40-4492

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 13, 1998

Mr. Mark Moxley
Wyoming Department of Environmental Quality
Land Quality Division
250 Lincoln Street
Lander, Wyoming 82520-2848

SUBJECT: FINAL RECLAMATION PLAN FOR POND #2, GAS HILLS SITE

Dear Mr. Moxley:

On April 10, 1996, Shepherd Miller, Inc. (SMI) transmitted to the U.S. Nuclear Regulatory Commission the Final Reclamation Plan for American Nuclear Corporation's (ANC's) Tailings Pond #2 and a preliminary reclamation plan for Pond #1, by copy of a letter to the State of Wyoming Department of Environmental Quality (WDEQ). The SMI letter stated that the final plan for Pond #2 incorporated NRC staff comments on the preliminary plan that was submitted to the NRC by letter dated November 17, 1995.

The NRC staff review of the final plan for Pond #2 identified areas in which clarification or additional information was required, and possible design improvements which could be made in the areas of surface water hydrology, erosion protection, and radiological protection. As requested by WDEQ and agreed to by NRC management, the NRC staff provided comments on the final plan to WDEQ and SMI by facsimile, telephone conversations, and in meetings, as listed in Enclosure 1, and SMI submitted various revisions to the plan which are also listed in Enclosure 1.

The Technical Evaluation Report (TER, Enclosure 2) is the NRC staff's formal documentation of the acceptability of the final WDEQ reclamation plan for Pond #2, as revised. The TER also documents the NRC staff evaluation of the completion report for the Bullrush Heap Leach. The staff's comments on the preliminary design for Pond #1 are provided in Enclosure 3.

NU17

If you have any questions concerning this letter or enclosures, please contact Ken Hooks, the NRC project manager for the Gas Hills site, at (301) 415-7777.

Sincerely,

[Original signed by D. Gillen for]

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures: As stated

cc: R. Chancellor, WDEQ Cheyenne
J. Voeller, AVI Cheyenne
W. Salisbury, ANC Casper
R. Edge, DOE Grand Junction

Cases closed: L51395, L51301

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DATE	02/4 /98	02/13/98	02/13/98			

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PARTIAL TIME LINE FOR RECLAMATION OF GAS HILLS SITE

05/09/94 - American Nuclear Corporation (ANC) notifies U.S. Nuclear Regulatory Commission (NRC) that it is discontinuing operations and going out of business.

07/15/94 - Wyoming Department of Environmental Quality (WDEQ) notifies U.S. Department of Energy (DOE) that the State of Wyoming does not intend to accept long term custody of Title II sites in Wyoming.

07/21/94 - WDEQ notifies NRC that it is prepared to undertake the reclamation of ANC's Gas Hills site, and will require timely NRC support to meet cost and schedule objectives.

09/27/97 - NRC commits to timely support of WDEQ and willingness to meet with DEQ as required to resolve questions and minimize paperwork.

10/05/94 - ANC's surety bond of $3,213,254 is forfeited to WDEQ.

03/02/95 - WDEQ notifies NRC it has begun procurement process to select firm to review NRC's 3/11/94 comments on ANC's reclamation plan and finalize site reclamation plan.

06/19/95 - NRC meets with WDEQ in Casper, WY to discuss reclamation of site. WDEQ states it has hired AVI pc/Shepherd Miller Inc. (SMI) to conduct site studies and prepare reclamation designs. NRC staff makes site familiarization visit and Region IV conducts inspection.

07/18/95 - NRC issues "Final Position on Review of Previously Approved Reclamation Plans."

08/25/95 - NRC sends draft Confirmatory Order for reclamation of site to WDEQ.

08/30/95 - WDEQ sends plans for Bullrush heap leach reclamation to NRC.

09/07/95 – NRC discusses radon emanation coefficients with WDEQ.

09/08/95 - WDEQ states intent "...to achieve a plan that will improve on the 1984 approved plan as well as to meet budgetary constraints."

09/11/95 - NRC discusses comments on Bullrush heap leach reclamation plans with WDEQ by telephone.

09/19/95 - NRC holds public meeting with WDEQ and DOE in Casper to discuss reclamation and conditions under which WDEQ can claim Title X funds.

09/26/95 - NRC meets with WDEQ to discuss surface erosion, differential settlement, and overall reclamation strategy.

10/25/95 - WDEQ provides budget analysis and time schedule for site reclamation.

11/02/95 - NRC visits Gas Hills site to become familiar with groundwater and surface conditions.

11/17/95 - WDEQ sends preliminary reclamation plan and site investigation report for ANC Gas Hills site to NRC

Enclosure 1

12/12/95 - WDEQ sends information on tailings ponds foundation conditions to NRC to resolve stability questions.

12/22/95 - NRC provides comments on preliminary reclamation plan by telephone to SMI.

01/02/96 - NRC provides comments on preliminary reclamation plan to SMI.

01/18/96 - NRC meets with WDEQ to discuss surface water hydrology and erosion protection for Gas Hills site.

01/26/96 - WDEQ sends memo to NRC on groundwater conditions at site.

02/05/96 - NRC issues Amendment 51 to License SUA-667 to relocate site boundary fence to facilitate soil cleanup.

03/01/96 - WDEQ submits request for NRC to consider alternate method of windblown cleanup.

03/08/96 - WDEQ submits Bullrush heap leach completion report (placed material on tailings Pond #1).

04/10/96 - WDEQ sends to NRC the final reclamation plan for Pond #2, which includes preliminary reclamation plan for Pond #1.

04/18/96 - NRC agrees to consider alternate method of windblown cleanup.

