UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION IV

URANIUM RECOVERY FIELD OFFICE
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DENVER, COLORADO 80225

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URFO:DLJ
Docket No. 40-8905
SUA-1473, Amendment No. 18
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04008905132E
04008905133E
04008905135E

MEMORANDUM FOR: Docket File No. 40-8905

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SUBJECT: AMENDMENT NO. 18 TO SOURCE MATERIAL LICENSE SUA-1473: RECLAMATION AND CLOSURE OF QUIVIRA'S AMBROSIA LAKE MILL DISPOSAL AREA NEAR GRANTS, NEW MEXICO

BACKGROUND

In accordance with 10 CFR 40, Appendix A, the licensee submitted a proposed reclamation plan by letter dated October 1, 1986. The review process of the initial plan resulted in requests for information, reevaluation, and redesign. A chronology of review activities is listed in Enclosure 1. As a result of the review process, a final design package was to have been submitted. However, the final proposed reclamation plan was not completed by the licensee in time to allow a surety instrument to be in place by 1991. Therefore, this technical review is based on Appendix E, "Specification Sheet" (Specifications), and the drawings of the licensee's August 1, 1990, submittal, which in turn is supported by all other submittals listed in Enclosure 1. Where conflicts between documents were identified, the most recent submittal was utilized. The material submitted by the licensee on September 7, and September 24, 1990, was

| PM:URFO | PM:URFO | PM:URFO | PM:URFO | DD:URFO | D:URFO:RIV |
|---|---|---|---|---|---|
| DLJacoby/db | ROGonzales | PWMichaud | PJGarcia | EFHawkins | REHall |
| 9/24/90 | 9/24/90 | 9/24/90 | 9/24/90 | 9/25/90 | 9/24/90 |

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incorporated into this review. Where necessary, assumptions were made in order to provide a reasonable basis for a surety amount.

The Ambrosia Lake Mill, located near Grants, New Mexico, was acquired in 1989, and is currently owned by Quivira Mining Company, a wholly-owned subsidiary of Rio Algom Mining Corporation. The Quivira Mining Company was originally owned by the Kerr-McGee Nuclear Corporation. The mill began operations in 1958, and is currently in standby status. Mill feed was supplied from several Quivira owned and operated mines in the area, and excess milling capacity was used for toll milling.

DISCUSSION

The process mill tailings were deposited by slurry transfer and spigoting to several disposal areas southwest of the mill. The sands portion of the tailings were used to develop embankments which contained the slurry. Liquors were decanted off and transferred to evaporation ponds. A list of the disposal areas, their function, and how they will be reclaimed is given in Table 1. Locations of all the disposal areas are shown on Figure 1.

The main disposal area, Pond 1, contains about 30 million tons of tailings over an area of about 247 acres. The height of the containment embankment varies from 25 feet to 90 feet. Pond 2 contains about 3 million tons of tailings over an area of about 127 acres. As indicated on Table 1, the reclamation plan will stabilize Pond 1, Pond 2, and Pond 3 in place after relocating the contaminated materials associated with the unlined evaporation Ponds 4-8 and lined evaporation Ponds 9 and 10, to either Pond 1 or 2. Ponds 11-21 will be reclaimed in place by placing the materials in Ponds 16-21 over the materials in Ponds 11-15. As the mill is in standby status, Pond 2, Pond 9, and Ponds 11-21 will remain active.

Review of the proposed reclamation plan was divided into seven sections: structural stability and liquefaction, settlement, radon attenuation, surface water hydrology, erosion protection, construction specifications, and cost estimates. Each of these sections is discussed below.

Structural Stability and Liquefaction

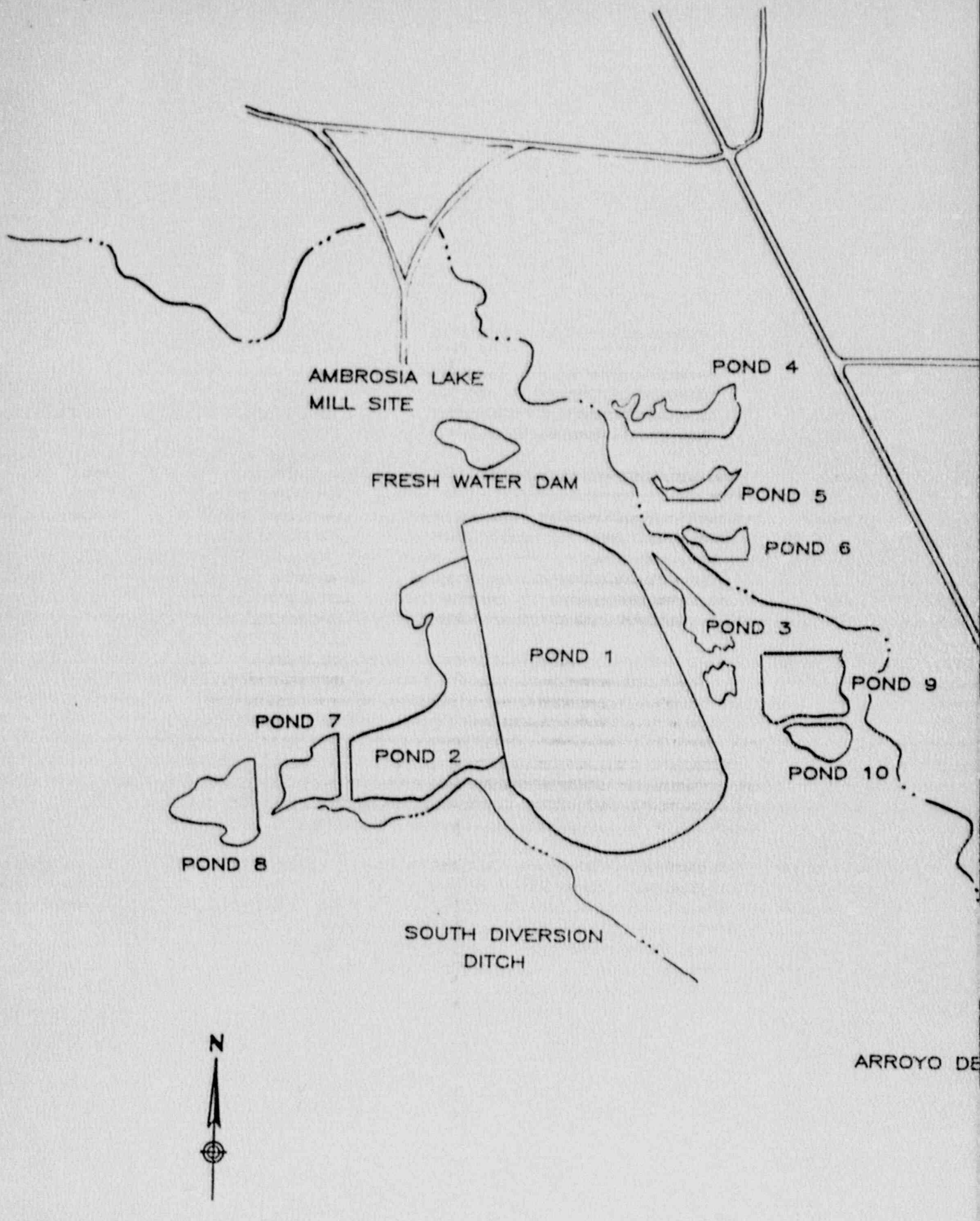
The major structure at the disposal site is the eastern section of the Pond 1 embankment. This section was appropriately selected as the critical section for slope stability analyses. The licensee has historically monitored this outslope and no signs of instability have been noted. Additionally, static and pseudo-static slope stability analyses were submitted to demonstrate that the existing critical slope satisfies the stability requirements of Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," (NRC, 1977). These analyses were based

