INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH

6935 Laurel Avenue, Suite 201
Takoma Park, MD 20912

Phone: (301) 270-5500
FAX: (301) 270-3029
e-mail: ieer@ieer.org
http://www.ieer.org

Residual Radioactivity in Your Neighborhood:

A Community Guide to Estimating Radiation Doses Resulting from Radioactive Contamination

Version 1

Brice Smith, Ph.D.

January 29, 2009

Acknowledgements ... v
Chapter One - Introduction to RESRAD ... 1
Section 1.1 - What is RESRAD and why should you care? ... 1
Section 1.2 - What is this manual for? ... 4
Section 1.3 - What RESRAD won't do ... 5
Section 1.4 - Getting started. ... 6
Chapter Two - Introduction to Important Variables ... 8
Section 2.1 - How and where are variables entered into RESRAD? ... 8
Section 2.2 - Calculation times ... 9
Section 2.3 - Contaminants in the soil ... 10
Section 2.4 - Distribution coefficients (K_d) ... 12
Section 2.5 - Water infiltration. ... 16
Section 2.6 - Erosion of the cover and contaminated zones ... 18
Section 2.7 - Exposure factors ... 19
Section 2.7.1 - Occupancy of the site ... 19
Section 2.7.2 - Food and drink ... 20
Section 2.7.3 - Soil ingestion and pica ... 26
Section 2.7.4 - Inhalation rates ... 27
Chapter Three - Preparing your own RESRAD run. ... 29
Section 3.1 - Creating your own RESRAD run. ... 29
Section 3.1.1 - Site-specific versus RESRAD default values ... 30
Section 3.1.2 - Calculating doses for different age groups ... 32
Section 3.2 - Running RESRAD ... 34
Section 3.3 - Reading the output files and interpreting the results. ... 35
Section 3.3.1 - Exploring the peak dose ... 35
Section 3.3.2 - Breaking down the peak dose ... 38
Section 3.3.3 - Interpreting the Single Radionuclide Soil Guidelines ... 39
Chapter Four - Summary and Conclusions. ... 42
Section 4.1 - How to use these results in your work. ... 42
Section 4.2 - Next steps in learning the tool ... 43
Appendix A - Summary of Current Common Radiation Standards ... 45
Appendix B - Summary of Important RESRAD Variables ... 47
Appendix C - Unit Conversions ... 50
Appendix D - Sample Summary Report Output File from RESRAD (Reference Man) ... 51
Appendix E - Sample Summary Report Output File from RESRAD (10 year old) ... 81
References ... 107

Acknowledgements

First, I would like to thank Joni Arends, Executive Director of Concerned Citizens for Nuclear Safety (CCNS) in Santa Fe, New Mexico, who read an early draft of this manual (or guide) and provided some very helpful questions and suggestions for improvements. In addition, I would like to thank Arjun Makhijani, President of the Institute for Energy and Environmental Research, who also reviewed early drafts of this manual and helped to shape its overall layout.

Second, I would like to thank Annie Makhijani, IEER Project Scientist, who checked many of the calculations and the RESRAD runs in this manual, and Lois Chalmers who helped with editing, with the bibliographic research, and with the references. As always, I, as the author, remain solely responsible for the contents of this report, its conclusions and recommendations, and any omissions or errors.

This study is part of IEER's technical support project for grassroots groups on nuclear waste related issues in the United States. As such, we gratefully acknowledge the generous support of Colombe Foundation, Educational Foundation of America, Ford Foundation, Livingry Foundation, Stewart R. Mott Charitable Trust, New-Land Foundation, Ploughshares Fund, Public Welfare Foundation, and Town Creek Foundation, as well as the individual donors who give generous support to our work.

Brice Smith
Ithaca, New York
November 7, 2008

Chapter One - Introduction to RESRAD

Section 1.1 - What is RESRAD and why should you care?

Since the Manhattan Project in World War II first launched the large scale nuclear enterprise in the United States, large amounts of radioactive waste have been generated by both civilian and military uses of nuclear power.[1] These wastes span a wide range of hazards from high-level wastes, such as spent reactor fuel and liquid wastes generated by the chemical separation of plutonium, to lightly contaminated soils, clothing, and building materials. In areas where these wastes will be disposed of, or areas where contamination will not be fully remediated during cleanup, the most important question to ask from the standpoint of protecting human health is how much of the radiation left in the ground will eventually reach people and thus be able to cause them harm. The closely related question of what impact the radioactive materials will have on the larger ecosystem, including plants and other animals, is outside the scope of the present work.

Determining how humans may be affected by radioactive waste or other types of contaminants buried in the soil is a significant challenge and requires a great deal to be known about the properties of the site and how it may be used by humans in the future. For long lived radionuclides, it may be necessary to project certain assumptions about the site and its uses into the distant future, adding to the complexity of this challenge.

Broadly speaking, the steps involved in going from a given level of contamination in the ground today to the dose received by an individual in the future involves three steps. The first step in this process is to evaluate how the site might be used by people in the future. The possible routes of exposure are very different for someone who lives on a contaminated site and grows her or his own food compared to someone who uses the site for recreational hunting and both of these scenarios would, in turn, be different from someone using the site for industrial purposes. The set of behaviors and activities that are assumed to occur at a particular site is called the "exposure scenario." For sites contaminated with long-lived radionuclides, it is often the case that the most appropriate exposure scenario to use is one involving a resident farmer who grows her or his own food and collects her or his own water from the site.[2] The assumption behind this general rule is that, if a resident farmer living on top of the waste is protected to a level regulations deem acceptable, then anyone else using the site for other purposes would be even more protected. Inherent in this approach is the need to ensure that the "farmer" chosen is truly the most vulnerable member of the population, otherwise the conclusion that all others will be adequately protected may not be valid. A major motivation for the writing of this manual is to allow you to calculate doses to children and compare them to those that would be received by adults (see sections 2.7 and 3.1.2). In this context it is important to note that at some sites (for

[1] See, for example, Fioravanti and Makhijani 1997, Zerriffi and Makhijani 2000, Makhijani and Boyd 2001, and Makhijani and Boyd 2004.
[2] See, for example, Makhijani and Gopal 2001.

example, sites where agriculture is not a possibility) there may be entirely separate child specific exposure scenarios that need to be considered.[3]

Once the exposure scenario is chosen, the second step in performing dose assessments is to predict how the radionuclides present in the soil will move through the environment from where they were initially to where they will eventually come into contact with humans. The exposure of the people to the contamination may be direct, such as gamma emitting wastes that are uncovered by erosion and thus directly irradiate an individual standing on top of them, or the exposure may be indirect, such as radionuclides that are taken up through the roots of food crops that are then consumed by humans. For some exposure scenarios, like the resident farmer, the contact may even involve several different steps. For example, radionuclides at a site might migrate through the soil eventually reaching groundwater. These waterborne radionuclides could be brought to the surface by a well and the contaminated groundwater could then be used to irrigate crops. The crops, thus contaminated by the irrigation water, could then be fed to cattle which are, in turn, killed and eaten by humans. As is clear from this brief description, the task of tracking where the radionuclides will be in the environment is a complex one, particularly for scenarios that include many different pathways through which the contamination can move.

The third and final step, in dose assessments, is to predict, based upon the type of exposure that occurs, what the dose received by an individual will be. The pathways by which a human may be exposed include such things as (1) ingestion of contaminated food, water, or soil, (2) inhalation of contaminated dust or gaseous radionuclides, and (3) external irradiation from gamma rays and high energy beta particles. Determining the dose received by an individual from each of these exposure pathways requires a number of different calculations. Finding the total dose from all these pathways is very important, because current radiation protection standards are typically written in terms of limits to the dose an individual may receive in a given period of time. Some of the more commonly referenced radiation protection standards are summarized in Appendix A of this manual.

In calculating how big a dose an individual will receive from the radionuclides inhaledor ingested, we must first understand how the material will interact with his or her body, including where, if anywhere, it may concentrate, how long it will remain in the body, and what kinds of damage it will do before being excreted or exhaled. Currently, all of this information is summarized in a single constant called the dose conversion factor (DCF). The DCF relates the total lifetime dose received by the individual (measured in rem) to the amount of the radionuclide that is ingested or inhaled (measured in curies). A dose conversion factor, therefore, has the units of rem per curie, or its equivalent in other unit systems.[4] As would be expected, given the differences in such things as body size and metabolism, the dose conversion factors for children are, in general, different from those of an adult. How to incorporate these differences in performing dose assessments will be discussed in greater detail in Section 3.1.2.

---

[3] For example, see Smith 2005 for a discussion of the child-specific "extended backyard scenario" used to set the cleanup standards in Acid Canyon at Los Alamos National Laboratory.
[4] For example, in the SI unit system the units of dose are the Sievert (Sv) while the unit of radioactivity is the Becquerel (Bq) giving the dose conversion factor the units of Sievert per Becquerel (Sv/Bq).

A related calculation must also be done for external irradiation that takes into account the dose received by an individual from penetrating radiation. These calculations depend on the type of radiation emitted by a radionuclide (i.e., alpha, beta, or gamma) as well as its energy. For a given type of radiation, the higher its energy, the more penetrating the radiation is and, thus, the bigger the dose it can deliver to organs deep inside the body. Additional considerations must be given to such things as the area contaminated by the radionuclide and the shielding effects of the soil and other materials that may be present between the contaminants and person being exposed. In making these calculations, RESRAD uses the relevant dose factors published by the EPA in Federal Guidance Report No. 12 from 1993.[5]

Given that many of the necessary calculations are clearly quite complex, dose assessments are best done on a computer. It is in this light that we introduce RESRAD, the focus of this manual. In an effort to create a single tool that could carry out the steps described above, RESRAD (short for RESidual RADioactivity), a computer based simulation program, was developed by the Environmental Assessment Division of Argonne National Laboratory and first released in 1989.[6] The RESRAD program allows the user to specify many features of a site and to select the types of exposure pathways that will be important. It can then use the information provided by the user to predict the annual dose received by an individual at anytime over the next 100,000 years.[7] Specifically, the exposure pathways considered by RESRAD include

- External radiation from contaminants in the soil.

- Inhalation of radon and its daughters, inhalation of other gaseous radionuclides like carbon-14 (C-14), and inhalation of contaminated dirt and dust that becomes resuspended in the air.

- Ingestion of plants such as vegetables, grains, and fruits, ingestion of meat and milk from cattle, ingestion of fish and other aquatic foods from an onsite pond, ingestion of contaminated soil, and drinking contaminated water from an onsite well or from an onsite pond.[8]

While there are other models, both from private and from government funded agencies, that have been developed to do similar types of calculations, RESRAD is particularly important for three reasons. First of all, it has been accepted for use in making regulatory decisions and has "been used widely by DOE and its contractors, the U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers, industrial firms, universities, and foreign government agencies and institutions."[9] Second, RESRAD represents a robust, useful, and generally reasonable balance between the complexity of the problems involved with carrying out a dose assessment and the need for ease of usability and understandability of results. Third, and finally, RESRAD, unlike some other models, is free and

---

[5] FGR 12
[6] Yu et al. 2001 p. xvii
[7] Unless otherwise specified all references to the features of the RESRAD program refer to version 6.4 released on December 19, 2007. (RESRAD 6.4)
[8] Yu et al. 2001 p. 1-4
[9] Yu et al. 2001 p. xi

readily available to any member of the public via the Internet so everyone can have equal access to the program and its supporting documentation.

Section 1.2 - What is this manual for?