05/03/96 - NRC provides comments on 4/10/96 reclamation plan to WDEQ by telephone and subsequent fax.

06/05/96 - NRC inspects site (IR 40-4492/96-01).

06/10/96 - WDEQ submits revisions to 4/10/96 reclamation plan, including revised soil cleanup plan.

06/25/96 - WDEQ submits gamma survey map to be included in 4/10/96 reclamation plan.

06/28/96 - NRC provides additional comments, specific to windblown cleanup, on 4/10/96 reclamation plan to WDEQ by telephone and fax.

07/30/96 - NRC visits site, discusses drainage/erosion with WDEQ.

10/08/96 - NRC issues final Confirmatory Order making WDEQ responsible for site reclamation; WDEQ signs acceptance on 10/15/96.

11/14/96 - NRC meets with SMI to discuss reclamation plan, particularly soil cleanup and radon flux testing.

11/15/96 - NRC meets with SMI to discuss erosion protection design in reclamation plan.

12/19/96 - ANC requests NRC to eliminate environmental monitoring and other non-relevant conditions from License SUA-667.

01/17/97 - WDEQ sends to NRC revisions to 4/10/96 final reclamation plan, including changes to contours, riprap and soil cleanup plan.

03/26/97 - WDEQ sends to NRC its review of groundwater information from site vicinity and recommendations for future investigations.

05/07/97 - WDEQ submits to NRC a revised plan for windblown cleanup.

06/19/97 - NRC provides comments to WDEQ by telephone and fax concerning 5/7/97 windblown cleanup plan.

07/29/97 - NRC inspects site (IR 40-4492/97-01). Open item identified concerning test frequency for cover materials.

09/08/97 - WDEQ submits revised windblown cleanup plan.

10/23/97 - NRC provides comments on 9/8/97 windblown cleanup plan by telephone to WDEQ.

11/05/97 - NRC clarifies items in reclamation plan concerning Pond #2 radon cover with WDEQ by telephone.

TECHNICAL EVALUATION REPORT
RECLAMATION PLAN FOR TAILINGS POND #2
AMERICAN NUCLEAR CORPORATION'S GAS HILL, WYOMING, SITE

DATE: December 2, 1997

DOCKET NO. 40-4492

LICENSE NO. SUA-667

LICENSEES: Wyoming Department of Environmental Quality Under Confirmatory Order and American Nuclear Corporation Under Source Material License SUA-667

FACILITY: American Nuclear Corporation's Uranium Mill and Tailings Site, Gas Hills, Wyoming

PROJECT MANAGER: Ken Hooks

TECHNICAL REVIEWERS: Elaine Brummett, Ted Johnson, and Dan Rom

BACKGROUND

The American Nuclear Corporation (ANC) site is located in the Gas Hills of Eastern Fremont County, Wyoming. The site contains two uranium tailings piles, Pond #1 and Pond #2, which are about 40 and 80 acres in size, respectively. The site also contains the Bullrush Heap Leach materials, which were moved to Pond #1 in 1995.

In 1994, ANC went out of business and forfeited its reclamation bond to the Wyoming Department of Environmental Quality (WDEQ). WDEQ subsequently assumed responsibility for redesigning and implementing the reclamation plan for the ANC site. In 1996, WDEQ signed a Confirmatory Order issued by the NRC making WDEQ formally responsible for site reclamation and entitling WDEQ to seek reimbursement from the U.S. Department of Energy under Title X of funds expended for reclamation. ANC remains the licensee and retains title to the site.

WDEQ proposed to perform the reclamation work in three, possibly four, phases. Phase I, completed in January 1996, consisted of relocating Bullrush Heap Leach material to Pond #1, placing an interim cover on the surface of Pond 1, and constructing interim drainage features. The completion report for Phase I was submitted to the NRC on March 8, 1996, and is reviewed in this Technical Evaluation Report (TER). The final reclamation plan for Pond #2, which includes the preliminary reclamation plan for Pond #1, was submitted to the NRC on April 10,

Enclosure 2

1996, and subsequently modified as shown in Enclosure I. Phase II, the reclamation of Pond #2, is the main subject of this TER. Phase III will include preparation of the final reclamation plan for Pond #1 and Pond #1 reclamation activities. Phase IV will include miscellaneous site work, if needed.

The Confirmatory Order requires WDEQ to perform reclamation in accordance with the ANC reclamation plan approved by the NRC in 1984, with those changes requested by WDEQ and approved by the NRC. The NRC criteria for approval of changes requested by WDEQ is that the changes result in a plan that is as good as, or better, than the 1984 plan. The final WDEQ reclamation plan is not required to meet current NRC criteria established subsequent to 1984. This is consistent with the Commission's decision recorded in SECY-95-155, dated June 14, 1995, provided to both ANC and WDEQ by NRC letter dated July 18, 1995.

During 1995 and 1996, the Bullrush Heap Leach was scraped up and placed on Pond #1. The completion report for this activity was submitted to the NRC by letter dated March 8, 1996 (WDEQ, March, 1986). Based on staff review of the report, and an on-site inspection June 5, 1996, the relocation of the heap leach material and liner to Pond #1 was found to be generally acceptable.

The groundwater aspects of site reclamation have not yet been agreed upon between WDEQ and the NRC. At this time, the NRC staff is waiting on WDEQ to concur with the groundwater Alternate Concentration Limits proposal made by ANC, or make alternate proposals to effect groundwater cleanup, which will be reviewed in detail by the staff. Cleanup of windblown contamination is not discussed in this TER, since the WDEQ plan is still being reviewed by NRC staff.

