Decommissioning Plan

Fansteel Inc.
Muskogee, Oklahoma Site

Volume 2 of 2

Fansteel Inc.
North Chicago, Illinois

Project No. 6473F
January 15, 2003

Earth Sciences Consultants, Inc.

Providing Environmental Consulting Services Since 1979

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DRAWING NO. 6473407, FIGURE 4-4, WHITE HOUSE, MACHINE SHOP, THERMITE BLDG., GROUNDWATER TREATMENT BLDG. LAYOUT DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473407, FIGURE 4-4

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DRAWING NO. 6473408, FIGURE 4-5 WEIR BUILDING LAYOUT DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

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DRAWING NO. 6473410, FIGURE 4-6
R & D LAB LAYOUT
DECOMMISSIONING PLAN
FANSTEEL, INC.
MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473410, FIGURE 4-6

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DRAWING NO. 6473409, FIGURE 4-7 LITTLE BERTHA, SODIUM REDUCTION BLDG., ORE STORAGE PAD DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473409, FIGURE 4-7

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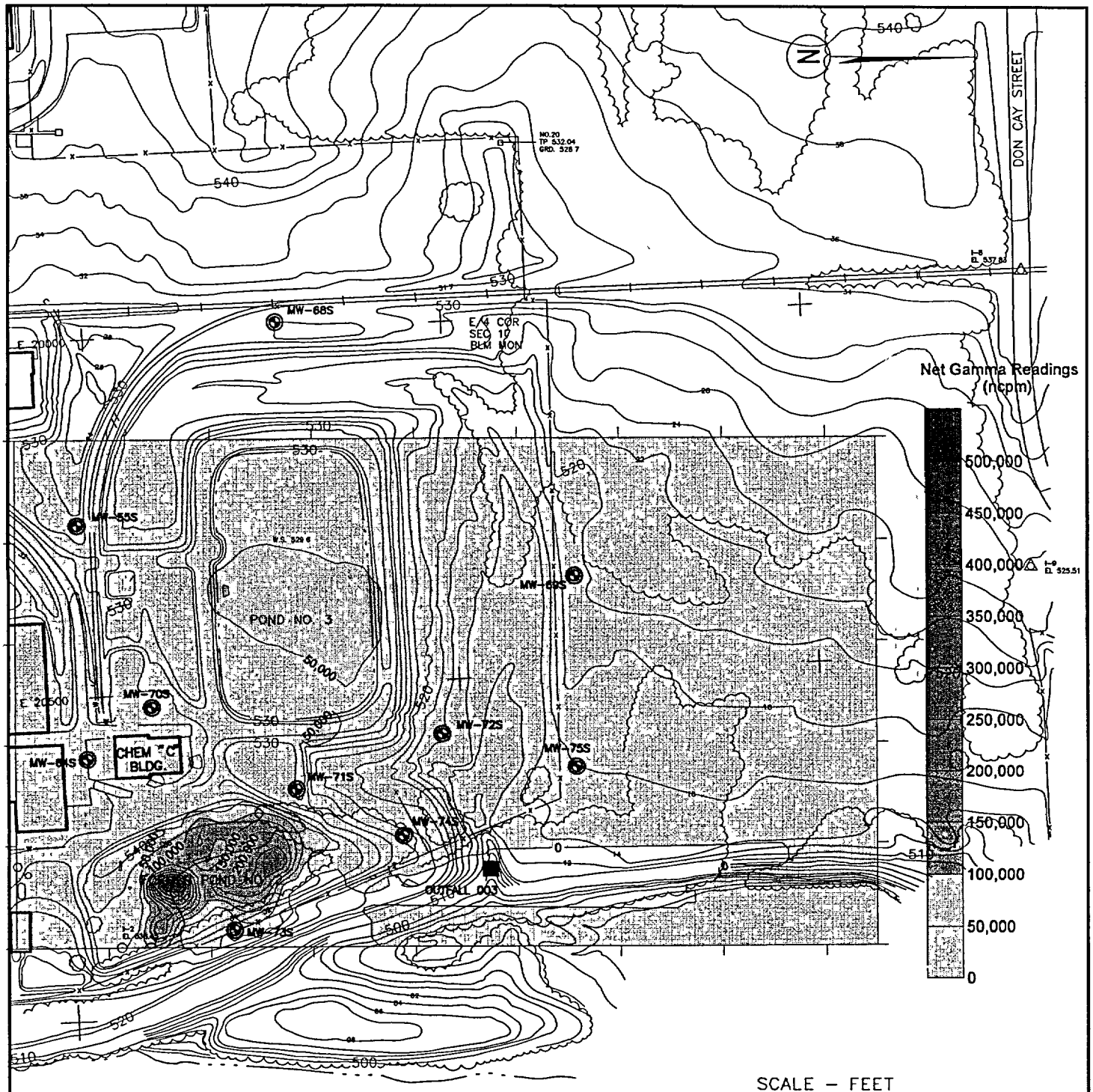

FIGURE 4–8
SURFACE GAMMA SURVEY
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

PREPARED FOR
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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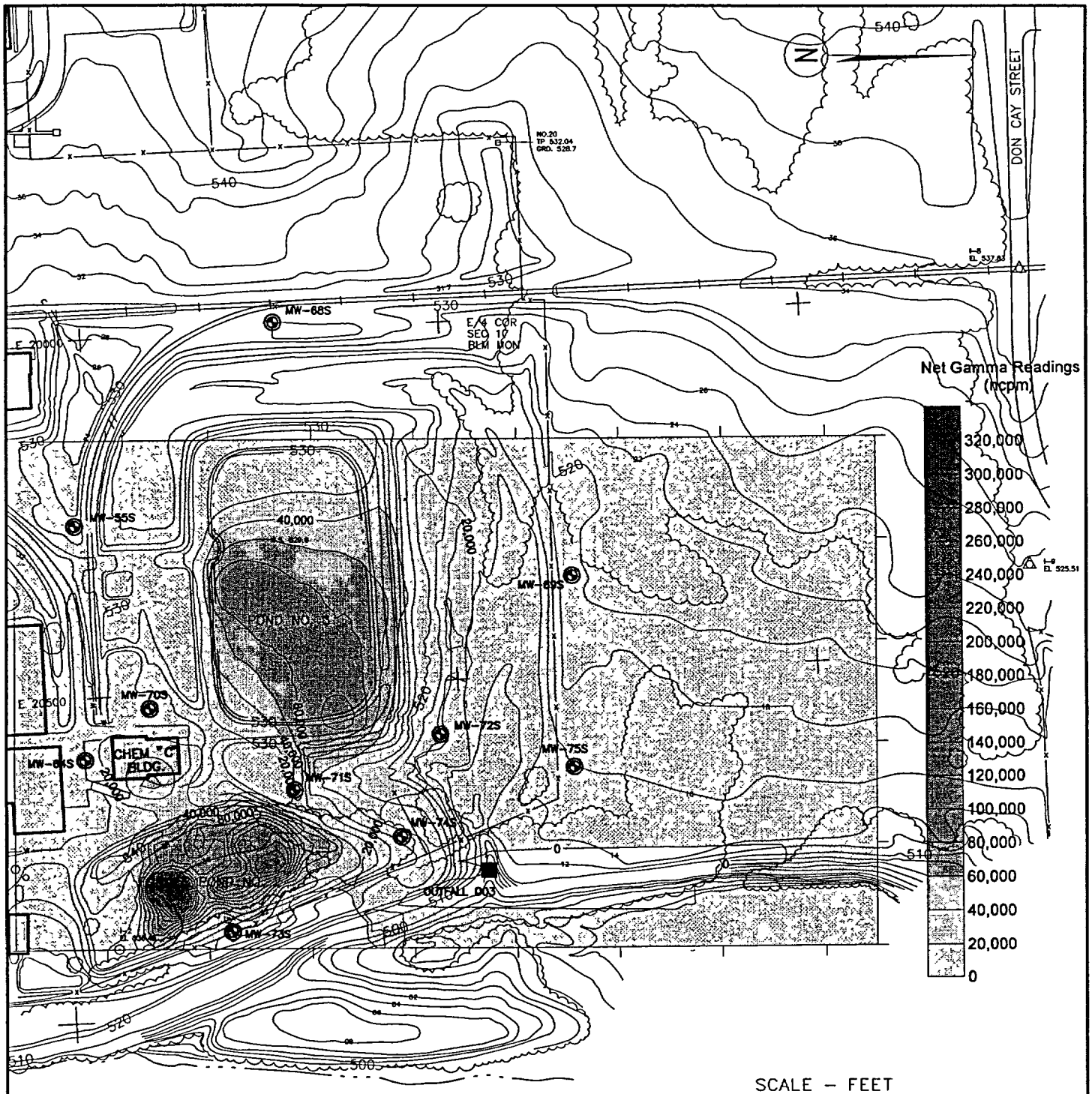

FIGURE 4–9
1–METER GAMMA SURVEY
DECOMMISSIONING PLAN
FANSTEEL INC.
MUSKOGEE, OKLAHOMA

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BACKGROUND DETERMINATION
LOCATION MAP
DECOMMISSIONING PLAN
FANSTEEL, INC.
MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473426, FIGURE 4-10

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DRAWING NO. 6473427, FIGURE 4-11 POND SAMPLE LOCATIONS DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473427, FIGURE 4-11

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D-06

5.0 Dose Modeling Evaluations

Dose modeling has been used to assess the TEDE to an average member of the critical group from residual radioactivity at the Fansteel site. The dose modeling evaluations were performed to demonstrate compliance with the release criteria of the NRC final rule on "Radiological Criteria for License Termination," published in the FR (62 FR 39058) which was incorporated as Subpart E to Title 10 CFR Part 20. The regulatory requirements are that the TEDE to an average member of the critical group does not exceed 25 mrem/yr and that the TEDE is ALARA. The guidance provided in the following documents was used in the evaluations:

- 63 FR 64132, November 18, 1998, Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination.
- 64 FR 68395, December 7, 1999, Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination.
- 65 FR 37186, June 13, 2000, Use of Screening Values to Demonstrate Compliance with the Final Rule on Radiological Criteria for License Termination.
- NUREG-1549, Decision Methods for Dose Assessment to Comply With Radiological Criteria for License Termination, NRC, July 1998.
- NUREG/CR-5512, Vol. 1, Residual Radioactive Contamination From Decommissioning, Technical Basis for Translating Contamination Levels To Annual Effective Dose Equivalent, Final Report, NRC, October 1992.
- NUREG/CR-5512, Vol. 2, Residual Radioactive Contamination From Decommissioning: User's Manual DandD Version 2.1, April 2001.
- NUREG/CR-5512, Vol. 3, Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment, NRC, October 1999.
- RG DG-4006, Demonstrating Compliance With The Radiological Criteria For License Termination, August 31, 1999.
- NUREG-1727, NMSS Decommissioning Standard Review Plan, September 15, 2000.
- Argonne National Laboratory (ANL), User's Manual For RESRAD Version 6.0, ANL/EAD-4, Argonne, IL, July 2001.
- Argonne National Laboratory (ANL), Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil, ANL/EAIS-8, Argonne, IL, 1993.
- NUREG/CR-6755, Technical Basis for Calculating Radiation Doses for the Building Occupancy Scenario Using Probabilistic RESRAD-BUILD 3.0 Code, NRC, February 2002.

Dose modeling has been used to estimate the TEDE to an average member of the critical group from residual radioactivity at the Fansteel site. The critical group is the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for the applicable set of circumstances or scenario as defined in 10 CFR 20.1003. Dose modeling has also been used to calculate the concentration of radioactivity that if uniformly distributed throughout the site area would result in a TEDE of 25 mrem to an average member of the critical group in any year. These radionuclide-specific values are called $DCGL_W$s for relatively uniform distributions of residual radioactivity across a survey unit.

5.1 Unrestricted Release Using NRC Screening Criteria

The NRC has published radionuclide-specific screening levels for structural surfaces and open land areas derived using the NRC DandD code that can be used to show compliance with the dose criterion of 25 mrem TEDE without submitting a site-specific dose assessment for NRC approval. However, the screening values are not based on an industrial future land use scenario, and they are only applicable to a "simple site" as described in NUREG-1727.

According to NUREG-1549 and NUREG-1727, there are several Fansteel site-specific features that require dose modeling beyond the basic DandD screening model. These features include the existence of surface or groundwater contamination, relatively large quantities of contaminated material such as slag ponds, and areas of subsurface contamination greater than 15 centimeters below the ground surface. For these reasons, assessment of the Muskogee site using screening criteria is not applicable and not considered further.

5.2 Unrestricted Release Using Site-Specific Information

Site-specific dose modeling evaluations were performed for development of the DP in the context of NUREG-1549: Decision Methods for Dose Assessment to Comply with Radiological Criteria for License Termination (NRC, July 1998). Fansteel followed the process illustrated by the decision framework, as shown in Figure 1 of NUREG-1549.

Consistent with NUREG-1549, a phased approach to decision making was used to evaluate a variety of remedial options. Generally, these iterations in the first phase utilized a generic screening process, using predefined models and generic screening parameters, and then proceeded to include more site-specific evaluations. Site-specific dose modeling evaluations for structures and for soil at the Fansteel Muskogee site are presented in the following sections.

5.2.1 Unrestricted Release for Structures, Surface and Subsurface Soil Residual Radioactivity

In accordance with NUREG-1549, site-specific evaluations range in complexity from:

a) use of NRC models with site-specific parameter values;
b) to using both site-specific parameter values and site-specific model assumptions;
c) to combinations of a and b and also remediating the site; or
d) combinations of a, b, c, and also restricting release of the site.

Using the framework presented in Figure 1 of NUREG-1549, Step 1, existing site characterization data were reviewed to determine the nature and extent of uranium- and thorium-contaminated soil, residues, and structures at the Fansteel site. This included defining the principal radionuclides and their chemical form and physical properties, and characterizing the spatial distribution of the contamination. Historical characterization documents were also used to obtain information regarding site conditions and geological and hydrogeological information.

In Step 2, Scenario Definition/Pathway Identification, exposure scenarios were defined using generic scenarios and critical groups described within NUREG-1549. Initially, generic exposure scenarios were used with all exposure pathways active, with the exception of indoor radon as explained below.

Radon is a radioactive gas formed by the radioactive decay of radium, a member of the naturally occurring Uranium-238 radioactive decay chain. Radionuclides from this decay chain are found in natural background in various concentrations in most soils and rocks. Compliance with the 25 mrem/yr dose criterion is considered to have been demonstrated as long as radium, the principal precursor to radon (Ra-226), meets the requirements for unrestricted release without including doses from the radon pathway.

Step 3 included development of a conceptual site model and selection of an appropriate computer code or model and input parameters for the model. RESRAD Version 6.21 and RESRAD-Build Version 3.21, NRC-endorsed software packages for modeling exposure from soil and structural contamination respectively, were selected for site modeling.

In Step 4, the dose assessment is performed to assess the potential future radiological dose from residual radioactivity remaining at the site after decommissioning activities are completed. This was performed by first calculating the dose for the no action alternative and then calculating the $DCGL_{WS}$s required to comply with the unrestricted site release criterion of 25 mrem/yr by removal of contaminated material. In

Step 5, the dose estimates were compared to the NRC's license termination requirements in 10 CFR 20, Subpart E for restricted and unrestricted use of facilities after license termination. Dose objectives for both unrestricted and restricted releases require assessments that consider cases in which the average member of the critical group (a hypothetical future land user) is located on the site. Because dose estimates for current site conditions (no action alternative) exceed the 25 mrem/yr dose criteria specified in 10 CFR 20.1402, the analysis proceeded past Step 6, ALARA requirements and Step 7, license termination, to Step 8.

Step 8 includes defining a range of options, including additional site characterization, remediation, and restricted-use options, to define the most effective and cost-efficient decontamination and decommissioning strategy. Because a relatively large proportion of the impacted soil exceeds the initial $DCGL_W$s, the analysis proceeded to evaluation of combinations of b, c, and d as stated above. Within this more complex framework of analysis, several options were considered that included remediating the site by removal of soil and pond residues, leaving some contaminated soil and/or pond residues on site, as well as developing site-specific exposure scenarios based on likely future uses of the site property.

Although inclusion of additional site-specific or regional characterization data, such as physical properties of the impacted zone, is likely to lower the estimated dose, the anticipated reduction is modest. Development of site-specific exposure scenarios and critical groups in light of plausible future site uses and surrounding property uses could reduce estimated doses. For example, consideration of site uses consistent with the industrial use environment, such as an industrial worker scenario, has been considered. Based on this assessment, Fansteel selected a decommissioning approach that will achieve unrestricted release in accordance with 10 CFR 20.1402. The dose evaluation for the selected approach is discussed below.

5.2.1.1 Source Term

5.2.1.1.1 Configuration /Principal Radionuclides

The raw materials used for tantalum and columbium production contained uranium and thorium as naturally occurring trace constituents. These radioactive species were present in the process feed materials at an approximate concentration of 0.1 percent uranium oxide and 0.25 percent thorium oxide. This concentration is sufficient to cause the ores and slag to be classified by the NRC as source materials. Uranium and thorium in the raw materials were not extracted from the ores by the digestion process. The radioactive species remained in the ore digestion residues that were disposed on site in the east plant area, specifically Pond Nos. 2 and 3. The radionuclides considered in this assessment are shown in Table 5-1

and include the long-lived isotopes of uranium, thorium, and radium present in the licensed radioactive material at the Fansteel site. The U-235 decay chain is included because U-235 constitutes 0.7 percent by weight (approximately 2.3 percent by radioactivity) of naturally occurring uranium. Tables 4-1 through 4-12 in Chapter 4.0 present soil and pond characterization data and relative activity ratios of the radionuclides identified by isotopic analysis. The data indicate that the decay chains of Uranium-238, Thorium-232, and Uranium-235 are present in secular equilibrium as expected based on past site operations described in Chapter 2.0, Section 2.1.4.

Table 5-1 Fansteel Licensed Radioactive Material in Soil

Radionuclide and Progeny Radionuclides	Half-life Parent (yrs)	Estimated Current Inventory (Ci)
U-238 (Th-234, Pa-234m, Pa-234)	4.5×10^9	9
U-234	2.4×10^5	9
Th-230	7.7×10^4	9
Ra-226 (including all progeny to stable Pb-206)	1.6×10^3	9
U-235 (including all progeny to stable Pb-207)	7.0×10^8	0.4
Th-232 (including all progeny from Ra-228, Ac-228 and Th-228 to stable Pb-208)	1.4×10^{10}	5.7

5.2.1.1.2 Chemical Form

The feed materials used for tantalum and columbium production contained uranium and thorium as naturally occurring trace constituents. These radioactive species were present in the process feed materials at an approximate concentration of 0.1 percent uranium oxide and 0.25 percent thorium oxide.

5.2.1.1.3 Residual Radioactivity Spatial Distribution

The characterization data presented in Tables 4-1 through 4-12 indicate that an area encompassing approximately 180,000 m^2 has potentially been impacted by historical operations at the Fansteel site. Approximately 40,000 m^2 of this area consists of ponds containing licensed radioactive material as a result of historical operations. The depth of licensed radioactive material in soil is generally within the top 0.762 m. Deeper layers of radioactive deposits at depths up to approximately 6 m were identified in samples taken east of the Chemical "A" Building and east of Former Pond No. 2. The depth of radioactivity in ponds ranges from approximately 5 to 6 m in Pond Nos. 2 and 3; 0.91 m to 1.5 m in Pond Nos. 5, 6, and 7; and approximately 7.6 m in Pond Nos. 8 and 9. At the time of FSS, the anticipated area-weighted average thickness of residual radioactivity in surface soil is estimated to be approximately 0.85 m (0.5 m for 70 percent of the site, 1 m for 20 percent of the site, and 3 m for 10 percent).

At the time of FSS and license termination, there will be several impacted and nonimpacted buildings located on the eastern portion of the Fansteel site. Most of the buildings are considered impacted from ore-processing activities that occurred during past operations described in Section 2.2.3. Building characterization data are presented in Section 4.2. The Chemical "C" Building is contaminated throughout while other impacted buildings contain only low levels of isolated contamination. At the time of FSS, structural contamination is expected to be only surface contamination. Any areas of volumetric contamination (greater than 0.4 inch or 10 mm) will be decontaminated so that only surface residual radioactivity remains.

5.2.1.2 Critical Groups, Scenarios, and Pathway Identification and Selection

Critical groups, pathway identification, and exposure scenarios were selected consistent with present and anticipated site use and Regulatory Guide DG-4006, NUREG-5512 and NUREG-1549.

5.2.1.2.1 Scenario Identification

Based on the current and expected future industrial land use of the Fansteel site, an industrial use scenario is the most appropriate to derive site-specific $DCGL_W$s for the residual radioactivity present in soil and on building surfaces at the time of FSS and Fansteel site release. The future use of the Fansteel site is controlled in accordance with the updated Master Plan for industrial properties issued by the Port of Muskogee (Master Plan of Development for the Muskogee Port and Industrial Park, Muskogee City-County Port Authority, November 28, 1967). Accordingly, it is anticipated that buildings and associated process equipment will be used for similar industrial processes as those previously conducted at the Fansteel site. Dose assessment results and corresponding DCGLs derived for the industrial occupancy scenario have been utilized for analysis, planning, design, and implementation of decommissioning activities at the site.

