Uranerz
ENERGY CORPORATION

October 3, 2013

Attn: Document Control Desk
Director, Office of Federal and State Materials and
Environmental Management Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attn: Document Control Desk
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Division of Waste Management and Environmental Protection
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RE: Uranerz Energy Corporation, Nichols Ranch Project, Source Materials License SUA-1597, Docket No. 40-9067, License Condition 12.12

Dear Mr. Director and Deputy Director,

License Condition 12.12 states "Prior to the preoperational inspection, the applicant will provide a survey plan for post reclamation and decommissioning verification surveys that demonstrates that residual radioactivity in soil meets the criteria in 10CFR Part 40, Appendix A, Criterion 6(6). The applicable cleanup criteria will be identified for radium-226 and soil cleanup criteria will be developed for natural uranium using the radium benchmark dose approach. Applicable criteria for thorium-230 will also be addressed in the plan."

In response to License Condition 12.12 please find the attached "Radium Benchmark Dose Assessment for Nichols Ranch facility. Within the attachment the chemical toxicity of uranium may also be found.

Upon review and acceptance of the Radium Benchmark Dose Assessment we request that License Condition 12.12 be removed from the license.

If you should have any questions regarding this matter or this proposed plan, please contact me by phone at 307-265-8900 or by e-mail at mthomas@uranerz.com.

Sincerely,

Dawn Kolkman
signing for Mike Thomas

Mike Thomas
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Uranerz Energy Corporation

MT/rs

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Radium Benchmark Dose Assessment

1. Introduction

On April 12, 1999, the U.S. Nuclear Regulatory Commission NRC) amended 10 CFR 40 by adding requirements to Criterion 6 (6) of Appendix A (64FR 17506, Radiological Criteria for License Termination of Uranium Recovery Facilities. The amendment to Criterion 6 (6) of 10CFR 40 was effective June 11, 1999, and required the use of a radium standard to derive a dose criterion for the cleanup of byproduct material. To comply with this "benchmark approach" the NRC licensees model site specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determination are then sent to the NRC with the site reclamation plan or as part of the license application. This report documents the modeling and assumptions made by Uranerz for developing standards for natural uranium in soil for the Nichols Ranch in-situ uranium recovery facility.

Final guidance (NRC, 2003) is published in Appendix E to the Standard Review Plan for In Situ Leach License Applications (NUREG-1569). This guidance outlines acceptable models and input parameters. This guidance along with the RESRAD User Manual (Yu et al. 2001), The Data Collection Handbook (ANL, 1993) , radium benchmark dose assessment provided for Dewey-Burdock and Ludaman sites by Environmental Restoration Group (ERG), and site specific parameters were used in the modeling as discussed in the following sections.

1.1. The RESRAD Code

The RESRAD family of codes was developed at Argonne National Laboratories (ANL), and are utilized to model dose as result of residual radioactivity. Default dose conversion factors in the RESRAD code are derived from the US EPA's Federal Guidance Report (FGR) Number 11 (EPA 1988). The RESRAD code calculates effective dose equivalents from external radiation and committed dose equivalent from internal exposures, providing a total dose equivalent (TEDE). Version 6.5 of RESRAD was used in Uranerz analysis. (ANL,2001).

The RESRAD code is an accepted code by the USNRC for application of the radium benchmark as described in NUREG 1569 *Guidance to the US Nuclear Regulatory Commission Staff on the Radium Benchmark Dose Approach.*

2. Receptor Scenario

USNRC guidance (USNRC 2003) provides many scenarios for consideration at individual sites. At the Nichols Ranch site, a resident rancher is the most restrictive and realistic resident scenario. Home-based businesses are unlikely due to the rural and remote location of the permit area. A resident farmer is unlikely scenario since agronomic studies of the site, outlined in Section 2.2.2 of the Technical Report (TR), have indicated soils in the area are best suited for livestock grazing only. Light industry and mining are potential scenarios, however they would be less restrictive than a rancher who lives in the restricted area on the contaminated area and eats food (meat and some vegetables) grown in the area. The

rancher is appropriate for the site as the area has been historically used for lower density livestock production of cattle. The resident rancher would likely spend a significant portion of their life outdoors and would be likely to obtain meat from their own livestock and a limited amount of vegetables from the home garden. The resident rancher would likely construct small stock ponds that their livestock could drink from. It is assumed there is no contamination in the groundwater at the site when the model begins. The contaminated area is calculated as 10,000 m^2, and the model was ran for 1000 years.

3. Determination of Radium Benchmark Dose

Doses for scenarios with both 5pCi/g Ra-226 in the first 15 cm of soil (surface scenario) and 15 pCi/g of Ra-226 in a 15 cm thick layer of soil with 15cm of clean cover (subsurface scenario) were calculated and are as follows.

Maximum Dose for surface scenario= 39.3 mrem/yr at t= 0 years
Maximum Dose for Subsurface Scenario= 103.6 mrem/yr at t= 299.7 ± 0.6 years.

Dose as a function of time in both scenarios is shown in Figure 1 and 2 for surface and subsurface scenarios respectively. Doses as a result of Ra-226 at the site are highly influenced by the soils strong absorption of Ra-226, making radium not mobile and allowing for removal primarily by erosion and radioactive decay. The two major dose pathways were external exposure and plant ingestion (water independent). Sensitivity analysis were performed on the parameters that would affect the maximum dose and can be seen in Appendix B and C.

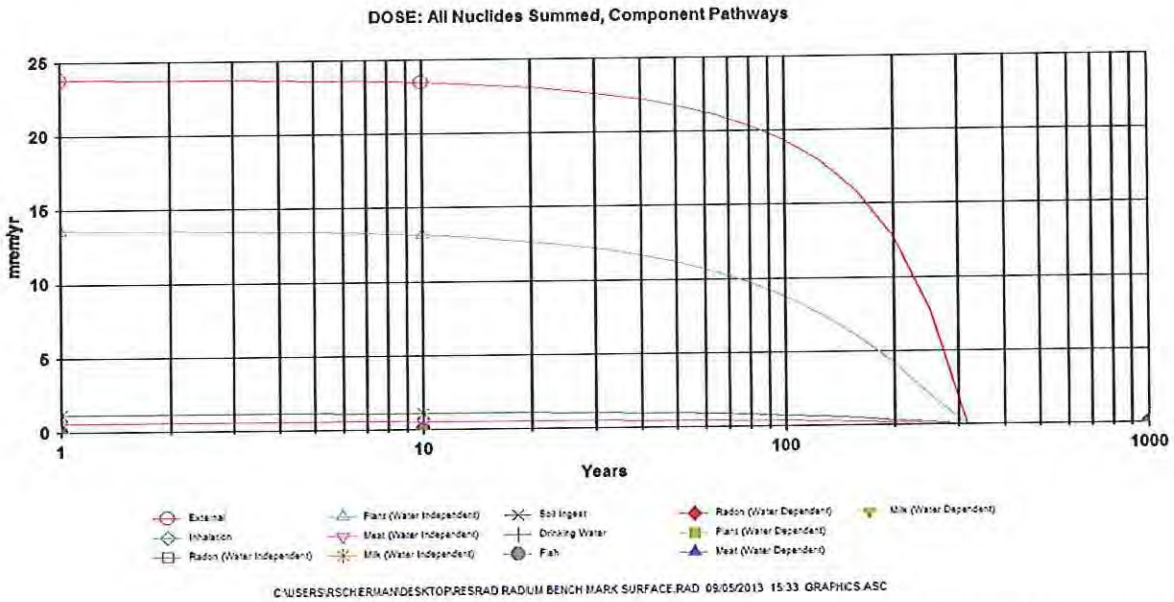

Figure 1: Dose from surface contamination of 5 pCi/g of Ra-226

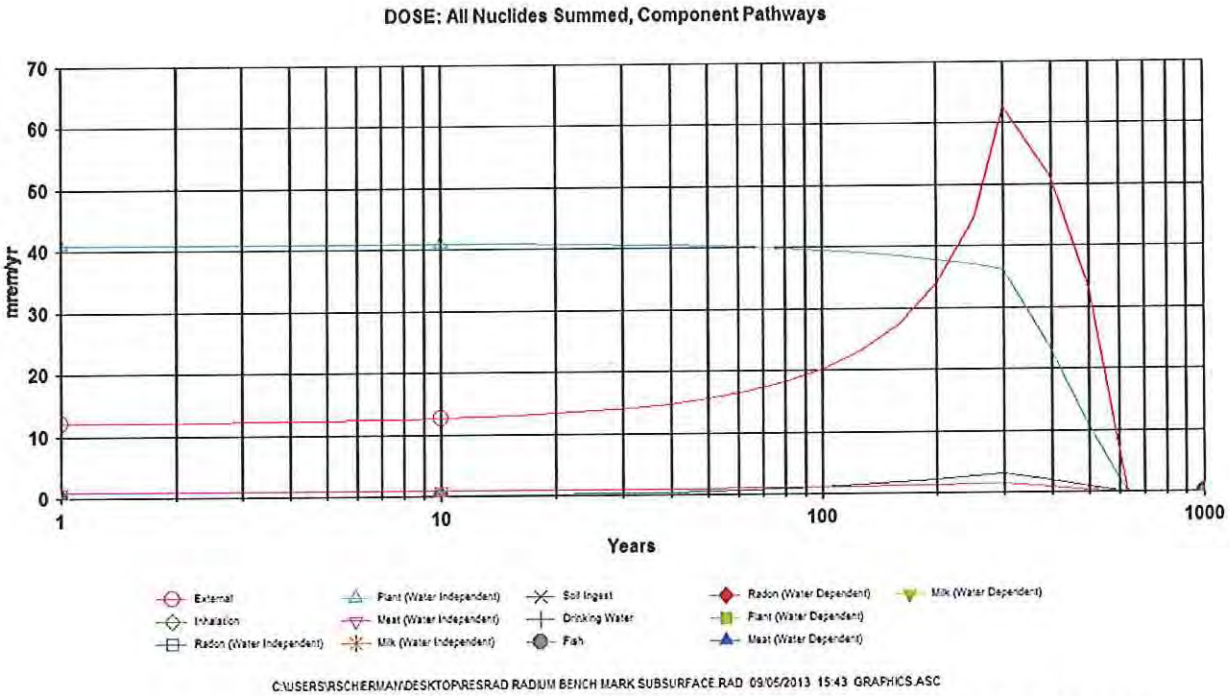

Figure 2: Dose from subsurface contamination of 15 pCi/g of Ra-226

4. Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of natural uranium (U-nat) in soil distinguishable from background that would result in a maximum dose of 38.1 mrem/yr for surface and 103.6 mrem/yr for subsurface radium. The maximum allowable U-nat concentration in the soil is determined by modeling a set concentration of U-nat in soil and scaling the results to the radium benchmark to arrive at the maximum allowable concentration of natural uranium.

For ease of calculation a concentration of 100 pCi/ g of U-nat was used being divided into 49.2 percent U-234, 48.6 percent U-238 and 2.2 percent U-235. Distribution coefficients were selected from the RESRAD manual Table E.3. All other inputs were the same used for the surface and subsurface Radium-226 assessment.

Doses from the uranium contamination are as follows and shown visually in Figure 3 and 4:

Maximum Dose for surface scenario= 6.8 mrem/yr at t= 0 years
Maximum Dose for Subsurface Scenario= 1.91mrem/yr at t= 0 years

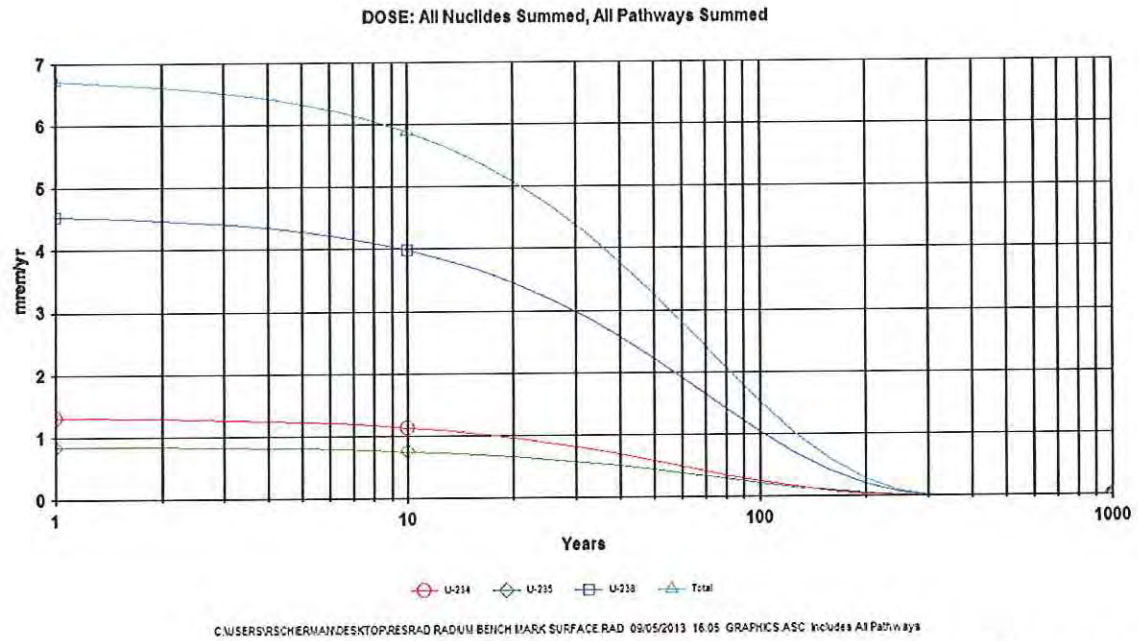

Figure 3: Dose from surface contamination of 100 pCi/g of U-nat

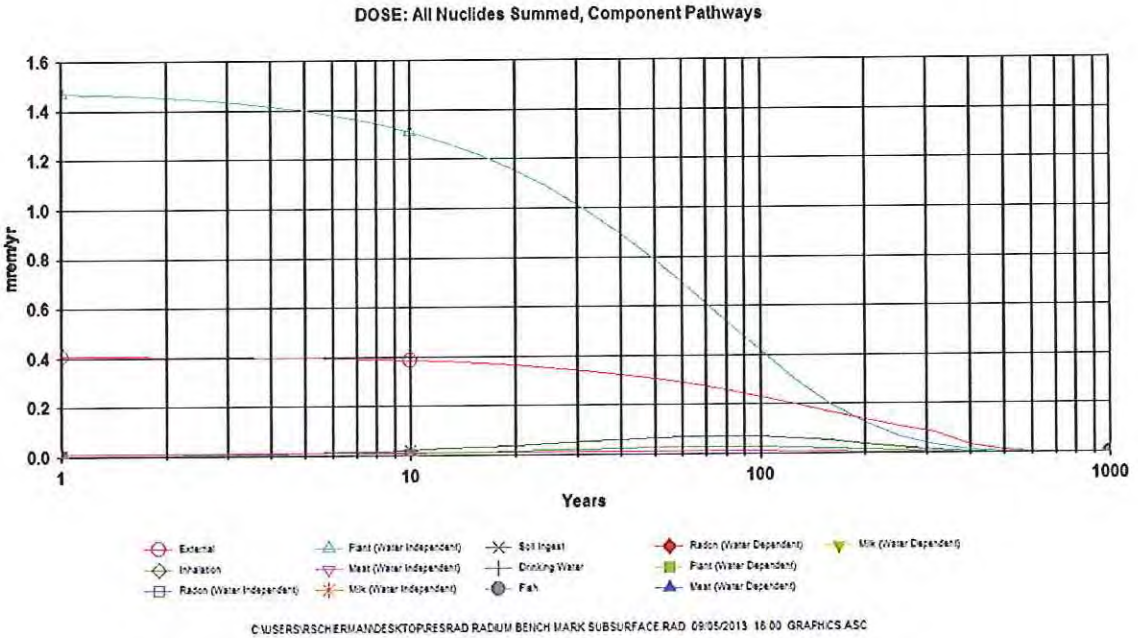

Figure 4: Dose from subsurface contamination of 100 pCi/g of U-nat

As shown in both scenarios the maximum dose from the uranium contamination occurs within the first year and then decreases with time. To determine the soil standard the uranium concentration was related to the radium bench mark by the following ratio:

Surface Scenario

$$\frac{6.8\,mrem/yr}{100pCi/g} = \frac{38.1\,mrem/yr}{XpCi/g} = 560\,\frac{pCi}{g}U$$

Subsurface scenario

$$\frac{1.91\,mrem/yr}{100pCi/g} = \frac{103.6\,mrem/yr}{XpCi/g} = 5424\,\frac{pCi}{g}U$$

The criteria for unrestricted use will be applied for Ra-226 and natural uranium using the unity rule, such that the radium benchmark dose is never exceeded for any combination of radionuclide concentration as required by 10CF 40 Appendix A criterion 6(6)

Surface Scenario

$$\frac{XpCi/gUnat}{560pCi/gUnat} + \frac{YpCi/g^{226}Ra}{5pCi/g^{226}Ra} \leq 1$$

Subsurface Scenario

$$\frac{XpCi/gUnat}{5424pCi/gUnat} + \frac{YpCi/g^{226}Ra}{15pCi/g^{226}Ra} \leq 1$$

This approach will be used at the Nichols Ranch facility to determine the radiological impact on the environment from releases of source and byproduct materials.

Additionally, it is noted that contamination by thorium isotopes were also considered. However, there is no evidence of elevated natural Th-230 mineralization in the Nichols Ranch environment and reports in the literature indicate very little Th-230 is mobilized in the ore body by the ISR process (Brown 2007). To verify this assumption samples of the incoming production fluid as well as fluids leaving the central processing plant will be collected and analyzed for thorium within one year from the start of operations. In the instance that thorium is present it will be applied to the unity rule.

5. Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated assuming the same exposure scenarios as that used in the radiation benchmark dose assessment. In that exposure scenario it was assumed that 25 percent of the meat, fruits, and vegetables are grown on site. Intake of food through aquatic or milk pathways were considered improbable since it is unlikely that these activities could be supported in the local area. The RESRAD model showed that the contamination would not affect groundwater quality, and that same model will be used to assess the chemical toxicity. The intake from eating meat was considered insignificant as shown in Figure 3. The plant ingestion pathway was significant and will be evaluated with the chemical toxicity assessment.

The parameters for estimating human intake of uranium from ingestion are based on parameters given in NUREG/CR-5512 Vol.1 (NRC,1992). The uptake of uranium is the product of the concentration of uranium in the soil and the soil-to-plant conversion factor. The annual intake to humans is the product of the annual consumption of a particular food product by the uranium concentration in that food product. Soil-to-plant conversion factors are based on a dry weight; the annual consumption is adjusted to a dry weight basis by multiplying by the dry-weight to wet-weight ratio. Parameters for these calculations are located in NUREG/CR-5512 VOL. 1 (NRC,1992). Table 5.1 outlines the parameter used in these calculation and results for leafy vegetables, other vegetables, and fruit. It was assumed the individual annual consumption rates for leafy vegetables, other vegetables, and fruit were 11kg, 51kg, and 46kg respectively. Consistent with the RESRAD radium benchmark assessment it was assumed 25 percent of the food was grown on site. Uranium concentrations for food grow off site was not considered. It was also assumed the uranium concentration in the garden or orchard were 560 pCi/g. This corresponds to the uranium benchmark concentration established for surface soils. Using a conversion factor for U-nat of 1mg = 677 pCi, then 560 pCi/g is equivalent to 827 mg/kg. The human annual intake of uranium is shown in table 5.1 and is the result of the product of the subsequent columns. The total annual intake from all food sources is as shown in table 5.1

Table 5.1 Annual Intake of Uranium from Ingestion

Human Intake (mg/yr)	Soil Concentration (mg/kg)	Soil to Plant Ratio (mg/kg plant to mg/kg soil)	Annual Consumption (kg)	Dry Weight to Wet Weight Ratio	Food Source
8.4	827	1.7E-2	3	0.2	Leafy Vegetable
37.6	827	1.4E-2	13	0.25	Other Vegetable
7.1	827	4.0E-3	12	0.18	Fruit
53.1					Total

The total burden to the kidney is the sum of the two compartments. The mathematical representation for the kidney burden of uranium at steady state can be derived as follows (ICRP,1995)

$$\mathrm{Qp} = \frac{IR\ x\ f_1}{\lambda_p(1 - f_{ps} - f_{pr} - f_{pl} - f_{pt} - f_{pkl})}$$

Where:

Qp = uranium burden in plasma, µg
IR = dietary consumption rate, mg U/d
f_1 = fractional transfer of uranium from GI tract to blood, unit less
f_{ps} = fractional transfer of uranium from plasma to skeleton, unit less
f_{pr} = fractional transfer of uranium from plasma to red blood cells, unit less
f_{pl} = fractional transfer of uranium from plasma to the liver, unit less
f_{pt} = fractional transfer of uranium from plasma to soft tissue, unit less
f_{pk1} = fractional transfer of uranium from plasma to the kidneys, compartment 1, unit less
λ_p = biological retention constant in plasma, d^{-1}

The burden in compartment 1 is

$$Q_{k1} = \lambda_p\ x\ Q_p\ x\ \frac{f_{pk1}}{\lambda_{k1}}$$

Where:

Q_{k1} = uranium burden in kidney compartment I, mg
Λ_{k1} = biological retention constant of uranium in kidney compartment I, d^{-1}

Similarly, for compartment 2 in the kidney, the burden is

$$Q_{k2} = \lambda_p\ x\ Q_p\ x\ \frac{f_{pk2}}{\lambda_{k2}}$$

Q_{k2} = uranium burden in kidney compartment 2, µg
λ_{k2} = biological retention constant of uranium in kidney compartment 2, d^{-1}

The total burden to the kidney is then the sum of the two compartments:

$$Q_{K1} + Q_{K2} = \frac{IR\ x\ f_1}{\lambda_p(1 - f_{ps} - f_{pr} - f_{pl} - f_{pt} - f_{pkl})}\ x\ \left(\frac{f_{pk1}}{\lambda_{k1}} + \frac{f_{pk2}}{\lambda_{k2}}\right)$$

The parameter input values for the two compartmental kidney model include the daily intake of uranium estimated for residents at the site, and the ICRP69 values recommended by ICRP as listed below (ICRP, 1995). The daily uranium intake rate was estimated to be 0.15 mg/day (53.1 mg/yr) from ingestion while residing at this site.

