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Revision 1

Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Report

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Plateau Remediation Company
P.O. Box 1600
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Freestone Environmental, Inc.

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Assistant Secretary for Environmental Management

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Environmental Calculation Cover Page

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Project: 100 and 300 Area Remedial Investigation/ Feasibility Study

Date: 12/18/2012

Calculation Title & Description: Documentation of Preliminary Remediation Goals (PRGs) for Radionuclides Using the IAROD Exposure Scenario for the 100 and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Report

Calculation of radiological soil preliminary remediation goals for the Interim Action Record of Decision exposure scenario for use in the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports.

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Senior Reviewer: Doug Evans	**Basis of Qualification: Education & experience**

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Rev. 0	**Initial Issue**	11/05/2010	All
Rev. 1.A	**Nickel-59, Plutonium-241, and Tin-126 were added to the list of analytes and a PRG was calculated. The kd for Nickel-63 was updated from 3 cm^3/g to 30 cm^3/g and PRG for Nickel-63 was updated to account for the kd value of 30 cm^3/g; addition of uranium values;**	12/18/2012	Pages 3-8, and Tables
Rev. 1.B	**Uranium-234 (same as Uranium-233/234—not calculated), were added to the list of analytes.**	12/18/2012	Pages 3-8, and Tables

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Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: 100 and 300 Area Remedial Investigation/ Feasibility Study

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Terms

DOE	Department of Energy
ECF	environmental calculation file
EPA	Environmental Protection Agency
HISI	Hanford Information Systems Inventory
NCP	National Contingency Plan
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RDL	Required Detection Limits
RDR/RAWP	Remedial Design Report/Remedial Action Work Plan
RI/FS	Remedial Investigation/Feasibility Study
IAROD	Interim Action Record of Decision

1 Purpose

This Environmental Calculation documents assumptions and methods for development of radiological soil Preliminary Remediation Goals (PRGs) for the Interim Action Record of Decision (IAROD) exposure scenario for use in the 100 Areas and 300 Area Remedial Investigation/Feasibility Study (RI/FS) Reports. PRGs are concentration goals for a specific medium (e.g. soil) that are intended to protect specified receptors from exposure to contaminants through identified exposure pathways.

The PRGs described in the environmental calculation represent concentrations goals that are protective of a potential future resident receptor. Potentially complete exposure pathways associated with this scenario include direct contact and food chain (i.e., the consumption of homegrown produce and livestock) pathways. The PRGs described in this Environmental Calculation are consistent with the radiological remedial action goals described in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area* except that exposure assumptions have been updated to reflect current EPA guidance. Exposure assumptions that were updated include the external gamma shielding factor and the outdoor time fraction. The PRGs were also updated from a protective level reflecting an annual dose rate of 15 millirem per year (mrem/yr) to a target risk of 10^{-4}. The exposure assumptions used to calculate the PRG values presented in this Environmental Calculation are described in Section 4.0 and listed in Attachment 1.

2 Background

As described in DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, and *DOE/RL-2009-30, 300 Area Remedial Investigation/Feasibility Study work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, the 100 Areas and 300 Area contain multiple source and groundwater operable units (OUs), that are part of the Hanford Site River Corridor, which encompasses approximately 570 km^2 (220 mi^2) adjacent to the Columbia River. To date, waste sites within the River Corridor have been remediated to unrestricted land use levels. Cleanup levels corresponding to unrestricted land use in the River Corridor are currently defined in the Interim Action Records of Decision (IAROD), and have been calculated in DOE/RL-96-17, *100 Area Remedial Design Report/Remedial Action Work Plan*. For the purposes of developing PRGs within this Environmental Calculation document, the following target objectives are used[1]:

- Prevent unacceptable risk to human health from exposure to soils and/or debris contaminated with radiological contaminants less than 4.6 m (15 ft) bgs. PRGs for radionuclides that achieve this objective achieve the CERCLA cumulative risk range of 10^{-4} to 10^{-6} increased lifetime cancer risk which is consistent with EPA/540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*. As described in DOE/RL-96-17, these PRGs are intended to limit radiation risks for 1,000 years following the completion of a remedial action. According to ANL/EAD-4, *User's Manual for RESRAD,* the 1,000-year timeframe ensures that the PRGs account for the decay of radionuclides to daughter products that are more radioactive.

This target objective has been developed only for the purpose of calculating PRGs that are presented in this Environmental Calculation. This target objective is not intended to supersede Remedial Action Objectives (RAOs) being developed as part of the 100 Areas RI/FS Reports or the 300 Area RI/FS Report. This Environmental Calculation document will be revised as needed to incorporate updates to these PRGs that may result from changes in RAOs occurring during development of the 100 and 300 Area RI/FS Report.

[1] The RAO used for calculating PRGs for purposes of this Environmental Calculation have been adapted from RAOs developed for the River Corridor, as presented in DOE/RL-96-17.

3 Methodology

The radionuclide PRGs presented in this Environmental Calculation are single radionuclide soil concentrations corresponding to a target cancer risk level of 1×10^{-4}, 1×10^{-5}, and 1×10^{-6} which are protective of the IAROD exposure scenario. These PRGs have been calculated using RESRAD. According to ANL/EAD-4 the RESRAD model and computer code was developed as a multifunctional tool to assist in developing cleanup criteria and assessing the dose or risk associated with residual radioactive material. The software application of RESRAD is presented in Section 5 of this Environmental Calculation.

The PRGs for protection of human health from radionuclides in soil are based on the following assumptions:

- The future land use will be unrestricted (includes irrigation).
- Future residents are potentially exposed for a 30 year duration.
- The potentially complete exposure pathways considered are external gamma exposure, inhalation of dust, ingestion of homegrown produce, meat and milk ingestion, aquatic foods ingestion, drinking water ingestion, and incidental soil ingestion.

The assumptions used to develop the radionuclide PRGs for protection of human health are presented in Section 4.1 and are listed in Attachment 1. Site-specific assumptions for the 100 and 300 Area have been developed to estimate radionuclide transport to groundwater; this is done to estimate potential future risks from use of groundwater for drinking water and irrigation (referred to in the RESRAD user's guide as "water-dependent" pathways).

