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MEMORANDUM FOR: Myron Fliegel
Operations Branch
Division of Low-Level Waste Management
and Decommissioning, NMSS

FROM: Michael Tokar
Technical Branch
Division of Low-Level Waste Management
and Decommissioning, NMSS

SUBJECT: TECHNICAL EVALUATION MEMORANDUM FOR THE REMEDIAL ACTIONS AT THE SHIPROCK SITE

Attached are Sections 2 and 3 of the Technical Evaluation Memorandum (TEM) for the remedial actions at the Shiprock site, prepared in response to your request. Although the Shiprock project is near the completion stage, this TEM input is written using information from the final RAP and preliminary design documents. As per the guidance from your section, the Table of Contents and format of these TEM sections are patterned after the Standard Review Plan (SRP) for UMTRCA projects.

TEM sections 2 and 3 present evaluations of the geotechnical engineering stability and radon attenuation aspects of the remedial action plan (RAP). There are no unresolved technical concerns in these two areas.

As per Chapter 2 of the SRP, Section 2 of the TEM should also present evaluations of geomorphic characterization and seismic and tectonic characterization aspects of the RAP. The Siting Section of LLTB is responsible for these topics. Section 2 of the attached TEM has blank subsections for these topics, which are to be provided separately by the Siting Section.

This evaluation was performed by Dr. B. Jagannath; please contact him should you have any questions.

Original Signed By

Michael Tokar
Technical Branch
Division of Low-Level Waste Management
and Decommissioning, NMSS

Enclosures: As stated

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Technical Evaluation Memorandum

Geotechnical Engineering Stability and Radon Attenuation

for

Shiprock Site Remedial Action Plan

Prepared by: Dr. Banad N. Jagannath, LLTB

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2.0 GEOTECHNICAL STABILITY

2.1 Proposed Remedial Action

The tailings at the Shiprock site are located in two adjacent piles covering approximately 72 acres. The piles contain 1.9 million cubic yards of tailings, contaminated rubble, and soil materials. The proposed remedial action calls for (1) relocation of radioactive tailings away from the edge of the escarpment; (2) removal of contaminated materials from the site yard area, adjacent and flood plain areas, and vicinity properties; and (3) consolidation of all contaminated materials in a single large embankment in the same approximate locations as the two existing tailings piles. The gently contoured embankment (side slope of 5 horizontal to 1 vertical) will then be covered with a thick earthen layer (approximately 7 ft thick) and a rock layer to ensure: (1) long-term stability while simultaneously reducing radon emissions; (2) reduced infiltration of precipitation (thereby avoiding contaminated recharge to the shallow ground water system); (3) protection of surface water quality; (4) prevention of animal intrusion; (5) minimized plant root intrusion; (6) prevention of inadvertent human intrusion; and (7) prevention of materials dispersion (Reference 1).

Relocating the tailings away from the escarpment will prevent the release of contaminated material resulting from the undercutting and slope degradation of the escarpment. Site regrading combined with stabilization of the escarpment edge will retard long-term escarpment erosion and prevent surface-water runoff and river contamination. Fencing the perimeter of the consolidated pile and posting warning signs will discourage human intrusion. The geotechnical aspects of the proposed remedial action have been reviewed for compliance with the EPA standards with respect to stability and radon control (40 CFR Part 192).

2.1.1 Areas of Review

The staff review (by the Engineering Section) of the geotechnical engineering aspects of this remedial action consisting of site characterization, engineering evaluation of the stability and settlement, and cover design are presented in Sections 2-2, 2-5 and 2-6 of this report. The staff review (by the Siting Section) of the geological aspects such as geomorphic characterization, and seismic and tectonic characterization of the site are presented in Sections 2.3 and 2.4 of this report.

2.2 Site Characterization

2.2.1 Site Description

The Shiprock site is located on the Navajo Indian Reservation on the south side of the town of Shiprock, New Mexico. It lies on an escarpment on the southwest bank of the San Juan River, 70 feet above the river flood plain. Farmington, New Mexico, is approximately 30 miles east of the Shiprock site. The designated site contains 144 acres, of which about 72 acres are covered with tailings in two adjacent piles. The upper (northern) pile covers 26 acres and varies from 14 to 40 feet in height. The lower (south) pile covers 46 acres and is approximately 15 to 30 feet in height. Four of the original mill buildings and two new buildings are on the site. The tailings pile was covered and stabilized during a previous remedial action, but the present condition of the pile does not meet the EPA standards. Dikes presently around the tailings pile prevent the spread of tailings from the run-off water erosion. The dikes and the site surface grading direct other off-site and on-site surface run-off toward existing arroyos off the edge of the escarpment.