While RESRAD can be a powerful tool for predicting doses from radioactive contamination, it continues to have a significant weakness in that its default values are chosen for adults and thus require significant adaptation in order to calculate doses to children. As currently configured, RESRAD continues to use the dose conversion factors published by the U.S. Environmental Protection Agency in its 1988 Federal Guidance Report No. 11 (FGR 11) as its default.[10] These dose conversion factors were developed for a model individual called "Reference Man."[11] The "Reference Man" of this model was clearly defined by the International Commission on Radiological Protection in 1975 as follows

> Reference Man is defined as being between 20-30 years of age, weighing 70 kg, is 170 cm in height, and lives in a climate with an average temperature of from 10^{o} to 20^{o}C. He is a Caucasian and is a Western European or North American in habitat and custom.[12]

Unlike the other limitations of RESRAD discussed in Section 1.3, doses to infants and children can be calculated using the most recent version of the program. Version 6.4 of RESRAD, released on December 19, 2007, is the first version of the program that includes dose conversion factors for children. Specifically, the program contains the dose conversion factors from the International Commission on Radiological Protection (ICRP) that were first published between 1990 and 1996.[13] To simplify the problem of dealing with different ages, the ICRP considered only five specific age ranges. These ranges were; from 0 to 1 years old (called "Infant" in RESRAD), from 1 to 2 years old ("Age 1"), more than 2 years to 7 years old ("Age 5"), more than 7 years to 12 years old ("Age 10"), more than 12 years to 17 years old ("Age 15"), and more than 17 years old ("Adult").[14] The age ranges used by the EPA in the 2002 update to the EPA's Federal Guidance Report No. 13 (FGR 13) are comparable to those used by ICRP.[15] Given that the dose factors from the ICRP are the ones included in the latest version of RESRAD, they will thus be the focus of the current work. The remainder of this manual will focus on how to setup and interpret your own RESRAD runs making use of the updated dose conversion factors included in the latest version of the program.

However, before proceeding, it is important to note that the goal of this manual is not to allow you to begin from scratch with a blank slate and to develop your own dose assessment from the ground up. Nor is it intended to provide a complete overview of the RESRAD program and all

---

[10] Yu et al. 2001 p. xii

[11] For more information on "Reference Man" and the need to update the radiation protection regime to take into account women, children, and the reproductive role of men see *Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk* (Makhijani, Smith, and Thorne 2006).

[12] ICRP 23 p. 4

[13] ICRP 56, ICRP 67, ICRP 69, ICRP 71, and ICRP 72

[14] For simplicity the ICRP referred to these age ranges as 3 month old, 1 year old, 5 year old, 10 year old, 15 year old, and Adult. (ICRP 72 p. 11)

[15] FGR 13 and Suppl.

its various inputs and outputs. The goal is, instead, for this manual to be used in cases where your site has already chosen to use RESRAD in support of a license or regulatory decision and has therefore already proposed its own set of model parameters. In such cases, you will be able to begin with the site operator's assumptions regarding the geology, meteorology, and other characteristics of the site as well as the assumptions about the pathways that may lead to human exposures in the future.[16] With the aid of this manual, and supporting documentation available from Argonne National Laboratory and the EPA, you will then be able to explore more deeply the realism and support for the assumptions made by the site operator, and to modify information as needed. Chapter Three will discuss in more detail how to make use of the site operator's information to setup your own RESRAD runs while Chapter Four will touch upon suggestions for how to interpret and make use of your results.

Section 1.3 - What RESRAD won't do

Before turning to what RESRAD can do, it is important to note what RESRAD cannot do, even with the updated dose conversion factors. First, RESRAD can only predict doses to individuals who actually enter the contaminated site. The doses to offsite individuals, such as neighbors living near the contaminated site, cannot be calculated by RESRAD.[17] This limitation is built into the model due to the assumption that if a person who lives, works, or plays directly on top of the contamination is protected to within regulatory limits, then so too would all offsite individuals. Thus, RESRAD can only be used in cases where institutional control of the site has been lost (i.e., there are no longer fences or guards to keep people out) and cannot be used to predict the impact from contamination on those living near active sites.

The next three limitations of RESRAD relate to the types of exposure pathways it includes. While a great many exposure pathways are accounted for in the program, RESRAD cannot currently predict doses to the embryo/fetus or to a breast fed infant nor can it predict doses arising from swimming in contaminated water. Dose conversion factors relating a woman's intake of radionuclides to the dose received by the embryo/fetus or breast fed infant were published by the International Commission of Radiological Protection in 2002 and 2004.[18] However, these dose conversion factors cannot be used directly in RESRAD because there are not adequate input parameters in the model to account for the exposure of the embryo/fetus or breast fed infant resulting from maternal pathways. If any of these types of exposures are important at your site, they will need to be handled in separate calculations outside of RESRAD program.

Finally, the last major limitation of RESRAD is that it cannot correctly calculate doses to children from external irradiation. Doses from external radiation in RESRAD are calculated using the EPA's Federal Guidance Report 12. In this model, the doses are calculated for the

[16] Throughout this manual we will refer to the "site operator" as the author of the RESRAD runs you are beginning with. These RESRAD runs may, of course, have been created by contractors, regulators, or other scientists without requiring any change to the steps described in this manual.
[17] A version of RESRAD called "RESRAD Offsite" has been developed at Argonne which allows some of these kinds of calculations to be done. RESRAD Offsite, however, will not be discussed in this manual.
[18] ICRP 88 and ICRP 95

average of a 59 kilogram, 160 centimeter tall (130 pound, 5 foot 3 inch) woman and a 70 kilogram, 170 centimeter tall (154 pound, 5 foot 7 inch) man.[19] Updated dose factors for children from the external radiation pathway are not available, even in the ICRP reports or the update to the EPA's FGR 13. In general, the doses to children from external exposures would be expected to be higher than those for adults given the same level of contamination. This increase is due to the smaller size of children, which provides their internal organs less shielding, and due to the fact that they are closer to the ground and thus are in closer proximity to the contamination. Taking these factors into account in detail, however, is quite involved since their importance depends upon the energy of the radiation emitted by the contaminants, and thus the impact is different for different radionuclides.

However, unlike the other limitations mentioned above in this section, a rough estimate of the importance of the effects for external radiation can be determined by making use of a recommendation of the National Council on Radiological Protection (NCRP). In 1999, the NCRP recommended that, for children up to at least 12 years of age, the estimated external dose for adults (i.e., the dose estimated by RESRAD) should be increased by 20 to 40 percent with a best estimate of a 30 percent increase.[20] This correction must be done outside of RESRAD, however, since no such built-in function exists in the program.

Section 1.4 - Getting started.

To download and install a copy of the RESRAD program and the supporting documentation onto your computer follow these seven instructions:

Step One Create a folder you will use for documentation supporting RESRAD, including this manual.

Step Two Download the two official RESRAD manuals from Argonne's website at the following web addresses and store them in the folder you just created

RESRAD 6 Manual
http://web.ead.anl.gov/resrad/documents/resrad6.pdf

RESRAD Data Collection Handbook
http://web.ead.anl.gov/resrad/documents/data_collection.pdf

Step Three After registering, download the latest version of the RESRAD program from http://web.ead.anl.gov/resrad/register2/

- Check top most box (currently RESRAD 6.4)
- Fill in the required information boxes to register
- Click on "Download Selected Codes"
- Save the setup file to your desktop

[19] FGR 12 p. 40
[20] NCRP 129 pp. 56-57

Step Four Launch the RESRAD setup file from your desktop and follow all instructions as prompted. (Note: Do not change the name of the directories that will be created.) Upon completion of the installation you may delete the setup file from your desktop.

Step Five Launch RESRAD 6.4 from the Start menu. Click on the “OK” button in the “About RESRAD” window that first appears. You are now ready to begin.

Chapter Two - Introduction to Important Variables

Section 2.1 - How and where are variables entered into RESRAD?

It is an old adage in computer programs that Garbage In equals Garbage Out, no matter how good your program is. Thus, it is very important to understand how information is supplied to RESRAD by the user. At its most fundamental level, the behavior of the RESRAD model is determined by a set of more than 150 variables describing everything from how much soil is contaminated and what it is contaminated with, to how much water a person will drink from an onsite well or pond. Each of these input parameters have been given a default value by RESRAD's developers at Argonne National Laboratory. While many of the parameters may often be left at the default value when performing calculations, their use should be closely scrutinized to make sure that important site specific differences haven't been overlooked or underplayed by their use.

The value of any parameter in the model can be changed by using popup windows accessed through the "Modify Data" button on the far left of the RESRAD screen. After clicking on "Modify Data," a series of 12 buttons will appear in a new panel.[21] Each of these 12 buttons will, when clicked, launch a popup data entry window in which you can modify the associated parameters. Appendix B gives a brief summary of some of the commonly important variables and details which button, or set of buttons, can be used locate them. Since RESRAD uses the metric system for its variables, Appendix C provides a guide to converting English units into metric units. Finally, we note that a yellow colored background for a parameter in these popup windows means that it is still set at the default value, while a white background denotes that the value has been changed by the user. If you wish to restore the default value for any parameter you can simply push the F6 button on your keyboard while the cursor is in the parameter's data entry box. This will return the parameter to its default value and switch the background back to yellow.

Before going on to discuss the parameters in RESRAD, however, it is important to note that only those variables used by the activated exposure pathways can be modified by the user. Selection among the nine possible pathways included in RESRAD can be made by clicking on the "Set Pathways" button.[22] By default all pathways other than "Radon" are turned on when you begin RESRAD. If one or more of the exposure pathways is not applicable to your site (for example, if your site does not have an onsite pond or lake to supply fish and other seafood), you can deactivate those pathways by clicking on the small square icon next to the pathway's name in the "Set Pathways" window.[23] An exposure pathway that is not currently activated will be indicated by a red slash through the icon. Although not absolutely required, it is typically recommended that radon doses be calculated separately from those of other radionuclides. In other words, the

[21] The 12 modify data buttons are "Soil Concentrations," "Calculation Times," "Contaminated Zone," "Cover/Hydrol.," "Saturated Zone," "Unsaturated," "Occupancy," "Ingestion: Dietary," "Ingestion: Non-Dietary," "Radon," "Storage Times," and "C-14."

[22] The nine exposure pathways are "External Gamma," "Inhalation," "Plant Ingestion," "Meat Ingestion," "Milk Ingestion," "Aquatic Foods," "Drinking Water," "Soil Ingestion," and "Radon."

[23] However, the question of whether a lake or pond might form at your site within the next 100,000 years should be considered before deactivating the "Aquatic Foods" pathway.

radon pathway should only be turned on if all other pathways are turned off.[24] The parameters associated with inactive exposure pathways appear shaded in the popup data windows and cannot be changed by the user until the pathway has been reactivated.

We are now ready to turn to an overview of some of the more important parameters used in RESRAD. The following sections will first highlight the parameters that define the characteristics of the site such as how it is contaminated and how those contaminants will migrate. We will then turn to a discussion of the parameters that are associated with the behavior of people. These so-called exposure factors will be particularly important when trying to calculate doses to children.

Section 2.2 - Calculation times

As noted above, RESRAD can project doses out as much as 100,000 years from the present. However, the program will only go out in time as far as specified by the user. Under the "Modify Data" button you can select "Calculation Times" which will allow you to enter up to nine different specific times at which RESRAD will calculate the dose.[25] While the specific times chosen in this window are important, particularly for some features of the program not discussed in this manual, the most important thing to note is that RESRAD will not calculate doses for times longer than the largest value included in this list. Thus, it is possible that the actual peak dose may be missed if too short a time interval is chosen.

