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Revision 0

Calculation of Soil Radiological Preliminary Remedial Goals for the Outdoor Worker Scenario

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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Richland, Washington 99352

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S. L. Lindberg
INTERA, Inc.

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Terms

AOC	Area of Contaminated Zone
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CHPRC	CH2M HILL Plateau Remediation Company
DOE	U.S. Department of Energy
ECF	environmental calculation file
EPA	U.S. Environmental Protection Agency
HISI	Hanford Information Systems Inventory
K_d	Distribution coefficients
OUs	Operable Units
PRGs	Preliminary Remediation Goals
RAO	Remedial Action Objective
RESRAD	RESidual RADioactivity
RI/FS	Remedial Investigation/Feasibility Study
SI	Sensitivity index

1 Purpose

This environmental calculation file (ECF) documents assumptions and methods for development of radiological soil Preliminary Remediation Goals (PRGs) for an outdoor worker exposure scenario for use in the Remedial Investigation/Feasibility Study (RI/FS) Reports for the Inner Area source operable units (OUs) located within the Central Plateau of the Hanford Site. The 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 and routes.

The PRGs documented in this Environmental Calculation represent concentration goals that are protective of a potential outdoor worker receptor. Potentially complete exposure pathways associated with this scenario include direct contact (incidental soil ingestion and direct external gamma exposure) and the inhalation pathways.

2 Background

The methods and parameters used in this ECF support the Central Plateau Inner Area cleanup principles and are based on guidance from the U.S. Environmental Protection Agency (EPA). Soil PRGs for radionuclides are calculated using a methodology that is consistent with the methodology used for the baseline risk assessments previously conducted at the Hanford Site that have been reviewed and approved by the regulatory agencies.

For the purposes of developing PRGs in this ECF, the following target objective is used:

- Prevent unacceptable risk to human health from exposure to soils and/or debris contaminated with radiological contaminants less than 4.6 m (15 ft) below ground surface (bgs). PRGs for radionuclides that achieve this objective achieve the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (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*. 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 Central Plateau RI/FS process. 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 Central Plateau RI/FS Reports.

3 Methodology

RESidual RADioactivity computer code (RESRAD) Version 7.0 (ANL, 2014) was used to calculate the soil PRGs for radiological contaminants based on the outdoor worker exposure scenario. The default DCFPAK 3.02 Morbidity risk factors within RESRAD version 7.0 were utilized during the calculation of soil PRGs. 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 outdoor worker. 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 RESRAD input parameters and radionuclide-specific distribution coefficients (K_d) used to develop the outdoor worker radionuclide PRGs are listed in Table 1 and Table 2, respectively. The assumptions associated with the parameters are further discussed in Section 4, as applicable.

The specific steps taken to calculate the outdoor worker scenario PRGs for radionuclides in soil are presented below:

1. Input the parameters from Table 1 into the RESRAD.
2. Input the arbitrary soil unit concentration of 1 pCi/g and the applicable K_d from Table 2 for each radionuclide evaluated.
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. Using "Standard Graphics" module located within the "View Output, make the following selections to identify the peak cancer risk for each individual radionuclide.
   - Plot Type: Risk
   - Radionuclide: Individual
   - Pathways : Summed
5. For each individual radionuclide, record the year associated with peak cancer risk in an intermediate calculations worksheet (Appendix A, Table A-1). If the peak risks occur at year 0 or year 1000, record the peak year directly from the displayed graphic. However, for those radionuclides where the peak risk occurs within an intermediate year between 0 and 1000, use the tool "Export to Excel" within the "Edit" Menu to obtain the risk output results in an excel worksheet (display results to four significant figures) to identify and highlight the year of peak cancer risk and save the results (Appendix A, Table A-1).
6. Save the corresponding summary report (SUMMARY.REP) with unique file name.
7. Save the existing RESRAD input file (*.RAD) with a new name.
8. Input calculation times corresponding to each unique year of peak risk (as identified in Step 4) into RESRAD.
9. Re-run RESRAD.
10. Open the "Health Risk Report" within "View Output" module.
11. For each calculation time, copy and paste the risk results for each individual radionuclide from the "All Pathways" column into an intermediate Microsoft Excel® worksheet (Appendix A, Table A-2).
    a. Create a set of headers that identify the calculation times associated with each set of risk outputs.
    b. Create a column that identifies the maximum risk per pCi/g for each radionuclide.
    c. Create another column that identifies the Year associated with the maximum risk.

® Microsoft Excel is a registered product of the Microsoft Corporation.

d. Create a column that calculates a preliminary PRG for each radionuclide associated with a target risk of 1×10^{-4}.

e. Calculate the preliminary PRG by dividing the target risk of 1×10^{-4} by the maximum risk per pCi/g.

12. Save the corresponding summary report and the health risk report (INTRISK.REP) with a unique file name.

13. Save the existing RESRAD file with a new name.

14. Input the preliminary PRG value for each individual radionuclide into the soil concentrations module.

15. Re-run RESRAD and verify that the estimated PRG value corresponds to a 1×10^{-4} risk (Appendix A, Table A-3); perform additional iterations as needed to obtain a soil concentration that corresponds to 1×10^{-4} risk to within a relative percent difference of 1%. This is to ensure the rounding of the PRG values does not affect calculated risk significantly (Appendix A, Table A-3). These concentrations represent the PRGs associated with an acceptable risk threshold of 1×10^{-4}.

16. Save the corresponding summary report and the health risk report with unique file names.

17. 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 are calculated by division (Appendix A, Table A-4).

As an additional step to support the remedy selection process for total uranium in Central Plateau soils, the RESRAD-calculated PRGs for the uranium isotopes are converted from activity-based concentrations (pCi/g) to mass-based concentrations (µg/kg). The activity-based uranium isotope PRGs (pCi/g) are converted to mass-based PRGs (µg/kg) using the following equation.

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

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
Exposure Pathways	External gamma Inhalation: Plant ingestion Meat ingestion Milk ingestion Aquatic foods Drinking water Soil ingestion: Radon:	NA	Active Active Suppressed Suppressed Suppressed Suppressed Suppressed Active Suppressed	Outdoor Worker Scenario	--
R011 – Contaminated Zone (CZ)	Area of CZ	m^2	10,000	RESRAD default value	--

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	Thickness of CZ	m	4.6	Direct exposure PRGs apply to the upper 4.6 m (15 ft)	--
	Length Parallel to Aquifer Flow	m	NA	Drinking water and food ingestion pathways are suppressed	--
	Does the initial contamination penetrate the water table?	NA	No	Drinking water and food ingestion pathways are suppressed	
R012 –Principal Radionuclides Concentrations	All radionuclide COPCs	pCi/g	1	Unit concentrations are input to obtain radionuclide-specific risk to source ratios (risk per pCi/g) at time of peak risk	--
R013 - Cover and CZ Hydrological Data	Cover Depth	m	0	Conservatively assumes no cover is present and direct exposure to contamination may occur	--
	Density of Cover Material	g/cm^3	NA	No soil cover	--
	Cover Erosion Rate	m/year	NA	No soil cover	
	Density of CZ	g/cm^3	1.87	Thickness-weighted average	PNNL-18564 (Table 6.2, site-wide values) Appendix A, Table A-5
	CZ Erosion Rate	m/year	0.001	RESRAD default	--
	CZ Total Porosity	Unitless	0.296	Thickness-weighted average	PNNL-18564 (Table 6.3, site-wide values) Appendix A, Table A-5
	CZ Field Capacity	Unitless	0.084	Thickness-weighted average	PNNL-18564 (Table 6.5, best-estimate values) Appendix A, Table A-5

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	CZ Hydraulic Conductivity	m/year	88.7	Thickness-weighted average	PNNL-18564 (Table 6.7, site-wide values) Appendix A, Table A-5
	CZ b Parameter	Unitless	2.89	Thickness-weighted average	PNNL-18564 (Table 6.8) Appendix A, Table A-5
	Humidity in Air	g/cm^3	8	RESRAD default	--
	Evapotranspiration Coefficient	Unitless	0.91	EPA, Region X guidance	Letter from EPA
	Wind Speed	m/s	3.4	Hanford Site average	PNNL-15160, Table 5.1
	Precipitation	m/year	0.177	Based on 6.98 in. (0.177 m) average annual rainfall	PNNL-15160, Table 4.1
	Irrigation Rate	m/year	0	No irrigation assumed for OUs within the Inner Area of the Central Plateau	--
	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/SoilComputations	Unitless	0.001	RESRAD default	--
R014 – Saturated Zone (SZ) Hydrological Data	Density of SZ	g/cm^3	NA	Not applicable because drinking water and food ingestion pathways are suppressed	--
	SZ Total Porosity	Unitless	NA		
	SZ Effective Porosity	Unitless	NA		
	SZ Field Capacity	Unitless	NA		
	SZ Hydraulic Conductivity	m/year	NA		
	SZ Hydraulic Gradient	Unitless	NA		
	SZ b Parameter	Unitless	NA		

