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INTEROFFICE CORRESPONDENCE

DATE: October 4, 1995

TO: Distribution

FROM: Rick Roberts, Technical Support, Remediation Services, X8508
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SUBJECT: RADIOLOGICAL DOSE & RISK ASSESSMENT COMPARISON FOR ASSESSMENT OF POTENTIAL SOIL ACTION LEVELS - RSR-007-95

ACTION: None

Attached is the draft "Radiological Dose & Risk Assessment Comparison For Assessment of Potential Soil Action Levels" for your review. If you have any questions or comments, please contact me.

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ADMIN RECORD

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RADIOLOGICAL DOSE & RISK ASSESSMENT COMPARISON FOR ASSESSMENT OF POTENTIAL SOIL ACTION LEVELS

INTRODUCTION

A radiation dose analysis and human health risk assessment were performed to support the unrestricted release of soils that contain radioactive materials. To support an unrestricted release, a radiation dose or risk limit must be specified along with the applicable exposure scenario. The radiation dose limit of 100 millirem is outlined in DOE Order 5400.5. A 15 millirem dose limit was also assessed in this exercise so that proposed regulations from the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) could be examined. EPA regulations state that an acceptable risk range is between 1E-04 and 1E-06.

The risk and dose analyses were performed assuming that a residential exposure scenario, an office worker exposure scenario or an open space exposure scenario may apply at the Rocky Flats Environmental Technology Site (RFETS). These exposure scenarios were chosen in order to assess an unrestricted release off the RFETS property (residential exposure scenario) as well as an unrestricted release on the RFETS property (office worker and open space exposure scenarios). The RFETS future site use working group has stated that lands within the RFETS boundary will be designated for either open space or commercial/industrial use.

The results of the radiation dose analysis and the radiation risk analysis are outlined in Table 1, "Radiation Risk & Dose Based Soil Action Levels." An "action level" is an acceptable level of radioactive material in soil at a specified dose or risk limit for a given exposure scenario. These results will be used to delineate unrestricted release criteria for soils and associated material.

RADIATION DOSE ASSESSMENT METHODOLOGY

This radiation dose analysis examined a residential exposure scenario, an office worker exposure

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scenario and an open space exposure scenario for the reasons outlined above. Table 2, "Exposure Scenario Definition," outlines the equation and exposure parameters used in this radiation dose analysis. The equation used to derive radiation dose based soil action levels was based on EPA and Colorado Department of Public Health and the Environment (CDPHE) approved equations used to derive risk based soil action levels. The soil action level equation was derived by summing the ingestion, inhalation and external irradiation pathways. Exposure parameters were also approved for use by EPA and CDPHE.

Tables 3 through 8 outline the soil action levels for all three exposure scenarios at the 15 millirem and 100 millirem radiation dose criteria. The radionuclides of concern are americium-241, plutonium-239, uranium-234, uranium-235 and uranium-238. All radionuclides of concern are listed with their inhalation dose conversion factor, ingestion dose conversion factor and external irradiation dose conversion factor. Daughter products are not incorporated into the dose conversion factors. These dose conversion factors were taken from two different sources; 1) Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors For Inhalation, Submersion, and Ingestion (EPA-520/1-88-020), and 2) External Exposure to Radionuclides in Air, Water and Soil (EPA/402-R-93-081). All combinations of ICRP lung class and Gastro-Intestinal (GI) absorption factors were evaluated and were also listed in the tables. If a number of soil action levels were calculated for a radionuclide due to multiple combinations, the lowest soil action level was placed into Table 1.

Per DOE Order 5400.5, Section IV.4.a, acceptable residual concentrations of radionuclides in soil shall be derived from the basic dose limit of 100 millirem effective dose equivalent in a year by means of an environmental pathway analysis using specific property data where available. A 15 millirem criteria was also used to be consistent with proposed regulations from the NRC and the EPA.

RADIATION RISK ASSESSMENT METHODOLOGY

The risk assessment methodology used to calculate risk based soil concentrations of radionuclides

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is based on the US DOE document entitled,"Programmatic Risk-based Preliminary Remediation Goals." This document has been approved for use at RFETS by EPA and CDPHE. This site-specific document is based on the risk assessment methodologies outlined in Risk Assessment Guidance For Superfund, Volume I, Human Health Evaluation Manual (Part A) (EPA/540/1-89/002) and Risk Assessment Guidance For Superfund, Volume I, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals) (OERR Publication 9285.7-01B). The equation and the exposure parameter values for the risk analysis were taken directly from the Programmatic Risk-based Preliminary Remediation Goals document. The risk equation is derived such that the sum of the ingestion, inhalation and external irradiation pathways is used. The exposure parameters are also conservative since they are based on EPAs Reasonable Maximum Exposure (RME) concept.

