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LICENSEE: United Nuclear Corporation Resources Company

FACILITY: Scrap Recovery Facility
Wood River Junction, Rhode Island

SUBJECT: SOIL DECONTAMINATION CRITERIA FOR THE DECOMMISSIONING OF THE UNC'S FACILITY

I Background

By letter dated April 29, 1980, United Nuclear Corporation Resources Company (UNC) informed NRC that it had decided to terminate the scrap recovery operations at its facility at Wood River Junction, Rhode Island. From 1963 until the present time, this facility was used to recover high-enriched uranium from scrap materials. A preliminary decontamination schedule was presented by UNC (see Appendix A). At the present time, the decontamination of the buildings and equipment is in process. NRC provides "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproducts, Source or Special Nuclear Materials " (see Appendix B). In the absence of specific criteria for contaminated land at the UNC site, NRC has established target criteria for land cleanup at the UNC site. A draft of this document had been given to the State, EPA official, licensee and concerned citizens for review and comment. Their comments are shown in Appendix D. Appendix E includes NRC's responses to their comments. After careful consideration of the above comments, the NRC has proposed the following soil clean up criteria for the decommissioning of the UNC site.

II Development of Proposed Soil Decontamination Criteria

A. General Description of the UNC's Operation

The recovery facility handled and processed various types of high-enriched nuclear fuel scrap to reclaim the uranium. The recovery process included various pretreatment steps which served one or more of the following functions: reduction of the bulk of the scrap (by oxidation of carbon or organic materials); removal of fuel element cladding; and change of the physical or chemical form to increase

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the rate of dissolution in the later steps. The uranium and associated materials were then dissolved in nitric and/or hydrofluoric acid, depending upon the type of material. In each case, the uranium was extracted into a kerosene-tributyl phosphate solution and re-extracted into water. Ammonia was added to precipitate solid ammonium diuranate (ADU). The ADU was then filtered, dried, and heated to convert it to U_3O_8 which was packaged for offsite shipment.

The facility processed five general categories of scrap:

1. Uranium-Zirconium Scrap generated from the fabrication of uranium-zirconium alloy fuels having zirconium alloy (Zircaloy) cladding. The scrap consisted of pieces of long, flat plates (or complete plates) containing a U-Zr alloy fuel core. In some cases, the uranium was contained in a ceramic material imbedded in a zirconium matrix. Removal of the ceramic material required dissolution in hydrofluoric acid. This scrap occasionally required a dissolution pretreatment with caustic to remove the metal cladding.

2. Uranium-Aluminum Scrap similar to the U-Zr scrap. Dissolution required a mercury-catalyzed nitric acid reaction.

3. Carbon Scrap generated from the production of fuel elements for high temperature gas cooled reactors. Uranium oxide particles were imbedded in a carbon (graphite) matrix. The graphite was removed by calcination in oxygen. The uranium oxide was then dissolved in nitric acid.

4. Thorium Scrap consisting of unclad pellets or particles containing uranium oxide. Dissolution was in nitric/hydrofluoric acid. The thorium was not recovered but was removed for burial at an approved site.

5. Miscellaneous Scrap consisting generally of "low-level" uranium contaminated materials generated during fuel processing. Typical examples were cleanup liquids, rags, paper towels, plastic gloves, residue from cleanup of processing hoods, purification sidestreams (contaminated organic) and insoluble uranium-bearing material from previous recovery attempts either by UNC or elsewhere. Pretreatment steps included incineration, calcination, grinding, oxidation-reduction. In addition, fuels from low-power experiments were occasionally processed batchwise.

The above operation resulted in the generation of gaseous, liquid and solid wastes consisting of radiological and chemical effluents.

B. Potential Pathways for Land Contamination of the UNC Site and the Characteristics of the Nuclides Involved

The routine release and accidental releases (if any) of gaseous effluents from past plant operations resulted in the deposition of radionuclides on soil surfaces which accumulated as a function of time. The leakage of the onsite lagoons where liquid wastes were stored has caused some groundwater contamination. Spillage of lagoon liquid due to high wind has also resulted in soil contamination around the lagoon area. In addition, the onsite burial of radioactive wastes may have resulted in additional soil contamination.

The important radionuclides involved in the soil contamination at the site consist of:

1. U-238, U-235 and U-234 generated from uranium scrap recovery operations.

2. Th-232, Ra-228 and Th-228 generated from thorium scrap recovery operations.

3. Mixture of fission products generated from processing slightly irradiated fuel from low power experiments. The liquid wastes containing fission products are stored in the onsite lagoons and onsite storage tank. Many of the fission products were short-lived isotopes. Current, independent analysis by NRC (see Appendix C) on radionuclides in the lagoons and storage tank indicated the presence of Sr-90 (tl/2 = 28.6 yr) and Cs-137 (tl/2 = 30.2 yr) in significant quantities that are important for dose assessment. Other fission products, because they are short-lived or in minute quantities, are not considered to be significant in the contribution of individual dose. Significant radionuclides, such as Th-230 and Ra-226 which are also found in the lagoons, are also important for dose assessment. The staff also includes Pu-239 as a potential nuclide in soil contamination although the NRC's independent analysis on lagoon effluents did not detect Pu-239 in significant quantity. (See comment from concerned citizen in Appendix D.)

The characteristics of the above-mentioned radionuclides are summarized in Table 1 (see page 8).

C. Proposed Interim Criteria for Soil Decontamination

As shown in Table 1, the major nuclides expected in soil consist of U-238, U-235, U-234, Th-230, Ra-226, Th-232, Ra-228, Th-228, Pu-239, Sr-90 and Cs-137. They emit alpha, gamma and beta radiation. Most of the soil contamination at the UNC site is believed from the lagoon leakage. The radionuclides are expected to be mostly in soluble form; however, other soil contamination may involve insoluble radionuclides.

In establishing soil decontamination criteria, NRC staff has applied the following rationale and objectives:

a. The radiation exposure to individuals using the land must be within current NRC and EPA radiation exposure guidelines including the requirement that these exposures be as low as reasonably achievable.

b. These criteria must be consistent with criteria currently being applied or developed for similar type situations.

The staff has also taken into consideration the natural background concentration of radionuclides in soil (see discussion in following sections) that must be distinguishable from these levels without requiring unnecessarily large costs associated with sampling and analysis and for demonstrating a compliance as compared to the cleanup cost. After considering all pertinent factors, the staff has derived target criteria, as listed in Table 2, for the immediate cleanup of the contaminated land. Table 2 also lists other existing criteria or guidance for comparison. The target criteria represent the objectives which the land cleanup efforts should strive to obtain and below which no additional cleanup is necessary. Other alternative criteria higher than the target criteria are not acceptable without a detailed cost-benefit consideration.

It is noted that the criteria listed in Table 2 are aimed at surface soil decontamination. The NRC will address the issues arising from groundwater contamination separately pending the completion of the geohydrological study conducted by NRC contractor Dr. D. Warner.