TECHNICAL EVALUATION

1.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

1.1 Site Conceptual Design

After examining various options to comply with NRC regulations in 10 CFR Part 40, Appendix A, that require stability of the tailings for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years, WDEQ proposes to stabilize the contaminated materials in Pond 2 to protect them from flooding and erosion. The design basis events for design of the erosion protection included one half of the Probable Maximum Precipitation (PMP) and one half of the Probable Maximum Flood (PMF) events, both of which are considered to have low probabilities of occurrence during a 200-year stabilization period.

As proposed by WDEQ, the tailings and soil covers of Pond #2 will be protected by rock covers. The rock cover for the top slope will consist of rock with an average size (D50) of 1.25 inches. The rock for the side slopes will have a D50 of 3.0 inches. The downstream portions of the side slopes of the disposal cell will be more heavily armored to minimize gully intrusion into the contaminated materials. In addition, three diversion channels and a drainage swale will be constructed to divert flood flows from the upland drainage areas away from the disposal cells toward existing natural drainage channels.

1.2 Flooding Determinations

The computation of peak flood discharges for various design features at the site was performed by WDEQ in several steps. These steps included: (1) selection of a design rainfall event; (2) determination of infiltration losses; (3) determination of times of concentration; and (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration. Input parameters were derived from each of these steps and were then used to determine the peak flood discharges to be used in water surface profile modelling and in the final determination of rock sizes for erosion protection.

1.2.1 Selection of Design Rainfall Event

One of the most disruptive phenomena affecting long-term stability is surface water erosion. WDEQ has recognized that it is very important to select an appropriately conservative rainfall event on which to base the flood protection designs.

For this site, WDEQ concluded that designing for a 1000-year stability was not reasonably achievable and provided information to show that high costs would be associated with such a design (WDEQ, November, 1995). The staff reviewed information provided by WDEQ that documented the limited availability of reclamation funds and the ability to construct an optimum design. In various submittals (WDEQ, September, 1995; WDEQ, October, 1995), WDEQ indicated its intent to provide a design that would improve on ANC's 1984 reclamation plan and provided schedules, budgets, costs, and other information regarding the costs of reclamation.

WDEQ examined five different design alternatives and developed an optimum design, based on available funds. Based on WDEQ documentation of the economic constraints imposed by the underfunded surety and an examination of the five alternative designs, the staff agrees that the design proposed by WDEQ is probably the best design reasonably achievable. On that basis, the staff concludes that the flood and precipitation events selected for design meet the suggested criteria of NRC Final Staff Technical Position (FSTP), "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites." This guidance document suggests that a flood or precipitation event less than the PMF or PMP may provide an acceptable design basis, in cases where the cost of achieving a design for the full PMP/PMF is not reasonably achievable.

In accordance with the suggested criteria of the FSTP, WDEQ utilized one half of the PMP for the design of the various erosion protection features at the site. The staff concludes that the probability of such an event being equaled or exceeded during the required 200-year stability period is small. Therefore, in consideration of the economic constraints imposed on WDEQ and the low probability of the design event, one half of the PMP/PMF is considered by the NRC staff to provide an acceptable design basis for this specific site and set of economic circumstances.

Prior to determining the runoff from the drainage basin, the flooding analysis requires the determination of rainfall amounts for the specific site location. Techniques for determining the rainfall amounts have been developed for the entire United States, primarily by the National Oceanographic and Atmospheric Administration (NOAA) in the form of hydrometeorological reports for specific regions. These techniques are widely used and provide straightforward procedures with minimal variability. The staff concludes that use of these reports to derive rainfall estimates is acceptable.

A PMP rainfall depth of approximately 9.2 inches in one hour was used by WDEQ to compute the PMF for the small drainage areas at the site. This rainfall estimate was developed by WDEQ using Hydrometeorological Report (HMR) 55A (Department of Commerce, 1988). The staff performed an independent check of the PMP value, based on the procedures given in HMR 55A. Based on this check of the rainfall computations, the staff concludes that the PMP was acceptably derived for this site.

1.2.2 Infiltration Losses

Determination of the peak runoff rate is dependent on the amount of precipitation that infiltrates into the ground during the occurrence of the rainfall. If the ground is saturated from previous rains, very little of the rainfall will infiltrate and most of it will become surface runoff. The loss rate is highly variable, depending on the vegetation and soil characteristics of the watershed. Typically, all runoff models incorporate a variable runoff coefficient or variable runoff rates. Commonly-used models such as the Rational Formula (USBR, 1977) incorporate a runoff coefficient (C); a C value of 1 represents 100% runoff and no infiltration. Other models, such as the U.S. Army Corps of Engineers Flood Hydrograph Package HEC-1 (COE, 1990) separately compute varying infiltration losses within a certain period of time to arrive at a runoff amount during that time period.

In computing the peak flow rates for the design of the rock riprap erosion protection covers at the ANC site, WDEQ used Soil Conservation Service (SCS) Curve Numbers (CNs) and the COE HEC-1 model. In using these methods, WDEQ accounted for watershed characteristics such as time of concentration, basin area, and infiltration capacity of the soils. Based on a detailed review of the computations and checks of the analyses, the staff concludes that the peak flow estimates were acceptably derived.

1.2.3 Times of Concentration

The time of concentration (tc) is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. The peak runoff for a given drainage basin is inversely proportional to the time of concentration. If the time of concentration is computed to be small, the peak discharge will be conservatively large. Various times of concentration and lag times for the riprap design were estimated by WDEQ using the Kirpich Method (USBR, 1977). This method is considered by the staff to be appropriate for estimating times of concentration for steep drainage basins. Based on the conservatism associated with this method, the staff concludes that the tc's have been acceptably derived. The staff further concludes that the procedures used for computing tc are representative of the drainage areas present at the ANC site.