The specific steps taken to calculate an IAROD exposure scenario PRG for radionuclides in soil are presented below:

1. Input the parameters from Attachment 1into RESRAD.
2. Input the arbitrary soil concentration of 1,000 pCi/g and a single radionuclide into RESRAD.
3. Input calculation times of 1, 3, 10, 30, 100, 300, and 1,000 years into RESRAD.
4. Run RESRAD and review the results to identify the year at which the peak cancer risk occurs; record the total cancer risk at the peak year associated with 1,000 pCi/g in the intermediate calculations worksheet (Attachment 2).
5. In the intermediate calculations worksheet (Attachment 2), estimate the concentration in soil required to achieve a 1×10^{-4} risk at the peak risk year; input that soil concentration into RESRAD; add the peak risk year to the calculation parameters.
6. Re-run RESRAD and verify that the estimated concentration corresponds to a 1×10^{-4} risk; perform additional iterations as needed to obtain a soil concentration that corresponds to 1×10^{-4} risk to within 1 percent (this is to allow rounding of the PRG value as appropriate), and record that concentration in the intermediate calculations worksheet (Attachment 2). Save the model inputs and outputs from the final run for documentation purposes (see Step 8 below).
7. Calculate concentrations in soil corresponding to 1×10^{-5} and 1×10^{-6} cancer risks. These are factors of 10 and 100 of the soil concentration corresponding to 1×10^{-4} cancer risk and can be

calculated simply by division – this is done in the intermediate calculations worksheet and does not require re-running the model to obtain these values.

8. Document RESRAD results: save the input file (the *.RAD file) that corresponds to a risk of 1×10^{-4} with a unique file name identifying the project and radionuclide. An electronic copy of this file shall accompany this Environmental Calculation. Save the summary report (SUMMARY.REP) and the health risk report (INTRISK.REP) with unique file names – these files shall accompany this Environmental Calculation.

9. Repeat this process with the next radionuclide.

As an additional step to support the remedy selection process for uranium in 300 Area soils (DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5*), the RESRAD-calculated PRGs for the uranium isotopes are converted from activity-based concentrations (pCi/g) to mass-based concentrations (μg/kg) to facilitate development of a mass-based PRG for total uranium, The activity-based uranium isotope PRGs (pCi/g) are converted to mass-based PRGs (μg/kg) using the following equation (the conversion calculations are provided in Section 7).

$$\text{PRG } (\mu\text{g isotope/kg soil}) = [\text{PRG (pCi isotope/g soil) / Specific Activity (pCi isotope/g isotope)}] \times 1\text{x}10^6 \ (\mu\text{g isotope/g isotope}) \times 1000 \ (\text{g soil/kg soil}) \quad (1)$$

4 Assumptions and Inputs

The inputs used in the RESRAD code to calculate PRGs for protection of human health from direct contact with radionuclides in soil are presented in Attachment 1.

The IAROD exposure scenario includes the assumption that a future resident would have a well and would obtain drinking water and water for irrigation from that well. The PRG accounts for transport of contaminants through soil to groundwater, and potential exposure through drinking water, consumption of homegrown produce irrigated with contaminated groundwater, and consumption of livestock and milk raised using contaminated groundwater. Parameters associated with the generic site model (e.g., contaminated zone area and thickness, cover depth) and hydrostratigraphic conditions are identified in DOE/RL-96-17:

- It is assumed that the entire 4.6-m (15-ft)-thick shallow zone is contaminated and the entire deep zone (assumed to be 12 m [39 ft]) is assumed uncontaminated. No cover material is assumed to exist on top of the contaminated shallow zone.
- The hydrogeological parameters used for the 15 foot contaminated zone are weighted by the thickness of the stratigraphic units.
- Distribution coefficients (K_d) were selected preferentially from DOE/RL-96-17. In cases where DOE/RL-96-17 did not include a radionuclide, the RESRAD default K_d value was used. The K_d values are summarized in Attachment 3.

Parameter values used to estimate inhalation rates, and ingestion of drinking water, foods and incidental ingestion of soil are consistent with the values used in the DOE/RL-96-17. Those values and their sources are presented in Attachment 1.

To reflect recent guidance, EPA/540-R-00-007, *Soil Screening Guidance for Radionuclides: User's Guide*, the external gamma shielding factor was revised from 0.8 to 0.4 based on current EPA guidance. The fraction of time spent outdoors was revised from 0.2 (based on 5 hr/day x 350 days/yr [1,752 hr

/8,760 hr]) to 0.12 (based on 3 hr/day x 350 days/yr [1,050 hr/8,760 hr]). The health protective level for each PRG was revised to reflect a target cancer risk of 10^{-4} from an annual dose rate of 15 mrem/yr as originally reported in the DOE/RL-96-17.

The specific activities used with Equation 1 to convert uranium isotope PRGs from activity-based concentrations (pCi/g) to mass-based concentrations (μg/kg) are shown in Table 4-1.

Table 4-1. Uranium Isotope Specific Activities

Isotope	Specific Activity (Bq/g)[a]	Conversion Factor (Bq/Ci)	Conversion Factor (pCi/Ci)	Specific Activity (pCi/g)[b]
Uranium-233/234	2.302E+08	3.70E+10	1.00E+12	6.222E+09
Uranium-234	2.302E+08	3.70E+10	1.00E+12	6.222E+09
Uranium-235	7.995E+04	3.70E+10	1.00E+12	2.161E+06
Uranium-238	1.243E+04	3.70E+10	1.00E+12	3.359E+05

a. *Table of Isotopes 8th Edition, 1995 , Last update 12th April, 1998.*

b. Formula = Specific Activity (Bq/g) / Conversion Factor (Bq/Ci) x Conversion Factor (pCi/Ci)

5 Software Applications

RESRAD is approved for use by CHPRC at the Hanford Site in accordance with the requirements of PRC-PRO-IRM-309, *Software Control Management*. All supporting calculations were performed on electronic spreadsheets using Microsoft Excel. Electronic versions of all spreadsheets are provided with calculations included to facilitate comparison with hand calculations and checking of logical or lookup functions. This approach meets the requirements for "Single Use Software" as described in PRC-PRO-EP-40205, *CHPRC Environmental Calculation Preparation and Issue*. These spreadsheets are listed below in Section 6.

