To: Loren Morton File: 39400166.10300

From: Kevin Sullivan, Britt Quinby

Date: May 22, 2007

Re: Review Findings
Denison Mines "Cell 4A Lining System Design Report, Response to DRC Request for Additional Information – Round 7 Interrogatory, Cell 4A Design", Dated May 15, 2007.

URS has reviewed the above referenced response from Denison Mines (USA) Corporation (DMUSA) to Round 7 Interrogatory on the Cell 4A System Design. This technical memorandum presents the results of this review. Round 7 Interrogatory had concerns with the following outstanding items:

1. The demonstration that the existing Cell 4A soil subgrade contamination levels are acceptable.
2. Some minor revisions and clarifications to the technical specifications and Construction Quality Assurance Plan (CQA Plan).
3. The GCL Field Hydration Plan.
4. The ability of the cell slimes drainage layer to drain the tailings solutions in a timely manner.

Each of these items is addressed below by stating the DRC's concern (in Round 7 Interrogatory), then DMUSA's response, followed by the results of URS's review of the respective item.

INTERROGATORY ITEM #1:

"A Radiation Survey Report to demonstrate that the existing subgrade for Cell 4A has radiation and contamination levels that are acceptable. This is currently being addressed under a separate cover."

DMUSA's Response:

Cleanup verification sample results have been submitted to DRC for staff review.

Results of URS's Review:

No comment. We understand this is being handled by the DRC under separate cover.

INTERROGATORY ITEM #2:

"Minor revisions and clarifications to the technical specifications and CQA Plan to address soil compaction lift thickness and soil material testing requirements."

Specifically:

- *Please state in Section 02220 (3.02) of the Technical Specifications that the subgrade soil shall be a minimum of 12-inches thick. Also include in this section that an acceptable maximum loose lift thickness before compaction of the subgrade soil is 8-inches.*

  <u>DMUSA's Response:</u>

  DMUSA does not believe that a minimum of 12-inches of subgrade soil is necessary for the performance of he proposed liner system. As this layer will be compacted and provides for a maximum protrusion height that will minimize potential damage to the liner system components. There appears to be no other reason to have a minimum thickness assigned to this layer.

  Technical Specifications Section 02220, Subgrade Preparation, has been revised to include requirements for a maximum 8-inch loose lift thickness.

  <u>Results of URS's Review:</u>

  A minimum compacted subgrade thickness will account for any underlying protrusions. It also accounts for the potential for the subgrade to consolidate on loading and expose underlying protrusion to the liner system. This is of particular concern considering the close location of bedrock to the subgrade surface under Cell 4A and it potential to be exposed. However, in consideration of the requirement that there be no protrusions greater than 0.5 inches, (per Section 02220 of the technical Specifications), and that the subgrade will be inspected prior to liner installation, this requirement can be lifted.

- *Please revise the use of the term "in general conformance" (with a specific test procedure) to state "in conformance". This applies to the use of this phase throughout the technical specifications and CQA Plan.*

  <u>DMUSA's Response:</u>

  The CQA Plan has been revised to include "in accordance" requirements.

  <u>Results of URS's Review:</u>

  No comment other than the request has been met.

- *Please revise Table 1B to state that at a minimum, one test per soil type will be performed for ASTM 422 and 1557.*

  <u>DMUSA's Response:</u>

  Table B has been revised to provide the testing for soil type.

Results of URS's Review:

No comment other than the request has been met.

INTERROGATORY ITEM #3 (as worded from DRC transmittal letter):

"Incorporation of specific listed items into the GCL hydration demonstration project. DUSA is authorized to begin the proposed hydration demonstration project as outlined in a letter from GeoSyntec Consultants dated March 27, 2007, in accordance with the following conditions: a.) The project must be continued, i.e. sampling and testing GCL moisture content, until the GCL hydration level is at a minimum of 140% in accordance with ASTM D 5993, and b.) The test pad must be moved away from the toe of the slope and preclude storm water run-on from effecting the test pad."

DMUSA's Response:

DUSA will begin implementation of the GCL hydration work plan on 21 May 2007. The test pad will be installed away form the toe of the slope and will be protected from storm water run-on. Furthermore, the GCL sampling will occur until the GCL moisture content reaches a minimum level of 140% in accordance with ASTM 5993.

Results of URS's Review:

No comment other than the request has been met.

INTERROGATORY ITEM #3

"Cell 4A slimes drain design needs to include a drainage layer over the strip drains that will have the ability to drain the tailings solution in a timely manner. The use of a drainage layer over the strip drains needs to be included in the demonstration of the effectiveness of the slimes drainage system. In addition there are a few clarifications on the demonstration provided that need to be addressed."