Several of these arroyos close to the tailings pile are actively eroding the escarpment from above. High winds combined with the steep side slopes on the upper tailings pile have exposed the thinly covered tailings to both rainfall and wind erosion.

2.2.2 Site Investigations

Subsurface investigations were performed at the Shiprock site by five contractors - Colorado State University (1979, 1981), Dames and Moore, (1982), Sergent, Hawkins & Beckwith (1983), Bendix Field Engineering Corporation (1983), International Engineering Company (1984) (References 1, 2, & 3). The scope of the geotechnical investigations included borings from which soil samples and rock cores were obtained, test pits from which bulk soil samples were obtained, and installation of monitoring wells. However, the work by Bendix was primarily for radiological survey of the tailings pile and adjacent areas.

2.2.3 Site Stratigraphy

The overburden generally consists of a surface layer of silt and silty sand underlain by sandy gravel with cobbles. These alluvial terrace deposits are about 10 ft thick at the escarpment and about 40 ft. thick at the southwest corner of the tailings pile. The bedrock at this site is identified as Mancos shale which predominantly consists of claystones and silt stones. Mancos shale is estimated to be several hundred feet thick at this site.

The upper natural soils at the site predominantly consist of non-plastic to low plasticity sandy silts, silty sands and sandy clays (ML, SM, CL). These soils generally extend to depths of 5 to 30 ft below the natural ground surface, thickening to the south-southwest.

These fine grained soils are underlain by a stratum of sandy gravel containing numerous cobbles and small boulders and is interbedded with layers of clean fine sand and sandy silt and clay.

The upper 10 to 30 feet of Mancos shale is typically highly weathered - exhibiting fractures, fissility, and low strength. Below the highly weathered zone, the bedrock is moderately weathered, more competent, and relatively impermeable.

Groundwater exists in the alluvial deposits near or below the tailings/soil interface. This water appears to be perched and laterally discontinuous across the site. A continuous water system exists in the upper weathered portion of the Mancos shale, which underlies the alluvial deposits. Refer to Section 4 of this report for a detailed discussion of the groundwater conditions at the site.

The tailings site is generally rectangular in shape consisting of two piles - an upper pile (closest to the river) and a lower pile. The upper pile is approximately 14 to 40 feet thick and the lower pile is about 15 to 30 feet thick above the natural soils. The side slopes are about 1.6 horizontal to 1.0 vertical. Soil cover placed during a previous remedial action is present only at some locations on the tailings pile. The tailings consist of interbedded sands (SP-SM) and slimes (CL-ML). These materials are interbedded in thin lenses that are discontinuous, both vertically and horizontally. The term, slime, is used to define the fine portion of the tailings with a relatively high moisture content and moderate plasticity. The slimes have layers of silt and clay interbedded during the mill tailings depositional process.

The staff finds that the scope of the geotechnical investigations conducted at the Shiprock site was adequate to establish the stratigraphy and soil conditions at the site and is in general conformance with the provisions of Section 2 of the SRP for UMTRACA Title 1 Mill Tailings Remedial Action Plans

2.2.4 Testing Program

Details of the borings, test pits, and laboratory tests comprising the geotechnical engineering subsurface exploration and testing program for the Shiprock site (References 1, 2, 3, & 5) were examined by the staff. Based on this review, the staff finds that the exploration programs have adequately covered the site and borrow area and were consistent with standard engineering practice. Because of the interbedded and erratic nature of the tailings pile it was difficult to obtain undisturbed samples of the slimes from borings; however, they were obtained from test pits. The staff finds that the testing program employed to define the material properties was appropriate for the support of the necessary engineering analyses described in the following sections and that the data collected in the exploration program was sufficient to describe the site characteristics.

2.3 Geomorphic Characterization

(To be provided by Siting Section)

2.4 Seismic and Tectonic Characterization

(To be provided by Siting Section)

2.5 Geotechnical Engineering Evaluation

The following geotechnical engineering aspects of the remedial action have been reviewed by the staff:

2.5.1 Slope Stability

$ Stabilized Tailings Pile

The evaluation of the geotechnical stability of the slopes of the tailings pile is presented in this section. The staff has reviewed the exploration data, test results, critical slope characteristics and methods of analyses pertinent to the slope stability aspects of the remedial action plan (Reference 1, 5, 6 and 8). The critical cross section of the slope, 5 horizontal to 1 vertical, used in the analysis has been compared with the exploratory records and design details. The staff finds that the characteristics of the slopes have been accurately represented, and that the most critical slope section (northeast section of the upper tailings pile) has been considered for the analysis.