1.2.4 Rainfall Distributions

After the PMP is determined, it is necessary to determine the rainfall intensities corresponding to shorter rainfall durations and times of concentration. A typical PMP value is derived for periods of about one hour. If the time of concentration is less than one hour, it is necessary to extrapolate the data presented in the various hydrometeorological reports to shorter time periods. WDEQ utilized the SCS Type II procedure to determine rainfall amounts for time periods less than one hour. The staff checked the rainfall estimates for the short durations associated with small drainage basins. Based on a review of this aspect of the flooding determination, the staff concludes that the computed rainfall amounts are acceptable.

1.2.5 Computation of PMF

1.2.5.1 Top and Side Slopes

One half of the PMF was calculated for the top and side slopes of Pond 2 using HEC-1. For a maximum top slope length of 630 feet, and an additional side slope length of about 600 feet, WDEQ estimated the peak flow rate to be about 0.91 cubic feet per second per foot of width (cfs/ft) for the top slope and 1.07 cfs/ft for the side slope. The staff reviewed the calculations and independently estimated the maximum flow rates using the Rational Formula (Chow, 1959) and assuming total runoff. These calculations indicate that for the total slope length of 1230 feet, the rainfall intensity that would produce a runoff rate of 1.07 cfs/ft would be approximately 38 inches per hour, assuming no flow concentrations. This rainfall rate is considerably higher than any recorded rainfall intensity in the State of Wyoming and approaches intensities produced by 100 percent of the PMP. Based on staff review of the calculations provided by WDEQ and the conservatism associated with the runoff rates, the estimates are considered to be acceptable.

1.2.5.2 Diversion Channels

The diversion channels are designed to intercept and divert runoff from the upland areas and to convey on-site runoff into natural channels at the site. The channels will be constructed upstream, and along the sides of, the disposal cell and will be aligned generally perpendicular to the natural grade.

HEC-1 (COE, 1990) was used to compute peak flow rates for the various channels. Maximum flow rates of 1896 cfs, 1061 cfs, and 163 cfs were estimated for Campsite Draw, Southwest Channel, and the Pond 1 East channel, respectively. Campsite Draw, for example, has a drainage area of about 0.52 square miles near the disposal cell. The computed peak discharge of 1896 cfs represents a flow rate of about 3650 cfs per square mile. Such a flow rate is considered to be significant and exceeds known historic peak flow rates in this area of Wyoming for streams of this size, based on examination of historic flooding (Crippen and Bue, 1977; USDOI, 1986). The 200-year design criteria provided in the NRC FSTP suggest that design discharges should be one half of the PMF or at least equal to known historic flood peaks. Thus, the reports of historic flooding show the acceptability of the design flows for the channels. Based on a check of the calculations of drainage area, time of concentration, and rainfall intensity, the staff concludes that the peak flow calculations are reasonable estimates of one half of the PMF and are, therefore, acceptable.

1.3 Water Surface Profiles and Channel Velocities

Following the determination of the peak flood discharge, it is necessary to determine the resulting water levels, velocities, and shear stresses associated with that discharge. These parameters then provide the basis for the determination of the required riprap size and layer thickness needed to assure stability during the occurrence of the design event.

1.3.1 Top and Side Slopes

In determining riprap requirements for the top slopes, WDEQ used the Shields Incipient Motion Relationship, which is similar to the Horton Method discussed in the NRC FSTP. For the side slopes, WDEQ used the Stephenson Method (Stephenson, 1979). The Shields method can be used for relatively flat slopes of less than 10 percent; the Stephenson Method is used for slopes greater than 10 percent. The validity of these design approaches has been verified by the NRC staff through the use of flume tests at Colorado State University. It was determined that the selection of an appropriate design procedure depends on the magnitude of the slope (Abt, et al., 1987). The staff therefore concludes that the procedures and design approaches used by WDEQ are acceptable and reflect state-of-the-art methods for designing erosion protection.

1.3.2 Diversion Channels

Manning's Equation and normal depth computations (Chow, 1959) were used to estimate flow depths and velocities for the estimated discharge conditions in the diversion channels. Based on staff review of the calculations, the analyses are acceptable. Additional detailed information related to the use of these computed depths and velocities for the design of erosion protection for the channels may be found in Section 1.4, below.

1.4 Erosion Protection

1.4.1 Sizing of Erosion Protection

Riprap layers of various sizes and thicknesses are proposed for use at the site. The design of each layer is dependent on its location and purpose.

1.4.1.1 Top Slopes and Side Slopes

The riprap on the top slope has been sized to withstand the erosive velocities resulting from one half of the PMP, as discussed above. WDEQ proposes to use a 3-inch-thick layer of rock with a minimum D50 of 1.25 inches. The Shields Method was used to determine the rock size. This rock may be difficult to place in such a thin layer. However, the staff concludes that the rock can be effective in preventing significant erosion, because the layer will simulate desert armor. The D50 size of the eventual soil/rock matrix will be greatly increased over natural desert armor conditions, resulting in an erosion protection barrier that should be very effective. The staff concludes that this layer will be effective if properly placed and intends to perform various inspections to assure that the rock layer is adequately placed.

The rock layer on the side slopes is also designed for an occurrence of one half of the PMP. WDEQ proposes to use a 6-inch-thick layer of rock with a minimum D50 of approximately 3.0 inches. Stephenson's Method was used to determine the required rock size. Conservative values were used for the specific gravity of the rock, the angle of internal friction, and porosity.

The riprap sizes proposed for the top and side slopes include an allowance for flow concentrations of 1.5. For the top slope and side slopes, therefore, riprap sizes will actually be designed for approximately 75 percent of the PMP/PMF.