Generally speaking, there is no scientific justification for artificially limiting the time over which dose projections are made. While it is true that uncertainties in variables from climate to human behavior grow significantly over time, it is still important to try and capture the actual peak dose associated with the contaminants present at a given site. This will help to ensure that future generations, even distant ones, are not subjected to unacceptable levels of risk as a result of our activities.[26] As a result, it is usually good practice to make at least one RESRAD run with an upper time limit of 100,000 years just to make sure that the use of a shorter calculation time does, in fact, capture the actual peak dose. If times less than 100,000 years still reveal the true peak dose, then they may be used to help shorten the length of time it takes RESRAD to complete its calculations.

---

[24] Currently RESRAD is not able to calculate radon doses for children even with version 6.4. Radon doses are not calculated using dose conversion factors as is done for all other radionuclides and, instead, the doses are calculated using a model based on information obtained from studies of uranium miners. As such, no child specific parameters for radon doses have been published by the ICRP or by the EPA in its update to FGR 13.

[25] By default, RESRAD calculates doses at 1, 3, 10, 30, 100, 300, and 1000 years. Thus, unless a longer time is added by the user, RESRAD will not calculate doses beyond 1,000 years.

[26] For more information on the problem of intergenerational equity in the context of high-level waste disposal and the need to protect future generations to at least the same level as current individuals see Makhijani and Smith 2005b p. 2-7.

Section 2.3 - Contaminants in the soil[27]

Given the complexity inherent in trying to model the transport of contaminants through the environment, RESRAD makes a number of simplifying assumptions in this regard. The first of these assumptions is that the geology of the site can be represented by a series of between two and eight soil layers, each of uniform thickness. These layers include

- either zero or one layer of clean, uncontaminated soil that resides on top of the contaminated zone
- one layer of contaminated soil in which all radionuclides are uniformly distributed throughout its volume[28]
- between zero and five layers of unsaturated (i.e., dry) soils between the contaminated zone and the water table, and
- one saturated zone into which a well can be drilled (i.e., the water table into which a well can be drilled).

Given its layered structure, this model can be thought of as a wedding cake view of geology. Since each layer of the cake can have its own unique soil properties, this model allows a large number of sites to be represented. At most sites, at least one, and often multiple unsaturated zones will be present between the contaminated zone and the water table, although this is not a requirement. If the contamination is in the saturated zone itself, more complicated measures must be taken to allow RESRAD to model this case. Given that having contaminants start off in the water table is not a common occurrence, we will not discuss it further in this manual.

One important limitation with the RESRAD approach to site characterization is that only a single layer of soil is allowed to be contaminated with radionuclides. If multiple discrete layers of soil are contaminated at your site, then you will need to make several different RESRAD runs and sum their results together. This can become quite complicated and thus should be done with great care. For example, one of the main complications with using multiple runs is that the peak dose in each case may occur at different times so it is not always straightforward to determine how to add the results together to find the actual peak dose. This may occur, for example, if one layer of contaminated soil is close to the surface while another is buried closer to the water table.

A second important limitation with RESRAD's approach is that the contaminated zone is assumed to be uniformly contaminated with each of the radionuclides present. In many cases this type of homogeneous distribution is not a very good approximation for what really exists in the soil. In such a case it is important to ensure that the environmental sampling that was done at

---

[27] For more information see Yu et al. 1993 Sections 30, 39, and 51 (p. 103, 123, and 140-141) and Yu et al. 2001 Sections 2.1.1 and 4.4.2 (pp. 2-2 and 4-19 to 4-20).

[28] The area and thickness of the contaminated zone are used internally by RESRAD in a number of calculations. For example, the dose from external gamma irradiation depends upon how large a volume is contaminated. Another example is that, by default RESRAD, adjusts the fraction of food that a person can grow on top of the contaminated zone based upon its area. As would be expected, the larger the area of contamination, the larger the percentage of a person's food can be grown onsite. (Yu et al. 2001 pp. A-13 to A-17, D-8, and F-4)

your site (i.e., the measurements of radioactivity in soil to be used as inputs to the model) was adequately representative so that a valid estimate for the effective level of contamination can be determined for use in RESRAD. In cases where the distribution of contamination at a site is not well known, it is often useful to conduct a so-called screening calculation in which the highest recorded soil measurement (i.e., the most contaminated sample of soil so far identified), or the highest expected concentration of waste to be disposed of, is used to represent the entire contaminated zone. This is called a screening calculation because, if the dose predicted for such a scenario is still below the regulatory limits by a wide margin, and the number of environmental samples is reasonably large and drawn from many different locations across the site, then it is likely that the true peak dose caused by the actual distribution of contamination in the soil would also meet the regulatory requirements. However, if the screening calculation results in a peak dose that is close to or over the regulatory limit or the adequacy of the sampling program is in doubt, a more detailed site specific analysis may be needed.

One final note regarding soil contamination is that, in addition to predicting doses from a given level of contamination, which is the most common use of RESRAD, the program can also be used to predict so-called Single Radionuclide Soil Guidelines (SRSG). These soil guidelines are site specific limits for the maximum concentration of a radionuclide that can be left in the soil and still have the regulatory dose limits met.[29] These are typically given in the units of picocuries of contaminant per gram of soil. These limits are called "Single Radionuclide" guidelines because the specified limits apply only when that one contaminant is present in the soil alone. If multiple contaminants are present simultaneously, as is often the case, the soil guidelines derived by RESRAD can still be used, but they must be combined so that the sum of all contaminant concentrations relative to the Single Radionuclide Soil Guidelines remain below the regulatory limit. This can be done by using what is known as the sum-of-fractions rule which is discussed in greater detail in Section 3.3.3.

When RESRAD is being used to derive Single Radionuclide Soil Guidelines, the concentration of the various radionuclides in the soil assigned by the user is not important so long as it is not zero. Thus, the initial soil concentration of each radionuclide present at your site may often be set by the site operator to an arbitrary level such as 1 picocurie per gram (pCi/g). In such a case, the adequacy of the site's environmental sampling program discussed above is still relevant, but it is now relevant in determining how the amount of contamination measured in the soil compares to the RESRAD derived soil guidelines and whether the sum of fractions for multiple contaminants remains below the limit of one. See Section 3.3.3 for an explanation of the sum of fractions concept. In other words, if the sampling program is not adequate to ensure that the measurements of the radioactivity in the soil are truly representative of the entire site, then these measurements cannot be used to demonstrate compliance with the regulatory limits regardless of how RESRAD is used.

[29] In RESRAD the dose limit used to set the soil guidelines is specified under the "Soil Concentrations" button on the "Modify Data" window. The "Basic Radiation Dose Limit" may be set in the upper right hand side of this popup window. By default, the dose limit is set to 25 millirem per year (see Appendix A).

Section 2.4 - Distribution coefficients (K_d)[30]

Perhaps the most complicated problem a program such as RESRAD has to deal with is how to model the transport of contaminants through the soil and into the groundwater. In order to allow the program to run at a reasonable speed on personal computers, RESRAD uses a fairly simplified transport model that is described by a small number of constants. These constants describe the soil properties and the ease with which particular radionuclides can dissolve into the water and move down through the different soil layers (i.e., down through the contaminated and unsaturated zones) and ultimately into the water table (i.e., the saturated zone). While the RESRAD transport model is widely used in performing environmental assessments, it cannot directly handle such real world problems as

- reactive transport where contaminants react chemically with each other and with chemicals found in the soil and groundwater during transport, or
- the impact of plants, animals, and microorganisms that may change the chemical or physical properties of the radionuclides or soil over time, or
- the complicated flow of water through cracks and fractures in rock, or
- transport pathways such as colloid mediated transport where the contaminants don't dissolve into the water, but are carried along by tiny particles that are suspended in ground or surface water.[31]

If these kinds of more complicated transport phenomenon are important at your site, it may be necessary to use a more sophisticated model than RESRAD. However, in many cases it is possible to find suitable parameters to adequately characterize a site within RESRAD, at least with respect to making regulatory decisions.

By far, one of the most important parameter that governs the movement of contaminants through the soil is the so-called distribution coefficient (K_d), also called the partition coefficient. The distribution coefficient measures the strength with which a contaminant will adsorb onto the soil under a given set of chemical conditions and soil properties. More specifically, the distribution coefficient relates the concentration of a contaminant adsorbed onto the solid phase (i.e., the concentration of the radionuclide adsorbed onto the soil) to that dissolved into the liquid phase (i.e., the concentration of the radionuclide that is dissolved into the water and that is thus moving down through the soil towards the water table).[32] As such the distribution coefficient is defined as

$$K_d = \text{concentration in the soil (pCi/kg)} / \text{concentration in the water (pCi/L)}$$

[30] For more information see Yu et al. 1993 Section 32 (pp. 105-113) and Yu et al. 2001 Section 4.4.3 and Appendices E and H (pp. 4-21 to 4-22, E-1 to E-28, and H-1 to H-14).
[31] See Smith and Amonette 2006 for a further discussion of the complexities involved in trying to model the transport of radionuclides through the environment.
[32] EPA 1999 pp. 2.16 to 2.18

This definition for K_d gives it the units of liters per kilogram (L/kg) or, equivalently, cubic centimeters per gram (cm^3/g).[33] The later unit is the one used by RESRAD, but that is not important since they are interchangeable. With this definition, a large value for K_d implies that the radionuclide is tightly bound to the soil and will migrate slowly compared to the speed with which water moves through the soil, while a small value implies the opposite behavior. In other words, a large value of K_d implies that the concentration of the radionuclide remaining adsorbed to the soil is large compared to the concentration that dissolves into the water and vice versa for a small value of the distribution coefficient.

One of the main drawbacks of the K_d approach is that the value of the distribution coefficient is highly dependent upon the local chemical and physical properties of the soil which may vary greatly across a contaminated site.[34] Despite this variation, however, the constant K_d approach, in which a single value for the distribution coefficient is selected to represent the entire site, is one of the most important transport models used today due to its relative simplicity.[35] This is the type of transport model used by RESRAD, so only a single value for K_d can be specified for each of the soil layers in the wedding cake (i.e., contaminated zone, unsaturated zone(s), and saturated zone).[36] No K_d value may be specified for the layer of clean cover soil since radionuclides are assumed to only migrate downward as water from the surface percolates down towards the water table. The only upward movement of contamination modeled in RESRAD is associated with the physical mixing of soil.

Given the sensitivity of the distribution coefficient to soil and water conditions it is very important that site specific analyses in RESRAD use site specific values of K_d, and that these values be based on a suitably wide range of measurements to ensure that the soil being studied is truly representative of the entire site. This was also the conclusion reached by the EPA in 1999 when they noted that

> It is important to note that soil scientists and geochemists knowledgeable of sorption processes in natural environments have long known that generic or default partition coefficient values found in the literature can result in significant errors when used to predict the absolute impacts of contaminant migration or site-remediation options. Accordingly, one of the major recommendations of this report is that for site-specific calculations, partition coefficient values measured at site-specific conditions are absolutely essential.[37]

The EPA went on to note that, not only are the number of samples taken and where they were taken from important, but also how the value of K_d is measured for these samples must be carefully considered when performing site specific analyses. Specifically, the EPA noted that there are five common methods for measuring K_d and that

> Each method has advantages and disadvantages, and perhaps more importantly, each method has its own set of assumptions for calculating K_d values from experimental data.