Soil parameters for the slimes, which is the critical layer for the slope stability analysis, have been established by appropriate testing. Values of soil parameters have been assigned to other non-critical layers (sand, sand-slime, etc.) on the basis of data obtained from geotechnical explorations at this site and data published in the literature. The staff finds that the methods used to estimate the values of these soil parameters were appropriate. The staff also finds that the stability analysis has employed an appropriate method of analysis (sliding wedge method of analysis) and has addressed the likely adverse conditions to which the slope might be subjected. Factors of safety against failure of the slope for both static and seismic loading conditions have been evaluated for short term or end-of-construction state. For the static loading conditions, the minimum factor of safety against failure of the slope was reported as 1.9. The staff finds the factor of safety to be acceptable for static loading conditions. The stability of the slope for the seismic loading condition was investigated by the pseudo-static method of analysis using a horizontal seismic coefficient of 0.14. The staff finds the pseudo-static method of analysis is acceptable considering the degree of conservatism in the soil parameter values and the flatness of the slope (5H:1V). A minimum factor of safety of 1.14 has been reported for the seismic loading condition. This is higher than an acceptable minimum factor of safety of 1.0 for seismic loading conditions.

The staff has noted that the reported stability evaluation has used short-term or undrained strength parameters for the slime materials. The long-term strength parameters for slimes would be significantly higher than the strength parameters used in the above analysis and the factors of safety of the slope for the long-term conditions would be higher than those calculated for the short-term conditions. Therefore, it is concluded that the slopes would be stable for the long-term conditions.

The staff concludes that the stabilized tailing pile slopes are expected to be stable under both short-term and long-term conditions.

$ Stability of Arroyo Slopes

The remedial action proposed to stabilize the Arroyos consist of: (1) modification of the top of the escarpment to drain surface-water runoff away from the edge and toward the embankment perimeter drain ditch; and (2) fill and recompaction of erosion gullies in the escarpment edge. The erosion gullies will be filled with pit run gravel and topped with a 2 feet thick select rock layer to a final slope of 2 horizontal to 1 vertical. At places where the escarpment needs to be cut, the final cut slope was 2 horizontal to 1 vertical with a 4-foot thick layer of pit run gravel placed on the slope surface. The top of the filled erosion gully will be capped with a seepage barrier (1-foot thick layer of compacted Mancos shale) overlain by a 1-foot thick layer of pit run gravel. The top will be sloped to drain the surface-water runoff away from the edge. This escarpment is nearly 300 feet away from the toe of the tailings pile; therefore it is not expected to pose a radiological hazard, even if there were a failure. The DOE states and the staff concurs that the slope or face of the remedied arroyos and escarpment will be stable under both short term and long term design conditions.

2.5.2 Settlement

The staff has reviewed the DOE's analysis of total and differential settlements resulting from compression and consolidation caused by the placement of a radon barrier cover over the reworked and compacted tailings in the stabilized pile. The staff considers that the in situ foundation soils (silty sand and sandy gravel) do not contribute to any time dependent settlement. Any compression of these foundation soils as a result of the imposed loading will be elastic settlement which will be accommodated during construction. The reported settlement analysis used consolidation parameters determined by laboratory tests (References 1, 2, 3 and 5). Staff review of the settlement calculations indicate that the material properties and stratigraphy used in the analyses are representative of the site conditions, and appropriate analyses and techniques have been used.

Maximum total settlement at the critical analysis section (thick slime pocket) has been estimated to be 1.0 foot and the differential settlement is estimated to be a maximum of 5 inches. Total settlement at typical (average condition) section is estimated to be 6 inches and the differential settlement is estimated to be 0.75 inch. Since the tailings will be mixed with sand and compacted, it is expected that most of the settlement will occur during construction. To limit the effect of settlement on cover, the DOE plans to monitor settlement during construction and to perform final grading of the cover only after most of the settlement has taken place.

Differential settlement can lead to cover cracking and/or concentration of surface runoff. The DOE has concluded that differential settlement expected to occur after cover placement will not be of a magnitude that would cause cover cracking. Although some differential settlement is expected to occur, the staff concludes that it will be minimized by the fact that tailings will be mixed with sand, which will promote drying, and compacted into an engineered fill and final grading will be performed after most of the settlement has taken place. The staff agrees with the DOE's conclusion that the estimated settlement at this site should not present a problem.