D. Natural Background Consideration

The gross-alpha, beta and uranium concentrations in background soil samples taken near and at the UNC site during 1963 (preoperational) are summarized in Table 3. The results provide some background characteristics of radioactivity in soil in the area; however, more detailed information, such as the background level on external radiation and concentrations of Th-232, Th-228, Ra-228, Pu-239, Cs-137 and Sr-90 in background soil samples, is needed to assign proper values for soil decontamination considerations at the UNC site. Such information is not available. Therefore, UNC will be requested to provide NRC with needed information in order to assign proper credit from background contributions.

Based on the available background information as summarized in Table 3, which was taken from the licensee's Environmental Report in 1974[1], the average gross-alpha, beta and uranium concentrations in soil at the vicinity of the UNC area are 4.0 pCi/g, 8.5 pCi/g and 0.09 pCi/g, respectively.

E. Compliance with the Proposed Interim Target Criteria

1. External Radiation

The direct radiation dose rate can be measured with instruments after the decontamination operation to demonstrate compliance with the external radiation criteria. For surveying and recording purposes, the affected area should be divided into grids about 30' x 30'. In order to meet the target criteria, the following conditions have to be met:

External radiation (gamma dose rate in air one meter above ground level) not to exceed 10 μr/hr (not including background) for a diffuse source area (a contaminated area greater than 30' x 30') and not to exceed 20 μr/hr (not including background) for a discrete area (a contaminated area smaller than 30' x 30').

2. Inhalation of Radon and Its Daughter

For open land cleanup, representative soil samples shall not exceed 3 pCi Ra-226/g of soil above background, which was used as the target criteria in NRC's "Staff Technical Position for Interim Land Cleanup Criteria for Uranium Mill Sites".[2] This limit is estimated to result in an average indoor radon level of 0.006 WL. Table 4 provides the potential exposure levels from radon inside a normal structure built on the contaminated land.

3. Inhalation of Particulates

The individual dose received from inhalation of resuspended particulates from soil is dependent on the solubility of radionuclides in soil and the particle sizes.[3] Tables 5-7 summarize the dose commitment resulting from inhalation of resuspended radionuclides from contaminated soil. Tables 5-7 are based on a unit concentration, 1 pCi/g of each radionuclide in the soil. The solubility of radionuclides is classified as Y, W and D compounds in accordance with the ICRP Task Group report on Lung Dynamics.[3] The resuspended particles are assumed to have an activity median aerodynamic diameter (AMAD) of 1 μm. The dose conversion factors are listed in Tables 8-10. The dry density of soil is assumed to be 2.5 g/cm^3. The resuspension factor is assumed to be 5×10^{-9} m^{-1}, in agreement with the approach taken by EPA in their proposed decontamination criteria for transuranium nuclides in soil.[4]

For compliance with the proposed criteria for the inhalation pathway, the licensee should determine the solubility classification of the identified nuclides in soil. After decontamination, representative surface soil samples shall be collected and analyzed to determine the average concentrations of radionuclides in soil. Isotopic analysis in soil will be required unless the licensee can demonstrate that other analysis, such as direct gamma or gross-alpha, beta measurement can be used to substitute for isotopic analysis. The licensee will be required to submit a detailed plan to describe and demonstrate how to comply with the above criteria. The adequacy of the plan will be reviewed by NRC.

An example shown on page 18 summarizes the calculation to demonstrate compliance with the inhalation criteria.

4. Ingestion of Radionuclides

For the ingestion pathway, the staff conservatively assumes that all the food is grown or produced on the contaminated land. Table 12 summarizes the dose commitment from ingestion of beef, milk and vegetable crops contaminated via resuspension or by root uptake. Figures are based on a unit concentration of 1 pCi/g of each radionuclide in the soil.

For compliance with the proposed criteria for the ingestion pathway, representative soil samples shall be collected and analyzed as described in Section 3.

III Summary

For the decommissioning of the UNC site, the staff has set target criteria for soil for land cleanup of the UNC site. The criteria for soil decontamination as summarized in Table 2 require UNC to remove soil in the affected area such that the external radiation (whole-body) dose shall not exceed 10 μr/hr above background; inhalation of radionuclides in air particulates dose shall not exceed 1 mrad/yr above background (lung or bone dose); average Ra-226 concentration in soil shall not exceed 3 pCi/g; and food ingestion dose shall not exceed 3 mrad/yr (bone dose) above background. These criteria are consistent with those currently being applied or developed for similar type situations.

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The licensee shall be required to submit a detailed decommissioning plan covering the land decontamination action to demonstrate compliance with the proposed target criteria. Upon completion of decontamination, the licensee shall provide the Commission with a close-out survey report to show that the decontaminated area meets the target criteria. Prior to decommissioning the site, a verification survey will be conducted by NRC to verify the findings and to assure that the affected land is cleaned up to acceptable levels prior to the release of the site for unrestricted use.

Edward Y. Shum

Edward Y. Shum
Uranium Process Licensing Section
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety

Table 1

Characteristics of Radioactive Nuclides from UNC's Operation

Nuclides	Half-lives (t1/2)	Principal Radiations	Exposure Pathway for Individual Dose	Critical Organ
U-238	4.49×10^{9} y	Alpha	Inhalation, ingestion	Lung, bone
U-235	7.1×10^{8} y	Alpha	Inhalation, ingestion	Lung, bone
U-234	2.48×10^{5} y	Alpha	Inhalation, ingestion	Lung, bone
Th-230	7.7×10^{4}	Alpha	Inhalation, ingestion	Lung, bone
Ra-226	1,600 y	Alpha, gamma	Inhalation, ingestion, direct radiation	Lung, bone whole body
Th-232	1.41×10^{10} y	Alpha	Inhalation, ingestion	Lung, bone
Ra-228	5.75 y	Beta	Inhalation, ingestion	Lung, bone
Th-228	1.913 y	Alpha, gamma	Inhalation, ingestion, direct radiation	Lung, bone, whole body
Sr-90	26.5 y	Beta	Ingestion	Bone
Cs-137	30.17 y	Beta, gamma	Ingestion, direct radiation	Bone, whole body
Pu-239	2.43×10^{4} y	Alpha	Inhalation, ingestion	Lung, bone

Table 2

Proposed Criteria for Soil Decontamination at the UNC Site

Exposure Pathway	Target Criteria	Other Existing Criteria or Guidance
External Radiation (whole body)	10 μr/hr (35 mrem/yr)[(a)]	20 μr/hr indoor[(b)]-EPA interim cleanup standard for Inactive Uranium Processing Site; 500 mrem/yr-10 CFR 20; 170 mrem/yr-FRC Guidance; 400-900 mrem/yr-Surgeon General's Guidance for indoor exposure; 25 mrem/yr-40 CFR 190.
Inhalation of Particulates (lung, bone)	1 mrad/yr (10 mrem/yr)[(f)]	1500 mrem/yr-10 CFR 20 25 mrem/yr-40 CFR 190 1 mrad/yr-EPA Transuranic Guidance[(c)]
Inhalation of Radon Daughters (bronchi)	<3 pCi Ra-226/g[(g)] (0.006 WL) (750 mrem/yr)[(d)]	0.033 WL-10 CFR 20 0.01-0.05 WL-Surgeon General's Guidance; 0.005-0.02 WL-EPA Florida Phosphate Guidance[(e)] 0.02-DOE Criteria[(e)]
Food Ingestion (bone)	3 mrad/yr (30 mrem/yr)[(f)]	3000 mrem/yr-10 CFR 20 25 mrem/yr-40 CFR 190 3 mrad/yr-EPA Transuranic Guidance[(c)]

(a) This value does not include background, the 35 mrem/yr includes shielding factor of 0.5 for general population and residence time 80 percent.