5.2.1.2.2 Critical Group Determination

Various site uses and scenarios were considered within the limits of plausible future uses of the site. Since the site is located in a zoned industrial area and is surrounded by other industrial sites, industrial workers are considered to comprise the critical group.

5.2.1.2.3 Exposure Pathways

External exposure to penetrating radiation, inhalation of soil dust (while outdoors and during building occupancy), and inadvertent ingestion of soil are the exposure pathways that were considered in deriving radionuclide-specific $DCGL_W$s for residual radioactivity in site soil for the industrial worker dose

assessment. Exposure pathways considered in the derivation of radionuclide-specific $DCGL_W$s for residual radioactivity on building and component surfaces included direct external gamma exposure including submersion, inhalation of resuspended residual radioactivity, inadvertent ingestion of residual radioactivity from surface sources, and ingestion of deposited radioactivity resulting from resuspension. Table 5-2 summarizes the exposure pathways identified for use in the industrial worker scenario. In the industrial worker scenario, it is assumed that no water or food from the site is consumed as indicated in Table 5-2. Table 5-3 summarizes key parameters used in the industrial worker scenario.

Ingestion of water or groundwater from an on-site well is not a pathway that is included in the industrial worker exposure as indicated in Table 5-2. The groundwater sample results from 1993 presented in Section 4.5 indicate that shallow groundwater has been impacted by Fansteel licensed material.

Table 5-2 Summary of Industrial Worker Exposure Pathways

Pathway	Industrial Worker Soil DCGL Pathways	Industrial Worker Building Occupancy DCGL Pathways
External Gamma Exposure	Yes	Yes
Inhalation of Dust or Resuspended Indoor Radioactivity	Yes	Yes
Ingestion of Plant Foods	No	No
Ingestion of Meat	No	No
Ingestion of Milk	No	No
Ingestion of Fish	No	No
Ingestion of Soil/Residual Radioactivity on Building Surface	Yes	Yes
Ingestion of Water	No	No

Table 5-3 Key Parameters in the Industrial Worker Scenario

Parameter	Unit	Industrial Worker	Technical Basis
Exposure Duration	yr	25	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Breathing Rate	m^3/yr	11,400	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Fraction of Time Indoors (Building Occupancy)	Fraction of yr	0.17	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Fraction of Time	Fraction	0.06	RESRAD[a] Section 2.4.2

Parameter	Unit	Industrial Worker	Technical Basis
Outdoors Directly on Residual Radioactive Material	of yr		based on 1997 USEPA Exposure Factor Handbook
Contaminated Fraction of Plant Food	-	Not used	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Contaminated Fraction of Milk	-	Not used	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Contaminated Fraction of Meat	-	Not used	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Contaminated Fraction of Aquatic Food	-	Not used	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Soil Ingestion	g/yr	18.25	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Drinking Water Intake	l/yr	Not used	RESRAD[a] Section 2.4.2 Generic Industrial Worker Scenario

a. RESRAD (Yu et al., 2001).

5.2.1.3 Conceptual Model

The conceptual model generically represents the actual site configuration as it will exist at the time of the FSS and license termination. The site will consist of an open land area of approximately 180,000 m^2, containing residual radioactivity with an average area-weighted depth of 0.85 m. There will be several buildings and concrete pads remaining on the property. The site is assumed to be used for industrial work consistent with present land use (zoning) at and around the Fansteel site.

5.2.1.3.1 Relative Location and Activities of the Critical Group

The critical group is made up of industrial workers. The industrial worker spends 8 hours per day on the site. Of the 8 hours, 6 hours are spent indoors and the remaining 2 hours are spent outside. The primary activity of the industrial worker during the 8 hours on site is work.

5.2.1.3.2 Hydrologic and Environmental Transport Processes

Only contaminated zone hydrologic parameters are evaluated for the industrial worker scenario to assess the removal of contamination by natural processes such as erosion from the contaminated zone. Resuspension of soil (dust), wind, and surface erosion are the primary environmental transport processes included in the industrial worker scenario.

5.2.1.3.3 Dimensions, Location, and Spatial Variability of the Source Term

At the time of the FSS and license termination, the site will consist of two large industrial buildings located on an open land area of approximately 180,000 m^2. The open land area will generally contain uniform residual radioactivity at an average area-weighted depth of 0.85 m. The use of an area-weighted depth or thickness of residual radioactivity accounts for the anticipated spatial extent of residual radioactivity anticipated at the time of FSS. There will likely also be areas of the site that have deeper and or thicker layers of residual radioactivity deposits located east of the Chemical "A" Building and east of Former Pond No. 2. The sensitivity analysis results presented in Section 5.2.2.5 indicate that increases in either thickness or area of residual radioactivity do not substantially affect the peak annual TEDE to the average member of the critical group under an industrial use scenario. This is primarily because the external exposure pathway limits dose from residual radioactivity in soil at the Fansteel site.

5.2.1.3.4 Major Assumptions

There are no major assumptions relative to the conceptual site model.

5.2.1.4 Calculations and Input Parameters

The deterministic mode of RESRAD Version 6.21 has been used to derive the radionuclide-specific $DCGL_W$s for the residual radioactivity present in soil at the time of the Fansteel site FSS and site release. Input parameters and justification for their use are discussed in Section 5.2.1.4.2. The deterministic mode of RESRAD-Build Version 3.21 has been used to derive the radionuclide-specific $DCGL_W$s for the residual radioactivity present on building and component surfaces at the time of the Fansteel site FSS and site release. Input parameters and justification for their use are discussed in Section 5.2.1.4.2.

5.2.1.4.1 Selection of Computer Model

Both RESRAD and RESRAD-Build computer models have been widely used for dose assessment in support of decommissioning. The RESRAD computer models were selected to derive Fansteel site-specific DCGLs, because they allow pathway modeling consistent with the conceptual site model and critical group.

5.2.1.4.2 Input Parameters

Estimates of physical, behavioral, and metabolic parameter values were developed from either site measurements or literature review. Available site-specific characterization data include meteorological, topographical, hydrogeological, soil texture characterization, and location and extent of contamination. Thus, site-specific data for annual precipitation, wind speed, area, and thickness of the contaminated zone

were used in the RESRAD analyses. Physical parameters related to industrial worker building occupancy used with RESRAD-Build, such as room size, deposition velocity, resuspension rate, building air exchange rate, air release fraction, and time for source removal, were adapted directly from NUREG/CR-6755 as recommended for deterministic analysis.

The parameter values used in the analysis of the Fansteel site industrial worker scenario are presented in Tables 5-4 through 5-7. As shown in Table 5-4, the radiation dose limit and time for calculations are 25 mrem/yr and 1,000 years respectively, as specified in 10 CFR 20.1401 and 20.1402.

Table 5-4 Industrial Worker Scenario: Contaminated Zone Parameters

Parameter	Parameter Value	Source/Justification
Area of Contaminated Zone	180,000 m^2 for the entire impacted area including the following: • 37,000 m^2 for combined area of ponds with residual contamination ~ 1 m thick • 18,000 m^2 for residual contamination ~ 3 m thick • 125,000 m^2 for residual contamination ~ 0.5 m thick	Fansteel Remediation Assessment[a] (1993) site-specific data presented in Chapter 4.0
Thickness of Contaminated Zone	0.85 m area-weighted average (representative thickness) for site	Calculated in accordance with NUREG–1727 recommendations for area weighting to determine representative thickness for the site
Length Parallel to Aquifer Flow	275 m	Fansteel Remediation Assessment (1993)
	Not used for industrial worker scenario	
Peak Annual Radiation Dose Limit	25 mrem/yr	10 CFR 20.1402
Time Since Placement of Material	Not used	
Time for Calculations	Through 1,000 years	10 CFR 20.1401(d)
Depth of Soil Mixing Layer	0.15 m	RESRAD[b]

a. Remediation Assessment, Fansteel Inc., Muskogee, Oklahoma, December 1993
b. (Yu et al., July 2001)

Table 5-5 Industrial Worker Scenario: Contaminated Zone Input Data

Parameter	Parameter Value	Source
Density of Contaminated Zone	1.51 g/cm3	Fansteel Remediation Assessment[a] (1993) soil type and DandD2\nrcvol3\hyddesc.htm[b] Equation 6.56 used to calculate average soil density based on pond soil type
Contaminated Zone Erosion Rate	0.00006 m/yr	RESRAD[c] Appendix A for sites with a slope of ~2% and nonagricultural use
Contaminated Zone Total Porosity	0.44	Fansteel Remediation Assessment[a] (1993) soil type in ponds and RESRAD[c] Table E8 average value for silt/sand
Contaminated Zone Effective Porosity	0.27	Fansteel Remediation Assessment[a] (1993) soil type in ponds and RESRAD[c] Table E8 average value for silt/sand
Contaminated Zone Hydraulic Conductivity	5,550 m/yr	Fansteel Remediation Assessment[a] (1993) soil type in ponds and RESRAD[c] Table E2 value for sand
Contaminated Zone b Parameter	4.05	Fansteel Remediation Assessment[a] (1993) soil type in ponds and RESRAD[c] Table E2 value for sand
Evapotranspiration Coefficient	0.99	Fansteel Remediation Assessment[a] (1993) soil type, slope and RESRAD[d] data collection handbook (1993) Equation 12.1
Precipitation	1.1 m/yr	NRC website: ftp://ftp.wcc.nrcs.usda.gov
Irrigation	0.0 m/yr	No irrigation is assumed for the industrial worker scenario
Runoff Coefficient	0.4	Fansteel Remediation Assessment[a] (1993) soil type and RESRAD[b] Table E1
Watershed Area for Stream or Pond	1.8×10^5 m^2 Not used for industrial worker scenario	Site-specific area
Average Annual Wind Speed	4.52 m/s	National Climatic Data Center
Partition Coefficients:		NUREG/CR-5512, Vol.3[e]
Ac-227	1730 cm^3/g	
Pa-231	4.8 cm^3/g	
Pb-210	2380 cm^3/g	
Ra-226, Ra-228	3530 cm^3/g	
Th-228, Th-230, Th-232	119 cm^3/g	
U-234, U-235, U-238	2.18 cm3/g	

a. Remediation Assessment, Fansteel Inc., Muskogee, Oklahoma, December 1993
b. DandD version 2.1 NUREG/CR-5512, Vol.2, HTML help document with user's manual
c. (Yu et al., 2001)
d. (Yu et al., 1993)
e. NUREG/CR-5512, Vol. 3

Table 5-6 Industrial Worker Scenario Soil (Dust) Inhalation and External Gamma Parameters

Parameter	Parameter Value	Source
Inhalation Rate	11,400 m3/yr	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Mass Loading for Inhalation	$1 \times 10\text{-}4$ g/m^3	DandD2\nrcvol3\cdxdesc.htm[b] outdoor dust loading Section 6.4.4.1
Exposure Duration	250 work days/year	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Shielding Factor, Inhalation	0.4	Fraction of outdoor dust in indoor air RESRAD[a]
Shielding Factor, External Gamma	0.552	NUREG-5512[c]
Fraction of Time Indoors, On Site per Year	0.17	RESRAD[a] Based on 1997 USEPA Exposure Factor Handbook
Fraction of Time Outdoors, On Site per Year	0.06	RESRAD[a] Based on 1997 USEPA Exposure Factor Handbook
Shape Factor, External Gamma	1	RESRAD[a]
Soil Ingestion Rate	18.25 gram/yr	NUREG-5512[c]

a. RESRAD (Yu et al., 2001).
b. DandD version 2.1 NUREG/CR-5512, Vol. 2, HTML document
c. NUREG-5512 vol. 3 (NRC, 1999)

Table 5-7 Industrial Worker Scenario: Building Occupancy Parameters

Parameter	Parameter Value	Source
Exposure Duration (days)	365.25	Evaluation for year of maximum dose (year 1)
Building Occupancy Fraction	0.17 or 6 hours/day	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
Number of Rooms	1	NUREG-5512 Building Occupancy
Room Floor Area (m^2)	8 m x 8 m = 64	NUREG-5512 Building Occupancy
Room Height (m)	3	NUREG-5512 Building Occupancy
Deposition Velocity in Room (m/s)	3.9×10^{-4}	NUREG/CR-6755 Table 4.2 for default deterministic input
Resuspension Rate (1/sec)	6.3×10^{-8}	NUREG/CR-6755 Table 4.2 for default deterministic input
Building Air Exchange Rate (1/h)	1.52	NUREG/CR-6755 Table 4.2 for default deterministic input
Receptor Location	Center of room	NUREG/CR-6755 Table 4.2 for default deterministic input
Receptor Indirect Ingestion (m^2/h)	1.12×10^{-4}	NUREG/CR-6755 Table 4.2 for default deterministic input

Parameter	Parameter Value	Source
Air Release Fraction for All 6 Sources	0.357	NUREG/CR-6755 Table 4.2 for default deterministic input
Time for Source Removal (days)	10,000	NUREG/CR-6755 Table 4.2 for default deterministic input
Receptor Inhalation Rate (m^3/day)	31.21	RESRAD[a] Section 2.4.2 based on 1997 USEPA Exposure Factor Handbook
6 Area Sources-Floor, Ceiling, 4 Walls		NUREG/CR-6755 Table 4.2 for default deterministic input
Direct Ingestion Rate for All Sources (1/h)	4.91×10^{-7}	NUREG/CR-6755 Table 4.2 for default deterministic input
Removable Fraction	0.03	Site-specific decon level for removable
Radon Release Fraction	0	See discussion in Section 5.2.1 (Step 2)

5.2.1.4.3 RESRAD Soil Results

Table 5-8 lists the individual radionuclide $DCGL_w$s for soil calculated by RESRAD for the residual radioactivity at the Fansteel site. Appendix 5-1 contains the RESRAD summary output report. The year of the peak dose associated with each radionuclide as indicated in Table 5-8 is year zero, because the radionuclide decay chains at Fansteel are already in equilibrium. For radionuclide decay chains already in equilibrium, the single radionuclide soil guidelines are shown on Page 21 of the RESRAD Summary Report Single Radionuclide Soil Guidelines G (i,tmax). As expected under an industrial use scenario with the radionuclides present at the Fansteel site, the RESRAD results indicate that over 97 percent of the TEDE at the time of peak dose (time zero) is due to the external exposure from residual radioactivity as shown in Figure 5-1.

Table 5-8 Industrial Worker Scenario Individual Radionuclide $DCGL_w$s for Soils

Radionuclide and Progeny	Industrial Worker [a]$DCGL_w$s at Time Zero (pCi/g)	Time of Maximum Dose (yrs)
U-238 (Th-234, Pa-234m, Pa-234)	967	0
U-234	7915	0
U-235 (Th-231)	211	0
Pa-231	251	0
Ac-227 (Th-227 to stable Pb-207)	54.6	0
Th-232	255	0
Th-230	3,300	0
Th-228 (Ra-224 to stable Pb-208)	19.2	0
Ra-226 (Rn-222 to Po-210)	14.7	0

Radionuclide and Progeny	Industrial Worker [a]$DCGL_w$s at Time Zero (pCi/g)	Time of Maximum Dose (yrs)
Ra-228 (Ac-228)	22.8	0
Pb-210 (Bi-210 thru Stable Pb-206)	799	0

a. Calculated by RESRAD using the parameters specified in Tables 5-4 through 5-6

The sum of fractions rule combined with the $DCGL_w$s presented in Table 5-8 will be used to determine whether the site has met the unrestricted release conditions during the FSS. For example, based on the characterization data presented in Chapter 4.0 and the anticipated radiological conditions at the time of the FSS, the U-238, U-235, and Th-232 decay chains are expected to each be in secular equilibrium and the Thorium-232 to Uranium-238 activity ratio is expected to be approximately 1:1. Uranium-235 activity is expected to comprise approximately 2.3 percent of the total uranium activity while Uranium-238 and Uranium-234 are expected to comprise approximately 97.7 percent of the total uranium activity which is typical for natural uranium. Based on a concentration of 5.8 pCi/g for the Uranium-238 and Thorium-232 decay series, and a Uranium-235 concentration of 0.271 pCi/g, the sum of $DCGL_w$ fractions using Table 5-10 $DCGL_w$ values is calculated as follows:

U-238 Decay Chain

$$5.8/967 + 5.8/7{,}915 + 5.8/3{,}300 + 5.8/14.7 + 5.8/799 = 0.41$$

Th-232 Decay Chain

$$5.8/255 + 5.8/22.8 + 5.8/19.2 = 0.579$$

U-235 Decay Chain

$$0.271/211 + 0.271/251 + 0.271/54.6 = 0.007$$

The sum of the fractions above is 0.996 which is equivalent to a TEDE of (25 mrem) * (0.996) or 24.9 mrem. The identical concentration inputs to RESRAD produce a RESRAD calculated peak annual dose of 24.9 mrem as indicated on Page 11 of the RESRAD summary report in Appendix 5-1.

In addition to the $DCGL_w$ values used to determine compliance for survey unit mean concentrations, the $DCGL_{EMC}$ concentration values for limited areas within a survey unit have been calculated. The $DCGL_{EMC}$ values are applicable to small, elevated areas of residual radioactivity within a larger survey area. Appendix 5-2 contains $DCGL_{EMC}$ values for limited areas ranging from 1 m^2 to 1,000 m^2.

Sensitivity analyses indicate that the $DCGL_{EMC}$ values in Appendix 5-2 are not sensitive to thickness beyond the base case of 0.85 m. The $DCGL_{EMC}$ values in Appendix 5-2 will be used to assess compliance for survey units as long as the following sum of fractions is satisfied:

$$\Sigma[(\delta / DCGL_w) + [(\text{average conc} - \delta)/ DCGL_{EMC}]] \leq 1$$

where:

δ is the average concentration for all samples outside the elevated area, and
average conc is the average concentration in the elevated area.

Area factors computed using $DCGL_{EMC}$ values in Appendix 5-2 are presented in Chapter 14.0.

5.2.1.4.4 RESRAD-Build Results

Table 5-9 lists the individual radionuclide $DCGL_w$s for the residual radioactivity on building and component surfaces calculated using RESRAD-Build. Appendix 5-3 contains the RESRAD-Build summary output report. The year of the peak dose associated with each radionuclide as indicated in Table 5-9 is year zero, because the radionuclide decay chains at Fansteel are already in equilibrium. The RESRAD-Build results indicate that over 87 percent of the TEDE at the time of peak dose (time zero) is attributable to the inhalation and ingestion exposure pathways.

Table 5-9 Industrial Worker Building Occupancy
Individual Radionuclide $DCGL_w$s

Radionuclide and Progeny	Dose Conversion Factors Based on RESRAD-Build Calculations (mrem/yr)/(1 dpm/100 cm^2)	Time of Maximum Dose (yrs)	Industrial Worker [a]$DCGL_w$s at Time Zero (dpm/100 cm)
U-238 (Th-234, Pa-234m, Pa-234)	4.3×10^{-4}	0	58,140
U-234	4.6×10^{-4}	0	54,349
U-235 (Th-231)	5.2×10^{-4}	0	48,076
Pa-231	6.2×10^{-3}	0	4,032
Ac-227 (Th-227 to stable Pb-207)	2.3×10^{-2}	0	1,087
Th-232	5.5×10^{-3}	0	4,545
Th-230	1.1×10^{-3}	0	22,727
Th-228 (Ra-224 to stable Pb-208)	1.6×10^{-3}	0	15,625
Ra-226 (Rn-222 to Po-210)	1.2×10^{-3}	0	20,833
Ra-228 (Ac-228)	7.9×10^{-4}	0	31,646

Radionuclide and Progeny			Dose Conversion Factors Based on RESRAD-Build Calculations (mrem/yr)/(1 dpm/100 cm^2)	Time of Maximum Dose (yrs)	Industrial Worker [a]DCGL$_w$s at Time Zero (dpm/100 cm)
Pb-210 (Bi-210 thru Pb-206)		Stable	1.6×10^{-3}	0	15,625

a. Based on calculations by RESRAD-Build using the parameters specified in Table 5-7

The sum of fractions rule combined with the DCGL$_w$s presented in Table 5-9 above will be used to determine whether the site has met the unrestricted release conditions after contamination measurements are obtained during the FSS. For example, based on the characterization data presented in Chapter 4.0 and the expected radiological conditions at the time of the FSS, the U-238, U-235, and Th-232 decay chains are expected to each be in secular equilibrium and the Thorium-232 to Uranium-238 activity ratio is expected to be approximately 1:1. Uranium-235 activity is expected to comprise approximately 2.3 percent of the total uranium activity which is typical for natural uranium. Based on a concentration level of 8.01×10^4 pCi/m^2 (1,780 dpm/100 cm^2) for the Uranium-238 and Thorium-232 decay series, and a Uranium-235 concentration of 3,770 pCi/m^2 (83.7 dpm/100 cm^2), the sum of DCGL$_w$ fractions using Table 5-9 DCGL$_w$ values is 1 calculated as follows:

U-238 Decay Chain

$$1{,}780/58{,}140 + 1{,}780/54{,}349 + 1{,}780/22{,}727 + 1{,}780/20{,}833 + 1{,}780/15{,}625 = 0.341$$

Th-232 Decay Chain

$$1{,}780/4{,}545 + 1{,}780/15{,}625 + 1{,}780/31{,}646 = 0.562$$

U-235 Decay Chain

$$83.7/48{,}076 + 83.7/4{,}032 + 83.7/1{,}087 = 0.0995$$

The sum of the fractions above is 1.0 which is equivalent to a TEDE of 25 mrem * (1.0) or 25 mrem. The identical concentration inputs to RESRAD-Build produce a RESRAD-Build-calculated peak annual dose of 25 mrem as indicated on Page 14 of the RESRAD-Build summary report in Appendix 5-3. Note that doses from ingrowth of progeny have been subtracted from the dose reported by RESRAD-Build as shown on Page 14 of the RESRAD-Build summary report, because the progeny are already in secular equilibrium.