---

[33] 1 milliliter (mL) = 0.001 liters (L) = 1 cubic centimeter (cm^3)

[34] EPA 1999 p. 2.1. For a further discussion of the limitations inherent in the constant K_d approach see Smith and Amonette 2006 pp. 7-9, 11-12, and 25.

[35] EPA 1999 p. iii

[36] Yu et al. 2001 pp. E-5 to E-17

[37] EPA 1999 p. iii (emphasis in the original)

> Consequently, it is not only common, but expected that K_d values measured by different methods will produce different values.[38]

Two examples will serve to highlight the problem with using "generic or default partition coefficient values" as noted by the EPA. First, we note that the values for the K_d of uranium measured at different pH values ranging from acidic (pH 5) to basic (pH 9) show a variation between the smallest and largest values of more than 6,000 to 10,000 times with a maximum spread of 625,000 times at a slightly basic pH of eight.[39] In other words, even for a given chemical environment, in this case a specific value of pH, different measurements of the distribution coefficient of uranium found values for K_d that were thousands of times different from each other and in one case hundreds of thousands of times different. Thus, the use of a mean value for the K_d of uranium would clearly not be adequate to capture the observed variability in these measurements of the distribution coefficient of uranium.

A second example highlighting the concern over using "generic or default" K_d values can be found in the case of radium. While the EPA does report geometric mean values, which have, in turn, been cited in the RESRAD *Data Collection Handbook* and used in the program, these average values were based on a very small number of measurements.[40] Specifically, the geometric mean values for radium were based on only three measurements for sandy soil, three measurements for silty/loamy soil, eight measurements for clay, and just one measurement for organic material. Despite the small number of samples, however, the variation among these measurements still ranged from more than 80 times between the largest and smallest measurements of K_d in clay to nearly 420 times for measurements of K_d in silty/loamy soil.[41]

Any RESRAD run which is meant to reflect a site specific projection of future doses that uses either the default K_d values or the geometric mean values summarized in Table 32.1 of the RESRAD *Data Collection Handbook* should be viewed with particular skepticism. In a case where the default or geometric mean values are being used, you may want to explore the implications of raising and lowering the values chosen for the distribution coefficient as you begin making your own RESRAD runs. These changes can affect both RESRAD's water dependent pathways such as drinking water and irrigation of crops and its water independent pathways such as soil ingestion or external gamma radiation. **If the water dependent pathways are important at your site, then a lower K_d will typically result in earlier, and larger doses since the contaminants will be less strongly bound to the soil and thus move more rapidly towards the water table. On the other hand, at sites where water independent pathways**

---

38 EPA 1999 p. 3.1

39 For example, the K_d values measured for uranium in samples at a pH of 8 ranged from a minimum of 0.4 cm^3/g to a maximum of 250,000 cm^3/g. (EPA 1999b p. 5.75)

40 The geometric mean is a way of averaging a set of values that does not weight very large or very small values as strongly as a traditional average (also known as an arithmetic mean). A geometric mean is found by multiplying all the values together and then raising that product to the $1/n^{th}$ power where n is the number of values you are averaging. For example, the geometric mean of 1, 10, and 100 is $(1 \times 10 \times 100)^{(1/3)} = (1{,}000)^{(1/3)} = 10$ while its arithmetic mean is $(1+10+100)/3 = (111)/3 = 37$.

41 For example, the three K_d values measured for radium in sandy soil used to derive the geometric mean value reported in Table 1 ranged from a minimum of 57 cm^3/g to a maximum of 21,000 cm^3/g. The geometric mean value of these measurements was 500 cm^3/g. Thus, the actual values for K_d, even in this data set of three measurements, could be as much as nine times smaller to 42 times larger than the average. (EPA 2004 p. 5.66)

are important, a higher K_d value will typically result in higher doses since less of the radionuclides will be washed out of the contaminated zone over time.

To help you recognize when these types of generic values are being used, Table 1 reproduces the default and geometric mean values for the distribution coefficient of radionuclides of common concern at Department of Energy sites.[42] It is important to note that the distribution coefficient is a chemical property, and thus depends only on the type of contaminant and not on its isotopic number. As such, the user must ensure that all isotopes of a given chemical (for example uranium-234, uranium-235, and uranium-238) all have the same value for K_d in a given soil layer since RESRAD makes no check of these values for consistency. This can be done by checking the distribution coefficient values for all isotopes of a given chemical (like uranium) in the "Soil Concentrations" popup window by highlighting the isotope and clicking on the "Transport" button (see Appendix B).

[42] The Environmental Science Division at Argonne, in collaboration with the Department of Energy's, Richland and Chicago Operations Offices, has published human health factsheets on 76 different isotopes that it believes are of potential long-term concern at Department of Energy sites. (DOE 2007) Of these isotopes, we chose 25 that are among the most common contaminants of greatest concern at many sites (Am-241, C-14, Cs-134, Cs-135, Cs-137, H-3, I-129, I-131, K-40, Np-237, Pa-231, Po-210, Pu-238, Pu-239, Pu-240, Pu-241, Ra-226, Ra-228, Sr-90, Tc-99, Th-230, Th-232, U-234, U-235, and U-238). In Table 1, we group these isotopes together into the 20 chemical elements shown because the partition coefficient depends only on the type of chemical element and not on its specific isotope.

Table 1: RESRAD default and geometric mean values for the distribution coefficient (K_d) for elements of common concern at DOE sites and their daughter products. All values are given in cm^3/g.[43]

Element	Sand (geometric value)	Silt / Loam (geometric value)	Clay (geometric value)	Organic (geometric value)	RESRAD Default
Actinium	450	1,500	2,400	5,400	**20**
Americium	1,900	9,600	8,400	112,000	**20**
Bismuth	100	450	600	1,500	**0**
Carbon	5	20	1	70	**0**
Cesium	280	4,600	1,900	270	**4600[(a)]**
Francium	n.a.	n.a.	n.a.	n.a.	**n.a.**
Iodine	1	5	1	25	**0.1**
Lead	270	16,000	550	22,000	**100**
Neptunium	5	25	55	1,200	**0**
Plutonium	550	1,200	5,100	1,900	**2,000[(a)]**
Polonium	150	400	3,000	7,300	**10**
Potassium	15	55	75	200	**5.5**
Protactinium	550	1,800	2,700	6,600	**50**
Radium	500	36,000	9,100	2,400	**70**
Strontium	15	20	110	150	**30[(a)]**
Technetium	0.1	0.1	1	1	**0**
Thorium	3,200	3,300	5,800	89,000	**60,000[(a)]**
Tritium	n.a.	n.a.	n.a.	n.a.	**0**
Uranium	35	15	1,600	410	**50[(a)]**
Yttrium	170	720	1,000	2,600	**720[(a)]**

Sources: EPA 1999b Table J.3; EPA 2004 Tables 5.6, 5.15, 5.22, 5.28, 5.77, Yu et al. 1993 pp. 110-112, and Yu et al. 2001 pp. E-10 to E-13

(a) In each of these five cases, the RESRAD default K_d value is larger than at least one of the geometric mean values summarized by the EPA.

Section 2.5 - Water infiltration.[44]

The previous section discussed at some length the constant K_d model used by RESRAD to predict how radionuclides move through the soil. In addition to the distribution coefficient, another important set of variables that determine how quickly radionuclides will migrate through the environment are those that specify how much water will flow from the surface down through the soil and into the water table each year. Since the water that penetrates down into the soil is responsible for moving the contamination towards the groundwater, specifying this parameter accurately is very important.

[43] Yu et al. 1993 pp. 110-112 and Yu et al. 2001 pp. E-10 to E-13

[44] For more information see Yu et al. 1993 Sections 9, 10, 11, and 12 (pp. 67-82) and Yu et al. 2001 Section 2.2.4.2 and Appendix E (pp. 2-9 to 2-12 and E-1 to E-28)

In RESRAD, the amount of water that infiltrates the soil is specified by four variables. These parameters are "Precipitation" and "Irrigation," which together specify the total amount of water that falls upon the soil in a year, and the "Evapotranspiration coefficient" and "Runoff coefficient," which specify how much of that water is lost to evaporation and runoff and, thus, how much is left to percolate down into the soil. The default values for "Precipitation" and "Irrigation" are 1.0 meters per year for total precipitation (rainfall, snow, etc.) and 0.2 meters for irrigation. For comparison, these default values are equivalent to about four inches of water per month. The default values for the "Evapotranspiration coefficient" and "Runoff coefficient" are 0.5 and 0.2. In other words, this means that 50 percent of the water that falls on the soil is assumed to be evaporated and returned to the air before it can penetrate into the soil while an additional 20 percent of the water runs off before it can penetrate the soil. Taken together these two default values means that just 40 percent of the water from "Precipitation" and "Irrigation" which falls onto the ground will manage to infiltrate the soil and begin moving towards the water table.[45]

A complication in this area arises because RESRAD allows only one layer of clean cover soil to be specified in the model. However, for many sites there may be multiple layers of different types of clean soil overlaying a contaminated region. Or, in the case of waste disposal sites, the waste may be placed under an engineered cover such as a layer of concrete or compacted clay which is meant to minimize the amount of water that reaches the waste from above. While such situations cannot be handled directly in RESRAD, these sites can still be analyzed with the aid of an additional computer program.

One program used commonly in such cases is the Hydraulic Evaluation of Landfill Performance (HELP) program developed by the U.S. Army Corps of Engineers.[46] While the use of this model is outside the scope of the present work, we note that the HELP program can be used to predict the total amount of water that will infiltrate through more complicated types of cover systems. With the information supplied by the HELP model, the four RESRAD input parameters can be chosen so that the amount of water infiltrating the soil in RESRAD is the same as that predicted by the HELP program. If unusual values for precipitation, irrigation, evapotranspiration, or runoff are being used by your site operator, it is possible that some type of outside modeling has been used to predict the rate of water infiltration and this information has been used to set the parameters in RESRAD. If such is not the case, however, these four parameters should be consistent with local meteorological conditions and agricultural practices.

---

[45] The total amount of water that will percolate down into the soil is equal to the sum of the precipitation rate and the irrigation rate times one minus the evapotranspiration coefficient times one minus the runoff coefficient. You must use one minus the evaporation and runoff rates in order to get the percentage that will not evaporate or runoff and thus the percentage that will infiltrate into the soil. For example, the RESRAD default values would give you (1.0 meters per year + 0.2 meters per year) x (1.0 - 0.5) x (1.0 - 0.2) = 1.2 meters per year x 0.40 = 0.48 meters per year (19 inches per year).

[46] See Hydraulic Evaluation of Landfill Performance (HELP) program at http://el.erdc.usace.army.mil/elmodels/helpinfo.html.

Section 2.6 - Erosion of the cover and contaminated zones[47]

In addition to the transport of radionuclides through water, RESRAD also allows for the cover and contaminated soil to erode away and be transported off site. Unlike transport through the water, however, once the contaminated soil is eroded, RESRAD no longer considers it to have any potential impacts. In other words, once a piece of contaminated soil is eroded in the model, it is assumed by RESRAD to have been entirely removed from the site and thus no longer able to contribute to the dose. This is due to the fact that only doses to an individual who spends her or his time on top of the contamination is being considered and that, while the eroded contamination still exists and can cause harm to offsite individuals, RESRAD assumes that once it has been removed from the site it is no longer of concern to the individual being considered.

