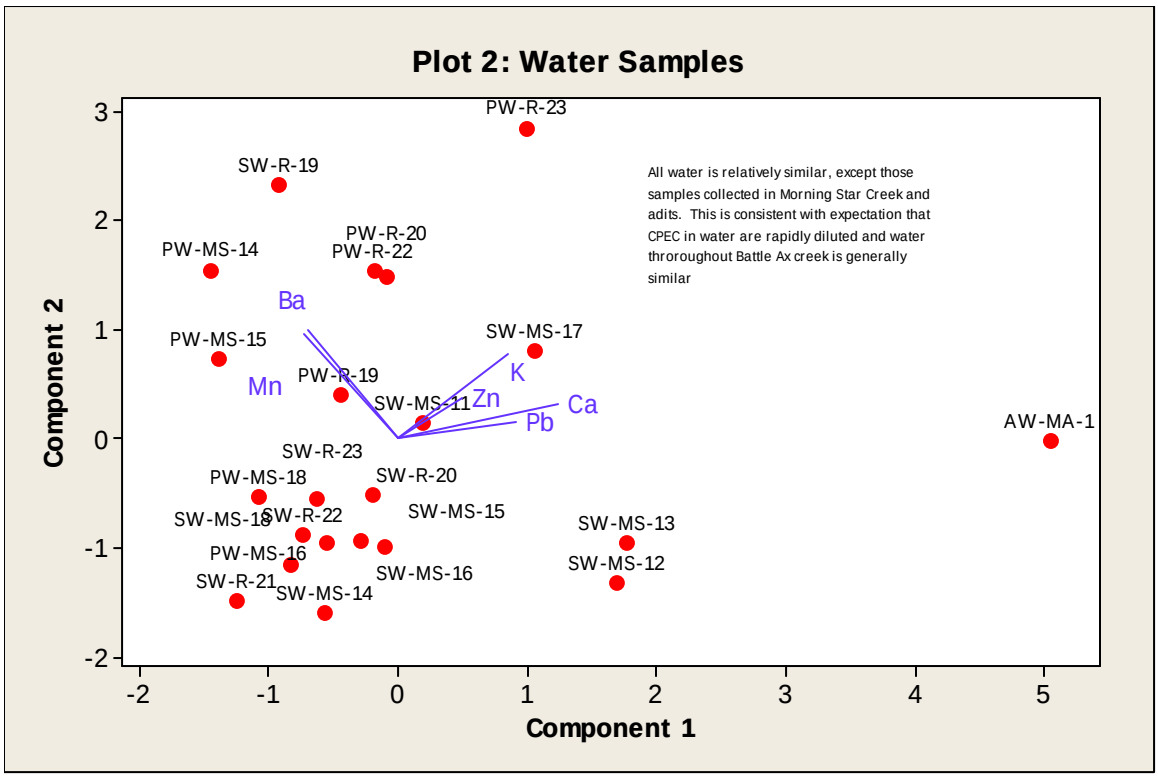
Soil/Sediment/Waste Rock



Plot 1 shows that al solid samples segregate into 3-4 categories. The left side of the plot consists of primarily background samples and trend from the bottom left toward the center of the plot. This indicates that the background samples themselves do differ along what I infer to be relatively less mineralized to more mineralized samples. This finding is consistent with the discussion on Monday the 26th. The Ruth and Morningstar Waste rock samples clearly differentiate into 2 separate groups and both are separated from background by high lead, zinc and cadmium. Ruth differs from Morningstar in that it has higher Nickel and Chromium.

Significantly, sediment samples cluster with the background samples with the exception of SED-MS-12, which was collected in Blue Jay Creek. This finding indicates that the Battle Ax Creek sediment quality is primarily determined by ambient geology, not primarily Mine inputs. This is consistent with the finding from the ecological assessment, that there was little or no discernable response in the benthic community based on a concentration gradient (Notwithstanding that we have some comments on the benthic evaluation). It is reasonable to expect that the invertebrate communities would be adapted to the ambient geologic conditions.

Water



Less information is available to interpret water samples due to the large number of non-detects for some analytes. However, I can say the left side of plot 2 appears to be generally representative of water throughout Battle Ax creek and the right side are the Morning Star creek and adit samples which are clearly different based on Lead, zinc and calcium. The difference among the other samples are probably just variation in other ions not associated with mine inputs. Again, this finding is consistent with soil sediment results and the benthic invertebrate results.

Arsenic and Lead Risk Findings

Arsenic (eco and human health)

Both arsenic and lead are associated with the waste rock (see Figure 1). As described in the January 26th meeting these samples were analyzed for total metals, and the extent to which arsenic and lead are incorporated into the mineralogy of the rock and particulate is available for biological uptake has not been assessed. As a conservative assumption common for screening level risk assessments such as this one, it is all assumed to be available for biological uptake and absorption.