(b) 40 CFR Part 192 - Federal Register, April 22, 1980.

(c) Proposed criteria.

(d) Based on projected working level inside structure of 0.006 WL.

(e) Proposed criteria.

(f) Based on quality factor of 10.

(g) Open land clean up not to exceed 3 pCi Ra-226/g of soil, background not included. This limit is estimated to result in an average indoor radon level of 0.006 WL.

Table 3

Operational Background Alpha, Beta and Uranium Concentrations in Soil (1963)

Location	Direction From Process Facility	Alpha Concentration (pCi/g)	Beta Concentration (pCi/g)	Uranium Concentration[1] (pCi/g)
Charlestown		3.3 ± 0.3	7.8 ± 0.6	0.10
Tuckertown		2.0 ± 0.3	6.6 ± 0.6	0.11
West Kingston		2.1 ± 0.4	4.5 ± 0.5	0.03
Drake		4.3 ± 0.5	4.6 ± 0.5	0.32
Woodville		4.1 ± 0.4	4.6 ± 0.5	0.04
Carolina		4.6 ± 0.5	17.3 ± 0.9	0.08
Alton		6.4 ± 0.5	9.7 ± 0.7	0.07
Bradford		5.1 ± 0.5	11.0 ± 0.7	0.15
Plant Site #1	S	3.8 ± 0.5	16.5 ± 0.9	0.04
Plant Site #2	SW	3.2 ± 0.4	7.3 ± 0.6	0.07
Plant Site #3	W	2.8 ± 0.4	7.5 ± 0.6	0.03
Plant Site #4	NW	4.0 ± 0.5	9.6 ± 0.7	0.06
Plant Site #5	N	3.4 ± 0.5	7.2 ± 0.6	0.04
Plant Site #6	NNE	5.5 ± 0.6	8.2 ± 0.6	0.05
Plant Site #7	NE	3.7 ± 0.5	5.8 ± 0.6	0.09
Plant Site #8	ENE	5.5 ± 0.6	8.0 ± 0.6	0.13

[1]Uranium concentration includes U-238 and U-234

Table 4

Potential Exposures from Radon Inside Structures on Contaminated Land 2

Soil Conc. pCi/g ^{226}Ra	Rn-222 Flux pCi/m^2-sec	Working Levels (WL) Range[a]	Working Levels (WL) Average[b]	Dose rem/year[c]
1.0	0.33-1.0	0.0002-0.008	0.002	0.25
3.0	1.0-3.0	0.0007-0.024	0.006	0.75
5.0	1.7-5.0	0.0024-0.04	0.012	1.25
10.0	3.3-10	0.0048-0.08	0.020	2.5

Radon Concentrations Inside Structures

The radon-222 concentrations inside structures from diffusion of radon from underlying soil may be estimated by the following calculation:

$$C = \frac{\phi AB}{V\lambda}$$

where:

C = radon-222 concentration (pCi/m^3)

ϕ = radon-222 flux (pCi/m^2-sec)

A = area over which flux enters structure (m^2)

B = flux reduction factor in entering structure

V = volume of structure (m^3)

λ = effective removal rate of radon-222 from the structure

(a) Calculations based on B = 0.1 - 0.5, λ = 1-2 hr^{-1}, A/V = 0.41, and 1 pCi/l Rn-222 = .005 WL.

(b) Average value based on midpoint of the range of input parameters.

(c) Calculated on the basis of 25 WLM/year per WL (continuous exposure) and a dose conversion factor of 5 rem per working level month.

Note: The above calculation is an exercise in estimating the range of working levels (WL) concentration inside a structure from radon-222 entering the structure from the underlying soil. As can be seen from these calculations, many complex factors influence this concentration; and a very wide range is possible for any given radium-226 soil contamination. Therefore, the 3 pCi/gm limit for open land clean up is based on as low as reasonably achievable (ALARA) concept rather than a fixed WL limit.

Table 5

Dose Commitments Resulting from Inhalation of Resuspended Radionuclides from Contaminated Soil. Figures Based on a Unit Concentration of 1 pCi/g of Each Nuclide in the Soil (Clearance Rate Class Y, Particle Size (AMAD) = 1 μm)

Radionuclide	Dose (millirem per year)	
	Lung	Bone
U-238	2.8E-1*	2.6E-3
U-235	3.1E-1	2.8E-3
U-234	3.8E-1	2.9E-3
Th-232	3.8E-1	6.8E-1
Th-230	3.2E-1	6.1E-1
Th-228	9.6E-1	6.5E-2
Ra-228	8.1E-1	5.9E-2
Ra-226	7.3E-1	2.5E-2
Sr-90	4.0E-3	3.7E-3
Cs-137	1.5E-3	3.5E-5
Pu-239	3.4E-1	4.3E-1

*2.8E-1 = 2.8×10^{-1}

Note: It is assumed that the first centimeter of surface soil is subject to resuspension.[4]

Example: U-238 (Y compound)

1 pCi (soil conc) x $\frac{10^{-6}\ \mu Ci}{pCi}$ x $\frac{2.5\ g}{cm^3}$ (soil density x 1 cm (surface soil) x $\frac{10^4\ c}{1\ m^2}$

x 5×10^{-9} 1/m (resuspension factor) x 7300 m^3/yr (breathing rate)

x 80% (percent of occupancy) x 390×10^3 mrem/μCi = 0.28 mrem/yr

Table 6

Dose Commitments Resulting from Inhalation of Resuspended Radionuclides from Contaminated Soil. Figures Based on a Unit Concentration of 1 pCi/g of Each Nuclide in the Soil (Clearance Rate Class W, Particle Size (AMAD) = 1 μm)

Radionuclide	Dose (millirem per year) Lung	Bone
U-238	2.9E-2	6.7E-3
U-235	3.1E-2	7.0E-3
U-234	3.3E-2	7.3E-3
Th-232	2.8E-2	1.8E-0
Th-230	3.2E-2	1.6E-0
Th-228	1.4E-1	4.0E-1
Ra-228	1.5E-2	8.1E-2
Ra-226	3.6E-2	1.8E-2
Sr-90	4.2E-4	4.7E-3
Cs-137	1.6E-4	3.6E-5
Pu-239	3.5E-2	1.1E-0