One area where the assumption that eroded soil is no longer of concern to the onsite individual is particularly questionable is in the transport of contaminants via runoff into the surface water. For example, at Los Alamos National Laboratory, it is know that erosion of soil during rain storms is one of the primary mechanisms by which long-lived contaminants like plutonium are migrating through the canyons towards the Rio Grande river.[48] While RESRAD does include the possibility of drinking contaminated surface water or eating contaminated fish from an onsite pond, the only transport pathway in the program by which radionuclides can reach the surface water is for them to first migrate down into the groundwater and then travel along the water table to where the groundwater feeds into the pond.[49] If direct erosion of contaminated soil and its movement via runoff into the surface water is important at your site, then this exposure pathway will have to be handled outside of the RESRAD program.

How rapidly soil is removed by erosion will depend in detail on the types of erosion at your site (light rain, wind, flash floods, etc.) as well as the properties of the soil, the types of vegetation that grows on top of it, and the type of animals that move on or through it. Given the uncertainties in predicting future climate states and future land use patterns, the possibility that erosion will uncover soil contaminated with long-lived radionuclides at some point in the future should be carefully considered.[50] For example, in the Draft Environmental Impact Statement supporting the low level waste classification rule, the Nuclear Regulatory Commission recommended that erosion rates between 0.00015 and 0.001 meters per year (0.006 to 0.04 inches per year) be used for generic analyses of shallow land disposal sites.[51] This range is consistent with the observed long-term erosion rates found in semi-arid climates.[52] The RESRAD default erosion rate is equal to the upper end of this range (0.001 meters per year). In other words, the default value assumes that it would take 1,000 years for one meter of soil to be removed by erosion.

---

[47] For more information see Yu et al. 1993 Section 14 (pp. 84-85) and Yu et al. 2001 Section A.2.1 (pp. A-8 to A-13).

[48] Smith and Amonette 2006 pp. 22-24

[49] Yu et al. 2001 pp. 2-9 to 2-12 and E-26

[50] For details on an example involving erosion at the Waste Control Specialists proposed low-level waste disposal facility in Texas see Makhijani and Smith 2005 pp. 11 – 16.

[51] 10 CFR 61 DEIS 1981 p. M-16 to M-18

[52] The range of erosion rates cited for normal slopes in semi-arid climates is 0.0001 to 0.001 meters per year (0.004 to 0.04 inches per year). (Saunders and Young 1983 pp. 493-497)

Section 2.7 - Exposure factors

After predicting how the contaminants will move through the environment, RESRAD must then determine how an individual will be exposed. As noted above, the possible pathways will be determined by the type of exposure scenario being used at your site (i.e., resident farmer, suburban housing development, children's playground, etc.). Once the pathways are determined, RESRAD must know how big each of the different types of exposures will be. In other words, how long will a person remain standing over soil contaminated with gamma emitting radionuclides, how much contaminated soil, food, or water will they ingest, how much contaminated dust or radon will they breath in, and so on. Taken together, the set of parameters that specify these details are known as "exposure factors."

In addition to changing the dose conversion factors (see Section 3.1.2), the most important parameters to change in order to determine the doses to children are the exposure factors. This is because children will, in general, consume, inhale, and act differently than the 154 pound "Reference Man" for whom most of the RESRAD default values were chosen. While choosing appropriate exposure factors is a complicated task and one that should explicitly take into account local customs, traditions, and climate, the Environmental Protection Agency has published a collection of recommendations for most exposure factors of interest.[53] They have, in addition, collected the information from these works relating to children, and have issued a *Child-Specific Exposure Factors Handbook* as well.[54]

One complication that arises when using these recommendations, however, is that the age ranges and units chosen by the EPA in its handbooks do not always match those chosen by the ICRP or EPA for the age specific dose conversion factors. Thus the EPA recommendations for exposure factors are, at times difficult to use in RESRAD. This difficulty is compounded by the fact that different studies were often conducted using different methodologies and were conducted at different times so comparing their results and selecting the value most likely to adequately represent a particular site becomes increasingly difficult. As a result, IEER has chosen only to summarize one set of recommendations for child exposure factors in most cases.[55] Our overall recommendation in this section is the same as that for the distribution coefficient or other important parameters, namely that default or generic values should be carefully scrutinized when used in site specific analyses and should be avoided where possible.

Section 2.7.1 - Occupancy of the site[56]

As noted above, RESRAD only calculates doses to individuals that reside directly on top of the contaminated soil. However, since most people do not spend their entire day in one location,

---

[53] EPA 1997
[54] EPA 2008
[55] For additional discussion of exposure factors for children see (Smith 2005 pp. 10-14) and (Makhijani, Smith, and Thorne 2006 pp. 16 and 35-40).
[56] For more information see Yu et al. 1993 Sections 28 and 29 (p. 101-102) and Yu et al. 2001 Section A.2 (pp. A-6 to A-8).

RESRAD allows you to specify both the fraction of the day spent indoors onsite and outdoors onsite. Whatever fraction of the day is not accounted for is assumed to be spent offsite away from the contamination, and thus not to contribute to the total dose. The time spent indoors and outdoors onsite are specified independently because the types of exposures experienced inside and outside a house are generally different. For example, inside the house you would be shielded from some of the gamma radiation coming from the contaminated soil which means that the external dose would be smaller than it would be when you were outside the house. On the other hand, radon and its daughters tend to concentrate inside a house since it has less air circulation than outside resulting in larger radon dose indoors.

These occupancy factors may be an important factor to change when considering exposures of children since they may spend either more or less time onsite than adults depending upon the type of scenarios being considered and that time may be spent in different proportions inside versus outside. For example, in the case of resident farmers, infants may spend all day onsite with most of that time spent indoors. On the other hand, in the case of a children's playground, the fraction of the day spent onsite may be only a few hours, and it would not include any time spent indoors. The default values used by RESRAD assume a residential scenario with 50 percent of the person's time (12 hours) spent indoors onsite, 25 percent (6 hours) spent outdoors onsite, and the remaining 25 percent spent offsite.

Section 2.7.2 - Food and drink[57]

For agricultural scenarios, the specification of how much food and water will be consumed by an individual is clearly very important to determining the dose. These parameters are also ones that will almost certainly have to be changed in order to calculate doses to children given their smaller size and different eating patterns compared to adults. In addition, these exposure factors are also likely to vary in important ways from site to site due to regional and cultural differences in diet. Table 2 below summarizes the default values for food and drink used by RESRAD.

Table 2: Default values used by RESRAD for the amount of food and drink consumed by an individual in scenarios with onsite food and water production.

Consumption Parameter	RESRAD Default (metric units per year)	RESRAD Default (English units per day)
Fruits, vegetables and grain	160 kg/yr	0.97 lbs/day[(a)]
Leafy vegetable	14 kg/yr	0.085 lbs/day
Meat and poultry	63 kg/yr	0.38 lbs/day
Fish	5.4 kg/yr	0.033 lbs/day
Other seafood	0.9 kg/yr	0.0054 lbs/day
Milk	92 liters/yr	8.5 fl oz/day
Drinking water	510 liters/yr	47 fl oz/day

(a) This is roughly equivalent to the weight of a small banana and bowl of cereal at breakfast, a sandwich and potato chips at lunch, and a serving of rice with dinner.[58]

[57] For more information see Yu et al. 1993 Sections 41, 42, 44, 46, 47, and 52 (pp. 125-128, 131, 133-134, and 142-143) and Yu et al. 2001 Appendix D (pp. D-1 to D-21).

Overall, RESRAD default values assume that roughly one and a half pounds of food (0.67 kilograms) will be consumed per day by an individual. This is primarily composed of fruits, vegetables and grains (71.6 percent by weight), followed by meat and poultry (25.8 percent), and finally fish and other aquatic foods (2.6 percent). To put these numbers in a different context, by default RESRAD assumes that about six ounces of meat or poultry will be consumed each day while just over four ounces of fish or other sea foods are consumed per week. If fish is an important source of dietary protein at your site, these parameters should be changed to reflect the local diet. Recall, however, that RESRAD does not model the erosion of contaminated soil into the surface water, so if this is occurring at your site, you will need to deal with the fish and other surface water pathways outside of RESRAD (see Section 2.6).

With respect to liquids, RESRAD assumes that an individual consumes about four twelve ounce glasses of water and just over one eight ounce glass of milk per day.[59] It is important to note, however, that this default water consumption is significantly below that typically used in screening calculations for adults. For example, the EPA recommends that an ingestion of two liters per day (730 liters per year) be used for such screening calculations. This is more than 40 percent higher than the default value used in RESRAD. Significantly, we note that the higher exposure factor of two liters per day was used by the EPA in setting its drinking water standards for radionuclides.[60]

Turning to milk, it is important to note that this is one of the few foods where children may, on average, consume larger quantities in absolute terms than adults. For example, in Federal Guidance Report No. 13, the EPA assumes that a 10 year old girl will consume more than 70 percent more milk per day than a 20 year old woman (156 liters per year versus 91 liters per year).[61] Thus, this parameter requires special attention in cases where doses from contaminated milk make a significant contribution to the overall peak dose. Among the radionuclides for which milk might be an important pathway are strontium-90, iodine-129, and iodine-131 since these radionuclides are all known to concentrate in milk.

Tables 3 and 4 summarize IEER's overall recommendations for exposure factors that may be used as a starting point for changing these parameters within RESRAD to reflect the doses received by children. In both tables, the values are based on information from EPA's FGR 13 and its 2008 *Child-Specific Exposure Factors Handbook*.[62] While other estimates for the exposure factors can be supported by the information included in these reports, the best values

---

[58] This corresponds to approximately 45 grams for cereal, 120 grams for a banana, 150 grams for a sandwich, 25 grams for potato chips, and 140 grams for rice in a typical day.

[59] In RESRAD, the contaminated drinking water is assumed to come either from a well drilled right next to the contaminated zone or from an onsite pond that has been contaminated via the groundwater pathway. For very small contaminated zones (less than 1,000 square meters (10,800 square feet)) RESRAD can alternately model a well drilled directly into the middle of the contaminated zone. To select this feature, click on the "Saturated Zone" button in the "Modify Data" window and change the "Model for Water Transport Parameters" in the popup window from the default "Nondispersion" to "Mass-Balance." (Yu et al. 2001 pp. 2-10 to 2-11)

[60] 40 CFR 141 Section 66

[61] FGR 13 p. 139

[62] EPA 2008

for use in site specific analyses will take into account local and regional climate, customs, and practices rather than simply relying on country wide surveys and averages. As such we will focus here on these estimates only as starting points for comparison to adult exposure factors and not try to outline factors that are meant for use in site specific analyses.

It is also important to note here that the values in Table 3 represent mean, or average, exposures and, as such, are more reliable than the values in Table 4 which represents exposures at the 95th percentile (i.e., only 5 percent of children would be expected to consume more than the specified level). This is the case because a child who is in the 95th percentile for fruit consumption, for example, may not simultaneously be in the 95th percentile for both vegetable and grain consumption as well, while the values in Table 4 assumes that they are.[63] Despite this caution, the upper percentile values in Table 4 are still useful as a starting point for performing screening calculations where children are involved. As noted in Section 2.3, if the doses in a screening calculation are well below the regulatory limits, even with the use of conservative assumptions like these exposure factors, then it is likely that the actual peak dose will remain below the specified limit. If the dose projections are not significantly below the limits, then more detailed analyses may be required taking into account more site specific information.

[63] For example, the information in Table 4 assumes that an infant (a child up to one year old) would consume more than 1.7 pounds of food per day while a 15 year old would consume in excess of 4.8 pounds of food per day. As such, the combined values are quite high in each age group.