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	Water Table Drop Rate	m/year	NA		
	Well Pump Intake Depth	m below water table	NA		
	Nondispersion (ND) or Mass-Balance (MB)	NA	NA		
	Well Pumping Rate	m^3/year	NA		
R015 - Uncontaminated and Unsaturated Strata Hydrological Data	Number of Unsaturated Strata	NA	NA	Not applicable because drinking water and food ingestion pathways are suppressed	--
	Thickness	m	NA		
	Soil Density	g/cm^3	NA		
	Total Porosity	Unitless	NA		
	Effective Porosity	Unitless	NA		
	Field Capacity	Unitless	NA		
	Soil-specific b Parameter	Unitless	NA		
	Hydraulic Conductivity	m/year	NA		
R016 - Distribution Coefficients and Leach Rates	CZ K_d	mL/g	Contaminant-specific (see Table 3-2)	K_d values assigned to the CZ are for sand-dominated sediment (H_{ss}). K_d values assigned to the uncontaminated unsaturated layers and saturated zone are for the sandy gravel (H_g) and are used only to assess transport to groundwater and do not affect outdoor worker PRGs.	Kd values are taken from the following hierarchy of information sources: PNNL-18564 Table 6.9 (first preference), Table 5.6 (second preference), RESRAD default (ANL 2009)
	Leach Rate	$year^{-1}$	NA	Not applicable (Kds are used for all leaching	--

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	Saturated Solubility	mol/L	NA	Not applicable (Kds are used for all leaching	--
R017 - Inhalation and External Gamma	Inhalation Rate	m^3/year	20,000	20 m^3/8 hr x 24 hr/day x 365 day/yr = 21,900 m^3/yr (value truncated at RESRAD upper bound input of 20,000 m^3/yr)	OSWER Directive 9285.6-03, Section 3.3
	Mass Loading for Inhalation	g/m^3	1.37E-08	(1/ PEF), where PEF = 7.3 x 10^{10} m^3/kg	ECF-HANFORD-11-0033
	Exposure duration	years	25	Outdoor Worker Scenario	OSWER Directive 9285.6-03 (Commercial/Industrial Land Use)
	Indoor Dust Filtration Factor	Unitless	0	Assumes no time spent indoors	--
	External Gamma Shielding Factor	Unitless	1	Assumes no time spent indoors	--
	Indoor Time Fraction	Unitless	0	Assumes no time spent indoors	--
	Outdoor Time Fraction	Unitless	0.2055	Assumes 8 hours/day, 225 days/year (1,800 hour/8,760 hour).	OSWER Directive 9285.6-03
	Shape Factor	NA	Circular	RESRAD default	--
R018 - Ingestion Pathway Data, Dietary Parameters	Fruits, Vegetables, and Grain Consumption	kg/year	NA	Incomplete exposure pathways for the Outdoor Worker scenario	--
	Leafy Vegetable Consumption	kg/year	NA		
	Milk Consumption	L/year	NA		
	Meat and Poultry Consumption	kg/year	NA		

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	Fish Consumption	kg/year	NA		
	Other Seafood Consumption	kg/year	NA		
	Soil Ingestion	g/year	36.5	Based on 100 mg/day x 365 days/year	OSWER Directive 9285.6-03
	Drinking Water Intake	L/year	NA	Incomplete exposure pathway for the Outdoor Worker scenario	--
	Drinking Water Contamination Fraction	Unitless	NA		
	Household Water Contamination Fraction	Unitless	NA		
	Livestock Water Contamination Fraction	Unitless	NA		
	Irrigation Water Contamination Fraction	Unitless	NA		
	Aquatic Food Contamination Fraction	Unitless	NA		
	Plant Food Contamination Fraction	Unitless	NA		
	Meat Contamination Fraction	Unitless	NA		
	Milk Contamination Fraction	Unitless	NA		
R019 - Ingestion Pathway Data, Nondietary	Livestock Fodder Intake for Meat	kg/day	NA	Incomplete exposure pathway for the Outdoor Worker scenario	--
	Livestock Fodder Intake for Milk	kg/day	NA		
	Livestock Water Intake for Meat	L/day	NA		
	Livestock Water Intake for Milk	L/day	NA		
	Livestock Intake of Soil	kg/day	NA		
	Mass Loading for Foliar Deposition	g/m^3	NA		

Table 1. Input Parameter Values Used in RESRAD to Calculate Preliminary Remediation Goals for Outdoor Worker Scenario

RESRAD Category	Parameter	Units	User Input Values	Rationale	Reference
	Depth of Soil Mixing Layer	m	0.15	RESRAD Default	--
	Depth of Roots	m	NA	Incomplete exposure pathway for the Outdoor Worker scenario	--
R020 – Groundwater Usage	Groundwater Fractional Usage - Drinking Water	Unitless	NA	Incomplete pathway for the Outdoor Worker exposure scenario	--
	Groundwater Fractional Usage - Household Usage	Unitless	NA		--
	Groundwater Fractional Usage - Livestock Water	Unitless	NA		--
	Groundwater Fractional Usage – Irrigation	Unitless	NA		--
R021 - Radon	Radon parameters are not used; Radon is not a Hanford Site contaminant of potential concern.				

CZ = contaminated zone
NA = not applicable
K_d = distribution coefficient
SZ = saturated zone
ANL, 2014, RESRAD for Windows, Version 7.0.
ECF-HANFORD- 11-0033, *Calculations of Inhalation Pathway Preliminary Remediation Goals Using Standard Method B Air Cleanup Levels for the 100 Areas and 300Area Remedial Investigation/Feasibility Study*
OSWER Directive 9285.6-03, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final.*
PNNL-13037, *Geochemical Data Package for the 2005 Hanford Integrated Disposal Facility Performance Assessment.*
PNNL-15160, *Hanford Site Climatological Summary 2004 With Historical Data.*
PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses – Fiscal Year 2008 Status Report.*

Table 2. Radionuclide-Specific Distribution Coefficients (K_d) by RESRAD Model Layer

Radionuclide	K_d (cm^3/g)	K_d Reference	K_d (cm^3/g)	K_d Reference
	Contaminated Zone (assumed sand dominated, Hss)		Uncontaminated Unsaturated Zone and Saturated Zone[a] (assumed sandy gravel, Hg)	
Americium-241	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Carbon-14	5	PNNL-18564, Table 6.9, Sand-Dominated	2.5	PNNL-18564, Table 6.9, Sandy Gravel
Cesium-137	2000	PNNL-18564, Table 6.9, Sand-Dominated	1200	PNNL-18564, Table 6.9, Sandy Gravel
Cobalt-60	10	PNNL-18564, Table 6.9, Sand-Dominated	6.2	PNNL-18564, Table 6.9, Sandy Gravel
Curium-243	300	PNNL-13037, Table 5.6	300	PNNL-13037, Table 5.6
Curium-243/244	300	PNNL-13037, Table 5.6	300	PNNL-13037, Table 5.6
Curium-244	300	PNNL-13037, Table 5.6	300	PNNL-13037, Table 5.6
Europium-152	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Europium-154	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Europium-155	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Iodine-129	0.2	PNNL-18564, Table 6.9, Sand-Dominated	0.1	PNNL-18564, Table 6.9, Sandy Gravel
Neptunium-237	10	PNNL-18564, Table 6.9, Sand-Dominated	5	PNNL-18564, Table 6.9, Sandy Gravel
Nickel-63	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Plutonium-238	600	PNNL-18564, Table 6.9, Sand-Dominated	370	PNNL-18564, Table 6.9, Sandy Gravel
Plutonium-239/240	600	PNNL-18564, Table 6.9, Sand-Dominated	370	PNNL-18564, Table 6.9, Sandy Gravel
Plutonium-241	600	PNNL-18564, Table 6.9, Sand-Dominated	370	PNNL-18564, Table 6.9, Sandy Gravel
Selenium-79	5	PNNL-18564, Table 6.9, Sand-Dominated	2.5	PNNL-18564, Table 6.9, Sandy Gravel
Strontium-90	20	PNNL-18564, Table 6.9, Sand-Dominated	12	PNNL-18564, Table 6.9, Sandy Gravel

