Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division

INTEROFFICE COMMUNICATION **DELIBERATIVE PROCESS**

To: Phil Egidi
Steve Tarlton

From: Larry Bruskin

Date: October 15, 2004

Subject: Cotter Impoundment Evaluation

You have requested that I evaluate the condition of the existing liner system of the tailings impoundments at the Cotter site, near Canon City, CO. You were particularly interested in determining whether the facility meets the requirements in Appendix A of Part 18, as well as whether the facility would potentially meet the requirements of RCRA Subtitle C for disposal facilities. Based on a review of existing documentation, the following are my observations and opinions.

Part 18, Appendix A, Criterion 5A(1)

Criterion 5A(1) states that a surface impoundment used to manage byproduct material shall have a liner that is designed, constructed and installed to prevent any migration of waste out of the impoundment to the adjacent subsurface soil, ground water or surface water at any time during the active life, including closure period, of the impoundment.

Hypalon Liner

It is my understanding that the lining system for the Cotter impoundments consists of 18-inches of moderately plastic compacted clay overlain by a minimum 45-mil Hypalon (plastic) liner. For some areas of the impoundments, a 60-mil Hypalon liner was used. A 12-inch thick "protective" earth cover of soil, consisting mostly of silty sand, was placed on top of the Hypalon.

Although the construction completion report written by Wahler Associates[1] does not list the gradation for the Zone 5 material, which was the material used as the 12-inch thick "protective" earth cover, the Remedial Investigation Report[2] (RI) states that rocks, up to boulder size, was

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[1] Wahler Associates, 1980, First Stage Construction Report, Cotter Corporation Tailings Impoundment, Canon City, Colorado.

[2] Remedial Investigation, 1986, Cotter Corporation Uranium Mill Site, Prepared for the State of Colorado Department of Law, Office of the Attorney General, prepared by GeoTrans, Inc., Rocky Mountain Consultants Inc., and ERI Logan, Inc.

part of the material placed directly on the Hypalon. The RI, written about 18 years ago in 1986, goes on to state that over 70 breaches in the Hypalon liner were documented. The RI also discusses other reasons why the physical condition of the Hypalon liner integrity is challenged, including numerous seam failures and the use of heavy equipment on the Hypalon.

In a report written by D.B. Stevens & Associates[3] in 1993, complete failure of the Hypalon liner was assumed to be a likely situation. The D.B. Stevens & Associates report makes this assumption based on discussion with personnel from the Colorado Geological Survey (CGS). The CGS personnel stated that numerous holes were present in the Hypalon at the time of installation.

Due to the documented condition of the Hypalon liner at the time of installation, my opinion is that the Hypalon liner should take no credit as a physical barrier for protection against liquid migration into the material below.

Permeability

From a geotechnical perspective, the 12-inch silty sand layer is not considered a low permeability material (i.e., having a hydraulic conductivity = 1×10^{-7} cm/sec). According to accepted soil property design charts[4], a compacted silty sand (assumed to classify as SM according to USCS) would have a permeability in the range of about 1×10^{-5} cm/sec. The material used for this layer apparently contained a range of rock sizes, assumed to include gravel, cobble and boulder sized materials. The inclusion of rock, particularly if the rock becomes segregated from the soil matrix during placement, would typically lead to an increase in the material's permeability. Therefore, it is my opinion that the evaluation of the liner system as a low permeability barrier should essentially be related to the condition of the 18-inch compacted clay material.

Compaction Specification

According to the Wahler Associates report, the required clay placement specification was a minimum 95% modified Proctor density (ASTM D 1557) at a moisture content 0% to 3% above optimum moisture content. The material generally met the compaction requirements, as shown through in-place density testing. The clay placement, therefore, met the general requirements of the "state of the practice" for the time when it was designed and constructed.

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[3] D.B. Stevens & Associates, 1993, Assessment of Potential Seepage Impacts on Ground Water, Cotter Uranium Mill, Canon City, Colorado, Volume II, Section 3.3.2.1, pg 10.

[4] Dept. of the Navy, 1982, Foundations and Earth Structures Design Manual 7.2, NAVFAC DM-7.2, Table 1, pg 7.2-39.