$IR = 0.15$ mg/day
$f_1 = 0.02$
$f_{ps} = 0.105$
$f_{pr} = 0.007$
$f_{pl} = 0.0105$
$f_{pt} = 0.347$
$f_{pk1} = 0.00035$
$f_{pk2} = 0.084$
$\lambda_{k1} = \ln(2)/(5\text{yrs}*365\text{ days/yr})$
$\lambda_{k2} = \ln(2)/7$ days

Given a daily uranium intake of 0.15 mg/day at this site and the above equation, the calculated uranium in the kidney is 0.010 mg U. Using the reference kidney mass the concentration in the kidneys is 0.032 µg of U per gram of kidney. This is 3.2 percent of the 1.0 µU/g value that has been understood to protect the kidney from the toxic effects of uranium. Other researchers have stated that mild health effects from uranium may be observable at levels as low as 0.1µg U/g of kidney tissue. Using this as the criterion then the intake is 32 percent of the level where mild effects may be observable.

The Environmental Protection Agency (EPA) evaluated the chemical toxicity data for Uranium when establishing the National Primary Drinking Water Standards. Mild proteinuria has been observed at drinking water between 20 and 100 µg/liter. Assuming an intake of 2 liters per day this corresponds to a daily intake of 0.04 to 0.2 mg/day. Through the use of animal data, and using a conservative factor of 100, the EPA arrived at a 30µg/liter standard for uranium in drinking water (Federal Register/Vol.65,No.236/Dec 7,2000). The standard results in a daily intake of 0.06mg/day for the average individual. Due to the fact that large diverse populations are potentially exposed to drinking water regulated with these standards, the EPA is very conservative in establishing their limits.

This analysis indicates that a soil limit of 560 pCi/g of U-nat would result in an intake of approximately 0.15 mg/day. Using the daily limit corresponding to the National Primary Drinking Water Standard the soil limit can be adjusted to address concerns regarding the chemical toxicity of uranium. A soil limit of 230 pCi/g corresponds to the EPA limit for drinking water with a daily intake of 0.06 mg/day. Therefore exposures to soils containing 230 pCi/g of natural uranium should not result in chemical toxicity effects. Since the root of a fruit tree may

penetrate to considerable depths, it would be best practice to limit subsurface uranium concentrations to the same limit.

6. Application of Radium Benchmark to Spills

Spills that occur at the Nichols Ranch will be evaluated to determine prudence of reclamation at the time of the spill or at decommissioning. The initial screening is to determine if the spill concentration will result in a dose greater than 100 mrem per year. The amount of contamination that would result in a 100mrem dose was calculated using the initial RESRAD output for 5 pCi/g as shown below:

Surface

$$\frac{39.3mrem/yr}{5pci/g} = \frac{7.86mrem/yr}{pCi/g}$$

$$\frac{100mrem/yr}{\frac{7.86mrem/yr}{pCi/g}} = 12.72\,pCi/g$$

The uranium concentration was calculated using the initial run for 100pCi/g of natural uranium and is shown as follows:

$$\frac{6.8\,mrem/yr}{100pCi/g} = \frac{100\,mrem/yr}{XpCi/g} = 1470.59\frac{pCi}{g}U$$

To ensure that the 100 mrem is not exceeded by a combination of uranium or radium the unity rule applies and is shown below:

$$\frac{XpCi/gUnat}{1470.59\,pCi/gUnat} + \frac{YpCi/g^{226}Ra}{12.72pCi/g^{226}Ra} \leq 1$$

The results of the unity rule will dictate if cleanup occurs at the time of decommissioning or sooner. Results that exceed the unity rule will be further evaluated using RESRAD specific calculations for the spill.

7. References

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USGS,2004, Estimated Use of Water in the United States in 2000, U.S. Geological Survey, U.S. Department of the Interior, USGS Circular 1268, Reston Virginia.

Yu. C, Zielen A.J, Cheng J.J, Lepoire D.J, Gnanapragasam S, Kamboj S, Arnish J, Wallo III A, Williams W.A, Peterson H,; "User's Manual for RESRAD Version 6," ANL/EAD-4, Argonne National Laboratory (2001)

Appendix A:RESRAD Data Inputs (Parameters)

This document summarizes the data input and modeling scenario that was used in determining the radium benchmark dose for the Nichols Ranch facility. RESRAD version 6.5 for windows was used for the analysis.

Data input was based on the following resources:

- NUREG-1569 (NRC,2003)
- Site Specific information found in license application
- The natural Resources Conservation Service (NRCS) 2003 Annual Natural Resources Inventory, State Report (NRCS 2007)
- US Geological Survey (USGS) Circular 1268 (USGS,2004)
- The Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil (Data Collection Handbook) (ANL, 1993)
- The RESRAD User Manual (ANL,2001)

Soil Concentration

Surface

- Lead-210: Used 5.0 pCi/g per NUREG-1569 (NRC,1993). Assumed to be in equilibrium at t=0

No sensitivity analysis on this parameter was performed based on the guidance.

- Radium-226: Used 5.0 pCi/g regulatory limit used for establishing benchmark

No sensitivity analysis on this parameter was performed based on regulatory limit.

Subsurface

- Radium-226: Used 15.0 pCi/g regulatory limit used for establishing benchmark

No sensitivity analysis on this parameter was performed based on regulatory limit.

- Lead-210: Used 15.0 pCi/g per NUREG-1569 (NRC,1993) assumed to be in equilibrium with the Radium at t=0

Distribution Coefficient (Kd)

Based on discussion in section 2.7-2.8 of the Technical Report the contaminated zone is classified as a loam and the unsaturated and saturated zones were modeled as sand. Values for distribution coefficients can be found in the RESRAD manual or Data Collection Handbook.

- Lead-210: 16,000 cm^3/g for the contaminated zone and 270 cm^3/g for the unsaturated and saturated zone

Sensitivity analysis indicated with a multiple of 100, no appreciable impact on maximum dose using higher K_d. Values of 160, 16,000, and 1,600,000. With the subsurface Radium there was a change in maximum dose using the lower value, however the mid value is what is in agreement with the literature and is more conservative.

- Radium 226:: 36000 cm^3/g for the contaminated zone and 500 cm^3/g for the unsaturated and saturated zone

Sensitivity analysis indicated with a multiple of 100, no appreciable impact on maximum dose using higher K_d. Values of 360, 36,000, 3,600,000. With the subsurface Radium there was a change in maximum dose using the lower value, however the mid value is what is in agreement with the literature and is more conservative.

Calculations Times

Times were set at 1 year, 200 years, and 1000 years. These times reflect recommendations that 200 years is the reasonable foreseeable time period for choosing the scenario of the critical group and 1000 years is the recommended total time of interest.

Contaminated Zone

- Area: Used default value of 10,000 square meters.

Sensitivity analysis was performed with a multiple 2 multiple, 5,000 10,000, and 20,000 square meters. There was no impact on maximum dose for the external component.

- Thickness: 15 cm based on regulatory guidance

No sensitivity analysis was performed for this parameter since it is based on regulatory guidance

- Length Parallel to aquifer flow: Default value of 100 meters was used. This is based upon the square root of 10,000 square meters of contaminated zone.

No sensitivity analysis was performed since water dependent pathways were not significant to dose.

Cover and Contaminated Zone

- Cover depth: 0 meters in accordance with NUREG-1569 (NRC, 2003)

- Density of contaminated zone: Used the value of 1.44 g/cm^3 which corresponds to a Sandy Loam in the Data Collection Handbook (ANL1993)

Since the RESRAD Data Collection Handbook considers the value to be representative of that soil characterization no sensitivity analysis was performed.

- Contaminated Zone Erosion Rate: Erosion rates were determined from values presented in NRCS National Resource Inventory, State Report (NCRS,2007) for the state of Wyoming. Erosion rates for Wyoming are listed as 0.4 tons/acre-year for water erosion and 2.5 tons/acre-year from wind erosion. The total erosion for the year would be 2.9 tons/acre-year. Using the contaminated zone soil density (1.44 g/cm^3), the total erosion rate was calculated as shown below:

$$Erosion\ Rate = \frac{2.9\ ton}{acre - yr} * \frac{9.07 * 10^5 g}{ton} * \frac{acre}{4.047 * 10^7 cm^2} * \frac{cm^3}{1.44\ g} * \frac{m}{100} = .00052$$

Sensitivity analysis of the external and plant (water independent) pathways were performed with a multiple of 2 (i.e. 0.001, 0.0005, and 00025). The maximum dose rate from external the external pathway did not change when the value was changed. The maximum dose rate for plant pathway decreased with the upper value. The midrange value represents Wyoming conditions and is both adequate for the model and conservative.

- Contaminated Zone total porosity: Default value of 0.4 was used based on the soil types at the Nichols Ranch Facility

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Contaminated Zone Field Capacity: Default value of 0.2 was used since it is the midpoint of the range for the soil types at Nichols Ranch.

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Contaminated Zone Hydraulic Conductivity: Section 2.8.2 of the Technical Report describes the soil as fine textured sandy loam. In table E.2 of the RESRAD User's manual the hydraulic conductivity is listed as 1.09E^{03} for sandy loams.

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Contaminated Zone B Parameter: Section 2.8.2 of the Technical Report describes the soil as fine textured sandy loam. In table E.2 of the RESRAD User's manual the b value is listed as 4.90

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Evapotranspiration Coefficient: The RESRAD default value is 0.5. NUREG-1569 suggests that a value of 0.6 to 0.99 be used for uranium recovery sites. This is because these sites are typically used in semi-arid environments. For our purposes we used a mid-value of 0.7

Sensitivity analysis of the evapotranspiration coefficient was performed using 1.4 multiplier with the values (i.e. .5, .7, and .98). The analysis shows no effect on the dose estimates. The coefficient is primarily used in calculating of leaching components however since Ra-226 and Pb-210 have low leach rates the factor should not have a great impact on the dose.

- Wind Speed: In section 2.5.3.3 of the TR the average wind speed is listed as 4.92 m/sec.

Sensitivity analysis was not performed since this is actual site data.

- Precipitation: in section 2.5.2.2 of the TR the average precipitation was 0.28 m/yr.

Sensitivity analysis was not performed since this is actual site data.

- Irrigation Rate: The area is quite arid and not used for production of crops, the irrigation rate was set to 0, which is supported in USNRC guidance (USNRC 2003)

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Runoff Coefficient: The Data Collection Handbook gives the following equation for runoff coefficient for an agricultural environment:

$$Runnoff\ Coefficient = 1 - C_1 - C_2 - C_3$$

The values of C_1, C_2, and C_3 used were 0.2 (rolling land), 0.2 (intermediate combinations of clay and loam), and 0.1 (cultivated land), respectively. The runoff coefficient was determined to be 0.5

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Watershed Area for nearby stream or pond: Used the default value of 1×10^5 m^2.

Sensitivity analysis was not performed since water dependent pathways were not significant contributors to dose.

- Accuracy: Used the default value of 0.001

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

Saturated Zone

- Density of the Saturated Zone: Used the default density of 1.5 g/cm^3 which corresponds with the RESRAD Handbook value for sands.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

- Saturated Zone Total Porosity: Value of 0.43 is based upon the formation type of the F sands (shallowest aquifer) described in section 2.7.2.3 TR and the RESRAD user manual for sands

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

- Saturated Zone Effective Porosity: Saturated Zone Total Porosity: Value of 0.33 is based upon the formation type of the F sands (shallowest aquifer) described in section 2.7.2.3 TR and the RESRAD user manual for sands

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Contamination Zone Field Capacity: Used the value obtained from subtracting the effective porosity of the saturated zone from the total porosity of the saturated zone for a value of .10.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Saturated Zone Hydraulic Conductivity: Used the value of 5550m/yr based on saturated zones physical properties and the RESRAD manual E.2

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Saturated Zone Hydraulic Gradient: Used the hydraulic gradient of .01 based on site specific data listed in 2.7.2.3 of the TR.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Saturated zone b parameter: Used the b parameter for sand listed in the Data Collection Handbook, 4.05.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Water Table Drop Rate: Used the default value of 0.001 m/yr. The site specific drop rate should be similar because there is little consumption of groundwater in the immediate area other than ranches that use local wells for domestic and livestock.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Well Pump Intake Depth: Used the default value of 10m

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Model for Water Transport Parameters: Used non-dispersion per NUREG-1569 (NRC,2003)

No sensitivity analysis on this parameter was performed based on the guidance.

- Well Pumping Rate: Used default of 250 m^3/yr

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Unsaturated Zone

- Unsaturated Zone Thickness: Used value of 22.86 m based on average distances to water at the site presented in Table 2-13 of TR

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

- Density of the Unsaturated Zone: Used the default density of 1.5 g/cm^3 which corresponds with the RESRAD Handbook value for sands.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

- Unsaturated Zone Total Porosity: Value of 0.43 is based upon the formation type of the F sands (shallowest aquifer) described in section 2.7.2.3 TR and the RESRAD user manual for sands

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose

- Unsaturated Zone Effective Porosity: Saturated Zone Total Porosity: Value of 0.33 is based upon the formation type of the F sands (shallowest aquifer) described in section 2.7.2.3 TR and the RESRAD user manual for sands

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Unsaturated Zone Field Capacity: Used the value obtained from subtracting the effective porosity of the saturated zone from the total porosity of the saturated zone for a value of .10.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Unsaturated Zone Hydraulic Conductivity: Used the value of 5550m/yr based on saturated zones physical properties and the RESRAD manual E.2

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

- Unsaturated Zone b Parameter: Used the b parameter for sand listed in the Data Collection Handbook, 4.05.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Occupancy

- Inhalation Rate: Used the default value of 8400 m^3/yr

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

- Mass loading for Inhalation: Used the default value of 0.0001 g/m^3

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

- Exposure Duration: Used default of 30 years
- Indoor dust filtration factor: Used the default value of 0.4

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

- External Gamma Shielding Factor: RESRAD default is 0.7, which assumes that inddor gamma radiation level is 30% lower than outdoor gamma radiation levels. NUREG-1569 requires that a value between 0.33 and 0.55 be used. The value of 0.55 was used as a screening methodology.

Sensitivity analysis of external pathways was performed using a multiple of 1.5 (i.e. 0.367, 0.55 and 0.825) The lower value resulted in a decrease in the maximum dose rate for external exposures. Using the higher value the maximum dose rate increased. The value 0.55 is the most conservative in the range specified in NUREG1569.

- Indoor/Outdoor Fractions: Used the values of 0.25 indoor time and 0.5 for outdoor time. It is assumed 25% of the rancher's time is spent off site. These alterations were made in accordance with NUREG-1569

No sensitivity analysis on this parameter was performed based on the guidance.

- Shape of Contaminated Zone: A circular shape was used.

Ingestion: Dietary

- Fruit, vegetable, and grain: Used the default value of 160 kg/yr which is based on EPA estimated consumptions. RESRAD adjusts for contaminated and uncontaminated fractions based upon the size of the contaminated area
- Leafy Vegetable: Used the default value of 14 Kg/yr. NRC regulatory guide 1.109 (NRC,1977) the consumption rate of leafy vegetables is 64 kg/yr while NRC recommend 30 Kg/yr when performing dose calculations for nuclear power plants. RESRAD adjusts for contaminated and uncontaminated fractions based upon the size of the contaminated area.
- Milk: No consumption of locally produced milk is assumed since dairy operations are not prevalent in the area. This is in accordance with NUREG-1569
- Meat and Poultry: Used RESRAD default value of 63 kg/yr.

- Fish /Seafood: No consumption of locally produced fish or seafood was assumed in agreement with NUREG-1569.
- Soil Ingestion: Used the RESRAD default of 36.5 g/yr
- Drinking Water Intake: Used the RESRAD default of 510L/yr which is based on EPA estimates of drinking water intakes.

Ingestion: Dietary

NUREG-1569 states that for sites with over 25 acres (10,117 square meters) of contamination, the fraction of diet from contaminated area should be assumed to be 25% (0.25). A sensitivity analysis on these parameters was not performed based upon the guidance.

- Water: Used the default value of 1. All current water use in the rural area around the site is from private wells and will continue for the foreseeable future.
- Live Stock Water: Used the default value of 1. All current water use in the rural area around the site is from private wells and will continue for the foreseeable future.
- Irrigation Water: The fraction of irrigation water was set to 0 as it is assumed no irrigation will be taking place in this region.
- Plant Food: The fraction for plant food was set to 0.25 as this is an arid region and it is unlikely that a family would be able to support all of the plant-based portions of their diets from a home garden alone.
- Meat: The fraction of meat was set at 0.25 default assuming that a resident rancher would have intake of meat locally raised.
- Aquatic Food: The fraction was set to 0 as there is no major bodies of water that support fish populations in the area.
- Milk: Used the value of 0 due to no consumption of locally produced milk per NUREG-1569.