Table 2. Radionuclide-Specific Distribution Coefficients (K_d) by RESRAD Model Layer

Radionuclide	K_d (cm^3/g)	K_d Reference	K_d (cm^3/g)	K_d Reference
	Contaminated Zone (assumed sand dominated, Hss)		Uncontaminated Unsaturated Zone and Saturated Zone[a] (assumed sandy gravel, Hg)	
Technetium-99	0	PNNL-18564, Table 6.9, Sand-Dominated	0	PNNL-18564, Table 6.9, Sandy Gravel
Tritium (H-3)	0	PNNL-18564, Table 6.9, Sand-Dominated	0	PNNL-18564, Table 6.9, Sandy Gravel
Uranium-233/234	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel
Uranium-234	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel
Uranium-235	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel
Uranium-238	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel
Daughter Radionuclides (included automatically by RESRAD with selection of parent)				
Actinium-227	300	PNNL-13037, Table 5.6	300	PNNL-13037, Table 5.6
Americium-243	300	PNNL-18564, Table 6.9, Sand-Dominated	180	PNNL-18564, Table 6.9, Sandy Gravel
Gadolinium-152[b]	-1	RESRAD default	-1	RESRAD default
Lead-210	50	PNNL-18564, Table 6.9	31	PNNL-18564, Table 6.9
Neodymium-144	158	RESRAD default	158	RESRAD default
Plutonium-240	600	PNNL-18564, Table 6.9, Sand-Dominated	370	PNNL-18564, Table 6.9, Sandy Gravel
Protactinium-231	50	RESRAD default	50	RESRAD default
Radium-226	20	PNNL-18564, Table 6.9, Sand-Dominated	12	PNNL-18564, Table 6.9, Sandy Gravel
Radium-228	20	PNNL-18564, Table 6.9, Sand-Dominated	12	PNNL-18564, Table 6.9, Sandy Gravel
Samarium-148[b]	-1	RESRAD default	-1	RESRAD default

Table 2. Radionuclide-Specific Distribution Coefficients (K_d) by RESRAD Model Layer

Radionuclide	K_d (cm^3/g)	K_d Reference	K_d (cm^3/g)	K_d Reference
	Contaminated Zone (assumed sand dominated, Hss)		Uncontaminated Unsaturated Zone and Saturated Zone[a] (assumed sandy gravel, Hg)	
Thorium-228	1000	PNNL-13037, Table 5.6	1000	PNNL-13037, Table 5.6
Thorium-229	1000	PNNL-13037, Table 5.6	1000	PNNL-13037, Table 5.6
Thorium-230	1000	PNNL-13037, Table 5.6	1000	PNNL-13037, Table 5.6
Thorium-232	1000	PNNL-13037, Table 5.6	1000	PNNL-13037, Table 5.6
Uranium-233	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel
Uranium-236	0.8	PNNL-18564, Table 6.9, Sand-Dominated	0.4	PNNL-18564, Table 6.9, Sandy Gravel

Notes:

a. K_ds for the uncontaminated unsaturated zone and saturated zone are not used to develop outdoor worker PRGs and are shown only for completeness. K_ds for these layers are required inputs but are only used in RESRAD to assess water-dependent pathways, which are suppressed for the outdoor worker exposure scenario.

b. For gadolinium-152 and samarium-148, RESRAD displays a default value of -1 on the K_d input screen, indicating the K_d value is derived internally by the code.

RESRAD = RESidual RADioactivity code (ANL 2014)

ANL, 2014, RESRAD for Windows, Version 7.0.

PNNL-13037, *Geochemical Data Package for the 2005 Hanford Integrated Disposal Facility Performance Assessment.*

PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses – Fiscal Year 2008 Status Report.*

4 Assumptions and Inputs

The inputs used in the RESRAD code to calculate PRGs for outdoor worker exposure scenario are presented in Table 1. The following assumptions are applicable to the outdoor worker exposure scenario.

- The reasonably anticipated future land use is industrial.
- Drinking water will be obtained from an offsite source and water beneath the Central Plateau will not be used for irrigation purposes.
- An outdoor worker is potentially exposed for a 25-year duration.
- The potentially complete exposure routes considered are incidental soil ingestion, inhalation of dust, and direct (external gamma) exposure.
- Direct exposure of an outdoor worker to radionuclides in soil to a depth of 4.6 m (15 ft) may occur. This represents a reasonable estimate of the depth of soil that could be excavated and distributed at

the soil surface as a result of site development activities. When the worker is outdoors, it is assumed that clean fill does not provide shielding from radiation (cover depth is zero).

- The hydrogeological parameters used for the 4.6 m (15 ft) contaminated zone are weighted by the thickness of the assumed stratigraphic units (Appendix A, Table A-5).
- Distribution coefficients (K_d) were selected preferentially from *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses – Fiscal Year 2008 Status Report* (PNNL-18564), and if not documented in PNNL-18564, then from *Geochemical Data Package for the 2005 Hanford Integrated Disposal Facility Performance Assessment* (PNNL-13037). For those radionuclides not referenced in either PNNL-18564 or PNNL-13037, the RESRAD default K_d value was used. The K_d values are summarized in Table 2.
- Parameter values used to estimate inhalation rates and incidental ingestion of soil are consistent with the values used for the outdoor worker scenario (EPA PRG User's Guide [https://epa-prgs.ornl.gov/radionuclides/prg_guide.html]). These values and referenced sources are presented in Table 1.
- The fraction of time spent outdoors is 0.21 (based on 8 hour/day × 225 days/year [1,800 hour /8,760 hour]).
- The health protective level for each PRG reflects a target cancer risk of 10^{-4}.

4.1 Mass Loading for Inhalation

RESRAD uses a mass loading model to compute exposures from dust inhalation and requires users to input a value for the average airborne dust concentration at the site (referred to as "mass loading for inhalation"). Because the RESRAD default (0.0001 g/m^3) is based on typical farm activities (ANL/EAD-4), a site-specific value was developed and used in lieu of the RESRAD default in this Environmental Calculation.

The site-specific value was developed using U.S. Environmental Protection Agency (EPA) guidance provided in OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, in which the inhalation of contaminants in the form of respirable particles is assessed using a particulate emission factor (PEF). The PEF relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions caused by wind from contaminated soil.

The methodology and calculation of the Hanford Site site-specific PEF is documented in ECF-HANFORD-11-0033, Rev. 1, *Calculation of Inhalation Pathway Preliminary Remediation Goals Using Standard Method B Air Cleanup Levels for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study.* The RESRAD mass loading factor (g/m^3) is derived from the calculated PEF (7.3×10^{10} m^3/kg) using the relationship g/m^3 = ($1/7.3 \times 10^{10}$ m^3/kg) × 1000 g/kg.

4.2 Calculation of Mass-based PRG for Uranium

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 3. 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 CH2M HILL Plateau Remediation Company (CHPRC) at the Hanford Site in accordance with the requirements of PRC-PRO-IRM-309, *Controlled Software 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, *RESRAD Software Management Plan* for further details regarding the use of this software:

- RESRAD for Windows
- Version 7.0, Created February 24, 2014
- HISI Identification Number: 2102
- Workstation type and property number: INTERA property number -00474 (Subcontractor Supplied Unique Property ID) and INTERA property number -00295 (Subcontractor Supplied Unique Property IDs).

5.2 Software Installation and Checkout

The software installation and checkout forms for RESRAD are provided as Appendix B to this Environmental Calculation.

5.3 Statement of Valid Software Application

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

® Microsoft Excel is a registered product of the Microsoft Corporation.

- RESRAD was developed for U.S. Department of Energy (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 (Table 1 and Table 2) 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 in the Excel workbook "ECF-HANFORD-16-0133_Appendix.xlsx". Input and output files from RESRAD are also listed below.