2.5.3 Liquefaction

The staff reviewed the results of the geotechnical investigations including boring logs, test data, and soil profiles, and conclude that the DOE has adequately assessed the potential for liquefaction at the Shiprock site. Because the compacted dry density of the stabilized pile will be equal to a minimum of 90 percent of maximum density determined by ASTM D-698 test, and the pile design provides for the pile materials to be in an unsaturated condition, the tailings pile is not considered to be susceptible to liquefaction. Pockets of saturated slime within the unsaturated stabilized pile are not susceptible to liquefaction because of the slight cohesive nature of the slime. However, pockets of slime located adjacent to embankment slope will undergo deformation during a seismic event. Therefore, small local deformation in the vicinity of the toe of the embankment cannot be ruled out.

The subsoils at the site are in a relatively dense condition and are expected to be in an unsaturated condition. Therefore, the foundation soil beneath the tailings embankment is also not considered susceptible to liquefaction.

The staff concludes that the stabilized pile is not susceptible to liquefaction. However, the staff expects that seismically induced ground motions may produce deformation in pockets of slime which might result in slight disruption at the toe of the pile. A license requirement for mandatory inspection following a significant seismic event is recommended. The magnitude of the seismic event which triggers a mandatory inspection should be defined in the long-term monitoring plan for this site.

2.5.4 Cover Design

The Technical Assistance Contractor's design (References 1, 6 and 8) of radon barrier cover over the stabilized tailings pile consist of an earth cover, 6.4 feet thick on the top of the pile and 7 feet thick on the side slopes of the pile. The earth cover was topped by a 6-inch thick select bedding layer and a one foot thick select rock layer. Both soil and rock are available in the designated borrow sites adjoining the tailings disposal site. The staff has reviewed the exploration data, laboratory test results, and construction criteria presented in the RAP and DSCR to assess various aspects of the soil cover design and find them to be acceptable. The evaluation of the radon barrier (earth cover) design is presented in Section 3.0 of this report.

2.6 Geotechnical Construction Criteria

The RAP presents general criteria for the excavation, fill placement, and compaction items associated with this project (Reference 5). The staff has reviewed the presented criteria and find them acceptable and consistent with standard engineering practice.

2.7 Conclusion

Based on a review of the reported geotechnical engineering aspects of the remedial action plan to stabilize the tailings present at the Shiprock site, the staff concludes that the long-term stability aspects of the plan are consistent with the EPA standards (40 CFR Part 192.02(a)) with respect to long term stability.

2.8 References

1. Letter dated December 14, 1984, from J. Themelis of DOE to L. Higginbotham of NRC; transmitting three documents - (1) Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings site at Shiprock, New Mexico, Revised Final, December 1984, (Vol. I, II, & III); (2) Shiprock Remedial Action Plan and Site Conceptual Design, NRC Comments, September 6, 1984, and DOE Responses, December 7, 1984; (3) Shiprock Remedial Action Plan and Site Conceptual Design, NRC Comments, October 4, 1984, and DOE Responses, December 7, 1984.

2. CSU (Colorado State University), 1982, Draft - Characterization of Inactive Uranium Mill Tailings sites: Shiprock, New Mexico.

3. CSU/HGCC (Colorado State University), 1983, Appendix A, CSU/HGCC Report, Interim Draft, Shiprock Tailings Site.

4. Attachment 1, Modifications to the Remedial Action Plan and Site conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Shiprock, New Mexico, UMTRA-DOE-AL-0505040039, October 1985.

5. Letter dated December 10, 1984, from R.E. Hopkins of Morrison-Knudsen Company, Inc., to L. Higginbotham of NRC; Subject: Shiprock Site - Shiprock, New Mexico - Phase II Construction-Preliminary Contract Documents and Design Calculations.

6. Modification No. 3 to the Shiprock, New Mexico, Remedial Action Plan, transmittal dated May 29, 1986, from DOE to NRC.

7. Letter dated July 30, 1986, from M. Knapp of NRC to J. Themelis of DOE; Subject: NRC's concurrence to Modification No. 1 to the Shiprock Remedial Action Plan.

8. Letter dated August 8, 1986, from M. Knapp of NRC to J. Themelis of DOE, Subject: NRC's Concurrence to Change No. 14 - Radon Barrier Thickness and Change No. 15 - Seismic Stability of Embankment.

