UNC

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NUCLEAR REGULATORY COMMISSION
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DOCKET NO.: 70-820

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 the following proposed target criteria for land cleanup at 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 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 prepared 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 soil and 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.

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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 ($t_{1/2}$ = 28.6 yr) and Cs-137 ($t_{1/2}$ = 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 characteristics of the above-mentioned radionuclides are summarized in Table 1 (see page 11).

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, 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..

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, 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 contribution.

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'.

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2. Inhalation of Radon and Its Daughter

To demonstrate compliance for the inhalation of radon and its daughters at a limit of 0.006 WL, which was used as target criteria in NRC's "Staff Technical Position for Interim Land Cleanup Criteria for Uranium Mill Sites"[2], the radon-222 flux (above background) at the soil-air interface should not exceed a flux equivalent to that which would result from a soil concentration of 3 pCi/g of radium-226 (excluding background). Table 4 provides the potential exposure levels from radon inside a 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 to 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 dry density of soil is assumed to be 2.5 g/cm^3. The resuspension factor is assumed to be 5 x 10^{-9} m^{-1}, in agreement with the approach taken by EPA in their proposed decontamination criteria for trans-uranium 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 17 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.

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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 not exceed 1 mrad/yr above background (lung or bone dose); inhalation of radon and daughters dose not exceed 0.005 WL (working level) bronchi dose above background; and food ingestion dose not exceed 3 mrad/yr (bone dose) above background. These criteria are consistent with those currently being applied or developed for similar type situations.

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.

Table 1

Characteristics of Radioactive Nuclides from UNC's Operation

Nuclides	Half-lives ($t_{\frac{1}{2}}$)	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 y	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	28.5 y	Beta	Ingestion	Bone
Cs-137	30.17 y	Beta, gamma	Ingestion, direct radiation	Bone, whole body

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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; 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)	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(c) 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%.

(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

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

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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	0.0002-0.000	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:

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

where:

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

ϵ = 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.

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

*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 $\frac{10^4\ cm^2}{1\ m^2}$

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

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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

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 m)

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

(a) ICRP-30 classifies thorium 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	390	3.6
U-235	420	3.8
U-234	450	3.9
Th-232	517	930
Th-230	440	830
Th-228	1310	89
Ra-228	1100	81
Ra-226	1000	33.9
Sr-90	55	5.1
Cs-137	2.0	0.048

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]

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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	40	9.2
U-235	42	9.6
U-234	45	10
Th-232	38	2,500
Th-230	44	2,200
Th-228	191	550
Ra-228	20	110
Ra-226	49.6	24.8
Sr-90	0.58	6.4
Cs-137	0.22	0.049

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	0.7	35
U-235	0.7	36
U-234	0.7	33
Th-232	(a)	(a)
Th-230	(a)	(a)
Th-228	(a)	(a)
Ra-228	0.006	210
Ra-226	1.7	510
Sr-90	0.004	12
Cs-137	0.011	0.049

(a) ICRP-30 classifies thorium compounds 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) =	0.15
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) --- =	
Sr-90	2.0(0.0000029) --- --- =	
Cs-137	2.0(0.0000081) --- --- =	

Total [illegible] 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	--	+ 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)	---	---	=	---
				Total	2.50 mrem/yr

Table 12

Dose Commitment Resulting from Ingestion (Vegetation, Beef, Milk) of Radionuclide 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	1.9
U-235	1.9
U-234	2.2
Th-232	2.1
Th-230	2.0
Th-228	0.4
Ra-228	4.5
Ra-226	8.9
Sr-90	8.8
Cs-137	0.23

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

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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 x 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 x 10^4g of soil/m^2 x 5 x $10^{-9}m^{-1}$ (resuspension factor) x 10^{-2}m/sec (deposition factor) x 3.15 x 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	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

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[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.

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Table 14

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

Radionuclide	Bone
Sr-90	1.2
Cs-137	6.82E-2
Ra-226	22
-228	11
Th-228	3 3
-230	1
-232	1
U-234	2
-235	1
-238	1

[a] ORNL/NUREG/TM-190 V1 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	0.04
Cs-137	1.20	2.08	0.26
Ra-226	1.20	2.37	2.44
-228	1.20	2.37	2.44
Th-228	1.18	$<10^{-3}$	0.01
-230	1.20	0.001	0.014
-232	1.20	0.002	0.03
U-234	1.20	0.08	0.023
-235	1.20	0.08	0.023
-238	1.20	0.08	0.023

[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

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

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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.

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Appendix A

Decontamination-Decommissioning Plan for UNC's Scrap Recovery Facility and Site

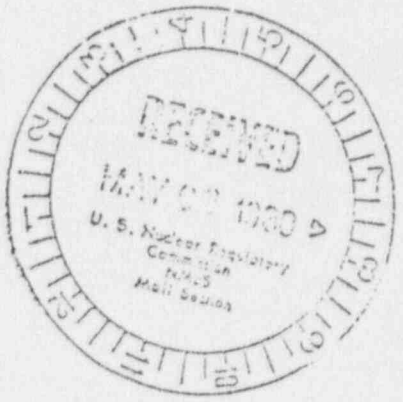
UNC RECOVERY SYSTEMS

70-820
07000820 DOCK
07000820 DCRS

CEB 80-88

Division of United Nuclear Corporation
A UNC RESOURCES Company
One Narragansett Trail
Wood River Junction, Rhode Island 02894
Telephone 401 364-7701

April 29, 1980



U. S. Nuclear Regulatory Commission
Mr. W. T. Crow, Section Leader
Uranium Fuel Fabrication Section
Fuel Processing and Fabrication Branch
Division of Fuel Cycle and Material Safety
Washington, DC 20555

Dear Mr. Crow:

UNC Resources has decided to terminate recovery of highly enriched uranium. Present planning calls for reprocessing of the small quantity of scrap on hand by about July 1, 1980, followed by a concentrated program of site decontamination.