The results from the PRG calculations presented in the Excel workbook (ECF-HANFORD-16-0133_Appendix.xlsx) are organized into the following worksheets:

- Appendix A, Table A-1 - Identification of Peak Year based on Peak Cancer Risk.
- Appendix A, Table A-2- Intermediate Calculation - Results of Cancer Risk at Year of Peak Risk, and Preliminary PRGs for Individual Radionuclides.
- Appendix A, Table A-3 - Intermediate Calculation - Calculation of Relative Percent Difference
- Appendix A, Table A-4– Calculation of PRGs for Corresponding Risk Thresholds of 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}
- Appendix A, Table A-5– Thickness Weighted Average Hydrological Parameters
- Appendix A, Table A-6– Conversion of Activity-based isotopic Uranium PRGs to Mass-based PRG for Total Uranium
- Appendix A, Table A-7 – Sensitivity Analysis Results for Area of Contamination and Depth of Contamination for Am-241, Cs-137 and Pu-239/340.

Input file names from RESRAD are organized as follows:

- RESRAD input file name for identifying year at peak cancer risk - "OUTDOORWORKERCP_PRGS.RAD"
- RESRAD input file name for calculating risk per unit concentration based on year at peak cancer risk – "OUTDOORWORKERCP_PRGS-PEAKYEARS.RAD"
- RESRAD input file name for calculating risk and relative percent differences based on PRGs – "OUTDOORWORKERCP_PRGS-CHECK.RAD" and "OUTDOORWORKERCP_PRGS-CHECK_2.RAD"
- RESRAD input file names for sensitivity analysis– "OUTDOORWORKERCP_PRGS-SENSAOC.RAD" and "OUTDOORWORKERCP_PRGS-SENSDEPTH.RAD"

Output file names from RESRAD are organized as follows:

- RESRAD output summary file name for identifying year at peak cancer risk - "OUTDOORWORKERCP_PRGS.sum"
- RESRAD output summary file name for calculating risk per unit concentration based on years at peak cancer risk – "OUTDOORWORKERCP_PRGS-PeakYears.sum"
- RESRAD output health risk file name for calculating risk per unit concentration based on the years of peak cancer risk – "OUTDOORWORKERCP_PRGS-PeakYears.int"
- RESRAD output health risk file name for calculating relative percent difference between risk threshold and the risk based on PRGs – "OUTDOORWORKERCP_PRGS-check.int" and "OUTDOORWORKERCP_PRGS-check2.int"

Input and output files - .RAD, .SUM and .INT files are archived under this ECF number (ECF-HANFORD-16-0133 CentralPlateau_OutdoorWorker RAD PRGs_Rev_0) in the Environmental Risk Modeling Archive.

7 Results/Conclusions

The outdoor worker PRGs for soil are based on the year that the peak risk occurs, within a 1,000-year timeframe. Except for two radionuclides (Pu-241 and U-234 [as well as undifferentiated U-233/234, for which uranium-234 is assumed to be the dominant isotope]), the peak cancer risk occurs at year zero. The peak cancer risk for U-234 (and U-233/234) occurs at year 1000. The peak risk for Pu-241 occurs at year 60. Appendix A, Table A-1 presents the year of peak cancer risk for each radionuclide. Appendix A, Table A-2 presents the results of the preliminary PRG calculation for each radionuclide. Appendix A, Table A-3 presents the result of maximum risk based on the preliminary PRG for each radionuclide to verify that the estimated PRG value corresponds to a 1 x 10^{-4} risk. Appendix A, Table A-4 summarizes the PRGs for the risk thresholds of 1×10^{-4}, 1×10^{-5}, 1×10^{-6}. The PRGs for radionuclides in soil are summarized in Table 4 for the corresponding target risk levels of 1×10^{-4}, 1×10^{-5}, 1×10^{-6}.

Table 4. Summary of Preliminary Remediation Goals for the Outdoor Worker Exposure Scenario

Radionuclide	Radionuclide PRG at 10^{-4} Target Risk Level (pCi/g)	Radionuclide PRG at 10^{-5} Target Risk Level (pCi/g)	Radionuclide PRG at 10^{-6} Target Risk Level (pCi/g)
Americium-241	613	61	6.1
Carbon-14	570,125	57,013	5,701
Curium-243	64	6.4	0.64
Curium-243/244[a]	64	6.4	0.64
Curium-244	7,402	740	74
Cobalt-60	5.7	0.57	0.057
Cesium-137	10.8	1.1	0.11
Europium-152	6.8	0.68	0.068
Europium-154	8.2	0.82	0.082
Europium-155	603	60	6

Table 4. Summary of Preliminary Remediation Goals for the Outdoor Worker Exposure Scenario

Radionuclide	Radionuclide PRG at 10^{-4} Target Risk Level (pCi/g)	Radionuclide PRG at 10^{-5} Target Risk Level (pCi/g)	Radionuclide PRG at 10^{-6} Target Risk Level (pCi/g)
Tritium (H-3)	12,594	1,259	126
Iodine-129	1,568	157	16
Nickel-63	599,520	59,952	5,995
Neptunium-237	24	2.4	0.24
Plutonium-238	3,438	344	34
Plutonium-239/240[b]	2,971	297	30
Plutonium-241	20,317	2,032	203
Selenium-79	56,818	5,682	568
Strontium-90	1,190	119	12
Technetium-99	117,055	11,705	1,171
Uranium-233/234[c]	2,201	220	22
Uranium-234	2,201	220	22
Uranium-235	36	3.6	0.36
Uranium-238	170	17	1.7

Notes:

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 undifferentiated uranium-233/234.

7.1 Sensitivity Analysis

A generic site area of 10,000 m^2 and a generic site thickness of 4.6 m were assumed for developing the outdoor worker PRGs. Two sensitivity analyses were performed (see Appendix A, Table A-7) using the RESRAD sensitivity graphic utility to determine how sensitive the PRG values are to changes in area of contamination (AOC) and thickness of contaminated zone. The RESRAD sensitivity utility operates by both reducing and increasing the selected input parameter by a common factor. A sensitivity index (SI) was calculated to determine which parameters have the greatest influence on the calculated PRGs by using the following formula.

$$SI = 1 - \frac{Risk_{Lower\ Value}}{Risk_{Upper\ Value}} \qquad (2)$$

A positive value of the SI indicates that the risk (hence, PRG) is directly proportional to the parameter of interest, whereas a negative value indicates the risk (hence, PRG) is inversely proportional to the parameter of interest. A value less than 0.01 indicates that the risk is independent of the parameter. The further the value of SI is from zero (0), the more sensitive the parameter is.

For the sensitivity analyses of AOC, the common factor of 5 was selected. The risks were then calculated for the base (assigned value, 10,000 m^2), the lower value (2,000 m^2), and upper value (50,000 m^2). A common factor of 2 was selected for the sensitivity analyses for thickness of the contaminated zone. The risks were calculated for the base (assigned value, 4.6 m), the lower value (2.3 m), and upper value (9.2 m). Am-241, Cs-137 and Pu-239/240 were selected for the sensitivity analyses.

Appendix A, Table A-7 presents the results of the sensitivity analyses for both parameters. The maximum risk output for three radionuclides were obtained by using the tool "Export to Excel" within the "Edit" Menu. Risk results are presented in lognormal plot, the maximum risks for all radionuclides were based on Year 1 instead of Year 0, as identified in Appendix A, Table A-1. The maximum risk results based on upper and lower values for each sensitive parameter were used to calculate the SI. The results of SI, based on AOC value showed that none of the selected radionuclides are sensitive for this parameter. The results of SI, based on thickness of contaminated zone values also showed that none of the selected radionuclides are sensitive for this parameter.

7.2 Mass-based PRG for Total Uranium

To calculate a PRG for total uranium, the RESRAD-calculated PRGs for the uranium isotopes are converted from activity-based concentrations (pCi/g) to mass-based concentrations (µg/kg). The conversions are made using the PRGs protective at the 1×10^{-4} risk level, which represents the upper threshold of the EPA target risk range of 1×10^{-4} to 1×10^{-6}, as shown in Table 5.

To determine an appropriate PRG for total uranium from the mass-based uranium isotope PRGs shown in Table 5, 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 6. 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 506,103 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 5. Conversion from Activity- to Mass-Based PRGs for Uranium Isotopes

Uranium Isotope	Outdoor Worker 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)	Outdoor Worker Scenario PRG at 10^{-4} Risk Level (µg isotope/ kg soil)[c]
U-233/234	2,201	6.222E+09	1,000,000	1,000	354
U-234	2,201	6.222E+09	1,000,000	1,000	354
U-235	36	2.161E+06	1,000,000	1,000	16,659
U-238	170	3.359E+05	1,000,000	1,000	506,103

a. See Table 4.

b. See Table 3.

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

Table 6. 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 1.