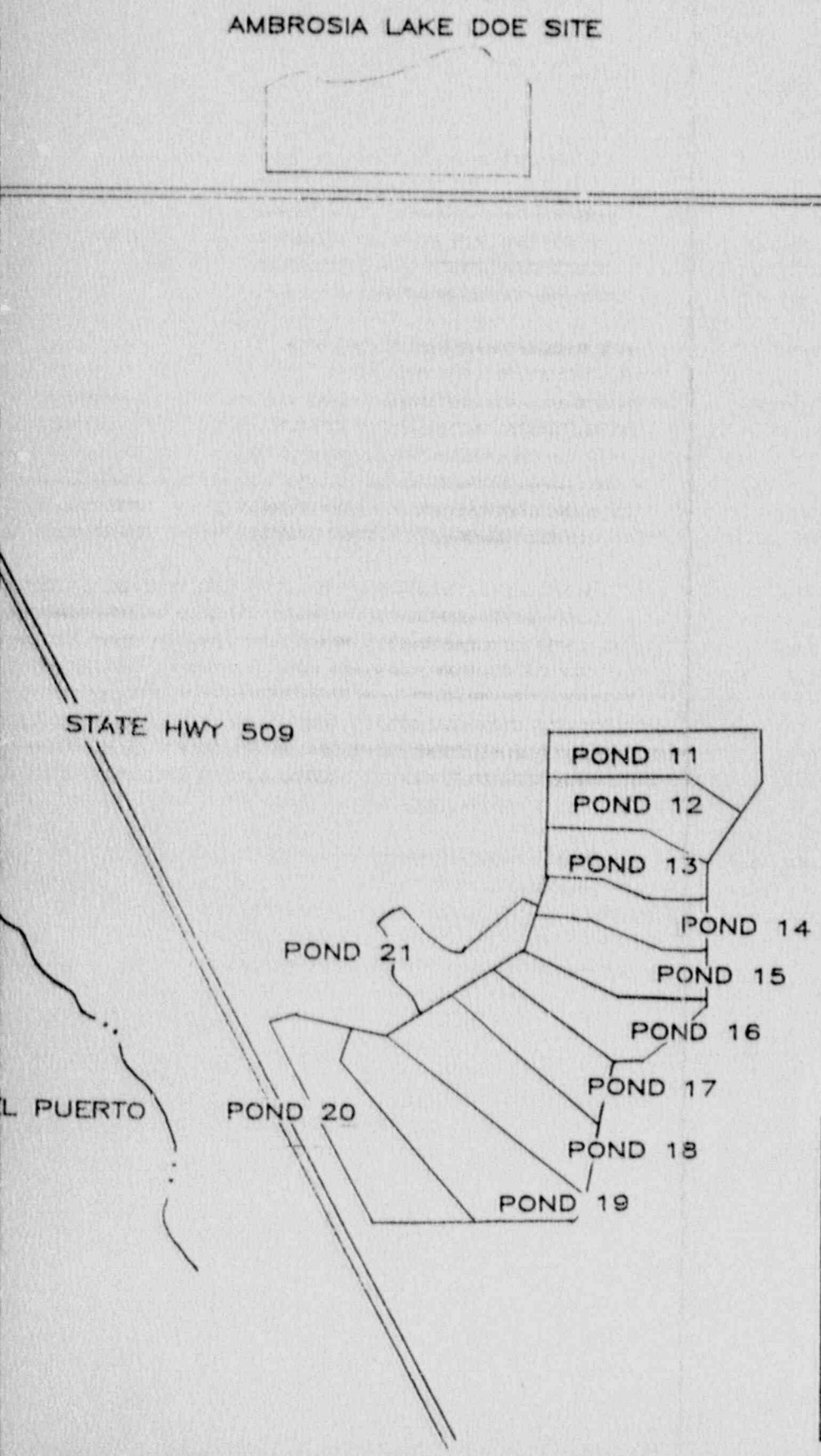
Table 1

Proposed Reclamation Scheme for Quivira's
Ambrosia Lake Mill Disposal Areas

| Area | Date Built | Type | Reclamation * |
|---|---|---|---|
| Pond 1 | 1958 | Solid Tailings Disposal | In place |
| Pond 2 | 1958 | Solid Tailings Disposal | In place |
| Pond 3 | 1958 | Decant & Seepage Collection | In place |
| Pond 4 | 1958 | Evaporation | Relocated/Reclaim |
| Pond 5 | 1958 | Evaporation | Relocated/Reclaim |
| Pond 6 | 1958 | Evaporation | Relocated/Reclaimed |
| Pond 7 | 1960's | Evaporation | Relocate to Pond 2 |
| Pond 8 | 1960's | Evaporation | Relocated/Reclaimed |
| Pond 9 | 1976 | Lined Evaporation | Relocate to Pond 2 |
| Pond 10 | 1976 | Lined Evaporation | Relocated/Reclaim |
| Pond 11 | 1976 | Lined Evaporation | In place |
| Pond 12 | 1976 | Lined Evaporation | In place |
| Pond 13 | 1976 | Lined Evaporation | In place |
| Pond 14 | 1976 | Lined Evaporation | In place |
| Pond 15 | 1976 | Lined Evaporation | In place |
| Pond 16 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Pond 17 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Pond 18 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Pond 19 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Pond 20 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Pond 21 | 1979-80 | Lined Evaporation | In place (Relocate) |
| Windblown | | | Relocate to Pond 2 |

* From September 24, 1990, Specifications


AMBROSIA LAKE
MILL SITE
POND 4
FRESH WATER DAM
POND 5
POND 6
POND 3
POND 1
POND 9
POND 7
POND 2
POND 10
POND 8
SOUTH DIVERSION
DITCH
N
ARROYO DE



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AMBROSIA LAKE MILL
RECLAMATION PLAN

GENERAL VINCINITY MAP

(MODIFIED FROM QUIVIRA SUBMITTALS)

Figure 1

on index and strength property testing of materials in accordance with accepted testing procedures. The pseudo-static seismic coefficient was selected at 0.1g based on the low seismic risk area in which the site is located. This value is also in agreement with the selected Maximum Credible Earthquake (MCE) of magnitude 4.9. The phreatic surface modeled in the analyses was based on the piezometric data from the embankments' instrumentation system.

The proposed configuration after reclamation was also analyzed under static and pseudo-static conditions. Soil parameters and the assumed phreatic surface were taken from the pre-reclamation studies. Minimum factors of safety on the reclaimed configuration were 3.4 under static conditions and 2.2 under pseudo-static conditions. Regulatory Guide 3.11 recommends minimum factors of safety of 1.5 for static conditions and 1.0 for earthquake conditions.

Further verification of the stability of the existing embankment was obtained through an independent review of the site and analyses submitted by Goodson & Associates, Incorporated, under NRC Contract No. NRC-30-85-377. Their final report dated April 3, 1987, concluded that the tailings embankment in its pre-reclamation configuration is stable and satisfies the stability requirements of Regulatory Guide 3.11. The report recommended additional study only if there was any change in conditions that increased the embankment's height, steepened the slopes, or raised the phreatic surface.

The proposed reclamation of the eastern section of Pond 1 will flatten the outslopes to 5:1 and the crest will not be raised above elevation 7030 feet. Further safety against slope failures will be realized as the phreatic surface within the ponds subsides during the reclamation process. The licensee's computer method and modeling utilized standard engineering procedures and the resulting factors of safety are greater than the minimum factors of safety recommended by Regulatory Guide 3.11 for active impoundments. Therefore, the slope stability of the reclaimed site is judged to be satisfactory over the design life of the project.

The liquefaction potential of the facility was evaluated in 1981 by the licensee's consultant using three accepted methods; the Seed & Idriss Simplified Procedure, the Yegian & Whitman Procedure, and the Direct Empirical Approach. The NRC review concurred in all three approaches which indicated that major damage or failure as a result of liquefaction is highly unlikely with the facility in its 1981 configuration. That report noted that liquefaction was possible in the impoundment areas where the phreatic surface was within 10 feet of the surface, but that liquefaction of these areas would have only a localized effect. The phreatic surface is presently lower than 10 feet in Pond 1 due to dewatering efforts and, as the structure is reclaimed and the radon barrier is constructed, the phreatic surface is expected to be further reduced. As saturation is a requirement for the liquefaction phenomenon, the potential for failure due to liquefaction will become negligible.

Although not currently considered part of the disposal area, a sudden release of water impounded by the fresh water dam (Figure 1) located upstream of the disposal area would negatively affect the integrity of the downstream toe of Pond 1. Therefore, as the stability of this structure has not been substantiated, the licensee will be required to breach the dam prior to final reclamation of the facility. Alternatively, the licensee may submit the necessary stability analyses for the dam to NRC for review and approval.

The structural stability of the reclaimed disposal areas has been judged to satisfy applicable portions of the requirements of Criteria 1, 6, and 12 of Appendix A to 10 CFR 40. These requirements contain the parameters necessary for the reclamation design to control radiological hazards for the design life without active maintenance after reclamation is complete.

Settlement

To monitor settlement, the licensee proposed to establish survey monuments on a 600-foot grid (approximately 20 stations for Pond 1) after the interim cover is in place on Ponds 1 and 2. Monitoring would be performed quarterly until the majority of settlement has occurred. The final cover system would not be placed until consolidation is complete enough that the surface monuments show no appreciable movement during three consecutive quarters.

The proposed monuments consisted of No. 4 rebar or equivalent, driven at least 3 feet into the ground surface, with no bearing plate on the bottom of the rebar (September 14, 1987, submittal). This monument configuration is not adequate, and the licensee will be required to place monuments consisting of a steel bar welded to a 1-foot square steel plate, or equivalent, located at least 3 feet below the surface.

Except for the monument configuration, the proposed method of monitoring settlement is acceptable, as it should assure that the significant settlement has occurred prior to the placement of the cover system. NRC will require review of the settlement surveys prior to placement of the final cover.

The proposed settlement program is considered to satisfy applicable portions of the requirements of Criteria 1, 6, and 12 of Appendix A to 10 CFR 40 regarding reclamation design to control radiological hazards for the design life, without active maintenance after reclamation is complete.

Radon Attenuation

Radon Barrier Soil Characteristics

The proposed borrow area for the interim and the radon barrier cover is the W series located to the south of the main impoundments as shown on Map 3 of the March 27, 1987, submittal. To characterize the materials, four locations were

selected for testing (Plate 1 of Appendix B, October 1986, submittal). These samples were characterized as silty sands and sandy silts. In addition to index testing, permeability, SAR (sodium absorption ratio), and dispersive soil testing was performed. The radon diffusion and emanation coefficient were determined for each sample. Test results are summarized in Table 2. In order to better define the borrow, the licensee has proposed additional exploration and testing in their submittal dated September 7, 1990.

Results of the soil testing indicated that the borrow could provide material that would be suitable for radon barrier material. The material would be nondispersive, and when compacted to 95 percent of the maximum dry density, would exhibit poor to practically impervious permeability. Selective borrowing techniques should provide material that will satisfy applicable portions of Criterion 6 of Appendix A to 10 CFR 40, regarding the requirements for the reclamation design to control radon attenuation.

Radon Attenuation Calculations

Calculations for the required cover thickness were provided for Pond 1 and Pond 2. The analyses submitted August 1, 1990, modeled; 1) Pond 1 and Pond 2 sands; 2) Pond 1 slimes covered with 5.4 feet of tailing sands; and 3) Pond 2 slimes covered with 2 feet of tailing sands.

The licensee's analyses were performed using the RADON computer code (NRC, 1989a). All values of the contaminated materials used in the models were substantiated by appropriate testing. Table 3 summarizes the licensee's input parameters to the RADON model along with modeling values for windblown materials and residues from Pond 3 and Pond 4. Although these parameters were not utilized in the final modeling, they do give an indication of the degree of conservatism that is incorporated in the modeling process by simplifying the cross sections.