In terms of gross alpha activity per decay of the uranium, thorium, and actinium (U-235) series in secular equilibrium, there are nine alpha particles emitted per decay of U-238, six alpha particles emitted per decay of Th-232, and eight alpha particles emitted per decay of U-235. Consequently, the gross alpha $DCGL_w$s for total alpha residual radioactivity at the Fansteel site are calculated as follows:

1,780 dpm/100 cm^2 (9 alpha/U-238 dpm) + 1,780 dpm/100 cm^2 (6 alpha/Th-232 dpm) + 83.7 dpm/100 cm^2 (8 alpha/U-238 dpm)
= 27, 300 dpm/100 cm^2.

In addition to the $DCGL_w$ values used to determine compliance for structural survey unit mean concentrations, the $DCGL_{EMC}$ concentration values for limited areas within a survey unit have been calculated. Appendix 5-4 contains $DCGL_{EMC}$ values for limited floor and wall areas ranging from 1 m^2 to 20 m^2 for walls and from 1 to 30 m^2 for floors. The $DCGL_{EMC}$ values in Appendix 5-4 will be used to assess compliance for survey units as long as the following sum of fractions is satisfied:

$$\Sigma[(\delta / DCGL_w) + [(\text{average conc} - \delta)/ DCGL_{EMC}]] \leq 1$$

where:

> δ is the average concentration for all samples outside the elevated area, and
> average conc is the average concentration in the elevated area.

Area factors computed using $DCGL_{EMC}$ values in Appendix 5-4 are presented in Chapter 14.0.

5.2.1.5 Uncertainty Analysis

The dose assessment employed a deterministic approach to modeling using single input parameter values and RESRAD Version 6.21. In accordance with the guidance provided in NUREG-1549, uncertainty has been addressed by providing reasonable assurance that the estimated dose or $DCGL_w$s values were derived using parameter values that can readily be demonstrated as being conservative. This is accomplished by use of a simple modeling approach, simple assumptions, and parameter values that readily can be demonstrated as being conservative.

The behavioral and metabolic characteristics of the average member of the critical group are simply conservative default values identified in the literature including NUREG/CR-5512 Vol. 2, NUREG-5512 Vol. 3 (NRC, 1998), or RESRAD Version 6.23.

The uncertainty associated with physical parameters has also been addressed by using conservative values from NUREG/CR-5512 Vol. 2, NUREG-5512 Vol. 3 (NRC, 1998), or RESRAD Version 6.23. In addition, a sensitivity analysis has been used to identify physical input parameters to which the calculated $DCGL_w$s or peak annual dose is most sensitive. The results of the sensitivity analysis are summarized in Table 5-10. As indicated in Table 5-10, there are no parameters sensitive to changes over the range of realistic yet conservative values that any given parameter value could take on at the Fansteel site.

Table 5-10 Industrial Worker Scenario Sensitivity Summary

Parameter Name	Parameter Value Used in DCGL Derivation (Baseline Value)	Sensitivity Upper and Lower Value of Parameter	Dose Increase with Increase or Decrease in Parameter Value	Comments
Contaminated Zone Area (m^2)	180,000	216,000/ 150,000	Increase	<1% increase in peak dose compared to baseline
Contaminated Zone Density (g/cm^2)	1.51	1.37/1.66	Increase	<1% increase in peak dose compared to baseline
Contaminated Zone Erosion Rate (m/y)	0.00006	0.0006/ 0.000006	No change	
Contaminated Zone Thickness (m)	0.85	8.5/0.085	Increase	<1% increase in peak dose compared to baseline
Contaminated Zone Evapotranspiration Coefficient	0.99	–	Increase	Maximum value has been used in DCGL derivation
Contaminated Zone Effective Porosity	0.27	0.135/0.54	No change	
Contaminated Zone Total Porosity	0.44	0.22/0.45	No change	
Contaminated Zone Hydraulic Conductivity (m/y)	5,550	15,000/100	No change	
Contaminated Zone b Parameter	4.05	11.3/1.44	No change	
Precipitation (m/y)	1.1	2.04/0.51	Decrease	<1% increase in peak dose compared to baseline
Runoff Coefficient	0.4	0.6/0.2	Increase	<1% increase in peak dose compared to baseline

5.2.1.6 Compliance with Radiological Criteria for License Termination

The NRC has established criteria for releasing a site for unrestricted use in 10 CFR Part 20, Subpart E. The objective of this dose assessment is to assess compliance with the dose criteria of these regulations.

	Unrestricted Release
Dose Criterion	25 mrem TEDE per year peak annual dose to the average member of the critical group
Time Frame	1,000 years
Other Requirements	ALARA

Dose modeling results to derive the radionuclide-specific DCGLs for unrestricted release are presented in Tables 5-8 and 5-9. Activity concentrations at the listed DCGL value for any of the radionuclides will result in 25 mrem TEDE. The sum of fractions rule is applied to the soil DCGL values in Section 5.2.1.4.3 and to the structures DCGL values in Section 5.2.1.4.4, based on the anticipated activity fractions of the radionuclides, to show compliance with the dose criterion. As previously stated, all dose estimates represent postremedial doses above background to the average members of the critical group under an industrial use scenario. To ensure compliance with the 25 mrem annual peak dose limitation, regardless of the ratio of Uranium-238 to Thorium-232, but taking secular equilibrium conditions into account for the U-238, U-235, and Th-232 decay chains, the $DCGL_w$s in Tables 5-11 and 5-12 below will be used in conjunction with the sum of fractions rule to evaluate FSS results and compliance.

Table 5-11 Industrial Worker Scenario Individual Radionuclide Decay Chain $DCGL_w$s for Soils

Radionuclide and Entire Decay Chain in Equilibrium	Industrial Worker $DCGL_w$s at Time Zero (pCi/g)	Time of Maximum Dose (yrs)
U-238 – Uranium Chain	14.1	0
U-235 – Actinium Chain	37	0
Th-232 – Thorium Chain	10	0

Table 5-12 Industrial Worker Scenario Individual Radionuclide Decay Chain $DCGL_w$s for Building and Component Surfaces

Radionuclide Decay Chain $DCGL_w$	Industrial Worker $DCGL_w$s at Time Zero (dpm/100 cm^2)	Time of Maximum Dose (yrs)
U-238 – Uranium Chain	5,200	0
U-235 – Actinium Chain	840	0
Th-232 – Thorium Chain	3,160	0

References

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4. Nuclear Regulatory Commission, August 1998, Draft Regulatory Guide DG-4006: Demonstrating Compliance with the Radiological Criteria for License Termination.

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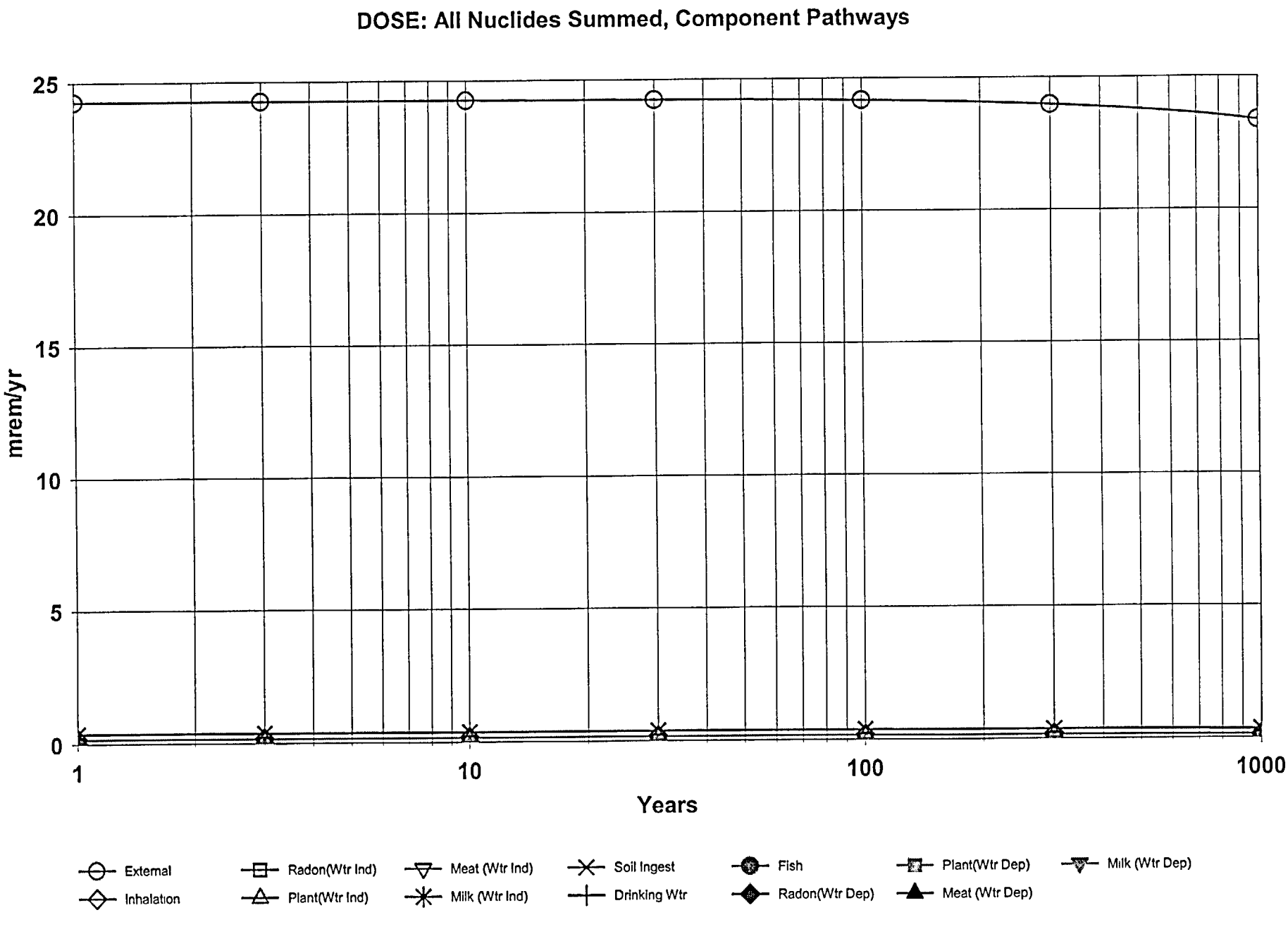
10. Pacific Northwest National Laboratory, October 1992, NRC, NUREG/CR-5512-V1, Residual Radioactive Contamination from Decommissioning – Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent: Final Report.

11. U.S. Department of Energy, September 1993, Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0.

12. U.S. Department of Energy, July 2001, RESRAD for Windows, Version 6.0, Environmental Assessment Division of Argonne National Laboratory.

Figure

FIGURE 5-1


DOSE: All Nuclides Summed, Component Pathways
mrem/yr
25
20
15
10
5
0
1
10
100
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Years
External
Inhalation
Radon(Wtr Ind)
Plant(Wtr Ind)
Meat (Wtr Ind)
Milk (Wtr Ind)
Soil Ingest
Drinking Wtr
Fish
Radon(Wtr Dep)
Plant(Wtr Dep)
Meat (Wtr Dep)
Milk (Wtr Dep)
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Appendices

Appendix 5-1

RESRAD Summary Report

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File HEAST 1995 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.720E+00	6.720E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(3)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(4)
B-1	Ra-228+D	5.080E-03	5.080E-03	DCF2(5)
B-1	Th-228+D	3.450E-01	3.450E-01	DCF2(6)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(7)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(8)
B-1	U-234	1.320E-01	1.320E-01	DCF2(9)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(10)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(11)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.480E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(3)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(4)
D-1	Ra-228+D	1.440E-03	1.440E-03	DCF3(5)
D-1	Th-228+D	8 080E-04	8.080E-04	DCF3(6)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(7)
D-1	Th-232	2.730E-03	2 730E-03	DCF3(8)
D-1	U-234	2.830E-04	2.830E-04	DCF3(9)
D-1	U-235+D	2.670E-04	2.670E-04	DCF3(10)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(11)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(5,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,3)
D-34				
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(6,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(6,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(6,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: HEAST 1995 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1 000E-03	1.000E-03	RTF(7,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(7,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5 000E-06	RTF(7,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(8,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2 500E-03	2.500E-03	RTF(9,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(10,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(10,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(10,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(11,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(11,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(11,3)
D-5	Bioaccumulation factors, fresh water, L/kg·			
D-5	Ac-227+D , fish	1 500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5 000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(5,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(5,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(6,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(6,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(7,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(7,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(8,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(8,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(10,1)
D-5	U-235+D , crustacea and mollusks	6 000E+01	6.000E+01	BIOFAC(10,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: HEAST 1995 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(11,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(11,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.800E+05	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	8.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	not used	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1 000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3 000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3 000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	2.710E-01	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	2.710E-01	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	5.800E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	5.800E+00	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Ra-228	5.800E+00	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): Th-228	5.800E+00	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): Th-230	5.800E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): Th-232	5.800E+00	0.000E+00	---	S1(8)
R012	Initial principal radionuclide (pCi/g): U-234	5.800E+00	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g): U-235	2.710E-01	0.000E+00	---	S1(10)
R012	Initial principal radionuclide (pCi/g): U-238	5.800E+00	0 000E+00	---	S1(11)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0 000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L). Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(9)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(10)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(11)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.510E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-05	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.400E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.700E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	5.550E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	4.050E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	4.520E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	9 900E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.100E+00	1.000E+00	---	PRECIP

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R013	Irrigation (m/yr)	0.000E+00	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	4.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	not used	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	not used	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	not used	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	not used	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	not used	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	not used	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	not used	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	not used	2.000E-02	---	HGWT
R014	Saturated zone b parameter	not used	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	not used	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	not used	1.000E+01	---	DWIBWT
R014	Model. Nondispersion (ND) or Mass-Balance (MB)	not used	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	not used	2.500E+02	---	UW
R015	Number of unsaturated zone strata	not used	1	---	NS
R015	Unsat. zone 1, thickness (m)	not used	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	not used	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	not used	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	not used	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	not used	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	not used	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	not used	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	1.730E+03	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	not used	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	not used	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2 972E-06	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	4.800E+00	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.033E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	2.380E+03	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	not used	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	not used	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.160E-06	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	3.530E+03	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.457E-06	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	3.530E+03	7.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	not used	7.000E+01	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	not used	7.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0 000E+00	1.457E-06	ALEACH(5)
R016	Solubility constant	0.000E+00	0 000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	1.190E+02	6.000E+04	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4 315E-05	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	1.190E+02	6.000E+04	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	not used	6.000E+04	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.315E-05	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	1.190E+02	6.000E+04	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	not used	6.000E+04	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	not used	6 000E+04	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.315E-05	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	2.180E+00	5.000E+01	---	DCNUCC(9)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(9,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.180E-03	ALEACH(9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(9)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	2.180E+00	5.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(10,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.180E-03	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	2.180E+00	5 000E+01	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	not used	5.000E+01	---	DCNUCU(11,1)
R016	Saturated zone (cm**3/g)	not used	5.000E+01	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.180E-03	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R017	Inhalation rate (m**3/yr)	1.140E+04	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	2 500E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5 520E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	1.700E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	6.000E-02	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5.	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7·	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0 000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
	·				
R017	Fractions of annular areas within AREA·				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0 000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	not used	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	not used	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	not used	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	not used	6 300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	not used	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	not used	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	1.825E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	not used	5.100E+02	---	DWI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R018	Contamination fraction of drinking water	not used	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	not used	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	not used	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	not used	5.000E-01	---	FR9
R018	Contamination fraction of plant food	not used	-1	---	FPLANT
R018	Contamination fraction of meat	not used	-1	---	FMEAT
R018	Contamination fraction of milk	not used	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	not used	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	not used	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	not used	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	not used	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	not used	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	not used	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1 500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	not used	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	not used	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	not used	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	not used	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	not used	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	not used	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	not used	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	not used	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	not used	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	not used	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	not used	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	not used	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	not used	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	not used	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	not used	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	not used	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	not used	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	8.894E+01	---	CO2F
STOR	Storage times of contaminated foodstuffs (days)				

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4 500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2 500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	suppressed
4 -- meat ingestion	suppressed
5 -- milk ingestion	suppressed
6 -- aquatic foods	suppressed
7 -- drinking water	suppressed
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	180000.00 square meters	Ac-227	2.710E-01
Thickness:	0 85 meters	Pa-231	2 710E-01
Cover Depth:	0.00 meters	Pb-210	5.800E+00
		Ra-226	5.800E+00
		Ra-228	5.800E+00
		Th-228	5.800E+00
		Th-230	5.800E+00
		Th-232	5.800E+00
		U-234	5.800E+00
		U-235	2.710E-01
		U-238	5.800E+00

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	2 491E+01	2.491E+01	2.490E+01	2.490E+01	2.488E+01	2.480E+01	2.458E+01	2 392E+01
M(t):	9 962E-01	9.962E-01	9 962E-01	9.959E-01	9 951E-01	9.918E-01	9.831E-01	9.569E-01

Maximum TDOSE(t): 2.491E+01 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	8 160E-02	0 0033	2.597E-02	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.657E-02	0.0007
Pa-231	9.191E-03	0.0004	5.438E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.232E-02	0.0005
Pb-210	5 373E-03	0.0002	1.919E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	1.743E-01	0.0070
Ra-226	9 822E+00	0.3944	7.525E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	3.509E-02	0.0014
Ra-228	6 324E+00	0.2539	4.886E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.607E-02	0.0014
Th-228	7.497E+00	0 3010	2.432E-02	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.650E-02	0.0007
Th-230	3.204E-03	0.0001	2.739E-02	0.0011	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.335E-02	0.0005
Th-232	3.621E-01	0 0145	1.380E-01	0.0055	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	6.862E-02	0.0028
U-234	3.578E-04	0.0000	1.108E-02	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.882E-03	0.0003
U-235	3.126E-02	0.0013	4.824E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.035E-04	0.0000
U-238	1.335E-01	0 0054	9.904E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.542E-03	0.0003
Total	2.427E+01	0.9744	2.502E-01	0.0100	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.865E-01	0 0155

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.241E-01	0.0050
Pa-231	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.695E-02	0.0011
Pb-210	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.816E-01	0.0073
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.858E+00	0.3958
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.365E+00	0.2555
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.538E+00	0.3026
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.394E-02	0.0018
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.687E-01	0.0228
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.832E-02	0.0007
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.205E-02	0.0013
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.500E-01	0.0060
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.491E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	7 904E-02	0.0032	2.515E-02	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	1.605E-02	0.0006
Pa-231	1.174E-02	0.0005	6.246E-03	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.282E-02	0.0005
Pb-210	5 209E-03	0 0002	1.861E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.689E-01	0.0068
Ra-226	9.818E+00	0.3942	8.109E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.041E-02	0.0016
Ra-228	7.744E+00	0.3109	1.127E-02	0.0005	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	3.668E-02	0.0015
Th-228	5.218E+00	0.2095	1.693E-02	0.0007	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.149E-02	0.0005
Th-230	7.458E-03	0.0003	2.739E-02	0.0011	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	1.336E-02	0.0005
Th-232	1.220E+00	0.0490	1.390E-01	0.0056	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.302E-02	0.0029
U-234	3.571E-04	0.0000	1 106E-02	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.867E-03	0.0003
U-235	3.119E-02	0.0013	4.815E-04	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.031E-04	0.0000
U-238	1.333E-01	0.0054	9.883E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.528E-03	0.0003
Total	2.427E+01	0.9744	2.501E-01	0.0100	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3 865E-01	0.0155

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.202E-01	0.0048
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.080E-02	0.0012
Pb-210	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.760E-01	0.0071
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.860E+00	0.3959
Ra-228	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	7.792E+00	0.3129
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	5.247E+00	0.2107
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.821E-02	0.0019
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.432E+00	0.0575
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.828E-02	0.0007
U-235	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.198E-02	0.0013
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.497E-01	0.0060
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2 491E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3 000E+00 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	7.416E-02	0.0030	2.360E-02	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	1.506E-02	0.0006
Pa-231	1.658E-02	0.0007	7.782E-03	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.378E-02	0.0006
Pb-210	4 895E-03	0 0002	1.749E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.588E-01	0.0064
Ra-226	9 810E+00	0.3939	9.222E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	5 055E-02	0.0020
Ra-228	8.441E+00	0.3389	1.650E-02	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0 000E+00	0.0000	3.401E-02	0 0014
Th-228	2 528E+00	0.1015	8.200E-03	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	5.564E-03	0.0002
Th-230	1 596E-02	0.0006	2.739E-02	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.340E-02	0 0005
Th-232	3.213E+00	0.1290	1.425E-01	0.0057	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	8.161E-02	0.0033
U-234	3.557E-04	0.0000	1.101E-02	0.0004	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	6.838E-03	0.0003
U-235	3.106E-02	0.0012	4.797E-04	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3 024E-04	0.0000
U-238	1.327E-01	0.0053	9.840E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.499E-03	0.0003
Total	2.427E+01	0.9744	2.500E-01	0 0100	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3 864E-01	0.0155