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

8 References

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

1

Appendix A

RESRAD Output Summaries

Table A-1
Intermediate Calculations - Identification of Peak Year based on Peak Cancer Risk

Radionuclide	Year of Maximum Risk
Am-241	0
C-14	0
Cm-243	0
Cm-244	0
Co-60	0
Cs-137	0
Eu-152	0
Eu-154	0
Eu-155	0
H-3	0
I-129	0
Ni-63	0
Np-237	0
Pu-238	0
Pu-239	0
Pu-241	60
Sr-90	0
Tc-99	0
U-234	1000
U-235	0
U-238	0

S:\PSC\CHPRC.C003.HANOFF\REL.038\RAD_PRGS_SOIL\ECF-HANFORD-16-		
	Risk-Selected Pathways Summed	
Years	Pu-241	U-234
1	2.70E-09	1.88E-08
1.29155	2.74E-09	1.88E-08
1.6681	2.79E-09	1.88E-08
2.15443	2.85E-09	1.88E-08
2.78256	2.93E-09	1.87E-08
3	2.95E-09	1.87E-08
3.59381	3.02E-09	1.87E-08
4.64159	3.14E-09	1.87E-08
5.99484	3.28E-09	1.86E-08
7.74264	3.45E-09	1.86E-08
10	3.64E-09	1.85E-08
10	3.64E-09	1.85E-08
12.9155	3.86E-09	1.84E-08
16.681	4.10E-09	1.83E-08
21.5444	4.34E-09	1.82E-08
27.8256	4.57E-09	1.81E-08
35.9381	4.75E-09	1.79E-08
46.4159	4.88E-09	1.76E-08
59.9484	4.92E-09	1.74E-08
77.4264	4.88E-09	1.71E-08
100	4.75E-09	1.68E-08
100	4.75E-09	1.68E-08
129.155	4.55E-09	1.65E-08
166.81	4.29E-09	1.64E-08
215.443	3.97E-09	1.66E-08
278.256	3.59E-09	1.73E-08
300	3.47E-09	1.76E-08
359.381	3.15E-09	1.88E-08
464.159	2.67E-09	2.17E-08
599.484	2.15E-09	2.66E-08
774.264	1.63E-09	3.43E-08
1000	1.14E-09	4.54E-08

NOTES:
Highlighted cells indicate maximum risk.

Table A-2

Intermediate Calculations - Results of Cancer Risks at Year of Peak Risk, and Preliminary PRGs for Individual Radionuclides

Radionuclide	t= 0.000E+00 years	t= 6.000E+01 years	t= 1.000E+03 years	Maximum Risk per pCi/g	Year of Maximum Risk	PRG
	All pathways	All pathways	All pathways			Risk Threshold = 1×10^{-4}
Am-241	1.63E-07	1.48E-07	3.33E-08	1.63E-07	0	613
C-14	1.75E-10	0.00E+00	0.00E+00	1.75E-10	0	570,125
Cm-243	1.57E-06	3.75E-07	6.77E-11	1.57E-06	0	64
Cm-244	1.35E-08	1.44E-09	8.18E-11	1.35E-08	0	7,402
Co-60	1.75E-05	6.51E-09	0.00E+00	1.75E-05	0	5.7
Cs-137	9.30E-06	2.34E-06	9.76E-16	9.30E-06	0	11
Eu-152	1.47E-05	6.80E-07	2.52E-22	1.47E-05	0	6.8
Eu-154	1.21E-05	9.60E-08	0.00E+00	1.21E-05	0	8.2
Eu-155	1.66E-07	2.67E-11	0.00E+00	1.66E-07	0	603
H-3	7.94E-09	7.95E-18	0.00E+00	7.94E-09	0	12,594
I-129	6.38E-08	4.52E-08	2.04E-10	6.38E-08	0	1,568
Ni-63	1.67E-10	1.10E-10	1.63E-13	1.67E-10	0	599,520
Np-237	4.19E-06	4.16E-06	3.62E-06	4.19E-06	0	24
Pu-238	2.91E-08	1.81E-08	2.48E-11	2.91E-08	0	3,438
Pu-239	3.37E-08	3.36E-08	3.26E-08	3.37E-08	0	2,971
Pu-241	2.57E-09	4.92E-09	1.14E-09	4.92E-09	60	20,317
Se-79	1.76E-09	1.73E-09	1.31E-09	1.76E-09	0	56,818
Sr-90	8.40E-08	1.97E-08	2.73E-18	8.40E-08	0	1,190
Tc-99	8.54E-10	1.83E-10	6.24E-21	8.54E-10	0	117,055
U-234	1.88E-08	1.74E-08	4.54E-08	4.54E-08	1000	2,201
U-235	2.78E-06	2.52E-06	5.79E-07	2.78E-06	0	36
U-238	5.87E-07	5.29E-07	1.04E-07	5.87E-07	0	170

NOTES:

RESRAD, Version 7.0 T« Limit = 180 days 09/16/2016 12:48

Intrisk : Central Plateau Outdoor Worker Rad PRGs--Peak Years of Risk

File : S:\PSC\CHPRC.C003.HANOFF\REL.038\RAD_PRGS_SOIL\ECF-HANFORD-16-0133_OUTDOORWORKER\RESRAD\OUTDOORWORKERCP_PRGS-PEAKYEARS.RAD

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p)

Total Risk at 0.000E+00 years

Total Risk at t= 6.000E+01 years

Total Risk at t= 1.000E+03 years

NOTES:

Highlighted cells indicate maximum risk.

Table A-3
Intermediate Calculations - Check Risks and Relative Percent Difference between Risk Threshold using Preliminary PRGs for Individual Radionuclides

RESRAD, Version 7.0 T« Limit = 180 days 09/16/2016 14:03

Intrisk : Central Plateau Outdoor Worker Rad PRGs--Peak Years of Risk

: S:\PSC\CHPRC.C003.HANOFF\REL.038\RAD_PRGS_SOIL\ECF-HANFORD-16-0133_OUTDOORWORKER\RESRAD\OUTDOORWORKERCP_PRGS-CHECK.I

Initial Check of PRGs versus Calculated Risk

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 0.000E+00

Radionuclide	RESRAD Concentration	All pathways-- Total Risk	%RPD
Am-241	613	1.00E-04	0.00
C-14	570,125	1.00E-04	0.00
Cm-243	64	1.00E-04	-0.20
Cm-244	7,402	1.00E-04	0.00
Co-60	5.7	1.00E-04	0.03
Cs-137	**11**	**1.02E-04**	**-2.27**
Eu-152	6.8	9.98E-05	0.21
Eu-154	8.2	9.96E-05	0.45
Eu-155	603	1.00E-04	-0.10
H-3	12,594	1.00E-04	0.01
I-129	1,568	1.00E-04	0.00
Ni-63	599,520	1.00E-04	0.00
Np-237	24	1.01E-04	-0.60
Pu-238	3,438	1.00E-04	0.00
Pu-239	2,971	1.00E-04	0.01
Pu-241	20,317		
Se-79	56,818	1.00E-04	0.00
Sr-90	1,190	1.00E-04	0.04
Tc-99	117,055	1.00E-04	0.00
U-234	2,201		
U-235	36	1.00E-04	-0.10
U-238	170	9.98E-05	0.23

t= 0.000E+00 years

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=

t= 6.000E+01 years

Radionuclide	All pathways-- Total Risk	%RPD
Am-241		
C-14		
Cm-243		
Cm-244		
Co-60		
Cs-137		
Eu-152		
Eu-154		
Eu-155		
H-3		
I-129		
Ni-63		
Np-237		
Pu-238		
Pu-239		
Pu-241	1.00E-04	0.01
Se-79		
Sr-90		
Tc-99		
U-234		
U-235		
U-238		

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=

t= 1.000E+03 years

Radionuclide	All pathways-- Total Risk	%RPD
Am-241		
C-14		
Cm-243		
Cm-244		
Co-60		
Cs-137		
Eu-152		
Eu-154		
Eu-155		
H-3		
I-129		
Ni-63		
Np-237		
Pu-238		
Pu-239		
Pu-241		
Se-79		
Sr-90		
Tc-99		
U-234	1.00E-04	0.00
U-235		
U-238		

RESRAD, Version 7.0 T« Limit = 180 days 09/16/2016 14:30

Intrisk : Central Plateau Outdoor Worker Rad PRGs--Peak Years of Risk

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Rerun of PRGs versus Calculated Risk (Cs-137: 11 --> 10.8)

