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RECLAMATION PLANS FOR MORTON RANCH OPERATIONS

January 31, 1979

Section 9 Mill Reclamation

9. MILL RECLAMATION

It is the intention of the operator to return the lands disturbed by the Morton Ranch Uranium Mill to their highest level of former use and/or productivity. Specifically, the reclamation plan for lands disturbed by milling has been designed to meet that goal through the execution of a careful facility decommissioning; through tailings stabilization/surveillance/maintenance, and land reclamation by a carefully planned revegetation and conservation management plan. The tailings stabilization plan consists of burial and protection of that material. The mill site reclamation consists of decontamination, removal and reclamation of the mill site.

Reclamation plans for the mill site, land clean-up, and tailings stabilization are discussed separately below. A discussion of criteria considered for developing this reclamation plan is presented.

a. Mill Site Reclamation

The mill site reclamation will consist of decontamination, dismantling, and removing or burying all buildings, machinery, process vessels, or other structures. Criteria for the mill site decontamination were obtained from the Nuclear Regulatory Commission, Annex C, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material", dated November, 1976. In the decommissioning and stabilization efforts, the operator will:

1. Submit a detailed decommissioning plan for approval prior to terminating the milling operation.
2. Demonstrate by measurements, instrumental and analytical, that contamination levels are within applicable state and federal guidelines and regulations prior to dismantling and

removing or burying buildings, vessels, equipment, and other structures. The following criteria apply to the decontamination of the mill facilities equipment:

a. The operator will make a reasonable effort to eliminate residual contamination.

b. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other material unless contamination levels, as determined by a survey and documented, are below the limits specified prior to applying the covering. A reasonable effort will be made to minimize the contamination prior to use of any covering. The attached Table I entitled "Acceptable Surface Contamination Levels", specifies limits of surface contamination.

c. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

TABLE I
ACCEPTABLE SURFACE CONTAMINATION LEVELS[g]

NUCLIDES[a]	AVERAGE[b c f]	MAXIMUM[b d f]	REMOVABLE[b e f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm /100 cm^2	1,000 dpm /100 cm^2
Transuranics, Ra-226, Ra228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	230 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except SR-90 and others noted above.	5,000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1,000 dpm $\beta\gamma$/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintergrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

TABLE I

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[f]The average and maximu radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

[g]Table I, II and III are taken directly from Annex "C" to 10CFR20, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, dated November 1976.

d. Upon request, to the Nuclear Regulatory Commission, the operator may relinquish possession or control of premises, equipment or scrap having surfaces contaminated with materials in excess of the limits specified. This may include but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such requests must:

1) Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent and degree of residual surface contamination.

2) Provide a detailed health and safety analysis which reflects that the residual amounts of material on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap are unlikely to result in an unreasonable risk to the health and safety of the public.

3. Dispose of all fuels and chemicals either by sale to suitable and reputable parties, by neutralization, or by other disposal methods suited to the nature of the materials, and their potential for environmental damage.

4. Dismantle and remove or bury all buildings and structures. All foundations will be either broken up and buried, or buried unbroken or with overburden and topsoil to a combined

minimum depth of five to six feet. The area of the mill will be regraded as necessary to blend properly with surrounding topography, and the disturbed area covered with topsoil and revegetated to rangeland.

5. Maintain the diversion ditches designed to protect that area from surface water erosion until erosion levels are reduced to levels comparable to natural erosion.
6. Maintain in place the fence built prior to operations for the restricted area until monitoring demonstrates that return to the original surface use of the land is acceptable.
7. Maintain a monitoring and maintenance program for the mill site area after completed reclamation, as necessary, until data shows further regular monitoring is no longer necessary. (See separate discussion of land clean-up criteria).
8. Maintain a bond with the State of Wyoming until successful reclamation of the disturbed lands is accomplished in an amount sufficient for the state to complete all above described reclamation in the event of default.
9. Prior to release of on-site premises for unrestricted use, the operator will make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table I. A copy of the survey report will be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction.

The report will be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

United Nuclear Corporation Map No. 2085 entitled "Reclamation - Topography Mill and Tailings Area", as revised January, 1979, illustrates the reclamation of the mill site area. Area conditions prior to operations are shown on UNC Map No. 2026 entitled "Pre-Mining Topography - Mill Tailings Area" as dated January, 1979.

b. Land Cleanup

In addition to tailings area reclamation and mill facilities and equipment decommissionings, the operator will perform a detailed survey and cleanup of the land area surrounding the mill facility, tailings disposal site and mill effluent pond.

The land area can become contaminated primarily from airborne dispersal of ore and tailings during the handling and storage of these materials. The operator will, during the course of mining and milling, control the dispersal of ore and tailings. Specifically, the operator will:

1. Perform an on-going operational monitoring program, which includes both air and soils sampling. The detailed operational monitoring program is included in Section 4 of the Mine Plan.