Table 3

Licensee's Modeling Parameters

| Zone | Long-term Moisture Percent | Dry Density $g/cm^3$ | Porosity | Radium Activity pCi/g | Emanation Coefficient | Diffusion Coefficient $cm^2/s$ |
|---|---|---|---|---|---|---|
| Cover | 8.3 | 1.82 | .31 | - | - | .013 |
| Sands | 7.5 | 1.66 | .38 | 237 | .19 | .018 |
| Slimes | 7.5 | 1.66 | .38 | 1131 | .19 | .018 |
| Windblown | 6 | 1.59[1] | .40[1] | 7.1 | .35[1] | -[2] |
| Pond #4 | 6 | 1.59[1] | .40[1] | 18.8 | .35[1] | -[2] |
| Pond #3 | 7.5 | 1.66 | .38 | 75 | .19 | .018 |

[1] NRC default value
[2] Calculated by model

Table 2

Summary of Test Results on the W Series Borrow

| Location | Gradation Fines % | Gradation Sands % | Gradation Gravel % | Limits LL % | Limits PI % | Maximum Density pcf | Optimum Moisture % | Permeability at 95% cm/sec | SAR | Dispersivity | Diffision Coeffient $cm^2/sec$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W-10 | 38 | 62 | 0 | 20 | 3 | 122.0 | 12.9 | 6 x 10E-6 | 1.0 | #1 | .015 |
| W-12 | 26 | 74 | 0 | NP | | 120.8 | 12.0 | 2 x 10E-5 | 1.8 | - | .012 |
| W-18 | 81 | 17 | 2 | 24 | 4 | 118.0 | 14.7 | 4 x 10E-7 | 1.6 | #1 | .014 |
| W-24 | 29 | 71 | 0 | NP | | 117.0 | 14.2 | 1 x 10E-5 | 0.9 | - | .012 |

Unified Soil Classifications

| | |
|---|---|
| W-10 | SM |
| W-12 | SM |
| W-18 | ML |
| W-24 | SM |

The licensee did not verify that the proposed depths of tailings sands could be recontoured over the slimes and still maintain the final elevations. Quivira has indicated in their September 7, 1990, submittal that they do not consider it meaningful to show final elevations at this time. Also, the parameters used for the cover material were based on all the test results from the W Series borrow. As indicated on Table 2, not all the material tested is acceptable as cover material. Additionally, there is a discrepancy between the licensee's models' long-term moisture (8.3 percent) and the Specifications' long-term moisture (6.6 percent). The licensee's analyses could not be considered representative or conservative and therefore were not acceptable.

To establish a cover depth for surety purposes, a series of models were independently analysed by the RADON computer code assuming varying degrees of conservatism. Models were generated only for Pond 1 and Pond 2. As shown in Table 3, the Pond 3 residue is less active than the material in Pond 1 or Pond 2, and therefore, an acceptable cover design for Pond 1 and Pond 2 will also be acceptable for this area. The portion of Pond 3 that will not be covered by the reclaimed Pond 1 outslope shall be relocated to Pond 2, as no erosion cover system design was submitted.

Radiological parameters were assigned the same values as in the licensee's analyses as they were based on test results from the actual field conditions. The computer code was allowed to calculate the diffusion coefficient. Since the licensee performed very limited borrow testing, it was necessary to independently determine many of the input values for the RADON code. Soil cover parameters were established based on average and minimum published values (USBR, 1987) associated with specific material types. Parameters were selected for materials identified as suitable for radon attenuation and infiltration in the licensee's borrow exploration program. Long-term moisture for the cover soil was conservatively set at 6.63 percent as specified in the licensee's Specifications. Model cross sections analyzed included cover placed directly on slime materials with no additional attenuation layers, i.e., recontoured sands or windblown. This very conservative model resulted in required radon barrier depths of up to 19 feet. To estimate a conservative but yet reasonable depth, a model was generated that used the average soil properties of a SM material, the prevalent material in the borrow exploration program. The maximum contributing depth of slimes material was overlain by 2 feet of recontoured sands. No credit was given for windblown materials or evaporation pond residues which would assist in the attenuation of the slimes radon flux. This model resulted in a cover depth of 10.0 feet. The percentage of surface area that is slimes in Pond 1 is estimated to be about 40 percent, and the percentage of the surface area of the slimes in Pond 2 is estimated to be about 30 percent. When determining the expected average release rates over the entire area, it must therefore be taken into consideration that a major portion of the disposal area will not require the maximum cover depth to meet the required release rate. The model of the same cover material over a maximum contributing depth of sands resulted in a required cover thickness of 6.4 feet.

A weighted average indicates that a cover depth of about 8 feet over the entire disposal area could be expected to result in average release rates that would not exceed the 20 picocuries per square meter per second ($pCi/m^2s$) standard.

It is recognized that this represents a conservative value for radon barrier thickness in that no credit has been given for the placement of less active materials on the slimes and sand surfaces and that conservatively estimated long-term moistures have been utilized. Additionally, the natural mixing of materials into the slimes that will occur during construction was not factored into the modeling process. This depth should, however, represent a conservative but reasonable value in terms of estimating a surety and will therefore be required by license condition. It is expected that the licensee will revisit the analyses and redesign the radon barrier thickness, based on final design elevations and refined soil parameters.

It should also be noted that the proposed plan intends to utilize the interim cover as part of the radon barrier cover. The proposed plan indicates that the interim cover will be "upgraded" to meet the moisture and density specifications prior to placement of the remaining radon barrier thickness. The plan states that "in all cases, the integrity of the interim cover will be assured prior to placement of the final cover" (September 14, 1987, submittal). The method that will be used to verify the integrity must be established and, prior to placement of the remaining cover, the NRC must concur that the interim cover will be acceptable. Therefore, the required radon barrier cover depth of 8 feet shall be in addition to the interim cover until NRC concurs with the integrity of the interim cover.

Under the proposed plan, the contaminated materials in Ponds 16-21 will be relocated to Ponds 11-15. This will add about 1.3 feet of additional material to the existing contaminated materials in Ponds 11-15. The level of activity associated with this material is low enough that a soil cover is not needed to attenuate radon releases to meet Criterion 6 of Appendix A. The licensee did not demonstrate that the additional 1.3 feet of material will not require attenuation. However, independent analyses verified that cover to attenuate radon releases is not needed.

In summary, the required cover depth of 8 feet over Ponds 1 and 2 will limit average radon releases to a maximum of 20 picocuries per square meter per second which satisfies the applicable parts of the requirements of Criterion 6 of Appendix A to 10 CFR 40, which addresses radon attenuation.

Surface Water Hydrology

Hydrologic Description and Conceptual Design

The Ambrosia Lake Mill is located in a broad valley at an elevation of about 7000 feet, approximately 20 miles north of Grants, New Mexico. The site lies within the drainage basin of Arroyo del Puerto, an intermittent tributary which

flows along the east boundary of the site. The drainage area of Arroyo del Puerto above the mill site is about 58 square miles. Surface water runoff from this area flows generally southeastward cutting through outcrops of sandstone in the vicinity of the mill site. A second drainage area of approximately 3.7 square miles is located just west of the mill site. Currently, runoff from this area is diverted around the tailings area by a diversion ditch.

As shown in Figure 2, Ponds 1 and 2 will be reclaimed in place. The top of Pond 1 will be provided with very flat slopes which will drain from north to south. A riprapped spillway on the south side will convey flood flows off the pile top into the South Diversion Ditch. The Pond 1 side slopes will be reduced to 20 percent (5H:1V) and will be protected against erosion with a layer of riprap.

Pond 2 is formed by the west portion of the Pond 1 embankment. The top of this pond will also be provided with very flat slopes. Runoff will also flow into the South Diversion Ditch.

Flood Determinations

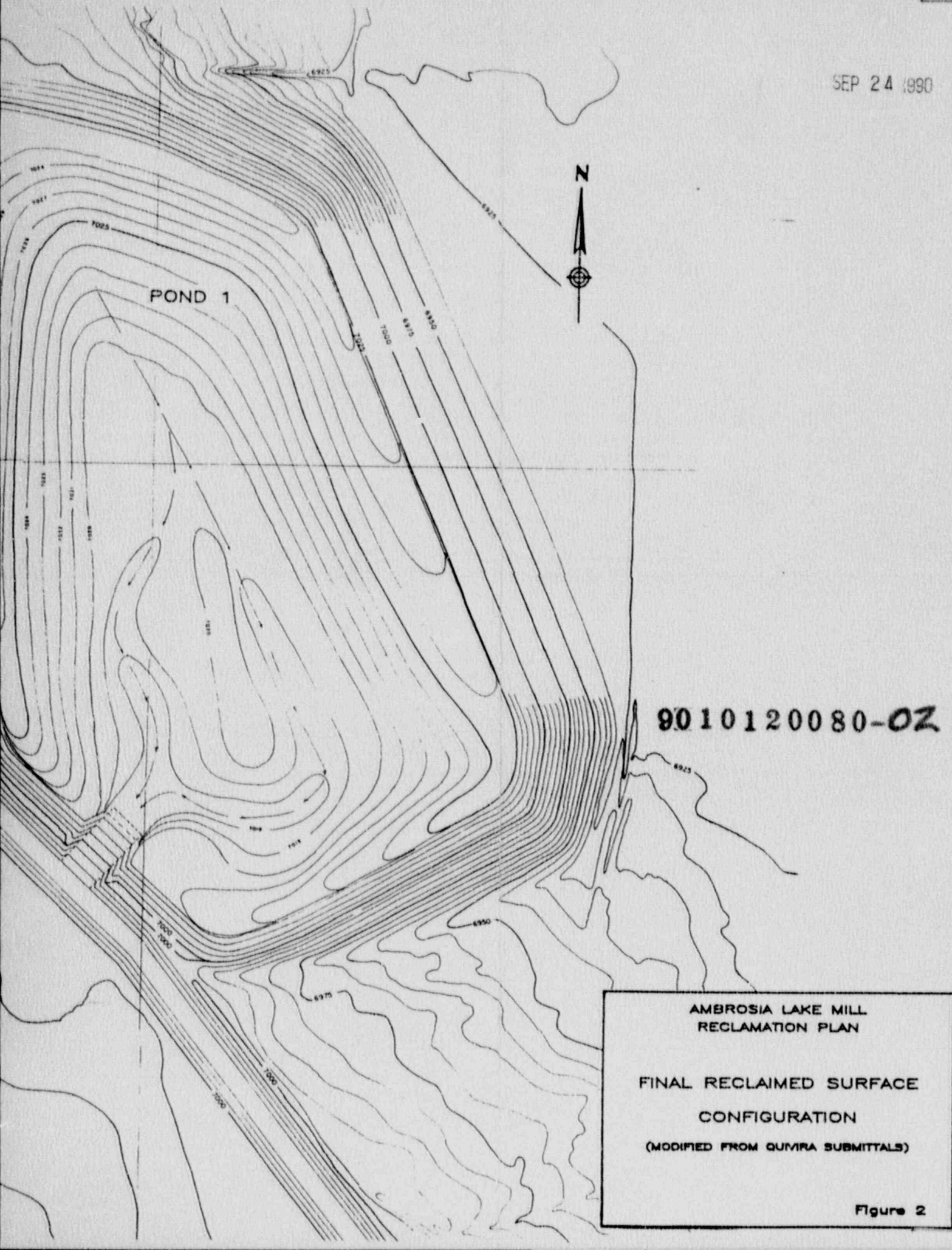
To evaluate the effects of flooding and to determine the need for erosion protection, the licensee analyzed flooding due to Probable Maximum Floods (PMFs) from the various drainage areas. The PMF design events meet or exceed the applicable parts of the requirements outlined in 10 CFR 40, Appendix A, particularly Criteria 4 and 6, and are therefore acceptable for use in designing any required erosion protection.