Total Excess Cancer Risk CNRS(i,p,t)*** for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 0.000E+00 years

t= 0.000E+00 years

Radionuclide	RESRAD Concentration	All pathways-- Total Risk	%RPD
Am-241	613	1.00E-04	0.00
C-14	570,125	1.00E-04	0.00
Cm-243	64	1.00E-04	-0.20
Cm-244	7,402	1.00E-04	0.00
Co-60	5.7	1.00E-04	0.03
Cs-137	10.8	1.00E-04	-0.40
Eu-152	6.8	9.98E-05	0.21
Eu-154	8.2	9.96E-05	0.45
Eu-155	603	1.00E-04	-0.10
H-3	12,594	1.00E-04	0.01
I-129	1,568	1.00E-04	0.00
Ni-63	599,520	1.00E-04	0.00
Np-237	24	1.01E-04	-0.60
Pu-238	3,438	1.00E-04	0.00
Pu-239	2,971	1.00E-04	0.01
Pu-241	20,317		
Se-79	56,818	1.00E-04	0.00
Sr-90	1,190	1.00E-04	0.04
Tc-99	117,055	1.00E-04	0.00
U-234	2,201		
U-235	36	1.00E-04	-0.10
U-238	170	9.98E-05	0.23

Table A-4
Calculation of PRGs for Corresponding Risk Thresholds of 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}

Radionuclide	PRG		
	Risk Threshold = 1×10^{-4}	Risk Threshold = 1×10^{-5}	Risk Threshold = 1×10^{-5}
Am-241	613	61	6.1
C-14	570,125	57,013	5,701
Cm-243	64	6.4	0.64
Cm-244	7,402	740	74
Co-60	5.7	0.57	0.057
Cs-137	11	1.1	0.11
Eu-152	6.8	0.68	0.068
Eu-154	8.2	0.82	0.082
Eu-155	603	60	6.0
H-3	12,594	1,259	126
I-129	1,568	157	16
Ni-63	599,520	59,952	5,995
Np-237	24	2.4	0.24
Pu-238	3,438	344	34
Pu-239	2,971	297	30
Pu-241	20,317	2,032	203
Se-79	56,818	5,682	568
Sr-90	1,190	119	12
Tc-99	117,055	11,706	1,171
U-234	2,201	220	22
U-235	36	3.6	0.36
U-238	170	17	1.7

Table A-5
Thickness Weighted Average Hydrological Parameters

The 200 North Area hydrostratigraphic template from PNNL-14702 (pg. A.13, 200I-X) is used to represent a generic vadoze zone stratigraphic sequence

Hss	3 ft	
Hg	167 ft	
total	170 ft	(depth to groundwater = 170 ft below ground surface)

Thickness weighted average parameter values are calculated for an assumed 15 ft thick contaminated zone (CZ) using the following mixture

Hss	3 ft
Hg	12 ft
total CZ	15 ft

Formula used is Pcz = (3*PHss+12*PHg)/15 where Pcz is weighted average parameter and PHss and PHg are corresponding parameters of Hss and Hg units respectively

Parameter	Units	PHss	PHg	Reference	Pcz
Density of CZ	g/cm3	1.61	1.93	PNNL-18564, Table 6.2, site-wide values	1.87
CZ total porosity	unitless	0.448	0.258	PNNL-18564, Table 6.3, site-wide values	0.296
CZ field capacity	unitless	0.175	0.061	PNNL-18564, Table 6.5, best-estimate values	0.084
CZ hydraulic conductivity	m/yr	8.58E-05 (cm/s)	3.30E-04 (cm/s)	PNNL-18564, Table 6.7, site-wide	88.7
CZ zone "b" parameter	unitless	2.63	2.96	PNNL-18564, Table 6.8	2.89

NOTES:

PNNL-14702, *Vadose Zone Hydrology Data Package for Hanford Assessments.*
PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses – Fiscal Year 2008 Status Report.*
PHss = parameter corresponding to Hanford formation silty sand unit
PHg = parameter corresponding to Hanford formation gravel unit
Pcz = parameter calculated for contaminated zone based on thickness-weighted assumptions

Table A-6
Conversion of activity-based isotopic uranium PRGs to mass-based PRG for Uranium

Conversion from Activity- to Mass-Based PRGs for Uranium Isotopes

Uranium Isotope	Outdoor Worker Scenario PRG at 10^{-4} Risk Level	Specific Activity	Conversion Factor	Conversion Factor	Outdoor Worker Scenario PRG at 10^{-4} Risk Level
	(pCi isotope/ g soil)[a]	(pCi isotope/ g isotope)[b]	(µg isotope/ g isotope)	(g soil/kg soil)	(µg isotope/kg soil)[c]
U-233/234	2,201	6.22E+09	1,000,000	1,000	354
U-234	2,201	6.22E+09	1,000,000	1,000	354
U-235	36	2.16E+06	1,000,000	1,000	16,659
U-238	170	3.36E+05	1,000,000	1,000	506,103

a. See Table 7-1 of ECF-HANFORD-16-0133.

b. See Table 4-1 of ECF-HANFORD-16-0133

c. PRG (µg isotope/kg soil) = [PRG (pCi isotope/g soil) / Specific Activity (pCi isotope/g isotope)] × $1x10^6$ (µg isotope/g isotope) × 1000 (g soil/kg soil)

Table A-7 (sheet 1 of 2)

Sensitivity Analysis Results for Area of Contamination and Depth of Contamination for Am-241, Cs-137 and Pu-239/340

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SI = 1 - $RISK_{Lower\ Value}$ / $RISK_{Upper\ Value}$

EXCESS CANCER RISK: Am-241, All Pathways Summed With SA on Area of contaminated zone				
Years	Upper: 50000	Mid: 10000	Lower: 2000	SI
1	1.63E-07	1.63E-07	1.58E-07	3.48E-02
1.25893	1.63E-07	1.63E-07	1.58E-07	3.48E-02
1.58489	1.63E-07	1.63E-07	1.58E-07	3.48E-02
1.99526	1.63E-07	1.63E-07	1.58E-07	3.48E-02
2.51189	1.63E-07	1.62E-07	1.57E-07	3.48E-02
3.16228	1.63E-07	1.62E-07	1.57E-07	3.48E-02
3.98107	1.63E-07	1.62E-07	1.57E-07	3.48E-02
5.01187	1.62E-07	1.62E-07	1.57E-07	3.48E-02
6.30957	1.62E-07	1.61E-07	1.56E-07	3.48E-02
7.94328	1.62E-07	1.61E-07	1.56E-07	3.48E-02
10	1.61E-07	1.61E-07	1.55E-07	3.48E-02
12.5893	1.60E-07	1.60E-07	1.55E-07	3.48E-02
15.8489	1.60E-07	1.59E-07	1.54E-07	3.48E-02
19.9526	1.59E-07	1.58E-07	1.53E-07	3.48E-02
25.1189	1.57E-07	1.57E-07	1.52E-07	3.48E-02
31.6228	1.56E-07	1.55E-07	1.50E-07	3.48E-02
39.8107	1.54E-07	1.53E-07	1.48E-07	3.48E-02
50.1187	1.51E-07	1.51E-07	1.46E-07	3.48E-02
60	1.49E-07	1.48E-07	1.44E-07	3.48E-02
63.0957	1.48E-07	1.47E-07	1.43E-07	3.48E-02
79.4328	1.44E-07	1.44E-07	1.39E-07	3.48E-02
100	1.40E-07	1.39E-07	1.35E-07	3.48E-02
125.893	1.34E-07	1.33E-07	1.29E-07	3.48E-02
158.489	1.27E-07	1.27E-07	1.23E-07	3.48E-02
199.526	1.19E-07	1.19E-07	1.15E-07	3.48E-02
251.189	1.10E-07	1.09E-07	1.06E-07	3.48E-02
316.228	9.88E-08	9.84E-08	9.53E-08	3.49E-02
398.107	8.67E-08	8.64E-08	8.37E-08	3.49E-02
501.187	7.36E-08	7.33E-08	7.10E-08	3.49E-02
630.957	5.98E-08	5.96E-08	5.78E-08	3.50E-02
794.328	4.62E-08	4.60E-08	4.46E-08	3.50E-02
1000	3.34E-08	3.33E-08	3.22E-08	3.51E-02