Research by Benson, et. al.[5], however, has shown that, due to the construction specifications utilized for this project, the clay used for the "clay subliner" may not achieve the 10^{-7} cm/sec permeability as assumed. Benson's research was based on evaluating the permeability of 85 full-scale compacted clay liners using large-scale field hydraulic conductivity testing.

The type of construction specification used for this project may not achieve the desired permeability because optimum water content for a given soil varies with compactive effort. (See the attached figure.) Even if a given soil density/moisture is measured within the approved compaction specification, the material may potentially be below the "line of optimums". According to Benson, the key to achieving low permeability barriers is to ensure that the density/moisture relationship of the compacted clay is at or above the "line of optimums".

Another factor challenging the viability of the clay liner as a low permeable barrier is the actual clay thickness. The existing clay thickness (18-inches) has been shown to be minimally capable of producing a 10^{-7} cm/sec permeability liner. Benson suggests that for hazardous waste disposal facilities, liner thicknesses = 1 m (~ 3.3 ft) should be considered for compacted clay liners in order to achieve and maintain 10^{-7} cm/sec permeability.

Another finding by Benson is that adequate hydration time is also required in order to achieve the desired permeability. Hydration time is the time required for a dry soil to thoroughly saturate the entire soil matrix after applying moisture. This is particularly important for addressing dry clay clods that are part of the material. For a clay soil, adequate hydration time is typically about 48 to 96 hours. It is unlikely that hydration time was considered for placing the compacted clay liner at the Cotter impoundments.

It should be noted that the "line of optimums" concept was not recognized until about 1990 or so, well after this impoundment was designed and constructed. However, based on current knowledge, the likelihood that the existing liner at the Cotter facility actually has achieved, and will continue to achieve a permeability = 1 x 10^{-7} cm/sec is, in my opinion, very low.

Other Factors for Consideration

- Permeability testing was not performed on the in-place material, either through in-situ field testing or samples of the compacted clay liner obtained for laboratory testing.
- Chemical compatibility testing, specifically to evaluate the potential effects that the leachate would have on the clay permeability, was never performed.
- During foundation excavation, the Wahler report states that "numerous" springs were encountered.
- During foundation excavation, the Wahler report states that a "few" open fractures in the sandstone bedrock were encountered.

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[5] Benson, C.H., Daniels, D.E., and Boutwell, G.P., 1999, Field Performance of Compacted Clay Liners, Journal of Geotechnical and Geoenvironmental Engineering, pp 390 – 403.

- Some winter work was performed, possibly including portions of the liner system. Any clay placement or liner seaming must be carefully evaluated if temperatures are below freezing.

6 CCR 1007-2, Part 2 – Rules and Regulations Pertaining to Solid and Hazardous Wastes, Requirements for Siting of Hazardous Waste Disposal Sites

Section 2.5.3 of the Part 2 Siting regulations requires that reasonable assurance be provided that hazardous wastes can be isolated within the designated disposal area of the site and away from environmental pathways that could expose the public for 1,000 years.

The 1,000-year demonstration typically involves detailed ground water modeling that demonstrates that the historic high water level beneath the site will not be impacted by contaminants in the leachate. Both natural geologic as well as engineered barriers are considered. For a liner with a permeability of 1 x 10^{-7} cm/sec, the distance traveled would be about 0.1 feet/year (~ 100 feet over 1,000 years).

D.B. Stevens & Assoc. performed modeling to assess the performance of the main and secondary impoundments for a variety of hypothetical configurations. The modeling showed that the seepage rates through the impoundments are initially high (10^{-6} to 10^{-7} cm/sec), principally due to transient drainage. After 200 to 300 years of transient drainage, the seepage reached a steady rate of about 10^{-8} cm/sec (~ 10 feet over 1,000 years).

Even without the modeling discussed above, the site would not satisfy the siting requirement. The ground water beneath the disposal areas essentially intersects the bottom of the impoundment, at least where the springs were encountered during the foundation excavation. This alone would render the site unusable with respect to the Part 2 Siting regulations.