5.1 Description

The following presents the description of RESRAD used for this Environmental Calculation. See CHPRC-00209, Rev. 0, *RESRAD Software Management Plan* for further details regarding the use of this software:

- RESRAD for Windows,
- Version 6.5, Created October 30, 2009
- HISI Identification Number: 2102
- Workstation type and property number: WC95091 and 0075 Freestone Environmental Property Tag.

5.2 Software Installation and Checkout

The software installation and checkout form for RESRAD is attached to this Environmental Calculation.

5.3 Statement of Valid Software Application

The following presents the statement that RESRAD is a valid software application.

- RESRAD was developed for DOE to assist in developing cleanup criteria and assessing the dose or risk associated with residual radioactive material. RESRAD has been used for this purpose in support of previous decision documents developed at the Hanford Site.
- RESRAD as it has been used in this Environmental Calculation has been implemented within the range of its limitations. The parameters used in the modeling (shown in Attachment 1) are presented in the modeling input files attached to this Environmental Calculation, and also in the modeling output files where they are shown alongside the default parameters provided with the model. As discussed in Section 7, a sensitivity analysis of selected parameters has been performed to evaluate the effects of variations in input values on model results.

6 Calculation

The PRG results for radionuclides in soil are presented in the following tables and attachments contained in the Excel workbook "ECF-HANFORD-10-0429 IAROD Rad PRGs Attachments_Rev_1". Input and output files from RESRAD are also listed below.

The results from the PRG calculations presented in the Excel workbook are organized into the following worksheets:

- Attachment 1 – Input Parameter Values Used in RESRAD to Calculate PRGs for Protection of Human Health from Direct Contact with Soil, 100 and 300 Area (IAROD exposure scenario).
- Attachment 2 - Intermediate Calculations for RESRAD used to Calculate PRGs for Protection of Human Health from Direct Contact with Soil, 100 and 300 Area (IAROD exposure scenario).
- Attachment 3 - Radionuclide-Specific Distribution Coefficients (Kd) by RESRAD Model Layer.
- Attachment 4 – Sensitivity Analysis (site area); this shows the change in PRGs for protection of human health from direct contact with soil with changes in the surface area of the site.
- Attachment 5– Sensitivity Analysis (site thickness); this shows the change in PRGs for protection of human health from direct contact with soil with changes in the thickness of contamination in the site.

Input and output files from RESRAD are organized as follows:

- Input files are grouped into the folder "IAROD RESRAD Inputs 12511.zip"
- Output files are grouped into the folder "IAROD RESRAD Outputs 12511.zip"

CHPRC Software Installation and Checkout Forms as follows:

- SICO-Singleton.pdf
- SICO-Ross.pdf

7 Results/Conclusions

The PRGs for radionuclides in soil are summarized in Table 7-1.

The PRGs in soil for protection of human health from direct contact with soil are based on the year that the peak risk occurs, within a 1,000 year timeframe. For most of the radionuclides examined, this occurs at year zero. The year with the peak risk for Cm-245, I-129, K-40, Np-237, Ra-226, Tc-99, Th-230, Th-232, and U-233/234 occurs later, because of the contribution to risk from the ingrowth of daughter products. The year with the peak risk for I-129 and the uranium isotopes occurs later as a result of breakthrough to groundwater, and potential exposure through water-dependent pathways (i.e. ingestion of drinking water, and ingestion of crops, meat and milk raised with irrigation water contaminated with radionuclides).

A generic site area of 10,000 m^2 and a generic site thickness of 4.6 m were assumed for developing the PRGs for protection of human health. A sensitivity analysis was performed (see Attachment 4) to determine how sensitive the PRG values are to changes in site area. The results from the uncertainty analysis show for select radionuclides that changes in site area do affect the calculation of the PRG values. The PRG for Am-241 decreases 3.2 percent with an increase in site area from 10,000 m^2 to 100,000 m^2. The PRG for Cs-137 decreases about 11 percent with an increase in site area from 10,000 m^2 to 100,000 m^2. The PRG for Pu-239/240 decreases about 4 percent with an increase in site area from 10,000 m^2 to 100,000 m^2. The PRG for Ra-226 decreases about 4 percent with an increase in site area from 10,000 m^2 to 100,000 m^2. The results from this analysis indicate these PRGs are relatively insensitive to changes in site area.

A sensitivity analysis was performed (see Attachment 5) to determine how sensitive the PRG values are to changes in site thickness. The results from the uncertainty analysis show for select radionuclides (Am-241and Pu-239-240), that changes in site thickness do not affect the calculation of the PRG values. The PRG for Ra-226 increases 1.8 percent with a decrease in site thickness from 4.6 m to 1 m. The PRG for Cs-137 increases 2.3 percent with a decrease in site thickness from 4.6 m to 1 m.

To provide a PRG for total uranium for use in the 300 Area Feasibility Study (DOE/RL-2010-99), the RESRAD-calculated PRGs for the uranium isotopes are converted from activity-based concentrations (pCi/g) to mass-based concentrations (μg/kg), as shown in Table 7-2. The conversions are made using the PRGs protective at the 1×10^{-4} risk level, which represents the upper threshold of the U.S. Environmental Protection Agency (EPA) target risk range of 1×10^{-4} to 1×10^{-6}. To determine an appropriate PRG for total uranium from the mass-based uranium isotope PRGs shown in Table 7-2, consideration is given to the mass fractions of the uranium isotopes in total uranium. For the purposes of this Environmental Calculation, uranium isotope mass fractions are calculated based on the Hanford Site uranium soil background concentrations reported in DOE/RL-96-12, *Hanford Site Soil Background: Part 2, Soil Background for Radioactive Analytes*. The mass fractions are calculated by converting each isotope's reported activity-based background concentration to a mass-based concentration, as shown in Table 7-3. This table shows that by mass, uranium-238 comprises over 98% of the total uranium soil background concentration. The mass-based PRG for uranium-238 of 160,740 μg/kg is therefore recommended for use as a PRG for total uranium. Use of the uranium-238 value is considered conservative in that the uranium-238 value is lower than the total uranium PRG value would be if uranium-233/234, uranium-234, and uranium-235 were also included.