Total SNM inventory, with the exception of process lagoon residues, should be below five kilograms by early fall, 1980. Lagoon processing and decontamination are scheduled for completion by April 1, 1981.

Under these circumstances, it is our understanding that license renewal and revision for the upgrade rule are not required. Accordingly, we are formalizing decontamination-decommissioning plans for discussion with you. In addition, we have been in contact with other former licenseholders with decommissioned facilities in an effort to develop an effective and coherent program.

Overall decommissioning planning, including nuclear safety and health physics aspects, is presently the responsibility of Mr. Robert Gregg; security aspects are under Richard Gigliotti. Either of these gentlemen or I will be happy to meet with you and your staff at your early convenience, to discuss NRC requirements and UNC planning.

Very truly yours,
UNC RECOVERY SYSTEMS

C. E. Bowers
Presedent

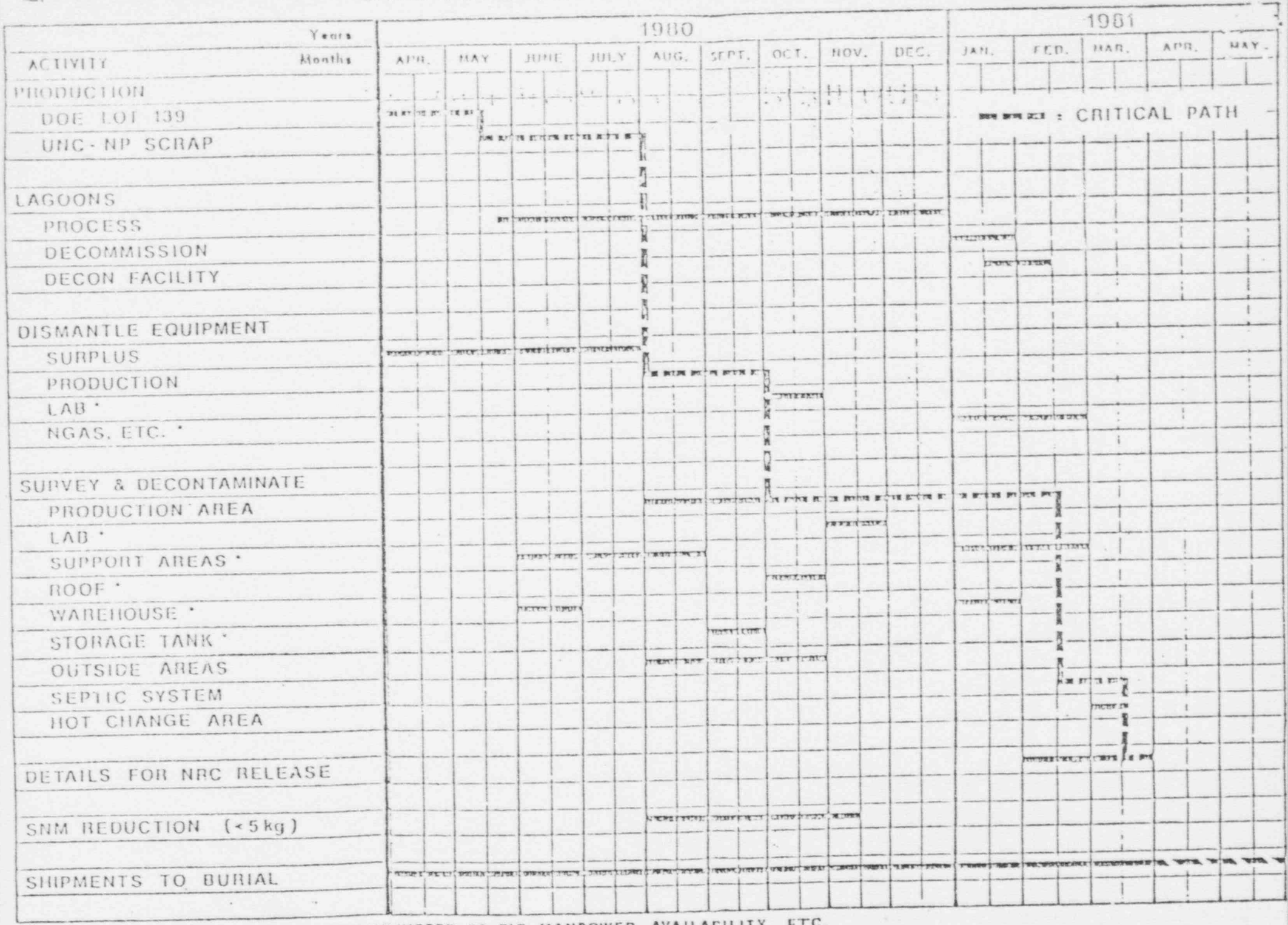
CEB:amc

FILE EXEMPT
info only

25343

(UNC)

DECOMMISSIONING 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 α/100 cm^2
MAXIMUM	15,000 dpm α/100 cm^2
REMOVABLE	1,000 dpm α/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)

Appendix B

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 1 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 1 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.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

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 α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, 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	200 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 (disintegrations 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. .

[f] The average and maximum 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.

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

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

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		(3.6±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

Wilfre

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

Mesa

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	(3.8±1.3)E-8	
Ac-228		(1.5±2.2)E-9

* ±25% systematic error due to solids.