2. Dispose of tailings below grade in depleted open pits.

3. Implement and maintain good operational practices of dust control in the haulage, storage and treatment of the ore and tailings.

It is expected that with the implementation of these practices the land contamination will be limited to areas in close proximity to the mill buildings, ore pads and tailings areas.

Guidelines for the land cleanup were obtained from the U. S. N. R. C., Fuel Processing and Fabrication Branch, Staff Technical Position entitled "Interim Land Cleanup Criteria for Decommissioning Uranium Mill Sites", dated May, 1978, and from the State of Wyoming, Department of Environmental Quality, Land Quality Division, Guideline No. 6 dated December, 1978.

The land cleanup criteria are presented in terms of limits on radon-222 flux and gamma dose rate since these are the exposure pathways which contribute the highest doses and have the greatest health significance at a contaminated uranium mill site. No criteria are presented for other potential exposure pathways such as inhalation of resuspended particulates or ingestion of contaminated food grown on the site, since these pathways will contribute less significant doses than those pathways for which criteria are presented. Limiting the potential exposures from inhalation of radon-222 daughters and external gamma-rays will also results in limitation of exposures from all other pathways to acceptable levels.

1. Criteria

The decommissioning program at the Morton Ranch mill site will reduce the radon-222 flux and gamma dose-rate above background to below the following criteria:

a. The radon-222 flux (above ground) at the soil-air interface will not exceed a flux equivalent to that which would result from a soil concentration of 3 pCi/g of radium-226 at infinite thickness (see note 3 below).

b. The gamma dose-rate in air one meter above the ground will not exceed five (5) microroentgens per hour (above background).

Notes

(1) These criteria apply if the soil nearest the surface contains the highest concentrations of contamination and that in general the soil contamination concentrations will decrease in depth. If the contamination profile is significantly different from that described above, land cleanup criteria will be developed based on actual conditions.

(2) Soil profile sampling or in-situ gamma ray measurements or bore holes will be made to define the profile and depth of contamination and to determine if any unsuspected subsurface contamination exists.

(3) When the soil contamination profile is known to be similar to that described in note 1 above (i.e., the highest concentration near the surface), then compliance with the gamma dose-rate criteria also indicates compliance with the radon-222 flux target criteria. Therefore, in these cases a simple gamma screening measurement technique can be used to identify contaminated area(>5 μr/hr) requiring cleanup. (As indicated above, if contamination profile indicates buried contamination, then this screening technique would not apply).

Attached are Table II, entitled "Summary of Potential Radiation Doses to Individual from a Decommissioned Mill Site", and Table III, entitled "Comparison of Exposures from Proposed Criteria with Exposure Criteria from Similar Type Situations". These two tables provide a basis for the criteria used.

2. Implementation

In order to properly implement the land cleanup program to achieve the established criteria, the operator will:

1. Adequately establish the background levels of Radon-222 flux and gamma dose-rate of the mill site areas. A detailed Pre-Operational monitoring program has been established which include these measurements and is included in Section 4 of the Mine Plan. In addition, bore holes of mill foundation testing will be analyzed to provide additional background data in the immediate mill area.
2. Submit a detailed land cleanup plan prior to mill decommissioning for approval. This plan will include plans for the site survey, land cleanup criteria as applicable at the time of decommissioning, and proposed methods of cleanup of contaminated areas.
3. Maintain a continued monitoring and maintenance program for areas found contaminated after cleanup, until such time as the data indicates that regular monitoring is no longer necessary.

Although details of cleanup methods will be established under current state and federal regulations at the time of decommissioning, the operator anticipates that contaminated areas will be covered by

TABLE II

SUMMARY OF POTENTIAL RADIATION DOSES TO INDIVIDUALS

FROM A DECOMMISSIONED MILL SITE[g]

Exposure Pathway	Organ[(a)]	Target Criteria millirem/year	Upper Limit Criteria millirem/year
Inhalation of Radon Daughters	Bronchi	750[(b)]	2500
External	Whole-Body	35	140
Inhalation of Particulates	Lung	5	17
Ingestion of Food	Bone	45	180

(a) Organ which would receive the highest dose from the exposure pathway.

(b) Based on projected Working Level inside structure of 0.006 WL.

(g) Table I, II and III are taken directly from Annex "C" to 10CFR20, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, dated November 1976.