Ingestion: Non-dietary

- Livestock fodder intake for meat: Used the default value of 68kg.day
- Livestock water intake for meat. Uses the default value of 50L/day

- Livestock intake of soil for meat: Used the default value of 0.5 g/day
- Mass loading for foliar deposition: Used default value of .0001 g/m^3

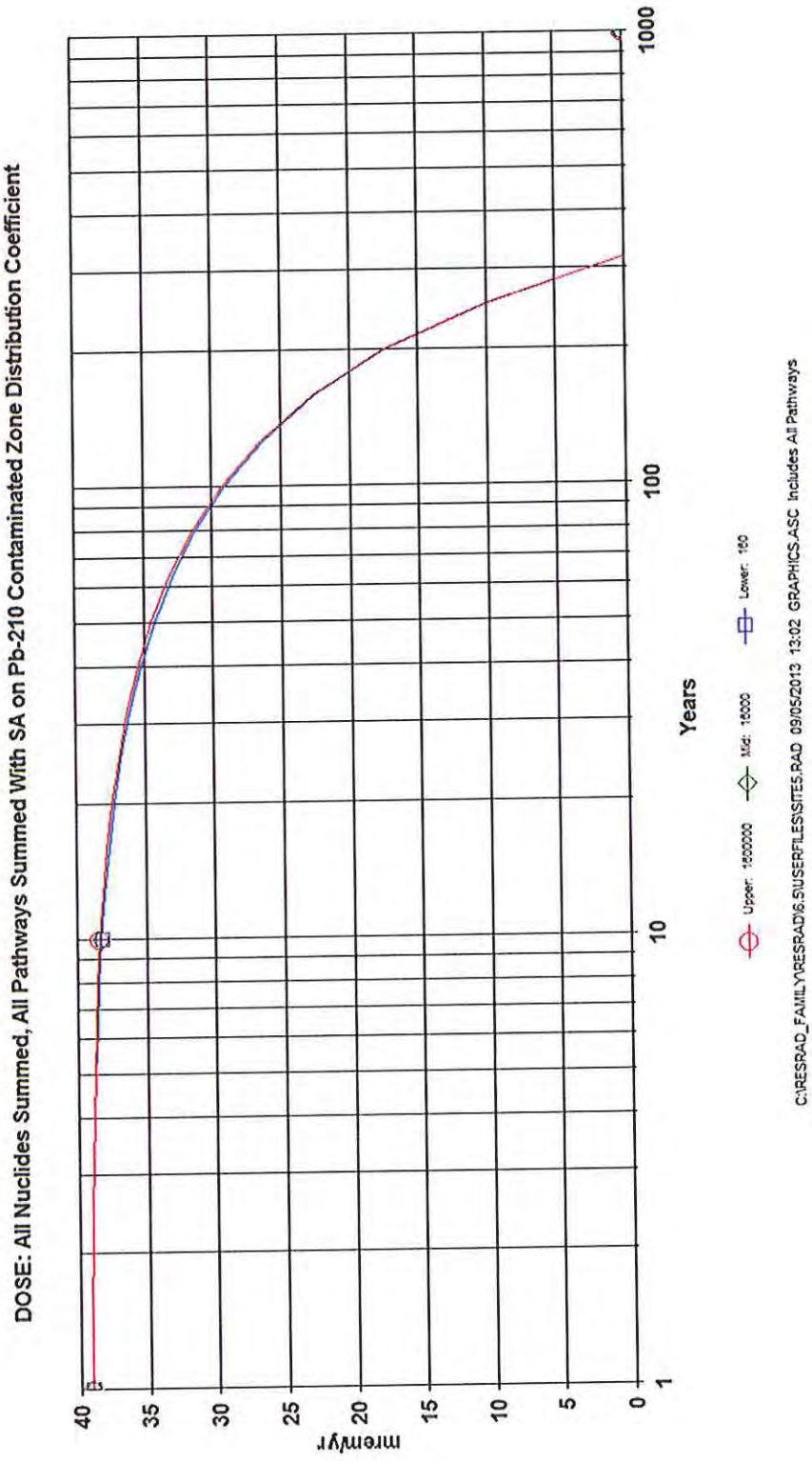
Sensitivity analysis on the plant (water independent) was performed with a multiple of 100 (i.e 0.000001, 0.0001, and 0.01 g/m^3)> The analysis displayed that there were no observable changes in the maximum dose between the different bounds.

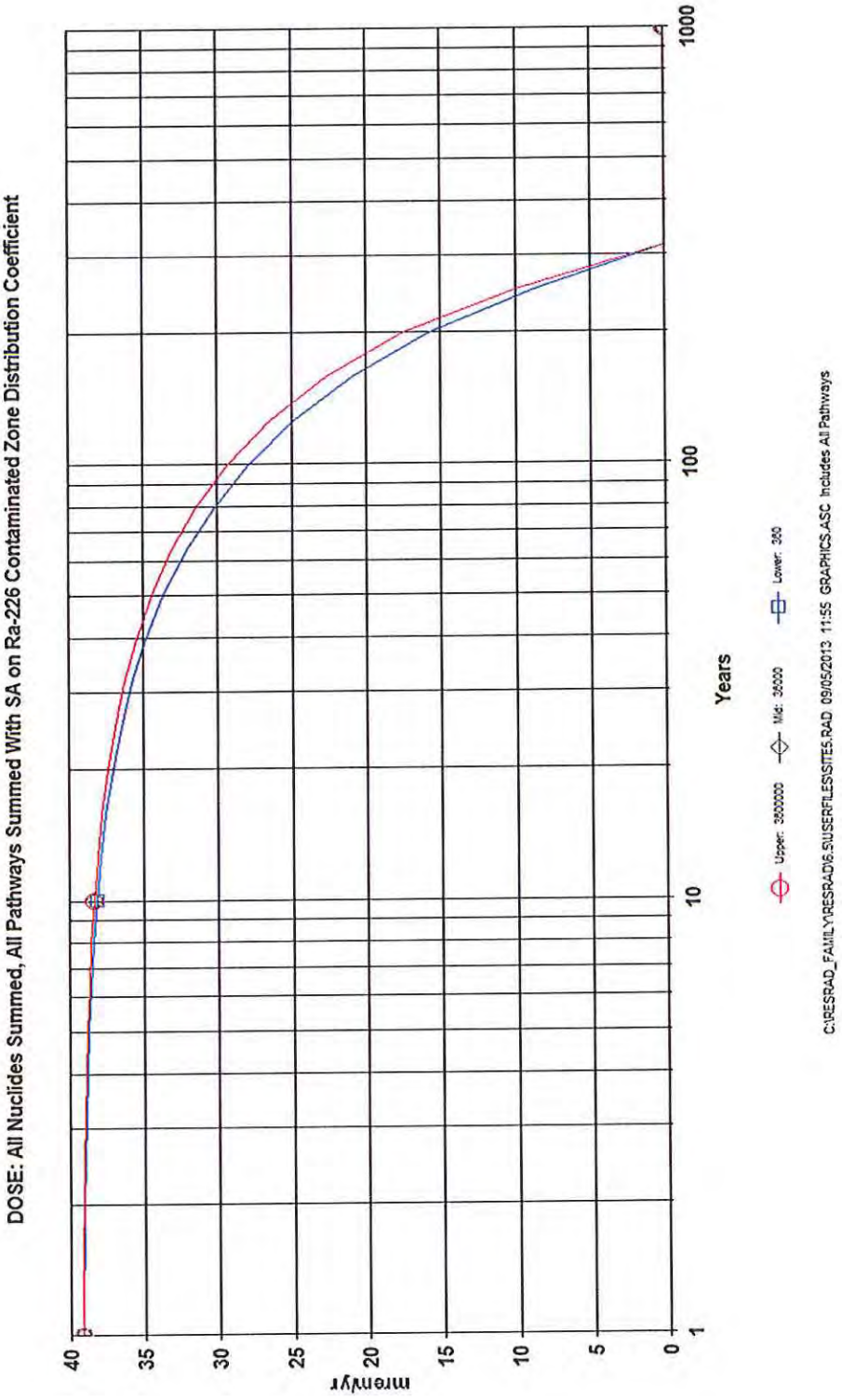
- Depth of Soil Mixing Layer: Used the default value of 0.15 meters
- Depth of Roots: Used 0.3 meters based on guidance in NUREG-1569

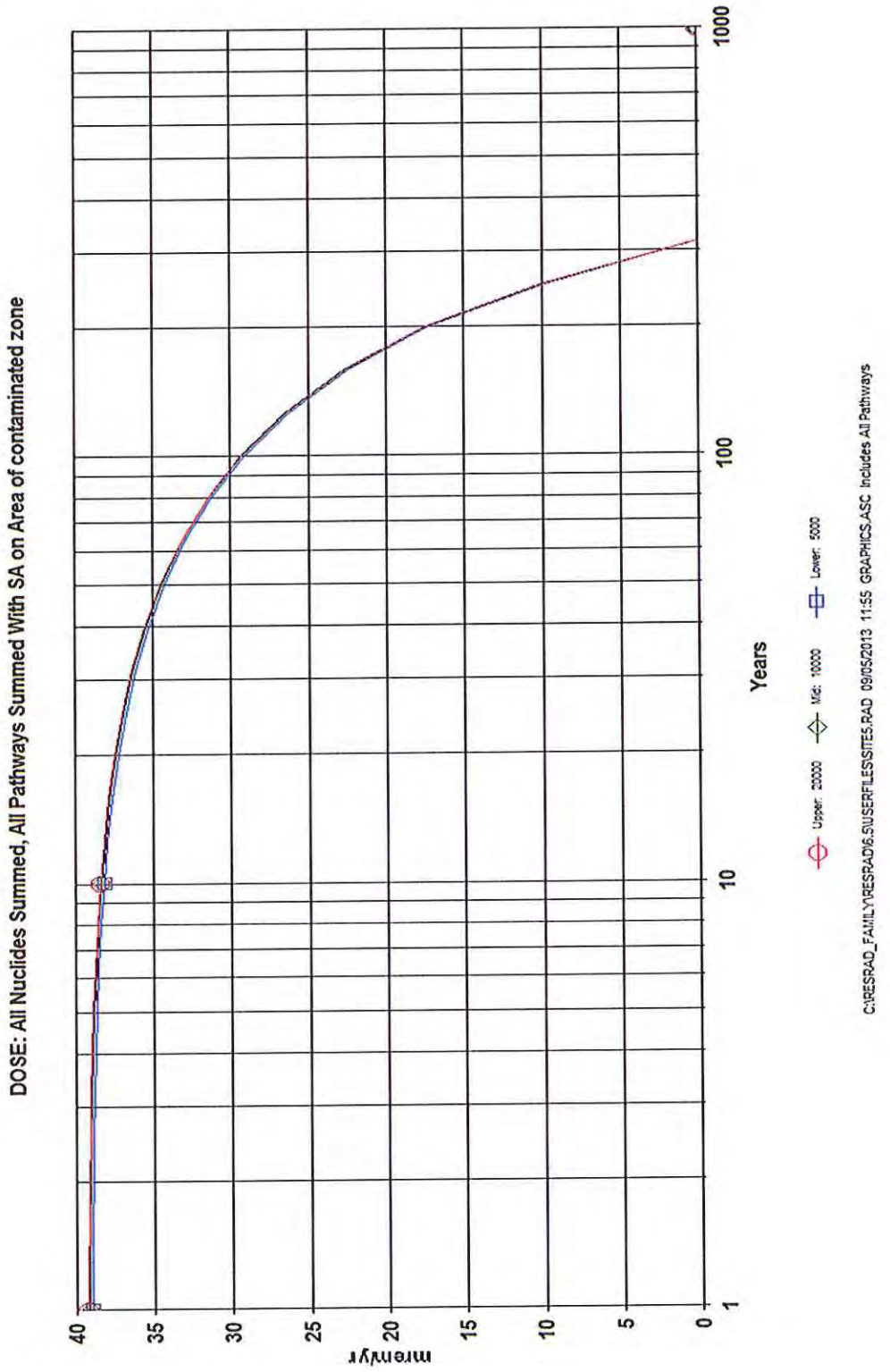
Sensitivity analysis on the plant (water independent) pathway was run with a multiple of 2 (i.e. 0.15, 0.3, and 0.6) There was a significant impact on the maximum dose for subsurface radium but the surface radium there were differences. Assumptions of shallow root systems increased the dose significantly. The NRC guidance is based on shallow root consumptions, and therefore the use of the NUREG-1569 root depth is conservative.

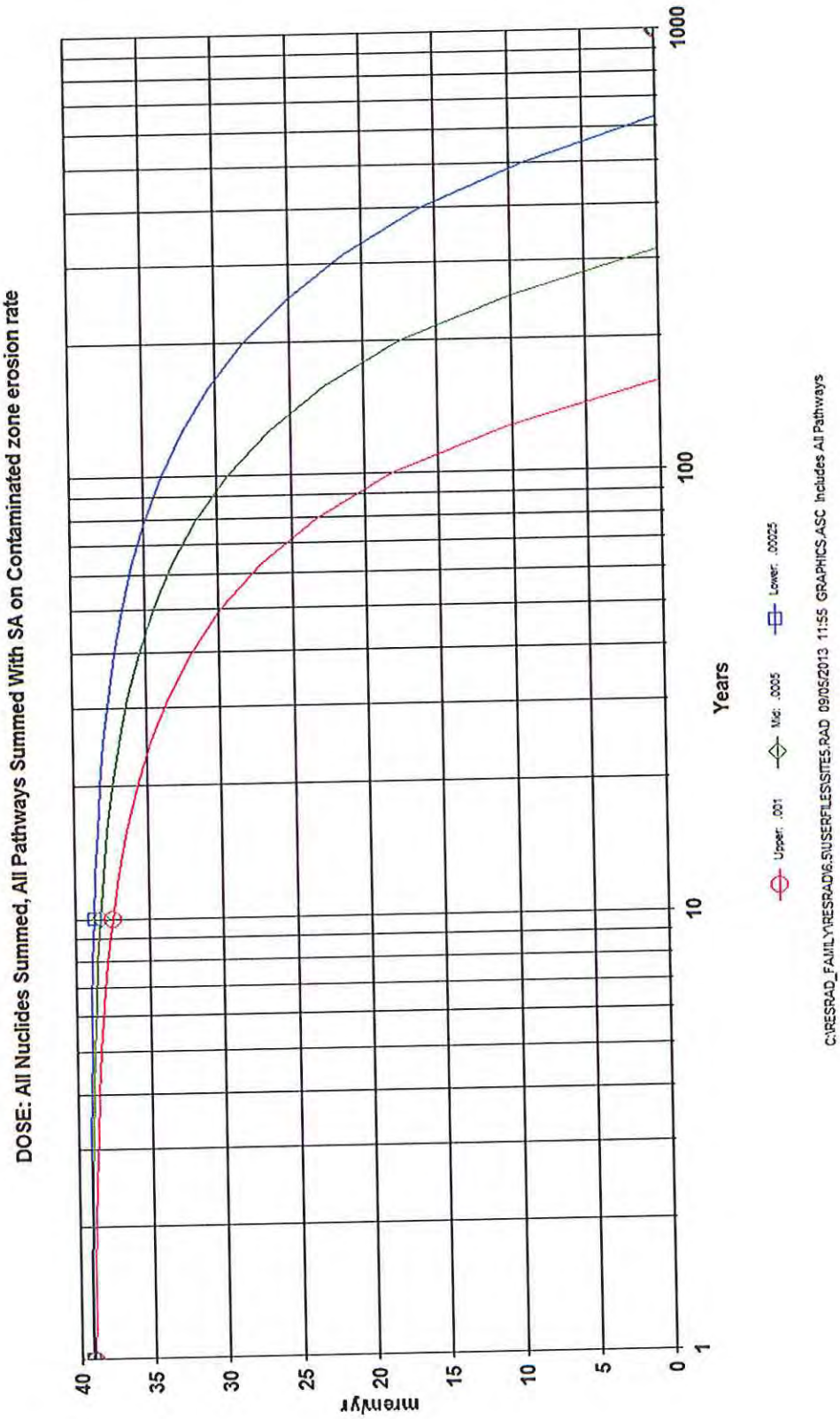
- Groundwater fractional usage: Used default of 1 for all values except irrigation where 0 was used since no irrigation is used in the area.
- Storage Times: Used all default values for storage times

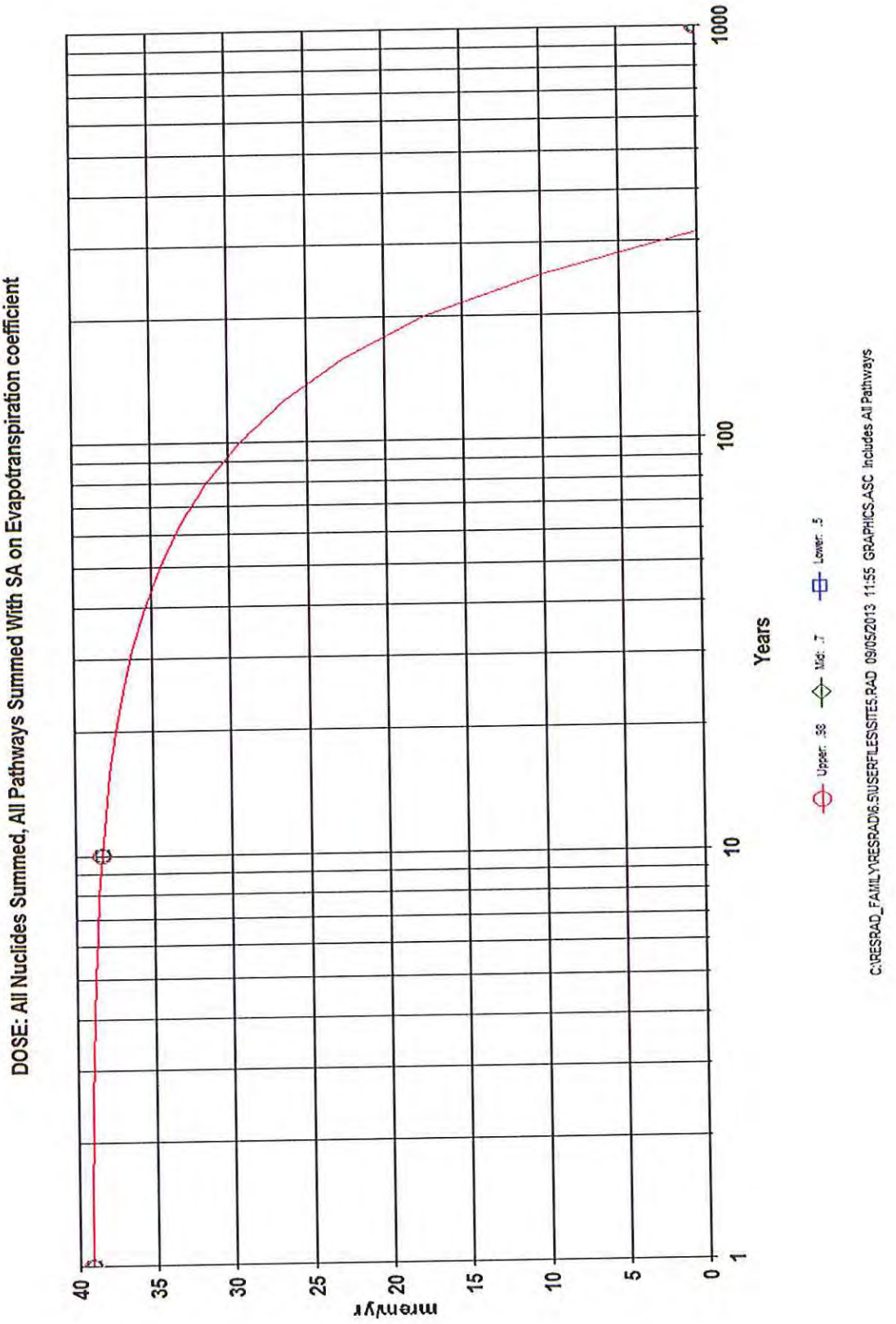
Appendix B: Sensitivity Analysis for Surface Contamination