EXCESS CANCER RISK: Cs-137, All Pathways Summed With SA on Area of contaminated zone				
Years	Upper: 50000	Mid: 10000	Lower: 2000	SI
1	9.32E-06	9.09E-06	8.72E-06	6.47E-02
1.25893	9.27E-06	9.03E-06	8.67E-06	6.47E-02
1.58489	9.20E-06	8.96E-06	8.60E-06	6.47E-02
1.99526	9.11E-06	8.88E-06	8.52E-06	6.47E-02
2.51189	9.01E-06	8.78E-06	8.42E-06	6.47E-02
3.16228	8.87E-06	8.64E-06	8.30E-06	6.47E-02
3.98107	8.71E-06	8.48E-06	8.14E-06	6.47E-02
5.01187	8.50E-06	8.29E-06	7.95E-06	6.47E-02
6.30957	8.25E-06	8.04E-06	7.72E-06	6.47E-02
7.94328	7.95E-06	7.75E-06	7.43E-06	6.47E-02
10	7.58E-06	7.39E-06	7.09E-06	6.47E-02
12.5893	7.14E-06	6.96E-06	6.68E-06	6.47E-02
15.8489	6.63E-06	6.46E-06	6.20E-06	6.47E-02
19.9526	6.03E-06	5.88E-06	5.64E-06	6.47E-02
25.1189	5.36E-06	5.22E-06	5.01E-06	6.47E-02
31.6228	4.61E-06	4.50E-06	4.31E-06	6.47E-02
39.8107	3.82E-06	3.72E-06	3.57E-06	6.47E-02
50.1187	3.02E-06	2.94E-06	2.82E-06	6.47E-02
60	2.40E-06	2.34E-06	2.25E-06	6.47E-02
63.0957	2.24E-06	2.18E-06	2.09E-06	6.47E-02
79.4328	1.54E-06	1.50E-06	1.44E-06	6.47E-02
100	9.59E-07	9.34E-07	8.97E-07	6.47E-02
125.893	5.29E-07	5.15E-07	4.95E-07	6.47E-02
158.489	2.50E-07	2.44E-07	2.34E-07	6.47E-02
199.526	9.74E-08	9.49E-08	9.11E-08	6.47E-02
251.189	2.97E-08	2.90E-08	2.78E-08	6.47E-02
316.228	6.67E-09	6.50E-09	6.24E-09	6.47E-02
398.107	1.02E-09	9.90E-10	9.50E-10	6.47E-02
501.187	9.51E-11	9.27E-11	8.89E-11	6.47E-02
630.957	4.82E-12	4.70E-12	4.51E-12	6.47E-02
794.328	1.13E-13	1.10E-13	1.06E-13	6.47E-02
1000	1.00E-15	9.76E-16	9.36E-16	6.47E-02

EXCESS CANCER RISK: Pu-239, All Pathways Summed With SA on Area of contaminated zone				
Years	Upper: 50000	Mid: 10000	Lower: 2000	SI
1	3.37E-08	3.37E-08	3.36E-08	1.44E-03
1.25893	3.37E-08	3.37E-08	3.36E-08	1.44E-03
1.58489	3.37E-08	3.37E-08	3.36E-08	1.44E-03
1.99526	3.37E-08	3.37E-08	3.36E-08	1.44E-03
2.51189	3.37E-08	3.37E-08	3.36E-08	1.44E-03
3.16228	3.37E-08	3.37E-08	3.36E-08	1.44E-03
3.98107	3.37E-08	3.37E-08	3.36E-08	1.44E-03
5.01187	3.37E-08	3.36E-08	3.36E-08	1.44E-03
6.30957	3.37E-08	3.36E-08	3.36E-08	1.44E-03
7.94328	3.37E-08	3.36E-08	3.36E-08	1.44E-03
10	3.37E-08	3.36E-08	3.36E-08	1.44E-03
12.5893	3.37E-08	3.36E-08	3.36E-08	1.44E-03
15.8489	3.37E-08	3.36E-08	3.36E-08	1.44E-03
19.9526	3.37E-08	3.36E-08	3.36E-08	1.44E-03
25.1189	3.36E-08	3.36E-08	3.36E-08	1.44E-03
31.6228	3.36E-08	3.36E-08	3.36E-08	1.44E-03
39.8107	3.36E-08	3.36E-08	3.36E-08	1.44E-03
50.1187	3.36E-08	3.36E-08	3.36E-08	1.44E-03
60	3.36E-08	3.36E-08	3.36E-08	1.44E-03
63.0957	3.36E-08	3.36E-08	3.36E-08	1.44E-03
79.4328	3.36E-08	3.36E-08	3.35E-08	1.44E-03
100	3.36E-08	3.36E-08	3.35E-08	1.44E-03
125.893	3.35E-08	3.35E-08	3.35E-08	1.44E-03
158.489	3.35E-08	3.35E-08	3.35E-08	1.44E-03
199.526	3.35E-08	3.34E-08	3.34E-08	1.44E-03
251.189	3.34E-08	3.34E-08	3.34E-08	1.44E-03
316.228	3.33E-08	3.33E-08	3.33E-08	1.44E-03
398.107	3.33E-08	3.32E-08	3.32E-08	1.44E-03
501.187	3.32E-08	3.31E-08	3.31E-08	1.44E-03
630.957	3.30E-08	3.30E-08	3.30E-08	1.44E-03
794.328	3.29E-08	3.28E-08	3.28E-08	1.44E-03
1000	3.26E-08	3.26E-08	3.26E-08	1.44E-03

Table A-7 (sheet 2 of 2)

Sensitivity Analysis Results for Area of Contamination and Depth of Contamination for Am-241, Cs-137 and Pu-239/340

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SI $= 1 - RISK_{Lower\ Value} / RISK_{Upper\ Value}$

EXCESS CANCER RISK: Am-241, All Pathways Summed With SA on Thickness of contaminated zone				
Years	Upper: 9.2	Mid: 4.6	Lower: 2.3	SI
1	1.63E-07	1.63E-07	1.63E-07	9.82E-05
1.25893	1.63E-07	1.63E-07	1.63E-07	1.04E-04
1.58489	1.63E-07	1.63E-07	1.63E-07	1.04E-04
1.99526	1.63E-07	1.63E-07	1.63E-07	1.05E-04
2.51189	1.62E-07	1.62E-07	1.62E-07	1.11E-04
3.16228	1.62E-07	1.62E-07	1.62E-07	1.17E-04
3.98107	1.62E-07	1.62E-07	1.62E-07	1.23E-04
5.01187	1.62E-07	1.62E-07	1.62E-07	1.30E-04
6.30957	1.62E-07	1.61E-07	1.61E-07	1.42E-04
7.94328	1.61E-07	1.61E-07	1.61E-07	1.55E-04
10	1.61E-07	1.61E-07	1.61E-07	1.62E-04
12.5893	1.60E-07	1.60E-07	1.60E-07	1.88E-04
15.8489	1.59E-07	1.59E-07	1.59E-07	2.07E-04
19.9526	1.58E-07	1.58E-07	1.58E-07	2.40E-04
25.1189	1.57E-07	1.57E-07	1.57E-07	2.81E-04
31.6228	1.55E-07	1.55E-07	1.55E-07	3.29E-04
39.8107	1.53E-07	1.53E-07	1.53E-07	3.85E-04
50.1187	1.51E-07	1.51E-07	1.51E-07	4.65E-04
60	1.48E-07	1.48E-07	1.48E-07	5.46E-04
63.0957	1.47E-07	1.47E-07	1.47E-07	5.70E-04
79.4328	1.44E-07	1.44E-07	1.44E-07	6.89E-04
100	1.39E-07	1.39E-07	1.39E-07	8.49E-04
125.893	1.33E-07	1.33E-07	1.33E-07	1.04E-03
158.489	1.27E-07	1.27E-07	1.26E-07	1.29E-03
199.526	1.19E-07	1.19E-07	1.18E-07	1.62E-03
251.189	1.09E-07	1.09E-07	1.09E-07	2.03E-03
316.228	9.85E-08	9.84E-08	9.82E-08	2.56E-03
398.107	8.65E-08	8.64E-08	8.62E-08	3.25E-03
501.187	7.34E-08	7.33E-08	7.31E-08	4.17E-03
630.957	5.97E-08	5.96E-08	5.94E-08	5.42E-03
794.328	4.61E-08	4.60E-08	4.58E-08	7.20E-03
1000	3.34E-08	3.33E-08	3.30E-08	9.88E-03