Table 7

Dose Commitments Resulting from Inhalation of Resuspended Radionuclides from Contaminated Soil. Figures Based on a Unit Concentration of 1 pCi/g of Each Nuclide in the Soil (Clearance Rate Class D, Particle Size (AMAD) = 1 μm)

Radionuclide	Dose (millirem per year) Lung	Bone
U-238	5.1E-4	2.6E-2
U-235	5.1E-4	2.6E-2
U-234	5.1E-4	2.8E-2
Th-232	(a)	(a)
Th-230	(a)	(a)
Th-228	(a)	(a)
Ra-228	4.4E-6	1.5E-1
Ra-226	1.3E-3	3.7E-1
Sr-90	2.9E-6	8.8E-3
Cs-137	8.1E-6	3.5E-5
Pu-239	(a)	(a)

(a) ICRP-30 classifies thorium and plutonium compounds as Y and W type.[6]

Table 8

Dose Conversion Factors[5] from Inhalation of Radionuclides (Clearance Rate Class Y, Particle Size AMAD = 1 μm)

Radionuclides	Dose Conversion Factors (Rem/μCi-Inhaled) Lung	Bone
U-238	3.9E+2	3.6E-0
U-235	4.2E+2	3.8E-0
U-234	4.5E+2	3.9E-0
Th-232	5.2E+2	9.3E+2
Th-230	4.4E+2	8.3E+2
Th-228	1.3E+3	8.9E+1
Ra-228	1.1E+3	8.1E+1
Ra-226	1.0E+3	3.4E+1
Sr-90	5.5E+1	5.1E+1
Cs-137	2.0E-0	4.8E-2
Pu-239	4.8E+2	6.0E+2

The dose conversion factors are derived based on the ICRP Task Group Lung Dynamics[3] and computer code "DACRIN" developed by Battelle Pacific Northwest Laboratories.[5]

Table 9

Dose Conversion Factors from Inhalation of Radionuclides (Clearance Rate W, Particle Size AMAD = 1 μm)

Radionuclides	Dose Conversion Factors (Rem/μCi Inhaled)	
	Lung	Bone
U-238	4.0E+1	9.2E-0
U-235	4.2E+1	9.6E-0
U-234	4.5E+1	1.0E+1
Th-232	3.8E+1	2.5E+3
Th-230	4.4E+1	2.2E+3
Th-228	1.9E+2	5.5E+2
Ra-228	2.0E+1	1.1E+2
Ra-226	5.0E+1	2.5E+1
Sr-90	5.8E-1	6.4E-0
Cs-137	2.2E-1	4.9E-2
Pu-239	4.9E+1	1.6E+3

Table 10

Dose Conversion Factors from Inhalation of Radionuclides
(Clearance Rate D, Particle Size AMAD = 1 μm)

Radionuclides	Dose Conversion Factors (Rem/μCi Inhaled)	
	Lung	Bone
U-238	6.5E-1	3.5E+1
U-235	7.4E-1	3.6E+1
U-234	7.0E-1	3.8E+1
Th-232	(a)	(a)
Th-230	(a)	(a)
Th-228	(a)	(a)
Ra-228	6.0E-3	2.1E+2
Ra-226	1.7E-0	5.1E+2
Sr-90	4.0E-3	1.2E+1
Cs-137	1.1E-2	4.9E-2
Pu-239	(a)	(a)

(a) ICRP-30 classifies thorium and plutonium as Y and W type.[6]

Example

The following is an example for the demonstration of compliance of the inhalation criteria. Assume that after decontamination of soil, the average concentrations of radionuclides in soil (after subtraction from background) and their solubility classification are as follows:

Table 11

Radionuclide	Concentration (pCi/g)		
	D Compound	W Compound	Y Compound
U-238	0.5	0.5	0.5
U-235	---	---	---
U-234	0.5	0.5	0.5
Th-232	---	0.5	0.5
Th-230	---	0.5	0.5
Th-228	---	0.5	0.5
Ra-228	---	0.5	---
Ra-226	---	0.5	---
Sr-90	2.0	---	---
Cs-137	2.0	---	---

Then using values from Tables 5-7, the lung dose would be:

					(mrem/yr)
U-238	0.5(0.00051) +	0.5(0.029) +	0.5(0.28)	=	0.16
U-234	0.5(0.00051) +	0.5(0.033) +	0.5(0.38)	=	0.21
Th-232	---	0.5(0.028) +	0.5(0.38)	=	0.20
Th-230	---	0.5(0.032)	0.5(0.32)	=	0.18
Th-228	---	0.5(0.140)	0.5(0.96)	=	0.55
Ra-228	---	0.5(0.015)	---	=	0.01
Ra-226	---	0.5(0.036)	---	=	0.02
Sr-90	2.0(0.0000029)	---	---	=	----
Cs-137	2.0(0.0000081)	---	---	=	----
Pu-239	---	---	---	=	----
				Total	1.33 mrem/yr

Table 11 cont'd.

The bone dose would be:

					(mrem/yr)
U-238	0.5(0.026)	+ 0.5(0.0067)	+ 0.5(0.0026)	=	0.02
U-234	0.5(0.028)	+ 0.5(0.0073)	+ 0.5(0.0029)	=	0.02
Th-232	---	+ 0.5(1.8)	+ 0.5(0.68)	=	1.3
Th-230	---	+ 0.5(1.6)	+ 0.5(0.61)	=	1.1
Th-228	---	+ 0.5(0.40)	+ 0.5(0.065)	=	---
Ra-228	---	+ 0.5(0.081)	---	=	0.04
Ra-226	---	+ 0.5(0.018)	---	=	0.01
Sr-90	2.0(0.0088)	---	---	=	0.02
Cs-137	2.0(0.000035)	---	---	=	---
Pu-239	---	---	---	=	---
				Total	2.50 mrem/yr

Table 12

Dose Commitment Resulting from Ingestion (Vegetation, Beef, Milk) of Radionuclides from Contaminated Soil. Figures Based on a Unit Concentration of 1 pCi/g of Each Nuclide in the Soil (the First 15 cm of Soil)

Radionuclides	Bone Dose[a] (mrem/yr)
U-238	1.9E-0
U-235	1.9E-0
U-234	2.2E-0
Th-232	2.1E-0
Th-230	2.0E-0
Th-228	4.0E-1
Ra-228	4.5E-0
Ra-226	8.9E-0
Sr-90	6.1E-0
Cs-137	2.3E-1
Pu-239	5.6E-2

(a) The following sections provide detailed ingestion dose calculations.

Dose Calculations for Ingestion Pathway

1. Ingestion dose from vegetable intake -

   Root uptake

   1×10^{-6} μCi/g (conc. in soil) x C_f (see Table 13) x 1.94×10^{5}g/yr. (veg. intake) x dose conversion factor (rem/μCi; see Table 14) x 1×10^{3} millirem/rem = 50 yr. dose commitment (millirem).