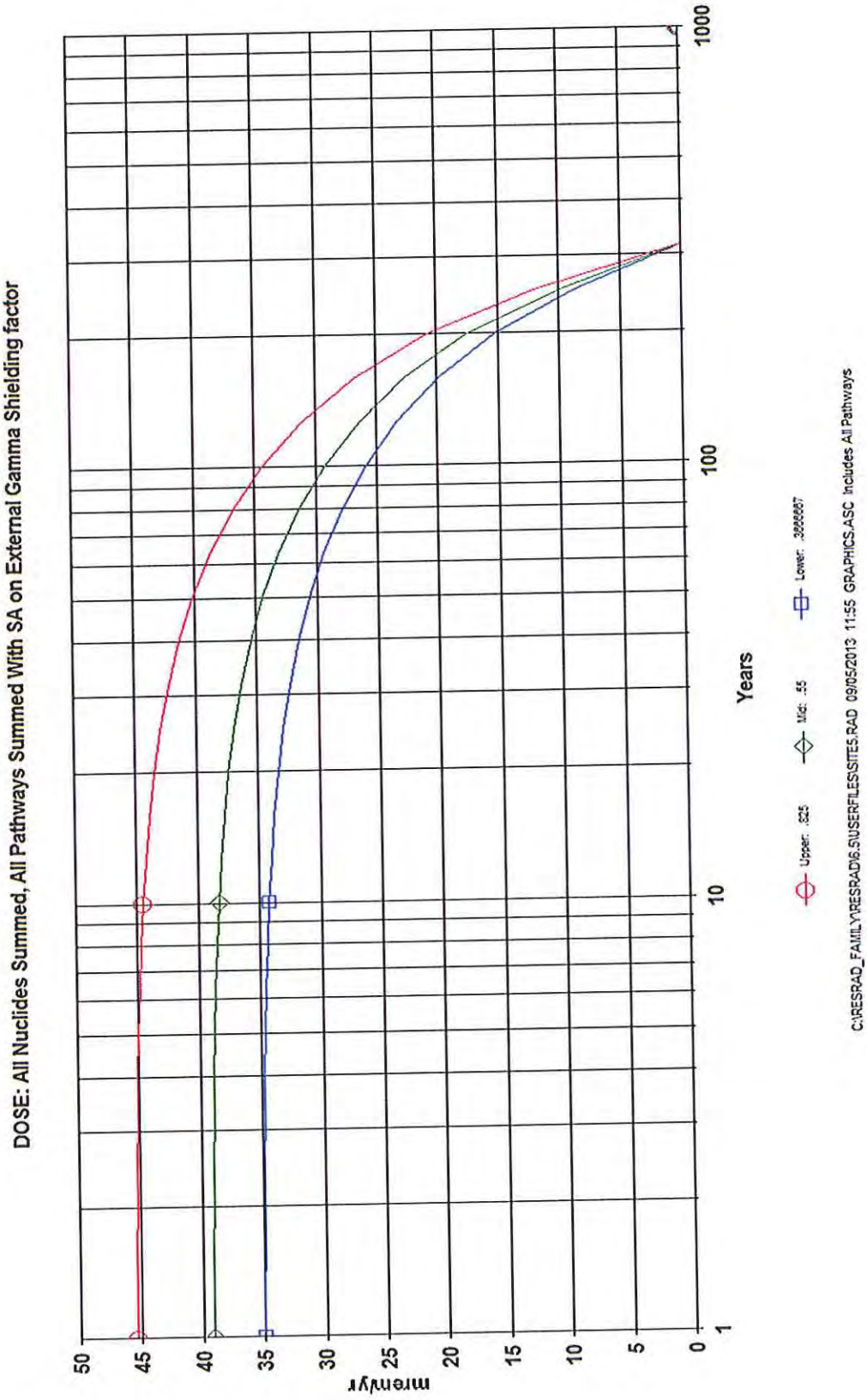

DOSE: All Nuclides Summed, All Pathways Summed With SA on Pb-210 Contaminated Zone Distribution Coefficient
mremyr
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: 1000000
Mid: 10000
Lower: 100
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITE5.RAD 09/05/2013 13:02 GRAPHICS.ASC Includes All Pathways

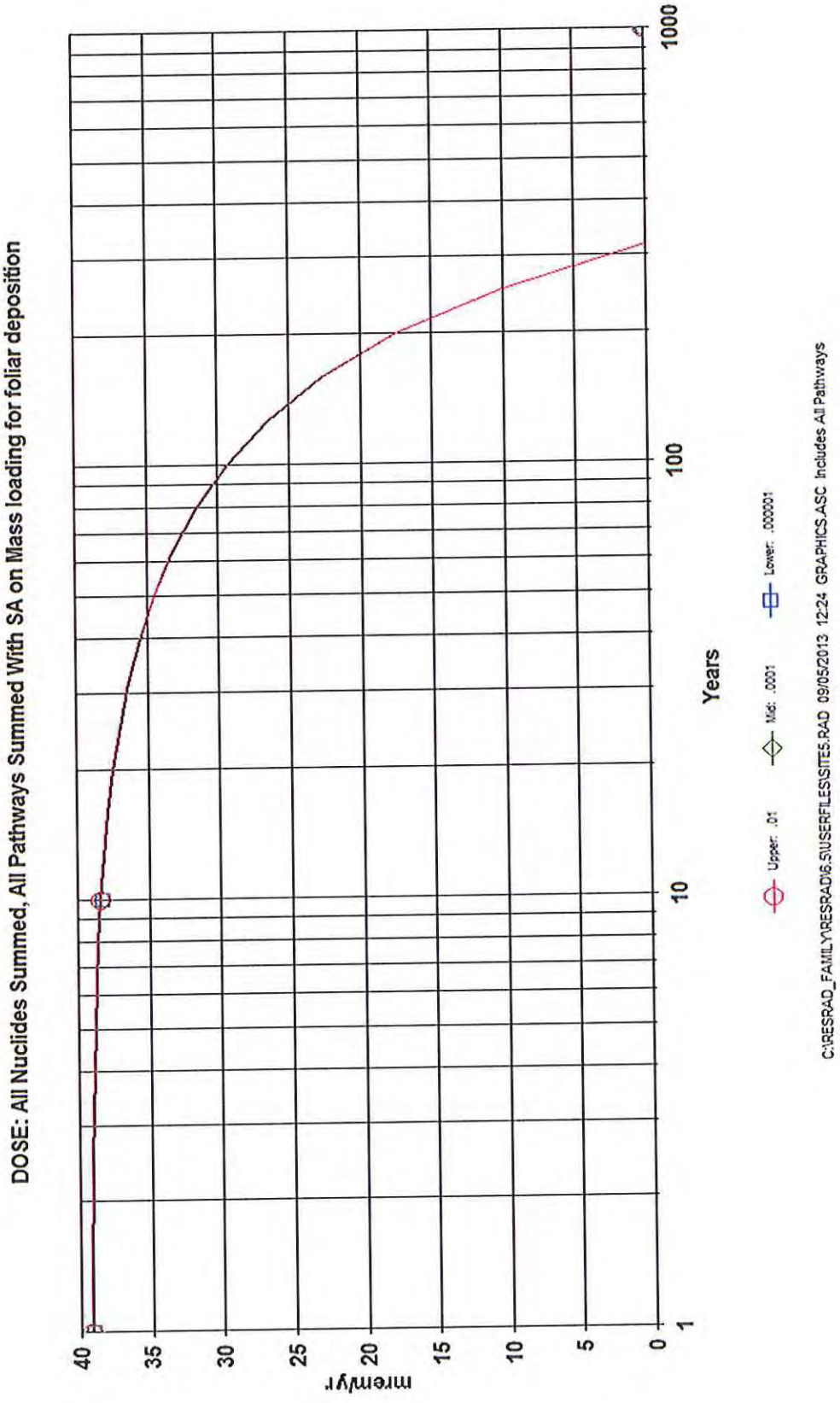

DOSE: All Nuclides Summed, All Pathways Summed With SA on Ra-226 Contaminated Zone Distribution Coefficient
mremyr
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: 3800000
Mid: 38000
Lower: 380
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITES.RAD 09/05/2013 11:55 GRAPHICS.ASC Includes All Pathways

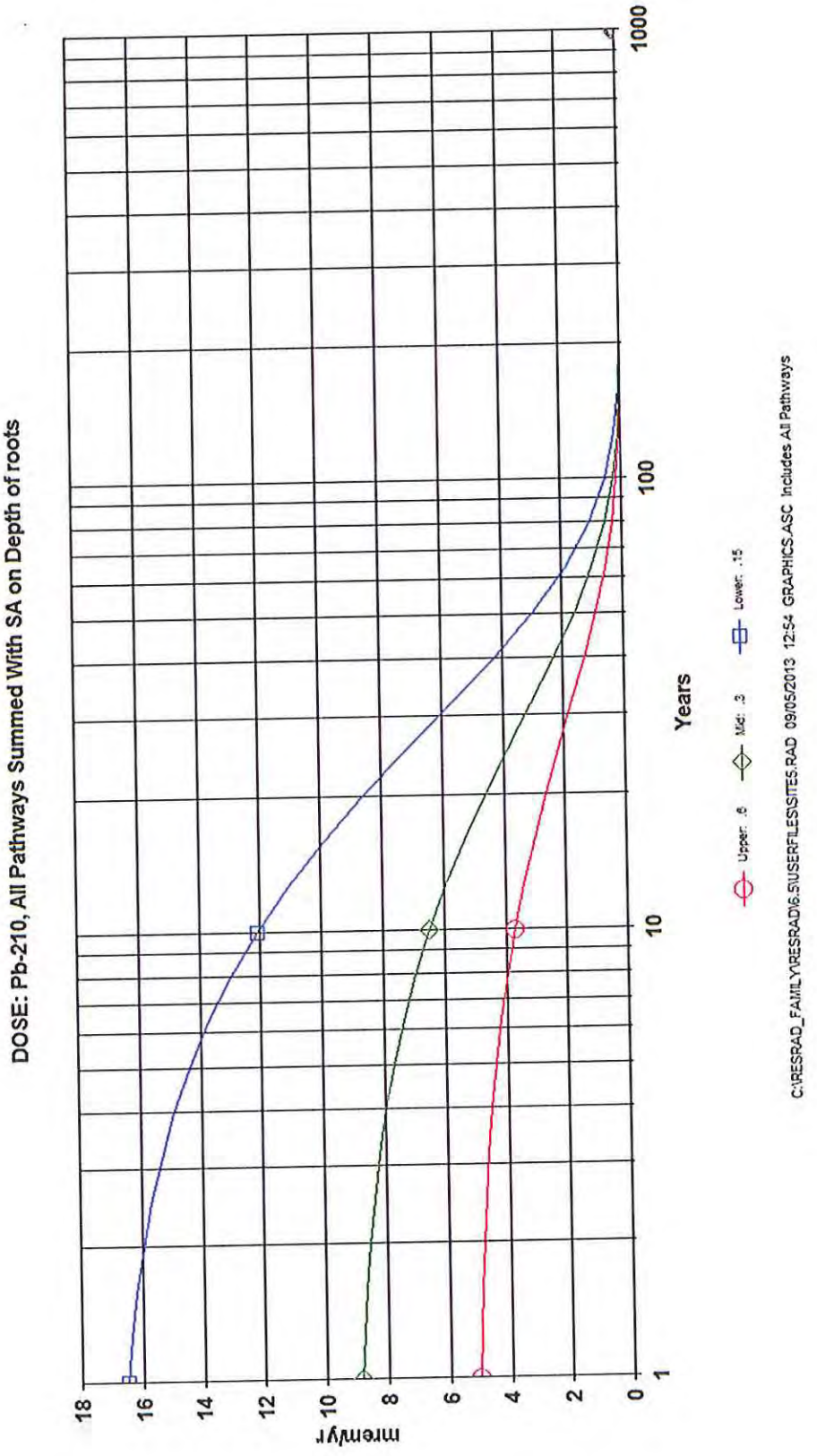

DOSE: All Nuclides Summed, All Pathways Summed With SA on Area of contaminated zone
mremyr
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: 20000
Mid: 10000
Lower: 5000
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITE5.RAD 09/05/2013 11:55 GRAPHICS.ASC Includes All Pathways


DOSE: All Nuclides Summed, All Pathways Summed With SA on Contaminated zone erosion rate
mremyr
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: .001
Mid: .0005
Lower: .00025
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITES.RAD 09/05/2013 11:55 GRAPHICS.ASC Includes All Pathways

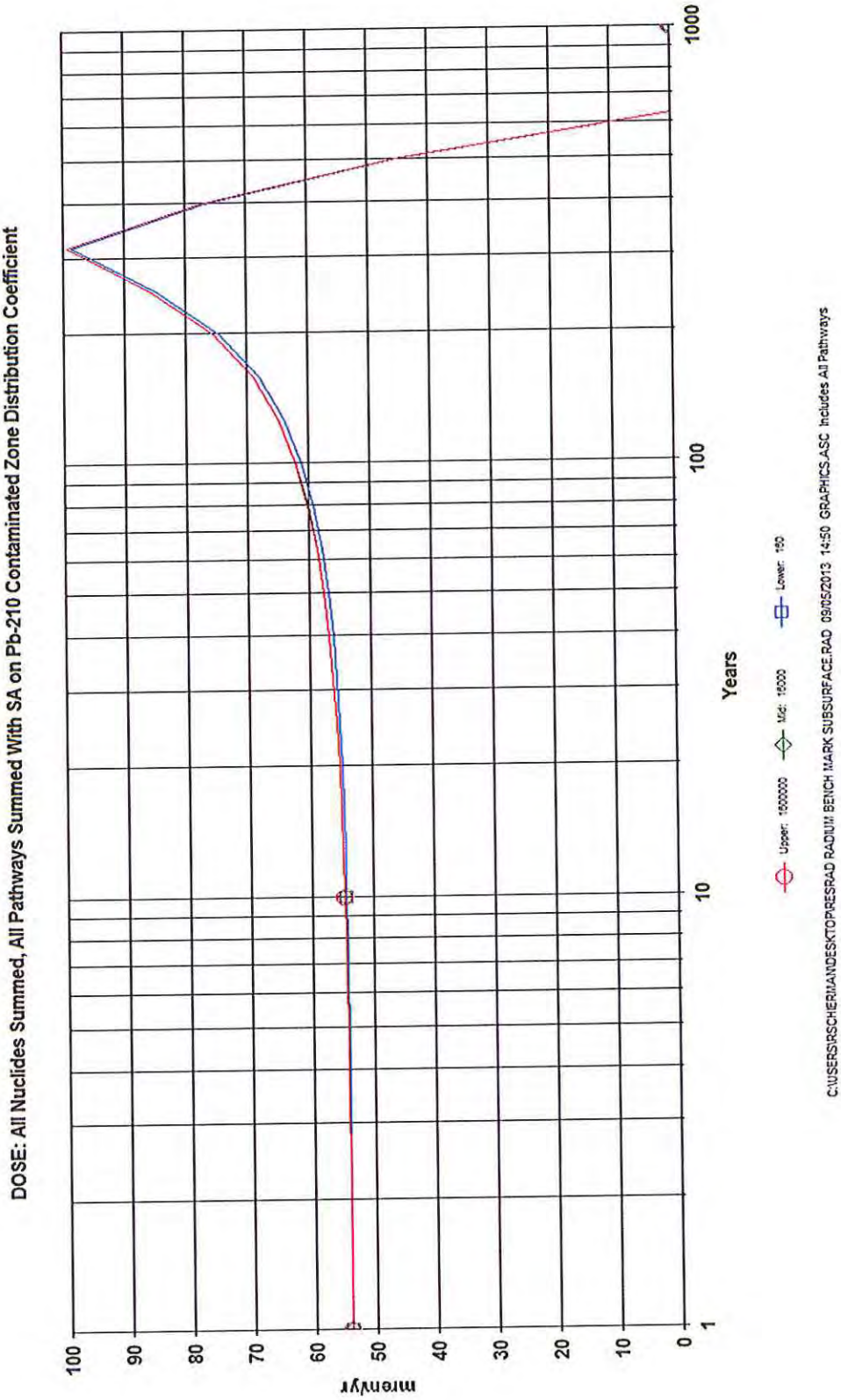

DOSE: All Nuclides Summed, All Pathways Summed With SA on Evapotranspiration coefficient
mremyr
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: .98
Mid: .7
Lower: .5
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITES.RAD 09/05/2013 11:55 GRAPHICS.ASC Includes All Pathways

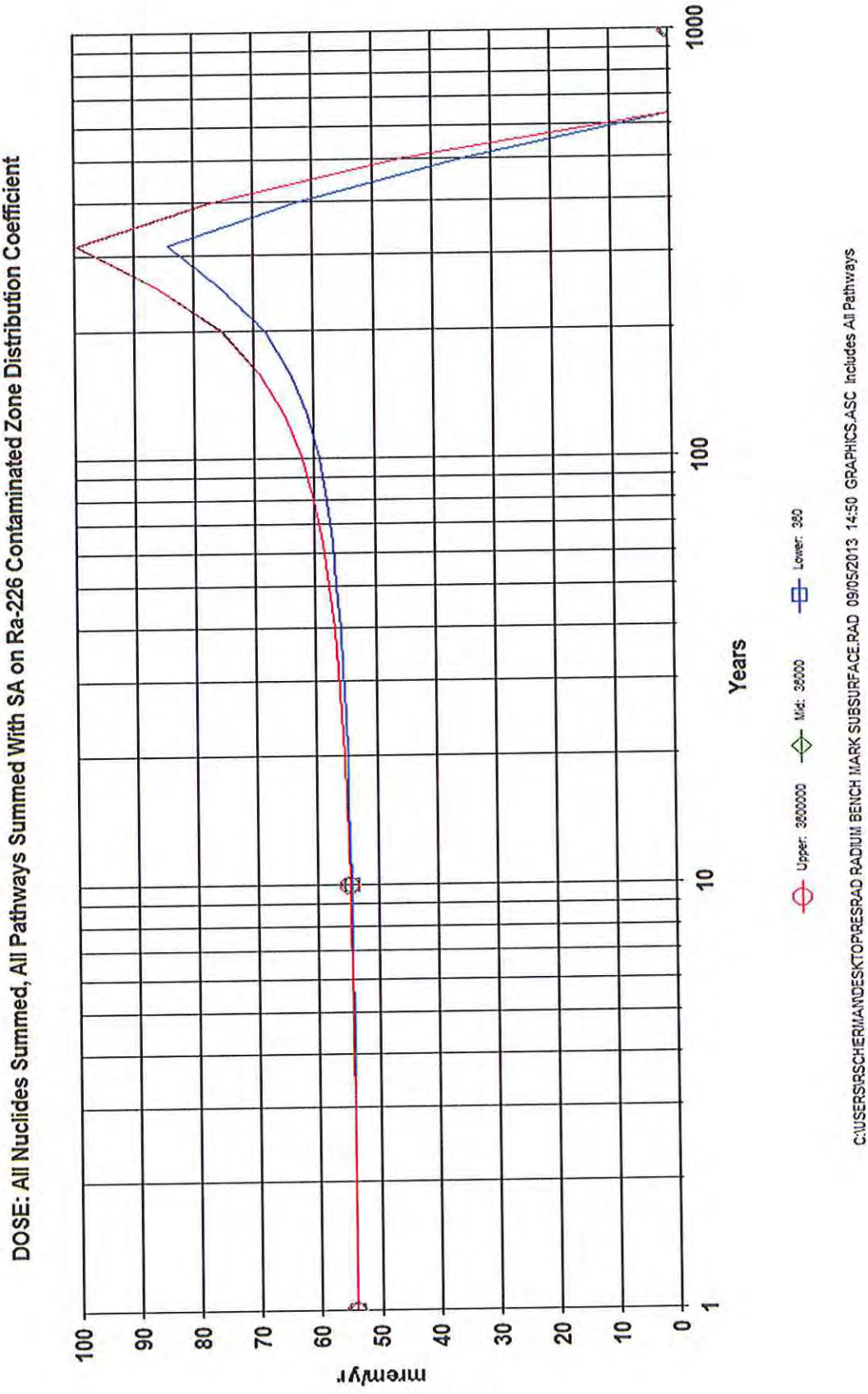

DOSE: All Nuclides Summed, All Pathways Summed With SA on External Gamma Shielding factor
mremlyr
50
45
40
35
30
25
20
15
10
5
0
1
10
100
1000
Years
Upper: .825
Mid: .55
Lower: .3666667
C:\RESRAD_FAMILY\RESRAD\6.SUSERFILES\SITES.RAD 09/05/2013 11:55 GRAPHICS.ASC Includes All Pathways