Table 7-1. Summary of Preliminary Remediation Goals for the 100 and 300 Area IAROD Exposure Scenario

Radionuclide	Selected Radionuclide Direct Exposure PRG at 10^{-4} Target Risk Level (pCi/g)	Selected Radionuclide Direct Exposure PRG at 10^{-5} Target Risk Level (pCi/g)	Selected Radionuclide Direct Exposure PRG at 10^{-6} Target Risk Level (pCi/g)
Ag (silver)-108m	1.37	0.137	0.0137
Americium-241	155	15.5	1.55
Carbon-14	81	8.1	0.81
Curium-243	30.3	3.03	0.303
Curium-243/244[a]	30.3	3.03	0.303
Curium-244	551	55.1	5.51
Curium-245	33.4	3.34	0.334
Cobalt-60	3.1	0.31	0.031
Cesium-137	4.4	0.44	0.044
Europium-152	3.66	0.366	0.0366
Europium-154	4.4	0.44	0.044
Europium-155	327	32.7	3.27
Tritium (H-3)	623	62.3	6.23
Iodine-129	0.076	0.0076	0.00076
Potassium-40	1.6	0.16	0.016
Niobium-94	1.35	0.135	0.0135
Nickel-59	1,337	133.7	13.37
Nickel-63	608	60.8	6.08
Neptunium-237	8.9	0.89	0.089
Plutonium-238	236	23.6	2.36
Plutonium-239/240[b]	203	20.3	2.03
Plutonium-241	5,080	508	50.8
Radium-226	0.56	0.056	0.0056
Radium-228	1.6	0.16	0.016
Strontium-90	2.27	0.227	0.0227
Technetium-99	1.5	0.15	0.015
Thorium-228	13.6	1.36	0.136
Thorium-230	1.59	0.159	0.0159
Thorium-232	0.43	0.043	0.0043
Tin-126	0.063	0.0063	0.00063
Uranium-233/234[c]	133	13.3	1.33
Uranium-234	133	13.3	1.33
Uranium-235	16.3	1.63	0.163
Uranium-238	54	5.4	0.54

a. Values presented are calculated for curium-243; curium-243 is assumed to be the dominant isotope in undifferentiated curium-243/244.

b. Values presented are calculated for plutonium-239; plutonium-239 is assumed to be the dominant isotope in undifferentiated plutonium-239/240.

c. Values presented are calculated for Uranium-234; uranium-234 is assumed to be the dominant isotope in

Table 7-1. Summary of Preliminary Remediation Goals for the 100 and 300 Area IAROD Exposure Scenario

Radionuclide	Selected Radionuclide Direct Exposure PRG at 10^{-4} Target Risk Level (pCi/g)	Selected Radionuclide Direct Exposure PRG at 10^{-5} Target Risk Level (pCi/g)	Selected Radionuclide Direct Exposure PRG at 10^{-6} Target Risk Level (pCi/g)
undifferentiated uranium-233/234.			

Table 7-2. Conversion from Activity- to Mass-Based PRGs for Uranium Isotopes

Uranium Isotope	IAROD Scenario PRG at 10^{-4} Risk Level (pCi isotope/ g soil)[a]	Specific Activity (pCi isotope/ g isotope)[b]	Conversion Factor (µg isotope/ g isotope)	Conversion Factor (g soil/ kg soil)	IAROD Scenario PRG at 10^{-4} Risk Level (µg isotope/ kg soil)[c]
U-233/234	133	6.222E+09	1,000,000	1,000	21.4
U-234	133	6.222E+09	1,000,000	1,000	21.4
U-235	16.3	2.161E+06	1,000,000	1,000	7,543
U-238	54	3.359E+05	1,000,000	1,000	160,740

a. See Table 7-1.

b. See Table 4-1.

c. Calculated using Equation 1 (see Section 3).

Table 7-3. Calculation of Uranium Isotope Mass Fractions

Uranium Isotope	Background Activity (pCi isotope/ g soil)[a]	Activity Fraction	Specific Activity (pCi isotope/ g isotope)[b]	Background Mass (µg isotope/ kg soil)[c]	Mass Fraction
U-233/234	1.10	0.458	6.222E+09	0.177	0.00006
U-234	1.10	0.458	6.222E+09	0.177	0.00006
U-235	0.11	0.048	2.161E+06	50.4	0.016
U-238	1.06	0.467	3.359E+05	3155	0.98

a. DOE/RL-96-12, *Hanford Site Soil Background: Part 2, Soil Background for Radioactive Analytes.*

b. See Table 4-1.

c. Formula = Background Activity (pCi/g) / Specific Activity (pCi/g) x 1E+06 (µg/g) x 1E+03 (g/kg)

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Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

			Interim Action Record of Decision Exposure Scenario		
RESRAD Category	**Parameter**	**Units**	**User Input**	**Rationale**	**Reference**
Exposure Pathways	External gamma: Inhalation: Plant ingestion: Meat ingestion: Milk ingestion: Aquatic foods: Drinking water: Soil ingestion: Radon:	NA	Active Active Active Active Active Active Active Active Suppressed		
R011 – Contaminated Zone (CZ)	Area of CZ	m^2	10,000	Generic site model	Surface area presented in RESRAD user's guide, ANL/EAD-4
	Thickness of CZ[c]	m	4.6	Direct exposure cleanup standards apply to the upper 4.6 m (15 ft)	
	Length Parallel to Aquifer Flow	m	100	Square root of contaminated site area	
	Radiation Dose Limit	mrem/yr	NA		
	Elapsed Time of Waste Placement	yr	0	RESRAD default	
R012 –Principal Radionuclides Concentrations	All radionuclide contaminants of concern	pCi/g	Contaminant-specific	Contaminant-specific soil remedial action levels (pCi/g) are endpoints of the RESRAD calculations	
R013 - Cover and CZ Hydrological Data	Cover Depth	m	0	Conservative assumption; assumes cover is not maintained and direct exposure to contamination may occcurein the future.	
	Density of Cover Material	g/cm^3	Not used		
	Cover Erosion Rate	m/yr	Not used		
	Density of CZ	g/cm^3	1.6	Hanford 100 Area-specific data	DOE/RL-90-07
	CZ Erosion Rate	m/yr	0.001	RESRAD default	
	CZ Total Porosity	Unitless	0.4	WDOH guidance	WDOH/320-015
	CZ Field Capacity	Unitless	0.15	Same as SZ Field Capacity	
	CZ Hydraulic Conductivity	m/yr	250	Hanford 100 Area-specific data	DOE/RL-96-11 DOE/RL-93-37
	CZ b Parameter	Unitless	4.05	WDOH guidance	WDOH/320-015
	Humidity in Air	g/cm^3	8	RESRAD default	