Because the risk-based concentrations for Arsenic are below background levels, it is necessary to consider both the degree of exceedance of risk-based criteria and background when making a judgment.

Arsenic concentrations in the background soils ranged from 1.9 to 7.4 mg/kg. This is typical for a non-enriched background. ODEQ uses a default estimate of 7 mg/kg for background screening of arsenic.

Sediment samples were also very low for arsenic except of Blue Jay Creek itself which had arsenic at 5 and 41 mg/kg. Note that the "probable effects concentration" or PEC for freshwater sediment for arsenic is 33 mg/kg. This is considered to be the level above which toxicity to benthic invertebrates is more likely but still uncertain. However, as we have seen, the concentration rapidly attenuates and our conceptual model is that Blue Jay creek itself was not considered habitat. Moreover, the maximum concentration measured in waste rock itself was 46 mg/kg, with an average estimated at 20-21 mg/kg, so under average conditions assuming that the sediments were all eroded waste rock, any real meaningful exceedance of the PEC seems unlikely.

Certainly the data indicates some arsenic and lead loadings from the adits and these creeks are the locations where criteria are exceeded. However, they also go dry for part of the year and would not represent a significant portion of invertebrate habitat. We may need to think about this further from a source control perspective. Discussions I have had lately would suggest that if it is connected to a waterway it could still be considered to be "waters of the state" So, it may be that concentration in Ruth and Blue Jay Creeks themselves could be a supporting basis for a "source control" action.

Arsenic in Waste rock samples ranged from 3.8 up to 37 mg/kg (previous years max was 46 mg/kg) and were mostly above the background estimated level of 7 mg/kg, and fairly consistently in the 10's of ppm. 90th UCLs estimated by Pascoe in Waste rock were 20.7 for Ruth and 21.5 mg/kg for MS. So, both sources of waste rock are very similar with respect to arsenic concentration.

For perspective on these arsenic concentrations, I conclude that the waste rock level, on average , exceeded our default estimate of background by roughly a factor of three at both sources. Because the risk estimation process is a linear function of concentrations, this is equivalent to saying that, all else being equal, the risk would be 3x the background, except:

- All things are not equal: The reason Pascoe calculates a risk level at 10^{-6} is because he is adjusting for a lower intensity of exposure in a recreational scenario relative to residential exposures. Moreover, as described above, it is only the waste rock samples that exceed, so these recreational exposures would assume continuous exposure to the waste rock over the entire exposure period, and assumes it is all available for biological uptake. Finally, because the risk calculations are all linear, an estimate of risks under different exposure assumptions can be derived from Pascoes risk estimate of $1x\ 10^{-6}$.
- If DEQs default child residential ingestion rate of 200 mg/kg were used the risk would be 2×10^{-6}. If the exposure frequency were also tripled to 60 days per year, that would result in a risk estimate of $6 \times 10^{-6.}$ While exceeding 1×10^{-6}, only under relatively unrealistic assumptions would the 10^{-4} threshold be approached, even under the conservative assumptions previously discussed. Overall, arsenic does not appear to be an important current human health issue.

Lead (ecological)

Lead concentration in background soils is estimated by DEQ at 17 mg/kg. If you exclude the two high "outliers" taken near Ruth mine from the background data set, the soils show some degree of enrichment, but overall are generally in the 10's of ppm.

Sediment samples appear highly elevated in Ruth and Blue Jay Creeks. Otherwise, sediments in Battle Ax creek are generally similar to soils, except at SED-23 and 22. As shown in Figure 1, these samples represent mixing from background and Ruth Mine waste rock. Although these samples have lead exceeding sediment quality criteria, they do not exceed the PEC of 128 mg/kg, and benthic community metrics do not show any effect, so ecological effects in Battle Ax creek are not apparent. As noted below (item 4), and in forthcoming additional comments from our aquatic ecologist, we would prefer some additional more regionally relevant analysis to allow more confidence in the benthic survey results. Despite the limitations, the available information does not indicate impacts. Lead definitely does exceed significantly in Blue Jay and Ruth creeks.

Along these same lines, lead in water sample SW-MS-17 at the confluence of Blue Jay and Battle Ax creek exceeded the U.S. EPA Ambient Water Quality Criterion of 2.5 ug/L aquatic life criteria. The lead criterion is hardness dependent, so we / I need to take a closer look at this to see if the hardness adjusted, dissolved concentration still exceeds, but the total measurement was 12 .7 ug/L, so it looks likely. This is significant because according to Oregon Rule OAR 340-122-0115(32)(a) hazardous substances having an adverse effect on beneficial use is a "hotspot". The beneficial use is protection of aquatic life and the AWQC is that threshold. Thus, there appears to be some correspondence between exceedance of sediment quality criteria in Blue Jay creek and exceedance of AWQC/hotspot level at the confluence of Blue Jay and Battle Ax. This could provide the basis for a source control action here, although we know that there do not appear to be measureable ecological effects in Battle Ax creek itself due to dilution & attenuation and other factors. Alternatively, this is only a single sample and some additional evaluation here might show that hardness adjusted dissolved lead is not exceeding AWQC.