EXCESS CANCER RISK: Cs-137, All Pathways Summed With SA on Thickness of contaminated zone				
Years	Upper: 9.2	Mid: 4.6	Lower: 2.3	SI
1	9.09E-06	9.09E-06	9.09E-06	1.32E-05
1.25893	9.03E-06	9.03E-06	9.03E-06	1.44E-05
1.58489	8.96E-06	8.96E-06	8.96E-06	1.45E-05
1.99526	8.88E-06	8.88E-06	8.88E-06	1.46E-05
2.51189	8.78E-06	8.78E-06	8.78E-06	1.48E-05
3.16228	8.65E-06	8.64E-06	8.64E-06	1.62E-05
3.98107	8.48E-06	8.48E-06	8.48E-06	1.77E-05
5.01187	8.29E-06	8.29E-06	8.29E-06	1.81E-05
6.30957	8.04E-06	8.04E-06	8.04E-06	1.87E-05
7.94328	7.75E-06	7.75E-06	7.75E-06	2.07E-05
10	7.39E-06	7.39E-06	7.39E-06	2.44E-05
12.5893	6.96E-06	6.96E-06	6.96E-06	2.73E-05
15.8489	6.46E-06	6.46E-06	6.46E-06	2.94E-05
19.9526	5.88E-06	5.88E-06	5.88E-06	3.40E-05
25.1189	5.22E-06	5.22E-06	5.22E-06	4.02E-05
31.6228	4.50E-06	4.50E-06	4.50E-06	4.89E-05
39.8107	3.72E-06	3.72E-06	3.72E-06	5.91E-05
50.1187	2.94E-06	2.94E-06	2.94E-06	6.81E-05
60	2.34E-06	2.34E-06	2.34E-06	8.11E-05
63.0957	2.18E-06	2.18E-06	2.18E-06	8.71E-05
79.4328	1.50E-06	1.50E-06	1.50E-06	1.00E-04
100	9.34E-07	9.34E-07	9.34E-07	1.23E-04
125.893	5.15E-07	5.15E-07	5.15E-07	1.53E-04
158.489	2.44E-07	2.44E-07	2.44E-07	1.89E-04
199.526	9.49E-08	9.49E-08	9.49E-08	2.35E-04
251.189	2.90E-08	2.90E-08	2.89E-08	2.90E-04
316.228	6.50E-09	6.50E-09	6.49E-09	3.65E-04
398.107	9.90E-10	9.90E-10	9.90E-10	4.55E-04
501.187	9.27E-11	9.27E-11	9.26E-11	5.70E-04
630.957	4.70E-12	4.70E-12	4.70E-12	7.15E-04
794.328	1.10E-13	1.10E-13	1.10E-13	8.90E-04
1000	9.76E-16	9.76E-16	9.75E-16	1.12E-03

EXCESS CANCER RISK: Pu-239, All Pathways Summed With SA on Thickness of contaminated zone				
Years	Upper: 9.2	Mid: 4.6	Lower: 2.3	SI
1	3.37E-08	3.37E-08	3.37E-08	5.05E-05
1.25893	3.37E-08	3.37E-08	3.37E-08	5.05E-05
1.58489	3.37E-08	3.37E-08	3.37E-08	5.35E-05
1.99526	3.37E-08	3.37E-08	3.37E-08	5.35E-05
2.51189	3.37E-08	3.37E-08	3.37E-08	5.65E-05
3.16228	3.37E-08	3.37E-08	3.37E-08	5.94E-05
3.98107	3.37E-08	3.37E-08	3.36E-08	6.24E-05
5.01187	3.37E-08	3.36E-08	3.36E-08	6.54E-05
6.30957	3.36E-08	3.36E-08	3.36E-08	6.84E-05
7.94328	3.36E-08	3.36E-08	3.36E-08	7.73E-05
10	3.36E-08	3.36E-08	3.36E-08	8.32E-05
12.5893	3.36E-08	3.36E-08	3.36E-08	9.21E-05
15.8489	3.36E-08	3.36E-08	3.36E-08	1.04E-04
19.9526	3.36E-08	3.36E-08	3.36E-08	1.19E-04
25.1189	3.36E-08	3.36E-08	3.36E-08	1.40E-04
31.6228	3.36E-08	3.36E-08	3.36E-08	1.64E-04
39.8107	3.36E-08	3.36E-08	3.36E-08	1.93E-04
50.1187	3.36E-08	3.36E-08	3.36E-08	2.32E-04
60	3.36E-08	3.36E-08	3.36E-08	2.68E-04
63.0957	3.36E-08	3.36E-08	3.36E-08	2.80E-04
79.4328	3.36E-08	3.36E-08	3.36E-08	3.40E-04
100	3.36E-08	3.36E-08	3.35E-08	4.17E-04
125.893	3.35E-08	3.35E-08	3.35E-08	5.13E-04
158.489	3.35E-08	3.35E-08	3.35E-08	6.33E-04
199.526	3.35E-08	3.34E-08	3.34E-08	7.86E-04
251.189	3.34E-08	3.34E-08	3.34E-08	9.82E-04
316.228	3.33E-08	3.33E-08	3.33E-08	1.22E-03
398.107	3.33E-08	3.32E-08	3.32E-08	1.53E-03
501.187	3.32E-08	3.31E-08	3.31E-08	1.92E-03
630.957	3.30E-08	3.30E-08	3.29E-08	2.40E-03
794.328	3.29E-08	3.28E-08	3.28E-08	3.01E-03
1000	3.27E-08	3.26E-08	3.25E-08	3.77E-03

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Appendix B

Software Installation and Checkout Forms

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: RESRAD Software Version No.: 7.0

EXECUTABLE INFORMATION:

2. Executable Name (include path):

   c:\RESRAD Family\RESRAD\7.0\RESWIN7.EXE

3. Executable Size (bytes): 1.852 KB

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):

   Compiled by Vendor (ANL)

5. Operating System (include version number):

   Compiled by Vendor (ANL)

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

   Intera-00474

7. Operating System (include version number):

   Windows 10 Pro

8. Open Problem Report? ◉ No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

   C:\RESRAD Family\RESRAD\7.0

10. Procedure(s):

    per CHPRC-00210 Rev 2, RESRAD Software Test Plan

11. Libraries:

    N/A

12. Input Files:

    Created in RESRAD per installation test instruction

13. Output Files:

    SUMMARY.REP

14. Test Cases:

    RESRAD-ITC-1

15. Test Case Results:

    Test results matched expected results; pass.

16. Test Performed By: SL Lindberg

17. Test Results: ◉ Satisfactory, Accepted for Use ○ Unsatisfactory

18. Disposition (include HISI update):

    Approved; installation added to HISI entry software user list.

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: RESRAD Software Version No.: 7.0

Prepared By:

19.	Software Owner (Signature)	ME Nichols Print	3 Aug 2016 Date

20. Test Personnel:

Sign	SL Lindberg Print	08/03/2016 Date
Sign	Print	Date
Sign	Print	Date

Approved By

21.	Software SME (Signature)	N/R per SMP Print	Date

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: RESRAD — Software Version No.: 7.0

EXECUTABLE INFORMATION:

2. Executable Name (include path):
   c:\RESRAD Family\RESRAD\7.0\RESRWTER.EXE
3. Executable Size (bytes): 1.876 MB

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):
   Compiled by Vendor (ANL)
5. Operating System (include version number):
   Compiled by Vendor (ANL)

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):
   Intara-00295
7. Operating System (include version number):
   Windows 7 Professional Service Pack 1
8. Open Problem Report? ◉ No ○ Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:
   C:\RESRAD Family\RESRAD\7.0\QAfiles
10. Procedure(s):
    per CHPRC-00210 Rev 2, RESRAD Software Test Plan
11. Libraries:
    N/A
12. Input Files:
    Created in RESRAD per installation test instruction
13. Output Files:
    SUMMARY.REP
14. Test Cases:
    RESRAD-ITC-1
15. Test Case Results:
    Test results matched expected results; pass.
16. Test Performed By: RD Evans
17. Test Results: ◉ Satisfactory, Accepted for Use ○ Unsatisfactory
18. Disposition (include HISI update):
    Installation accepted; computer and user added to HISI entry for RESRAD software.

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: RESRAD — Software Version No.: 7.0

Prepared By:

19.	Software Owner (Signature)	ME Nichols (Print)	30 APRIL 2015 (Date)

20. Test Personnel:

Sign	RD Evans (Print)	4/30/2015 (Date)
Sign	Print	Date
Sign	Print	Date

Approved By:

21.	Software SME (Signature)	N/R per SMP (Print)	Date

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