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.128E-01	0.0045
Pa-231	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.815E-02	0.0015
Pb-210	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.654E-01	0.0066
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	9.862E+00	0.3960
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	8.491E+00	0.3410
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.542E+00	0.1021
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	5.675E-02	0.0023
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.437E+00	0.1380
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.820E-02	0 0007
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	3 184E-02	0 0013
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.490E-01	0.0060
Total	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	2 490E+01	1 0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	5.935E-02	0.0024	1.889E-02	0.0008	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.205E-02	0.0005
Pa-231	3 122E-02	0.0013	1.242E-02	0.0005	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.668E-02	0.0007
Pb-210	3.938E-03	0.0002	1.407E-03	0.0001	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.277E-01	0.0051
Ra-226	9 781E+00	0.3929	1.261E-03	0.0001	0.000E+00	0 0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	8.139E-02	0.0033
Ra-228	4.959E+00	0.1992	1.141E-02	0 0005	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.755E-02	0.0007
Th-228	2.001E-01	0.0080	6.490E-04	0.0000	0.000E+00	0 0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.404E-04	0.0000
Th-230	4.565E-02	0.0018	2.738E-02	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.360E-02	0.0005
Th-232	9.020E+00	0.3623	1.551E-01	0.0062	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1 032E-01	0 0041
U-234	3.522E-04	0.0000	1.084E-02	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.735E-03	0.0003
U-235	3.059E-02	0.0012	4.739E-04	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	3.000E-04	0.0000
U-238	1.307E-01	0.0052	9.691E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	6.401E-03	0.0003
Total	2 426E+01	0.9745	2.495E-01	0 0100	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.860E-01	0.0155

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	9 029E-02	0.0036
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	6 032E-02	0.0024
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.331E-01	0.0053
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.864E+00	0.3962
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.988E+00	0.2003
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.012E-01	0.0081
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	8 664E-02	0.0035
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9 278E+00	0.3727
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.793E-02	0.0007
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.136E-02	0 0013
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.468E-01	0.0059
Total	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	2.490E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	3.140E-02	0.0013	9.991E-03	0 0004	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	6.375E-03	0.0003
Pa-231	5.819E-02	0 0023	2 095E-02	0 0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.194E-02	0.0009
Pb-210	2 115E-03	0.0001	7.554E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0 0000	0.000E+00	0.0000	6.858E-02	0.0028
Ra-226	9.698E+00	0 3899	1 898E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	1.395E-01	0.0056
Ra-228	4.717E-01	0 0190	1.110E-03	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	1.634E-03	0.0001
Th-228	1.425E-04	0.0000	4.622E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	3.136E-07	0 0000
Th-230	1.300E-01	0.0052	2.737E-02	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.457E-02	0.0006
Th-232	1.370E+01	0.5506	1.659E-01	0.0067	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	1.194E-01	0.0048
U-234	3.527E-04	0.0000	1.038E-02	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	6.450E-03	0.0003
U-235	2.930E-02	0.0012	4 608E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.954E-04	0.0000
U-238	1.251E-01	0.0050	9.278E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.128E-03	0.0002
Total	2 424E+01	0 9746	2.481E-01	0.0100	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.849E-01	0.0155

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.776E-02	0 0019
Pa-231	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	1.011E-01	0.0041
Pb-210	0 000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.145E-02	0.0029
Ra-226	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	9.840E+00	0.3955
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.744E-01	0.0191
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.433E-04	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.719E-01	0.0069
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.398E+01	0.5621
U-234	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.719E-02	0.0007
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0 0000	3.006E-02	0.0012
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.405E-01	0.0056
Total	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.488E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	3.380E-03	0.0001	1 076E-03	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	6.865E-04	0.0000
Pa-231	8.072E-02	0.0033	2.795E-02	0 0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.580E-02	0.0010
Pb-210	2.400E-04	0.0000	8 574E-05	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	7.784E-03	0 0003
Ra-226	9.410E+00	0.3795	2.497E-03	0 0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.949E-01	0.0079
Ra-228	1.021E-04	0.0000	2.403E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.536E-07	0 0000
Th-228	1.373E-15	0.0000	4.455E-18	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.023E-18	0.0000
Th-230	4.187E-01	0.0169	2.734E-02	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	1.989E-02	0 0008
Th-232	1.413E+01	0.5697	1 665E-01	0.0067	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.207E-01	0.0049
U-234	4.657E-04	0.0000	8 929E-03	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.546E-03	0 0002
U-235	2.526E-02	0.0010	4.315E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.878E-04	0.0000
U-238	1.074E-01	0.0043	7 967E-03	0 0003	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.262E-03	0 0002
Total	2.417E+01	0.9748	2.428E-01	0.0098	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.809E-01	0 0154

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.143E-03	0.0002
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.345E-01	0.0054
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.110E-03	0.0003
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	9.607E+00	0.3874
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.027E-04	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	1.381E-15	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.659E-01	0.0188
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.441E+01	0 5813
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.494E-02	0.0006
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.598E-02	0.0010
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	1.206E-01	0.0049
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.480E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract	mrem/yr	fract.
Ac-227	5.801E-06	0.0000	1.846E-06	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.178E-06	0.0000
Pa-231	6.820E-02	0.0028	2 354E-02	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.147E-02	0.0009
Pb-210	4.789E-07	0.0000	1.711E-07	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.553E-05	0.0000
Ra-226	8.626E+00	0.3510	2.369E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0 0000	1.859E-01	0.0076
Ra-228	3.454E-15	0.0000	8.130E-18	0 0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.196E-17	0.0000
Th-228	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	1.191E+00	0.0485	2.727E-02	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	3.632E-02	0.0015
Th-232	1.400E+01	0 5698	1.651E-01	0.0067	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	1.196E-01	0.0049
U-234	1.525E-03	0.0001	5.810E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0 000E+00	0.0000	3.626E-03	0.0001
U-235	1.659E-02	0.0007	3.677E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.671E-04	0.0000
U-238	6.944E-02	0 0028	5.155E-03	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	3.405E-03	0.0001
Total	2.398E+01	0 9756	2.296E-01	0.0093	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.707E-01	0.0151

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	8.826E-06	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.132E-01	0.0046
Pb-210	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	1.618E-05	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	8.815E+00	0.3586
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.474E-15	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.255E+00	0.0510
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.429E+01	0.5814
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.096E-02	0.0004
U-235	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.723E-02	0.0007
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	7.800E-02	0.0032
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.458E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	1.215E-15	0.0000	3.866E-16	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	2.467E-16	0.0000
Pa-231	3.262E-02	0 0014	1.126E-02	0.0005	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	1.027E-02	0.0004
Pb-210	1.699E-16	0 0000	6 069E-17	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.510E-15	0.0000
Ra-226	6.363E+00	0 2660	1.748E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	1.372E-01	0.0057
Ra-228	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000
Th-230	3 361E+00	0.1405	2.690E-02	0.0011	0.000E+00	0 0000	0.000E+00	0 0000	0.000E+00	0.0000	0 000E+00	0.0000	8.271E-02	0.0035
Th-232	1 359E+01	0.5680	1.602E-01	0.0067	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.161E-01	0.0049
U-234	8.737E-03	0.0004	1.348E-03	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.002E-03	0.0000
U-235	3.941E-03	0.0002	1.953E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.633E-04	0.0000
U-238	1.510E-02	0.0006	1.123E-03	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.419E-04	0.0000
Total	2.337E+01	0.9770	2.027E-01	0.0085	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.481E-01	0.0146

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.848E-15	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5 414E-02	0.0023
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	5 741E-15	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	6.502E+00	0.2718
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0 0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.471E+00	0.1451
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.386E+01	0.5795
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.109E-02	0.0005
U-235	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.300E-03	0.0002
U-238	0.000E+00	0.0000	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.697E-02	0.0007
Total	0 000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0 0000	2.392E+01	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Branch Fraction*	DSR(j,t) (mrem/yr)/(pCi/g) t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1 000E+03
Ac-227	Ac-227	1.000E+00	4.581E-01	4.437E-01	4.163E-01	3.332E-01	1.762E-01	1.898E-02	3.257E-05	6.820E-15
Pa-231	Pa-231	1.000E+00	9.210E-02	9 200E-02	9 181E-02	9.114E-02	8.924E-02	8 289E-02	6.713E-02	3.210E-02
Pa-231	Ac-227	1.000E+00	7.327E-03	2.166E-02	4 896E-02	1.315E-01	2.838E-01	4.133E-01	3.506E-01	1.677E-01
Pa-231	∑DSR(j)		9.943E-02	1.137E-01	1.408E-01	2.226E-01	3.730E-01	4.962E-01	4.177E-01	1.998E-01
Pb-210	Pb-210	1.000E+00	3.130E-02	3.035E-02	2.852E-02	2.294E-02	1.232E-02	1.398E-03	2.790E-06	9.898E-16
Ra-226	Ra-226	1.000E+00	1.699E+00	1.698E+00	1.697E+00	1.692E+00	1.677E+00	1.627E+00	1.491E+00	1.100E+00
Ra-226	Pb-210	1.000E+00	4.890E-04	1.447E-03	3.274E-03	8.831E-03	1.932E-02	2.945E-02	2 829E-02	2.087E-02
Ra-226	∑DSR(j)		1.700E+00	1.700E+00	1.700E+00	1.701E+00	1.697E+00	1.656E+00	1.520E+00	1.121E+00
Ra-228	Ra-228	1.000E+00	8.577E-01	7.603E-01	5.974E-01	2.569E-01	2.305E-02	4.989E-06	1.688E-16	0.000E+00
Ra-228	Th-228	1.000E+00	2.396E-01	5.832E-01	8.666E-01	6.031E-01	5.874E-02	1.272E-05	4.302E-16	0.000E+00
Ra-228	∑DSR(j)		1.097E+00	1.343E+00	1.464E+00	8.600E-01	8.179E-02	1.771E-05	5.990E-16	0.000E+00
Th-228	Th-228	1.000E+00	1.300E+00	9.046E-01	4.382E-01	3.468E-02	2.470E-05	2.381E-16	0.000E+00	0 000E+00
Th-230	Th-230	1.000E+00	7.208E-03	7.208E-03	7.207E-03	7.205E-03	7.197E-03	7.171E-03	7.097E-03	6 842E-03
Th-230	Ra-226	1.000E+00	3.681E-04	1.104E-03	2.575E-03	7.711E-03	2.229E-02	7.221E-02	2.058E-01	5 809E-01
Th-230	Pb-210	1.000E+00	7.079E-08	4.911E-07	2.544E-06	2.120E-05	1.479E-04	9.420E-04	3.460E-03	1.059E-02
Th-230	∑DSR(j)		7.577E-03	8.313E-03	9.785E-03	1.494E-02	2.964E-02	8.033E-02	2.163E-01	5.984E-01
Th-232	Th-232	1.000E+00	3.530E-02	3.530E-02	3.529E-02	3.528E-02	3.525E-02	3.515E-02	3.484E-02	3.381E-02
Th-232	Ra-228	1.000E+00	5.274E-02	1.501E-01	3.130E-01	6.534E-01	8.865E-01	9.068E-01	8.991E-01	8.723E-01
Th-232	Th-228	1.000E+00	1.002E-02	6.146E-02	2.443E-01	9.111E-01	1.489E+00	1.543E+00	1.530E+00	1.484E+00
Th-232	∑DSR(j)		9.805E-02	2.469E-01	5.926E-01	1.600E+00	2.411E+00	2 485E+00	2.464E+00	2.390E+00
U-234	U-234	1.000E+00	3.159E-03	3.152E-03	3.138E-03	3.090E-03	2.958E-03	2.539E-03	1.641E-03	3.560E-04
U-234	Th-230	1.000E+00	3.242E-08	9.717E-08	2.262E-07	6.734E-07	1.913E-06	5.840E-06	1.418E-05	2.548E-05
U-234	Ra-226	1.000E+00	1.104E-09	7.722E-09	4.074E-08	3.622E-07	3.001E-06	3.064E-05	2.312E-04	1.503E-03
U-234	Pb-210	1.000E+00	1.595E-13	2.375E-12	2.727E-11	6.832E-10	1.431E-08	3.231E-07	3.574E-06	2.694E-05
U-234	∑DSR(j)		3.159E-03	3.152E-03	3.138E-03	3.091E-03	2 963E-03	2.576E-03	1.890E-03	1.911E-03
U-235	U-235	1.000E+00	1.183E-01	1.180E-01	1.175E-01	1.157E-01	1.108E-01	9.509E-02	6.149E-02	1.337E-02
U-235	Pa-231	1.000E+00	9.738E-07	2.917E-06	6.785E-06	2.013E-05	5 661E-05	1.666E-04	3.621E-04	4.077E-04
U-235	Ac-227	1.000E+00	5.179E-08	3.589E-07	1.855E-06	1.534E-05	1.044E-04	6.086E-04	1.713E-03	2.090E-03
U-235	∑DSR(j)		1.183E-01	1.180E-01	1.175E-01	1.157E-01	1.109E-01	9.586E-02	6.356E-02	1.587E-02
U-238	U-238	1.000E+00	2.586E-02	2.580E-02	2.569E-02	2.530E-02	2.422E-02	2.080E-02	1.345E-02	2.923E-03
U-238	U-234	1.000E+00	4.476E-09	1.340E-08	3.113E-08	9.199E-08	2.558E-07	7.235E-07	1.399E-06	1.011E-06
U-238	Th-230	1.000E+00	3.063E-14	2.141E-13	1.129E-12	9.993E-12	8.183E-11	8.023E-10	5.400E-09	2.419E-08
U-238	Ra-226	1.000E+00	7.822E-16	1.172E-14	1 364E-13	3.588E-12	8.566E-11	2.817E-09	5.954E-08	1.026E-06
U-238	Pb-210	1.000E+00	9.052E-20	2.789E-18	6.930E-17	5.160E-15	3.199E-13	2.498E-11	8.473E-10	1.799E-08
U-238	∑DSR(j)		2.586E-02	2.580E-02	2.569E-02	2.530E-02	2.422E-02	2.080E-02	1.345E-02	2.925E-03

*Branch Fraction is the cumulative factor for the j'th principal radionuclide daughter: CUMBRF(j) = BRF(1)*BRF(2)* ... BRF(j).
The DSR includes contributions from associated (half-life ≤ 0.5 yr) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3 000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	5 458E+01	5.634E+01	6.005E+01	7.504E+01	1.419E+02	1.317E+03	7.676E+05	*7 230E+13
Pa-231	2.514E+02	2.199E+02	1.776E+02	1.123E+02	6.702E+01	5 039E+01	5.985E+01	1.251E+02
Pb-210	7.986E+02	8.238E+02	8 767E+02	1.090E+03	2.029E+03	1 788E+04	8 961E+06	*7.631E+13
Ra-226	1.471E+01	1.471E+01	1.470E+01	1.470E+01	1.474E+01	1.509E+01	1.645E+01	2.230E+01
Ra-228	2.278E+01	1.861E+01	1.708E+01	2.907E+01	3.056E+02	1.412E+06	*2.726E+14	*2.726E+14
Th-228	1.924E+01	2.764E+01	5.705E+01	7.208E+02	1.012E+06	*8.192E+14	*8.192E+14	*8.192E+14
Th-230	3.300E+03	3 007E+03	2.555E+03	1.674E+03	8.436E+02	3.112E+02	1.156E+02	4.178E+01
Th-232	2.550E+02	1.013E+02	4.219E+01	1.563E+01	1.037E+01	1.006E+01	1.015E+01	1 046E+01
U-234	7.915E+03	7 932E+03	7.966E+03	8.087E+03	8.437E+03	9 705E+03	1.323E+04	1.308E+04
U-235	2.114E+02	2.119E+02	2 128E+02	2.160E+02	2.254E+02	2.608E+02	3 933E+02	1.576E+03
U-238	9 667E+02	9.688E+02	9.730E+02	9.880E+02	1.032E+03	1.202E+03	1.859E+03	8.546E+03

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	2.710E-01	0.000E+00	4.581E-01	5.458E+01	4.581E-01	5.458E+01
Pa-231	2.710E-01	104.6 ± 0.2	4.964E-01	5.037E+01	9.943E-02	2.514E+02
Pb-210	5.800E+00	0.000E+00	3.130E-02	7.986E+02	3 130E-02	7.986E+02
Ra-226	5 800E+00	8.82 ± 0.02	1.701E+00	1.470E+01	1.700E+00	1.471E+01
Ra-228	5.800E+00	2.703 ± 0.005	1.467E+00	1.704E+01	1.097E+00	2.278E+01
Th-228	5.800E+00	0.000E+00	1 300E+00	1.924E+01	1.300E+00	1.924E+01
Th-230	5.800E+00	1.000E+03	5.984E-01	4.178E+01	7.577E-03	3.300E+03
Th-232	5.800E+00	67.5 ± 0.1	2.488E+00	1.005E+01	9.805E-02	2.550E+02
U-234	5.800E+00	0.000E+00	3.159E-03	7.915E+03	3 159E-03	7.915E+03
U-235	2.710E-01	0.000E+00	1.183E-01	2.114E+02	1.183E-01	2.114E+02
U-238	5.800E+00	0.000E+00	2.586E-02	9.667E+02	2.586E-02	9.667E+02

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	1.241E-01	1.202E-01	1.128E-01	9.029E-02	4.776E-02	5.143E-03	8.826E-06	1.848E-15
Ac-227	Pa-231	1.000E+00	1.986E-03	5.871E-03	1.327E-02	3.562E-02	7.691E-02	1.120E-01	9.501E-02	4.544E-02
Ac-227	U-235	1.000E+00	1.404E-08	9.727E-08	5.028E-07	4.156E-06	2.830E-05	1.649E-04	4.642E-04	5.665E-04
Ac-227	∑DOSE(j)		1.261E-01	1.261E-01	1.261E-01	1.259E-01	1.247E-01	1.173E-01	9.548E-02	4.600E-02
Pa-231	Pa-231	1.000E+00	2.496E-02	2.493E-02	2.488E-02	2.470E-02	2.418E-02	2.246E-02	1.819E-02	8.700E-03
Pa-231	U-235	1.000E+00	2.639E-07	7.906E-07	1.839E-06	5.455E-06	1.534E-05	4.516E-05	9.814E-05	1.105E-04
Pa-231	∑DOSE(j)		2.496E-02	2.493E-02	2.488E-02	2.470E-02	2.420E-02	2.251E-02	1.829E-02	8.810E-03
Pb-210	Pb-210	1.000E+00	1.816E-01	1.760E-01	1.654E-01	1.331E-01	7.145E-02	8.110E-03	1.618E-05	5.741E-15
Pb-210	Ra-226	1.000E+00	2.836E-03	8.390E-03	1.899E-02	5.122E-02	1.121E-01	1.708E-01	1.641E-01	1.211E-01
Pb-210	Th-230	1.000E+00	4.106E-07	2.849E-06	1.476E-05	1.230E-04	8.578E-04	5.463E-03	2.007E-02	6.144E-02
Pb-210	U-234	1.000E+00	9.251E-13	1.378E-11	1.582E-10	3.962E-09	8.298E-08	1.874E-06	2.073E-05	1.562E-04
Pb-210	U-238	1.000E+00	5.250E-19	1.617E-17	4.020E-16	2.993E-14	1.855E-12	1.449E-10	4.914E-09	1.043E-07
Pb-210	∑DOSE(j)		1.844E-01	1.844E-01	1.844E-01	1.844E-01	1.844E-01	1.844E-01	1.842E-01	1.827E-01
Ra-226	Ra-226	1.000E+00	9.855E+00	9.851E+00	9.843E+00	9.813E+00	9.728E+00	9.436E+00	8.651E+00	6.381E+00
Ra-226	Th-230	1.000E+00	2.135E-03	6.403E-03	1.493E-02	4.473E-02	1.293E-01	4.188E-01	1.193E+00	3.370E+00
Ra-226	U-234	1.000E+00	6.403E-09	4.479E-08	2.363E-07	2.101E-06	1.740E-05	1.777E-04	1.341E-03	8.717E-03
Ra-226	U-238	1.000E+00	4.537E-15	6.798E-14	7.912E-13	2.081E-11	4.968E-10	1.634E-08	3.454E-07	5.948E-06
Ra-226	∑DOSE(j)		9.858E+00	9.858E+00	9.858E+00	9.857E+00	9.857E+00	9.855E+00	9.845E+00	9.759E+00
Ra-228	Ra-228	1.000E+00	4.975E+00	4.410E+00	3.465E+00	1.490E+00	1.337E-01	2.893E-05	9.788E-16	0.000E+00
Ra-228	Th-232	1.000E+00	3.059E-01	8.708E-01	1.815E+00	3.789E+00	5.142E+00	5.260E+00	5.215E+00	5.059E+00
Ra-228	∑DOSE(j)		5.281E+00	5.281E+00	5.281E+00	5.280E+00	5.276E+00	5.260E+00	5.215E+00	5.059E+00
Th-228	Ra-228	1.000E+00	1.390E+00	3.382E+00	5.026E+00	3.498E+00	3.407E-01	7.377E-05	2.495E-15	0.000E+00
Th-228	Th-228	1.000E+00	7.538E+00	5.247E+00	2.542E+00	2.012E-01	1.433E-04	1.381E-15	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	5.810E-02	3.564E-01	1.417E+00	5.284E+00	8.636E+00	8.950E+00	8.873E+00	8.609E+00
Th-228	∑DOSE(j)		8.986E+00	8.985E+00	8.985E+00	8.983E+00	8.977E+00	8.950E+00	8.873E+00	8.609E+00
Th-230	Th-230	1.000E+00	4.181E-02	4.181E-02	4.180E-02	4.179E-02	4.174E-02	4.159E-02	4.116E-02	3.968E-02
Th-230	U-234	1.000E+00	1.880E-07	5.636E-07	1.312E-06	3.906E-06	1.110E-05	3.387E-05	8.223E-05	1.478E-04
Th-230	U-238	1.000E+00	1.776E-13	1.242E-12	6.546E-12	5.796E-11	4.746E-10	4.654E-09	3.132E-08	1.403E-07
Th-230	∑DOSE(j)		4.181E-02	4.181E-02	4.180E-02	4.179E-02	4.175E-02	4.163E-02	4.124E-02	3.983E-02
Th-232	Th-232	1.000E+00	2.047E-01	2.047E-01	2.047E-01	2.046E-01	2.045E-01	2.038E-01	2.021E-01	1.961E-01
U-234	U-234	1.000E+00	1.832E-02	1.828E-02	1.820E-02	1.792E-02	1.716E-02	1.473E-02	9.517E-03	2.065E-03
U-234	U-238	1.000E+00	2.596E-08	7.772E-08	1.806E-07	5.335E-07	1.484E-06	4.196E-06	8.111E-06	5.865E-06
U-234	∑DOSE(j)		1.832E-02	1.828E-02	1.820E-02	1.792E-02	1.716E-02	1.473E-02	9.525E-03	2.071E-03
U-235	U-235	1.000E+00	3.205E-02	3.198E-02	3.184E-02	3.135E-02	3.002E-02	2.577E-02	1.666E-02	3.623E-03
U-238	U-238	1.000E+00	1.500E-01	1.497E-01	1.490E-01	1.468E-01	1.405E-01	1.206E-01	7.799E-02	1.696E-02