A PMF is based on the Probable Maximum Precipitation (PMP) which is defined as the greatest depth of precipitation that is physically possible at a particular geographic location. PMP values were estimated by the licensee using Hydrometeorological Report (HMR) No. 55 (U.S. Department of Commerce, 1984). However, when the licensee requested additional information concerning HMR No. 55 from the National Weather Service (NWS), they were advised that the storm maps in the report were being revised. Subsequently, in a letter dated February 9, 1987, the NWS provided the licensee appropriate PMP values to use for the Ambrosia Lake area.

A 1-hour PMP of 9.2 inches was used as a basis for estimating a PMF for the 58-square mile drainage area of Arroyo del Puerto. For the 3.7-square mile drainage area to the west that drains into the South Diversion Ditch, a 1-hour PMP of 9.45 inches was used. For the tops of the tailings ponds, the appropriate PMP was 9.6 inches. Based on a review of the letter provided by the NWS and a check of the licensee's rainfall computations, the staff concludes that the PMP was acceptably derived for the site. PMP amounts for durations of 0.25, 0.50, 0.75, 2, 3, 4, 5, and 6 hours were estimated by the licensee by multiplying the 1-hour PMP values by appropriate percentages. The percentages used were those recommended in HMR-55. These percentages are similar to those recommended in NUREG/CR-4620 (Nelson and others, 1986) and are therefore acceptable.


POND 2
7000
7050
7025
6995
6990
6985
1000
1050
400' 200' 0 400' 800' 1200
SCALE IN FEET

SEP 24 1990

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AMBROSIA LAKE MILL
RECLAMATION PLAN

FINAL RECLAIMED SURFACE
CONFIGURATION

(MODIFIED FROM QUIVIRA SUBMITTALS)

Figure 2

Probable Maximum Flood (PMF) Estimates

PMFs were estimated by the licensee using procedures developed by the Soil Conservation Service (SCS, 1972). The PMF peak discharge for Arroyo del Puerto was estimated to be about 78,000 cubic feet per second (cfs) at the mill site. This estimate was provided in the July 20, 1987, submittal. The PMF peak discharges for Ponds 1 and 2 were estimated to be 1760 cfs and 13,600 cfs, respectively. The PMFs for the two ponds were provided in the licensee's June 20, 1988, submittal. The Pond 1 surface area used to estimate the PMF was 195 acres (.305 $mi^2$). For Pond 2, the drainage area was 3.7 $mi^2$. This included the pond surface area plus the adjacent contributing drainage area to the west of the pond.

To check the adequacy of the licensee's calculations, the staff independently estimated PMF peak discharges for the various drainage areas. A comparison between the licensee's estimates and those of the staff is shown below:

Table 4

PMF Peak Discharges

| Drainage Area | Licensee's estimate (cfs) | NRC's estimate (cfs) |
|---|---|---|
| Pond 1 | 1,760 | 1,780 |
| Pond 2 and South Diversion Ditch | 13,600 | 14,700 |
| Arroyo del Puerto | 78,000 | 84,000 |

Based on this close comparison, the licensee's PMF estimates are reasonable and thus acceptable.

Water Surface Profiles and Flow Velocities

Water surface elevations and velocities for the pile tops, South Diversion Ditch, and the Pond 1 spillway, were estimated by the licensee using Manning's equation. This procedure provides acceptable estimates of water levels and velocities provided that the channel is uniform in slope and cross section and the discharge is constant. The South Diversion Ditch does have a constant slope and cross section. However, the design of the ditch is complicated because it receives inflow from Pond 2 at its upper end and inflow from Pond 1 near the middle of its length. Consequently, Manning's equation was considered inadequate to describe the flow characteristics of the South Diversion Ditch. In a letter dated May 11, 1990, the licensee was requested to check the adequacy of the design assuming gradually varied flow conditions using a

standard step method such as the Corps of Engineers HEC-2 Computer Program (COE, 1982). The licensee has not yet responded to this request. Therefore, the flow velocities associated with the South Diversion Ditch were independently verified. The licensee has stated that parts of the ditch will be cut into sandstone, and has proposed a riprap design for areas that are not. This riprap design ($D_{50}$ = 1 inch) has independently been determined adequate.

For Arroyo del Puerto which is located directly east of Pond 1, the licensee used HEC-2 (COE, 1982) to estimate water surface elevations and velocities using the accepted PMF peak discharge of 78,000 cfs. This analysis showed that at the northeast corner of reclaimed Pond 1, the PMF water level will be at the same elevation as the toe of the embankment outslope. Therefore, the licensee concluded that the stability of Pond 1 will not be affected by a PMF in Arroyo del Puerto. The licensee assumed that the PMF will result in a level surface across the entire flood plain. Since this is not a conservative assumption, an independent analysis was performed using HEC-2 (COE, 1982) and a flood flow equal to two times the PMF (156,000 cfs). This analysis indicated that the water level would be about 2 feet higher than the toe of the Pond 1 embankment outslope. The riprap at the toe, which has a $D_{50}$ of 3.2 inches, was then checked to determine if it could withstand the horizontal shear stresses from the flow in Arroyo del Puerto. This analysis indicated that the riprap is stable even if the flow in the arroyo is much larger than the PMF. On the basis of these analyses, it is concluded that the stability of Pond 1 will not be affected by a PMF in Arroyo del Puerto.

Geomorphic Stability

As discussed above, the stability of Pond 1 will not be affected by a PMF in Arroyo del Puerto. A second stability issue concerns whether long-term geomorphic changes in the arroyo could affect the stability of Pond 1. This issue was addressed through an independent geologic analysis and site visit.

As shown on Figure 2, the tailings pile is located on the southwestern side of the valley of Arroyo del Puerto. The alluvial valley in this area is about 1 mile wide. The pile is underlain by unconsolidated materials associated with small tributaries to the arroyo, and weathered and unweathered sandstone and shale. The arroyo is located along the northeastern side of the tailings pile. It is incised, naturally and artificially, up to about 20 feet deep. Observations along the entire reach below the pile indicate that bedrock forms the channel bank on the southwestern side.

Minor incision of a channel, and headcutting of the channel is occurring about 1 mile downstream of the tailings pile. The channel is about 3 feet deep and, again, occurs along the southwestern side of the valley.

Pond 1 is located in a relatively stable position on a bedrock/alluvial slope above the alluvial valley containing Arroyo del Puerto. The arroyo occurs on the side of the valley closest to the disposal area. With bedrock exposed along much of the channel, however, the arroyo is likely to migrate northeastward across the less resistant alluvial valley, if at all.

Channel headcutting toward the tailings pile is occurring on a small scale more than 1 mile downstream. The incision process could migrate up-valley during the performance period. However, this process is restricted to the alluvial valley fill, and is not able to have an impact on the pile for the same reasons cited above.

Based on a review of the applicant's submittals, independent analyses, and site inspections, Arroyo del Puerto does not appear to present a geomorphic threat to the stability of Pond 1.

The surface water hydrology design of the reclamation plan contributes to meeting the requirements of Criterion 2 in that proliferation of waste sites is avoided by relocating the contaminated contents of the evaporation ponds. The designs of the disposal areas satisfy the applicable parts of Criterion 4 that require using either rock or very flat slopes to minimize erosion potential to assure long-term stability. In addition, use of the PMP and PMF events for estimating design bases floods provides reasonable assurance of stability for 1000 years without any active maintenance, as required by Criteria 6 and 12.

Erosion Protection

Pond 1

As shown on Figure 2 the top of Pond 1 will be graded to slope from north to south. Runoff from the pond will convey off the top to the South Diversion Ditch through a 200-foot wide spillway. The top of the pond will have two gently sloping swales that will converge at the spillway. The slopes of these two swales will average about 0.001. The slopes of the areas draining into the swales will be about 0.01.