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

RESRAD Category	Parameter	Units	Interim Action Record of Decision Exposure Scenario		
			User Input	Rationale	Reference
	Evapotranspiration Coefficient	Unitless	0.91		Letter from EPA
	Wind Speed	m/s	3.4	Hanford Site average	PNNL-12087
	Precipitation	m/yr	0.16	Based on 16 cm (6.3 in.) average annual rainfall	DOE/RL-90-07
	Irrigation Rate	m/yr	0.76	EPA, Region X guidance	Letter from EPA
	Irrigation Mode	NA	Overhead	RESRAD default	
	Runoff Coefficient	Unitless	0.2	RESRAD default	
	Watershed Area for Nearby Stream or Pond	m^2	1,000,000	RESRAD default	
	Accuracy for Water/Soil Computations	Unitless	0.001	RESRAD default	

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

			Interim Action Record of Decision Exposure Scenario		
RESRAD Category	**Parameter**	**Units**	**User Input**	**Rationale**	**Reference**
R014 - SZ Hydrological Data	Density of SZ	g/cm^3	1.6	Hanford 100 Area-specific data	DOE/RL-90-07
	SZ Total Porosity	Unitless	0.4	WDOH guidance	WDOH/320-015
	SZ Effective Porosity	Unitless	0.25	Agreement among the Tri-Parties [a]	ANL/EAD/LD-2, Table 3.2
	SZ Field Capacity	Unitless	0.15	Field capacity = total porosity - effective porosity	ANL/EAD/LD-2, Equation 4.4
	SZ Hydraulic Conductivity	m/yr	5,530	Hanford 100-Area specific data	DOE/RL-96-11 DOE/RL-93-37
	SZ Hydraulic Gradient	Unitless	1.25E-03	Based on GW velocity = 27.8 m/yr, porosity = 0.25, hydraulic conductivity = 5,530	DOE/RL-94-136
	SZ b Parameter	Unitless	4.05	WDOH guidance	WDOH/320-015
	Water Table Drop Rate	m/yr	0.001	RESRAD default	
	Well Pump Intake Depth	m below water table	4.6	Typical RCRA well screen length	
	Nondispersion (ND) or Mass-Balance (MB)	NA	ND		
	Well Pumping Rate	m^3/yr	250	RESRAD default	
R015 - Uncontaminated and Unsaturated Strata Hydrological Data	Number of Unsaturated Strata	NA	1	Generic site model; one contaminated zone, one uncontaminated zone	
	Thickness	m	12	Generic site model	
	Soil Density	g/cm^3	1.6	Hanford 100 Area-specific data	DOE/RL-90-07
	Total Porosity	Unitless	0.4	WDOH guidance	WDOH/320-015
	Effective Porosity	Unitless	0.25	Agreement among the Tri-Parties	ANL/EAD/LD-2, 1993, Table 3.2
	Field Capacity	Unitless	0.15	Field capacity = total porosity - effective porosity	ANL/EAD/LD-2, 1993, Equation 4.4
	Soil-specific b Parameter	Unitless	4.05	WDOH guidance	WDOH/320-015
	Hydraulic Conductivity	m/yr	250	Hanford 100-Area specific data	DOE/RL-96-11 DOE/RL-93-37

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

RESRAD Category	Parameter	Units	Interim Action Record of Decision Exposure Scenario		
			User Input	Rationale	Reference
R016 - Distribution Coefficients and Leach Rates	CZ K_d	mL/g	Contaminant-specific	Kds values assigned to contaminated zone are for sand-dominated sediment (Hss). Kds values assigned to uncontaminated unsaturated zone and saturated zone are for sandy gravel (Hg).	Kd values are taken from following hierarchy of information sources: DOE/RL-96-17 Table (first preference), and RESRAD default (ANL 2009)
	Leach Rate	yr^{-1}	Contaminant-specific	RESRAD manual	Note - leach rates are not used; Kd values are used for all radionuclides for leaching calculations
	Saturated Solubility	mol/L	0	RESRAD default	Not used - Kd values are used for all leaching calculations

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

			Interim Action Record of Decision Exposure Scenario		
RESRAD Category	**Parameter**	**Units**	**User Input**	**Rationale**	**Reference**
R017 - Inhalation and External Gamma	Inhalation Rate	m^3/yr	7,300	WDOH guidance	WDOH/320-015
	Mass Loading for Inhalation	g/m^3	0.0001	WDOH guidance	WDOH/320-015
	Exposure duration	yr	30		EPA/540/R-92/003
	Indoor Dust Filtration Factor	Unitless	0.4	RESRAD default	
	External Gamma Shielding Factor	Unitless	0.4		EPA/540-R-00-007, Equation 4
	Indoor Time Fraction	Unitless	0.6	Based on 15 hr/day x 350 day/yr (5,250 hr/8,760 hr)	
	Outdoor Time Fraction	Unitless	0.12	Based on 3 hr/day x 350 days/yr (1,050 hr/8,760 hr)	
	Shape Factor	NA	Circular	RESRAD default	
R018 - Ingestion Pathway Data, Dietary Parameters	Fruits, Vegetables, and Grain Consumption	kg/yr	110	WDOH guidance	WDOH/320-015
	Leafy Vegetable Consumption	kg/yr	2.7	WDOH guidance	WDOH/320-015
	Milk Consumption	L/yr	100	WDOH guidance	WDOH/320-015
	Meat and Poultry Consumption	kg/yr	36	WDOH guidance	WDOH/320-015
	Fish Consumption	kg/yr	19.7	WDOH guidance	WDOH/320-015
	Other Seafood Consumption	kg/yr	0.9	RESRAD default	
	Soil Ingestion	g/yr	36.5	Based on 100 mg/day x 365 days/yr	EPA/540/R-92/003
	Drinking Water Intake	L/yr	730	WDOH guidance	WDOH/320-015
	Drinking Water Contamination Fraction	Unitless	1	RESRAD default	
	Household Water Contamination Fraction	Unitless	1	RESRAD default	
	Livestock Water Contamination Fraction	Unitless	1	RESRAD default	
	Irrigation Water Contamination Fraction	Unitless	1	RESRAD default	
	Aquatic Food Contamination Fraction	Unitless	0.5	RESRAD default	
	Plant Food Contamination Fraction	Unitless	-1	RESRAD default	