TABLE III

COMPARISON OF EXPOSURES FROM PROPOSED CRITERIA
WITH EXPOSURE CRITERIA FOR SIMILAR TYPE SITUATIONS[g]

Exposure Pathway	Target Criteria	Upper Limit Criteria	Other Existing Criteria or Guidance
Inhalation of Radon Daughters	0.006 WL [(a)]	0.02 WL	0.033 WL - 10 CFR-20 0.01-0.05 - Surgeon General's Guidance 0.005-0.02 WL - EPA Florida Phosphate Guidance[(b)] 0.02 - DOE Criteria[(b)]
External (whole-body)	5 ur/hr (35 mrem/year)[(c)]	20 ur/hr (140 mrem/year)[(c)]	500 mrem/year - 10 CFR-20 170 mrem/year - FRC Guidance 400-900 mrem/year - Surgeon General's Guidance 25 mrem/year - 40 CFR-190
Inhalation of Particulates (lung)	4 mrem/year	17 mrem/year	1500 mrem/year - 10 CFR-20 25 mrem/year - 40 CFR-190 10 mrem/year - EPA Transuranic Guidance[(b)]
Food Ingestion (bone)	45 mrem/year	180 mrem/year	3000 mrem/year - 10 CFR-20 25 mrem/year - 40 CFR-190 30 mrem/year - EPA Transuranic Guidance[(b)]

(a) Average working level concentration inside structure predicted to be associated with radon flux target criteria

(b) Proposed criteria

(c) Based on shielding factor of 0.8

(g) Table I, II and III are taken directly from Annex "C" to 10CFR20, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material, dated November 1976.

an appropriate thickness of overburden and compacted clay, contoured, covered with topsoil and revegetated.

Details of the land reclamation for the mill effluent disposal pond are included in the discussion of tailings reclamation below.

c. Tailings Disposal Reclamation

Viable alternatives for tailings management and reclamation have been discussed and reviewed with the Nuclear Regulatory Commission. The operator will utilize a below grade tailings disposal system in the mined out open pits. Site selection for this in-pit disposal system lies southeast of the staff office and mill site area. The solid tailings disposal areas located in Section 11, 14, and 15, T35N, R72W, 6th PM, will eventually encompass approximately 130 acres over the estimated project life. A clay lined tailings effluent pond is located immediately to the southeast of the mill bench area which provides for the effluent evaporation and disposal. UNC Map No. 2016 entitled "Tailings Disposal System and Related Cross Sections Location Map" dated January, 1979, is included in Section 4 of the Mine Plan and provides a layout of the tailings disposal system.

The mined out pits are backfilled and clay lined for long term stability, containment of the tailings, and protection of the ground water quality. During mill operations, the tailings would initially be disposed in the northeast end of the ore trend. Dewatered tailings are emplaced into the pits with effluent pumped to the evaporation pond.

As tailings fill the pit, they would be stabilized and allowed to dry in order for heavy equipment to operate on the surface. Extreme care will be taken to assure dust control of these areas as the drying process occurs. Then, a minimum of 4 feet of overburden and a minimum

of 8 inches of topsoil would be revegetated for stabilization and reclamation. Included in Section 4 of the Mine Plan are cross sections AA through HH on UNC Map Nos. 2017 through 2024 which illustrate the emplacement and reclamation for the in-pit tailings burial system.

The reclamation of the solid tailings will be accomplished throughout the life of the project. As one open pit area is filled, reclamation and stabilization would be immediately initiated on that area. At the close of milling operations, the northeast portion of the ore trend will have already been reclaimed.

The effluent disposal pond will be reclaimed at the end of milling operations. Any slimes that may have accumulated in the pond area will be removed. Additionally, it is planned that 4½ feet would be scraped from the pond bottom including the dam face. This would include all of the clay liner and underlying 1½ feet of soil. The exact depth of removal would be determined by a precise radiological survey at the time in accordance with the Interim Land Cleanup criteria.

All slimes and solids removed from the effluent pond area will be placed in a depleted open pit. The pond material would then be covered in a manner similar to the solid tailings.

After removal of slimes, clay and soil from the effluent pond area, the pond area will be backfilled with overburden, contoured appropriate to the surrounding area, covered with topsoil and revegetated. Alternately, should the rancher desire, the area could be covered with a clay liner including the dam face to form a water holding pond for livestock use. As this choice will not be made until decommissioning, the bond requirements would be based on the higher cost option (backfilled and revegetated).

The radon emanation rates would be measured onsite for both the ore trend tailings, effluent pond and all of the mill site surrounding area. Sufficient measurements would be made to map emanation rates for

the impoundment areas and also determine a reasonably accurate average emanation rate for the surrounding land areas.

The calculations for depths of overburden and clay were based on a 0.20% U_3O_8 ore grade and the radioactivity level of the slimes portion of the tailings, which is more than three times the level of the overall tailings. Thus, the covering depths used are considered conservative and should insure meeting the stated emanation criteria. Additionally, overall ore grade is now estimated at 0.086% U_3O_8. The lower ore grade and lower associated radioactivity provide an additional margin of safety to the calculations of required cover.