DMUSA's Response:

DMUSA provided in the response an explanation and revised calculations to demonstrate the proposed slimes drainage system has the ability to drain the tailings solution in a timely manner.

Results of URS's Review:

Review of "Analysis of Slimes Drain" (Revision 1) Computation by Geosyntec Consultants provided with DMUSA's response is as follows:

Documents Reviewed:

URS has reviewed and evaluated the following document in connection with the Utah Division of Radiation Control, Cell 4A Lining System, Demison Mines (USA) Corporation, White Mesa Mill, Blanding Utah - Round 7 Interrogatories.

"Analysis of Slimes Drain," Geosyntec Consultants, SC0349-01, May 12, 2007.

All interrogatories provided to date on the subject of the slimes drain design have requested a demonstration that the slimes drain system will remove the tailings solution in the cell (after the cell has become full) in a timely manner. To meet this requirement, DMUSA first proposed an exposed slimes drain system that was limited to the southwest corner of the cell. In response to concerns expressed by the DRC on the adequacy of this system, it was then expanded to cover the entire bottom of the cell. The proposed drain system included exposed strip drains (wrapped in fabric) connected to a collection header and extraction sump. No filter layer or blanket was included between the drains and the tailings. At one point DMUSA proposed the use of a cyclone to separate out the tailings courser fraction and place it in the cell over the drain system as a drainage and filter blanket. However, due to complications with placement of the material generated by the cyclone, this was not carried through to the current proposed design. Other than a geotextile wrap around the strip drain, the current design has no drainage/filter material between the strip drain and the tailings.

In addition, although the revised calculation presented does appear to be correct, the applicability of the Darcy equation to this type of multi-dimensional problem is questionable. URS maintains that the best means of solving the flowrate question presented in this calculation is through the use of a two- or three-dimensional model (i.e., modflow). These types of models are capable of including consideration of the linear flow of groundwater further from the dewatering point, as well as the two dimensional flow that occurs nearer to the dewatering point. The solution presented herein should be considered an estimation and therefore employ only conservative assumptions.

As stated in all of the interrogatories, the primary concerns expressed by URS with the proposed slimes drain system design for Cell 4A are:

1. Inadequate capacity of the drain system to remove the tailings solution in a timely manner. Specifically for the current design, inadequate surface area available to allow for timely removal (flow) of solution out of the tailings and into the strip drains.

2. The lack of adequate filter blanket material between the tailings and the strip drains, which would result in the clogging of the drains.

The current Best Available Technology (BAT) that addresses these concerns is to include a properly designed drainage and filtration layer between the tailings and the drains. If properly designed, this layer will be more permeable than the overlying tailings material and will function to expose more surface area of the tailings to the more permeable filter layer. The filter layer will also significantly reduce the flow time for the solution to the drain, and will ensure that, regardless of the actual permeability of the slimes material, the best available technology is being used to provide timely drainage. Further discussion on the drainage time is presented below. Again, if properly designed, this layer will function to filter out the fines in the tailings and minimize the potential for clogging of the drain.

Provision for Adequate and Timely Drainage

The revised slimes drain calculation provided by DMUSA in response to this interrogatory includes revised (increased) permeability estimate for the tailings of 3.31×10^{-4} cm/sec. This estimate is extracted from DMUSA milling material gradation data, a Colorado School of mines 1978 grinding study, and published permeability values estimated for similar soil types (per soil gradation/classification). These are all estimated values; no DMUSA tailings specific permeability values developed from permeability testing of the material are available. The results show that using the current design and the estimated tailing permeability (assuming the drain does not clog), the tailings solution would be removed from Cell 4A in approximately 5.5 years.

The assumed value for permeability of the tailings is the key factor in this demonstration. Assuming a value of permeability that is one order of magnitude lower will cause the estimated time to dewater the cell (days) to increase by one order of magnitude (i.e., 300 days to 3,000 days). Assuming that the potential for the drain to clog is addressed, ensuring that the permeability of the tailings is 3.31×10^{-4} cm/sec or greater is critical. The tailings could be tested during production to ensure that the permeability assumption is accurate. However, this becomes problematic if the tailings are shown to have a lower permeability, particularly since the drains will have been installed and inaccessible. Another alternative is prior to the start of construction obtain samples from tailings currently onsite and test them for permeability. The preferred alternative, however, is to ensure conservatism in the design, and include a filter blanket over the strip drains.

Filter Blanket over the Strip Drains

Under the proposed design where a filter blanket is not being used between the tailings and the strip drain, DMUSA proposes that the slurry placement technique will allow the courser tailings to fall out over the slimes drain and provide for a filter (and drainage blanket). However, the material properties (i.e., it's suitability as a filter blanket) are not known, and the ability of this method to cover the drainage system with appropriate filter material is of concern. None of these parameters have been demonstrated in the current design.