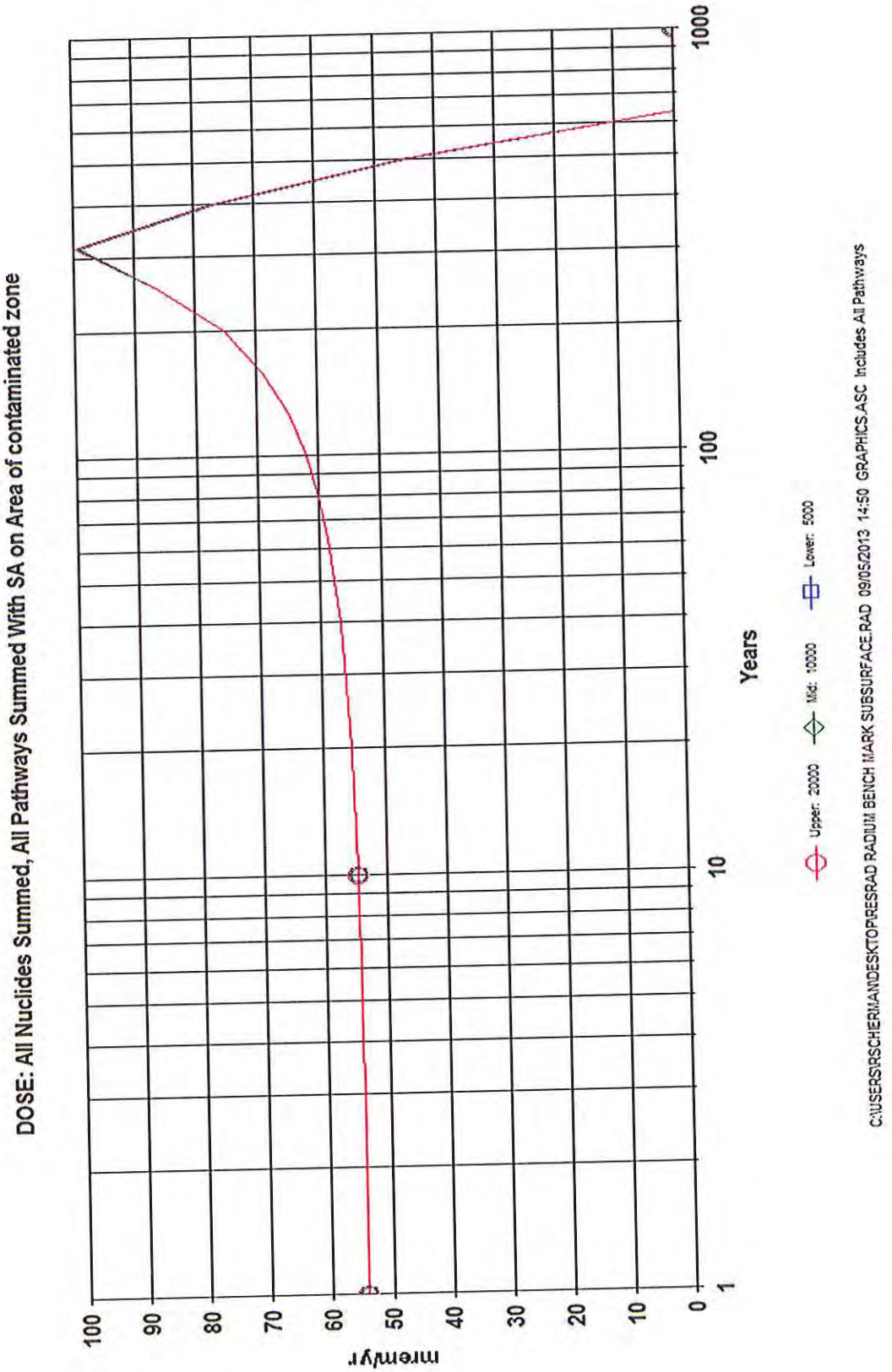

DOSE: All Nuclides Summed, All Pathways Summed With SA on Mass loading for foliar deposition
mremdyr
0
5
10
15
20
25
30
35
40
1
10
100
1000
Years
Upper: .01
Mid: .0001
Lower: .000001
C:\RESRAD_FAMILY\RESRAD6.5\USERFILES\SITE5.RAD 09/05/2013 12:24 GRAPHICS.ASC Includes All Pathways

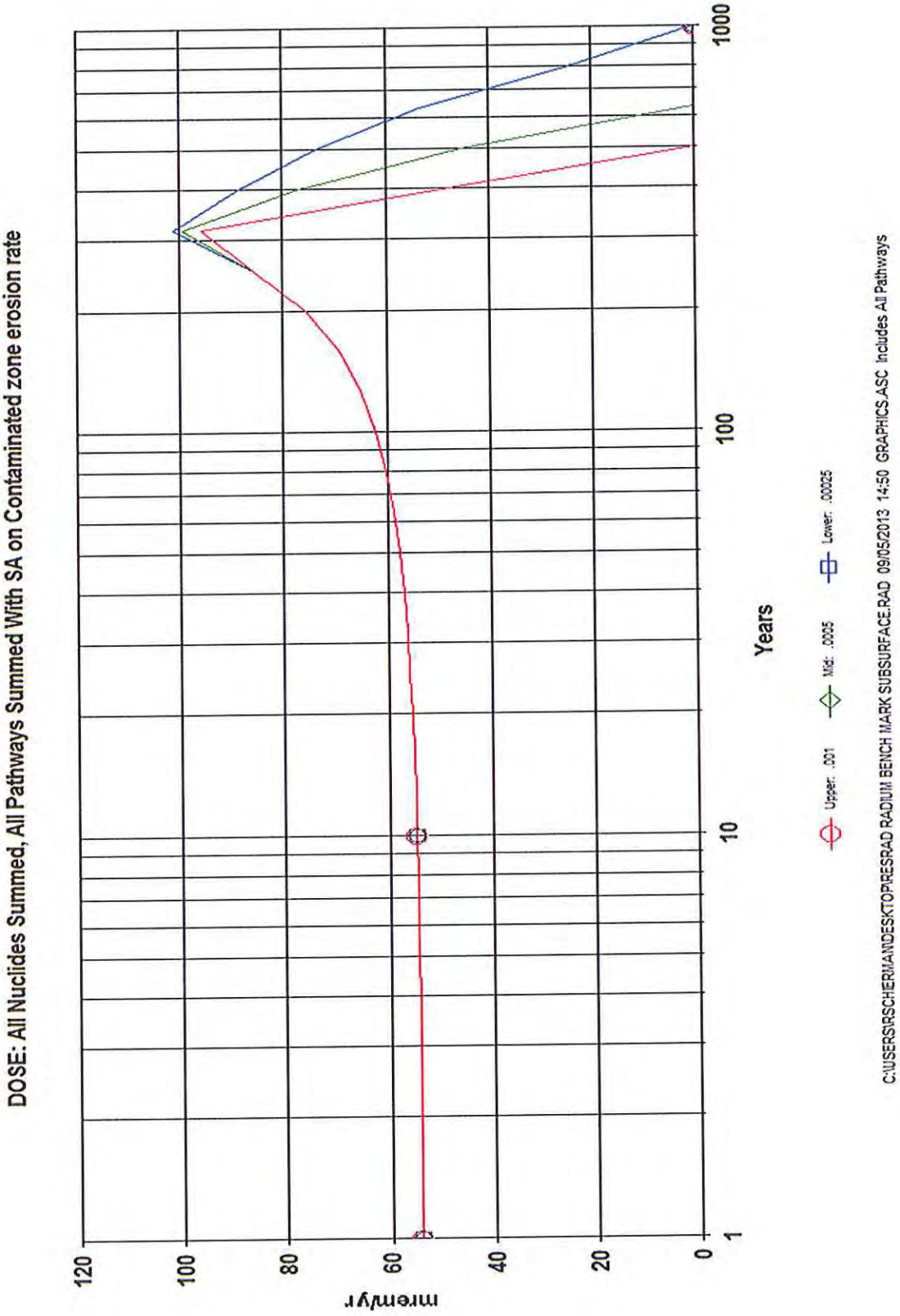

DOSE: Pb-210, All Pathways Summed With SA on Depth of roots
mremyr
0
2
4
6
8
10
12
14
16
18
1
10
100
1000
Years
Upper: .6
Mid: .3
Lower: .15
C:\RESRAD_FAMILY\RESRAD\6.5\USERFILES\SITES.RAD 09/05/2013 12:54 GRAPHICS.ASC Includes All Pathways

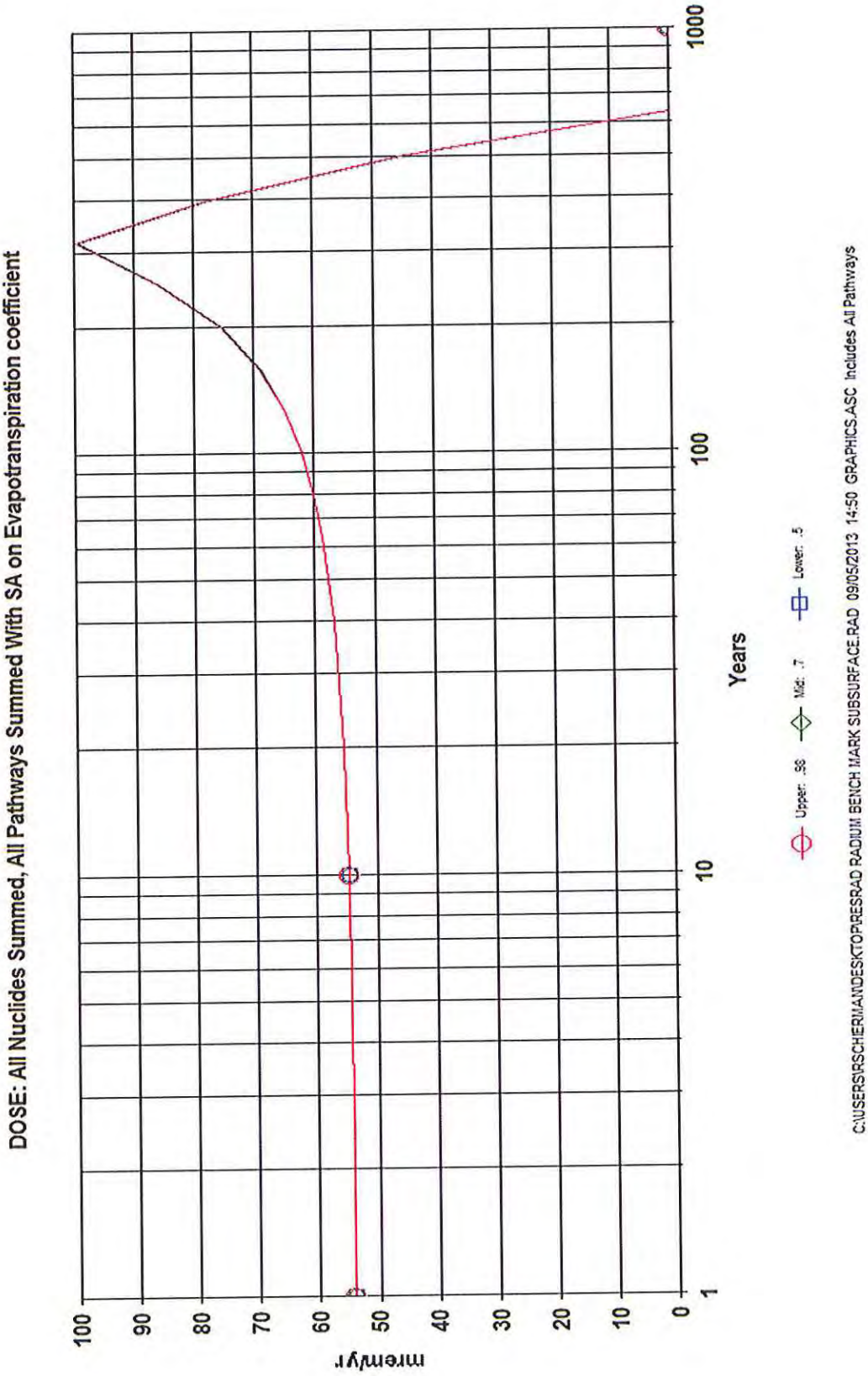
Appendix C: Sensitivity Analysis for Subsurface Contamination

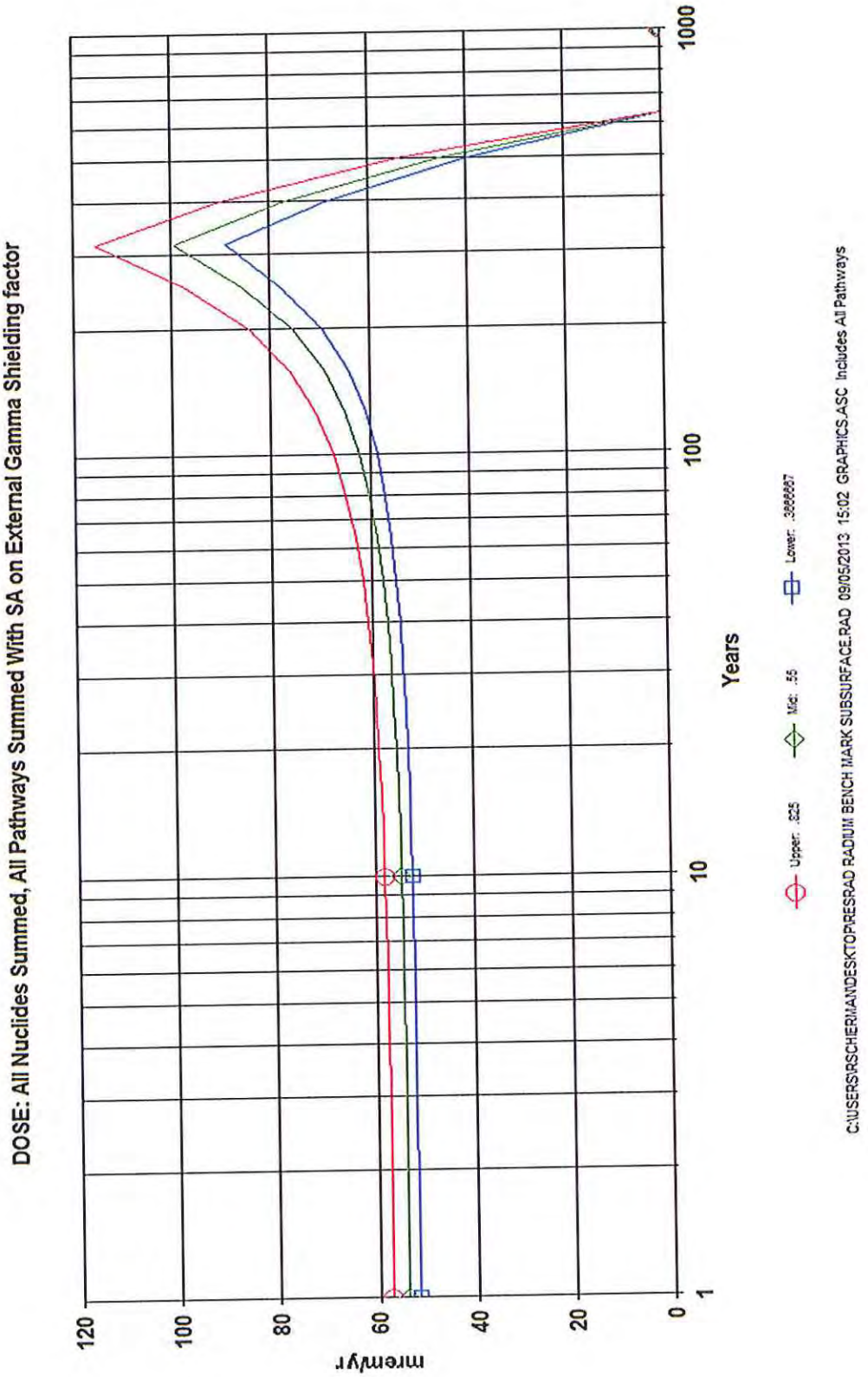

DOSE: All Nuclides Summed, All Pathways Summed With SA on Pb-210 Contaminated Zone Distribution Coefficient
mremyr
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: 1500000
Mid: 15000
Lower: 150
C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 14:50 GRAPHICS.ASC Includes All Pathways

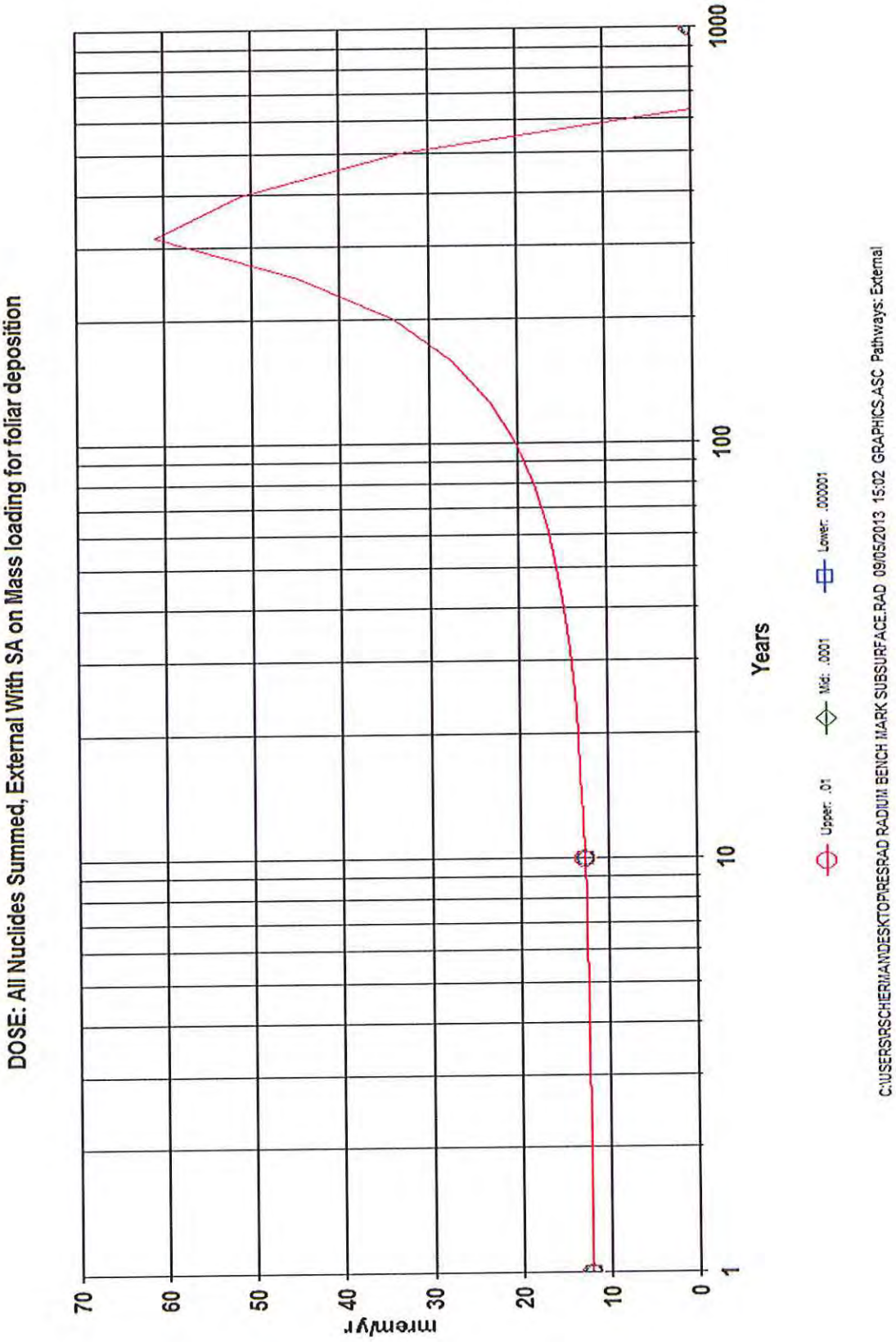

DOSE: All Nuclides Summed, All Pathways Summed With SA on Ra-226 Contaminated Zone Distribution Coefficient
mremyr
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: 3800000
Mid: 38000
Lower: 380
C:\USERS\RSCHERMA\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 14:50 GRAPHICS.ASC Includes All Pathways