BRF(i) is the branch fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	BRF(i)	S(j,t), pCi/g t= 0 000E+00	1.000E+00	3.000E+00	1 000E+01	3.000E+01	1.000E+02	3.000E+02	1 000E+03
Ac-227	Ac-227	1.000E+00	2 710E-01	2.625E-01	2 463E-01	1.971E-01	1.043E-01	1.123E-02	1.927E-05	4 035E-15
Ac-227	Pa-231	1.000E+00	0.000E+00	8.487E-03	2.464E-02	7.348E-02	1.637E-01	2.406E-01	2.043E-01	9 768E-02
Ac-227	U-235	1.000E+00	0 000E+00	9.021E-08	7.933E-07	8.140E-06	5.912E-05	3.522E-04	9 964E-04	1 218E-03
Ac-227	∑S(j)·		2.710E-01	2.710E-01	2.710E-01	2.706E-01	2.680E-01	2.522E-01	2.053E-01	9 890E-02
Pa-231	Pa-231	1.000E+00	2.710E-01	2.707E-01	2.701E-01	2.682E-01	2.626E-01	2.439E-01	1.975E-01	9 446E-02
Pa-231	U-235	1.000E+00	0.000E+00	5.725E-06	1.712E-05	5.642E-05	1.639E-04	4.880E-04	1.064E-03	1 199E-03
Pa-231	∑S(j):		2.710E-01	2.707E-01	2.702E-01	2.682E-01	2.627E-01	2.444E-01	1.986E-01	9 566E-02
Pb-210	Pb-210	1.000E+00	5.800E+00	5.622E+00	5.284E+00	4 250E+00	2.283E+00	2.591E-01	5.169E-04	1.834E-13
Pb-210	Ra-226	1.000E+00	0.000E+00	1.775E-01	5.160E-01	1.546E+00	3.491E+00	5.369E+00	5.162E+00	3.808E+00
Pb-210	Th-230	1.000E+00	0.000E+00	3.864E-05	3.406E-04	3.524E-03	2.622E-02	1.707E-01	6.302E-01	1.932E+00
Pb-210	U-234	1.000E+00	0.000E+00	1.162E-10	3.085E-09	1.079E-07	2.492E-06	5.823E-05	6.498E-04	4.911E-03
Pb-210	U-238	1.000E+00	0.000E+00	8.245E-17	6.584E-15	7.738E-13	5.478E-11	4.479E-09	1.538E-07	3.278E-06
Pb-210	∑S(j):		5.800E+00	5.800E+00	5.800E+00	5.800E+00	5.800E+00	5.799E+00	5.794E+00	5.745E+00
Ra-226	Ra-226	1.000E+00	5.800E+00	5 797E+00	5.792E+00	5.775E+00	5.725E+00	5.553E+00	5.091E+00	3.755E+00
Ra-226	Th-230	1 000E+00	0.000E+00	2.512E-03	7.532E-03	2.507E-02	7.483E-02	2.452E-01	7.011E-01	1.982E+00
Ra-226	U-234	1 000E+00	0.000E+00	1.130E-08	1.015E-07	1.121E-06	9 911E-06	1.036E-04	7.868E-04	5.126E-03
Ra-226	U-238	1.000E+00	0.000E+00	1.067E-14	2.875E-13	1.056E-11	2.783E-10	9.476E-09	2.023E-07	3.496E-06
Ra-226	∑S(j):		5.800E+00	5.800E+00	5.800E+00	5.800E+00	5.800E+00	5.799E+00	5.793E+00	5.742E+00
Ra-228	Ra-228	1.000E+00	5.800E+00	5 141E+00	4.040E+00	1.737E+00	1.559E-01	3.373E-05	1.141E-15	0.000E+00
Ra-228	Th-232	1.000E+00	0.000E+00	6.587E-01	1.760E+00	4.062E+00	5.639E+00	5.777E+00	5 727E+00	5.557E+00
Ra-228	∑S(j):		5.800E+00	5.800E+00	5.800E+00	5.799E+00	5.794E+00	5.777E+00	5 727E+00	5.557E+00
Th-228	Ra-228	1.000E+00	0.000E+00	1.655E+00	3.123E+00	2.371E+00	2.334E-01	5.054E-05	1 710E-15	0.000E+00
Th-228	Th-228	1.000E+00	5.800E+00	4.037E+00	1.956E+00	1.548E-01	1.102E-04	1.063E-15	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.081E-01	7.210E-01	3.273E+00	5.561E+00	5.777E+00	5 727E+00	5.557E+00
Th-228	∑S(j):		5.800E+00	5.800E+00	5.799E+00	5.799E+00	5.794E+00	5.777E+00	5.727E+00	5.557E+00
Th-230	Th-230	1.000E+00	5.800E+00	5.800E+00	5.799E+00	5.797E+00	5.791E+00	5.770E+00	5.710E+00	5.505E+00
Th-230	U-234	1.000E+00	0.000E+00	5.215E-05	1.561E-04	5.163E-04	1.515E-03	4.678E-03	1.139E-02	2.050E-02
Th-230	U-238	1.000E+00	0.000E+00	7.390E-11	6.631E-10	7 293E-09	6.374E-08	6.396E-07	4 333E-06	1.946E-05
Th-230	∑S(j):		5.800E+00	5.800E+00	5.799E+00	5.797E+00	5.792E+00	5.775E+00	5 721E+00	5.526E+00
Th-232	Th-232	1.000E+00	5 800E+00	5.800E+00	5.799E+00	5.797E+00	5.792E+00	5.775E+00	5.725E+00	5.555E+00
U-234	U-234	1.000E+00	5.800E+00	5.787E+00	5 762E+00	5.675E+00	5.432E+00	4.663E+00	3.013E+00	6.538E-01
U-234	U-238	1.000E+00	0.000E+00	1.641E-05	4.901E-05	1.609E-04	4.620E-04	1.322E-03	2.564E-03	1.856E-03
U-234	∑S(j)·		5 800E+00	5.787E+00	5.762E+00	5.675E+00	5.433E+00	4.664E+00	3.016E+00	6.556E-01
U-235	U-235	1.000E+00	2.710E-01	2.704E-01	2.692E-01	2.652E-01	2.538E-01	2.179E-01	1.409E-01	3.063E-02
U-238	U-238	1.000E+00	5.800E+00	5.787E+00	5.762E+00	5.675E+00	5.433E+00	4.664E+00	3.016E+00	6 556E-01

BRF(i) is the branch fraction of the parent nuclide.

RESCALC.EXE execution time = 20.04 seconds

Appendix 5-2

RESRAD $DCGL_{EMC}$ Values

Table 1 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 1000 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,083	0
U-234	10,670	0
U-235 (Th-231)	230	0
Pa-231	284	0
Ac-227 (Th-227 to stable Pb-207)	63.9	0
Th-232	303	0
Th-230	4,526	0
Th-228 (Ra-224 to stable Pb-208)	21	0
Ra-226 (Rn-222 to Po-210)	16.1	0
Ra-228 (Ac-228)	25	0
Pb-210 (Bi-210 thru Stable Pb-206)	804	0

Table 2 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 750 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,106	0
U-234	12,430	0
U-235 (Th-231)	232	0
Pa-231	328	0
Ac-227 (Th-227 to stable Pb-207)	67.1	0
Th-232	318	0
Th-230	5,143	0
Th-228 (Ra-224 to stable Pb-208)	21.2	0
Ra-226 (Rn-222 to Po-210)	16.3	0
Ra-228 (Ac-228)	25.2	0
Pb-210 (Bi-210 thru Stable Pb-206)	1,061	0

Table 3 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 500 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero(pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,132	0
U-234	14,990	0
U-235 (Th-231)	234	0
Pa-231	389	0
Ac-227 (Th-227 to stable Pb-207)	70.8	0
Th-232	336	0
Th-230	6,000	0
Th-228 (Ra-224 to stable Pb-208)	21.5	0
Ra-226 (Rn-222 to Po-210)	16.4	0
Ra-228 (Ac-228)	25.6	0
Pb-210 (Bi-210 thru Stable Pb-206)	1,559	0

Table 4 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 250 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,189	0
U-234	19,300	0
U-235 (Th-231)	242	0
Pa-231	489	0
Ac-227 (Th-227 to stable Pb-207)	76.8	0
Th-232	365	0
Th-230	7,374	0
Th-228 (Ra-224 to stable Pb-208)	22.4	0
Ra-226 (Rn-222 to Po-210)	17.1	0
Ra-228 (Ac-228)	26.6	0
Pb-210 (Bi-210 thru Stable Pb-206)	2,944	0

Table 5 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 100 m^2 Area

Radionuclide and Progeny	Industrial Worker [a]$DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,285	0
U-234	24,430	0
U-235 (Th-231)	258	0
Pa-231	602	0
Ac-227 (Th-227 to stable Pb-207)	84.8	0
Th-232	403	0
Th-230	8,966	0
Th-228 (Ra-224 to stable Pb-208)	24.1	0
Ra-226 (Rn-222 to Po-210)	18.3	0
Ra-228 (Ac-228)	28.5	0
Pb-210 (Bi-210 thru Stable Pb-206)	6,373	0

Table 6 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 75 m^2 Area

Radionuclide and Progeny	Industrial Worker [a]$DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,338	0
U-234	25,900	0
U-235 (Th-231)	269	0
Pa-231	641	0
Ac-227 (Th-227 to stable Pb-207)	88.4	0
Th-232	421	0
Th-230	9,445	0
Th-228 (Ra-224 to stable Pb-208)	25.1	0
Ra-226 (Rn-222 to Po-210)	19.1	0
Ra-228 (Ac-228)	29.7	0
Pb-210 (Bi-210 thru Stable Pb-206)	7,960	0

Table 7 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 50 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,408	0
U-234	27,880	0
U-235 (Th-231)	282	0
Pa-231	692	0
Ac-227 (Th-227 to stable Pb-207)	93.2	0
Th-232	445	0
Th-230	10,090	0
Th-228 (Ra-224 to stable Pb-208)	26.5	0
Ra-226 (Rn-222 to Po-210)	20.1	0
Ra-228 (Ac-228)	31.3	0
Pb-210 (Bi-210 thru Stable Pb-206)	10,630	0

Table 8 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 25 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	1,640	0
U-234	31,170	0
U-235 (Th-231)	328	0
Pa-231	811	0
Ac-227 (Th-227 to stable Pb-207)	108	0
Th-232	516	0
Th-230	11,280	0
Th-228 (Ra-224 to stable Pb-208)	31.1	0
Ra-226 (Rn-222 to Po-210)	23.5	0
Ra-228 (Ac-228)	36.7	0
Pb-210 (Bi-210 thru Stable Pb-206)	16,680	0

Table 9 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 10 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	2,156	0
U-234	35,530	0
U-235 (Th-231)	430	0
Pa-231	1,038	0
Ac-227 (Th-227 to stable Pb-207)	138	0
Th-232	665	0
Th-230	13,020	0
Th-228 (Ra-224 to stable Pb-208)	41.8	0
Ra-226 (Rn-222 to Po-210)	31.4	0
Ra-228 (Ac-228)	48.9	0
Pb-210 (Bi-210 thru Stable Pb-206)	27,840	0

Table 10 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 5 m^2 Area

Radionuclide and Progeny	Industrial Worker [a]$DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	3,173	0
U-234	39,210	0
U-235 (Th-231)	641	0
Pa-231	1,406	0
Ac-227 (Th-227 to stable Pb-207)	194	0
Th-232	923	0
Th-230	14,730	0
Th-228 (Ra-224 to stable Pb-208)	63	0
Ra-226 (Rn-222 to Po-210)	47.3	0
Ra-228 (Ac-228)	73.7	0
Pb-210 (Bi-210 thru Stable Pb-206)	42,840	0

Table 11 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 1 m^2 Area

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero (pCi/g)	Time of Maximum Dose (Years)
U-238 (Th-234, Pa-234m, Pa-234)	8,640	0
U-234	48,330	0
U-235 (Th-231)	1,865	0
Pa-231	2,741	0
Ac-227 (Th-227 to stable Pb-207)	427	0
Th-232	1,973	0
Th-230	18,970	0
Th-228 (Ra-224 to stable Pb-208)	195	0
Ra-226 (Rn-222 to Po-210)	145	0
Ra-228 (Ac-228)	226	0
Pb-210 (Bi-210 thru Stable Pb-206)	105,000	0

Appendix 5-3

RESRAD-BUILD Summary Report

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld

RESRAD-BUILD Table of Contents

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld

RESRAD-BUILD Input Parameters

Number of Sources : 6
Number of Receptors: 1
Total Time : 3.652500E+02 days
Fraction Inside : 1.700000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	4.000	4.000	1.000	1.000	3.12E+01	1.12E-04

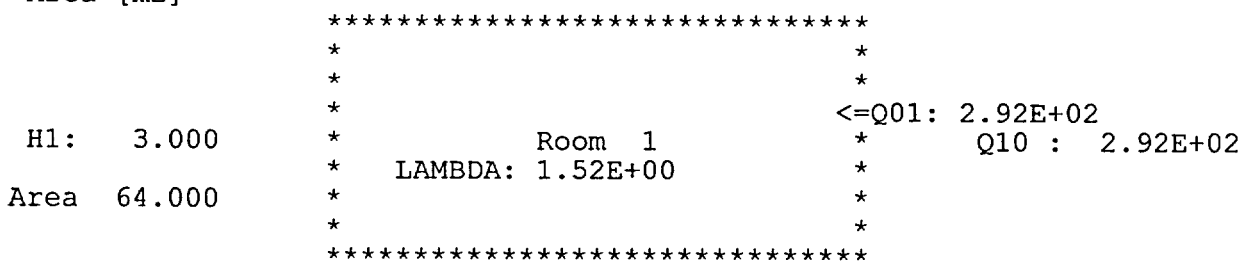
Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete
1	2	2.40E+00	0.00E+00	Concrete
1	3	2.40E+00	0.00E+00	Concrete
1	4	2.40E+00	0.00E+00	Concrete
1	5	2.40E+00	0.00E+00	Concrete
1	6	2.40E+00	0.00E+00	Concrete

Building Information

Building Air Exchange Rate: 1.52E+00 1/hr

Height[m] Air Exchanges [m3/hr]
Area [m2]



Deposition velocity: 3.90E-04 [m/s] Resuspension Rate: 6.30E-08 [1/s]

Source Information

Source: 1
Location:: Room : 1 x: 4.00 y: 4.00 z: 0.00[m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Source: 2
Location:: Room : 1 x: 4.00 y: 4.00 z: 3.00[m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Source: 3
Location:: Room : 1 x: 0.00 y: 4.00 z: 1.50[m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Source: 4
Location:: Room : 1 x: 8.00 y: 4.00 z: 1.50[m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Source: 5
Location:: Room : 1 x: 4.00 y: 0.00 z: 1.50[m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Source: 6
Location:: Room : 1 x: 4.00 y: 8.00 z: 1.50[m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 0.000E+00

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library:		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	8.010E+04	2.690E-04	1.180E-01	1.600E-04
U-235	3.770E+03	2.670E-04	1.230E-01	9.030E-04
U-234	8.010E+04	2.830E-04	1.320E-01	8.930E-07
PA-231	3.770E+03	1.060E-02	1.280E+00	2.010E-04
TH-232	8.010E+04	2.730E-03	1.640E+00	1.020E-06
TH-230	8.010E+04	5.480E-04	3.260E-01	2.040E-06
TH-228	8.010E+04	8.080E-04	3.450E-01	9.410E-03
AC-227	3.770E+03	1.480E-02	6.720E+00	2.160E-03
RA-228	8.010E+04	1.440E-03	5.080E-03	5.590E-03
RA-226	8.010E+04	1.330E-03	8.600E-03	1.040E-02
PB-210	8.010E+04	7.270E-03	2.320E-02	1.050E-05

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 4.00 y: 4.00 z: 0.00 [m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	8.010E+04
U-235	3.770E+03
U-234	8.010E+04
PA-231	3.770E+03
TH-232	8.010E+04
TH-230	8.010E+04
TH-228	8.010E+04
AC-227	3.770E+03
RA-228	8.010E+04
RA-226	8.010E+04
PB-210	8.010E+04

Source: 2
Location:: Room : 1 x: 4.00 y: 4.00 z: 3.00 [m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]

U-238	8.010E+04
U-235	3.770E+03
U-234	8.010E+04
PA-231	3.770E+03
TH-232	8.010E+04
TH-230	8.010E+04
TH-228	8.010E+04
AC-227	3.770E+03
RA-228	8.010E+04
RA-226	8.010E+04
PB-210	8.010E+04

Source: 3
Location:: Room : 1 x: 0.00 y: 4.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	8.010E+04
U-235	3.770E+03
U-234	8.010E+04
PA-231	3.770E+03
TH-232	8.010E+04
TH-230	8.010E+04
TH-228	8.010E+04
AC-227	3.770E+03
RA-228	8.010E+04
RA-226	8.010E+04
PB-210	8.010E+04

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

Source: 4
Location:: Room : 1 x: 8.00 y: 4.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	8.010E+04
	U-235	3.770E+03
	U-234	8.010E+04
	PA-231	3.770E+03
	TH-232	8.010E+04
	TH-230	8.010E+04
	TH-228	8.010E+04
	AC-227	3.770E+03
	RA-228	8.010E+04
	RA-226	8.010E+04
	PB-210	8.010E+04

Source: 5
Location:: Room : 1 x: 4.00 y: 0.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	8.010E+04
	U-235	3.770E+03
	U-234	8.010E+04
	PA-231	3.770E+03
	TH-232	8.010E+04
	TH-230	8.010E+04
	TH-228	8.010E+04
	AC-227	3.770E+03
	RA-228	8.010E+04
	RA-226	8.010E+04

PB-210 8.010E+04

Source: 6
Location:: Room : 1 x: 4.00 y: 8.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 3.000E-02
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	8.010E+04
	U-235	3.770E+03
	U-234	8.010E+04
	PA-231	3.770E+03
	TH-232	8.010E+04
	TH-230	8.010E+04
	TH-228	8.010E+04
	AC-227	3.770E+03
	RA-228	8.010E+04
	RA-226	8.010E+04
	PB-210	8.010E+04

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	8.14E+00	7.37E+00	2.59E+00	2.59E+00	2.59E+00	2.59E+00	2.59E+01
Total	8.14E+00	7.37E+00	2.59E+00	2.59E+00	2.59E+00	2.59E+00	2.59E+01

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.87E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.77E+00
Total	1.87E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.77E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.10E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.77E+00
Total	1.10E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.77E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.63E-01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.25E-01	2.25E-01
U-234	3.30E-07	3.30E-07
TH-230	2.35E-12	2.35E-12
U-235		
U-235	1.40E-02	1.40E-02
PA-231	1.57E-06	1.57E-06
AC-227	6.28E-08	6.28E-08
U-234		
U-234	2.33E-01	2.33E-01
TH-230	2.51E-06	2.51E-06
RA-226	6.01E-10	6.01E-10
PB-210	4.09E-12	4.09E-12
PA-231		
PA-231	1.48E-01	1.48E-01
AC-227	8.88E-03	8.88E-03
TH-232		
TH-232	2.80E+00	2.80E+00
TH-228	7.93E-03	7.93E-03
RA-228	3.48E-02	3.48E-02
TH-230		
TH-230	5.57E-01	5.57E-01
RA-226	2.00E-04	2.00E-04
PB-210	1.89E-06	1.89E-06
TH-228		
TH-228	1.03E+00	1.03E+00
AC-227		
AC-227	5.55E-01	5.55E-01
RA-228		
TH-228	1.90E-01	1.90E-01
RA-228	5.66E-01	5.66E-01
RA-226		
RA-226	9.26E-01	9.26E-01
PB-210	1.30E-02	1.30E-02
PB-210		
PB-210	8.34E-01	8.34E-01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