BAT for subsurface drains is to include a filter blanket material (backfill) around the drain. The filter material must be properly designed to filter out the fines and still allow fluid to pass to the drain. The design includes proper gradation and thickness of filter material. Recent observations of failed drain systems have shown that wrapping of drainpipes with filter fabric without the inclusion of a properly designed filter layer have resulted in clogging and failure of the drain. This is further supported by the installation recommendations provided by the respective manufacturers of the drainpipe. For example, the technical information for the strip drains provided by Multi-Flow, as referred to in DMUSA design calculations, recommends that the strip drain be placed in a suitable filter material backfill. They recommend the following (as copied from their web site www.varicore.com):

> "*Fine and very fine sand may slow down the inflow of water and may even pass through the filter. Larger aggregates, on the other hand, will not do an adequate job of filtering.*
>
> *"Very coarse sand" is recommended as backfill medium for drainage products. According to the USDA system of classification, very coarse sand has an approximate particle size of between 1.0 and 2.0 mm.*
> *When passed over sieves very coarse sand will have:*
>
> - *less than 5% retained on a #10 U S standard sieve*
> - *less than 5% passing a # 30 U S standard sieve*
> - *No more than 1 % pass through a # 50 U S standard sieve*
>
> *Should it be necessary to deviate from this recommended backfill material due to lack of availability or other constraints placed upon the drainage system design, a reduction in the life of the drainage system can be anticipated.*"

Based on the DMUSA testing presented, the slimes material may contain approximately 98% passing the #30 sieve, with almost 80% passing a #70 sieve (which is smaller than the #50 sieve). Therefore, even the majority of course material contained in the tailings does not meet the manufactures requirements for filter blanket material. In short, there appears to be less than 20% of the slimes material that might even be suitable for this filter material.

The thickness and extent of the filter blanket is specific to the application. In this case, in consideration of the need to maximize the potential for the tailings to drain, the extent of fines in the tailings, and the potential for disturbance of this layer during slurry placement, it is recommended (and would be consistent with BAT) that a continuous course sand blanket be placed over the strip drains on the bottom of the cell with a minimum thickness of 18-inches, and that meets the manufactures material property recommendations.

<u>Other Minor Discrepancies</u>:

Some other minor discrepancies identified are:

- At the bottom of page 3/11 of the calculation, the reference to porosity should be 0.22 not 0.022. The calculation uses the correct number.

- The drawings (Sheet 5 of 7; Section C), and Section 02616 of the Technical Specifications call for Contech Stripdrain 80. However, the calculations refer to Multi-Flow Drainage Systems (12-inch width strip drain). We believe the strip drain to be used is from Multi-Flow, it is our understanding that the Contech 80 is no longer available. The drawings should be revised accordingly.

Summary of Comments on the Slimes Drain Design

This calculation, similar to the previous revision, presents a conceptual plan whereby there are 1-foot-wide drains located at 50-foot intervals across the base of the pond. The concept does not include installation of a granular drainage layer to aid in the drainage, filter fines, and extend the life of the drainage system. There exist uncertainties both in the material physical parameters (assumed hydraulic conductivity values) and in the material placement method (slurry placement allowing fines to separate from the course fraction in the slimes). These uncertainties are manageable and can likely both be addressed by the proper design of a sand filter layer over the slimes drain system. The sand filter layer will allow maximization of the rate of drainage from the slimes material, mitigating the adverse effects inherent with poorly draining soils. In this case, the issue of permeability is also resolved.

We understand DMUSA'a concern over the impact of slurry placement (discharge into the cell) on a sand drainage/filter layer. However, we feel a properly designed sand layer that allows for simple energy dissipation and/or diffusion at the slurry discharge will allow the proposed slurry placement method to be employed with minimal impact on the sand layer and provides for minimal potential for clogging the fabric, slimes drains, or collection headers. In addition, if a drainage/filter layer is included, there will be no need to confirm or rely on the assumed permeability value of the tailings, which is a more practical approach when considering future operations and monitoring.

Recommendations

The recommendation is that the slimes drain design should incorporate a continuous sand drainage/filter layer that will both alleviate issues with permeability uncertainty, and drainage filtration. This layer shall be properly designed to account for the manufacturer's recommendations, the anticipated gradation of the tailings, and include measures to minimize the impact of the slurry discharge. A typical filter/drainage layer of this type is 12-inches thick. However, considering that it will be submerged, and the potential for disturbance during slurry placement, we recommend this layer be increased to 18-inches.