The topographic map provided in the licensee's September 7, 1990, submittal was reviewed and the slopes on the Pond 1 top were checked using the Horton Method as recommended in the draft NRC Staff Technical Position (NRC, 1989). On the basis of this review and analysis, it was concluded that the Pond 1 top slopes are sufficiently flat to minimize the potential for erosion and are therefore acceptable. Although the top of Pond 1 will be vegetated, the long-term stability is not dependent on the vegetation.

As discussed above, the PMF for the top of Pond 1, as estimated by the licensee, had a peak discharge of 1760 cfs. This flood flow will be conveyed off the top of the reclaimed pond through the 200-foot wide spillway having a slope of 0.10. To determine the peak flow in the spillway, the licensee performed a reservoir routing analysis assuming that water would pond temporarily on the top of the pond. This analysis indicated that the PMF peak of 1760 cfs would be attenuated to about 1680 cfs. Using this discharge and the Stephenson 1979 method, the licensee estimated that a 15-inch thick layer of riprap with a median stone diameter ($D_{50}$) of 7.7 inches will be required for

the spillway on Pond 1. The licensee shall be required to extend the riprap 45 feet onto the flatter pond surface rather than their proposed 10 feet distance, and this riprap shall be placed over a 6-inch thick bedding layer of smaller rock. The riprap extension is necessary to assure that unacceptable erosion upstream of the spillway will not occur.

Verification of the licensee's reservoir routing analysis was not possible due to the lack of detailed topography. However, to check the adequacy of the licensee's design, the $D_{50}$ for the spillway was independently estimated assuming a peak discharge of 1780 cfs instead of the 1680 cfs used by the licensee. This analysis confirmed the adequacy of the licensee's riprap design for the Pond 1 spillway.

The embankment outslopes of Pond 1 will be reduced to 20 percent (5H:1V) and will be armored with a 6-inch thick layer of riprap placed over a 6-inch thick bedding layer of smaller rock. Although the extent of the bedding layer was not clearly defined in the Specifications, a standard 6-inch bedding layer will be required by license condition under all riprap on the disposal area have a $D_{50}$ of two (2) inches or larger. At the toe of the outslopes, a 5-foot wide transition apron will be provided as shown in the licensee's August 1, 1990, submittal. The $D_{50}$ of the riprap as shown in the licensee's February 28, 1990, submittal, will vary from 1 inch at the crest of the embankment to 3.2 inches at the toe, according to the following table:

Table 5

Pond 1 Outslope Riprap

| Horizontal distance from crest of embankment outslope (ft.) | Median stone diameter (in.) ($D_{50}$) |
|---|---|
| 0-150 | 1.0 |
| 150-270 | 2.0 |
| 270-420 | 2.8 |
| 420-toe of slope | 3.2 |

An independent analysis, performed using the Stephenson 1979 method verified the adequacy of the riprap on the embankment outslopes of Pond 1. A second independent evaluation performed using HEC-2 (COE, 1982) and the Corps of Engineers Sheer Stress Method for sizing riprap (COE, 1970) verified that the 3.2 inch $D_{50}$ riprap on the embankment outslopes is more than adequate to resist the horizontal shear forces that would result from a PMF in Arroyo del Puerto.

Based on a review of the licensee's calculations and on independent analyses and evaluation, the riprap design of the Pond 1 embankment outslopes is acceptable.

Pond 2

As shown on Figure 2, Pond 2 will be graded to drain into the South Diversion Ditch. The slopes of the reclaimed surface of the pond will be sufficiently flat to minimize the potential for excessive erosion.

Pond 2 will receive flood runoff from a small drainage area to the west. The slopes of this area vary from about 6 to 8 percent. As flows from this area run onto the much flatter surface of Pond 2, the flow velocity will be reduced and a hydraulic jump will form. This may cause erosion of the radon cover. The licensee did not address the potential for erosion where the steeper 6 to 8 percent slopes transitions onto Pond 2. For surety purposes, the staff estimated riprap having a $D_{50}$ of about 7.7 inches will be required in this transitional area. The volume of riprap required was estimated at 700 cubic yards, and the licensee's surety amount was increased accordingly. By license condition, the licensee will be required to provide a trench design for NRC review and approval.

Ponds 11-21

The proposed plan will relocate the materials from Ponds 16-21 to Ponds 11-15. The final grade across Ponds 11-15 will average about 2 percent and will slope from north to south. On the south side of Pond 15, the slope will increase to 5H:1V and a 6 inch thick layer of riprap having a $D_{50}$ of 1 inch will be placed on these steeper slopes. The costs associated with this design have been adequately estimated by the licensee. The licensee, however, will be required to submit the calculations supporting the adequacy of the erosion protection design for Ponds 11-15.

Wind and Sheet Water Erosion

Although the top surfaces of Ponds 1 and 2 have been designed so that excessive erosion is not expected during the design life, there is a potential for soil to be lost due to wind and sheet water erosion. To compensate for this potential soil loss, the licensee will place 10 to 13 inches of soil on the surface of the ponds in addition to the soil required for radon attenuation. Based on a review of the licensee's submittal, 10 to 13 inches is acceptable.

Rock Gradation

The riprap should be composed of a well-graded mixture composed primarily of the larger stone sizes, but with a sufficient amount of smaller size stones to fill the voids between the larger stones. All stones should be contained reasonably well within the layer thickness, and the surface of the riprap should be a dense, well-keyed, graded rock mass.

In the September 7, 1990, submittal, the licensee proposed gradation specifications in the form of a single curve for each riprap size. These curves were reviewed and were found acceptable. However, it will be difficult for the licensee to meet the proposed gradation specifications because if a

rock size when plotted does not fall exactly on the curve, it will be out of specifications. A rock specification should define a minimum and maximum requirement for each rock size so that if a rock size plots within these extremes, it is acceptable.

Since the licensee's proposed rock specifications are acceptable but not practical, as discussed above, independent gradation limits were estimated for each rock size. These gradation limits are shown in Table 6.

Table 6

Gradation Limits for Riprap

$D_{50}$ = 1"

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 2 inch | 100 |
| 1 inch | 16-50 |
| 3/4 inch | 2-30 |
| 1/2 inch | 0-10 |

$D_{50}$ = 2"

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 4 inch | 100 |
| 3 inch | 66-100 |
| 2 inch | 18-50 |
| 1 inch | 0-10 |

$D_{50}$ = 2.8 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 5 inch | 100 |
| 4 inch | 50-100 |
| 3 inch | 25-58 |
| 2 inch | 2-28 |
| 1 inch | 0-5 |

$D_{50}$ = 3.2 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 6 inch | 100 |
| 5 inch | 78-100 |
| 4 inch | 35-100 |
| 3 inch | 12-45 |
| 2 inch | 0-20 |

$D_{50}$ = 7.7 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 13 inch | 100 |
| 12 inch | 80-100 |
| 10 inch | 49-100 |
| 8 inch | 26-54 |
| 6 inch | 7-32 |
| 4 inch | 0-13 |

The licensee will be required to meet these gradation specifications by license condition.

Gradation specifications for the bedding material were not provided by the licensee. These specifications are necessary to prevent migration of radon barrier material into the riprap, to dissipate dynamic water forces between bedding layers, and to stabilize the riprap layers. The gradation of the bedding is not as crucial as the riprap, and the gradation can sometimes be adjusted so that available rock material can be used provided it meets acceptable criteria. Therefore, the licensee will be required by license condition to provide gradation specifications for the bedding materials to be used.

Rock Durability

Currently, the licensee proposes to use dense basalt from La Cuchilla Ridge as a source of riprap. The required specifications for the rock are shown in the "Construction Specifications" section below. Based on a review of these specifications, it is concluded that the proposed rock will resist long exposure to weathering and is therefore acceptable. The licensee has requested the right to use an alternative source of rock. Should that occur, durability tests will be required as outlined in the draft NRC Staff Technical Position on Design of Erosion Protection (NRC, 1989b). Test results must be submitted to NRC for review and approval.

The Specifications did not provide a source for the bedding materials. Therefore, the quality of the bedding material shall be required by license condition to be equivalent to that of the riprap.

Construction Specifications

The Specifications for the project were initially submitted as Appendix E to letter dated August 1, 1990. Requested revisions were incorporated into the licensee's September 24, 1990, submittal. For the purposes of this review and evaluation, these September 24, 1990, specifications were considered to contain the licensee's latest information.

Material Specifications

Radon Barrier Materials - The proposed specifications for the radon barrier material were based on the parameters used in the radon attenuation model and were not acceptable for field control. The material types proposed in the licensee's September 7, 1990, submittal were very broad and allowed the use of material that is not acceptable as cover material without additional design considerations.

As the licensee did not provide adequate material specifications, they will be required by license condition. The condition will require the radon barrier material to be classified as SM or ML material by the Unified Soil Classification System. The maximum particle size shall be 3 inches with a

minimum of 35 percent passing the No. 200 sieve. The material must be plastic. These material specifications are based on the limited soils data available from the proposed borrow source (see the data summarized in the section entitled Radon Barrier Soil Characteristics).

Riprap - The source for material used for riprap shall be dense basalt and shall meet the following criteria:

| | |
|---|---|
| Specific Gravity | not less than 2.60. Average of any five consecutive test results shall not be less than 2.65. |
| Sodium Sulfate Loss | 5 percent or less after 5 cycles. |
| Petrographic Examination | The licensee shall furnish a report for review. |

If a rock source other than La Cuchilla Ridge is selected, the licensee shall perform durability tests as outlined in the draft Staff Technical Position on Erosion Protection (NRC, 1989b) and submit the results of those tests for review and approval.

Placement Specifications

Relocated Contaminated Materials - The proposed specifications require the recontoured sands to be placed within 3 percent of the optimum moisture content and to at least 90 percent of the maximum dry density after the initial lift is placed. The licensee will be required to limit the lift thickness to 12 inches.

Radon Barrier Materials - The proposed specifications require the radon barrier materials to be placed at 95 percent of maximum dry density in 6-inch lifts. As no specifications for the required moisture content were submitted, the licensee will be required to place the material within 2 percent of the optimum moisture content.