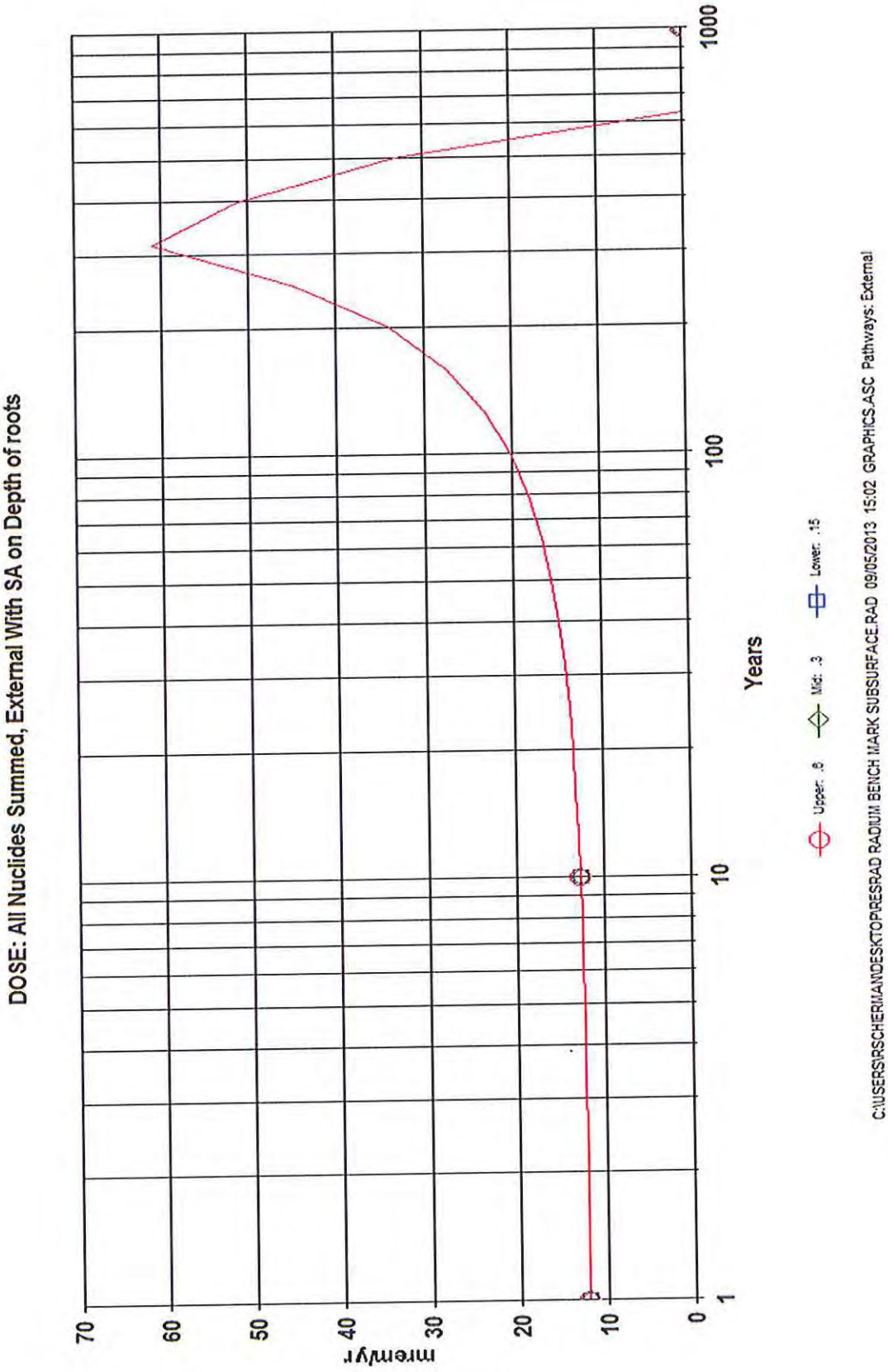

DOSE: All Nuclides Summed, All Pathways Summed With SA on Area of contaminated zone
mremyr
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: 20000
Mid: 10000
Lower: 5000
C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 14:50 GRAPHICS.ASC Includes All Pathways


DOSE: All Nuclides Summed, All Pathways Summed With SA on Contaminated zone erosion rate
mremyr
120
100
80
60
40
20
0
1
10
100
1000
Years
Upper: .001
Mid: .0005
Lower: .00025
C:\USERS\RSCHIERM\ANDESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 14:50 GRAPHICS.ASC Includes All Pathways


DOSE: All Nuclides Summed, All Pathways Summed With SA on Evapotranspiration coefficient
mremyr
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: .86
Mid: .7
Lower: .5
C:\USERS\RSCHERM\ANDESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 14:50 GRAPHICS.ASC Includes All Pathways


DOSE: All Nuclides Summed, All Pathways Summed With SA on External Gamma Shielding factor
mremyr
120
100
80
60
40
20
0
1
10
100
1000
Years
Upper: .825
Mid: .55
Lower: .3666667
C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 15:02 GRAPHICS.ASC Includes All Pathways


DOSE: All Nuclides Summed, External With SA on Mass loading for foliar deposition
mremlyr
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: .01
Mid: .0001
Lower: .0000001
C:\USERS\RSCHER\MANDESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 15:02 GRAPHICS.ASC Pathways: External


DOSE: All Nuclides Summed, External With SA on Depth of roots
mremyr
70
60
50
40
30
20
10
0
1
10
100
1000
Years
Upper: .8
Mid: .3
Lower: .15
C:\USERS\RSCHERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD 09/05/2013 15:02 GRAPHICS.ASC Pathways: External

Appendix C Radium Surface Report

surface final

1RESRAD, Version 6.5 T« Limit = 180 days 09/09/2013 07:14 Page 1
Summary : RESRAD surface radium benchmark
File : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SURFACE.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

1RESRAD, Version 6.5 T« Limit = 180 days 09/09/2013 07:14 Page 2
Summary : RESRAD surface radium benchmark
File : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SURFACE.RAD

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Base Case*	Parameter Name	Parameter	Current Value#
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)		
A-1	At-218	(Source: FGR 12)	5.847E-03
5.847E-03	DCF1(1)		
A-1	Bi-210	(Source: FGR 12)	3.606E-03
3.606E-03	DCF1(2)		
A-1	Bi-214	(Source: FGR 12)	9.808E+00
9.808E+00	DCF1(3)		
A-1	Pb-210	(Source: FGR 12)	2.447E-03
2.447E-03	DCF1(4)		
A-1	Pb-214	(Source: FGR 12)	1.341E+00
1.341E+00	DCF1(5)		
A-1	Po-210	(Source: FGR 12)	5.231E-05
5.231E-05	DCF1(6)		
A-1	Po-214	(Source: FGR 12)	5.138E-04
5.138E-04	DCF1(7)		
A-1	Po-218	(Source: FGR 12)	5.642E-05
5.642E-05	DCF1(8)		
A-1	Ra-226	(Source: FGR 12)	3.176E-02
3.176E-02	DCF1(9)		
A-1	Rn-222	(Source: FGR 12)	2.354E-03
2.354E-03	DCF1(10)		
A-1	Tl-210	(Source: no data)	0.000E+00
-2.000E+00	DCF1(11)		
B-1	Dose conversion factors for inhalation, mrem/pCi:		
B-1	Pb-210+D		2.320E-02
1.360E-02	DCF2(1)		

```
                                    surface final
 B-1  ³ Ra-226+D                                                    ³ 8.594E-03 ³
8.580E-03 ³ DCF2(  2)                                               ³           ³
          ³                                                         ³           ³
 D-1  ³ Dose conversion factors for ingestion, mrem/pCi:            ³           ³
          ³                                                         ³           ³
 D-1  ³ Pb-210+D                                                    ³ 7.276E-03 ³
5.370E-03 ³ DCF3(  1)                                               ³           ³
 D-1  ³ Ra-226+D                                                    ³ 1.321E-03 ³
1.320E-03 ³ DCF3(  2)                                               ³           ³
          ³                                                         ³           ³
 D-34 ³ Food transfer factors:                                      ³           ³
          ³                                                         ³           ³
 D-34 ³ Pb-210+D  , plant/soil concentration ratio, dimensionless   ³ 1.000E-02 ³
1.000E-02 ³ RTF(  1,1)                                              ³           ³
 D-34 ³ Pb-210+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 8.000E-04 ³
8.000E-04 ³ RTF(  1,2)                                              ³           ³
 D-34 ³ Pb-210+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 3.000E-04 ³
3.000E-04 ³ RTF(  1,3)                                              ³           ³
 D-34 ³                                                             ³           ³
          ³                                                         ³           ³
 D-34 ³ Ra-226+D  , plant/soil concentration ratio, dimensionless   ³ 4.000E-02 ³
4.000E-02 ³ RTF(  2,1)                                              ³           ³
 D-34 ³ Ra-226+D  , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)   ³ 1.000E-03 ³
1.000E-03 ³ RTF(  2,2)                                              ³           ³
 D-34 ³ Ra-226+D  , milk/livestock-intake ratio, (pCi/L)/(pCi/d)    ³ 1.000E-03 ³
1.000E-03 ³ RTF(  2,3)                                              ³           ³
          ³                                                         ³           ³
 D-5  ³ Bioaccumulation factors, fresh water, L/kg:                 ³           ³
          ³                                                         ³           ³
 D-5  ³ Pb-210+D  , fish                                            ³ 3.000E+02 ³
3.000E+02 ³ BIOFAC(  1,1)                                           ³           ³
 D-5  ³ Pb-210+D  , crustacea and mollusks                          ³ 1.000E+02 ³
1.000E+02 ³ BIOFAC(  1,2)                                           ³           ³
 D-5  ³                                                             ³           ³
          ³                                                         ³           ³
 D-5  ³ Ra-226+D  , fish                                            ³ 5.000E+01 ³
5.000E+01 ³ BIOFAC(  2,1)                                           ³           ³
 D-5  ³ Ra-226+D  , crustacea and mollusks                          ³ 2.500E+02 ³
2.500E+02 ³ BIOFAC(  2,2)                                           ³           ³

 #For DCF1(xxx) only, factors are for infinite depth & area.  See ETFG table in
Ground Pathway of Detailed Report.
 *Base Case means Default.Lib w/o Associate Nuclide contributions.
1RESRAD, Version 6.5      T« Limit = 180 days        09/09/2013  07:14  Page   3
 Summary : RESRAD surface radium benchmark
 File    : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SURFACE.RAD

                                                  Site-Specific Parameter Summary
0     ³                                                    ³   User    ³           ³
     Used by RESRAD          ³  Parameter
 Menu ³                      Parameter                      ³   Input   ³  Default  ³
(If different from user input) ³    Name

 R011 ³ Area of contaminated zone (m**2)                    ³ 1.000E+04 ³ 1.000E+04 ³
        ---                  ³ AREA
 R011 ³ Thickness of contaminated zone (m)                  ³ 1.500E-01 ³ 2.000E+00 ³
        ---                  ³ THICK0
 R011 ³ Fraction of contamination that is submerged         ³ 0.000E+00 ³ 0.000E+00 ³
        ---                  ³ SUBMFRACT
 R011 ³ Length parallel to aquifer flow (m)                 ³ 1.000E+02 ³ 1.000E+02 ³
                                        Page 2
```

			surface	final
		LCZPAQ		
R011	Basic radiation dose limit (mrem/yr)	BRDL	1.000E+02	3.000E+01
R011	Time since placement of material (yr)	TI	0.000E+00	0.000E+00
R011	Times for calculations (yr)	T(2)	1.000E+00	1.000E+00
R011	Times for calculations (yr)	T(3)	1.000E+01	3.000E+00
R011	Times for calculations (yr)	T(4)	1.000E+03	1.000E+01
R011	Times for calculations (yr)	T(5)	not used	3.000E+01
R011	Times for calculations (yr)	T(6)	not used	1.000E+02
R011	Times for calculations (yr)	T(7)	not used	3.000E+02
R011	Times for calculations (yr)	T(8)	not used	1.000E+03
R011	Times for calculations (yr)	T(9)	not used	0.000E+00
R011	Times for calculations (yr)	T(10)	not used	0.000E+00
R012	Initial principal radionuclide (pCi/g): Pb-210	S1(1)	5.000E+00	0.000E+00
R012	Initial principal radionuclide (pCi/g): Ra-226	S1(2)	5.000E+00	0.000E+00
R012	Concentration in groundwater (pCi/L): Pb-210	W1(1)	not used	0.000E+00
R012	Concentration in groundwater (pCi/L): Ra-226	W1(2)	not used	0.000E+00
R013	Cover depth (m)	COVER0	0.000E+00	0.000E+00
R013	Density of cover material (g/cm**3)	DENSCV	not used	1.500E+00
R013	Cover depth erosion rate (m/yr)	VCV	not used	1.000E-03
R013	Density of contaminated zone (g/cm**3)	DENSCZ	1.440E+00	1.500E+00
R013	Contaminated zone erosion rate (m/yr)	VCZ	5.000E-04	1.000E-03
R013	Contaminated zone total porosity	TPCZ	4.000E-01	4.000E-01
R013	Contaminated zone field capacity	FCCZ	2.000E-01	2.000E-01
R013	Contaminated zone hydraulic conductivity (m/yr)	HCCZ	1.090E+03	1.000E+01
R013	Contaminated zone b parameter	BCZ	4.900E+00	5.300E+00
R013	Average annual wind speed (m/sec)	WIND	4.920E+00	2.000E+00
R013	Humidity in air (g/m**3)	HUMID	not used	8.000E+00
R013	Evapotranspiration coefficient	EVAPTR	7.000E-01	5.000E-01
R013	Precipitation (m/yr)	PRECIP	2.800E-01	1.000E+00
R013	Irrigation (m/yr)	RI	0.000E+00	2.000E-01

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R013	Irrigation mode	IDITCH	overhead	overhead
R013	Runoff coefficient	RUNOFF	5.000E-01	2.000E-01
R013	Watershed area for nearby stream or pond (m**2)	WAREA	1.000E+06	1.000E+06
R013	Accuracy for water/soil computations	EPS	1.000E-03	1.000E-03
R014	Density of saturated zone (g/cm**3)	DENSAQ	1.500E+00	1.500E+00
R014	Saturated zone total porosity	TPSZ	4.300E-01	4.000E-01
R014	Saturated zone effective porosity	EPSZ	3.300E-01	2.000E-01
R014	Saturated zone field capacity	FCSZ	1.000E-01	2.000E-01
R014	Saturated zone hydraulic conductivity (m/yr)	HCSZ	5.550E+03	1.000E+02
R014	Saturated zone hydraulic gradient	HGWT	1.000E-02	2.000E-02
R014	Saturated zone b parameter	BSZ	4.050E+00	5.300E+00
R014	Water table drop rate (m/yr)	VWT	1.000E-03	1.000E-03
R014	Well pump intake depth (m below water table)	DWIBWT	1.000E+01	1.000E+01
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	MODEL	ND	ND

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	Used by RESRAD (If different from user input)	Parameter Name	User Input	Default
R014	Well pumping rate (m**3/yr)	UW	2.500E+02	2.500E+02
R015	Number of unsaturated zone strata	NS	1	1
R015	Unsat. zone 1, thickness (m)	H(1)	2.286E+01	4.000E+00
R015	Unsat. zone 1, soil density (g/cm**3)	DENSUZ(1)	1.500E+00	1.500E+00
R015	Unsat. zone 1, total porosity	TPUZ(1)	4.300E-01	4.000E-01
R015	Unsat. zone 1, effective porosity	EPUZ(1)	3.300E-01	2.000E-01
R015	Unsat. zone 1, field capacity	FCUZ(1)	1.000E-01	2.000E-01
R015	Unsat. zone 1, soil-specific b parameter	BUZ(1)	4.050E+00	5.300E+00
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	HCUZ(1)	5.550E+03	1.000E+01

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R016	Distribution coefficients for Pb-210			
R016	Contaminated zone (cm**3/g)	DCNUCC(1)	1.600E+04	1.000E+02
R016	Unsaturated zone 1 (cm**3/g)	DCNUCU(1,1)	2.700E+02	1.000E+02
R016	Saturated zone (cm**3/g)	DCNUCS(1)	2.700E+02	1.000E+02
R016	Leach rate (/yr)	ALEACH(1)	0.000E+00	0.000E+00
R016	Solubility constant	SOLUBK(1)	0.000E+00	0.000E+00
	1.215E-05		not used	
R016	Distribution coefficients for Ra-226			
R016	Contaminated zone (cm**3/g)	DCNUCC(2)	3.600E+04	7.000E+01
R016	Unsaturated zone 1 (cm**3/g)	DCNUCU(2,1)	5.000E+02	7.000E+01
R016	Saturated zone (cm**3/g)	DCNUCS(2)	5.000E+02	7.000E+01
R016	Leach rate (/yr)	ALEACH(2)	0.000E+00	0.000E+00
R016	Solubility constant	SOLUBK(2)	0.000E+00	0.000E+00
	5.401E-06		not used	
R017	Inhalation rate (m**3/yr)	INHALR	8.400E+03	8.400E+03
R017	Mass loading for inhalation (g/m**3)	MLINH	1.000E-04	1.000E-04
R017	Exposure duration	ED	3.000E+01	3.000E+01
R017	Shielding factor, inhalation	SHF3	4.000E-01	4.000E-01
R017	Shielding factor, external gamma	SHF1	5.500E-01	7.000E-01
R017	Fraction of time spent indoors	FIND	5.000E-01	5.000E-01
R017	Fraction of time spent outdoors (on site)	FOTD	2.500E-01	2.500E-01
R017	Shape factor flag, external gamma	FS	1.000E+00	1.000E+00
R017	>0 shows circular AREA. Radii of shape factor array (used if FS = -1):		not used	5.000E+01
R017	Outer annular radius (m), ring 1:	RAD_SHAPE(1)	not used	7.071E+01
R017	Outer annular radius (m), ring 2:	RAD_SHAPE(2)	not used	0.000E+00
R017	Outer annular radius (m), ring 3:	RAD_SHAPE(3)	not used	0.000E+00
R017	Outer annular radius (m), ring 4:	RAD_SHAPE(4)	not used	0.000E+00
R017	Outer annular radius (m), ring 5:	RAD_SHAPE(5)	not used	0.000E+00
R017	Outer annular radius (m), ring 6:	RAD_SHAPE(6)	not used	0.000E+00
R017	Outer annular radius (m), ring 7:	RAD_SHAPE(7)	not used	0.000E+00
R017	Outer annular radius (m), ring 8:	RAD_SHAPE(8)	not used	0.000E+00
R017	Outer annular radius (m), ring 9:			

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R017	Outer annular radius (m), ring 9:	RAD_SHAPE(9)	not used	0.000E+00
R017	Outer annular radius (m), ring 10:	RAD_SHAPE(10)	not used	0.000E+00
R017	Outer annular radius (m), ring 11:	RAD_SHAPE(11)	not used	0.000E+00
R017	Outer annular radius (m), ring 12:	RAD_SHAPE(12)	not used	0.000E+00

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Menu	Used by RESRAD (If different from user input)	Parameter Name	User Input	Default
R017	Fractions of annular areas within AREA:			
R017	Ring 1	FRACA(1)	not used	1.000E+00
R017	Ring 2	FRACA(2)	not used	2.732E-01
R017	Ring 3	FRACA(3)	not used	0.000E+00
R017	Ring 4	FRACA(4)	not used	0.000E+00
R017	Ring 5	FRACA(5)	not used	0.000E+00
R017	Ring 6	FRACA(6)	not used	0.000E+00
R017	Ring 7	FRACA(7)	not used	0.000E+00
R017	Ring 8	FRACA(8)	not used	0.000E+00
R017	Ring 9	FRACA(9)	not used	0.000E+00
R017	Ring 10	FRACA(10)	not used	0.000E+00
R017	Ring 11	FRACA(11)	not used	0.000E+00
R017	Ring 12	FRACA(12)	not used	0.000E+00
R018	Fruits, vegetables and grain consumption (kg/yr)	DIET(1)	1.600E+02	1.600E+02
R018	Leafy vegetable consumption (kg/yr)	DIET(2)	1.400E+01	1.400E+01
R018	Milk consumption (L/yr)	DIET(3)	not used	9.200E+01
R018	Meat and poultry consumption (kg/yr)	DIET(4)	6.300E+01	6.300E+01
R018	Fish consumption (kg/yr)	DIET(5)	0.000E+00	5.400E+00
R018	Other seafood consumption (kg/yr)	DIET(6)	0.000E+00	9.000E-01
R018	Soil ingestion rate (g/yr)	SOIL	3.650E+01	3.650E+01
R018	Drinking water intake (L/yr)		5.100E+02	5.100E+02