   Resuspension

   1×10^{-6} μCi/g x 2.50×10^{4}g of soil/m^2 x $5 \times 10^{-9} m^{-1}$ (resuspension factor) x 10^{-2} m/sec (deposition factor) x 3.15×10^{7} sec/yr x $\frac{\mu Ci/day}{\mu Ci/m^2\text{-}day}$ (Table 15) x dose conversion factor (rem/μCi) x 1×10^{3} (millirem/rem) = dose

2. Ingestion dose from meat intake -

   Root uptake

   1×10^{-6} μCi/g x C_f (pasture grass; Table 13) x 1×10^{4}g/day (grass eaten) x d/kg (F_f; Table 16) x 94kg/year (meat intake) x dCF (rem/μCi) x 1×10^{3} (millirem/rem) = dose

   Resuspension

   1×10^{-6} μCi/g x 2.50×10^{4}g of soil/m^2 x $5 \times 10^{-9} m^{-1}$ (resuspension factor) x 10^{-2}m/sec (deposition factor) x 3.15×10^{7} sec/yr x $\frac{\mu Ci/day}{\mu Ci/m^2\text{-}day}$ x dCF (rem/μCi) x 10^{3} (millirem/rem) = dose

3. Ingestion dose from milk intake -

Root uptake

1×10^{-6} μCi/g x C_f (Table 13) x 1.0×10^4g/day (grass intake) x d/l (F_M; Table 16) x 0.31 l/d of milk x 365 d/yr x dCF (rem/μCi; Table 14) x 10^3 (millirem/rem) = dose

Resuspension

1×10^{-6} μCi/g x 2.50×10^4g of soil/m^2 x $5 \times 10^{-9} m^{-1}$ (resuspension factor) x 10^{-2}m/sec (deposition factor) x 3.15×10^7sec/yr x $\frac{\mu Ci/day}{\mu Ci/m^2\text{-}day}$ x dCF (rem/μCi) x 10^3 (millirem/rem) = dose

Table 13

The plant/soil bioaccumulation factors (B_{iv1})[a]

or concentration factor (C_f) soil to plant

Radionuclide	Concentration factor (C_f) Pasture grass (B_{iv1})	Concentration factor (C_f)[a] Edible Produce (B_{iv2})
Sr-90	1.2 E-0	1.7E-2[b]
Cs-137	1.5E-1	9.3E-3
Ra-226	9.7E-2	3.1E-4[b]
-228	9.7E-2	3.1E-4[b]
Th-228	2.7E-3	3.5E-4
-230	2.7E-3	3.5E-4
-232	2.7E-3	3.5E-4
U-234	8.5E-3	2.9E-4
-235	8.5E-3	2.9E-4
-238	8.5E-3	2.9E-4
Pu-239	2.2E-3	2.5E-4

[a]Ref. - AIRDOS-EPA - EPA 520/1-79-009.[7] Tables 9 and 10.

[b]Ref. - C_f are taken from NRC Regulatory Guide 1.109[8]

The staff used NCRP-45[12] for some of the basis for the selection of appropriate plant-soil transfer parameters.

Table 14

Ingestion Dose Conversion Factors (rem/μCi)[a]

Radionuclide	Bone
Sr-90	1.2E-0
Cs-137	6.8E-2
Ra-226	2.2E+1
Ra-228	1.1E+1
Th-228	3.3E-0
Th-230	1.7E+1
Th-232	1.8E+1
U-234	2.0E+1
U-235	1.8E+1
U-238	1.8E+1
Pu-239	5.7E-1

[a] ORNL/NUREG/TM-190 VL and V2[9]

Table 15. Radionuclide intake rates $\left(\frac{\mu Ci/day}{\mu Ci/day\text{-}m^2}\right)^a$

Radionuclide	Above Surface Food	Milk	Beef
Sr-90	1.20	0.295	0.040
Cs-137	1.20	2.080	0.260
Ra-226	1.20	2.370	2.440
-228	1.20	2.370	2.440
Th-228	1.18	$<10^{-3}$	0.010
-230	1.20	0.001	0.014
-232	1.20	0.002	0.030
U-234	1.20	0.080	0.023
-235	1.20	0.080	0.023
-238	1.20	0.080	0.023
Pu-239	1.20	0.001	0.004

[a] Ref. - ORNL-4992, Table 2-8.[10]

Table 16

Estimates of transfer coefficients[a]

for milk and meat

Radionuclide	Milk (F_M) (day/liter)	Meat (F_f) day/kg
Sr-90	8.0E-3	6.0E-4
Cs-137	1.2E-2	4.0E-3
Ra-226	5.9E-4	5.1E-4
Ra-228	5.9E-4	5.1E-4
Th-228	5.0E-6	2.0E-4
Th-230	5.0E-6	2.0E-4
Th-232	5.0E-6	2.0E-4
U-234	5.0E-4	3.4E-4
U-235	5.0E-4	3.4E-4
U-238	5.0E-4	3.4E-4
Pu-239	2.0E-6	1.4E-5

[a]Ref. - NRC Reg. Guide 1.109 and NRC Task RH 802-4[11]

References

1. Environmental Information on the Rhode Island Uranium Recovery Plant - United Nuclear Corporation, UNC-EI-1, December 1974.

2. Memorandum for Fuel Processing and Fabrication Branch - from Leland C. Rouse, Chief, Fuel Processing and Fabrication Branch, "Branch's Staff Technical Position for Interim Land Cleanup Criteria for Uranium Mill Sites," May 24, 1978.

3. Task Group of Committee 2, ICRP, Task Group on Lung Dynamics for Committee II of the ICRP, Health Physics, Vol. 12, 1966.

4. Persons Exposed to Transuranium Elements in the Environment - Federal Radiation Protection Guidance on Dose Limits - Federal Register, Vol. 42, No. 230, Wednesday, November 30, 1977.

5. J. R. Houston, D. L. Strengh, and E. C. Watson, DACRIN - A Computer Program for Calculating Organ Dose from Acute or Chronic Radionuclides Inhalation, BNWL-B-389, Battelle Pacific Northwest Laboratories, Richland, Washington 1975.

6. International Commission on Radiological Protection Publication 30 - Pergamon Press, July 1978.

7. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man for Airborne Releases of Radionuclides, EPA 520/1-79-009, December 1979.

8. NRC Regulatory Guide 1.109 - Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, March 1976.

9. NUREG/CR-0150, Vol. I and II, Estimates of Internal Dose Equivalent to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, 1979.

