From: "Phil Stoffey" <psstoffe@smtpgate.dphe.state.co.us>
To: <tab2@nrc.gov>
Date: 9/7/05 4:32PM
Subject: hecla responses

attached are my responses to your July 15 e-mail. May be a little much. Did not take out the language on the thorium-230.

Thinking about the cover-what I believed happened is that they went and found discrete areas-less than 10X 10 meters as identified by the gamma meter and removed the elevated material as part of ALARA and placed this material in the cover.

Am faxing again what I sent you.

Response # 1

3.1.6 Evaporation Pond and Raffinate Pond Stabilization-Closure Cell

Six evaporation ponds contained residual soils and liquids that were byproducts of the leachate-extraction process. They occupied an area of approximately 13.4 acres. The salts, gels and liquids were mixed and solidified and consolidated into a single 4-acre repository or closure cell adjacent to the "Mancos Hill". The closure cell was designed to contain these wastes for not less than 200 years.

The evaporation pond materials were mixed with Mancos Shale in order to solidify and neutralize the contaminants present. Laboratory tests performed in 1992 showed that mixing of the calcareous shale with the pond material would help to neutralize the pond material. The materials were mixed at an approximate ratio of 1 part shale to 2 parts pond material by volume until it was dry enough to be placed as a soil. This mixed material was called solidified pond material (SPM). Any SPM containing moisture contents higher than those that would allow the required compaction were reworked, disked, scarified, or otherwise manipulated so as to dry those materials to the necessary moisture content for compaction prior to their relocation and placement within the closure cell.

SPM materials that had sufficiently reacted, solidified, and allowed to dry were excavated and hauled to locations within the closure cell and placed in lifts not to exceed 8.0 inch uncompacted lift thickness. Each lift of SPM was compacted to not less than 90% of maximum Standard Procter density before placement of subsequent lifts.

Four small (80 ft. wide by 80 ft. long and 10 ft. deep) lined raffinate ponds were located near the north side of leach tank 201. The raffinate was mixed in place with Mancos shale so that it could be solidified sufficiently to be hauled to the evaporation ponds and mixed with the SPM and eventually taken to the closure cell.

The closure cell was constructed with a one-foot compacted clay liner on top of scarified Mancos Shale. The liner was constructed to meet a permeability of $1x10^{-7}$ cm/sec. The sideslopes of the cell have a 5H: 1V slope and the top of the cell is sloped at 2 percent. A three-foot thick soil cover was constructed on the sideslopes of the waste cell. **The top cover was initially to be 3 feet thick, but because additional low-level radioactive material was encountered, the cap was increased to 8.7 feet. Most of the materials placed in 1996 and 1997 placed in the cap contained significant quantities of clay that was moisture conditioned and compacted to the radon barrier or cover specifications when placed. These materials were removed from along haul roads, the wind blown areas, and within the evaporation ponds. The final soils removed from the evaporation pond were placed in the upper 0.5-feet of the closure cell as the final cover. A rock cover for erosion protection was also placed on the top and on the sideslopes. The rock cover prevents the soil from becoming airborne and being dispersed from the closure cell. This eliminated the need to consider the air pathway for off-site exposure.**

The radium-226 activity throughout the closure cell, including the SPM, is low. Results from clean-up verification samples collected in 1995 and 1996 revealed that

several contaminated areas remained within the old Evaporation ponds. Results showed that soils contained minor quantities of radioactive materials. Contaminated soils were removed, and placed and compacted on top of the Closure Cell. Only minor amounts of contaminated soils were encountered. Laboratory results from samples collected within the Closure Cell revealed that after excavation and transfer to the Closure Cell, radium-226 activity levels decreased to near background (1.0 pCi/gm) due to the significant quantity of "clean" soil removed with the contaminated soil. The radium –226 activity of the SPM averaged 6.4 pCi/g. This is only slightly elevated over the approved site cleanup level for radium-226 of 6 pCi/g. The measured average radium-226 activity of each layer of the upper 12.7 feet of the closure cell ranges from 1.8-2.3 pCi/g. The top 0.5 feet of the closure cover has an average radium-226 activity of 1.8 pCi/g. <u>When the thorium-230 and radium-226 activities are decayed for 1,000 years, the radium activity in the upper 0.5 feet of the cell calculates to 6 pCi/g, which is equivalent to the radium activity used as the cutoff for site cleanup.</u> Therefore the cover radium-226 activity is essentially the same as in the surrounding surface soils both currently and in 1,000 years. Further, a 0.5 –feet layer of rock, which will help to maintain high moisture content in the cover, overlies the cover. The cell cover meets the condition of criterion 6 for longevity and control of radon release.