Radiation risk slope factors are EPA derived factors that were taken from the Health Effects Assessment Summary Tables (HEAST) FY 1994, Supplement Number 2. Radionuclide slope factors are calculated for each radionuclide individually and are based on the NAS BEIR V report and ICRP Publication 60. In the HEAST tables, there is no choice for the ICRP lung class and the GI absorption factors since one conservative default value is given. These default values are outlined in the table. Daughter products are incorporated into the radionuclide slope factors when appropriate. Soil levels corresponding to a carcinogenic risk of 1E-04 and 1E-06 are outlined in Table 9, "Risk Based Soil Action Levels."

TABLES

Table 1: Radiation Risk & Dose Based Soil Action Levels
Table 2: Exposure Scenario Definition
Table 3: Residential Exposure Scenario, 15 Millirem Limit
Table 4: Residential Exposure Scenario, 100 Millirem Limit
Table 5: Office Worker Exposure Scenario, 15 Millirem Limit
Table 6: Office Worker Exposure Scenario, 100 Millirem Limit
Table 7: Open Space Exposure Scenario, 15 Millirem Limit
Table 8: Open Space Exposure Scenario, 100 Millirem Limit
Table 9: Risk Based Soil Action Levels

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TABLE 1
RADIATION RISK & DOSE BASED SOIL ACTION LEVELS

Radionuclide	10^{-06} Risk (pCi/gram)	10^{-04} Risk (pCi/gram)	15 Millirem Radiation Dose (pCi/gram)	100 Millirem Radiation Dose (pCi/gram)
RESIDENTIAL EXPOSURE SCENARIO				
Americium-241	1.9	190.0	80.6	537.0
Plutonium-239	2.5	250.0	100.0	669.0
Uranium-234	17.5	1750.0	1230.0	8210.0
Uranium-235	0.2	15.6	36.8	246.0
Uranium-238	0.7	74.7	1390.0	9270.0
OFFICE WORKER EXPOSURE SCENARIO				
Americium-241	7.7	767.0	286.0	1900.0
Plutonium-239	10.1	1010.0	338.0	2250.0
Uranium-234	70.8	7080.0	4160.0	27800.0
Uranium-235	0.6	62.3	173.0	1160.0
Uranium-238	3.0	299.0	4690.0	31200.0
OPEN SPACE EXPOSURE SCENARIO				
Americium-241	23.6	2360.0	2380.0	15900.0
Plutonium-239	69.8	6980.0	2820.0	18800.0
Uranium-234	467.0	46700.0	34700.0	231000.0
Uranium-235	0.6	62.8	1460.0	9710.0
Uranium-238	3.2	315.0	39000.0	260000.0

TABLE 2
EXPOSURE SCENARIO DEFINITION

SOIL ACTION LEVEL EQUATION

$$DSP = \frac{\text{TARGET DOSE LEVEL}}{EDD \times [\,(EF \times IRA \times DCFI \times (3.7E{+}09) \times 1.0E{-}06(uCi/pCi) \times 1.0E{+}03(g/kg) \times (1/PEF)) + (EF \times DCFO \times (3.7E{+}09) \times 1.0E{-}06(uCi/pCi) \times 1.0E{-}03(g/mg) \times IRS) + (DCFE \times (1.868E{+}23) \times (1 - SE) \times TE \times AE \times 1.0E{-}06(uCi/pCi))]}$$

EXPOSURE FACTOR DEFINITION

Exposure Factors Description	Exposure Factor Units	Residential Radiation Dose Analysis Exposure Factor Values	Office Worker Radiation Dose Analysis Exposure Factor Values	Open Space Radiation Dose Analysis Exposure Factor Values
Dose Based Soil Action Level (DSP)	pCi/gram			
Exposure Duration(EDD)	years	1.0	1.0	1.0
Exposure Frequency (EF)	days/year	350.0	250.0	25.0
Inhalation Rate (IRA)	m^3/day	20.0	6.64	7.0
Inhalation Dose Conversion Factor (DCFI)	mrem/uCi	Radionuclide-Specific	Radionuclide-Specific	Radionuclide-Specific
Particulate Emission Factor (PEF)	m^3/kg	4.63E+09	4.63E+09	4.63E+09
Oral Dose Conversion Factor (DCFO)	mrem/uCi	Radionuclide-Specific	Radionuclide-Specific	Radionuclide-Specific
Soil Ingestion Rate (IRS)	mg/day	120.0	50.0	60.0
External Dose Conversion Factor (DCFE)	[(mrem/yr) per (uCi/gram)]	Radionuclide-Specific	Radionuclide-Specific	Radionuclide-Specific
Gamma Shielding Factor (SE)	unitless	0.2	0.2	0.0
Gamma Exposure Factor (TE)	unitless	1.0	0.3	0.2
Gamma Annual Exposure Factor (AE)	unitless	1.0	0.7	0.1