Uncontaminated Fill - The proposed plan does not provide specifications for placement of any uncontaminated fill. However, the licensee has indicated in the August 1, 1990, submittal that the fill section associated with the Pond 1 spillway will be constructed to the same specifications as the radon barrier material. Therefore, this will be a required license condition.

Rock - The licensee will be required to place all riprap in a manner that prevents segregation of the material. The material placed shall be reasonably well graded within the gradation requirements specified.

Six inches of bedding material shall be placed under all riprap with a $D_{50}$ of 2 inches or larger in the disposal areas. The bedding material shall be reasonably well graded. The bedding shall be spread and compacted in one layer.

Site Engineering and Inspection

Reporting - The Project Engineer will maintain a daily log summarizing construction QA/QC and prepare a weekly report to summarize the daily log information. The individual shall report directly to the General Manager of the facility.

Field Testing - The Project Engineer will be responsible for all construction testing. Tests shall be conducted in accordance with approved ASTM or equivalent methods.

In place Density and Moisture - The proposed specifications require testing for in place density and moisture once for every 1,000 cubic yards placed. This testing frequency may be relaxed to one test for every 2,500 cubic yards if results indicate that compaction procedures are adequate. Satisfactory effort shall be defined as 85 percent passing results out of 20 successive tests, excluding retests. The proposed specifications allow the use of, but do not provide for, correlation between test procedures equivalent to sand cone testing and oven drying. Therefore, the licensee will be required to submit correlation procedures for NRC review and approval prior to implementation.

Classification and Compaction - The proposed specifications require classification tests of the radon barrier materials at least once for each 10,000 cubic yards placed. Proctor compaction tests will be performed on all new materials. One-point compaction tests shall be performed at a frequency of one test for each 10,000 cubic yards placed. A Proctor compaction test will be performed whenever a one-point test does not match an existing curve or if the gradation of the materials change significantly.

Rock Quality and Gradations - The proposed specifications require gradation and durability testing for each 10,000 cubic yards (cy) to be delivered. Rock durability tests will include specific gravity, soundness, abrasion, and absorption. A minimum of 2 sets of tests will be performed for each riprap size.

The proposed construction specifications were not totally adequate to ensure that the construction process would support the design. Therefore, the licensee will be required by license condition to meet acceptable criteria so that the requirements of Criteria 1, 6, and 12 of Appendix A to 10 CFR 40, are met regarding reclamation design to control radiological hazards for the design life without active maintenance after reclamation is complete.

Cost Estimates

A detailed review of the reclamation cost estimate was performed. The purpose of this review was to verify that all required reclamation activities were included and funded at an appropriate level. Criteria 9 and 10 of Appendix A to 10 CFR 40 contain the financial requirements which must be met.

The licensee's June 30, 1988, cost estimate was calculated based on completion of each task by a third party, as required. Unit costs were obtained from the "1988 Dodge Heavy Construction Cost Data" book in most cases. These costs were adjusted for geographic location, open shop labor rates, and job efficiency. The unit costs were extended using estimated quantities of materials, which were independently verified. To these costs, line item costs were added for mill demolition, based on the licensee's updated 1979 cost estimate; salary costs, based on 45 percent of the total labor cost; and an estimated cost for revegetation. The total was then increased 10 percent for overhead and profit, 15 percent for contingencies, and adjusted to 1990 dollars. Finally, the estimated cost of ground-water cleanup and the Criterion 10, long-term surveillance fee were added to achieve the total cost estimate.

The licensee's cost estimate was adjusted due to changes in certain quantities or assumptions or to add items which were omitted by the licensee.

Changes in quantities: The thickness of W-series alluvium to be placed on Ponds 1 and 2 for radon attenuation was increased from about 5 feet to 8 feet over the entire area. The amount of soil to be placed over the top of Pond 1 and over the entire Pond 2 area for erosion protection was changed to 1 foot since the licensee stated it would vary from 10 to 13 inches. The amount of beach sand placed for consolidation of the slimes in Pond 2 was changed to 2 feet over the entire slimes area. Areas for Ponds 1 and 2 were revised to reflect these changes and from map takeoffs.

The amount of rock to be placed on Pond 1 for erosion protection was revised to include a 6-inch thick bedding layer for all riprap having a $D_{50}$ of 2 inches or greater and 6 inches of riprap over the outslope area. The amount of rock to be placed in the Pond 1 spillway was changed to 15 inches over the entire area. Rock was also added to line a trench on the west side of Pond 2. The final swell factor for quarried rock was changed to 130 percent rather than 140 percent, based on standard swell factors normally used in such estimates.

Work Completed: Costs were reduced to account for activities completed in the cleanup of Pond 10, shaping of Pond 1 side slopes, recontouring of Pond 8, extension of the seepage ditch, and placement of beach sand on Pond 1.

Unit Cost Revisions: The unit cost for dozer production was independently obtained from the "1988 Means Site Work Cost Data" book rather than using multiple adjustment factors based on the Dodge and Caterpillar manuals as in the licensee's estimate. The unadjusted dozer costs are $0.27/cy for labor and $1.16/cy for equipment. The cost for revegetation was revised to include fixed costs of the contractor. A decrease in unit costs for a fuel adjustment was not allowed.

Where costs were required to be increased to account for the effects of inflation, the change in the Consumer Price Index (CPI-U) was used to determine the inflation factor, as required by Criteria 9 and 10 of Appendix A to 10 CFR 40.

Soil and Rock Testing and Radiological Monitoring were not included in the licensee's cost estimate. The cost for soil and rock testing was based on one technician with equipment, 5 days a week, 50 weeks a year, for 6 years. The cost for radiological monitoring was based on one technician with equipment in a similar fashion for 3 years.

Finally, an amount for the State of New Mexico's gross receipts tax equal to 5.125 percent of total costs, was included. This factor was omitted in the licensee's cost estimate.

The revised cost estimate is detailed in Table 7. With these revisions, the estimated total reclamation cost is approximately $21,000,000. This is considered to provide a sufficient basis for establishing the required surety amount.

EVALUATION OF RECLAMATION PLAN AGAINST APPENDIX A CRITERIA

Appendix A to 10 CFR 40 establishes criteria for the technical, financial, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of uranium milling facilities. Each site-specific licensing decision is to be based on the criteria in the appendix, taking into account the public health and safety and the environment. Decisions as to the ability of the design to meet "reasonably achievable" criteria must take into consideration the state of technology as well as a comparison of the economic cost to resulting benefit.

The following Appendix A criteria were considered for the proposed licensing decision to amend Source Material License SUA-1473 in accordance with the reclamation plan submittals. Criterion 2, 8, and 11 are not applicable for review and approval of a reclamation plan and were therefore not considered.

Criterion 1

Criterion 1 addresses the general goal of siting and designing facilities to provide for the permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces without the need for ongoing maintenance. Items that were considered when evaluating the proposed plan include:

TABLE 7

REVISED COST ESTIMATE

| | BCY | LABOR | EQUIPMENT | TOTAL |
|---|---|---|---|---|
| W-SERIES ALLUVIUM | 5,290,712 | 1,375,585 | 6,031,412 | 7,406,997 |
| BEACH SAND | 101,621 | 21,340 | 81,297 | 102,637 |
| ROCK (LA CUCHILLA RIDGE) | 93,236 | 282,505 | 1,199,015 | 1,481,520 |
| CLEANUP POND 2 | 5,683 | 682 | 5,626 | 6,308 |
| CLEANUP POND 7 | 60,694 | 12,139 | 50,983 | 63,122 |
| CLEANUP POND 9 | 20,973 | 4,614 | 19,295 | 23,909 |
| CLEANUP PONDS 16-21 | 271,620 | 59,756 | 249,890 | 309,647 |
| CLEANUP MAKEUP | 12,261 | 2,697 | 11,280 | 13,978 |
| CLEANUP MILL | 33,235 | 6,647 | 27,917 | 34,564 |
| CLEANUP IX | 18,392 | 11,587 | 45,796 | 57,383 |
| CLEANUP WINDBLOWN | 160,300 | 41,678 | 182,742 | 224,420 |
| RECONTOUR POND 2 | 11,366 | 2,387 | 8,865 | 11,252 |
| RECONTOUR POND 4 | 15,833 | 3,325 | 12,350 | 15,675 |
| RECONTOUR POND 5 | 6,300 | 1,323 | 4,914 | 6,237 |
| RECONTOUR POND 7 | 10,083 | 2,117 | 7,865 | 9,982 |
| RECONTOUR POND 9 | 10,487 | 2,202 | 8,180 | 10,382 |
| RECONTOUR POND 10 | 4,033 | 847 | 3,146 | 3,993 |
| RECONTOUR PONDS 11-15 | 316,390 | 66,442 | 246,784 | 313,226 |
| CONSTRUCT SOUTH DITCH | 19,719 | 4,141 | 15,775 | 19,916 |
| RECLAIM PONDS 11-15 | 102,000 | 49,980 | 176,460 | 226,440 |
| RECLAIM MAKEUP | 6,131 | 1,288 | 4,905 | 6,192 |
| RECLAIM MILL | 8,309 | 1,662 | 6,980 | 8,641 |
| RECLAIM IX | 4,598 | 966 | 3,678 | 4,644 |
| RECLAIM QUARRY | 2,330 | 466 | 1,957 | 2,423 |
| RECLAIM BORROW | 176,357 | 35,271 | 148,140 | 183,411 |
| SUB-TOTAL | 6,762,663 | 1,991,648 | 8,555,253 | 10,546,900 |

(CONTINUED)