3.0 RADON ATTENUATION

3.1 Areas of Review

The review of design for radon attenuation encompassed evaluation of the pertinent design parameters for both the tailings and the radon barrier soils, and the calculations of the radon barrier (earth cover) thickness (References 1, 2, 3 and 5).

The design parameters for the tailings and earth cover materials evaluated for acceptability include: long-term moisture content, material thickness, bulk density, specific gravity, porosity, and radon diffusion coefficient. In addition to the above properties, radium content and radon emanation coefficient parameters were evaluated for the tailings materials only. The computer code RAECOM (Reference 7) was used to calculate the radon barrier cover thickness, and the input included the above parameters.

3.2 Evaluation of Parameters

In order to meet the EPA Standards for release of Radon-222 from residual radioactive material to the atmosphere, the tailings pile is covered with earth (radon barrier), to attenuate the release of radon from the tailings. The thickness of the barrier depends on the phenomenon of the diffusion of radon gas through the materials, while trying to escape into the atmosphere. The DOE proposed to use sandy silt as earth cover for radon attenuation. The material properties and radiological parameters used in the design of the radon barrier for the stabilized tailings pile at the Shiprock site are reviewed.

The long-term moisture content of the cover material (sandy silt) was determined by three methods - Rawls (Ref. 6), U.S. Soil Conservation Service (USSCS) computer code, and laboratory tests performed at 15 bar capillary pressure. The soil samples used in these tests and the parameters used in the USSCS calculations are representative of the in situ conditions. The long-term moisture content (average value) determined by the above three methods were 6.6%, 7.6% and 8.6% respectively. The USSCS method is based on a data base larger than that of Rawls method, and therefore, was preferred by the DOE. The laboratory tests (at 15 bar negative pressure) yielded a long-term moisture content higher than that calculated by the USSCS method. To be conservative, the DOE has used a long-term moisture of 7.6% for the cover material. The long-term moisture content for other materials below the cover were either determined by laboratory tests or assigned a conservative value based on field measurements combined with engineering judgment. The staff has reviewed the information and concur with the values of the long-term moisture content used in the design.

The material thickness (layers) used in the DOE's analysis are based on the conceptual design of the remedial action plan and field data available from construction records. The stabilized pile was divided into 8 areas, 4 on the top-slope and 4 on the side-slope, in modeling the site for radon attenuation analysis. The areas were chosen by the primary type of material located in each area, i.e., sand, sand/slime, or slime as well as separating areas of low and high radium concentration. Each area is further broken down into vertical layers where the top 4 feet of the tailings is the most critical, then the next

6 feet, and finally below the top 10 feet of the tailings surface down to the interface between the tailings and the original ground being the least critical. These layers are still further divided into in situ and relocated tailings as well as sand, slime, and sand/slime. For RAECOM modeling, the top 10 feet below the bottom of the cover was considered to be either relocated tailings or in situ sand. The next 5 feet (i.e., 10' to 15') the material was considered to be either in situ sand or sand/slime. From a depth of 15 feet below the bottom of the cover to the interface with the original ground, the material was considered to be slime. The material thickness and layering used by the DOE in the analysis are a reasonable representation of the field conditions.

Material properties such as bulk density and specific gravity were determined by both field and laboratory tests, and the corresponding porosity was calculated. The bulk density and porosity parameters for the layers used in the RAECOM model were 1.70 gm/cm3 and 0.356 for cover; 1.51 gm/cm3 and 0.41 for material from 0 to 10' below the bottom of cover; 1.38 gm/cm3 and 0.44 for material from 10' to 15' below the bottom of the cover; 1.65 gm/cm3 and 0.35 for the material from 15' below the bottom of cover to interface with the natural ground. The values of the parameter used by the DOE are based on test data performed on representative samples and are acceptable to the staff.

Radon diffusion coefficients for the cover material and tailings were derived from a correlation curve of moisture content versus radon diffusion coefficients. Diffusion coefficient corresponding to the estimated long-term moisture content of the material was read from the curve. This curve was developed using diffusion coefficient and moisture content data from both field and laboratory measurements on soil samples that are representative of the conditions in the stabilized pile. The values of the diffusion coefficients used in the RAECOM model were - 0.15 cm2/sec for earth cover (sandy silt); 0.039 cm2/sec for material between 0 to 10' below the bottom of the cover; 0.042 for the material from 10 feet below the bottom of the cover to the interface with the natural ground surface. The diffusion coefficient values used in the design are reasonable and acceptable to the staff.