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

RESRAD Category	Parameter	Units	Interim Action Record of Decision Exposure Scenario		
			User Input	Rationale	Reference
	Meat Contamination Fraction	Unitless	-1	RESRAD default	
	Milk Contamination Fraction	Unitless	-1	RESRAD default	

Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

RESRAD Category	Parameter	Units	Interim Action Record of Decision Exposure Scenario		
			User Input	Rationale	Reference
R019 - Ingestion Pathway Data, Nondietary	Livestock Fodder Intake for Meat	kg/d	68	RESRAD default	
	Livestock Fodder Intake for Milk	kg/d	55	RESRAD default	
	Livestock Water Intake for Meat	L/d	50	RESRAD default	
	Livestock Water Intake for Milk	L/d	160	RESRAD default	
	Livestock Intake of Soil	kg/d	0.5	RESRAD default	
	Mass Loading for Foliar Deposition	g/m^3	0.0001	RESRAD default	
	Depth of Soil Mixing Layer	m	0.15	RESRAD default	
	Depth of Roots	m	0.9	RESRAD default	
R020 – Groundwater Usage	Groundwater Fractional Usage - Drinking Water	Unitless	1	RESRAD default	
	Groundwater Fractional Usage - Household Usage	Unitless	1	RESRAD default	
	Groundwater Fractional Usage - Livestock Water	Unitless	1	RESRAD default	
	Groundwater Usage – Irrigation	Unitless	1	RESRAD default	
R021 - Radon	Radon parameters are not used; Radon is not a Hanford Site COPC.			WDOH guidance	WDOH/320-015

a. Use of an effective porosity of 0.25 as a generic 100 Area input parameter is based upon agreement among the Tri-Parties. An effective porosity of 0.25 corresponds to values for sand and gravel reported in ANL/EAD/LD-2, Table 3.2.

ANL = Argonne National Laboratory
COPC = contaminant of potential concern
CZ = contaminated zone
EPA = U.S. Environmental Protection Agency
NA = not applicable
ND = nondispersion
RCRA = *Resource Conservation ond Recovery Act of 1976*
RESRAD = RESidual RADioactivity code
SZ = saturated zone
WDOH = Washington State Department of Health

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Attachment 1. Input Parameters to RESRAD for Calculation of PRGs for Radionuclides in Soil for Protection of Human Health for the 100 Area RI/FSs

			Interim Action Record of Decision Exposure Scenario		
RESRAD Category	**Parameter**	**Units**	**User Input**	**Rationale**	**Reference**

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Attachment 2. Intermediate Calculations

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Final PRG (pCi/g)	Target Risk
Ag-108	1000	7.316E-02	0	1.00E-04	1.37	1.37	1.002E-04	0.1996%	1.37	1.00E-04
									0.137	1.00E-05
									0.0137	1.00E-06
Am-241	1000	6.453E-04	0	1.00E-04	154.97	155	1.000E-04	0.0000%	155	1.00E-04
									15.5	1.00E-05
									1.55	1.00E-06
C-14	1000	1.235E-03	0	1.00E-04	80.97	81	1.002E-04	0.1996%	81	1.00E-04
									8.1	1.00E-05
									0.81	1.00E-06
Cm-243	1000	3.299E-03	0	1.00E-04	30.31	30.3	9.997E-05	-0.0300%	30.3	1.00E-04
									3.03	1.00E-05
									0.303	1.00E-06
Cm-243/243	1000	3.299E-03	0	1.00E-04	30.31	30.3	9.997E-05	-0.0300%	30.3	1.00E-04
									3.03	1.00E-05
									0.303	1.00E-06
Cm-244	1000	1.815E-04	0	1.00E-04	550.96	551	1.000E-04	0.0000%	551	1.00E-04
									55.10	1.00E-05
									5.510	1.00E-06
Cm-245	1000	2.993E-03	575	1.00E-04	33.41	33.4	9.998E-05	-0.0200%	33.4	1.00E-04
									3.34	1.00E-05
									0.334	1.00E-06
Co-60	1000	3.228E-02	0	1.00E-04	3.10	3.1	1.007E-04	0.6951%	3.1	1.00E-04
									0.310	1.00E-05
									0.0310	1.00E-06
Cs-137	1000	2.269E-02	0	1.00E-04	4.41	4.4	9.954E-05	-0.4621%	4.4	1.00E-04
									0.440	1.00E-05
									0.0440	1.00E-06
Eu-152	1000	2.733E-02	0	1.00E-04	3.66	3.66	1.000E-04	0.0000%	3.66	1.00E-04
									0.37	1.00E-05
									0.037	1.00E-06
Eu-154	1000	2.277E-02	0	1.00E-04	4.39	4.4	1.002E-04	0.1996%	4.4	1.00E-04
									0.440	1.00E-05
									0.0440	1.00E-06
Eu-155	1000	3.062E-04	0	1.00E-04	326.58	327	1.001E-04	0.0999%	327	1.00E-04
									32.7	1.00E-05
									3.27	1.00E-06
H-3	1000	1.605E-04	0	1.00E-04	623.05	623	1.000E-04	0.0000%	623	1.00E-04