10. A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment, ORNL-4992, March 1976.

11. NRC Task RH 802-4 - Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations.

12. NCRP Report No. 45 Natural Background Radiation in the United States, November 15, 1975.

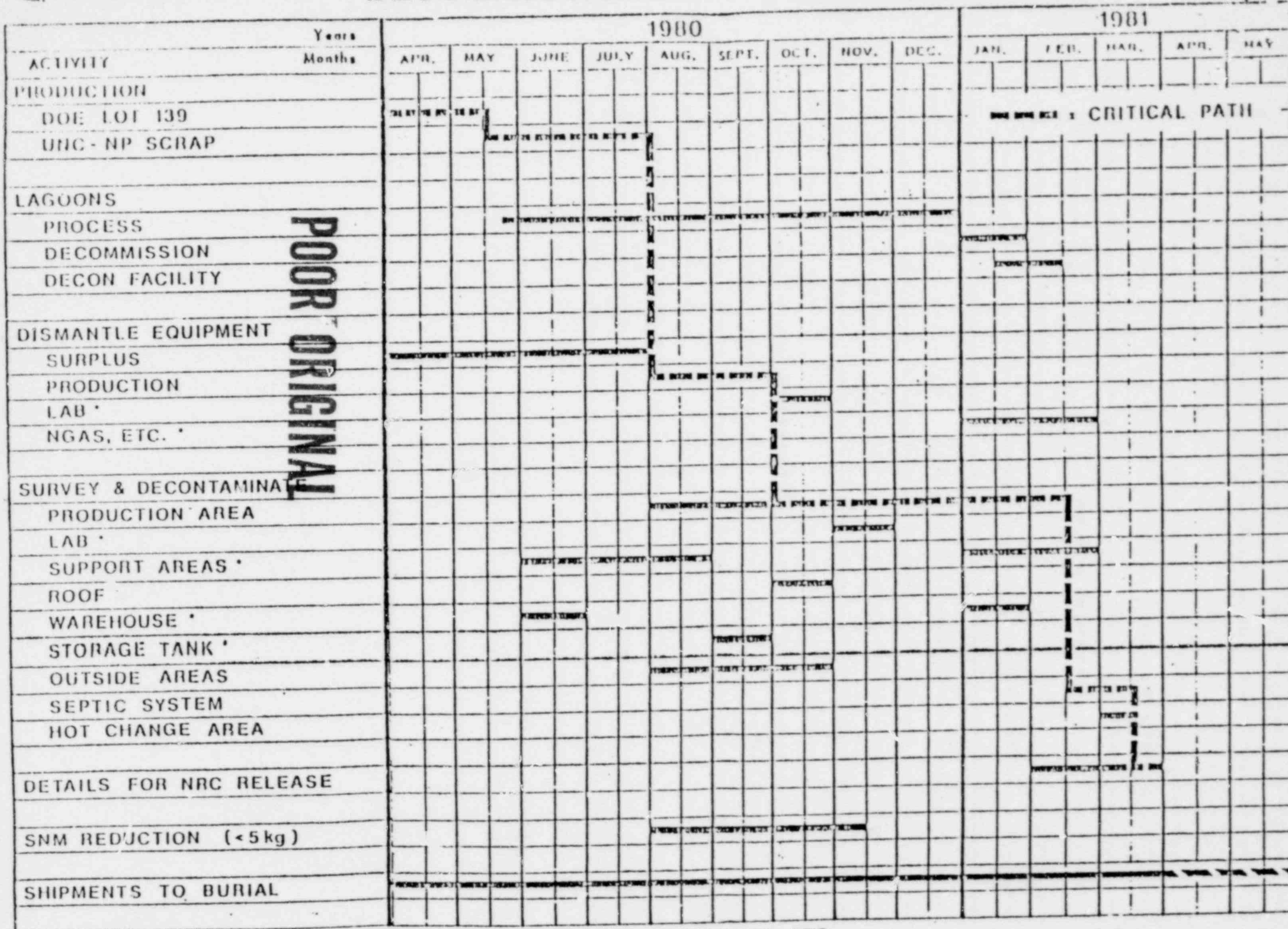
Appendix A

Decc ination-Decommissioning Plan for

UNC's Scrap Recovery Facility and Site

UNC

DECOMMISSIONINC SCHEDULE



* TIMING NOT CRITICAL — MAY BE ADJUSTED TO FIT MANPOWER AVAILABILITY, ETC.

III. DECONTAMINATION PROGRAM

A. IN GENERAL, ALL EQUIPMENT IN THE PROCESS AREA IS EXPECTED TO BE DISMANTLED, PACKAGED, AND SHIPPED TO A LICENSED SITE FOR BURIAL. SOME ITEMS MAY BE TRANSFERRED TO OTHER LICENSEES, OR DECONTAMINATED AND RELEASED TO UNRESTRICTED USE.

B. EQUIPMENT IN INTERMEDIATE AREAS WILL BE CLEANED AND RELEASED.

C. INTERIOR SURFACES IN CONTAMINATION CONTROL AREAS WILL BE MAPPED, CLEANED, AND SURVEYED. PAINTED SURFACES WILL HAVE THE PAINT REMOVED, OR WILL BE SAMPLED AND ANALYZED FOR CONTAMINATION.

D. HIGHLY CONTAMINATED AREAS MAY BE PHYSICALLY REMOVED AND SHIPPED TO BURIAL, IN LIEU OF DECONTAMINATION.

E. OUTSIDE AREAS WILL BE SURVEYED AND CLEANED AS NECESSARY. SPECIFIC AREAS MAY REQUIRE REMOVAL (E.G. PLANT SEPTIC SYSTEM; PORTIONS OF THE PLANT ROOF, ETC.) AND SHIPMENT TO BURIAL.

F. A COMPREHENSIVE SURVEY WILL BE MADE, TO VERIFY THAT CONTAMINATION MEETS THE FOLLOWING LIMITS:

AVERAGE ($1M^2$ MAX)	5,000 dpm $\alpha/100\ cm^2$
MAXIMUM	15,000 dpm $\alpha/100\ cm^2$
REMOVABLE	1,000 dpm $\alpha/100\ cm^2$

A COPY OF THE SURVEY REPORT WILL BE SENT TO THE NRC LICENSING AND REGION I OFFICES.

UNC RECOVERY SYSTEMS
DECOMMISSIONING PROGRAM

I. BASIC SEQUENCE OF EVENTS

A. COMPLETE URANIUM RECOVERY ACTIVITY

1. APPROXIMATELY 100 KG UNC-NP MATERIAL
2. FINAL RESIDUES, CLEANOUT MATERIAL

B. REMOVE EQUIPMENT FROM PROCESS AREA

1. SURPLUS, CONCURRENT WITH FINAL RECOVERY
2. ALL REMAINING EQUIPMENT (MAY RETAIN SPECIFIC ITEMS TO ASSIST IN DECON ACTIVITIES)

C. SURVEY AND DECONTAMINATE

1. SIMULTANEOUSLY WITH EQUIPMENT REMOVAL, START MAPPING, SURVEYING, AND DECON WORK
2. PRIMARY EFFORT IN THE PROCESS AREA, WITH PARALLEL EFFORTS IN AUXILIARY AREAS (E.G. ROOF, YARD, WAREHOUSE, LAB, ETC.)

D. NRC REVIEW DECONTAMINATION RECORDS, PERFORM INDEPENDENT SURVEYS, AND RELEASE THE FACILITY.

II. SNM INVENTORY REDUCTION

A. REDUCE TO < 5 KG U-235 (>20% ENRICHMENT)

BASIS: ACCOUNTABILITY BOOKS SHOW NO MORE THAN 5 KG ON INVENTORY, AND ALL PROCESS EQUIPMENT HAS BEEN CLEANED OUT (MATERIAL CLEANED OUT WILL BE MEASURED AND INCLUDED IN THE ACCOUNTABILITY BOOKS). LAGOON MATERIALS WILL NOT BE INCLUDED IN THE 5 KG.