<u>Response number 2</u>

3.1.9 Cover

The covers for the cells were constructed from soils, available at the site, and found to meet the design criterion. The soils ranged in type from clayey sand to sandy clay. The permeability of the soils used ranged from 5.0×10^{-7} to 3.7×10^{-8} cm/sec with an average permeability of 1.9×10^{-7} cm/sec. These soils are relatively impermeable which means that they will not transmit large volumes of water or radon gas. The compacted soils were suitable for use as cover material to reduce both radon flux and infiltration of precipitation.
Radon emanation was evaluated using the U.S. Nuclear Regulatory Commission RADON Model. The parameter values selected for the model were also evaluated and found to be reasonable. The RADON model resulted in an estimate of 2.8 feet of soil cover to meet the radon flux requirement of 20 pCi/ m^2s. **The final cover thickness for the leach tanks was 5.28 feet thick and 8.7 feet thick for the cover /radon barrier for the closure cell (see Section 4.5 for further discussion on radon emanation). In a response to State comments, Hecla indicated that soil that is not saturated will not experience frost damage and that due to the low permeability of the compacted cover, the depth of saturation will be a few inches at most. Hecla stated that a few inches of frozen soil would not alter the effectiveness of the cover as a radon barrier. In the worst case, the frost depth is not anticipated to exceed 24 inches. Nevertheless, the five-foot plus cover thickness on the leach tanks and 8.7 foot cover thickness of the closure cell provide an adequate margin of safety to control radon and to insure that frost heaving will not impact the performance of the cover.**

The frost depth in the area does not exceed two feet according to the Montrose office of the U.S. Soil Conservation Service and local contractors. Top slopes were designed to promote runoff. In a response to State comments during its completeness review of the *Durita Site Reclamation Plan* Hecla indicated the following: According to the Montrose office of the U. S. Conservation Service, there are five soil types in the area, all of which are loams. All have "low potential frost action." The actual depth of frost will vary depending on average soil moisture, which depends in turn on variables such as surface drainage and exposure to sun and wind. However, with positive drainage and good exposure provided during reclamation, the "low potential" should minimize frost depth by limiting the depth of soil saturated by infiltration of moisture.

It has been suggested that the depth of cover influenced by frost be taken as that depth to which soil temperatures drop below freezing, as commonly used in determining depths for buried utilities or foundations. However, there is an important difference about depth of freezing around utilities and foundations and the concern for soil cover behavior. It is appropriately assumed that water will concentrate around buried pipes, subgrades, and footings and be subject to freezing – these features are anomalies in the soil medium, with interfaces and surfaces that facilitate seepage and/or heat loss and that tend to trap water. Therefore building codes and general practice all for placement of these features at depth below the maximum depth of freezing temperature. In all engineered soil cover these penetrating anomalies are not present, and the cover constructed uniformly to preclude trapping of water and to limit seepage.

A soil that is not saturated will not experience frost damage (i.e., reduction of density) because the soil pores will contain both air and water, not just water. As the water in the unsaturated soil freezes and expands by about 4% to become ice, the air will compress to accommodate the expansion but the soil structure should remain unchanged, held together by both friction and cohesion. Only when the soil is saturated can it experience dilation (reduction in density) because the pores are fully occupied by water and there is no air to compress and offset the pore-fluid volumetric increase as water freezes to ice. Therefore, regardless of the depth to which the soil temperature drops below freezing, the soil density will be affected only to the depth of saturation. Because the permeability of the compacted cover will be low (site soils tested at 1.6E-& to 3.7E-8 cm/sec) and the surface was sloped to drain off moisture, the depth of saturation will only be a few inches at most. As the design of the cover was based on overly conservative modeling, a few inches of frozen soil will not alter the effectiveness of the cover as a radon barrier or to water infiltration. In the worst case, the frost depth is not anticipated to exceed 24 inches. Nevertheless, the five-foot plus cover thickness on the leach tanks and 8.7-foot thickness of the cap on the closure cell provided an adequate margin of safety to control radon and to insure that frost heaving will not impact the performance of the cover.