Source: 2

Nuclide	Receptor 1	Total
U-238		
U-238	2.18E-01	2.18E-01
U-234	3.29E-07	3.29E-07
TH-230	2.35E-12	2.35E-12
U-235		
U-235	1.24E-02	1.24E-02
PA-231	1.56E-06	1.56E-06
AC-227	6.24E-08	6.24E-08
U-234		
U-234	2.32E-01	2.32E-01
TH-230	2.50E-06	2.50E-06
RA-226	3.98E-10	3.98E-10
PB-210	4.08E-12	4.08E-12
PA-231		
PA-231	1.48E-01	1.48E-01
AC-227	8.83E-03	8.83E-03
TH-232		
TH-232	2.80E+00	2.80E+00
TH-228	6.24E-03	6.24E-03
RA-228	2.45E-02	2.45E-02
TH-230		
TH-230	5.57E-01	5.57E-01
RA-226	1.33E-04	1.33E-04
PB-210	1.88E-06	1.88E-06
TH-228		
TH-228	8.10E-01	8.10E-01
AC-227		
AC-227	5.52E-01	5.52E-01
RA-228		
TH-228	1.49E-01	1.49E-01
RA-228	3.98E-01	3.98E-01
RA-226		
RA-226	6.12E-01	6.12E-01
PB-210	1.30E-02	1.30E-02
PB-210		
PB-210	8.33E-01	8.33E-01

Source: 3

Nuclide	Receptor 1	Total
U-238		
U-238	8.04E-02	8.04E-02

U-234	1.23E-07	1.23E-07
TH-230	8.80E-13	8.80E-13
U-235		
U-235	4.30E-03	4.30E-03
PA-231	5.85E-07	5.85E-07
AC-227	2.33E-08	2.33E-08
U-234		
U-234	8.71E-02	8.71E-02
TH-230	9.39E-07	9.39E-07
RA-226	1.03E-10	1.03E-10
PB-210	1.53E-12	1.53E-12
PA-231		
PA-231	5.53E-02	5.53E-02
AC-227	3.30E-03	3.30E-03
TH-232		
TH-232	1.05E+00	1.05E+00
TH-228	1.96E-03	1.96E-03
RA-228	6.84E-03	6.84E-03
TH-230		
TH-230	2.09E-01	2.09E-01
RA-226	3.42E-05	3.42E-05
PB-210	7.05E-07	7.05E-07
TH-228		
TH-228	2.54E-01	2.54E-01
AC-227		
AC-227	2.06E-01	2.06E-01
RA-228		
TH-228	4.68E-02	4.68E-02
RA-228	1.11E-01	1.11E-01
RA-226		
RA-226	1.58E-01	1.58E-01
PB-210	4.87E-03	4.87E-03
PB-210		
PB-210	3.12E-01	3.12E-01

Source: 4

Nuclide	Receptor 1	Total
U-238		
U-238	8.04E-02	8.04E-02
U-234	1.23E-07	1.23E-07
TH-230	8.80E-13	8.80E-13
U-235		
U-235	4.30E-03	4.30E-03
PA-231	5.85E-07	5.85E-07
AC-227	2.33E-08	2.33E-08
U-234		
U-234	8.71E-02	8.71E-02
TH-230	9.39E-07	9.39E-07

RA-226	1.03E-10	1.03E-10
PB-210	1.53E-12	1.53E-12
PA-231		
PA-231	5.53E-02	5.53E-02
AC-227	3.30E-03	3.30E-03
TH-232		
TH-232	1.05E+00	1.05E+00
TH-228	1.96E-03	1.96E-03
RA-228	6.84E-03	6.84E-03
TH-230		
TH-230	2.09E-01	2.09E-01
RA-226	3.42E-05	3.42E-05
PB-210	7.05E-07	7.05E-07
TH-228		
TH-228	2.54E-01	2.54E-01
AC-227		
AC-227	2.06E-01	2.06E-01
RA-228		
TH-228	4.68E-02	4.68E-02
RA-228	1.11E-01	1.11E-01
RA-226		
RA-226	1.58E-01	1.58E-01
PB-210	4.87E-03	4.87E-03
PB-210		
PB-210	3.12E-01	3.12E-01

Source: 5

Nuclide	Receptor 1	Total
U-238		
U-238	8.04E-02	8.04E-02
U-234	1.23E-07	1.23E-07
TH-230	8.80E-13	8.80E-13
U-235		
U-235	4.30E-03	4.30E-03
PA-231	5.85E-07	5.85E-07
AC-227	2.33E-08	2.33E-08
U-234		
U-234	8.71E-02	8.71E-02
TH-230	9.39E-07	9.39E-07
RA-226	1.03E-10	1.03E-10
PB-210	1.53E-12	1.53E-12
PA-231		
PA-231	5.53E-02	5.53E-02
AC-227	3.30E-03	3.30E-03
TH-232		
TH-232	1.05E+00	1.05E+00
TH-228	1.96E-03	1.96E-03
RA-228	6.84E-03	6.84E-03

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 0.00000000E+00 years

TH-230		
TH-230	2.09E-01	2.09E-01
RA-226	3.42E-05	3.42E-05
PB-210	7.05E-07	7.05E-07
TH-228		
TH-228	2.54E-01	2.54E-01
AC-227		
AC-227	2.06E-01	2.06E-01
RA-228		
TH-228	4.68E-02	4.68E-02
RA-228	1.11E-01	1.11E-01
RA-226		
RA-226	1.58E-01	1.58E-01
PB-210	4.87E-03	4.87E-03
PB-210		
PB-210	3.12E-01	3.12E-01

Source: 6

Nuclide	Receptor 1	Total
U-238		
U-238	8.04E-02	8.04E-02
U-234	1.23E-07	1.23E-07
TH-230	8.80E-13	8.80E-13
U-235		
U-235	4.30E-03	4.30E-03
PA-231	5.85E-07	5.85E-07
AC-227	2.33E-08	2.33E-08
U-234		
U-234	8.71E-02	8.71E-02
TH-230	9.39E-07	9.39E-07
RA-226	1.03E-10	1.03E-10
PB-210	1.53E-12	1.53E-12
PA-231		
PA-231	5.53E-02	5.53E-02
AC-227	3.30E-03	3.30E-03
TH-232		
TH-232	1.05E+00	1.05E+00
TH-228	1.96E-03	1.96E-03
RA-228	6.84E-03	6.84E-03
TH-230		
TH-230	2.09E-01	2.09E-01
RA-226	3.42E-05	3.42E-05
PB-210	7.05E-07	7.05E-07
TH-228		
TH-228	2.54E-01	2.54E-01
AC-227		
AC-227	2.06E-01	2.06E-01
RA-228		

TH-228	4.68E-02	4.68E-02
RA-228	1.11E-01	1.11E-01
RA-226		
RA-226	1.58E-01	1.58E-01
PB-210	4.87E-03	4.87E-03
PB-210		
PB-210	3.12E-01	3.12E-01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

Assessment for Time: 2
Time =1.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 4.00 y: 4.00 z: 0.00 [m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination:: Nuclide	Concentration [pCi/m2]
U-238	8.001E+04
U-235	3.766E+03
U-234	8.001E+04
PA-231	3.766E+03
TH-232	8.001E+04
TH-230	8.001E+04
TH-228	8.001E+04
AC-227	3.766E+03
RA-228	8.001E+04
RA-226	8.001E+04
PB-210	8.001E+04

Source: 2
Location:: Room : 1 x: 4.00 y: 4.00 z: 3.00 [m]
Geometry:: Type: Area Area:6.40E+01 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination:: Nuclide	Concentration [pCi/m2]

U-238	8.001E+04
U-235	3.766E+03
U-234	8.001E+04
PA-231	3.766E+03
TH-232	8.001E+04
TH-230	8.001E+04
TH-228	8.001E+04
AC-227	3.766E+03
RA-228	8.001E+04
RA-226	8.001E+04
PB-210	8.001E+04

Source: 3
Location:: Room : 1 x: 0.00 y: 4.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	8.001E+04
U-235	3.766E+03
U-234	8.001E+04
PA-231	3.766E+03
TH-232	8.001E+04
TH-230	8.001E+04
TH-228	8.001E+04
AC-227	3.766E+03
RA-228	8.001E+04
RA-226	8.001E+04
PB-210	8.001E+04

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

Source: 4
Location:: Room : 1 x: 8.00 y: 4.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	8.001E+04
	U-235	3.766E+03
	U-234	8.001E+04
	PA-231	3.766E+03
	TH-232	8.001E+04
	TH-230	8.001E+04
	TH-228	8.001E+04
	AC-227	3.766E+03
	RA-228	8.001E+04
	RA-226	8.001E+04
	PB-210	8.001E+04

Source: 5
Location:: Room : 1 x: 4.00 y: 0.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	8.001E+04
	U-235	3.766E+03
	U-234	8.001E+04
	PA-231	3.766E+03
	TH-232	8.001E+04
	TH-230	8.001E+04
	TH-228	8.001E+04
	AC-227	3.766E+03
	RA-228	8.001E+04
	RA-226	8.001E+04

PB-210 8.001E+04

Source: 6
Location:: Room : 1 x: 4.00 y: 8.00 z: 1.50 [m]
Geometry:: Type: Area Area:2.40E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 4.910E-07 [1/hr]
Fraction released to air: 3.570E-01
Removable fraction: 2.894E-02
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	8.001E+04
U-235	3.766E+03
U-234	8.001E+04
PA-231	3.766E+03
TH-232	8.001E+04
TH-230	8.001E+04
TH-228	8.001E+04
AC-227	3.766E+03
RA-228	8.001E+04
RA-226	8.001E+04
PB-210	8.001E+04

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	8.07E+00	7.30E+00	2.56E+00	2.56E+00	2.56E+00	2.56E+00	2.56E+01
Total	8.07E+00	7.30E+00	2.56E+00	2.56E+00	2.56E+00	2.56E+00	2.56E+01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.87E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.70E+00
Total	1.87E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.70E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.10E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.70E+00
Total	1.10E+00	1.04E-04	3.36E-06	4.50E+00	1.93E-06	1.70E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01
Total	2.38E-01	3.89E-05	1.26E-06	1.69E+00	7.23E-07	6.38E-01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	2.24E-01	2.24E-01
U-234	9.85E-07	9.85E-07
TH-230	1.65E-11	1.65E-11
PB-210	3.66E-14	3.66E-14
U-235		
U-235	1.39E-02	1.39E-02
PA-231	4.63E-06	4.63E-06
AC-227	4.34E-07	4.34E-07
U-234		
U-234	2.32E-01	2.32E-01
TH-230	7.49E-06	7.49E-06
RA-226	4.18E-09	4.18E-09
PB-210	6.02E-11	6.02E-11
PA-231		
PA-231	1.46E-01	1.46E-01
AC-227	2.61E-02	2.61E-02
TH-232		
TH-232	2.78E+00	2.78E+00
TH-228	4.85E-02	4.85E-02
RA-228	9.79E-02	9.79E-02
TH-230		
TH-230	5.55E-01	5.55E-01
RA-226	5.97E-04	5.97E-04
PB-210	1.26E-05	1.26E-05
TH-228		
TH-228	7.14E-01	7.14E-01
AC-227		
AC-227	5.35E-01	5.35E-01
RA-228		
TH-228	4.60E-01	4.60E-01
RA-228	4.96E-01	4.96E-01
RA-226		
RA-226	9.19E-01	9.19E-01
PB-210	3.72E-02	3.72E-02
PB-210		
PB-210	7.80E-01	7.80E-01

Title : Fansteel Occupancy RESRAD-BUILD
Input File : C:\Program Files\RESRAD_Family\BUILD\FANSTEEL.bld
Evaluation Time: 1.00000000 years

Source: 2

Nuclide	Receptor 1	Total
U-238		
U-238	2.17E-01	2.17E-01
U-234	9.84E-07	9.84E-07
TH-230	1.65E-11	1.65E-11
PB-210	3.66E-14	3.66E-14
U-235		
U-235	1.24E-02	1.24E-02
PA-231	4.62E-06	4.62E-06
AC-227	4.31E-07	4.31E-07
U-234		
U-234	2.31E-01	2.31E-01
TH-230	7.48E-06	7.48E-06
RA-226	2.76E-09	2.76E-09
PB-210	6.01E-11	6.01E-11
PA-231		
PA-231	1.46E-01	1.46E-01
AC-227	2.60E-02	2.60E-02
TH-232		
TH-232	2.78E+00	2.78E+00
TH-228	3.81E-02	3.81E-02
RA-228	6.87E-02	6.87E-02
TH-230		
TH-230	5.54E-01	5.54E-01
RA-226	3.94E-04	3.94E-04
PB-210	1.26E-05	1.26E-05
TH-228		
TH-228	5.62E-01	5.62E-01
AC-227		
AC-227	5.32E-01	5.32E-01
RA-228		
TH-228	3.62E-01	3.62E-01
RA-228	3.48E-01	3.48E-01
RA-226		
RA-226	6.06E-01	6.06E-01
PB-210	3.71E-02	3.71E-02
PB-210		
PB-210	7.79E-01	7.79E-01

Source: 3

Nuclide	Receptor 1	Total
U-238		

U-238	8.00E-02	8.00E-02
U-234	3.68E-07	3.68E-07
TH-230	6.19E-12	6.19E-12
PB-210	1.37E-14	1.37E-14
U-235		
U-235	4.28E-03	4.28E-03
PA-231	1.73E-06	1.73E-06
AC-227	1.61E-07	1.61E-07
U-234		
U-234	8.67E-02	8.67E-02
TH-230	2.81E-06	2.81E-06
RA-226	7.09E-10	7.09E-10
PB-210	2.25E-11	2.25E-11
PA-231		
PA-231	5.45E-02	5.45E-02
AC-227	9.71E-03	9.71E-03
TH-232		
TH-232	1.04E+00	1.04E+00
TH-228	1.20E-02	1.20E-02
RA-228	1.91E-02	1.91E-02
TH-230		
TH-230	2.08E-01	2.08E-01
RA-226	1.01E-04	1.01E-04
PB-210	4.72E-06	4.72E-06
TH-228		
TH-228	1.76E-01	1.76E-01
AC-227		
AC-227	1.99E-01	1.99E-01
RA-228		
TH-228	1.13E-01	1.13E-01
RA-228	9.67E-02	9.67E-02
RA-226		
RA-226	1.56E-01	1.56E-01
PB-210	1.39E-02	1.39E-02
PB-210		
PB-210	2.92E-01	2.92E-01

Source: 4

Nuclide	Receptor 1	Total
U-238		
U-238	8.00E-02	8.00E-02
U-234	3.68E-07	3.68E-07
TH-230	6.19E-12	6.19E-12
PB-210	1.37E-14	1.37E-14
U-235		
U-235	4.28E-03	4.28E-03
PA-231	1.73E-06	1.73E-06
AC-227	1.61E-07	1.61E-07

U-234		
U-234	8.67E-02	8.67E-02
TH-230	2.81E-06	2.81E-06
RA-226	7.09E-10	7.09E-10
PB-210	2.25E-11	2.25E-11
PA-231		
PA-231	5.45E-02	5.45E-02
AC-227	9.71E-03	9.71E-03
TH-232		
TH-232	1.04E+00	1.04E+00
TH-228	1.20E-02	1.20E-02
RA-228	1.91E-02	1.91E-02
TH-230		
TH-230	2.08E-01	2.08E-01
RA-226	1.01E-04	1.01E-04
PB-210	4.72E-06	4.72E-06
TH-228		
TH-228	1.76E-01	1.76E-01
AC-227		
AC-227	1.99E-01	1.99E-01
RA-228		
TH-228	1.13E-01	1.13E-01
RA-228	9.67E-02	9.67E-02
RA-226		
RA-226	1.56E-01	1.56E-01
PB-210	1.39E-02	1.39E-02
PB-210		
PB-210	2.92E-01	2.92E-01

Source: 5

Nuclide	Receptor 1	Total
U-238		
U-238	8.00E-02	8.00E-02
U-234	3.68E-07	3.68E-07
TH-230	6.19E-12	6.19E-12
PB-210	1.37E-14	1.37E-14
U-235		
U-235	4.28E-03	4.28E-03
PA-231	1.73E-06	1.73E-06
AC-227	1.61E-07	1.61E-07
U-234		
U-234	8.67E-02	8.67E-02
TH-230	2.81E-06	2.81E-06
RA-226	7.09E-10	7.09E-10
PB-210	2.25E-11	2.25E-11
PA-231		
PA-231	5.45E-02	5.45E-02
AC-227	9.71E-03	9.71E-03

TH-232		
TH-232	1.04E+00	1.04E+00
TH-228	1.20E-02	1.20E-02
RA-228	1.91E-02	1.91E-02
TH-230		
TH-230	2.08E-01	2.08E-01
RA-226	1.01E-04	1.01E-04
PB-210	4.72E-06	4.72E-06
TH-228		
TH-228	1.76E-01	1.76E-01
AC-227		
AC-227	1.99E-01	1.99E-01
RA-228		
TH-228	1.13E-01	1.13E-01
RA-228	9.67E-02	9.67E-02
RA-226		
RA-226	1.56E-01	1.56E-01
PB-210	1.39E-02	1.39E-02
PB-210		
PB-210	2.92E-01	2.92E-01

Source: 6

Nuclide	Receptor 1	Total
U-238		
U-238	8.00E-02	8.00E-02
U-234	3.68E-07	3.68E-07
TH-230	6.19E-12	6.19E-12
PB-210	1.37E-14	1.37E-14
U-235		
U-235	4.28E-03	4.28E-03
PA-231	1.73E-06	1.73E-06
AC-227	1.61E-07	1.61E-07
U-234		
U-234	8.67E-02	8.67E-02
TH-230	2.81E-06	2.81E-06
RA-226	7.09E-10	7.09E-10
PB-210	2.25E-11	2.25E-11
PA-231		
PA-231	5.45E-02	5.45E-02
AC-227	9.71E-03	9.71E-03
TH-232		
TH-232	1.04E+00	1.04E+00
TH-228	1.20E-02	1.20E-02
RA-228	1.91E-02	1.91E-02
TH-230		
TH-230	2.08E-01	2.08E-01
RA-226	1.01E-04	1.01E-04
PB-210	4.72E-06	4.72E-06

TH-228		
TH-228	1.76E-01	1.76E-01
AC-227		
AC-227	1.99E-01	1.99E-01
RA-228		
TH-228	1.13E-01	1.13E-01
RA-228	9.67E-02	9.67E-02
RA-226		
RA-226	1.56E-01	1.56E-01
PB-210	1.39E-02	1.39E-02
PB-210		
PB-210	2.92E-01	2.92E-01

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]	
	0.00E+00	1.00E+00
1	2.59E+01	2.56E+01

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]	
	0.00E+00	1.00E+00
1	2.59E+01	2.56E+01

Appendix 5-4

RESRAD-BUILD $DCGL_{EMC}$ Values

Table 1 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 30 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	400,000	-
U-234	410,000	-
U-235 (Th-231)	270,000	-
Pa-231	30,000	-
Ac-227 (Th-227 to stable Pb-207)	8,000	-
Th-232	34,000	-
Th-230	170,000	-
Th-228 (Ra-224 to stable Pb-208)	69,000	-
Ra-226 (Rn-222 to Po-210)	67,000	-
Ra-228 (Ac-228)	110,000	-
Pb-210 (Bi-210 thru Stable Pb-206)	110,000	-

Table 2 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 20 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	-	660,000
U-234	-	610,000
U-235 (Th-231)	-	580,000
Pa-231	-	45,000
Ac-227 (Th-227 to stable Pb-207)	-	12,000
Th-232	-	51,000
Th-230	-	260,000
Th-228 (Ra-224 to stable Pb-208)	-	210,000
Ra-226 (Rn-222 to Po-210)	-	330,000
Ra-228 (Ac-228)	-	480,000
Pb-210 (Bi-210 thru Stable Pb-206)	-	170,000

Table 3 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 15 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	770,000	880,000
U-234	810,000	820,000
U-235 (Th-231)	460,000	770,000
Pa-231	60,000	61,000
Ac-227 (Th-227 to stable Pb-207)	16,000	16,000
Th-232	68,000	68,000
Th-230	340,000	340,000
Th-228 (Ra-224 to stable Pb-208)	110,000	280,000
Ra-226 (Rn-222 to Po-210)	94,000	440,000
Ra-228 (Ac-228)	160,000	620,000
Pb-210 (Bi-210 thru Stable Pb-206)	230,000	230,000

Table 4 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 10 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	1,100,000	1,300,000
U-234	1,200,000	1,200,000
U-235 (Th-231)	620,000	1,200,000
Pa-231	89,000	91,000
Ac-227 (Th-227 to stable Pb-207)	23,000	24,000
Th-232	100,000	100,000
Th-230	510,000	510,000
Th-228 (Ra-224 to stable Pb-208)	140,000	410,000
Ra-226 (Rn-222 to Po-210)	120,000	640,000
Ra-228 (Ac-228)	210,000	920,000
Pb-210 (Bi-210 thru Stable Pb-206)	340,000	340,000