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			surface	final
		DWI		
R018	Contamination fraction of drinking water		1.000E+00	1.000E+00
		FDW		
R018	Contamination fraction of household water		not used	1.000E+00
		FHHW		
R018	Contamination fraction of livestock water		1.000E+00	1.000E+00
		FLW		
R018	Contamination fraction of irrigation water		0.000E+00	1.000E+00
		FIRW		
R018	Contamination fraction of aquatic food		0.000E+00	5.000E-01
		FR9		
R018	Contamination fraction of plant food		2.500E-01	-1
		FPLANT		
R018	Contamination fraction of meat		2.500E-01	-1
		FMEAT		
R018	Contamination fraction of milk		not used	-1
		FMILK		
R019	Livestock fodder intake for meat (kg/day)		6.800E+01	6.800E+01
		LFI5		
R019	Livestock fodder intake for milk (kg/day)		not used	5.500E+01
		LFI6		
R019	Livestock water intake for meat (L/day)		5.000E+01	5.000E+01
		LWI5		
R019	Livestock water intake for milk (L/day)		not used	1.600E+02
		LWI6		
R019	Livestock soil intake (kg/day)		5.000E-01	5.000E-01
		LSI		
R019	Mass loading for foliar deposition (g/m**3)		1.000E-04	1.000E-04
		MLFD		
R019	Depth of soil mixing layer (m)		1.500E-01	1.500E-01
		DM		
R019	Depth of roots (m)		3.000E-01	9.000E-01
		DROOT		
R019	Drinking water fraction from ground water		1.000E+00	1.000E+00
		FGWDW		
R019	Household water fraction from ground water		not used	1.000E+00
		FGWHH		
R019	Livestock water fraction from ground water		1.000E+00	1.000E+00
		FGWLW		
R019	Irrigation fraction from ground water		1.000E+00	1.000E+00
		FGWIR		
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)		7.000E-01	7.000E-01
		YV(1)		
R19B	Wet weight crop yield for Leafy (kg/m**2)		1.500E+00	1.500E+00
		YV(2)		
R19B	Wet weight crop yield for Fodder (kg/m**2)		1.100E+00	1.100E+00
		YV(3)		
R19B	Growing Season for Non-Leafy (years)		1.700E-01	1.700E-01
		TE(1)		
R19B	Growing Season for Leafy (years)		2.500E-01	2.500E-01
		TE(2)		
R19B	Growing Season for Fodder (years)		8.000E-02	8.000E-02
		TE(3)		

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Menu (If different from user input)	Used by RESRAD	Parameter Name	Parameter	User Input	Default
R19B		TIV(1)	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01
R19B		TIV(2)	Translocation Factor for Leafy	1.000E+00	1.000E+00
R19B		TIV(3)	Translocation Factor for Fodder	1.000E+00	1.000E+00
R19B		RDRY(1)	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01
R19B		RDRY(2)	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01
R19B		RDRY(3)	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01
R19B		RWET(1)	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01
R19B		RWET(2)	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01
R19B		RWET(3)	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01
R19B		WLAM	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01
C14		C12WTR	C-12 concentration in water (g/cm**3)	not used	2.000E-05
C14		C12CZ	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02
C14		CSOIL	Fraction of vegetation carbon from soil	not used	2.000E-02
C14		CAIR	Fraction of vegetation carbon from air	not used	9.800E-01
C14		DMC	C-14 evasion layer thickness in soil (m)	not used	3.000E-01
C14		EVSN	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07
C14		REVSN	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10
C14		AVFG4	Fraction of grain in beef cattle feed	not used	8.000E-01
C14		AVFG5	Fraction of grain in milk cow feed	not used	2.000E-01
STOR			Storage times of contaminated foodstuffs (days):		
STOR		STOR_T(1)	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01
STOR		STOR_T(2)	Leafy vegetables	1.000E+00	1.000E+00
STOR		STOR_T(3)	Milk	1.000E+00	1.000E+00
STOR		STOR_T(4)	Meat and poultry	2.000E+01	2.000E+01
STOR		STOR_T(5)	Fish	7.000E+00	7.000E+00
STOR		STOR_T(6)	Crustacea and mollusks	7.000E+00	7.000E+00
STOR		STOR_T(7)	Well water	1.000E+00	1.000E+00

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STOR	Surface water	STOR_T(8)	1.000E+00	1.000E+00	
STOR	Livestock fodder	STOR_T(9)	4.500E+01	4.500E+01	
R021	Thickness of building foundation (m)	FLOOR1	not used	1.500E-01	
R021	Bulk density of building foundation (g/cm**3)	DENSFL	not used	2.400E+00	
R021	Total porosity of the cover material	TPCV	not used	4.000E-01	
R021	Total porosity of the building foundation	TPFL	not used	1.000E-01	
R021	Volumetric water content of the cover material	PH2OCV	not used	5.000E-02	
R021	Volumetric water content of the foundation	PH2OFL	not used	3.000E-02	
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	DIFCV	not used	2.000E-06	
R021	in foundation material	DIFFL	not used	3.000E-07	
R021	in contaminated zone soil	DIFCZ	not used	2.000E-06	
R021	Radon vertical dimension of mixing (m)	HMIX	not used	2.000E+00	
R021	Average building air exchange rate (1/hr)	REXG	not used	5.000E-01	
R021	Height of the building (room) (m)	HRM	not used	2.500E+00	
R021	Building interior area factor	FAI	not used	0.000E+00	
R021	Building depth below ground surface (m)	DMFL	not used	-1.000E+00	
R021	Emanating power of Rn-222 gas	EMANA(1)	not used	2.500E-01	
R021	Emanating power of Rn-220 gas	EMANA(2)	not used	1.500E-01	
TITL	Number of graphical time points	NPTS	32	---	

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(continued) 0 Used by RESRAD Menu (If different from user input)	Parameter	Parameter Name	User Input	Default
TITL	Maximum number of integration points for dose	LYMAX	17	---
TITL	Maximum number of integration points for risk	KYMAX	1	---

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Summary of Pathway Selections

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

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Contaminated Zone Dimensions

Area: 10000.00 square meters
Thickness: 0.15 meters

Cover Depth: 0.00 meters

Initial Soil Concentrations, pCi/g

Pb-210 5.000E+00
Ra-226 5.000E+00

0
Total Dose TDOSE(t), mrem/yr

Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	1.000E+01	1.000E+03
TDOSE(t):	3.925E+01	3.917E+01	3.833E+01	0.000E+00
M(t):	3.925E-01	3.917E-01	3.833E-01	0.000E+00

0Maximum TDOSE(t): 3.925E+01 mrem/yr at t = 0.000E+00 years
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
0 Water Independent Pathways (Inhalation excludes radon)

0 Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.
Pb-210	1.498E-02	0.0004	2.907E-03	0.0001	0.000E+00	0.0000	7.780E+00	0.1982	3.787E-01	0.0096	0.000E+00	0.0000	9.790E-01	0.0249
Ra-226	2.382E+01	0.6068	1.139E-03	0.0000	0.000E+00	0.0000	5.880E+00	0.1498	2.016E-01	0.0051	0.000E+00	0.0000	1.957E-01	0.0050
#######	#########	######	#########	######	#########	######	#########	######	#########	######	#########	######	#########	######
Total	2.383E+01	0.6072	4.047E-03	0.0001	0.000E+00	0.0000	1.366E+01	0.3480	5.803E-01	0.0148	0.000E+00	0.0000	1.175E+00	0.0299

0
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

0 Radio-Nuclide	Water mrem/yr	fract.	Fish mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.
	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Water Dependent Pathways All Pathways* mrem/yr	fract.		
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	9.156E+00	0.2332		
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	3.010E+01	0.7668		
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	3.925E+01	1.0000		

0*Sum of all water independent and dependent pathways.
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years

0 Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.
	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.		
Pb-210	1.452E-02	0.0004	2.809E-03	0.0001	0.000E+00	0.0000	7.517E+00	0.1919
	3.659E-01	0.0093	0.000E+00	0.0000	9.459E-01	0.0242		
Ra-226	2.378E+01	0.6072	1.224E-03	0.0000	0.000E+00	0.0000	6.099E+00	0.1557
	2.129E-01	0.0054	0.000E+00	0.0000	2.249E-01	0.0057		
Total	2.380E+01	0.6076	4.033E-03	0.0001	0.000E+00	0.0000	1.362E+01	0.3476
	5.787E-01	0.0148	0.000E+00	0.0000	1.171E+00	0.0299		

0 Excludes radon)

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

0 Radio-Nuclide	Water mrem/yr	fract.	Fish mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.
	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Water Dependent Pathways All Pathways* mrem/yr	fract.		
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	8.846E+00	0.2259		
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	3.032E+01	0.7741		
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	3.917E+01	1.0000		

0*Sum of all water independent and dependent pathways.
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surface final
Summary : RESRAD surface radium benchmark
File : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SURFACE.RAD

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

0 Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.
Pb-210	1.094E-02	0.0003	2.059E-03	0.0001	0.000E+00	0.0000	5.511E+00	0.1438	2.682E-01	0.0070	0.000E+00	0.0000	6.934E-01	0.0181
Ra-226	2.344E+01	0.6116	1.845E-03	0.0000	0.000E+00	0.0000	7.667E+00	0.2000	2.920E-01	0.0076	0.000E+00	0.0000	4.406E-01	0.0115
Total	2.346E+01	0.6119	3.905E-03	0.0001	0.000E+00	0.0000	1.318E+01	0.3438	5.603E-01	0.0146	0.000E+00	0.0000	1.134E+00	0.0296

0
Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
0 Water Dependent Pathways

0 Radio-Nuclide	Water mrem/yr	fract.	Fish mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	All Pathways* mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.485E+00	0.1692
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.185E+01	0.8308
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.833E+01	1.0000

0*Sum of all water independent and dependent pathways.
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Summary : RESRAD surface radium benchmark
File : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SURFACE.RAD

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

0 Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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```
                                        surface final
 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0
                        Total Dose Contributions TDOSE(i,p,t) for Individual
Radionuclides (i) and Pathways (p)
                                    As mrem/yr and Fraction of Total Dose At t =
1.000E+03 years
0                                                       Water Dependent Pathways
0             Water             Fish              Radon             Plant
  Meat              Milk          All Pathways*
 Radio-
 Nuclide  mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.
mrem/yr  fract.   mrem/yr  fract.   mrem/yr  fract.

 Pb-210  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
 Ra-226  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000

 Total   0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0.000E+00 0.0000  0.000E+00 0.0000  0.000E+00 0.0000
0*Sum of all water independent and dependent pathways.
1RESRAD, Version 6.5     T« Limit = 180 days        09/09/2013  07:14  Page  13
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              Dose/Source Ratios Summed Over All Pathways

    Parent and Progeny Principal Radionuclide Contributions Indicated

0  Parent    Product    Thread  DSR(j,t) At Time in Years   (mrem/yr)/(pCi/g)

    (i)        (j)      Fraction   0.000E+00 1.000E+00 1.000E+01 1.000E+03

 Pb-210+D   Pb-210+D   1.000E+00  1.831E+00 1.769E+00 1.297E+00 0.000E+00
ORa-226+D   Ra-226+D   1.000E+00  5.986E+00 5.974E+00 5.864E+00 0.000E+00
 Ra-226+D   Pb-210+D   1.000E+00  3.355E-02 9.011E-02 5.049E-01 0.000E+00
 Ra-226+D   äDSR(j)                6.019E+00 6.064E+00 6.369E+00 0.000E+00

 The DSR includes contributions from associated (half-life ó 180 days) daughters.

0
    Single Radionuclide Soil Guidelines G(i,t) in pCi/g

       Basic Radiation Dose Limit = 1.000E+02 mrem/yr

ONuclide
   (i)    t= 0.000E+00   1.000E+00   1.000E+01   1.000E+03

 Pb-210      5.461E+01   5.652E+01   7.710E+01  *7.634E+13

 Ra-226      1.661E+01   1.649E+01   1.570E+01  *9.885E+11


 *At specific activity limit
0
            Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
            and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
         at tmin = time of minimum single radionuclide soil guideline
      and at tmax = time of maximum total dose = 0.000E+00 years
ONuclide  Initial        tmin       DSR(i,tmin) G(i,tmin) DSR(i,tmax) G(i,tmax)
   (i)    (pCi/g)      (years)                   (pCi/g)               (pCi/g)
```

			surface final			
Pb-210	5.000E+00	0.000E+00	1.831E+00	5.461E+01	1.831E+00	5.461E+01
Ra-226	5.000E+00	34.20 ñ 0.07	6.643E+00	1.505E+01	6.019E+00	1.661E+01

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Summary : RESRAD surface radium benchmark
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Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

ONuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	1.000E+01	1.000E+03
Pb-210	Pb-210	1.000E+00	9.156E+00	8.846E+00	6.485E+00	0.000E+00
Pb-210	Ra-226	1.000E+00	1.677E-01	4.505E-01	2.524E+00	0.000E+00
Pb-210	äDOSE(j)		9.323E+00	9.296E+00	9.010E+00	0.000E+00
ORa-226	Ra-226	1.000E+00	2.993E+01	2.987E+01	2.932E+01	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

ONuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	1.000E+01	1.000E+03
Pb-210	Pb-210	1.000E+00	5.000E+00	4.847E+00	3.664E+00	1.565E-13
Pb-210	Ra-226	1.000E+00	0.000E+00	1.530E-01	1.333E+00	3.269E+00
Pb-210	äS(j):		5.000E+00	5.000E+00	4.996E+00	3.269E+00
ORa-226	Ra-226	1.000E+00	5.000E+00	4.998E+00	4.978E+00	3.225E+00

THF(i) is the thread fraction of the parent nuclide.
ORESCALC.EXE execution time = 0.37 seconds

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Part I: Mixture Sums and Single Radionuclide Guidelines

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Summary : RESRAD surface radium benchmark
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Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 12 & FGR 11

Base Menu Case*	Parameter Name	Parameter	Current Value#
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)		
A-1	At-218	(Source: FGR 12)	5.847E-03 DCF1(1)
A-1	Bi-210	(Source: FGR 12)	3.606E-03 DCF1(2)
A-1	Bi-214	(Source: FGR 12)	9.808E+00 DCF1(3)
A-1	Pb-210	(Source: FGR 12)	2.447E-03 DCF1(4)
A-1	Pb-214	(Source: FGR 12)	1.341E+00 DCF1(5)
A-1	Po-210	(Source: FGR 12)	5.231E-05 DCF1(6)
A-1	Po-214	(Source: FGR 12)	5.138E-04 DCF1(7)
A-1	Po-218	(Source: FGR 12)	5.642E-05 DCF1(8)
A-1	Ra-226	(Source: FGR 12)	3.176E-02 DCF1(9)
A-1	Rn-222	(Source: FGR 12)	2.354E-03 DCF1(10)
A-1	Tl-210	(Source: no data)	0.000E+00 -2.000E+00 DCF1(11)
B-1	Dose conversion factors for inhalation, mrem/pCi:		
B-1	Pb-210+D		2.320E-02 1.360E-02 DCF2(1)

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B-1	Ra-226+D		
8.580E-03	DCF2(2)	8.594E-03	
D-1	Dose conversion factors for ingestion, mrem/pCi:		
D-1	Pb-210+D		
5.370E-03	DCF3(1)	7.276E-03	
D-1	Ra-226+D		
1.320E-03	DCF3(2)	1.321E-03	
D-34	Food transfer factors:		
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless		
1.000E-02	RTF(1,1)	1.000E-02	
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)		
8.000E-04	RTF(1,2)	8.000E-04	
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)		
3.000E-04	RTF(1,3)	3.000E-04	
D-34			
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless		
4.000E-02	RTF(2,1)	4.000E-02	
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)		
1.000E-03	RTF(2,2)	1.000E-03	
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)		
1.000E-03	RTF(2,3)	1.000E-03	
D-5	Bioaccumulation factors, fresh water, L/kg:		
D-5	Pb-210+D , fish		
3.000E+02	BIOFAC(1,1)	3.000E+02	
D-5	Pb-210+D , crustacea and mollusks		
1.000E+02	BIOFAC(1,2)	1.000E+02	
D-5			
D-5	Ra-226+D , fish		
5.000E+01	BIOFAC(2,1)	5.000E+01	
D-5	Ra-226+D , crustacea and mollusks		
2.500E+02	BIOFAC(2,2)	2.500E+02	

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Used by RESRAD	Parameter	User	
(If different from user input)	Parameter Name	Input	Default	
R011	Area of contaminated zone (m**2) AREA	1.000E+04	1.000E+04	
R011	Thickness of contaminated zone (m) THICK0	1.500E-01	2.000E+00	
R011	Fraction of contamination that is submerged SUBMFRACT	0.000E+00	0.000E+00	
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	

			subsurface	final
		LCZPAQ		
R011	Basic radiation dose limit (mrem/yr)		1.000E+02	3.000E+01
		BRDL		
R011	Time since placement of material (yr)		0.000E+00	0.000E+00
		TI		
R011	Times for calculations (yr)		1.000E+00	1.000E+00
		T(2)		
R011	Times for calculations (yr)		1.000E+01	3.000E+00
		T(3)		
R011	Times for calculations (yr)		1.000E+03	1.000E+01
		T(4)		
R011	Times for calculations (yr)		not used	3.000E+01
		T(5)		
R011	Times for calculations (yr)		not used	1.000E+02
		T(6)		
R011	Times for calculations (yr)		not used	3.000E+02
		T(7)		
R011	Times for calculations (yr)		not used	1.000E+03
		T(8)		
R011	Times for calculations (yr)		not used	0.000E+00
		T(9)		
R011	Times for calculations (yr)		not used	0.000E+00
		T(10)		
R012	Initial principal radionuclide (pCi/g): Pb-210		1.500E+01	0.000E+00
		S1(1)		
R012	Initial principal radionuclide (pCi/g): Ra-226		1.500E+01	0.000E+00
		S1(2)		
R012	Concentration in groundwater (pCi/L): Pb-210		not used	0.000E+00
		W1(1)		
R012	Concentration in groundwater (pCi/L): Ra-226		not used	0.000E+00
		W1(2)		
R013	Cover depth (m)		1.500E-01	0.000E+00
		COVER0		
R013	Density of cover material (g/cm**3)		1.440E+00	1.500E+00
		DENSCV		
R013	Cover depth erosion rate (m/yr)		5.000E-04	1.000E-03
		VCV		
R013	Density of contaminated zone (g/cm**3)		1.440E+00	1.500E+00
		DENSCZ		
R013	Contaminated zone erosion rate (m/yr)		5.000E-04	1.000E-03
		VCZ		
R013	Contaminated zone total porosity		4.000E-01	4.000E-01
		TPCZ		
R013	Contaminated zone field capacity		2.000E-01	2.000E-01
		FCCZ		
R013	Contaminated zone hydraulic conductivity (m/yr)		1.090E+03	1.000E+01
		HCCZ		
R013	Contaminated zone b parameter		4.900E+00	5.300E+00
		BCZ		
R013	Average annual wind speed (m/sec)		4.920E+00	2.000E+00
		WIND		
R013	Humidity in air (g/m**3)		not used	8.000E+00
		HUMID		
R013	Evapotranspiration coefficient		7.000E-01	5.000E-01
		EVAPTR		
R013	Precipitation (m/yr)		2.800E-01	1.000E+00
		PRECIP		
R013	Irrigation (m/yr)		0.000E+00	2.000E-01
		RI		

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		subsurface final	
R013	Irrigation mode	overhead	overhead
R013	Runoff coefficient	5.000E-01	2.000E-01
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00
R014	Saturated zone total porosity	4.300E-01	4.000E-01
R014	Saturated zone effective porosity	3.300E-01	2.000E-01
R014	Saturated zone field capacity	1.000E-01	2.000E-01
R014	Saturated zone hydraulic conductivity (m/yr)	5.550E+03	1.000E+02
R014	Saturated zone hydraulic gradient	1.000E-02	2.000E-02
R014	Saturated zone b parameter	4.050E+00	5.300E+00
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND

Site-Specific Parameter Summary

(continued)

Menu (If different from user input)	Used by RESRAD Parameter	Parameter Name	User Input	Default
R014	Well pumping rate (m**3/yr)	UW	2.500E+02	2.500E+02
R015	Number of unsaturated zone strata	NS	1	1
R015	Unsat. zone 1, thickness (m)	H(1)	2.286E+01	4.000E+00
R015	Unsat. zone 1, soil density (g/cm**3)	DENSUZ(1)	1.500E+00	1.500E+00
R015	Unsat. zone 1, total porosity	TPUZ(1)	4.300E-01	4.000E-01
R015	Unsat. zone 1, effective porosity	EPUZ(1)	3.300E-01	2.000E-01
R015	Unsat. zone 1, field capacity	FCUZ(1)	1.000E-01	2.000E-01
R015	Unsat. zone 1, soil-specific b parameter	BUZ(1)	4.050E+00	5.300E+00
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	HCUZ(1)	5.550E+03	1.000E+01

		subsurface	final
R016	Distribution coefficients for Pb-210		
R016	Contaminated zone (cm**3/g) DCNUCC(1)	1.600E+04	1.000E+02
R016	Unsaturated zone 1 (cm**3/g) DCNUCU(1,1)	2.700E+02	1.000E+02
R016	Saturated zone (cm**3/g) DCNUCS(1)	2.700E+02	1.000E+02
R016	Leach rate (/yr) ALEACH(1) 1.215E-05	0.000E+00	0.000E+00
R016	Solubility constant SOLUBK(1) not used	0.000E+00	0.000E+00
R016	Distribution coefficients for Ra-226		
R016	Contaminated zone (cm**3/g) DCNUCC(2)	3.600E+04	7.000E+01
R016	Unsaturated zone 1 (cm**3/g) DCNUCU(2,1)	5.000E+02	7.000E+01
R016	Saturated zone (cm**3/g) DCNUCS(2)	5.000E+02	7.000E+01
R016	Leach rate (/yr) ALEACH(2) 5.401E-06	0.000E+00	0.000E+00
R016	Solubility constant SOLUBK(2) not used	0.000E+00	0.000E+00
R017	Inhalation rate (m**3/yr) INHALR	8.400E+03	8.400E+03
R017	Mass loading for inhalation (g/m**3) MLINH	1.000E-04	1.000E-04
R017	Exposure duration ED	3.000E+01	3.000E+01
R017	Shielding factor, inhalation SHF3	4.000E-01	4.000E-01
R017	Shielding factor, external gamma SHF1	5.500E-01	7.000E-01
R017	Fraction of time spent indoors FIND	5.000E-01	5.000E-01
R017	Fraction of time spent outdoors (on site) FOTD	2.500E-01	2.500E-01
R017	Shape factor flag, external gamma FS >0 shows circular AREA.	1.000E+00	1.000E+00
R017	Radii of shape factor array (used if FS = -1):		
R017	Outer annular radius (m), ring 1: RAD_SHAPE(1)	not used	5.000E+01
R017	Outer annular radius (m), ring 2: RAD_SHAPE(2)	not used	7.071E+01
R017	Outer annular radius (m), ring 3: RAD_SHAPE(3)	not used	0.000E+00
R017	Outer annular radius (m), ring 4: RAD_SHAPE(4)	not used	0.000E+00
R017	Outer annular radius (m), ring 5: RAD_SHAPE(5)	not used	0.000E+00
R017	Outer annular radius (m), ring 6: RAD_SHAPE(6)	not used	0.000E+00
R017	Outer annular radius (m), ring 7: RAD_SHAPE(7)	not used	0.000E+00
R017	Outer annular radius (m), ring 8: RAD_SHAPE(8)	not used	0.000E+00
R017	Outer annular radius (m), ring 9:	not used	0.000E+00

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                                   subsurface final
         ---                     ³ RAD_SHAPE( 9)
R017 ³   Outer annular radius (m), ring 10:          ³ not used  ³ 0.000E+00 ³
         ---                     ³ RAD_SHAPE(10)
R017 ³   Outer annular radius (m), ring 11:          ³ not used  ³ 0.000E+00 ³
         ---                     ³ RAD_SHAPE(11)
R017 ³   Outer annular radius (m), ring 12:          ³ not used  ³ 0.000E+00 ³
         ---                     ³ RAD_SHAPE(12)
     ³                           ³                   ³           ³           ³
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                                        Site-Specific Parameter Summary
(continued)
0    ³                                               ³   User    ³           ³
       Used by RESRAD          ³  Parameter
Menu ³                       Parameter               ³   Input   ³  Default  ³
(If different from user input) ³    Name

R017 ³ Fractions of annular areas within AREA:       ³           ³           ³
                                 ³
R017 ³   Ring  1                                     ³ not used  ³ 1.000E+00 ³
         ---                     ³ FRACA( 1)
R017 ³   Ring  2                                     ³ not used  ³ 2.732E-01 ³
         ---                     ³ FRACA( 2)
R017 ³   Ring  3                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 3)
R017 ³   Ring  4                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 4)
R017 ³   Ring  5                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 5)
R017 ³   Ring  6                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 6)
R017 ³   Ring  7                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 7)
R017 ³   Ring  8                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 8)
R017 ³   Ring  9                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA( 9)
R017 ³   Ring 10                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA(10)
R017 ³   Ring 11                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA(11)
R017 ³   Ring 12                                     ³ not used  ³ 0.000E+00 ³
         ---                     ³ FRACA(12)
     ³                           ³                   ³           ³           ³
R018 ³ Fruits, vegetables and grain consumption (kg/yr) ³ 1.600E+02 ³ 1.600E+02 ³
         ---                     ³ DIET(1)
R018 ³ Leafy vegetable consumption (kg/yr)           ³ 1.400E+01 ³ 1.400E+01 ³
         ---                     ³ DIET(2)
R018 ³ Milk consumption (L/yr)                       ³ not used  ³ 9.200E+01 ³
         ---                     ³ DIET(3)
R018 ³ Meat and poultry consumption (kg/yr)          ³ 6.300E+01 ³ 6.300E+01 ³
         ---                     ³ DIET(4)
R018 ³ Fish consumption (kg/yr)                      ³ 0.000E+00 ³ 5.400E+00 ³
         ---                     ³ DIET(5)
R018 ³ Other seafood consumption (kg/yr)             ³ 0.000E+00 ³ 9.000E-01 ³
         ---                     ³ DIET(6)
R018 ³ Soil ingestion rate (g/yr)                    ³ 3.650E+01 ³ 3.650E+01 ³
         ---                     ³ SOIL
R018 ³ Drinking water intake (L/yr)                  ³ 5.100E+02 ³ 5.100E+02 ³
                                   Page 6
```