The radium content (Ra-226) of several materials at the site was measured. The average radium content to be used in the analysis was determined by weighted averaging with depth in a measurement hole and then averaging over an area at any given depth. The weighted average value of the radium content for the entire pile was calculated to be 303 pci/gm for material between 0 to 4 feet below the bottom of the cover; 351 pci/gm for material between 4 feet to 10 feet below the bottom of the cover; 643 pci/gm for material between 10 feet to 15 feet below the bottom of the cover; 419 pci/gm for material from 15 feet below the bottom of the cover to the interface with the natural ground surface. The staff concurs with these values and the methodology used in establishing the average radium content to be used in the design.

The radon emanation coefficient parameter was measured in the laboratory on samples representative of field conditions. Conservative values were used in the design. Emanating coefficient of 0.21 was used for the top layer (0 feet - 10 feet) below the bottom of the cover. For the material from 10 feet below the bottom of the cover to the interface with the natural ground surface an emanating coefficient of 0.25 was used.

The ambient air radon concentration was measured to be 0.80 pci/1.

3.3 Evaluation of Radon Barrier

The Radon Barrier (earth cover) thickness was calculated using the RAECOM computer code (Reference 7). For a given input, assumed thickness of the earth cover, the RAECOM code calculates the radon gas release rate. The EPA standard requires that the release of radon-222 from residual radioactive material to the atmosphere not exceed an average release rate of 20 picocuries per square meter per second. The DOE has assumed a cover thickness of 7 feet on the side-slopes. The side-slopes areas were divided into 4 areas and the average release rate for these areas were computed using RAECOM code. The required radon gas release from the top-slope was then determined by area weighted averaging so as to limit the average radon release to 20 pci/m2/sec for the entire pile. The evaluation of the parameters used in this analysis is discussed in Section 3.2 of this report. The DOE has calculated a cover thickness of 6.4 feet for the top-slope of the pile to result in an average radon release rate of 20 pci/m2/sec for the entire pile. The staff concurs with the methodology used and the thickness of the radon barrier cover calculated by the DOE. The earth cover is protected against erosion by a 1.0-foot thick layer of select rock placed over a 6-inch thick gravel bedding. The bedding and the select rock gradations meet the filter criteria. The stability of the rock cover against erosion is addressed in Section 1.0 of this report.

3.4 Conclusion

Based on review of the information provided by the DOE on the radon barrier design aspect of the remedial action plan at the Shiprock site, the staff concludes that the radon attenuation aspect of the plan satisfies the EPA standards (40 CFR Part 192.02) with respect to release of radon-222 from a remediated tailings pile.

3.5 References

1. Letter dated December 14, 1984, from J. Themelis of DOE to L. Higginbotham of NRC; transmitting three documents - (1) Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings site at Shiprock, New Mexico, Revised Final, December 1984, (Vol. I, II, & III); (2) Shiprock Remedial Action Plan and Site Conceptual Design, NRC Comments, September 6, 1984, and DOE Responses, December 7, 1984; (3) Shiprock Remedial Action Plan and Site Conceptual Design, NRC Comments, October 4, 1984, and DOE Responses, December 7, 1984.

2. Letter dated December 10, 1984, from R. E. Hopkins of Morrison-Knudsen Company, Inc., to L. Higginbotham of NRC; Subject: Shiprock Site - Shiprock, New Mexico - Phase II Construction-Preliminary Contract Documents and Design Calculations.

3. Modification No. 3 for the Shiprock, New Mexico, Remedial Action Plan, transmittal dated May 29, 1986, from DOE to NRC.

4. Letter dated August 8, 1986, from M. Knapp of NRC to J. Themelis of DOE, Subject: NRC's Concurrence to Change No. 14 - Radon Barrier Thickness and Change No. 15 - Seismic Stability of Embankment.

5. Attachment 1, Modifications to the Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Shiprock, New Mexico, Revised Final, RAP Modification No. 3A, September 1985.

6. Rawls, W. J., and Brakensiek, D. L.; "Estimating Soil Water Retention from Soil Properties," Journal of Irrigation and Drainage Division, ASCE, Vol. 108, No. IR2, June 1982.

7. Rogers, V. C., Nielson, K. K., and Kalkwarf, D. R., "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," NUREG/CR-3533, prepared for Nuclear Regulatory Commission.