Diffusion parameters for compacted clays and unclassified overburden would be experimentally determined and used to calculate necessary thickness to reduce radon emanation from tailings to twice the background rate. Emanation rates would be checked and additional overburden added, if necessary, prior to placing topsoil.

d. Discussion of Tailings Reclamation Criteria

The selection of the proper method of disposal considered the following factors:

Reduction of radon concentrations

Reduction of direct gamma radiation

Prevention of tailings spreading to the environment

Prevention of groundwater contamination

Prevention of surface water contamination

Long-term stability with minimization of monitoring requirements

A brief discussion of the criteria is given below:

Reduction of Radon Concentrations

Radon-222 from the tailings will be the principal source of exposure. Uncovered, semi-dry tailings will result in ambient radon concentrations that are above background levels for distances up to ½ miles from the tailings.

Reduction of these radon concentrations is necessary to allow unrestricted use of the surface of the retention area and to assure that non-occupational radiation doses remain as low as is reasonably achievable even if local population distribution or land occupancy rates significantly increase.

The tailings reclamation plan utilizes a diffusion barrier to reduce the radon concentrations. The diffusion of radon through a barrier is dependent upon the thickness of the barrier, the percent of void spaces (nonsolids) in the barrier material, and the fluid (air, water, oil, etc.) in the barrier voids. The equation gives the formula for determining the emanation rate through a barrier from a plane source of radon:

$$C_{(X)} = C_p\, e^{-\sqrt{\lambda\, v/D_e}\,x}$$

$C_{(X)}$ = radon emanation rate through the barrier

C_p = radon emanation rate from plane source

x = thickness of the barrier

D_e = effective barrier diffusion coefficient for radon through the fluid (air, water, etc.) in the void spaces between the solid particles

λ = decay constant of radon-222 = 0.692/half-life = 2.1×10^{-6} sec

v = barrier void fraction; the fraction of the total volume which is not occupied by solid particles (this is often called the porosity and should not be confused with the porosity of an individual particle)

The calculated attenuation factors $C_{(X)}$ for various thickness and materials are given in the table below. Comparing the calculated attenuation factors with the measured concentration shows that the proposed diffusion barrier will reduce radon concentrations to background levels.

DIFFUSION BARRIER ATTENUATION FACTORS $\frac{C_{(X)}}{C_p} = \exp \sqrt{\lambda \quad V/D_e} \; x$

Depth	Overburden $e^{-0.4x}$	Clay (x) $e^{-0.6x}$
2"	.94	.90
1'	.67	.55
2'	.45	.30
6'	.09	.03
10'	.02	2.5 E-3
20'	3.3 E-4	1.6 E-5

(x) = This value if for varved clay. The clay utilized onsite will be compacted bentonitic clay, which should be a more effective diffusion barrier.

Reduction of Direct Gamma Radiation

Gamma radiation from the tailings is not expected to cause above background radiation levels. The gamma dose rate three feet above uncovered tailings would be 1-2 mR/hr (*). Utilization of the clay and soil radon diffusion barrier should reduce the direct gamma radiations to essentially background.

Prevention of Tailings Spreading to the Environment

The proposed reclamation program will prevent tailings from spreading to the environment. In the event that tailings are inadvertently spilled during mill operations or restoration activities, they will be cleaned up and returned to the impoundment area prior to final reclamation.

(*) Separation and deep burial of slimes would reduce dose rates to 0.2-0.4 mR/hr.

Prevention of Groundwater Contamination

The reclamation plan provides for groundwater protection over the long term. The depleted open pits are backfilled with overburden to a minimum of ten (10) feet above the water table. The bottom is lined with compacted clay interfaced with sidewall clay lenses to form a natural long term seepage barrier. The area is covered with a clay cap and contoured to prevent surface water erosion and leaching of the tailings.

Prevention of Surface Water Contamination

The soil and clay cap will be graded and contoured to prevent erosion and leaching by surface waters. The sites small rainfall and high evaporation rate and diversion ditching will further assure that surface waters will not become contaminated by tailings.

Long-Term Stability with Minimum Monitoring and Maintenance

Long-term stability with minimum monitoring and maintenance is one of the primary criteria for the reclamation of the uranium mill site. Ideally, a satisfactory reclamation option should become self-sustaining within a relatively short time period (approximately five (5) years) and maintenance and monitoring should not be necessary after this time. Man-made membranes and covers provide excellent short-term protection, but by themselves, cannot be expected to provide long-term stability. We, therefore, propose to utilize stable geological and hydrological conditions, below grade disposal with suitable soil (clay) layers, and a naturally contoured, properly drained, and revegetated soil cover to provide the best long-term stability.