Table 3: IEER's recommended values for use as a starting point in estimating **average** age-specific exposure factors for food and drink consumption. [64]

Consumption Parameter	Infant	1 year old	5 year old	10 year old	15 year old	RESRAD Default
Fruit, vegetable and grain (kg/yr)[(a)]	66	90	110	130	140	160
Leafy vegetable (kg/yr)[(a)]	0.74	2.3	3.3	4.4	8.1	14
Meat and poultry (kg/yr)[(a)]	10	19	28	36	49	63
Fish (kg/yr)[(a)]	n.a.[(b)]	n.a.[(b)]	28	39	52	5.4
Other seafood (kg/yr)[(b)]	n.a.	n.a.	n.a.	n.a.	n.a.	0.9
Milk (L/yr) [(c)]	130	130	150	170	160	92
Drinking water (L/yr) [(c)]	69	80	190	250	290	510

Note: These values are based on recommendations from the U.S. Environmental Protection Agency and are given on a per year basis for consistency with RESRAD.
(a) EPA 2008 Table 8-22, 9-1, 10-1,11-1, and 12-1
(b) No recommendation for the general public provided by the EPA in either FGR 13 or EPA 2008
(c) FGR 13 p. 139

[64] To make these estimates, we used the age ranges from the EPA's *Child-Specific Exposure Factors Handbook* of 0 to 1 years of age, 1 to 2 years, 3 to 5 years, 6 to 11 years, and 12 to 19 years since those were the ones closest to the age ranges used by the ICRP in setting the dose conversion factors. We then used an estimate for the average weight of children in these age ranges to calculate the total amount of food they would consume based on the information supplied by the EPA for each age range on a per kilogram of body mass basis. We chose to use the estimates for consumers only and not for the general public to help ensure that the most important ingestion pathway at contaminated sites is properly identified. Since no separate estimate was given for leafy vegetable consumption, we used other data in the *Handbook* to estimate an appropriate fraction for each age range, and then allocated the total amount of vegetable consumption between the leafy and non-leafy categories used in RESRAD. As noted above, the values in Table 3 for the average exposures are more reliable than these values for exposure at the 95th percentile.

Table 4: IEER's recommended values for use as a starting point in estimating **upper percentile** age-specific exposure factors for food and drink consumption to use in screening calculations..[65]

Consumption Parameter	Infant	1 year old	5 year old	10 year old	15 year old	RESRAD Default
Fruit, vegetable and grain (kg/yr)[(a)]	170	210	270	330	350	160
Leafy vegetable (kg/yr)[(a)]	1.9	5.6	8.3	11	19	14
Meat and poultry (kg/yr)[(a)]	31	45	63	80	110	63
Fish (kg/yr)[(a)]	n.a.[(b)]	n.a.[(b)]	67	110	150	5.4
Other seafood (kg/yr)[(b)]	n.a.	n.a.	n.a.	n.a.	n.a.	0.9
Milk (L/yr) [(c)]	470	310	320	390	460	92
Drinking water (L/yr) [(c)]	240	250	530	670	820	510

Note: These values are based on recommendations from the U.S. Environmental Protection Agency and are given on a per year basis for consistency with RESRAD.
(a) EPA 2008 Table 8-22, 9-1, 10-1,11-1, and 12-1
(b) No recommendation for the general public provided by the EPA in either FGR 13 or EPA 2008
(c) FGR 13 p. 139 and EPA 2008 Table 3-1 and 11-1.

For comparison, we have included in Tables 5 and 6 the recommendations from the 1977 Nuclear Regulatory Commission's *Regulatory Guide 1.109* which provide guidance on how to implement the NRC's regulations governing the protection of individuals from radioactive releases from nuclear facilities.[66] These NRC recommendations are intended for use where no site specific data was available and are extensively cited in the RESRAD *Data Collection Handbook*.[67] As such, the NRC recommendations provide a useful point of comparison when starting to calculate doses to children.

Table 5 contains the NRC recommendations for the *average* amount of food and drink consumed and can thus be compared to our recommendations, based on more recent EPA guidance, in Table 3. Table 6 contains the NRC recommendations for a *maximally exposed* individual, and can thus be compared to our upper percentile values summarized in Table 4. One complication to note, however, is that the NRC only considered three age ranges; namely "Infant" (0 to 1 years old), "Child" (1 to 11 years old), and "Teenager" (11 to 17 years old), and they made few recommendations for the exposure factors of infants.[68] While they are different in many details, the NRC recommendations are, overall, somewhat comparable to those we have made, and thus

[65] See footnote 63 for details of how we arrived at these estimates. For both milk and water consumption, the same fractional increase from the mean to the 95th percentile recommended by the EPA in their 2008 *Handbook* was used to scale the consumption factors given in FGR 13.
[66] NRC 1977
[67] Yu et. al. 1993 pp. 125-128, 131, and 133-134
[68] NRC 1977 p. 1

reinforce the reasonableness of our recommendations based on data from the Environmental Protection Agency.[69]

Table 5: Nuclear Regulatory Commission recommendations from 1977 for the exposure factors to use for an **average** person.

Consumption Parameters	Infant	Child	Teenager
Fruits vegetables and grain (kg/yr)	n.a.	200	240
Leafy vegetable (kg/yr)	n.a.	n.a.	n.a.
Meat and poultry (kg/yr)	n.a.	37	59
Fish (kg/yr)	n.a.	2.2	5.2
Other seafood (kg/yr)	n.a.	0.33	0.75
Milk (L/yr)	n.a.	170	200
Drinking Water (L/yr)	n.a.	260	260

Source: NRC 1977 Table E-4

Table 6: Nuclear Regulatory Commission recommendations from 1977 for the exposure factors to use for the **most exposed** person.

Consumption Parameter	Infant	Child	Teenager
Fruits, vegetables, and grain (kg/yr)	n.a.	520	630
Leafy vegetable (kg/yr)	n.a.	26	42
Meat and poultry (kg/yr)	n.a.	41	65
Fish (kg/yr)	n.a.	6.9	16
Other seafood (kg/yr)	n.a.	1.7	3.8
Milk (L/yr)	330	330	400
Drinking Water (L/yr)	330	510	510

Source: NRC 1977 Table E-5

[69] Comparing the NRC "child" to our 5 year old and the NRC "teenager" to our 15 year old, we find that, for the average exposure factors, the two estimates differ by an average of 15 to 30 percent aside from the consumption of fish and thus they are reasonably consistent. The upper percentile differ by an average of less than 10 to 15 percent, again aside from the consumption of fish.

As a final note, it is important to point out that while the generic terms “meat” and “milk” are used by RESRAD, the default parameters in the program assume that the meat is beef and that the milk is cow’s milk. If you consume other types of meats like deer or rabbit, or if you get milk from something other than a cow (such as a goat), you will want to make sure that these changes have been fully taken this into account. Changing the meat or milk source requires changing several RESRAD parameters including such things as the amount of fodder eaten and water drunk by the animals, how much of that food and water is contaminated (which will be different for game animals), and how much of the contamination an animal eats or drinks ends up in its meat or milk. Making all of the required changes can become fairly involved, and are not discussed in the present work, but these changes need to be made at sites where cattle are not the main source of meat and milk.

Section 2.7.3 - Soil ingestion and pica[70]

In addition to the consumption of contaminated food and drink, RESRAD also includes consumption of contaminated soil. This can be either through incidental means such as dust settling on food or swallowing dirt breathed into the mouth or through intentional means such as a child eating a mud pie. The default value for soil ingestion in RESRAD is 36.5 grams per year. This is equivalent to one-tenth of a gram per day or a volume of dirt about 0.067 cubic centimeters per day using the default soil density in RESRAD. This is equivalent to a speck of dirt just five millimeters (three sixteenths of an inch) in diameter.

The default value for soil ingestion used by RESRAD is the same as one of the EPA’s recommendations to be used for estimating the average incidental soil ingestion of children. However, the EPA also recommends that a value twice as big (73 grams per year) can be used as a more conservative estimate for the average soil ingestion of children given the uncertainty inherent in the available studies. Finally, for screening calculations in which upper percentile values should be used, the EPA recommends the use of a value four times higher than the RESRAD default (146 grams per year).[71]

In addition to the unintentional ingestion of soil, however, there may also be cases where individuals, particularly children, intentionally consume significant quantities of dirt.[72] This behavior, known as geophagia or soil pica, has been found to occur across “geographic, ethnic and cultural boundaries” and has “been noted not to be a rare event.”[73] Estimates for how much soil a child with pica might intentionally ingest or over what number of days a child might display this behavior, have significant uncertainties given the relatively small number of observations that have so far been made. The typical assumptions used in modern dose assessments are that a child will consume between 5 and 10 grams of soil per day during the period in which they experience pica. This range has been adopted by the Environmental

---

[70] For more information see Yu et al. 1993 Section 38 (pp. 120-122) and Yu et al. 2001 Appendix F (pp. F-1 to F-5).
[71] EPA 1997 p. 4-20
[72] For additional discussion of the soil ingestion pathway for children see Smith 2005 pp. 11-14.
[73] Simon 1998 pp. 649 and 659

Protection Agency, the Centers for Disease Control, and the Agency for Toxic Substances and Disease Registry.[74]

For the purposes of screening calculations at sites where soil ingestion is an important contributor to the peak dose, the ingestion of at least 30 to 40 grams of soil per year, occurring on a small number of days due to pica, should be considered in addition to the child's exposure from routine, inadvertent soil ingestion described above.[75] Thus, screening calculations for children should explore the impact of soil ingestion on the order of 176 to 186 grams per year (0.48 to 0.51 grams per day) in order to capture both unintentional and intentional ingestion of soil. If local customs or traditions might lead to larger levels of soil ingestion, then this should also be taken into account.

Section 2.7.4 - Inhalation rates[76]

Finally, in addition to the ingestion pathways, care must be taken to consider the inhalation of gaseous radionuclides such as radon or carbon-14 and the inhalation of contaminated dirt and dust that has been stirred up. How much air individuals breathe in a given amount of time depends strongly upon the type of activities they are doing. The EPA identifies five broad categories into which activities can be broken. These categories are resting, sedentary, light, moderate, and heavy. Resting is "defined as lying," sedentary is "defined as sitting and standing," light activity is "defined as walking at speed level 1.5 - 3.0 mph," moderate activity is "defined as fast walking (3.3 - 4.0 mph) and slow running (3.5 - 4.0 mph)," and heavy activity is "defined as fast running (4.5 - 6 mph)."[77] The mixture of these activities occurring at your site will depend upon what type of exposure scenario is being considered. For example, residential scenarios will, among other types of activities, include periods of sleeping onsite (i.e., a period of resting activity), while playground scenarios would involve higher percentages of light, moderate, and heavy activities and few, if any, periods of resting.[78]

As with the amount of food, water, and soil that will be consumed, the total volume of air that will be inhaled is also very likely to be different for children than adults. Specifically, given the

---

[74] EPA 1997 pp. 4-20 and 4-25 and Simon 1998 p. 661

[75] The soil ingestion pathway is a particular concern when there is contamination with actinides like plutonium, given their typically lower mobility and stronger affinity for adsorbing to soil. Actinides also pose a challenge given their typically inhomogeneous distribution in the soil. This is due to the fact that pica events are acute exposures that occur over a short period of time. In other words, a pica child might consume all 10 grams of soil one day in just one location rather than from many different locations as would be the case for incidental exposures. If the location where the pica child was ingesting the dirt happened to correspond to a hot spot with a higher than average level of contamination, than the child might be more heavily exposed than predicted by the use of annual averages. Such a case would have to be considered outside of RESRAD.