Based on staff review of the analyses and the acceptability of using design methods recommended by the NRC staff, as discussed in Section 4.3 of this report, the staff concludes that the proposed rock sizes and thicknesses are adequate.

1.4.1.2 Rock Toes

Due to cost constraints, WDEQ did not design a rock toe at the downstream end of the pile side slopes. Such a rock toe is normally provided to reduce the potential for gully intrusion into the tailings, if gullying and gully headcutting were to occur. WDEQ did, however, provide flatter slopes along the north/northeast toe of the pile, where flow lengths were longest and where there was the greatest potential for gully intrusion.

WDEQ provided geomorphic information and qualitative analyses to indicate that the reclaimed pile would not be subject to erosion and gullying. The report provided opinions that the pile location is ideal and will not be subject to erosion. However, this conclusion is not supported by the evidence of nearby headcutting and recent erosion of the unarmored pile side slopes from normal rainfall and runoff events.

From a qualitative standpoint, the staff considers it unlikely that tailings will be eroded and transported downstream. Along the north/northeast portion of the pile, the tailings will be located more than 600 feet from the toe of the slope. Along the east side of the cell, the tailings will be located at least 150 feet from the toe of the slope. Because the slopes will be covered with rock, the rock will collapse into any advancing gully and prevent erosion of the tailings.

To quantitatively determine the adequacy of the rock, the staff independently checked the ability of the side slope rock to prevent gully intrusion. Using recently-developed methods (Abt and Johnson, 1991), the staff determined that the rock would be stable, even if a flow concentration factor of 2 were to occur in the gullied areas. For a flow rate of 2.0 cfs/ft on a slope of 0.085 (north/northeast side) and a flow rate of 1.5 cfs/ft on a slope of 0.20 (east side), the staff determined that the required rock sizes would be about 3 inches, in each case. Because 3-inch rock will be provided on the slopes in this area, the staff concludes that the potential for significant erosion of the toes has been reduced (as compared to the ANC previous design).

However, because gullies can have flow concentrations much greater than 2, the staff suggests that the toe areas of the pile be monitored carefully as part of the long-term surveillance and maintenance program (LTSP). The staff recommends that these areas receive specific attention when the LTSP is developed for this site.

1.4.1.3 Diversion Channels

1.4.1.3.1 Riprap Design

Riprap layers with minimum D50s of 8 and 4 inches are proposed for the Campsite Draw and Southwest diversion channels, respectively. These rock sizes were determined using COE methods (COE, 1970). Based on a check of the calculations, the staff concludes that these rock sizes are adequate to effectively resist erosion. In addition, the staff checked the rock sizes using recently-developed riprap design methods (Abt and Johnson, 1991). These checks indicate that the rock is properly sized.

It should be emphasized that some damage can be expected to occur to the diversion channels. Even though some minor erosion may occur in unprotected channels or in channels that are underdesigned for the full PMF, the damage is not expected to be extensive or to compromise the stability of the tailings over a 200-year period. This conclusion is based on the following: (1) the channel are located a substantial distance from the tailings; (2) the erosion that occurs to the diversion channel will likely occur in a limited area; and (3) the slopes of the regraded ground surfaces are from the tailings embankment toward the channels (the channels are lower than the tailings), preventing flows from reaching the tailings pile side slopes. Expected conditions of minor erosion should be noted in the LTSP.

1.4.1.3.2 Sediment Considerations

In general, sediment deposition can be a problem in diversion channels when the slope of the diversion channel is less than the slope of the natural ground where flows enter the channel. It is usually necessary to provide sufficient slope and capacity in the channel to flush or store any sediments which will enter the channel. In particular, significant design features may be necessary in areas where natural gullies are intercepted by the diversion channel. Concentrated flows and high velocities which could transport large quantities of sediment, and the size of the particles transported by the natural gully, may be larger than the man-made channel ditch can effectively flush out.

WDEQ provided designs to minimize the potential for sediments to enter the channels by constructing buffer areas between the upland areas and the channels. These buffer areas are relatively wide and are capable of providing storage volume for a considerable amount of sediment. The staff concludes that this design approach will be effective in reducing the amount of sediment that will enter the diversion channels.

For this site, some sediment from the upland drainage area can be expected to enter the diversion channels, because the upland drainage areas have relatively large slopes. However, the diversion channels also have sufficiently large slopes in the reaches adjacent to the tailings embankment to flush away a considerable amount of sediment. In addition, some blockage of the channels can be tolerated, because a positive slope will be maintained from tailings toward the ditches. If blockage occurs in a specific area and flows overtop the channel banks, the flow will return to the channel immediately downstream of the blockage and will not cause erosive velocities in the tailings area. Expected areas and conditions of sedimentation should be noted in the LTSP.

1.4.2 Rock Durability

10 CFR 40 Appendix A requires that tailings control be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The previous sections of this report examined the ability of the erosion protection to withstand flooding events reasonably expected to occur in 200 years. In this section, rock durability is considered to determine if there is reasonable assurance that the rock itself will survive and remain effective for 200 years.

Rock durability is defined as the ability of a material to withstand the forces of weathering. Factors that affect rock durability are (1) chemical reactions with water, (2) saturation time, (3) temperature of the water, (4) scour by sediments, (5) windblown scour, (6) wetting and drying, and (7) freezing and thawing.

WDEQ identified an acceptable source of rock in the immediate site vicinity. The suitability of the rock as a protective cover was then assessed by laboratory tests to determine its physical characteristics. WDEQ conducted the tests and used the results of these tests to classify the rock's quality and to assess the expected long-term performance of the rock. The tests included:

1. Bulk Specific Gravity (ASTM C127). The specific gravity of a rock is an indicator of its strength or durability; in general, the higher the specific gravity, the better the quality of the rock.