Table 5 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 5 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	2,100,000	2,600,000
U-234	2,400,000	2,500,000
U-235 (Th-231)	1,100,000	2,300,000
Pa-231	180,000	180,000
Ac-227 (Th-227 to stable Pb-207)	46,000	49,000
Th-232	200,000	200,000
Th-230	1,000,000	1,000,000
Th-228 (Ra-224 to stable Pb-208)	220,000	810,000
Ra-226 (Rn-222 to Po-210)	180,000	1,200,000
Ra-228 (Ac-228)	320,000	1,800,000
Pb-210 (Bi-210 thru Stable Pb-206)	680,000	680,000

Table 6 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 3 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	3,400,000	4,400,000
U-234	4,000,000	4,100,000
U-235 (Th-231)	1,600,000	3,800,000
Pa-231	290,000	300,000
Ac-227 (Th-227 to stable Pb-207)	76,000	81,000
Th-232	340,000	340,000
Th-230	1,700,000	1,700,000
Th-228 (Ra-224 to stable Pb-208)	320,000	1,300,000
Ra-226 (Rn-222 to Po-210)	250,000	2,000,000
Ra-228 (Ac-228)	460,000	3,000,000
Pb-210 (Bi-210 thru Stable Pb-206)	1,100,000	1,100,000

Table 7 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 2 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	4,900,000	6,600,000
U-234	6,000,000	6,100,000
U-235 (Th-231)	2,200,000	5,700,000
Pa-231	440,000	450,000
Ac-227 (Th-227 to stable Pb-207)	110,000	120,000
Th-232	510,000	510,000
Th-230	2,500,000	2,600,000
Th-228 (Ra-224 to stable Pb-208)	440,000	2,000,000
Ra-226 (Rn-222 to Po-210)	350,000	3,000,000
Ra-228 (Ac-228)	630,000	4,400,000
Pb-210 (Bi-210 thru Stable Pb-206)	1,700,000	1,700,000

Table 8 Industrial Worker Scenario Individual Radionuclide $DCGL_{EMC}$s 1 m^2

Radionuclide and Progeny	Industrial Worker $DCGL_{EMC}$s at Time Zero Floor Area (dpm/100 cm^2)	Industrial Worker $DCGL_{EMC}$s at Time Zero Wall Area (dpm/100 cm^2)
U-238 (Th-234, Pa-234m, Pa-234)	9,500,000	13,000,000
U-234	1,200,000	12,000,000
U-235 (Th-231)	4,100,000	11,000,000
Pa-231	870,000	910,000
Ac-227 (Th-227 to stable Pb-207)	230,000	240,000
Th-232	1,000,000	1,000,000
Th-230	5,100,000	5,100,000
Th-228 (Ra-224 to stable Pb-208)	790,000	4,000,000
Ra-226 (Rn-222 to Po-210)	620,000	6,100,000
Ra-228 (Ac-228)	1,100,000	8,800,000
Pb-210 (Bi-210 thru Stable Pb-206)	3,400,000	3,400,000

6.0 Alternatives Considered and Rationale for the Chosen Alternative

To assist the NRC in fulfilling their environmental review obligations pursuant to the National Environmental Policy Act codified at 10 CFR 51.45 and 51.60, Fansteel will prepare an applicant's environmental report (AER) supporting this DP. The AER will be developed using guidance provided in Chapter 6 of draft NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs." Fansteel may request a pre-licensing meeting with the NRC licensing and environmental project managers to discuss and confirm the information needed to support NRC's environmental review. Currently available information studied by Fansteel suggests that the AER will support a Finding of No Significant Impact with or without mitigation as documented in an ensuing NRC environmental assessment. Furthermore, Fansteel is not seeking to decommission the Muskogee installation using the restricted or alternate release criteria of 10 CFR 20.1403-1404. Accordingly, Fansteel expects that the required complexity and detail of the AER will be substantially less than that needed by the NRC to prepare an environmental impact statement.

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7.0 Remediation ALARA Analysis Plan

The information presented in this chapter describes how Fansteel will demonstrate that doses to the average member of the critical group are ALARA following implementation of the preferred decommissioning alternative/option for unrestricted use, as required by 10 CFR 20.1402. The Fansteel remediation ALARA analysis plan addresses the following:

- Cost-benefit feasibility analyses (or qualitative feasibility arguments when credible monetary values cannot be assigned) of the preferred and competing alternatives/options postulated to reduce residual radioactivity to levels no greater than the radiological criteria for unrestricted use (25 mrem TEDE per year).
- The method (predetermined or performance-based) for showing compliance with the ALARA requirement at the time decommissioning is completed.

The remediation ALARA analysis is an optimization technique separate from the operational ALARA program described in Chapter 10.0, but uses the same underlying principle to seek the proper balance of remediation costs and benefits below the 10 CFR 20.1402 radiological criteria:

> "Reasonably achievable" is judged by considering the state of technology and the economics of improvements in relation to all the benefits from these improvements. Determination of the ALARA level will consider any detriments, such as deaths from transportation accidents, expected to potentially result from remediation and waste disposal. However, a comprehensive consideration of risks and benefits will include risks from non-radiological hazards. An action taken to reduce radiation risks should not result in a significantly larger risk from other hazards."

Fansteel has elected to decommission the Muskogee site for unrestricted use under the assumption that the critical group is industrial workers. Accordingly, Fansteel will perform remediation ALARA analyses for the following purposes:

- To discriminate remediation alternatives/options (identify incremental benefit and cost differences).
- Establish a remediation goal for decommissioning under each remediation alternative/option (i.e., the dose or residual radioactivity level at which the quantitative or qualitative benefits and costs are equal).
- Justify cases where a candidate remediation will not be performed.

Planned remediation activities to achieve the unrestricted use radiological criteria or execute good operations practice (e.g., surface washing) are examples of work that Fansteel will perform without a justifying remediation ALARA analysis. Also, since the NRC has previously shown (NUREG-1496) that shipping soil for off-site disposal is unlikely to be cost effective for unrestricted release, Fansteel will not perform ALARA evaluations justifying soil shipment campaigns. For reasons unrelated to the net dose to workers or members of the public averted by off-site shipment for disposal, reclamation, or reuse, Fansteel has concluded that off-site disposition of the material is the most cost-effective approach to achieve the decommissioning objective. Fansteel recognizes that the performance of a remediation action, not necessarily the outcome, is a fundamental demonstration of ALARA requirement implementation.

When the beneficial effects ("benefits") of a candidate remediation alternative/option exceed its undesirable effects ("costs"), the remediation is deemed cost effective and implementable. Conversely, if costs outweigh benefits, the existing residual radioactivity is ALARA and the remediation is not considered implementable. The ultimate comparison of interest is the incremental difference in benefits and costs among all remediation alternatives/options evaluated. Where possible, benefits and costs will be described in monetary (dollar) amounts. In the special cases where residual radioactivity cannot be detected at the prescribed sensitivity or is indistinguishable from background, Fansteel will assume that the radioactivity has been reduced to levels that are ALARA. In these situations, an explicit analysis to meet the ALARA requirement will not be conducted.

Where necessary, relevant NRC findings (e.g., "Statements of Consideration" for 10 CFR Part 20, Subpart E and the Final Generic Impact Statement (NUREG-1496) for the license termination rule) will be used to complete remediation ALARA analyses.

Fansteel will prepare and approve documents (e.g., procedures) implementing the provisions of this section.

7.1 Calculation of Benefits

In Appendix D to NUREG-1727, the NRC identified four possible benefits associated with decommissioning: (1) collective dose averted, (2) regulatory costs avoided, (3) changes in land values, and (4) aesthetics/reduction in public opposition. Numerical benefit estimates are typically calculable only for the first three benefits, however, making description of the last benefit possible in semiquantitative or qualitative terms only. The approach that Fansteel will use to determine the value of these benefits is

discussed below. Additional benefits may become apparent while evaluating remediation alternatives/options; where justified, the value of these benefits will be accrued in the benefit calculation.

7.1.1 Collective Dose Averted

The collective dose averted is generalized as the incremental TEDE difference between the remediation alternative/option pair being evaluated. Fansteel will calculate benefits using the correct site and region of influence (ROI) parameters (e.g., population density and area). The bases for each benefit estimate will be properly documented including, as necessary, consultations with local/state/federal subject matter experts (SME). Averted dose will be calculated using the methods for deriving acceptable residual radioactivity concentrations at the site (see Chapter 5.0) and Appendix D to NUREG-1727, with the following stipulations:

- For buildings, the collective averted dose from residual radioactivity will be based on the industrial worker occupancy scenario.
- For land areas, the collective averted dose will be based on the industrial worker scenario.

The monetary value assigned to the averted dose benefit will not be discounted so as to preserve the true value of adverting dose in later time periods (unbiased accounting). The benefit from collective averted dose, B_{CAD} , is calculated by determining the present worth of the future collective averted dose and multiplying it by a factor to convert the dose to monetary value:

$$B_{CAD} = 2{,}000 PW_{CAD}$$

where:

B_{CAD} = benefit from averted dose for a remediation action, $;
2,000 = monetary value of collective dose averted, $/person-rem; and
PW_{CAD} = present worth of future collective averted dose.

For most situations, the present worth of the future collective averted dose will be estimated from the following equation:

$$PW_{CAD} = 0.025 P_D AF \left(\frac{Conc}{DCGL_W} \right) \frac{1 - e^{-(r-\lambda)N}}{r + \lambda}$$

where:

0.025 = annual dose to an average member of the critical group from residual radioactivity at the $DCGL_W$ concentration, rem TEDE;

P_D = population density for the critical group ≡ 0.09 persons/m^2 (buildings) and 0.0004 persons/m^2 (open land);

A = area being evaluated, m^2;

F = fraction of the residual radioactivity removed by the remediation or the removable fraction for the remediation being evaluated;

Conc = average concentration of residual radioactivity in the area being evaluated, activity per unit area (surfaces) or activity per unit volume (soils);

$DCGL_W$ = derived concentration guideline equivalent to the average concentration of residual radioactivity that would give a dose of 25 mrem/yr to the average member of the critical group, activity per unit area (surfaces), or activity per unit volume (soils);

r = monetary discount rate, yr^{-1} ≡ 0 [adverted dose benefit will not be discounted];

λ = radiological decay constant for the radionuclide, yr^{-1}; and

N = collective dose delivery duration, years. Unless otherwise justified, the baseline exposure durations are 70 years for buildings and 1,000 years for open land.

The present worth of the benefit calculated above assumes that the peak dose occurs in the first year of the modeling horizon (e.g., building occupancy scenario). To avoid overestimating benefits in scenarios where the peak dose occurs in later years, Fansteel will calculate the dose during each year of the modeling horizon and then calculate the present worth of each year's dose.

If more than one radionuclide is present, the total benefit from collective averted dose is determined as the sum of the collective averted dose for each radionuclide. When multiple radionuclides have a fixed concentration (i.e., secular equilibrium), residual radioactivity below the dose criteria is normally demonstrated by measuring one radionuclide and comparing its concentration to a $DCGL_W$ that has been calculated to account for the dose from the other radionuclides. In this case, the adjusted $DCGL_W$ may be used with the concentration of the radionuclide being measured. The other case is when the ratio of the radionuclide concentrations is not fixed and varies from location to location within a survey unit; this benefit is the sum of the collective averted dose from each.

7.1.2 Regulatory Costs Avoided

While this benefit usually manifests in ALARA analyses of restricted release versus unrestricted release decommissioning goals, there may be remediation alternatives/options that have associated regulatory costs. When manifested, such avoidance expenses will be accrued as quantitative, semiquantitative, or qualitative benefit costs in the calculation of remediation alternative/option costs.

7.1.3 Changes in Land Values

The change in value of the Muskogee site or facilities under each remediation alternative/option will be evaluated to the extent known and accrued as a quantitative, semiquantitative, or qualitative benefit cost. Land value changes will be estimated based on consultations with community representatives.

7.1.4 Aesthetics and Reduction in Stakeholder Opposition

To the extent practical, the effect of each remediation alternative/option with respect to the overall aesthetics (including the decommissioning activities themselves) of the site and surrounding area will be evaluated. This evaluation will also consider the perceived reduction in stakeholder opposition to the remediation alternative/option. These effects will be accrued as semiquantitative or qualitative benefit costs.

7.2 Calculation of Costs

RA alternative/option costs generally included are the monetary costs of: (1) remediation planning, execution, and management; (2) waste packaging, transportation, and disposal (T&D); (3) T&D conveyance incidents; (4) workplace incidents; (5) remediation workforce radiological doses; and (6) radiological dose to members of the public. Cost estimates will be prepared following the guidance in Section 15.0 of NUREG-1727 with the following provisions:

- The remediation alternative/option cost estimate will be based on actual costs expected to be incurred by decommissioning the facility and may not necessarily assume that the work will be performed by an independent third-party contractor.
- The remediation alternative/option cost estimate will credit: (1) any salvage value that might be realized from the sale of potential assets during or after decommissioning, or (2) reduced taxes that might result from payment of decommissioning costs and/or site control and maintenance costs.
- To the extent practical, the remediation alternative/option cost estimates will reflect the actual situation rather than maximized assumptions.

The total cost, C_T, to be balanced against accrued benefits for each remediation alternative/option has several components as shown below:

$$C_T = C_R + C_{T\&D} + C_{T\&Dinc} + C_{Winc} + C_{Wdose} + C_{Pdose} + C_{Other}$$

where:

C_R = monetary cost of the remediation action including mobilization and demobilization;
$C_{T\&D}$ = monetary cost for waste packaging, transport, and disposal;
$C_{T\&Dinc}$ = monetary cost of T&D incidents resulting in fatalities;
C_{Winc} = monetary cost of worker occupational safety incidents resulting in fatalities;
C_{Wdose} = monetary cost of the dose delivered to workers;
C_{Pdose} = monetary cost of the dose delivered to members of the public from on-site activities; and
C_{Other} = other applicable or relevant and appropriate costs.

All the cost terms defined above do not necessarily have to be calculated. For example, if any of the terms exceeds the benefit, the remediation alternative/option will have been shown to be unnecessary without calculating other costs. Each of the cost terms is discussed in the following subsections.

7.2.1 Remediation Costs

At a minimum, calculation of remediation costs will include project management, labor, equipment, and administrative (e.g., licensing fees) factors. Unless otherwise justified, a workforce efficiency of 1.62 person-hours/m^3 will be specified to cost soil excavation, monitoring, packaging, and handling remediation tasks. If the remediation alternative/option involves radiological surveys to evaluate compliance at the 25 mrem TEDE limit, these survey costs will be excluded from the summation of remediation costs.

7.2.2 Waste Packaging, Transport, and Disposal Costs

The cost of waste packaging, transport, and disposal, $C_{T\&D}$, will be estimated using the following equation for each waste stream (i.e., MSW, LLW, LLMW, HW):

$$C_{T\&D} = \sum_i C_{Vi} V_i$$

where:

C_{Vi} = waste packaging, transportation, and disposal unit cost for waste stream *i*, $/m^3$; and
V_i = volume of waste stream *i* generated, m^3.

7.2.3 T&D Incident Costs

The cost of T&D incidents resulting in fatalities during waste transportation, $C_{T\&Dinc}$, will be estimated using the following equations for each conveyance used:

$$C_{T\&Dinc} = C_{Truck} + C_{Rail}$$

$$C_{Truck} = 3{,}000{,}000 \frac{V_{Tpkg}}{V_{Tship}} F_T D_T$$

$$C_{Rail} = 3{,}000{,}000 \frac{V_{Rpkg}}{V_{Rship}} F_R D_R$$

where:

C_{Truck} = cost of incidents resulting in fatalities from conveyance by large truck;

C_{Rail} = cost of incidents resulting in fatalities from conveyance by rail;

3,000,000 = monetary value of an equivalent radiological detriment (1,500 person-rem), $/fatality;

V_{Tpkg} = total volume of waste packaged for conveyance by large truck, m^3;

V_{Rpkg} = total volume of waste packaged for conveyance by rail, m^3;

V_{Tship} = large truck shipment package capacity ≡ 13.6 m^3/truck;

V_{Rship} = rail shipment package capacity, m^3/railcar;

F_T = large truck fatality incidence ≡ 3.8×10^{-8} fatalities/truck-km;

F_R = rail fatality incidence, fatalities/railcar-km;

D_T = roundtrip or halftrip large truck route distance, km; and

D_R = roundtrip or halftrip rail route distance, km.

The rail conveyance fatality incidence will be based on official modal statistics published by the Bureau of Transportation Statistics (BTS). The decision to use roundtrip or halftrip route distances will be based on the planned return of the conveyance to the Muskogee site.

7.2.4 Worker Occupational Safety Incident Costs

The cost of worker occupational safety incidents resulting in fatalities, C_{Winc}, will be estimated using the following equation:

$$C_{Winc} = 3{,}000{,}000 F_W T_A$$

where:

3,000,000 = monetary value of an equivalent radiological detriment (1,500 person-rem), $/fatality;

F_W = workplace fatality incidence $\equiv 4.2 \times 10^{-8}$ fatalities/person-hour; and

T_A = remediation labor level of effort, person-hours.

7.2.5 Worker Dose Cost

The cost of the radiological dose delivered to remediation workers, C_{Wdose}, will be estimated using the following equation:

$$C_{Wdose} = 2{,}000 \sum_i N_{Wi} D_{Wi} t_{Wi}$$

where:

2,000 = monetary value of collective dose, $/person-rem;

N_{Wi} = worker population performing remediation task *i*, persons;

D_{Wi} = average remediation worker TEDE rate during completion remediation task *i*, rem/hour; and

t_{Wi} = worker exposure duration for remediation task *i*, hours.

The definition and duration of remediation tasks will include potential worker TEDE deliveries following remediation completion. Unless otherwise justified, the baseline exposure durations following remediation completion are 613,620 hours (70 years) for buildings and 8,766,000 hours (1,000 years) for open land.

7.2.6 Public Dose Cost

The cost of the radiological dose delivered to members of the public, C_{Pdose}, will be estimated using the following equation:

$$C_{Pdose} = 2{,}000 \sum_{i} N_{Pi} D_{Pi} t_{Pi}$$

where:

2,000 = monetary value of collective dose, $/person-rem;
N_{Pi} = public population affected during remediation task *i*, persons;
D_{Pi} = average member of the public TEDE rate during remediation task *i*, rem/hour; and
t_{Pi} = public exposure duration for remediation task *i*, hours.

The definition and duration of remediation tasks will include potential public TEDE deliveries following remediation completion. Unless otherwise justified:

- the baseline exposure durations following remediation completion are 613,620 hours (70 years) for buildings and 8,766,000 hours (1,000 years) for open land; and
- the public population affected, N_{Pi}, will be based on population densities of 0.09 persons/m^2 (buildings) and 0.0004 persons/m^2 (open land).

7.2.7 Other Costs

Other costs could include, and are not limited to:

- the fair market rental value or economic use for the site during the time the additional remediation work is being performed, and
- damage to an ecologically valuable area or other adverse environmental impact caused by remediation completion.

7.3 The ALARA Residual Radioactivity Level

The residual radioactivity level that is ALARA is the concentration, Conc, at which the remediation benefit equals the remediation cost. After equating the total cost, C_T, with the present worth of future averted collective dose, PW_{CAD}, the concentration ratio, Conc:$DCGL_W$, is solved as follows:

$$\frac{Conc}{DCGL_W} = \frac{C_T}{2{,}000 P_D 0.025 FA}\left(\frac{r+\lambda}{1-e^{-(r-\lambda)N}}\right)$$

All the terms in the above equation are as defined previously, except that monetary discount rates will be applied (0.07 per year for the first 100 years and 0.03 per year thereafter; or 0.07 per year for buildings and 0.03 per year for open land). Since the derivation of the above equation explicitly considers only the benefits related to reduction in collective dose, the numerical value of nondose-related benefits will be subtracted from the total cost, C_T.

Since P_D, N, and r are constants having generic values for all locations on the Muskogee site, Fansteel will only need to redetermine the total cost, C_T, and effectiveness, F, for each remediation alternative. If the concentration at a location exceeds Conc (i.e., the calculated fraction or multiple of the $DCGL_W$ concentration), it will be deemed cost effective to remediate the location by a method whose total cost is C_T or less. Although the concentration, Conc, that is ALARA can be higher or lower (more or less stringent) than the $DCGL_W$, Fansteel will meet the $DCGL_W$ concentration in all cases.

7.4 Additional Considerations for Residual Radioactivity in Groundwater

The groundwater beneath the Muskogee site contains limited amounts of radioactive material attributed to historical operations at the site. Although on-site consumption of this groundwater is excluded from the industrial worker scenario, Fansteel will evaluate the necessity of including a groundwater ingestion dose component in the remediation alternative/option ALARA analyses. If deemed necessary, the critical group for this dose component is expected to be members of the public who obtain drinking water supplied by a municipal system withdrawing water from the Arkansas River located downstream of the Muskogee site. The decision to perform this ALARA evaluation will also consider any groundwater quality recommendations offered by the USEPA that are adopted by the NRC pursuant to Section V.C.2 of the NRC-USEPA Memorandum of Understanding executed on October 9, 2002 (*Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites*). Fansteel acknowledges that the possibility of reducing the collective dose attributable to groundwater ingestion by remediation is a benefit.