TABLE 7 (CONTINUED)

| | |
|---|---|
| SUB-TOTAL | 10,546,900 |
| Salary costs at 45% of total labor costs | 896,242 |
| Overhead & Profit at 10% of total costs | 1,054,690 |
| Mill Demolition: 740,458 in 1979 dollars<br>June 1979 CPI = 72.3, June 1988 CPI = 118.0<br>This results in a 63.2% inflation factor. | 1,208,427 |
| Revegetation: $335/acre X 822.57 acres = $275,561<br>plus fixed costs of $77,884/year X 6 years | 742,865 |
| Radiological Monitoring: 1 Technician and equipment<br>at $200/day X 250 days/year X 3 years = | 150,000 |
| Soils and Rock Testing: 1 Technician and equipment<br>at $200/day X 250 days/year X 6 years = | 300,000 |
| SUB-TOTAL | 14,899,124 |
| Contingencies at 15% | 2,234,869 |
| New Mexico gross receipts tax at 5.125% | 763,580 |
| SUB-TOTAL | 17,897,573 |
| Inflation Adjustment: The above costs are in mid-1988<br>dollars and must be adjusted to mid-1990 dollars.<br>June 1988 CPI = 118.0, June 1990 CPI = 129.9<br>This results in a 10.08% inflation factor. | 1,804,075 |
| Groundwater Cleanup: A cost estimate was provided by<br>Quivara on June 1, 1989 and must be adjusted for<br>inflation. June 1989 CPI = 124.1, June 1990<br>CPI = 129.9; this results in a 4.67% inflation | 1,102,807 |
| Criterion 10 Long Term Surveillance Fee:<br>$250,000 in 1978 dollars, adjusted to 1990 dollars | 479,690 |
| TOTAL | 21,284,145 |

1. Remoteness from populated areas: The site is located in McKinley County, New Mexico, in the relatively remote area know as Ambrosia Lake. Grants, located 20 miles south, is the largest community in the immediate vicinity, having a population of about 9,100 people. Population projections for these areas are difficult to make, due to the unpredictable nature of the uranium industry. However, there is no reason to believe that there will be significant population increases within 10 miles of the site.

2. Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources: The reclaimed disposal area will be capped with a cover system designed to minimize infiltration.

   A ground-water review of the site to assure compliance with 10 CFR 40, Appendix A, is currently being done under other licensing actions. Compliance standards were set in December, 1988. The licensee is currently implementing the corrective action program to return ground-water quality to established standards.

3. Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long-term. The potential for erosion will be minimized by several design features as follows: The reclaimed top surfaces of Ponds 1 and 2 and Ponds 11-15 will be provided with very flat slopes which will prevent the formation of rills and gullies. The embankment outslopes of Pond 1 and the south embankment of Pond 15 will be flattened to 5H:1V and will be protected against erosion by riprap. The toe of the outslopes will be keyed into the existing ground to prevent headcutting of the slope. Runoff from the stable surface of Pond 1 will be conveyed down the outslope by a riprap-lined spillway. At the break in slope between the top of Pond 1 and the spillway, the spillway riprap will be extended 45 feet onto the pile top to prevent erosion at the transition. The South Diversion Ditch will be excavated into sandstone. If during construction, sandstone is not present in the ditch, riprap will be provided. In Pond 2, where the existing steeper slopes transition onto the pile top, sufficient riprap will be provided to minimize the potential for erosion.

Criterion 3

Criterion 3 sets below grade disposal as the prime option for tailings disposal. Relocation of the tailings to another site so that all the contaminated material could be placed below grade is technically feasible. However, the benefits over stabilizing the tailings in place would be negligible. Since the existing facility is essentially sound, the cost of disposing the contaminated materials below grade by relocating the disposal area would be much greater than the benefit realized, making relocation economically impracticable.

If below grade disposal is not practicable, the disposal plan must provide reasonably equivalent isolation of the tailings from natural erosional forces. The licensee utilized PMP/PMF events to design the erosion protection for the facility. Wind and sheet water erosion losses on the pile tops were calculated for 1000 years, and additional soil will be added to provide for this soil loss. Therefore, the tailings will be acceptably isolated from natural erosional processes.

Criterion 4

Criterion 4 sets specific technical criteria for disposal of tailings.

Criterion 4(a) requires that upstream rainfall catchment areas be minimized so that the tailings are protected from floods. This criterion will be met by directing runoff from the Pond 1 surface into a rock-lined spillway so that the only runoff that flows off the embankment outslopes will be from precipitation that occurs on the outslopes. There is a 3.7 square mile drainage area to the west of Pond 2 that will flow onto the pond. Although this area was not diverted, the reclamation plan was appropriately designed to compensate for this external drainage area.

Criterion 4(b) states that topographic features should provide good wind protection. The Quivira site is located in a northwest to southeast oriented valley. High mesas located northeast and southwest of the site modify the wind regime in the area such that the prevailing wind direction is westerly through north-northwesterly. There are no topographic features to shelter the tailings from the prevailing winds.

Relocation of the piles to another site, which would provide good wind protection, is technically feasible but the benefits over stabilizing the piles in place would be negligible. Since the facility is essentially sound, the cost of disposing the contaminated materials in an alternate location that would offer good wind protection would be much greater than the benefit realized.

Criterion 4(c) states that cover slopes must be relatively flat such that final slopes should be as close as possible to those which would be provided if tailings were disposed of below grade. In general, slopes should not be steeper than 5H:1V. The proposed reclamation plan places tailings under covers which are protected with riprap or under very flat vegetated slopes designed to be stable even under extreme runoff conditions.

Criterion 4(d) requires a full self-sustaining vegetative cover be established or a rock cover employed. The licensee has opted for a combination of rock, and extremely flat vegetated slopes. Due to the arid nature of the site, the licensee made no attempt to substantiate self-sustaining vegetation over a 1000-year period. Therefore, although vegetative cover will be placed on some areas of the site, vegetation is not necessary to assure long-term stability.

Criterion 4(e) requires that the impoundment not be located near a capable fault. The licensee assessed the literature, evaluated local faults, and determined that no capable faults exist near the site. The staff's independent evaluation concludes that capable faulting probably does not exist to the extent that tailings piles would be adversely affected.

On the basis of independent reviews and analyses, it is concluded that all the requirements of Criterion 4 will be met by the licensee's reclamation plan.

Criterion 5, 7, and 13

Criteria 5, 7, and 13 concern ground-water protection standards. As previously discussed, ground water is being addressed under separate licensing actions. Ground-water protection standards, however, at the site will be in accordance with these criteria.

Criterion 6

Criterion 6 requires that waste disposal areas be closed in accordance with a design which provides reasonable assurance that average releases of radon-222 and radon-220 to the atmosphere will be limited to 20 picocuries per square meter per second ($pCi/m^2s$). The design is to be effective for 1000 years to the extent reasonably achievable and, in any case, for at least 200 years.

The evaluation of the radon barrier utilized a RADON computer model (NRC, 1989a) and assumed conservative parameters to estimate radon emanation from the tailings. The design will be supported by adequate construction specifications, settlement monitoring, and quality control programs. The cover design as modified is acceptable, and the average release of radon-222 and radon-220 will meet the criterion.

The design basis events for erosion protection of the pile tops, embankment outslopes, and diversion ditch are the Probable Maximum Precipitation (PMP) and the Probable Maximum Flood (PMF) events. Both of these events are considered to be the most severe that are reasonably possible and thus provide reasonable assurance of not being exceeded during the 1000-year design life. This design should assure that excessive erosion does not occur during the design life. Accordingly, it is concluded that the design meets the requirements of Criterion 6.

Criteria 9 and 10

Criteria 9 and 10 require that a financial surety arrangement be established to assure that sufficient funds are available to carry out the decontamination and decommissioning of the facility and the reclamation of the disposal area. The licensee's cost estimate includes amounts for the performance of reclamation by a third party. All costs and assumptions were independently reviewed and revised to include appropriate estimates for activities to be performed under Source Material License SUA-1473 for decommissioning, decontamination,

reclamation, and long-term surveillance for the Ambrosia Lake Mill site. The surety amount of $21,000,000 is sufficient to meet the requirements of Criteria 9 and 10 of Appendix A to 10 CFR 40. License Condition No. 22 will be amended to reflect the revised surety requirements. The licensee will be allowed 90 days from the issuance of the amendment revising License Condition No. 22 to submit, for NRC approval, the information and forms required to evidence a surety in the amount of $21,000,000.

Criterion 12

Criterion 12 requires that the final disposition of tailings or wastes at milling sites should be such that ongoing active maintenance is not necessary to preserve isolation.

Every reasonable concern has been considered in the design of the facility. The technical criteria in Appendix A have been met, to the extent reasonably achievable, by considering economics and by utilizing state-of-the-art design methods and conservative design basis events. Therefore, ongoing maintenance is not required to assure that the reclaimed disposal areas will remain effective for 1000 years and that radon emanation will be limited to an average of 20 $pCi/m^2s$. There will be, however, a long-term program of surveillance and maintenance administered through a license as required by Criterion 11. It is expected that routine maintenance will be performed as needed, but it is not required to preserve the facility. Therefore, the requirements of Criterion 12 are met by the design.

CONCLUSIONS

Review and independent analysis of the reclamation plan for the Ambrosia Lake Mill site has identified numerous open items in the design that are not consistent with 10 CFR 40, Appendix A. Therefore, it is recommended that Source Material License SUA-1473 be amended by modifying License Condition No. 22 and by adding License Condition No. 37 to read as follows:

22. By December 24, 1990, the licensee shall submit a surety instrument, acceptable to the NRC, in an amount no less than $21,000,000. This surety amount is based on the approved reclamation plan as supplemented by the NRC assumptions identified in License Condition No. 37. This surety shall be written in favor of the NRC for the purpose of complying with 10 CFR 40, Appendix A, Criteria 9 and 10, and shall be continuously maintained until a replacement is authorized by the NRC.