2. Absorption (ASTM C127). A low absorption is a desirable property and indicates slow disintegration of the rock by salt action and mineral hydration.

3. Sulfate Soundness (ASTM C88). In locations subject to freezing or exposure to salt water, a low percentage is desirable.

4. Los Angeles Abrasion (ASTM C131 or C535). This test is a measure of rock's resistance to abrasion.

WDEQ then used a step-by-step procedure for evaluating durability of the rock, in accordance with the FSTP (NRC, 1990), as follows:

Step 1. Test results from representative samples are scored on a scale of 0 to 10. Results of 8 to 10 are considered "good"; results of 5 to 8 are considered "fair"; and results of 0 to 5 are considered "poor".

Step 2. The score is multiplied by a weighting factor. The effect of the weighting factor is to focus the scoring on those tests that are the most applicable for the particular rock type being tested.

Step 3. The weighted scores are totaled, divided by the maximum possible score, and multiplied by 100 to determine the rating.

Step 4. The rock quality scores are then compared to the criteria which determines its acceptability, as defined in the NRC scoring procedures.

In accordance with the procedures suggested in the FSTP, WDEQ determined from preliminary testing that the rock proposed for the disposal site scored approximately 92. Rock of this quality is acceptable in all areas of the pile. Therefore, the staff concludes that the rock will be of sufficient quality to meet NRC requirements.

1.4.3 Testing and Inspection of Erosion Protection

The staff has reviewed and evaluated the testing and inspection quality control requirements for the erosion protection materials. WDEQ intends to regularly check durability, gradation, and placement of the riprap. Based on a review of the information provided, the staff concludes that the proposed testing program is acceptable.

1.5 Upstream Dam Failures

There are no impoundments near the site whose failure could potentially affect the site.

1.6 Conclusions

Based on review of the information submitted by WDEQ, the staff concludes that the site design is an improvement over the previously-approved design (that was found to meet NRC requirements, as stated in 10 CFR 40 Appendix A) with regard to flood design measures and erosion protection. The staff suggests that careful attention be devoted to the development of the LTSP for this site, particularly for the rock toes, diversion channels, and other erosion protection features that fall short of meeting the current criteria for long-term stabilization, as suggested in the FSTP.

2.0 GEOTECHNICAL ENGINEERING

2.1 Settlement

By letter to ANC dated July 23, 1991, the NRC staff concurred with ANC's April 24, 1991, report that settlement data indicated the 90 percent consolidation point had been reached in Pond #2. The settlement monitoring program for Pond #1 which is proposed in Section 3.0 of the final reclamation plan is acceptable to the NRC staff. A report, including field data, which demonstrated 90 percent primary consolidation of Pond #1, was submitted to the NRC staff on April 9, 1996. Although it was demonstrated that 90 percent of the primary consolidation had occurred at the test locations, significant settlement (greater than five feet) could still result. Calculations were provided to show that the amount of settlement could be decreased to satisfactory levels by preloading the affected areas. Since the current plan provides for continued monitoring and the placement of a significant pre-load in the future, the submittal is deemed acceptable.

2.2 Stability

Slope stability requirements are specified in 10 CFR 40, Appendix A, Criterion 4(c) and 4(e). The initial NRC staff stability analysis of Pond #2, using the PCSTABL5 code, resulted in a safety factor exceeding 1.0, indicating that the stability analysis of Pond #2 included in Section 3.0 of the final reclamation plan is acceptable. However, the staff analysis of Pond #1, based on the information in Section 3.0, resulted in a safety factor of less than 1.0. In order to address this situation, a discussion of applicable seismic considerations was presented along with stability analyses on April 9, 1996. The discussion substantiated that a higher applicable seismic acceleration factor was appropriate, thus a safety factor in excess of 1.0 will apply. The revised submittal substantiates the design as proposed, and thus is deemed acceptable.

2.3 Cover Materials

The NRC staff considers the soils data given in Appendix A to the final reclamation plan, and the cover material parameter derived from the soils data, to be reasonable. The field test frequency for moisture/density of one test per 5,000 cubic yards during placement of cover material, as stated in Section 6.2.2 of the reclamation plan is acceptable, subject to review of construction records during a future inspection. The conditional approval is based on the supposition that cover materials are relatively uniform in makeup. If review of the records show that the materials vary significantly in makeup, then additional testing may be required.

2.4 Frost Protection

Mine spoil-derived cover soils and clean borrow cover thicknesses are sufficient to prevent penetration of frost into the embankment. Based on the composition and thickness of the final covers for Pond #1 and Pond #2, the NRC staff does not expect significant cracking of the radon barrier due to frost penetration.

2.5 Bullrush Heap Leach

On March 8, 1996, WDEQ issued its report on the status of the cleanup and removal of byproduct materials from the old Bullrush Heap Leach (WDEQ, March, 1986). The materials were placed on Pond #1, and the work was substantially completed on January 16, 1996. The placement of materials on Pond # 1 was in accordance with the specifications, as modified in response to NRC's previously expressed concerns. Based on review of the completion report, the staff considers that reclamation of the Bullrush Heap Leach is acceptable, subject to visual observation of completed work and review of the construction records during a future inspection.

2.6 Conclusions

The staff concludes that the geotechnical aspects of the final reclamation plan for Pond #2 meet the requirements of 10 CFR 40, Appendix A, and are acceptable. Placement of Bullrush Heap Leach materials on Pond #1 is acceptable, subject to visual observations and review of construction records during a future inspection.