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Target Risk	Estimated concentration at 10^{-6} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Final PRG (pCi/g)	Target Risk
									62.3	1.00E-05
									6.23	1.00E-06

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Final PRG (pCi/g)	Target Risk
I-129	1000	1.322E+00	189	1.00E-04	0.076	0.076	1.005E-04	0.4975%	0.076	1.00E-04
									0.008	1.00E-05
									0.0008	1.00E-06
K-40	1000	6.193E-02	1000	1.00E-04	1.61	1.6	9.909E-05	-0.9184%	1.6	1.00E-04
									0.16	1.00E-05
									0.016	1.00E-06
Nb-94	1000	7.392E-02	0	1.00E-04	1.35	1.35	9.980E-05	-0.2004%	1.35	1.00E-04
									0.135	1.00E-05
									0.0135	1.00E-06
Ni-59	1000	7.480E-05	0	1.00E-04	1336.90	1337	1.00E-04	0.0000%	1337	1.00E-04
									133.7	1.00E-05
									13.37	1.00E-06
Ni-63	1000	1.645E-04	0	1.00E-04	607.90	608	1.000E-04	0.0000%	608	1.00E-04
									60.8	1.00E-05
									6.08	1.00E-06
Np-237	1000	1.130E-02	0	1.00E-04	8.85	8.9	1.006E-04	0.5964%	8.9	1.00E-04
									0.890	1.00E-05
									0.0890	1.00E-06
Pu-238	1000	4.246E-04	0	1.00E-04	235.52	236	1.002E-04	0.1996%	236	1.00E-04
									23.6	1.00E-05
									2.36	1.00E-06
Pu-239/240	1000	4.934E-04	0	1.00E-04	202.68	203	1.001E-04	0.0999%	203	1.00E-04
									20.3	1.00E-05
									2.03	1.00E-06
Pu-241	1000	1.970E-05	56	1.00E-04	5076.14	5080	1.001E-04	0.0999%	5080	1.00E-04
									508.0	1.00E-05
									50.80	1.00E-06
Ra-226	1000	1.778E-01	9.20E+01	1.00E-04	0.56	0.56	9.957E-05	-0.4319%	0.56	1.00E-04
									0.056	1.00E-05
									0.0056	1.00E-06
Ra-228	1000	6.239E-02	0	1.00E-04	1.60	1.6	9.983E-05	-0.1703%	1.6	1.00E-04
									0.16	1.00E-05
									0.016	1.00E-06
Sr-90	1000	4.411E-02	0	1.00E-04	2.27	2.27	1.001E-04	0.0999%	2.27	1.00E-04
									0.227	1.00E-05
									0.0227	1.00E-06
Sn-126	1000	1.592E+00	18.6	0.0001	0.063	0.063	1.00E-04	0.30%	0.063	1.00E-04
									0.0063	1.00E-05

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Final PRG (pCi/g)	Target Risk
									0.00063	1.00E-06
Tc-99	1000	6.560E-02	18	1.00E-04	1.52	1.52	9.971E-05	-0.2908%	1.52	1.00E-04
									0.15	1.00E-05
									0.015	1.00E-06
Th-228	1000	7.382E-03	0	1.00E-04	13.55	13.6	1.004E-04	0.3984%	13.6	1.00E-04
									1.36	1.00E-05
									0.136	1.00E-06

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Final PRG (pCi/g)	Target Risk
Th-230	1000	6.308E-02	1000	1.00E-04	1.59	1.59	1.003E-04	0.2991%	1.59	1.00E-04
									0.2	1.00E-05
									0.02	1.00E-06
Th-232	1000	2.319E-01	54	1.00E-04	0.43	0.43	9.973E-05	-0.2707%	0.43	1.00E-04
									0.043	1.00E-05
									0.0043	1.00E-06
U-233/234	1000	7.516E-04	1000	1.00E-04	133.05	133	9.996E-05	-0.0400%	133	1.00E-04
									13.300	1.00E-05
Note: Uranium-234 breakthrough occurs at 20,170 years									1.3300	1.00E-06
U-234	1000	7.516E-04	1000	1.00E-04	133.05	133	9.996E-05	-0.0400%	133	1.00E-04
									13.300	1.00E-05
Note: Uranium-234 breakthrough occurs at 20,170 years									1.3300	1.00E-06
U-235	1000	6.146E-03	0	1.00E-04	16.27	16.3	1.002E-04	0.1996%	16.3	1.00E-04
									1.630	1.00E-05
Note: Uranium-235 breakthrough occurs at 20,170 years									0.1630	1.00E-06
U-238	1000	1.863E-03	0	1.00E-04	53.68	54	1.006E-04	0.5964%	54.00	1.00E-04
									5.400	1.00E-05
Note: Uranium-238 breakthrough occurs at 20,170 years									0.5400	1.00E-06

Attachment 3. Radionuclide-Specific Distribution Coefficients (K_d) by RESRAD Model Layer.

Radionuclide	K_d (cm^3/g)	K_d Reference	K_d (cm3/g)	K_d Reference
	Contaminated Zone Layer (assumed sand dominated, Hss)		Uncontaminated Unsaturated Zone and Saturated Zone Layers (assumed sandy gravel, Hg)	
Ag (silver)-108m	90	DOE/RL-96-17, Table B-7	90	DOE/RL-96-17, Table B-7
Americium-241	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Carbon-14	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Cesium-137	50	DOE/RL-96-17, Table B-7	50	DOE/RL-96-17, Table B-7
Cobalt-60	50	DOE/RL-96-17, Table B-7	50	DOE/RL-96-17, Table B-7
Curium-243	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Curium-243/244[a]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Curium-244[a]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Curium-245[a]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Europium-152	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Europium-154	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Europium-155	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Iodine-129	1	DOE/RL-96-17, Table B-7	1	DOE/RL-96-17, Table B-7
Neptunium-237	15	DOE/RL-96-17, Table B-7	15	DOE/RL-96-17, Table B-7
Nickel-59[b]	30	DOE/RL-96-17, Table B-7	30	DOE/RL-96-17, Table B-7
Nickel-63	30	DOE/RL-96-17, Table B-7	30	DOE/RL-96-17, Table B-7
Niobium-94	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Plutonium-238	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Plutonium-239/240	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Plutonium-241[c]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Potassium-40	5.5	DOE/RL-96-17, Table B-7	5.5	DOE/RL-96-17, Table B-7
Radium-226	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Radium-228	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Strontium-90	25	DOE/RL-96-17, Table B-7	25	DOE/RL-96-17, Table B-7
Technetium-99	0	DOE/RL-96-17, Table B-7	0	DOE/RL-96-17, Table B-7
Thorium-228	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Thorium-230	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Thorium-232	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Tin-126	0	RESRAD default	0	RESRAD default
Tritium (H-3)	0	DOE/RL-96-17, Table B-7	0	DOE/RL-96-17, Table B-7
Uranium-233/234	50	RESRAD default	50	RESRAD default

Attachment 3. Radionuclide-Specific Distribution Coefficients (K_d) by RESRAD Model Layer.

