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TECHNICAL MEMORANDUM

To: Mary Beth Marks – On Scene Coordinator

From: Michael Cormier
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Date: April 8, 2005

Re: Potential Methods to Estimate Drainage into the Repository Sump
Selective Source Repository Expansion
New World Mining District Response and Restoration Project

This memorandum was prepared to present potential methods that could be used to estimate draindown from waste that will be placed in the repository during the upcoming repository expansion and to monitor the performance of repository cover and liner. These methods are meant to improve on the methods Maxim used to estimate draindown from the waste placed in the repository in 2001 (Maxim, 2003). The purpose of estimating draindown from repository waste is to determine the volume of water that might reasonably drain into the repository sump. This information can then be used to plan operation and maintenance activities at the repository in the future.

CURRENT REPOSITORY STATUS

The Selective Source Repository will be expanded over a two-year period beginning in 2005 to accommodate waste rock removed from the Glengarry, Gold Dust, Black Warrior, Little Daisy, McLaren Millsite, and Great Republic Smelter. Expansion of the repository will involve removing the temporary HDPE cover liner that was installed in 2002, tying into the existing bottom liner and expanding the bottom liner uphill, placing cushioning material and waste, and constructing the final cover system. The total amount of waste that will be added is about 30,000 cubic meters (39,300 cubic yards). This will bring the total waste in the repository to about 54,000 cubic meters (70,700 cubic yards).

When the first phase of the repository was constructed in 2001/2002, precipitation collected in the waste during construction and over-wintering between construction seasons. This precipitation increased the moisture content of the waste and added to drainage that accumulates in the repository sump. Water has collected in the sump at a rate of about 40,000 gallons per year. Since 2002, about 120,000 gallons of water have been removed from the repository sump and disposed in the Cody, Wyoming sewage lagoon.

Following calculation of the original draindown estimate in 2003, more frequent monitoring of the sump in 2003 and 2004 showed that water was likely leaking into the repository during the spring snowmelt period. Water accumulating in the repository sump has been attributed to three potential sources: (1) water draining from placed waste (draindown); (2) precipitation leaking through the temporary cover liner; and, (3) groundwater leaking into the sump through the repository bottom liner. With the expansion of the repository, the bottom and top liners will be replaced during repository expansion construction in the areas where potential leaks are most likely occurring.

PREVIOUS DRAINDOWN ESTIMATE

Drainage estimates for water entering the repository sump were made in 2003 using limited data that was collected during the initial phase of repository construction. Data used to calculate these estimates included the following:

- Area of the repository footprint
- Placed material types and volumes
- Placed material characteristics
- Moisture content of placed waste

Because these data were not specifically collected for use in a drainage estimate, there was a considerable amount of uncertainty associated with the variables that were used to generate the estimates of drainage. In addition, other parameters needed for the calculation had to be estimated. Drainage estimates are sensitive to each of the inputs used in the calculations as well as being sensitive to some of the assumptions used in the analysis. This resulted in several rather widely ranging estimates of draindown, with professional judgment being used to determine which estimate best represented actual conditions. Table 1 summarizes the results of the three methods used in 2003 to estimate potential draindown from the repository.

Table 1
Repository Draindown Estimates – June 2003

Method	Range
Moisture content and storage	503 cubic meters (m^3) to 2,104 m^3 (133,000 gallons to 556,000 gals)
Moisture content	503 m^3 to 2,764 m^3 (133,000 gallons to 730,000 gallons)
Moisture content plus infiltration:	620 m^3 to 2,881 m^3 (164,000 gallons to 761,000 gallons)

The estimate based on moisture content and storage (133,000 gallons to 556,000 gallons) was identified as the most reasonable range for potential drainage volume from the repository. In calculating this estimate, we assumed that no additional moisture entered the repository following September 2002, an assumption that proved to be incorrect.

CALCULATIONS OF DRAINDOWN

Calculating the volume of draindown can be a fairly straightforward exercise if the proper data are available. Draindown volume is a function of moisture content of materials in the repository, the specific retention characteristics of these materials, and the specific yield of the materials. Specific yield (S_y) is equal to the ratio of the volume of water that drains from saturated soil or rock due to gravity to the total volume of the soil or rock. Specific retention (S_r) is the ratio of the volume of water the material can retain against the force of gravity to the total volume of the material. The relationship between these materials can be expressed by the equation:

$$n = S_y + S_r$$

where n is equal to the porosity of the material. The specific retention of different earth materials can vary considerably based on grain size distribution.

The rate of draindown is a function of many parameters including the initial moisture content and the variability of placement of materials with different physical characteristics. Measuring the rate of accumulation in the repository sump allows calculation of the draindown rate from existing materials in the repository. If the initial moisture content of repository materials was well known, a reasonable estimates of the volume of water remaining to be drained from the repository material could be made based on the rate of draindown measured.