7.5 Determination of "Net Public or Environmental Harm"

Fansteel is not seeking license termination on the basis of restricted use under the provisions of 10 CFR 20.1403; therefore, special ALARA analyses determining that further remediation would cause net public or environmental harm are not required and will not be performed.

7.6 Demonstration of "Not Technically Achievable"

Fansteel is not seeking license termination on the basis of restricted use under the provisions of 10 CFR 20.1403; therefore, demonstrations that further reductions in residual radioactivity would not be technically achievable are not required and will not be performed.

7.7 Demonstration of "Prohibitively Expensive"

Fansteel is not seeking license termination on the basis of restricted use under the provisions of 10 CFR 20.1403; therefore, demonstrations that further reductions in residual radioactivity would be prohibitively expensive are not required and will not be performed. Nonetheless, Fansteel acknowledges that the monetary value of dose adverted under such circumstances would be no greater than $20,000/person-rem.

7.8 ALARA Compliance Demonstration

Fansteel is evaluating two approaches for demonstrating that doses to the average member of the critical group following site decommissioning are ALARA. At this time, there is insufficient information available to select an approach, although the first of the following two approaches being evaluated is favored for its simplicity:

- *Deterministic* – Predetermined acceptable remediation dose limit or concentration guideline(s).
- *Performance-Based* – An acceptable remediation preferred option and decommissioning goal with organizational oversight and review during decommissioning.

Both of these approaches are discussed below. Following selection of the compliance approach, Fansteel will amend this DP accordingly.

7.8.1 Deterministic Approach

Under the deterministic approach, Fansteel would commit to meet the dose calculated for the remediation preferred option or the radiological concentrations associated with this dose. Compliance with this commitment would be demonstrated by providing FSS data of sufficient quality and quantity showing that the

residual radioactivity is below concentration limits for the site. Alternatively, compliance could be demonstrated by dose modeling using as-left FSS radiological conditions for the site and NRC-approved modeling parameters and assumptions. Under this approach, if the FSS results demonstrate that the concentration limits or dose limit have not been exceeded, then Fansteel will conclude that the ALARA requirement has been satisfied.

7.8.2 Performance-Based Approach

The performance-based approach would permit Fansteel to adjust its ALARA assessment during decommissioning to deal with actual site conditions experienced and actual costs incurred. If this approach were used, Fansteel would establish the following minimum criteria for its implementation:

- The preferred remediation alternative/option, based on valid assumptions, would result in reducing residual activity to ALARA levels, as described in this section.
- Decommissioning guidelines (either dose or concentrations) based on the DP's analysis are established.
- Provide a documented protocol to review the effectiveness of remediation activities including:
  - ALARA/Radiation Safety committee review similar to operations requirements;
  - appropriate ALARA/Radiation Safety committee review frequencies;
  - acceptable criteria on the scope of activities/commitments the ALARA/Radiation Safety committee can change;
  - a commitment for acceptable documentation of ALARA findings that result in Fansteel making changes in its remediation activities or decommissioning guidelines; and
  - a commitment to provide annually to the NRC all necessary page changes to the DP due to implementation of the performance-based approach.
- At the end of remediation implementation phase:
  - demonstrate compliance with the appropriate dose limit(s) using FSS results;
  - resolve any substantial weaknesses in the ALARA program that were found during internal audits or NRC inspections; and
  - properly justify through ALARA/Radiation Safety committee findings any deviation from the decommissioning goal presented in the Fansteel DP.

8.0 Planned Decommissioning Activities

Planned decommissioning activities for the Fansteel site include the following:

- Cleaning of contaminated structures and equipment
- Outdoor site remediation preparation
- Excavation of affected soil and pond residue
- Off-site shipment for disposal or reclamation of above-criteria soil, residue, demolition debris, and equipment
- Backfilling of excavations
- Diversion of surface water
- Restoration of the site
- Pumping and treatment of groundwater

Fansteel will complete the decommissioning with the assistance of contractors, subcontractors, and consultants. A conceptual engineering plan for site remediation activities is presented below. After plan approval by NRC, designs and specifications will be developed to better detail approaches to accomplish the objectives set forth in the approved plan. These detailed plans and specifications may differ somewhat from the conceptual engineering approach provided herein.

8.1 Contaminated Structures

8.1.1 Summary of Remediation Tasks

Removable contamination is located on surfaces throughout the Chemical "A" and Chemical "C" buildings. Decommissioning will include decontamination of building surfaces to below release criteria. It is expected that portions of the floor of the Chemical "A" and Chemical "C" buildings, and possibly parts of the ore storage pad, will have to be removed and disposed as LLR waste.

The following presents a list of structures to be remediated, along with a delineation of the rooms within.

8.1.1.1 Chemical "A" Building

The Chemical "A" Building is four stories and consists of the following rooms/areas as shown in Figures 4-3A through 4-3D:

- Platform 101, Office Area Roof
- Platform 102, Big Berth A
- Platform 201
- Platform 301, Little Berth A

- Platform 401
- Platform 403
- Room 101
- Room 102
- Room 103
- Room 104
- Room 105
- Room 106
- Room 107
- Room 108
- Room 109
- Room 110
- Room 111
- Room 112
- Room 113
- Room 301, Women's Shower Room
- Room 302
- Room 303
- Room 304
- Room 305
- Room 306
- Room 307
- Room 308
- Room 309
- Room 310
- Room 311
- Room 312
- Room 313
- Room 314
- Room 315
- Room 401
- Room 402
- Elevator

8.1.1.2 Chemical "C" Building

The Chemical "C" Building is one story and consists of the following rooms as shown in Figure 4-2:

- Room 101
- Room 102

8.1.1.3 White House Building

The White House Building is one story and consists of the following rooms as shown in Figure 4-4:

- Room 101
- Room 102
- Room 103
- Room 104
- Room 105

However, the White House Building was constructed in 1999 and is considered nonaffected.

8.1.1.4 Thermite Building

The Thermite Building is one story and consists of one room as shown in Figure 4-4.

8.1.1.5 Weir Building

The Weir Building is one story and consists of one room as shown in Figure 4-5.

8.1.1.6 Sodium Reduction Building

The Sodium Reduction Building is one story and consists of the following rooms as shown in Figure 4-7:

- Room 101
- Room 102
- Room 103

8.1.1.7 New Maintenance Building

The New Maintenance Building (Machine Shop) is one story and consists of the following rooms as shown in Figure 4-4:

- Room 101
- Room 102
- Room 103

The Old Maintenance Building (Bulk Sodium Building) structure was destroyed by a tornado in 1999. The New Maintenance Building was constructed west of what remains of the Old Maintenance Building (i.e., foundation slab) and is considered radiologically unaffected.

8.1.1.8 R&D Lab Building

The R&D Lab Building is two stories and consists of the following rooms as shown in Figure 4-6:

- Room 101
- Room 102

- Room 103
- Room 104
- Room 105
- Room 106
- Room 107
- Room 108
- Room 109
- Room 110
- Room 201
- Room 202
- Room 203
- Room 204
- Room 205
- Room 206
- Room 207

8.1.2 Remediation Techniques

Specific remediation techniques and order of occurrence will be developed in conjunction with contractors for structures at the Fansteel site. The perceived sequence of remediation techniques is as follows:

- Installation of engineering and access controls.
- Cleaning of removable contamination from building surfaces starting at the highest part of each room and proceeding down to the floor.
- Scabbling of nonremovable contamination from concrete surfaces.
- Maintenance of access controls on completed rooms and areas.

Dry cleaning methods will be preferred. The following presents a general discussion of techniques to be used.

8.1.2.1 Removable Contamination

Decontamination of building surfaces will consist of cleaning with appropriate solvents, cleaning solutions, high-power vacuum cleaners, pressure washers, etc. Wet techniques will not be used on porous materials.

8.1.2.2 Nonremovable Contamination

As stated above, it is expected that portions of the floor (10 percent) of the Chemical "A" and Chemical "C" buildings, and possibly parts of the ore storage pad, will have to be scabbled and disposed as LLR waste. Such portions of structures or building facilities will be cut or broken down into the smallest practicable size for handling, shipping, and/or disposal purposes. Debris will be staged in on-site piles and subsequently loaded into disposal containers, or suitably packaged for transport. In addition to some concrete surfaces, other materials such as duct work, corroded sheet metal, porous materials, and flooring materials may be discarded as LLR waste. Alternately, Fansteel may consider scrapping of some material, depending on economic conditions.

8.1.2.3 Disposal

Solid material that meets unrestricted release criteria will be disposed off site as conventional construction/demolition debris in accordance with Oklahoma solid waste management regulations (OK 252:520-9). All surface materials and components that will be disposed as LLR will be loaded onto Department of Transportation- (DOT) approved trucks or railcars for transportation to an approved off-site disposal facility. Some debris will require packaging before loading.

8.1.2.4 Radiation Protection Methods

Fansteel is committed to maintaining occupational exposures ALARA during all operations involving the management of radioactive materials. Dust controls and air monitoring will be maintained. Workers will wear suitable personal protective equipment (PPE). Access to and from the site (and specific work areas) will be controlled. Radiation protection methods are described in Chapters 10.0 through 14.0.

Cleaning of building surfaces and facility components will be performed under controlled conditions with access restricted. HPT support will be used to monitor the demolition debris removed; the surfaces left in place; as well as workers, equipment, and loaded cars/containers leaving the site.

When materials are being vacuumed to remove loose surface soil, the vacuum cleaning unit will be equipped with a High-Efficiency Particulate Air (HEPA) filter. In addition, the vacuum unit will be separated from the workers by a plastic curtain. The outside vent of the vacuum will be clearly marked.

After loose material has been removed, bristles and/or wire brushes will be used to loosen any caked or otherwise hardened accumulations of ore or process material.

All effluents from cleaning will be recovered for appropriate disposal or treatment. Liquid and solid residues that would be hazardous wastes when discarded will be segregated from other wastes and disposed appropriately. Nonhazardous liquid and solid residues from building surface and facility decontamination will be analyzed for total activity prior to being discarded. Liquid wastes that meet NRC's standard for discharge to unrestricted areas will be routed to the wastewater treatment plant located at the Fansteel facility. Solid residues that are not hazardous waste will be packaged and disposed as LLR waste.

8.1.2.5 Procedures

Decommissioning activities will be conducted in accordance with written, approved procedures as outlined in this plan. Radiation control procedures are described in Chapters 10.0 through 14.0.

8.1.2.6 Unique Safety or Remediation Issues

There are no safety or removal/remediation issues uniquely associated with decommissioning of structures at this site.

8.1.2.7 Dismantling of Structures

Fansteel does not intend to dismantle structures or buildings under this DP.

8.2 Contaminated Systems and Equipment

8.2.1 Summary of Remediation Tasks

It is intended that all equipment presently at the Fansteel facility will be cleaned for unrestricted release. Equipment that cannot be cleaned for unrestricted release will be cut or broken down into the smallest practicable size for handling, shipping, and/or disposal purposes. Disassembled equipment and debris will be staged in on-site piles and subsequently loaded into disposal containers, or suitably packaged for transport.

8.2.2 Remediation Techniques

Specific remediation techniques and order of occurrence will be developed in conjunction with contractors for systems and equipment at the Fansteel site. Dry cleaning methods will be preferred. The following presents a general discussion of techniques to be used.

8.2.2.1 Cleaning

Removable material will be cleaned from site equipment by use of vacuum cleaners, hand scrubbing, steam cleaners, solvent washes, high-pressure power washers, etc., as may be compatible with the individual component's material(s) of construction. Effluents from the cleaning operation will be conveyed to a settling basin (or tank) where the particulates will settle out. The supernatant wash water will be sampled and analyzed for dissolved radioactivity. If the wash water is suitable for discharge, the supernatant will be pumped to the site treatment plant for eventual discharge. The solids from the washing operation will be tested for the presence of licensed materials and handled accordingly.

8.2.2.2 Disposition of Equipment

Some equipment will be sold. Equipment for sale will be secured in appropriate packing and shipped in appropriate containers for transport to their destination. If the equipment is defined by the DOT as radioactive material following decontamination, all of the DOT requirements for transport of radioactive materials (packaging, placards, labeling, and routing) will be strictly followed.

Equipment that cannot be cleaned for unrestricted release will be cut or broken down into the smallest practicable size for handling, shipping, and/or disposal purposes. Disassembled equipment and debris will be staged in on-site piles and subsequently loaded into disposal containers, or suitably packaged for transport. Alternately, Fansteel may consider scrapping of some material, depending on economic conditions.

8.2.2.3 Summary of Equipment to be Removed

At this time, Fansteel does not plan to remove any of the equipment at the site. However, if Fansteel decides to remove equipment, it would be accomplished in accordance with applicable regulations.

8.2.2.4 Radiation Protection Methods

Fansteel is committed to maintaining occupational exposures ALARA during all operations involving the management of radioactive materials. Dust controls and air monitoring will be maintained. Workers will wear suitable PPE. Access to and from the site (and specific work areas) will be controlled. Radiation protection methods are described in Chapters 10.0 through 14.0.

Washing and cleaning of equipment will take place under controlled conditions. HPT support will be used to monitor the equipment removed; the equipment left in place; as well as workers, equipment, and

loaded cars/containers leaving the site. Vacuum cleaning will utilize HEPA filtration to remove potentially radioactive particulates from the effluent airstream.

After loose material has been removed, bristles and/or wire brushes will be used to loosen any caked or otherwise hardened accumulations of ore or process material.

All effluents from cleaning will be recovered for appropriate disposal from the WWTP located at the Fansteel facility. Liquid and solid residues that would be hazardous wastes when discarded will be segregated from other wastes and disposed appropriately. Nonhazardous liquid and solid residues from building surface and facility decontamination will be analyzed for total activity prior to being discarded. Solid residues that are not hazardous waste will be packaged and disposed as LLR waste.

8.2.2.5 Procedures

Decommissioning activities will be conducted in accordance with written, approved procedures as outlined in this plan. Radiation control procedures are described in Chapters 10.0 through 14.0.

8.2.2.6 Unique Safety or Remediation Issues

There are no safety or removal/remediation issues uniquely associated with decommissioning of systems and equipment at this site.

8.3 Soil and Residues

8.3.1 Summary of Remediation Tasks

Radiologically impacted soils and residues are isolated to plant areas within and surrounding Pond Nos. 2 3, 5, 6, 7, 8, and 9, and areas to the east of the Chemical "A" and Chemical "C" plant buildings. Soil contamination was also detected to the east of the wastewater treatment ponds and Pond No. 5, however, at levels typically lower than that exhibited in the areas of the site associated with manufacturing and ore processing.

The planned soil remediation requires identifying soils and pond residues with concentrations above the limiting DCGL, excavating, and segregating it on site. Above-criteria material will be shipped to a licensed and or permitted facility in accordance with regulatory requirements. Below-criteria material will be returned to the excavation.

Approximately 16,000 tons (20 percent moisture content by weight) of residues from the WIP will be excavated, packaged, and shipped from Pond Nos. 2 and 3 for reclamation at a licensed facility. An estimated 68,000 tons (20 percent moisture content) of residue will be excavated and disposed from Pond Nos. 5, 6, 7, 8, and 9. Excavation and disposal of soil from the surrounding plant area and beneath the ponds account for approximately 15,855 tons (ambient moisture content).

8.3.2 Remediation Techniques

8.3.2.1 Site Preparation

Prior to remediation activities, a segment of the site (most likely to the northwest of the Sodium Reduction Building) will be prepared as a stockpile and material processing area. The stockpile area will be lined with 60-mil high-density polyethylene geomembrane, or equivalent. Berms and ditches will be constructed at the perimeter to handle precipitation falling onto the stockpile. Haul roads, drainage channels, culverts, berms, E&S controls, and access controls will be constructed during the site preparation phase.

8.3.2.2 Excavation

As shown in Figure 8-1, remediation activities within Pond Nos. 2 and 3 will require installation of sheet piling for lateral support and groundwater control. Excavation in the Pond No. 2 area will extend to a depth of about 12 feet, while excavation in the area of Pond No. 3 will extend down to approximately 14 feet. Soil remediation in the surrounding plant area will vary to up to a depth of approximately 20 feet.

Standard construction equipment will be used to complete soil remediation. This equipment will include, but not be limited to, the following:

- Backhoes
- Scrapers
- Excavators
- Bulldozers
- Loaders
- Dump trucks
- Water trucks
- Pickup trucks

8.3.2.3 Material Segregation

Gamma scanning will be used to identify above-criteria from below-criteria materials. Excavated material will be transported to a stockpile area where it will be air-dried and relocated to a feed pile.

Alternately, if economically feasible, Fansteel may utilize other methods, such as natural gas-driven dryers, or the use of a filter press to further dry the soils. Oversize materials will be identified and removed before the materials are fed into the segregation system. Segregated materials that are below the limiting DCGL will be stockpiled temporarily and eventually returned to the excavations.

8.3.2.4 Backfilling

Below-criteria material will be used to backfill (in part) the pond excavations. Additional off-site borrow material will be necessary to bring the site to the final grades shown (conceptually) in Figure 8-2. Backfill will be placed in 8-inch loose lifts and suitably compacted.

8.3.2.5 Off-Site Shipment

Above-criteria soil will be transported (most likely by rail) to a licensed or permitted facility for disposal, in accordance with regulatory requirements. The quantity of soil and residue for off-site shipment is estimated to be approximately 99,855 tons.

8.3.2.6 Site Restoration

The site will be restored as each area is completed so that weathering is minimized. Restoration will include the following:

- Placement of vegetative material
- Seeding and mulching
- Permanent surface water controls
- Permanent E&S controls

8.3.2.7 Radiation Protection Methods

HPT support will be used to monitor all excavation material, the material left in place, workers, equipment, and loaded cars/containers leaving the site. As stated above, dust controls and air monitoring will be maintained. Site access will be controlled.

8.3.2.8 Procedures

Decommissioning activities will be conducted in accordance with written, approved procedures as outlined in this plan. Radiation control procedures are described in Chapters 10.0 through 14.0.

8.3.2.9 Unique Safety or Remediation Issues

There are no safety or removal/remediation issues uniquely associated with remediation of soils at this site.

8.4 Surface and Groundwater

8.4.1 Summary of Remediation Tasks

Remediation of groundwater is not included in this DP. However, management of surface water and groundwater will be necessary during remediation activities. The existing groundwater treatment program will remain in place at the Fansteel site during most of the decommissioning activities. Surface water will be managed so that contact with affected material is avoided.

8.4.2 Remediation Techniques

The existing WWTP will be used to process surface water accumulated in ponds and groundwater encountered in excavations until Pond Nos. 6, 7, 8, and 9 are no longer available. The existing plant will then be modified to use sand-drying bed units to filter the water from the solids and remove free liquid from the solids prior to off-site disposal of the recovered solids. The water will be monitored and discharged to the Arkansas River after treatment. If necessary, an activated carbon filtration system may be used as a final wastewater-polishing step prior to its discharge to the Arkansas River. Alternatively, after Pond Nos. 6, 7, 8, and 9 are no longer available, accumulated water may be pumped to an evaporator treatment system to obviate the need for liquid discharges.

8.5 Schedules

Upon approval of this DP by the NRC, Fansteel will undertake preparation of designs and specifications. Subsequently, a construction contractor will be selected. Fansteel may choose to develop performance specifications and require the contractor to develop design details. Alternatively, Fansteel may opt to develop detailed designs/specifications. In either case, preconstruction activities are expected to take approximately 12 months.

Construction activities will not be conducted during the months of December through February. Therefore, remediation is anticipated to begin in March following completion of the design/contractor selection tasks and extend over a period of approximately 3 years. Contingent upon NRC approval of this DP, the

tentative schedule for decommissioning activities is outlined in Figure 8-3. Conceptual equipment requirements and labor allocations are included in Chapter 15.0.

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Figures

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

DRAWING NO. 6473423, FIGURE 8-1
EXCAVATION PLAN
DECOMMISSIONING PLAN
FANSTEEL, INC.
MUSKOGEE, OKLAHOMA

WITHIN THIS PACKAGE... OR BY SEARCHING USING THE DOCUMENT/REPORT NO. 6473423, FIGURE 8-1

NOTE: Because of these page's large file size, it may be more convenient to copy the file to a local drive and use the Imaging (Wang) viewer, which can be accessed from the Programs/Accessories menu.

D-07

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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DRAWING NO. 6473424, FIGURE 8-2 CONCEPTUAL SITE RESTORATION PLAN DECOMMISSIONING PLAN FANSTEEL, INC. MUSKOGEE, OKLAHOMA

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D-08

Fansteel
Muskogee, Oklahoma
Decommissioning Plan
Figure 8-3

ID	Task Name	Duration
1	NRC review and approval of DP	260 days
2	Prepare engineering design and specs	225 days
3	Bidding	25 days
4	Predecommissioning activities	260 days
5	Installation of sheet piling	180 days
6	**Decommissioning Activities**	**2007 days**
7	Excavation of Pond 3	300 days
8	Excavation of Pond 2	300 days
9	Backfill and reclamation of Ponds 2 and 3	180 days
10	Cleaning of structures and equipment	1280 days
11	Excavation of Ponds 5 - 9	719 days
12	Backfill and reclamation of Ponds 5 - 9	260 days
13	Remediate soil areas	260 days
14	Final status survey report	105 days