Radionuclide	K_d (cm^3/g)	K_d Reference	K_d (cm3/g)	K_d Reference
	Contaminated Zone Layer (assumed sand dominated, Hss)		Uncontaminated Unsaturated Zone and Saturated Zone Layers (assumed sandy gravel, Hg)	
Uranium-234	50	RESRAD default	50	RESRAD default
Uranium-235	50	RESRAD default	50	RESRAD default
Uranium-238	50	RESRAD default	50	RESRAD default
Daughter Radionuclides (included automatically by RESRAD with selection of parent)				
Actinium-227	20	RESRAD default	20	RESRAD default
Americium-243[d]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Gadolinium-152[e]	-1	RESRAD default	-1	RESRAD default
Lead-210	100	RESRAD default	100	RESRAD default
Plutonium-240[c]	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Protactinium-231	50	RESRAD default	50	RESRAD default
Thorium-229	200	DOE/RL-96-17, Table B-7	200	DOE/RL-96-17, Table B-7
Uranium-236	50	RESRAD default	50	RESRAD default

a. The referenced Kd value for Curium-243 is used

b. The referenced Kd value for Nicklel-63 is used

c. The referenced Kd value for Plutonium-239/240 is used

d. The referenced Kd value for Americium-241 is used

e. RESRAD displays a default value of -1 on the Kd input screen for gadolinium-152 indicating the Kd value is derived internally by the code.

RESRAD - RESidual RADioactivity code (ANL 2009)

ANL, 2009, RESRAD for Windows, Version 6.5, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

DOE/RL-96-17, 2009, Remedial Design Report/Remedial Action Work Plan for the 100 Area, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Attachment 4. Site Area Sensitivity Analysis

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Surface Area (m^2)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Percent Difference in PRGs Between Base Case (10,000 m^2) and Alternate Site Areas
Am-241	1000	6.453E-04	0	10,000	1.00E-04	154.97	155	1.000E-04	0.0000%	
	1000	6.654E-04	0	100,000	1.00E-04	150.29	150	9.980E-05	-0.2004%	3.2%
	1000	6.207E-04	0	1,000	1.00E-04	161.11	161	9.993E-05	-0.0700%	-3.9%
Cs-137	1000	2.269E-02	0	10,000	1.00E-04	4.41	4.4	9.982E-05	-0.1803%	
	1000	2.575E-02	0	100,000	1.00E-04	3.88	3.9	1.004E-04	0.3984%	11.4%
	1000	1.961E-02	0	1,000	1.00E-04	5.10	5.1	9.999E-05	-0.0100%	-15.9%
Pu-239/240	1000	4.934E-04	0	10,000	1.00E-04	202.68	203	1.002E-04	0.1996%	
	1000	5.131E-04	0	100,000	1.00E-04	194.89	195	1.001E-04	0.0999%	3.9%
	1000	4.763E-04	0	1,000	1.00E-04	209.95	210	1.000E-04	0.0000%	-3.4%
Ra-226	1000	1.778E-01	92	10,000	1.00E-04	0.56	0.56	9.957E-05	-0.4319%	
	1000	1.872E-01	92	100,000	1.00E-04	0.53	0.54	9.920E-05	-0.8065%	3.6%
	1000	1.686E-01	92	1,000	1.00E-04	0.59	0.59	9.945E-05	-0.5530%	-5.4%

Attachment 5. Site Thickness Sensitivity Analysis

Radionuclide	Input Conc (pCi/g)	Risk	Time of Max Risk (yr)	Site Thickness (m)	Target Risk	Estimated concentration at 10^{-4} target risk (pCi/g)	Concentration Input to RESRAD (pCi/g)	Calculated Cancer Risk from RESRAD	Percent Difference in Risk Between Estimated and Input Concentrations	Percent Difference in PRGs Between Base Case (4.6 m) and Alternate Site Areas
Am-241	1000	6.453E-04	0	4.6	1.00E-04	154.97	155	1.000E-04	0.0000%	
	1000	6.454E-04	0	10	1.00E-04	154.94	155	1.000E-04	0.0000%	0.0%
	1000	6.433E-04	0	1	1.00E-04	155.45	155	9.971E-05	-0.2908%	0.0%
Cs-137	1000	2.269E-02	0	4.6	1.00E-04	4.41	4.4	9.982E-05	-0.1803%	
	1000	2.266E-02	0	10	1.00E-04	4.41	4.4	9.969E-05	-0.3110%	0.0%
	1000	2.239E-02	0	1	1.00E-04	4.47	4.5	1.008E-04	0.7937%	-2.3%
Pu-239/240	1000	4.934E-04	0	4.6	1.00E-04	202.68	203	1.002E-04	0.1996%	
	1000	4.933E-04	0	10	1.00E-04	202.72	203	1.001E-04	0.0999%	0.0%
	1000	4.917E-04	0	1	1.00E-04	203.38	203	9.981E-05	-0.1904%	0.0%
Ra-226	1000	1.778E-01	92	4.6	1.00E-04	0.56	0.56	9.957E-05	-0.4319%	
	1000	1.784E-01	92	10	1.00E-04	0.56	0.56	9.991E-05	-0.0901%	0.0%
	1000	1.742E-01	75	1	1.00E-04	0.57	0.57	9.929E-05	-0.7151%	-1.8%