    Annual updates to the surety amount, required by 10 CFR 40, Appendix A, Criteria 9 and 10, shall be submitted to the NRC at least three (3) months prior to the anniversary date, which is designated as December 24 of each year. Along with each proposed revision or annual update, the licensee shall submit supporting documentation showing a breakdown of costs and the basis for the cost estimates

with adjustments for inflation, changes in engineering plans, activities performed, maintenance of a fifteen (15) percent contingency fee, and any other conditions affecting the estimated costs for decommissioning and decontamination of the mill and mill site, reclamation of the tailings and waste disposal areas, soil and water sample analysis to confirm decontamination, long-term surveillance, and ground water restoration as warranted. Reductions in the surety amount shall not be made without prior NRC approval.

37. The licensee shall reclaim the disposal area as stated in the September 24, 1990, submittal as supplemented by the following conditions. Though recognized as conservative, these conditions were assumed when evaluating the acceptability of the reclamation plan as submitted, and are identified pending submittal of acceptable design alternatives. Justification for any design alternatives must be submitted for NRC review and approval prior to implementation.

A. The radon barrier thickness shall be 8 feet over the entire surface area of Pond 1 and Pond 2.

B. The radon barrier shall be constructed from material which classifies as a SM or ML material in accordance with the Unified Soil Classification System and have a maximum particle size of 3 inches and at least 35 percent passing the No. 200 sieve. The material shall be plastic.

C. The relocated contaminated material shall be placed in lifts not to exceed 12 inches and compacted to at least 90 percent of the maximum standard dry density after a stable work base has been established.

D. In place density and moisture, laboratory compaction, soil classification, and rock quality testing shall be performed in accordance with the licensee's September 24, 1990, submittal. If test procedures other than the sand cone test or oven dry moisture are used in the construction quality control, procedures that will be used to establish correlation between the tests must be submitted for NRC review and approval prior to implementation.

E. A detailed cover design for Ponds 11-21 must be submitted for NRC review and approval. All contaminated materials in Pond 3 that are not covered by the reclaimed Pond 1 outslope shall be relocated to Pond 2 unless an erosion protection plan is submitted for NRC review and approval.

F. The settlement survey data shall be submitted for NRC review and approval prior to placement of the radon barrier on the interim cover.

G. The fresh water dam (mill reservoir) must be breached during final reclamation activities.

H. Settlement monuments shall consist of a steel bar welded to a 1-foot square steel plate, or equivalent, placed at least 3 feet below the surface.

I. The fill associated with the Pond 1 spillway shall be constructed to the same specifications and quality control program as the radon barrier material.

J. If a rock source is selected other than the La Cuchilla Ridge source, the licensee shall submit the results of durability tests as outlined in the draft Staff Technical Position on Design of Erosion Protection, August 1989, for NRC review and approval prior to placement of any of the material.

K. All riprap shall be placed in a manner that prevents segregation of the material. The material placed shall be reasonably well graded and shall be within the following gradation specifications.

$D_{50}$ = 1"

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 2 inch | 100 |
| 1 inch | 16-50 |
| 3/4 inch | 2-30 |
| ½ inch | 0-10 |

$D_{50}$ = 2"

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 4 inch | 100 |
| 3 inch | 66-100 |
| 2 inch | 18-50 |
| 1 inch | 0-10 |

$D_{50}$ = 2.8 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 5 inch | 100 |
| 4 inch | 50-100 |
| 3 inch | 25-58 |
| 2 inch | 2-28 |
| 1 inch | 0-5 |

$D_{50}$ = 3.2 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 6 inch | 100 |
| 5 inch | 78-100 |
| 4 inch | 35-100 |
| 3 inch | 12-45 |
| 2 inch | 0-20 |

$D_{50}$ = 7.7 inch

| Sieve Size | Percent Passing (by weight) |
|---|---|
| 13 inch | 100 |
| 12 inch | 80-100 |
| 10 inch | 49-100 |
| 8 inch | 26-54 |
| 6 inch | 7-32 |
| 4 inch | 0-13 |

L. A minimum 6-inch bedding layer with a $D_{50}$ of 1 inch shall be placed under all riprap on the disposal area having a $D_{50}$ of two (2) inches or larger. The bedding material shall be reasonably well graded to prevent migration of the base material into the riprap. The quality of the bedding material shall be equivalent to that of the riprap.

M. A riprap filled toe trench shall be placed on the west side of Pond 2 where the existing steep slopes transition onto the flatter surface of Pond 2. The licensee shall submit a proposed design of the trench for NRC review and approval prior to construction.

N. The spillway riprap shall be extended 45 feet onto the top of Pond 1 to prevent erosion.

O. Riprap with a $D_{50}$ of one (1) inch shall be placed in all areas of the South Diversion Ditch which are not excavated in rock.

This amendment was discussed and agreed to with Mr. Marvin Freeman on September 24, 1990.

Dawn L. Jacoby
Project Manager

Raymond O. Gonzales
Project Manager

SEP 24 1990

Paul W. Michaud

Paul W. Michaud
Project Manager

Enclosure:
1. Ambrosia Lake Mill Reclamation Plan Chronology

Cases Closed: 040089051300
04008905132E
04008905133E
04008905135E

bcc:
LFM3
PDR/DCS
URFO r/f
ABBeach, RIV
LLO Branch, LLWM
DJacoby
RGonzales
PMichaud
JGrimm
PGarcia
BGarcia, RCPD, NM
EMontoya, NM
8905/1300/132-135E/DLJ/90/09/7

## REFERENCES


COE, 1970, Hydraulic Design of Flood Control Channels, EM 1110-2-1601, U.S. Army Corps of Engineers, July, 1970.

COE, 1982, Water Surface Profiles, HEC-2, U.S. Army Corps of Engineers, September, 1982.

Nelson, J. D., Abt, S. R., Hinkle, N. E., Staub, W. P., Volpe R. L., and van Zyl, D., 1986, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments, Phase I Report: U.S. Nuclear Regulatory Commission, NUREG/CR-4620, June, 1986.

NRC, 1977, Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills, Revision 2: NRC Regulatory Guide 3.11, December, 1977.

NRC, 1989a, Calculation of Radon Flux Attenuation by Earthern Uranium Mill Tailings Covers: NRC Regulatory Guide 3.64, June, 1989.

NRC, 1989b, DRAFT Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites: Washington, D.C., Division of Low-Level Waste Management and Decommissioning, August, 1989.

SCS, 1972, National Engineering Handbook, Section 4-Hydrology, Soil Conservation Service, U.S. Department of Agriculture, August, 1972.

Stephenson, D., 1979, Rockfill in Hydraulic Engineering, Developments in Geotechnical Engineering, 27, Elsevier Scientific Publishing Company.

USBR, 1987, Design of Small Dams, U.S. Department of the Interior, Bureau of Reclamation, Third Edition, 1987.

U.S. Department of Commerce, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, 1984, Hydrometeorological Report No. 55, "Probable Maximum Precipitation Estimates - United States Between the Continental Divide and the 103rd Meridian," March, 1984.

Enclosure 1

Ambrosia Lake Mill Reclamation Plan Chronology

| | |
|---|---|
| October 1, 1986 | Quivira submits their reclamation plan for the Ambrosia Lake Mill. |
| January 8, 1987 | NRC letter requesting surface water/erosion protection information. |
| March 16, 1987 | Quivira submits responses to NRC's January 8, 1987, letter. |
| February 18, 1987 | NRC letter requesting additional information. |
| March 27, 1987 | Quivira submits geotechnical portion of responses to NRC's February 18, 1987, letter, including specifications. |
| May 5, 1987 | Meeting to discuss surface water/erosion protection aspects of the proposed reclamation plan. |
| July 20, 1987 | Quivira submits additional flood studies. |
| August 19, 1987 | Quivira submits results of additional geotechnical testing on the proposed cover material. |
| August 27, 1987 | NRC letter requesting additional geotechnical information. |
| September 14, 1987 | Quivira submits additional geotechnical information including QA/QC frequency. |
| September 21, 1987 | Quivira submits additional flood studies. |
| October 7, 1987 | Quivira submits revised radon attenuation calculations. |
| March 21, 1988 | NRC letter transmitting remaining open items in the reclamation plan. |
| April 8, 1988 | Meeting to discuss the reclamation plan. Quivira indicated that a revised plan to be submitted on or about June 30, 1988. |
| April 21, 1988 | Quivira submits information requested by NRC's March 21, 1988, letter (partial). |

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|---|---|
| June 30, 1988 | Quivira submits major redesign of reclamation plan. |
| December 20, 1989 | NRC letter transmitting comments on surface water/erosion and geotechnical aspects of the revised reclamation plan. |
| February 28, 1990 | Quivira submits responses to information requested by NRC's December 20, 1989, letter. |
| May 11, 1990 | NRC letter transmitting request for additional information and scheduling of the response so that a surety instrument can be in place by 1991. Also requested meeting. |
| May 21, 1990 | Meeting to discuss NRC's May 11, 1990, letter. |
| June 5, 1990 | Rio Algom Mining Corp. (RAM) letter delaying response to NRC's May 11, 1990, letter. |
| June 11, 1990 | NRC letter further addressing concerns discussed in the May 21, 1990, meeting. |
| July 18, 1990 | Meeting to discuss remaining open items. |
| August 1, 1990 | Quivira submits responses to information requested by NRC's May 11, 1990, letter. |
| August 23, 1990 | Telephone conference call with RAM to discuss August 1, 1990, submittal and request additional information. Documented by NRC letter dated August 28, 1990. Further discussions are documented by NRC memorandum dated August 30, 1990. |
| September 7, 1990 | Quivira submits responses to NRC's August 23, 1990, request for information (partial). |
| September 13, 1990 | Quivira resubmits HE2-1 results. |
| September 14, 1990 | Telephone conference call with Quivira to propose amendment. Documented by NRC letter dated September 19, 1990. |
| September 20, 1990 | Meeting to discuss surety amount. |
| September 24, 1990 | Quivira submits responses to September 20, 1990, meeting. |