B. REDUCE TO < 1 KG U-235

BASIS: ACCOUNTABILITY BOOKS SHOW NO MORE THAN 1 KG ON INVENTORY, AND ALL URANIUM RECOVERY EQUIPMENT HAS BEEN CLEANED AND PACKAGED FOR DISPOSAL (MATERIAL CLEANED OUT WILL BE MEASURED AND INCLUDED IN THE ACCOUNTABILITY BOOKS), AND FACILITY INSPECTED FOR SNM (GROSS ACCUMULATIONS TO BE CLEANED UP, MEASURED, AND PLACED ON INVENTORY)

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

U. S. Nuclear Regulatory Commission
Division of Fuel Cycle and
Material Safety
Washington, D.C. 20555

NOVEMBER 1976

The instructions in this guide in conjunction with Table I specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table I do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table I prior to applying the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. 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.

4. Upon request, the Commission may authorize a licensee to 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:

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

   b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials 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.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table I. A copy of the survey report shall 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 should 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.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

Appendix C

Radiological Concentrations in Water Samples
Collected and Analyzed by NRC in UNC's Lagoons,
Storage Tank and Monitoring Wells.
(Samples Collected in July, August 1980)

UNITED NUCLEAR

μCi/cc

Analysis	Lagoon C	Lagoon D	Lagoon G	UNC Tank	Well W-B	Well W-3
Gross α*	(1.2±0.1)E-6	(1.4±0.1)E-6	(3.5±0.2)E-6	(4.3±0.5)E-7	(3.5±0.1)E-7	(3.2±0.1)E-7
Gross β	(1.9±0.1)E-5	(1.7±0.1)E-5	(1.5±0.1)E-5	(2.1+0.1)E-5	(4.9±0.4)E-8	(1.2±0.2)E-7
Th-232	(4.1±1.2)E-9	(1.9±0.1)E-7	(4.1±0.2)E-7	(7.0±7.0)E-10	(0.0±4.0)E-11	(0.0±2.0)E-11
Th-230	(1.7±0.3)E-8	(6.9±0.1)E-6	(2.8±0.1)E-5	(-2 ± 2)E-9	(1.2±0.7)E-11	(-10±3.0)E-11
Th-228	(1.8±0.2)E-8	(9.5±0.6)E-6	(1.8±0.2)E-7	(2.6±0.2)E-8	(1.2±0.6)E-10	(2.4±0.4)E-10
U-234	(2.6±0.1)E-7	(2.7±0.1)E-7	(8.6±0.1)E-7	(1.5±0.1)E-7	(2.1±0.1)E-7	(3.0±0.1)E-7
U-235	(8.6±0.3)E-9	(9.2±0.3)E-9	(3.2±0.1)E-8	(6.3±0.0)E-9	(7.1±0.3)E-9	(1.2±0.0)E-8
U-236	(4.0±2.0)E-10	(7.0±2.0)E-10	(7.0±3.0)E-10	(2.0±1.0)E-10	(2.1±0.2)E-9	(1.1±0.2)E-9
Ra-226	(-3±2.0)E-9	(9.0±3.0)E-9	(1.0±0.4)E-9	(1.0±3.0)E-9	(1.8±0.5)E-9	(1.0±0.3)E-9
Sr-90	(2.2±0.2)E-6	(2.2±0.2)E-6	(2.2±0.2)E-6	(1.4±0.2)E-6	(1.0±5.0)E-9	(1.0±5.0)E-9
Cs-137	(2.6±0.1)E-6	(2.3±0.1)E-6	(2.0±0.1)E-6	(1.5±0.1)E-6		
Ac-228	(4.6±0.0)E-7	(3.3±0.0)E-7		(3.2±0.0)E-7		
Th-208	(9.3±2.0)E-8	(4.0±2.0)E-8	(7.0±2.0)E-8	(7.0±2.0)E-8		
K-40	(1.1±0.1)E-6	(1.0±0.1)E-6		(6.0±1.0)E-7		
Pb-212		(7.0±2.0)E-8				

* ±25% systematic error due to solids.

UNITED NUCLEAR

μCi/cc

Analysis	T-1	T-6	W-12	W-11	Lagoon A/B	PW-1
Gross α*	(3±2)E-10	(2.0±0.2)E-8	(3.5±0.2)E-8	(2.4±0.4)E-9	(2.6±0.2)E-7	(6±2)E-10
Gross β	(3±3)E-9	(4.9±2.0)E-7	(9.0±4.0)E-7	(1.6±0.1)E-7	(8.7±0.4)E-6	(-5±3)E-9
Cs-137		(2.0±0.8)E-8	(4.0±3.0)E-9	(5.0±6.0)E-9	(1.2±0.0)E-6	
Ac-228	(-6±3)E-8				(7.0±3.0)E-8	(2±3)E-8
Th-208			(6.0±2.0)E-8	(5.0±2.0)E-8		
K-40	(2±1)E-7	(1.2±0.8)E-7	(1.1±0.9)E-7		(3.0±1.0)E-7	(2.2±1.0)E-7
Pb-212		(3.0±1.0)E-8				(2.0±2.0)E-8
Pb-214		(2.0±2.0)E-8				
Bi-214			(3.0±1.0)E-8			
Pa=234m			(1.6±0.6)E-6			
Mn-54					(2.1±0.7)E-8	

* ±25% systematic error due to solids.

UNITED NUCLEAR

$\mu Ci/cc$

Analysis	PW-2	W-D	W-8A	T-2	T-3	76-U
Gross α*	(9.0±3.0)E-10	(1.2±0.2)E-9	(1.1±0.1)E-7	(3.7±0.4)E-9	(3.0±0.2)E-8	(5.8±0.6)E-9
Gross β	(3.4±2.0)E-9	(-1±3)E-9	(2.4±0.1)E-7	(2.3±0.4)E-8	(1.1±0.1)E-6	(1.1±0.1)E-7
Cs-137	(1.6±0.8)E-8		(-9±6)E-9	(1.0±1.3)E-8	(1.1±0.8)E-8	(4.2±6.5)E-9
Ac-228	(2.4±2.0)E-8	(-2±3)E-8		(8.30±1.7)E-8	(4.40±1.4)E-8	
Th-208				(4.5±1.6)E-8	(2.0±1.9)E-8	(4.4±1.7)E-8
K-40	(9.0±8.0)E-8			(2.4±1.0)E-8		(1.6±1.0)E-7
Pb-212	(5.0±1.0)E-8		(2.4±1.2)E-8		(1.49±1.1)E-8	(6.1±1.2)E-8
Pb-214	(2.0±2.0)E-8					
Bi-214		(5±1)E-8				

* ±25% systematic error due to solids.