			subsurface	final
	---	DWI		
R018	Contamination fraction of drinking water		1.000E+00	1.000E+00
	---	FDW		
R018	Contamination fraction of household water		not used	1.000E+00
	---	FHHW		
R018	Contamination fraction of livestock water		1.000E+00	1.000E+00
	---	FLW		
R018	Contamination fraction of irrigation water		0.000E+00	1.000E+00
	---	FIRW		
R018	Contamination fraction of aquatic food		0.000E+00	5.000E-01
	---	FR9		
R018	Contamination fraction of plant food		2.500E-01	-1
	---	FPLANT		
R018	Contamination fraction of meat		2.500E-01	-1
	---	FMEAT		
R018	Contamination fraction of milk		not used	-1
	---	FMILK		
R019	Livestock fodder intake for meat (kg/day)		6.800E+01	6.800E+01
	---	LFI5		
R019	Livestock fodder intake for milk (kg/day)		not used	5.500E+01
	---	LFI6		
R019	Livestock water intake for meat (L/day)		5.000E+01	5.000E+01
	---	LWI5		
R019	Livestock water intake for milk (L/day)		not used	1.600E+02
	---	LWI6		
R019	Livestock soil intake (kg/day)		5.000E-01	5.000E-01
	---	LSI		
R019	Mass loading for foliar deposition (g/m**3)		1.000E-04	1.000E-04
	---	MLFD		
R019	Depth of soil mixing layer (m)		1.500E-01	1.500E-01
	---	DM		
R019	Depth of roots (m)		3.000E-01	9.000E-01
	---	DROOT		
R019	Drinking water fraction from ground water		1.000E+00	1.000E+00
	---	FGWDW		
R019	Household water fraction from ground water		not used	1.000E+00
	---	FGWHH		
R019	Livestock water fraction from ground water		1.000E+00	1.000E+00
	---	FGWLW		
R019	Irrigation fraction from ground water		1.000E+00	1.000E+00
	---	FGWIR		
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)		7.000E-01	7.000E-01
	---	YV(1)		
R19B	Wet weight crop yield for Leafy (kg/m**2)		1.500E+00	1.500E+00
	---	YV(2)		
R19B	Wet weight crop yield for Fodder (kg/m**2)		1.100E+00	1.100E+00
	---	YV(3)		
R19B	Growing Season for Non-Leafy (years)		1.700E-01	1.700E-01
	---	TE(1)		
R19B	Growing Season for Leafy (years)		2.500E-01	2.500E-01
	---	TE(2)		
R19B	Growing Season for Fodder (years)		8.000E-02	8.000E-02
	---	TE(3)		

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Summary : RESRAD surface radium benchmark
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Site-Specific Parameter Summary

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Menu (If different from user input)	Used by RESRAD	Parameter Name	Parameter	User Input	Default
R19B			Translocation Factor for Non-Leafy	1.000E-01	1.000E-01
R19B	---	TIV(1)	Translocation Factor for Leafy	1.000E+00	1.000E+00
R19B	---	TIV(2)	Translocation Factor for Fodder	1.000E+00	1.000E+00
R19B	---	TIV(3)	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01
R19B	---	RDRY(1)	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01
R19B	---	RDRY(2)	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01
R19B	---	RDRY(3)	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01
R19B	---	RWET(1)	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01
R19B	---	RWET(2)	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01
R19B	---	RWET(3)	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01
	---	WLAM			
C14			C-12 concentration in water (g/cm**3)	not used	2.000E-05
C14	---	C12WTR	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02
C14	---	C12CZ	Fraction of vegetation carbon from soil	not used	2.000E-02
C14	---	CSOIL	Fraction of vegetation carbon from air	not used	9.800E-01
C14	---	CAIR	C-14 evasion layer thickness in soil (m)	not used	3.000E-01
C14	---	DMC	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07
C14	---	EVSN	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10
C14	---	REVSN	Fraction of grain in beef cattle feed	not used	8.000E-01
C14	---	AVFG4	Fraction of grain in milk cow feed	not used	2.000E-01
	---	AVFG5			
STOR			Storage times of contaminated foodstuffs (days):		
STOR			Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01
STOR	---	STOR_T(1)	Leafy vegetables	1.000E+00	1.000E+00
STOR	---	STOR_T(2)	Milk	1.000E+00	1.000E+00
STOR	---	STOR_T(3)	Meat and poultry	2.000E+01	2.000E+01
STOR	---	STOR_T(4)	Fish	7.000E+00	7.000E+00
STOR	---	STOR_T(5)	Crustacea and mollusks	7.000E+00	7.000E+00
STOR	---	STOR_T(6)	Well water	1.000E+00	1.000E+00
	---	STOR_T(7)			

		subsurface final			
STOR	Surface water	STOR_T(8)	1.000E+00	1.000E+00	
STOR	Livestock fodder	STOR_T(9)	4.500E+01	4.500E+01	
R021	Thickness of building foundation (m)	FLOOR1	not used	1.500E-01	
R021	Bulk density of building foundation (g/cm**3)	DENSFL	not used	2.400E+00	
R021	Total porosity of the cover material	TPCV	not used	4.000E-01	
R021	Total porosity of the building foundation	TPFL	not used	1.000E-01	
R021	Volumetric water content of the cover material	PH2OCV	not used	5.000E-02	
R021	Volumetric water content of the foundation	PH2OFL	not used	3.000E-02	
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	DIFCV	not used	2.000E-06	
R021	in foundation material	DIFFL	not used	3.000E-07	
R021	in contaminated zone soil	DIFCZ	not used	2.000E-06	
R021	Radon vertical dimension of mixing (m)	HMIX	not used	2.000E+00	
R021	Average building air exchange rate (1/hr)	REXG	not used	5.000E-01	
R021	Height of the building (room) (m)	HRM	not used	2.500E+00	
R021	Building interior area factor	FAI	not used	0.000E+00	
R021	Building depth below ground surface (m)	DMFL	not used	-1.000E+00	
R021	Emanating power of Rn-222 gas	EMANA(1)	not used	2.500E-01	
R021	Emanating power of Rn-220 gas	EMANA(2)	not used	1.500E-01	
TITL	Number of graphical time points	NPTS	32	---	

Site-Specific Parameter Summary

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Menu (If different from user input)	Used by RESRAD	Parameter Name	User Input	Default
TITL	Maximum number of integration points for dose	LYMAX	17	---
TITL	Maximum number of integration points for risk	KYMAX	1	---

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

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Contaminated Zone Dimensions

Area: 10000.00 square meters
Thickness: 0.15 meters

Cover Depth: 0.15 meters

Initial Soil Concentrations, pCi/g

Pb-210 1.500E+01
Ra-226 1.500E+01

0

Total Dose TDOSE(t), mrem/yr

Basic Radiation Dose Limit = 1.000E+02 mrem/yr

Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	1.000E+01	1.000E+03
TDOSE(t):	5.399E+01	5.407E+01	5.469E+01	0.000E+00
M(t):	5.399E-01	5.407E-01	5.469E-01	0.000E+00

0Maximum TDOSE(t): 1.036E+02 mrem/yr at t = 299.7 ñ 0.6 years
0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.997E+02 years
0
Water Independent Pathways (Inhalation excludes radon)
0

Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.	Radio-Nuclide
Pb-210	4.021E-06	0.0000	7.819E-07	0.0000	0.000E+00	0.0000	2.093E-03	0.0000	1.018E-04	0.0000	0.000E+00	0.0000	2.633E-04	0.0000	Pb-210
Ra-226	6.270E+01	0.6050	1.076E-02	0.0001	0.000E+00	0.0000	3.625E+01	0.3498	1.542E+00	0.0149	0.000E+00	0.0000	3.128E+00	0.0302	Ra-226
Total	6.270E+01	0.6050	1.076E-02	0.0001	0.000E+00	0.0000	3.625E+01	0.3498	1.542E+00	0.0149	0.000E+00	0.0000	3.128E+00	0.0302	

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 2.997E+02 years

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0 Water Dependent Pathways
0 Water Fish Radon Plant
Meat Milk All Pathways*
Radio-
Nuclide mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract.
Nuclide

Pb-210 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 2.462E-03 0.0000
Ra-226 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 1.036E+02 1.0000

Total 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 1.036E+02 1.0000
0*Sum of all water independent and dependent pathways.
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Summary : RESRAD surface radium benchmark
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
0 Water Independent Pathways (Inhalation excludes radon)
0 Ground Inhalation Radon Plant
Meat Milk Soil
Radio-
Nuclide mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract.

Pb-210 1.347E-03 0.0000 1.449E-05 0.0000 0.000E+00 0.0000 2.337E+01 0.4329 4.614E-01 0.0085 0.000E+00 0.0000 4.878E-03 0.0001
Ra-226 1.204E+01 0.2231 5.781E-06 0.0000 0.000E+00 0.0000 1.767E+01 0.3272 4.391E-01 0.0081 0.000E+00 0.0000 1.006E-03 0.0000

Total 1.204E+01 0.2231 2.027E-05 0.0000 0.000E+00 0.0000 4.104E+01 0.7601 9.005E-01 0.0167 0.000E+00 0.0000 5.883E-03 0.0001
0
Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
0 Water Dependent Pathways
0 Water Fish Radon Plant
Meat Milk All Pathways*
Radio-
Nuclide mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract. mrem/yr fract.

Pb-210 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 2.384E+01 0.4416
Ra-226 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 3.015E+01 0.5584
f
Total 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 5.399E+01 1.0000
0*Sum of all water independent and dependent pathways.
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Summary : RESRAD surface radium benchmark
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
0
Water Independent Pathways (Inhalation excludes radon)
0

Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.
Pb-210	1.319E-03	0.0000	4.227E-05	0.0000	0.000E+00	0.0000	2.266E+01	0.4190	4.494E-01	0.0083	0.000E+00	0.0000	1.423E-02	0.0003
Ra-226	1.210E+01	0.2239	1.852E-05	0.0000	0.000E+00	0.0000	1.839E+01	0.3400	4.548E-01	0.0084	0.000E+00	0.0000	3.414E-03	0.0001
Total	1.211E+01	0.2239	6.079E-05	0.0000	0.000E+00	0.0000	4.104E+01	0.7591	9.043E-01	0.0167	0.000E+00	0.0000	1.765E-02	0.0003

0
Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
0
Water Dependent Pathways
0

Radio-Nuclide	Water mrem/yr	fract.	Fish mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	All Pathways* mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.312E+01	0.4276
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.095E+01	0.5724
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.407E+01	1.0000

0*Sum of all water independent and dependent pathways.
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Summary : RESRAD surface radium benchmark
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
0
Water Independent Pathways (Inhalation excludes radon)
0

Radio-Nuclide	Ground mrem/yr	fract.	Inhalation mrem/yr	fract.	Radon mrem/yr	fract.	Plant mrem/yr	fract.	Meat mrem/yr	fract.	Milk mrem/yr	fract.	Soil mrem/yr	fract.
Pb-210	1.086E-03	0.0000	2.240E-04	0.0000	0.000E+00	0.0000	1.713E+01	0.3132	3.546E-01	0.0065	0.000E+00	0.0000	7.543E-02	0.0014
Ra-226	1.268E+01	0.2318	2.008E-04	0.0000	0.000E+00	0.0000	2.383E+01	0.4357	5.729E-01	0.0105	0.000E+00	0.0000	4.796E-02	0.0009
Total	1.268E+01	0.2319	4.249E-04	0.0000	0.000E+00	0.0000	4.096E+01	0.7489	9.275E-01	0.0170	0.000E+00	0.0000	1.234E-01	0.0023

0
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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years

0

0	Water		Fish		Water Dependent Pathways Radon		Plant	
Meat		Milk		All Pathways*				
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.		
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	1.756E+01	0.3211		
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	3.713E+01	0.6789		
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	5.469E+01	1.0000		

0*Sum of all water independent and dependent pathways.

Summary : RESRAD surface radium benchmark

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

0

Water Independent Pathways (Inhalation excludes radon)

0	Ground		Inhalation		Radon		Plant	
Meat		Milk		Soil				
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.		
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		

0

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)

As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years

0

0	Water		Fish		Water Dependent Pathways Radon		Plant	
Meat		Milk		All Pathways*				
Radio-Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.		
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000		

0*Sum of all water independent and dependent pathways.

subsurface final
Summary : RESRAD surface radium benchmark
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Dose/Source Ratios Summed Over All Pathways

Parent and Progeny Principal Radionuclide Contributions Indicated

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years 0.000E+00	1.000E+00	1.000E+01	1.000E+03 (mrem/yr)/(pCi/g)
Pb-210+D	Pb-210+D	1.000E+00	1.589E+00	1.542E+00	1.171E+00	0.000E+00
0Ra-226+D	Ra-226+D	1.000E+00	1.980E+00	1.984E+00	2.019E+00	0.000E+00
Ra-226+D	Pb-210+D	1.000E+00	2.978E-02	7.928E-02	4.564E-01	0.000E+00
Ra-226+D	ãDSR(j)		2.010E+00	2.063E+00	2.475E+00	0.000E+00

The DSR includes contributions from associated (half-life ó 180 days) daughters.

0
Single Radionuclide Soil Guidelines G(i,t) in pCi/g

Basic Radiation Dose Limit = 1.000E+02 mrem/yr

0Nuclide (i)	t= 0.000E+00	1.000E+00	1.000E+01	1.000E+03
Pb-210	6.292E+01	6.487E+01	8.543E+01	*7.634E+13
Ra-226	4.975E+01	4.847E+01	4.040E+01	*9.885E+11

*At specific activity limit

0
Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 299.7 ñ 0.6 years

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin) (pCi/g)	G(i,tmin)	DSR(i,tmax) (pCi/g)	G(i,tmax)
Pb-210	1.500E+01	0.000E+00	1.589E+00	6.292E+01	1.642E-04	6.091E+05
Ra-226	1.500E+01	299.7 ñ 0.6	6.909E+00	1.447E+01	6.909E+00	1.447E+01

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Summary : RESRAD surface radium benchmark
File : C:\USERS\RSCHIERMAN\DESKTOP\RESRAD RADIUM BENCH MARK SUBSURFACE.RAD

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

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	1.000E+01	1.000E+03
Pb-210	Pb-210	1.000E+00	2.384E+01	2.312E+01	1.756E+01	0.000E+00
Pb-210	Ra-226	1.000E+00	4.467E-01	1.189E+00	6.846E+00	0.000E+00
Pb-210	ãDOSE(j)		2.429E+01	2.431E+01	2.440E+01	0.000E+00
0Ra-226	Ra-226	1.000E+00	2.970E+01	2.976E+01	3.028E+01	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated
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ONuclide (j)	Parent (i)	THF(i)	subsurface final S(j,t), pCi/g			
			t= 0.000E+00	1.000E+00	1.000E+01	1.000E+03
Pb-210	Pb-210	1.000E+00	1.500E+01	1.454E+01	1.099E+01	4.696E-13
Pb-210	Ra-226	1.000E+00	0.000E+00	4.590E-01	3.998E+00	9.808E+00
Pb-210	äS(j):		1.500E+01	1.500E+01	1.499E+01	9.808E+00
ORa-226	Ra-226	1.000E+00	1.500E+01	1.499E+01	1.493E+01	9.674E+00

THF(i) is the thread fraction of the parent nuclide.
ORESCALC.EXE execution time = 0.40 seconds