3.0 RADON ATTENUATION DESIGN

3.1 General

This section of the staff evaluation of the final reclamation plan addresses the demonstration of compliance with that portion of Criterion 6 of 10 CFR 40 Appendix A that requires that a disposal cell design limit releases of radon (Rn-222) from uranium byproduct materials to not exceed an average (over at least a year) release rate of 20 pCi/m^2/s from the surface of the cell for 1000 years, to the extent reasonably achievable, but at least 200 years.

By letter dated April 10, 1996, the Wyoming Department of Environmental Quality (WDEQ) submitted the final reclamation plan for Tailings Pond #2 that also includes a preliminary radon attenuation design for Pond #1. The NRC staff comments on the radon attenuation design were discussed during phone conferences with WDEQ on May 3 and June 28, 1996. Final reclamation plan revisions related to radon attenuation were provided by letter of January 17, 1997.

The final reclamation plan for Pond #2 presents a radon flux model for each of the tailings disposal cells (ponds) that supports, via the RADON computer code (NRC, 1989) estimation of radon flux, use of a 2.5-foot-thick layer each of mine spoils (overburden soil) and clean soil for the radon barrier for Pond #1 and 3.0-foot-thick layers of each material for the barrier of Pond #2. The ponds also have approximately 5.1 and 2.7 feet of overburden interim cover on the tailings, respectively, that was also represented in the models.

Because radon (Rn-222) is a gas with a short half-life (3.8 days), the amount of radon from uranium mill tailings reaching the atmosphere is reduced by restricting the gas movement long enough so that radon decays to a solid daughter which remains within the disposal cell. The physical and radiological parameters influencing the amount of radon available to the soil pore spaces and its movement are incorporated into a computer code.

The NRC staff review of the cover design for radon attenuation included evaluation of the pertinent design criteria for the contaminated materials and radon barrier soil, and a review of the specifications for materials placement. The staff considered that the barrier layer is designed to satisfy criteria for construction, settlement, cracking, and infiltration of surface water, as well as reduction of radon gas release at the surface of the completed cell. Also, the parameters of the other layers of the cover were evaluated for their ability to protect the radon barrier layer from drying and disruption and the stability of the cell as a whole was assessed because of the potential for cracking of the barrier layer due to settlement or heaving. Sections 1 and 2 of this TER provide discussion of the cell materials and cell design from the aspect of stability (subsidence, freeze-thaw damage, erosion, etc.).

The required thickness of the radon barrier depends on the characteristics (parameters) of the radon barrier soil(s) and the underlying contaminated materials. As discussed below, NRC staff evaluated the parameter (input) values that were used to calculate the long-term radon flux from the cover. The staff then performed an independent analysis of the radon attenuation design using the RADON code.

3.2 Evaluation of Radon Flux Model for Pond #2

3.2.1 Radon Flux Model Assumptions

The sideslopes (embankments) of the disposal cell are not considered in a separate model. The site map (Figure A.1) indicates that most of the east and south embankments of Pond #2 consist of tailings. However, it appears from drawings 17 and 22 in Volume 2 of the plan, that the full cover thickness will extend pass the edge of the tailings on the sideslopes and the tailings on the sideslopes should be similar to the central tailings. A previous submittal had indicated that the slime tailings are in the north portion of the pond.

The layer sequence and average thicknesses used in the model apparently reflect the cell as constructed.

3.2.2 Model Parameter Values

The staff's review addressed the adequacy of the parameter values (i.e., code input) by evaluating the justification or assumptions made for each value to confirm that each value was representative of the material or a conservative estimate, consistent with site construction specifications, and based on long-term conditions. Results of materials testing data obtained in 1992 and 1995 are presented, older data are referenced, and default values as suggested in Regulatory Guide 3.64 (NRC, 1989) are used in the model.

3.2.2.1 Radium Level

Appendix F of the plan indicates that the tailings Ra-226 levels are fairly homogeneous so the average value of 232 pCi/g (based on average of results from three analytical methods) was used. The staff notes that the Ra-226 values (6 locations, 18 samples) vary from 11 to 556 pCi/g so cannot agree that the tailings are radiologically fairly homogeneous. The staff determined that the average of samples from the upper four feet of tailings results in approximately the model value of 232 pCi/g. The 10.4 pCi/g average Ra-226 level of the overburden material was based on analysis of 45 samples from the overburden stockpile so the value should be representative of that material.

3.2.2.2 Radon Emanation Coefficient

The radon model utilizes a tailings radon emanation coefficient based on data provided by Energy Laboratories Inc. (ELI). The ELI method includes placing the soil sample in a vacuum desiccator for 3 hours, preserving the original moisture which would be higher than the expected long-term moisture content. The staff notes that the method referenced in Regulatory Guide 3.64 states that samples are vacuum-dried for 48 hours or oven-dried to a constant weight. Also, the staff is aware of two sets of data on split samples that indicate that the ELI emanation results are lower (less conservative) than results provided by the oven-drying method. For example, nine samples analyzed by ELI averaged 0.04, but splits of the samples analyzed by another laboratory averaged 0.27. Therefore, staff used a value of 0.20 instead of the 0.14 ELI value, to represent the tailings emanation coefficient in the radon flux model, based on experience and information in NUREG 3533. An estimated emanation coefficient of 0.20 was used for the overburden layer in the model. The staff does not consider this value justified and used a more appropriate value, as discussed below.

3.2.2.3 Long-Term Moisture

The Rawls-Brankenseik equation was used to estimate the long-term moisture value for all the layers. The equation is conservative in most cases, but may result in questionable results for high clay-content soil. The staff determined that the model moisture values were reasonable and most were conservative.