UNITED NUCLEAR

μCi/cc

Analysis	77-B	77-D
Gross α*	(1.8±0.2)E-8	(1.1±0.1)E-8
Gross β	(4.2±0.2)E-7	(4.0±0.2)E-7
Cs-137	(8.8±1.3)E-8	
Ac-228		(1.5±2.2)E-9

* ±25% systematic error due to solids.

APPENDIX D

COMMENTS ON NRC'S DRAFT SOIL DECONTAMINATION CRITERIA
FOR UNC RECOVERY SYSTEMS

APPENDIX E

NRC'S RESPONSES TO COMMENTS ON DRAFT SOIL DECONTAMINATION CRITERIA FOR UNC RECOVERY SYSTEMS

Comments from the Rhode Island Radiation Advisory Commission

Comment

The present and future effects on ground water from radioactive materials that might remain in the soil do not appear to be addressed in the document. It is possible that the Nuclear Regulatory Commission intends to address these items separately in another document. The Commission feels, however, that it should point out this exception and its feeling that the issue should be addressed.

Response

The criteria listed in Table 2 of this document are aimed at surface soil contamination. The NRC will address the issues arising from ground water contamination separately pending the completion of NRC contractor Dr. D. Warner's final evaluation and recommendation.

Comment

The appropriateness of the data upon which the Nuclear Regulatory Commission based its calculation of the criteria for the inhalation of radon daughters in Table 2; specifically, why an effective removal rate of 1 to 2 hours (see Table 4) was used in these calculations.

Response

Please refer to the NRC's responses to Dr. C. G. Orton's letter.

Comments from the Citizens Advisory Committee

Comment

Table 1 and most subsequent tables: This is a listing of the Characteristics of Radioactive Nuclides from UNC's Operation. The inclusion in this table of SR-90 and CS-137 indicates the recognition of nuclides from irradiated fuel. Always included with irradiated fuel is Pu-239. This nuclide should be included in all tables, where appropriate.

Response

As suggested, Pu-239 is included in all tables for various significant pathways consideration altnough NRC's independent analysis on lagoon and storage tank liquid effluents did not detect plutonium at concentrations significant to the proposed soil decontamination limits.

Comment

Table 2. This gives proposed criteria for soil decontamination at the UNC site. The first item is External Radiation (whole body), with a target criterion of 35 mrem/yr. My understanding is that, as of December 1979, the EPA standard lowered the allowable level from 170 mrem/yr to 25 mrem/yr. I think that the target criterion should be decreased to conform to this new standard.

Response

The Federal Radiation Council (FRC) recommended the use of 170 mrem for yearly whole body exposure of average population groups. The FRC has since been dissolved and it's responsibilities have been transfered to the EPA. The EPA has not changed this dose recommended by the FRC as you indicated in your comment. Accordingly, the 170 mrem continues to be the acceptable average dose for the general public.

The 25 mrem dose, to which you refer, is a dose limit to the whole body and any organ except the thyroid (75 mrem) which was established by EPA for light water reactors generating electric power and the associated fuel cycle activities. This dose was established using the "As Low As Reasonably Achievable (ALARA)" concept and was not justified on the basis of health and safety.

Neither of the above limits are appropriate to use as a criterion for soil decontamination such as that at the UNC site. As noted in Table 2 EPA set a limit of 20 μr/hour including background, for a similar decontamination effort. The limit of 10 μr/hour above background specified in Table 2 is consistent with the EPA number.

Comment

Table 2. Inhalation of Particulates (lung, bone). This is fundamental matter which might be out of order here, but an equivalent 10 mrem/yr (and this must be recognized as a smeared-out whole body equivalent) actually corresponds to about 8 rem/yr if one considers that alpha-particle ingestion (from Pu-239) concentrates in the lungs. This, by the way, is 1/10th a generally accepted acknowledgement of a lethal dose (amounting to about 10 micrograms of Pu). The question of "point source" versus "whole body radiation" has been the subject of controversy for some time.

Response

The 10 mrem/yr bone or lung limits for inhalation pathway represents the critical organ limits for inhalation of alpha particles. Based on ICRP 26, the 10 mrem/yr has a whole-body equivalent of 1.2 mrem/yr. In fact, the inhalation and ingestion limits are based on EPA's current proposed guidance on dose limits for persons exposed to transuranium elements in the general environment and Pu-239 is included as transuranium element. The 30 mrem bone dose limit for ingestion is equivalent to:

$$30\times10^{-3}\ \text{Rem}\times\frac{\mu\text{Ci ingested}}{0.57\ \text{Rem}}\ \text{(Table 14)}\times\frac{\mu g}{6.13\times10^{-2}\ \mu\text{Ci}}\text{(specific activity)}$$

= 0.858 μg Pu-239 ingested. According to EPA, the annual risk of bone cancer to each person from lifetime exposure at this level is about 2.4×10^{-6} per year.

Comments from EPA Environmental Research Laboratory, Narragansett, Rhode Island

Comment

Pg. 3 C Proposed interim criteria for Soil decon. Generally good with acceptable criteria for decontaminating.
Question? Who determines what is as low as reasonably achievable?

Response

While EPA is responsible for setting environmental radiation standards, the NRC is responsible for enforcing the standards. Therefore, it is the NRC in their enforcement action who will determine what is as low as reasonably achievable.

Comments from Dr. C. G. Orton, RI State Radiation Commission

Comments

See letter from Dr. C. G. Orton in Appendix C.

Response

See following NRC letter to Dr. C. G. Orton.

Comments from United Nuclear Corporation (the Licensee)

Comment

Section II.D - Natural Background Consideration

UNC is currently in the process of measuring the concentration of the various radionuclides in soil samples taken from surrounding background locations. The results of these evaluations will be transmitted to the NRC when they are available. We assume that the decontamination levels are subject to reassessment by the NRC based on the background measurement results.

Response

The proposed limits for soil decontamination do not include background levels. The credit of appropriate background values will be given when the background measurement results are available.

Comment

Section II.E.2 - Inhalation of Radon and Its Daughter

It is not clear why the NRC has chosen a flux level equivalent to that which would result from a soil concentration of 3 pCi/g of radium-226, when 5 pCi/g is the level receiving uniform utilization under other government programs (e.g., EPA Proposed Standards for Inactive Uranium Processing Sites; DOE FUSRAP Program, NRC criteria for Docket 40-8035, Latty Avenue Site, Hazelwood, Missouri). We would appreciate your reassessment of this proposed limit and modification to a more reasonable level.

Response

The EPA proposed standard of 5 pCi Ra-226/g includes background while the 3 pCi Ra-226/g limit does not include background. When the background level is included, it should not make much of a difference.

Comment

Sections II.3.3 & 4 - Inhalation of Particulates and Ingestion of Radionuclides

Based on the Note to Table 5 and the heading to Table 12, we assume that:

1. verification of acceptability to limits involving inhalation of resuspended soil only requires measurement of the top centimeter of the soil, and

2. verification of acceptability to limits involving ingestion (vegetation, beef, milk) only requires measurement of the top 15 centimeters of the soil.

Response

The above assumptions are correct.