[76] For more information see Yu et al. 1993 Sections 35, 36, and 43 (p. 116-118 and 129-130) and Yu et al. 2001 Appendix B (p. B-1 to B-10).

[77] EPA 2008 Table 6-31

[78] In addition, the amount of contaminated soil that will become resuspended in the air and thus become available to be inhaled will also be affected by the type of scenario chosen. The RESRAD default assumes a resuspension rate applicable to an agricultural setting and may therefore be changed if other uses of the site are envisioned. This parameter is set under the "Occupancy" popup window and is called "Mass loading for inhalation." (Yu et al. 1993 p. 116-117)

smaller size of their lungs, among other differences, children will, on average, be expected to inhale less air than adults in circumstances where they are doing comparable types of activities. The RESRAD default value for the inhalation rate is 8,400 cubic meters per year or 0.96 cubic meters per hour. For comparison, this rate is roughly equivalent to the EPA's recommendation for continuous moderate to heavy activity for children or slightly more than twice the EPA's recommended value for use in long-term exposure scenarios for a five year old child.[79]

Table 7 summarizes two sets of EPA estimates for inhalation rates of children derived from different sources. In both cases the values are applicable to chronic, long-term exposure scenarios for average individuals. Upper percentile values useful in screening calculations were reported by the EPA only in their 2008 Handbook and thus only those data are reported in Table 8.

Table 7: EPA recommendations for age-specific inhalation rates for use in chronic / long-term exposure scenarios.

Parameter	**Infant**	**1 year old**	**5 year old**	**10 year old**	**15 year old**	**RESRAD Default**
Inhalation (m^3/yr)[(a)]	1,060	1,900	3,210	5,580	6,530	8,400
Inhalation (m^3/yr)[(b)]	1,760	2,920	3,980	4,530	5,660	8,400

(a) FGR 13 p. 139
(b) EPA 2008 Table 6-1

Table 8: EPA recommendations for 95th percentile age-specific inhalation rates for use in screening calculations.

Parameter	**Infant**	**1 year old**	**5 year old**	**10 year old**	**15 year old**	**RESRAD Default**
Inhalation (m^3/yr)[(a)]	2,700	4,670	5,910	6,830	9,010	8,400

(b) EPA 2008 Table 6-1

[79] EPA 2008 Tables 6-1 and 6-2

Chapter Three - Preparing your own RESRAD run.

As noted above, the goal of this manual is not to try to allow you to begin from scratch and to develop your own site model and RESRAD runs starting from a blank slate. Such a task is very time consuming and requires significant amounts of information regarding the geology, meteorology, and other physical properties of the site, as well as how much contamination is in the soil and where it is located. The goal for this manual is, instead, for it to be used where your site has already chosen to use RESRAD in support of regulatory decisions, and thus where a RESRAD template has already been created by your site operator which you can modify. In these cases, you will be able to begin with the parameter values chosen by the site operator and to adjust only those necessary to take into account the doses to children or to explore the site operator's use of default or generic values. This chapter will show you how to setup your own RESRAD runs starting from the information provided by the site operator and how to access the updated dose conversion factor libraries provided in version 6.4 of the RESRAD program.

Section 3.1 - Creating your own RESRAD run.

As noted throughout the discussion in Chapter Two, the use of default or generic values for important parameters like the distribution coefficient should be closely scrutinized to ensure that the values being used are appropriate to the site being investigated. In official reports in which RESRAD is being used to justify a regulatory decision, the authors should specify which parameters they have changed from their default values and what the justification is for their choice in each case. The authors should also note whether they consider their work to be a screening calculation, in which more conservative values should be chosen, or whether they are trying to use average or representative values.

Regardless of what type of calculation you are interested in, the first step in creating your run will be to launch RESRAD and to save the site file as a new document. After starting ResRead, select the "Save As" option under the "File" menu and give your site profile a name. This will be saved as a .RAD file into RESRAD's user files directory (My Computer → Local Disk (C:) → Program Files → RESRAD_Family → RESRAD → Userfiles). You should not move this file or save it to another folder since RESRAD can only work with it if it remains in the program's default directory. In the future, you can load this .RAD file into RESRAD by selecting "Open" under the "File" menu.

Now that you have a .RAD file ready, you can begin updating the site parameters as necessary. In order to identify which of the parameters you will need to change in order to recreate the model used by the site operators, the easiest way is to find the RESRAD output files if they have been included in the official reports. When the output files from the site operator are not included in the reports, there will often be a table summarizing the non-default parameter values they chose which can be used instead. If no such summary exists, you may want to contact the site operators and request that they provide you with a list of the non-default parameter values, or preferably, to provide you with a copy of the RESRAD summary report discussed in this section. The specific output file you are looking for is called the summary report, and is given the file name "SUMMARY.REP." In the heading of this file you will find, among other information, the version of RESRAD used as well as the date and time the run was conducted. It will also include the heading “Summary : RESRAD Default Parameters” and give the file name of the RESRAD document used to create it.

We have included a sample summary report in this manual as Appendix D which you can use for practice. By following the instructions in this chapter you should be able to reproduce the output in Appendix D, and to modify the site profile to predict doses to children as well. In setting up your RESRAD run, it is the first three sections of the summary report that will initially be of the most interest. These sections are entitled

- Dose Conversion Factor (and Related) Parameter Summary,
- Site-Specific Parameter Summary, and
- Summary of Pathway Selections

The following will discuss how to read each of these summary report sections and how to use them to create your own RESRAD site file to run.

Section 3.1.1 - Site-specific versus RESRAD default values

The first step in recreating a copy of the RESRAD model run is to select the exposure pathways that are relevant at your site (see Section 2.1). In the summary report under the heading “Summary of Pathway Selections” (which comes just before the pages giving the peak dose information) you will find which of the nine RESRAD pathways have been chosen to be “active” and which have been “suppressed” by the site operator. You can turn on and off these pathways under the “Set Pathways” button on the left side of the main RESRAD screen. If the small icon to the left of the pathway name has a red slash through it, then the pathway is suppressed. If there is no slash, the pathways is active. By default all of the pathways, other than radon, are initially active when RESRAD starts.[80] Once you have selected the appropriate pathways to use at your site based on the site operator’s summary report, be sure to save your .RAD file in RESRAD so you do not lose your work.

Once the active exposure pathways match the example you are working with, you are ready to begin modifying the other RESRAD parameters. A popup window for each variable can be accessed under the “Modify Data” button on the far left of the screen (see Appendix B). Recall that only those variables used by the active exposure pathways can be modified. Variables not being used by the active pathways will appear light grey and cannot be changed. While it will be necessary to change the exposure factors as discussed in Section 2.7 in order to calculate the dose to children, you should begin by first reproducing exactly the set of parameters used by the site operator to ensure that you are beginning from the same place that they ended.

[80] Recall that radon doses should generally be treated in a separate RESRAD run in which it is the only pathway active. In other words, the “Radon” pathway should not generally be turned on when other pathways are in use.

The value for each of the more than 150 parameters used in RESRAD can be found in the summary report under the section entitled "Site-Specific Parameter Summary." This section begins with an entry for the "Area of contaminated zone (m**2)" and continues until the section containing the "Summary of Pathway Selections." For the example summary report included in Appendix D of this manual the "Site-Specific Parameter Summary" spans pages 7 to 14. For each of the variables listed there are two columns labeled "User Input" and "Default" which are the most important for you. If the values in the two columns are the same, then the default value is being used and you do not need to make any changes in your copy of the model. However, if the values in the two columns are not the same, then you will need to change that parameter in your model to reflect the value listed in the "User Input" column. Unfortunately, RESRAD does not indicate the variables in the summary report that have been changed so you must read this table carefully in order to determine which of the parameters you need to work with.

Most of the variable descriptions used in the summary file are easy to identify and correlate with their corresponding parameters in the RESRAD program. For example, "Area of contaminated zone (m**2)" from the summary file has almost exactly the same name as the parameter in the popup window accessed via the "Contaminated Zone" button under the "Modify Data" window. While it may take a little hunting to find where each of these variables is stored in RESRAD, it should be fairly straightforward to make most of these changes (see Appendix B for a list of where the more commonly important variables can be found). One important point to note at this point is that the summary report uses a form of scientific notation similar to that used by programs like Microsoft Excel. For example a value of 17,000 would be reported in the output file as 1.700E+04, while a value of 0.00017 would be given as 1.700E-04.

Recall that when you change a variable's value in the popup windows that it will change from having a yellow background, signifying a default value, to a white background. To restore a variable to its default value, simply hit the F6 button on your keyboard while the cursor is in the variable's data entry box. After making the needed changes in each popup window, be sure to click on the "Save" button to return to the main RESRAD window or else you will lose your work. It would also be wise to save your .RAD file periodically from the "File" menu so that you won't have to make these changes a second time.

Two possible exceptions to the ease of translation between the summary report and RESRAD should be noted, however. These are the concentration of contaminants in soil and the K_d values associated with each radionuclide present. The initial concentration of contaminants in the soil are listed in the summary report as "Initial principal radionuclide (pCi/g): *radionuclide*" where *radionuclide* represents any one of the contaminants present. These radionuclides can be entered into RESRAD under the "Soil Concentrations" popup window (see Appendix B). Units other than picocuries per gram (pCi/g) can be used in RESRAD, but this is the most common unit. The K_d values associated with each of these radionuclides (as well as all their daughter products) are listed later in the summary report under the heading "Distribution coefficients for *radionuclide*." The K_d values in the contaminated zone, the unsaturated zone(s), and the saturated zone for each radionuclide are all listed together in the summary file for each of the given radionuclides. These K_d values can be entered into RESRAD by selecting the desired radionuclide from the "Nuclide Concentration" list under the "Soil Concentrations" popup window and clicking on the "Transport" button (see Appendix B). As noted above, the user must ensure that each isotope of a given substance has the same distribution coefficient in each of the soil layers as all of the other isotopes of that substance since RESRAD makes no such self consistency check for you.

After you have finished translating the information from the site operator's summary report into your .RAD file you should save your work and then make a test run of RESRAD. This will ensure that you have correctly entered all of the information from the site operator by checking to make sure that your results agree with those of the site operator. After saving the .RAD file, click on the icon of the space shuttle on the top row of small buttons (it is the fourth button from the left) or select "Run RESRAD" from under the "File" menu. When RESRAD has finished calculating the doses, it will open a new window with your summary report in it. Section 3.3 will discuss in more detail how to read these results, but for now skip ahead in the summary report to the first page of the "Contaminated Zone and Total Dose Summary" section (for the example report included in this manual that would be page 15). Compare the "Maximum TDOSE(t)" both in terms of its magnitude (i.e., the number of millirem per year) and its timing (i.e., when the peak dose occurs) to those given in the site operator's summary report. For the example included in Appendix D, the peak dose is 48.84 millirem per year and it will occur at 1,221 ± 2 years. While your answer may be slightly different due to rounding inside the computer, if you find a significant difference in either the magnitude or timing of the peak dose you will want to go back and check the parameters you entered to ensure that each value in your "User Input" columns match those from the site operator's summary report.

Once you have proven to yourself that your site profile is the same as that used by the site operator, you should again save the .RAD file and then save a copy of it in the same directory under a different name to use later as a backup and template. This way you will always be able to go back to the template if you want to start over with the original set of assumptions from the site operator and will not have to go through these initial steps again.