TABLE 3
RESIDENTIAL EXPOSURE SCENARIO - 15 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	8.06E+01
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	5.33E+03
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	9.20E+02
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	1.00E+02
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	9.56E+03
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	1.23E+03
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	1.23E+03
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	3.78E+01
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	3.68E+01
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	3.68E+01
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	1.19E+04
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	1.39E+03
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	1.39E+03

TABLE 4
RESIDENTIAL EXPOSURE SCENARIO - 100 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	5.37E+02
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	3.55E+04
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	6.14E+03
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	6.69E+02
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	6.37E+04
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	8.21E+03
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	8.21E+03
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	2.52E+02
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	2.46E+02
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	2.46E+02
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	7.95E+04
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	9.27E+03
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	9.28E+03

TABLE 5
OFFICE WORKER EXPOSURE SCENARIO - 15 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	2.86E+02
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	1.89E+04
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	3.13E+03
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	3.38E+02
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	3.48E+04
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	4.16E+03
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	4.17E+03
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	1.80E+02
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	1.73E+02
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	1.73E+02
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	4.21E+04
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	4.69E+03
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	4.69E+03

TABLE 6
OFFICE WORKER EXPOSURE SCENARIO - 100 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	1.90E+03
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	1.26E+05
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	2.08E+04
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	2.25E+03
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	2.32E+05
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	2.78E+04
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	2.78E+04
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	1.20E+03
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	1.16E+03
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	1.16E+03
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	2.81E+05
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	3.12E+04
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	3.13E+04

TABLE 7
OPEN SPACE EXPOSURE SCENARIO - 15 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	2.38E+03
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	1.60E+05
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	2.62E+04
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	2.82E+03
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	2.94E+05
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	3.47E+04
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	3.47E+04
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	1.51E+03
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	1.46E+03
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	1.46E+03
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	3.56E+05
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	3.90E+04
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	3.91E+04

TABLE 8
OPEN SPACE EXPOSURE SCENARIO - 100 MILLIREM LIMIT

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Inhalation Dose Conversion Factor (Sv/Bq)	Oral Dose Conversion Factor (Sv/Bq)	External Dose Conversion Factor [(Sv/sec) per (Bq/m^3)]	Potential Soil Action Level (pCi/gram)
Americium-241/W/1.0E-03	1.20E-04	9.84E-07	2.18E-19	1.59E+04
Plutonium-239/Y/1.0E-05	8.33E-05	1.40E-08	1.15E-21	1.07E+06
Plutonium-239/W/1.0E-04	1.16E-04	9.96E-08	1.15E-21	1.74E+05
Plutonium-239/W/1.0E-03	1.16E-04	9.56E-07	1.15E-21	1.88E+04
Uranium-234/Y/2.0E-03	3.58E-05	7.06E-09	1.82E-21	1.96E+06
Uranium-234/W/5.0E-02	2.13E-06	7.66E-08	1.82E-21	2.31E+05
Uranium-234/D/5.0E-02	7.37E-07	7.66E-08	1.82E-21	2.31E+05
Uranium-235/Y/2.0E-03	3.32E-05	7.22E-09	2.65E-18	1.01E+04
Uranium-235/W/5.0E-02	1.97E-06	7.19E-08	2.65E-18	9.71E+03
Uranium-235/D/5.0E-02	6.85E-07	7.19E-08	2.65E-18	9.71E+03
Uranium-238/Y/2.0E-03	3.20E-05	6.42E-09	5.45E-22	2.37E+06
Uranium-238/W/5.0E-02	1.90E-06	6.88E-08	5.45E-22	2.60E+05
Uranium-238/D/5.0E-02	6.62E-07	6.88E-08	5.45E-22	2.60E+05

TABLE 9
RISK BASED SOIL ACTION LEVELS

Radionuclide/ ICRP Lung Class/ GI Absorption Factor	Residential Soil 10^{-06} Risk Level (pCi/gram)	Residential Soil 10^{-04} Risk Level (pCi/gram)	Office Worker Soil 10^{-06} Risk Level (pCi/gram)	Office Worker Soil 10^{-04} Risk Level (pCi/gram)	Open Space Soil 10^{-06} Risk Level (pCi/gram)	Open Space Soil 10^{-04} Risk Level (pCi/gram)
Americium-241/W/1.00E-03	1.9	190	7.67	767	23.6	2360
Plutonium-239/Y/1.00E-03	2.5	250	10.1	1010	69.8	6980
Uranium-234/Y/5.00E-02	17.5	1750	70.8	7080	467	46700
Uranium-235/Y/5.00E-02	0.156	15.6	0.623	62.3	0.628	62.8
Uranium-238/Y/5.00E-02	0.747	74.7	2.99	299	3.15	315