The compacted cover for the closure cell was 8.7 feet. The evaporation pond material was mixed with Mancos Shale and was compacted into a soil-like state at a

moisture content that met compaction criteria (see Section 4.3). The soils placed in 1995 through 1997contained significant quantities of clay that were moisture conditioned and compacted to the radon barrier of cover specifications when placed. Therefore all of the materials in the closure cell were engineered placed and constructed and are much denser, less permeable and are unsaturated then are most other radioactive site repositories.

The infiltration through the cover was evaluated using the Hydraulic Evaluation of Landfill Performance (HELP) model developed by the US Army Engineer Waterways Experiment Station under a cooperative agreement with the U.S. Environmental Protection Agency. The model tends to predict more infiltration than is actually observed and thus is an appropriate model for evaluating the potential for long-term failures. In addition to reviewing Hecla's model, the Division prepared it's own evaluation of the data. The evaluation showed a steady state flux of liquids through the cover. Concerns were expressed about the buildup of liquids on the liner at the bottom of the cell. However, the underdrains were dry for several years prior to the start of reclamation. Borings conducted to characterize the leach tank materials indicated that the bottom few feet of tailings, in some locations might be saturated. The placement of low permeability cover material and the establishment of vegetation would reduce potential for infiltration and soil from becoming airborne.

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The erosion potential of the vegetated top slopes was evaluated using the Horton Method; one of the U.S. Nuclear Regulatory Commission-approved methods to evaluate gully erosion. The top slopes were designed to be less than 2 percent and were shown to be stable for flows up to the probable maximum flood event, 8.4 inches per hour of rainfall. Regrading the side slopes to 5H: 1V reduced the potential for erosion of the side slopes. The slopes were also protected with a rock cover. The size of the rock was calculated in order to withstand the erosive forces of the probable maximum flood. In the original design the D_{50} rock sizes varied from 4 inches to 20 inches. The plans were revised in 1997 to reduce the number of different sizes of rock needed. The D_{50} sizes either increased or remained the same.

During a May 2001 site visit, U. S. Nuclear Energy Division staff requested an evaluation of the top cover's resistance to erosion. Hecla Mining Company submitted a stability evaluation done by Monster Engineering dated October 31, 2001. The State concurred

with the findings of the evaluation that the top-slope covers were stable (CDPHE, Nov. 2001). The cover would provide long-term protection from radon emanation and erosion.

Response number 3

Acid Pit – This area was located immediately west of the ore preparation area at the base of Mancos Hill. It appears that tailings and soils were placed as backfill material to create a level storage area for large acid storage tanks. Contaminated soils were excavated from this area and placed in the closure cell. All analytical results were well below the cleanup criterion for radium-226 and the cleanup goals for metals with the exception of 4 selenium results taken in the Mancos Shale. **Significant concentrations of selenium occur naturally in many Upper Cretaceous and Tertiary geologic formations in Colorado. The Mancos Shale in western Colorado is one of the most highly seleniferous formations in Colorado. In addition, where cleanup could not be obtained adequately, areas had one-foot of compacted clay placed over them and were then backfilled.**

Editorial comment 2

Criterion 6: An earthen cover shall be placed over tailings or wastes which provides reasonable assurance of control of radiological hazards for 1,000 years to the extent reasonably achievable, and, in any case, for at least 200 years.
The earth and clay covers designed for the leach tanks are at least 5.28 feet thick on top and four feet thick on the sides, with at least six inches of rock on the sides of the earthen cover, a vegetative cover on the tops, and additional rock protection in the diversion channels adjacent to the cells. The closure cell cover is at least 8-feet thick and has a six-inch rock cover over the sides and top.

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