Lead (human health)

The same considerations for the arsenic assessment also apply to lead. That is, concentration and hence risks are determined by the elevated concentration in the waste rock, so risks assume that exposure is to waste rock. U.S. EPA default screening value for occupational exposure is 800 mg/kg. I have made inquiry into the Lead models, and we do accept evaluations based on these models. The most critical aspect of the lead evaluation are the adjustments made to derive a 370 mg/kg time weighted average concentration to represent exposure. Since the result is less than EPAs residential criteria of 400 mg/kg, this result itself is indicative of no risk without any further evaluation required. Hence, we will need to review this adjustment when it arrives.

HotSpots:

Oregons hotspot definition is provided in OAR 340-122-0115 (32)

It is a 2-part definition, (a) and (b):

(a) Applies to groundwater of surface water having a adverse effect on benefical water use. As discussed above exceeding an Ambient Water Quality Criteria is considered as meeting the definition, and therefore lead reaching Battle Ax Creek could be considered a hotspot. Acknowledging that this is a single sample, it still remains an unresolved issue.
(b) For (32)(b)(A) this would apply to the waste rock if they exceed risk levels by 100x for carcinogen or 10 x for ecological effect then a hotspot is applicable. Since, no risks are predicted, no hotspot can exist by this definition.

<u>However, by</u>

(32)(b)(B) If they are reasonably likely to migrate to such an extent that that (a) or (b) above might be created, then that constitutes a hotspot.

By this last definition in (33)(b)(B), mass wasting to Battle Ax Creek at Adit 5 or erosion of the waste rock piles into Ruth or MS Creeks to Battle Ax creek *may* meet this definition. Be advised, it could be argued that since current conditions represent equilibrium over many years that erosion is unlikely to result in conditions that meet the criterion. However, this seems to me to be a subjective matter of interpretation, and I do not pretend to be an expert in this area. If needed, I could solicit a formal opinion.

Based on the foregoing, while the site does not appear to pose current risk, it might migrate to create unacceptable risks in the future and this would be the basis for controlling that potential. Seems worthy of some additional discussion.

<u>Benthic Community Evaluation</u>

Our aquatic ecologist noted some concerns with respect to how and where invertebrate samples were collected. Specifically, methods form the Oregon Plan monitoring guidebook were used. However, the

guidebook methods were developed for Coastal Oregon Streams, and for Riffle habitats, not for Oregon Cascade pools. Thus, it is more difficult to determine if the interpretative criteria for these benthic metrics are meaningful in the Oregon Cascades. Thus, this interpretation is not as robust as it could be. Having said that, there do not appear to be significant shifts in the metric scores between riffle samples for each mine, so the available information presented so far, does not appear to suggest a significant impact, and this finding is somewhat consistent with the analytical chemistry. I will be providing additional details, and I expect we will comment on the draft report that data should be re-analyzed before the final report using indices that are more locally relevant to Battle Ax Creek and better suited to the Cascades. Generally, it's good to be aware that the intended use of the data should be accounted for in the sampling plan and we should be involved earlier in the sampling plan process in the future on projects.

Summary & Conclusion:

Human health risk potential is determined by arsenic and lead as the two most potent site related toxic metals, both are enriched in the waste rock primarily, while area soils more closely approach typical background although some samples are elevated. Hence, human health risk potential is primarily associated with waste rock. Under plausible exposure assumptions for recreational or visitor exposure risks are unlikely under current conditions. For aquatic ecological, the sediments in Blue Jay and Ruth Creeks exceed sediment quality criteria for lead (PEC = 128 mg/kg), and the water sample in Battle Ax creek at the confluence with Blue jay creek exceeds the AWQC, indicating a potential hotspot there, according to OAR 340-122-0115(32)(a).

In Battle Ax Creek sediments are a mixture of ambient geologic conditions and some mine inputs at a few locations, and there is no concentration related relationship to any metrics of benthic community structure. Benthic data would best be re-analyzed with metrics that are locally relevant to Battle Ax Creek. Ecological risks in Battle Ax creek appear to be acceptable.

The remaining issue to be resolved is the potential for hotspot to exist due to mass wasting or erosion and continued loading of battle Ax Creek with Lead OAR 340-122-0115(32)(b)(B). I imagine some consolidation or capping scenario would address these issues, as well as an institutional control.