In an ideal situation, an extensive body of real-time data would be collected as materials are placed in the repository until construction of the repository cover is complete. These data would include the volume, types, moisture content, engineering classification, and sequence of the materials placed. This is generally unpractical during construction due to heavy equipment operations during placement and grading of the waste. Also, because a portion of the repository has already been constructed and uncertainties associated with these previously placed wastes would not change, extensive real-time monitoring during construction would still leave some level of uncertainty in calculating draindown.

Outlined below are several approaches that could be used to collect data for the purpose of estimating draindown in the completed repository. The different approaches are listed in order from more intensive data collection approaches to less intensive approaches. At this conceptual stage of potential monitoring approaches, details regarding the number of monitoring points, monitoring frequency, and monitoring costs have not been developed. These details can be provided when further decisions have been made toward the desired level of monitoring.

Through-the-Cover Monitoring Approach

One means of establishing the material characteristics in the repository is to determine them in-situ by using a drilling and sampling program after the repository cover is finished. Ideally, the repository would be instrumented with devices that allow direct measurement of potential (head) and water content in the repository as wells as soil moisture content. Installation of a series of piezometers attached to pressure transducers and data loggers would allow continuous monitoring of the elevation of the free water surface in the repository. Matric potential could be monitored in the unsaturated portion of the repository using advanced tensiometers to track unsaturated flow. Soil moisture content would also be monitored using neutron probes and monitoring tubes (similar to those installed in the McLaren Pit) or other devices. Data collected using these methods would allow for three dimensional mapping of water flow in both the saturated and unsaturated zones as well as quantification of water remaining in repository material.

Installation of such direct measurement installation has several drawbacks. Borings would need to be drilled through the completed cover following construction using vibracore drilling equipment that is capable of collecting a continuous core of placed waste. Installation of these borings could compromise the integrity of the cover liner, and, because this equipment is very specialized, installation and maintenance of such a system could be costly.

Recent research has used temperature monitoring in groundwater beneath surface water to determine flux rates from streams and rivers into underlying groundwater. This approach could possibly be applied to monitoring liner performance by installing low cost temperature probes and data recorders within the saturated portions of the repository. Temperature profiles could potentially identify areas where ground or surface water may be entering defects in the liner system. Modeling using this approach may allow quantification of such inputs to the repository. Installation of a temperature monitoring array would also require installation of borings through the cover liner.

Conduct Monitoring Following Completion of Waste Placement

To facilitate estimation of draindown volume and rate following construction of the repository without using through-the-cover methods of monitoring, soil sampling and moisture measurements could be collected from emplaced material during construction. Samples would be collected immediately after all the waste has been placed but prior to installation of the cover liner. Sampling of the entire interval of waste from the top of the waste surface to the base of the repository would be done using a technique that will allow relatively undisturbed sample collection, such as direct push, Shelby tube, or vibracore. Lithologic logs for each of the sample boreholes would be made based on observation of the sample cores. Sample cores would be submitted to the laboratory for analysis of grain-size distribution, moisture content, porosity, bulk density, specific yield/retention, and saturated hydraulic conductivity. In addition to soil characteristic data, precipitation would be measured throughout the construction period to help quantify the initial quantity of water in the waste at the time the repository cover is completed. Precipitation monitoring can be done using the Natural Resource Conservation Service (NRCS) SNOTEL station located at the White Mill. This station records hourly precipitation, snow depth, and temperature data, and the data is available on the NRCS website on a real-time basis. The White Mill SNOTEL station is located about one mile north of the repository at an elevation of 8,700 feet. The repository site is located at an elevation of about 8,440 feet.

Data Collection During Construction

Data needed for a draindown calculation could also be collected during construction. This approach to estimating draindown is similar in some aspects to the approach used for the first phase of repository construction, with the important difference that site-specific data would be collected to narrow the range of error associated with soil parameters used to estimate draindown. While there are some drawbacks to this approach, particularly due to moisture changes that could occur in placed waste between the time a moisture measurement is taken and when the final cover liner is installed, this approach requires the lowest level of effort, does not interfere with construction operations or depend on construction scheduling, and is the least expensive approach to implement since site personnel would be able to collect data while conducting their normal construction inspection duties.

Data collected for this approach would include tracking approximate volumes placed from each waste source, recording moisture measurements from nuclear density testing of placed materials, recording Unified Soil Classification System soil textures based on field observations, collecting bulk soil samples for laboratory testing, and monitoring precipitation data during waste placement operations. Nuclear density tests would be performed on each lift of waste placed, and soil classification would be observed at each site tested. Grab soil samples would be collected from a subset of the nuclear density sites and composited for laboratory analysis. Laboratory analysis would include proctor testing for bulk density and unit weight determinations, porosity, permeability, specific yield, and specific retention. Precipitation data would be obtained from the NRCS SNOTEL station located at the White Mill.

References

Maxim Technologies, 2003. Final Technical Memorandum – Estimate of Drainage from Waste into Repository Sump. Prepared for Mary Beth Marks and Frank Ehernberger, Gallatin National Forest, New World Mining District Response and Restoration Project. June 20.