3.2.2.4 Dry Density and Porosity

The density value of the tailings was an average of measurements and the porosity was calculated based on specific gravity measurements. The staff considers the values conservative because the weight of the cover and the drying of the tailings over the years will increase the density and decrease the porosity. The default values were used for the overburden soil and calculated values were used for the clean soil cover based measured values and assuming 80 percent compaction. Since the clean layer will be compacted to 90 and 95 percent, the clean soil model values are conservative.

3.2.2.5 Diffusion Coefficient

The diffusion coefficient values for all layers of material were calculated by the code. This method is acceptable.

3.2.3 Model/Code Results

Use in the RADON code of the model values presented in the submittal result in a calculated radon flux of 19.1 $pCi/m^2/s$ for Pond #2. The staff calculation used higher emanation coefficient values (0.20 for tailings and 0.30 for overburden) and more realistic moisture values for the overburden and clean soil layers (7 and 6 percent, respectively, based on average borrow moisture of 11.9 percent). This resulted in a calculated radon flux of 17.0 $pCi/m^2/s$. Therefore, based on the NRC staff's comparative analyses, the results of the WDEQ radon flux model are acceptable.

3.3 Conclusion

Assuming that the cover remains stable (only minor, shallow cracking) for at least 200 years, there is reasonable assurance that the long-term radon flux limit can be achieved by the Pond #2 cover design presented in the final reclamation plan.

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------- Letter to J. Holonich, September 8, 1995.

------- Letter to J.Holonich, October 25, 1995.

--------"American Nuclear Corporation Site, Preliminary Reclamation Plan," Shepherd Miller Inc., November 13, 1995; transmittal letter to K. Hooks, November 17, 1995.

--------"American Nuclear Tailings Reclamation Project, Phase I, Bullrush Heap Leach Reclamation Completion Report," March 8, 1996.

--------"American Nuclear Corporation Site, Final Reclamation Plan for Tailings Pond #2," April 9, 1996; transmittal letter to M. Moxley, WDEQ, April 10, 1996.

--------"Revisions to Final Reclamation Plan for Tailings Pond #2;" transmittal letter to M. Moxley; WDEQ, June 10, 1996.

--------"Additional Drawing to be Included in Final Reclamation Plan for Tailings Pond #2;" transmittal letter to M. Moxley, WDEQ, June 25, 1996.

--------"Revisions to Final Reclamation Plan for Tailings Pond #2;" transmittal letter to M. Moxley, WDEQ, January 17, 1997.

Comments on the Preliminary Design for Pond #1

The staff reviewed the preliminary design for Pond #1 provided in the final reclamation plan for Pond #2 and reached the following conclusions. From the 1995 data for Pond #1, staff determined that 3 samples from the depth interval 1-2 feet below the interim cover average 576 pCi/g Ra-226 while 4 samples from 3-5 feet below the interim cover average 446 pCi/g (using the intrinsic germanium results on dry samples and the sodium iodide results corrected for moisture). The code in Appendix F of the plan utilizes an average value of 474 pCi/g based on 15 samples from 5 locations. The layering effect of the Ra-226 values should be accounted for in the model in the final design for Pond #1.

Data on the Bullrush Heap Leach material (which has been placed on Pond #2) included in the December 21, 1988, submittal indicated that 12 heap leach samples were tested and Ra-226 concentrations ranged from 19 to 467 pCi/g with an average of 96 pCi/g (standard deviation 120.6). The 1995 data (three locations) indicated an average value of 87.7 pCi/g. The final plan for Pond #1 should indicate why the older data was ignored.

Acceptance of the reclamation plan for Pond #1 will be based on a detailed NRC staff review which will be conducted on the final plan when it is submitted by WDEQ.

Mr. Mark Moxley
Wyoming Department of Environmental Quality
Land Quality Division
250 Lincoln Street
Lander, Wyoming 82520-2848

SUBJECT: FINAL RECLAMATION PLAN FOR POND #2, GAS HILLS SITE

Dear Mr. Moxley:

On April 10, 1996, Shepherd Miller, Inc. (SMI) transmitted to the U.S. Nuclear Regulatory Commission the Final Reclamation Plan for American Nuclear Corporation's (ANC's) Tailings Pond #2, by copy of a letter to the State of Wyoming Department of Environmental Quality (WDEQ). The SMI letter stated that the final plan incorporated NRC staff comments on the preliminary plan submitted to the NRC by letter dated November 17, 1995.

The NRC staff review of the final plan identified areas in which clarification or additional information was required, and possible design improvements which could be made in the areas of surface water hydrology, erosion protection and radiological protection. As requested by WDEQ and agreed to by NRC management, the NRC staff provided comments on the final plan to WDEQ and SMI by facsimile, telephone conversations, and in meetings, as listed in Enclosure 1, and SMI submitted various revisions to the plan which are also listed in Enclosure 1.

The Technical Evaluation Report (Enclosure 2) is the NRC staff's formal documentation of the acceptability of the final WDEQ reclamation plan for Pond #2, as revised. It also documents the NRC staff evaluation of the completion report for the Bullrush Heap Leach. If you have any questions concerning this letter or enclosures, please contact Ken Hooks, the NRC project manager for the Gas Hills site, at (301) 415-7777.

Sincerely,

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Docket No.: 40-4492
License No.: SUA-667

Enclosures: As stated
cc: R. Chancellor, WDEQ Cheyenne
J. Voeller, AVI Cheyenne
W. Salisbury, ANC Casper
R. Edge, DOE Grand Junction

Cases closed: L51395, L51301

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