Section 3.1.2 - Calculating doses for different age groups

After making the required changes to the active exposure pathways and associated site parameters to match the information in the site operator's summary report, you are now ready to begin modifying your .RAD file to calculate doses to children and to examine the consequences of changing other assumptions used by the site operator. The first step is to change the exposure factors discussed in Chapter Two so that they are appropriate to the age range you are interested in (i.e., infant, 5 year old, etc.). This is one of the most important parts of the process, and great care should be taken when using any of the recommendations from Tables 3, 4, or 7 to be sure that they are reasonable for your site. You should save this .RAD file under a new name that will help remind you which age child you are trying to model. Remember to save this new file periodically to prevent yourself from loosing your work in case of a power failure or computer malfunction.

After making the necessary changes to the relevant exposure factors, the next step is to change the dose conversion factors from those of "Reference Man" (i.e., those from FGR 11) to those appropriate for the child you are modeling (i.e., those from the International Commission on

Radiological Protection). To check that this has not already been done by the site operator you can look in the summary report under the "Dose Conversion Factor (and Related) Parameter Summary" section which immediately follows the table of contents. In the example summary report in Appendix D, this section starts on page 2. In this section, the summary report lists the dose conversion factors for all contaminants in two columns. At the top of the page there will be a heading entitled "Dose Library: *library*" where *library* can be any one of the built-in dose conversion factor libraries or any library created by the user. If the *library* is "FGR 11" then RESRAD is using the "Reference Man" default values. If the *library* is one of the ICRP 72 libraries then the site operator is using one of the built in libraries which contain age specific dose conversion factors.

In order to change which dose conversion factor library you are using, you need to click on the "Change Title" button at the far left of the screen. In the popup window that opens there will be a pull down menu entitled "Dose Factor Library" and it will default to "FGR 13 Morbidity."[81] Under this pull down menu, the six choices of interest in the present work are :

- ICRP 72 (Adult)
- ICRP 72 (Age 1)
- ICRP 72 (Age 10)
- ICRP 72 (Age 15)
- ICRP 72 (Age 5)
- ICRP 72 (Infant)

Each of these libraries contains the age specific dose conversion factors from the International Commission on Radiological Protection as summarized in its publication 72 entitled *Age-Dependent Doses to the Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Coefficients*.[82] These dose factors are comparable in most cases to those from the 2002 update to the EPA's Federal Guidance Report No. 13 (FGR 13 and Suppl.).

After selecting the appropriate dose factor library, you will want to make three other changes to the "Change Title" screen before exiting. First, under "Time Integration Parameters" in the middle right part of the window, change the "Maximum number of points for:" "Risk" from 257 down to 1. This will make your computer run faster and won't cost you anything in accuracy for dose assessments. Second, click on the check box for "Save All files after each run" in the lower left hand corner of the window. Third, in the drop down menu entitled "Cut-off Half Life" change the value from "180 days" to "1 day." This is only needed if iodine-131 or polonium-210 are contaminants of concern at your site, but it will not cause any problems to make this change for all sites. When these three additional changes having been made, click on the "OK" button

[81] RESRAD calls this library FGR 13 since it uses the EPA's cancer risk factors from the 1999 release of Federal Guidance Report 13. However, the dose conversion factors in this library are still those of FGR 11 as noted in Section 2.1. In order to return your RESRAD run to the "Reference Man" model you must reset the dose library in this pull down menu to "FGR 13 Morbidity."
[82] ICRP 72

and then save your .RAD file. Once you have made these changes you will not need to make them again unless you want to switch which age group you are looking at. Otherwise they will remain in effect as long as you use this .RAD file.

Finally, it is important to recall that, for young children, you will need to increase the external dose predicted by RESRAD by 20 to 40 percent, with a best estimate of 30 percent in order to take into account the smaller stature of these children as discussed in Section 1.3. This will have to be done after you make your runs, however, since RESRAD offers no built in function to make this correction. Section 3.3.2 below will discuss where to find the dose from external irradiation in the summary report so that you can increase it after completing each RESRAD run.

Section 3.2 - Running RESRAD

You are now ready to begin making your own RESRAD runs. If you are following along in this manual for the first time, you will have already made one run of RESRAD up to this point in order to check that you accurately entered all of the information contained in the site operator's summary report (or the example summary report included in Appendix D of this manual). For each subsequent run of RESRAD, the procedure is the same. To run the code and make a new prediction of peak dose you can click on the icon of the space shuttle on the top row of small buttons (it is the fourth button from the left) or select "Run RESRAD" from under the "File" menu. Before running the dose simulation, however, you will need to save your .RAD file. If you have made changes since you last saved the file, you will be prompted to save the changes when you try to run the code (you should always click "Yes" to save the changes before running). When RESRAD is finished with its calculations, which may take from a few seconds to a few minutes depending upon the complexity of the site and the speed of your computer, it will open a summary report in a new viewing window for you to examine. Section 3.3 discusses in greater detail how to read and interpret the output in this summary report.

It is important to note at this point, however, that each time you run RESRAD, the file containing the summary report is overwritten. In other words, the previous version of the summary report is lost each time you make a new run. If you wish to save the summary report for a particular run you will need to copy the file "SUMMARY.REP" from the RESRAD home directory (My Computer → Local Disk (C:) → Program Files → RESRAD_Family → RESRAD) into another folder on your computer. It would be good practice to give this summary report file a new name so that you can easily identify what it contains. For example, is your summary report an estimate of dose for infants or 10 year olds, is it a screening calculation or does it use the mean exposure factors and so on. Recall that you must leave the .RAD files in the RESRAD user files directory or the program will not be able to properly make use of them. Only the summary report should be copied into a separate directory.

If you want to go back and look at a summary report after you have closed its viewing window in RESRAD you have two options. If it is the last summary report generated by RESRAD (i.e., if you have not done another run since it was created) you can reopen the summary report within RESRAD either by clicking on the "Results" tab of the "Navigator" window on the right hand side of the main window and then clicking on the "Summary Report" button or by selecting

"Summary Report" under the "View" → "Text output" menu at the top of the screen. If the summary file you wish to view is older (i.e., you have done another run since it was created) you can open the summary report by right-clicking on the .REP file you saved in a folder on your computer and selecting "Open With" → "WordPad." Upon opening the summary report in WordPad, you will notice that it does not appear to be formatted correctly. To fix this, select all of the text in the report by using the "Select All" feature under the "Edit" menu. Next, with the text still highlighted, select "Font" from under the "Format" menu and choose the font "MS LineDraw" from the list on the left. Finally, click on "OK" and the summary report should look much like it did when viewed inside RESRAD. Unfortunately this font change will have to be made each time you open a summary report in the WordPad program and the page breaks of the file may not be the same as when it is viewed in RESRAD.

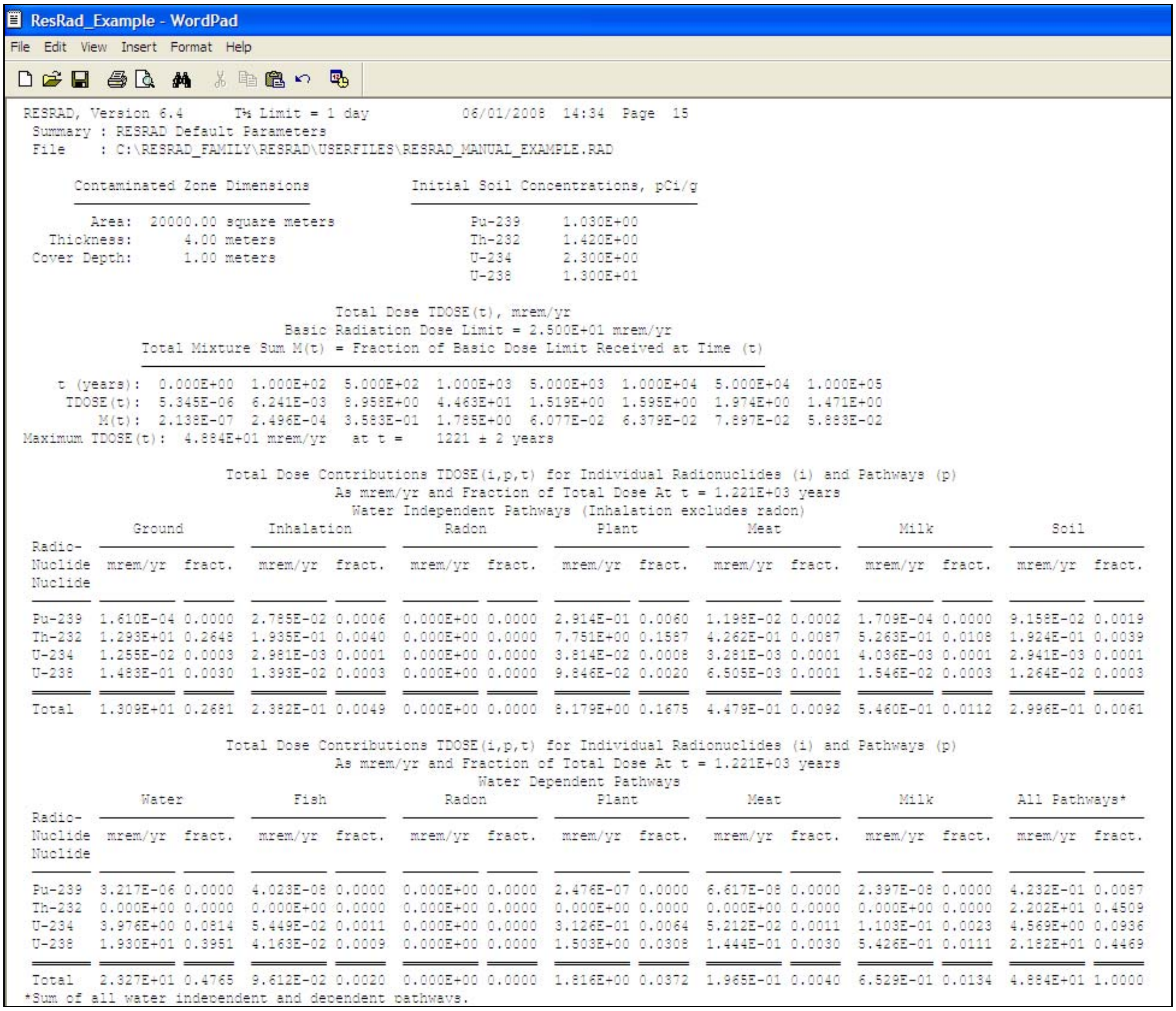
In addition to calculating the doses to children, it is at this point that you can begin to examine the importance of changing other assumptions made by the site operator such as the calculation cutoff time, the distribution coefficients of the various radionuclides, the amount of water infiltration through the cover, and the erosion rate for the cover and contaminated zones (see Sections 2.4 through 2.6). While other characteristics may be important at your site, these parameters are generally among the most important in determining what the peak dose will be. If you have saved a template file containing the site operator's assumptions as recommended above, you should feel free to explore the impact of changing any parameter value in RESRAD since you can always easily restore the site operator's assumptions by reopening the template file you created.

Section 3.3 - Reading the output files and interpreting the results.

RESRAD is a very powerful tool that can be used in many ways not discussed in this manual. As such, the summary and detailed reports RESRAD produces contain a great deal of information, only some of which we will discuss here. As a first use, the pieces of information that will be most valuable to you are the peak dose, when it occurs, and how it is broken down among the various exposure pathways (i.e., external irradiation, inhalation, soil ingestion, drinking water, etc.). In addition you may, in some cases, be interested in the Single Radionuclide Soil Guidelines (SRSG) predicted by RESRAD. The following section will explore each of these pieces of information in turn.

Section 3.3.1 - Exploring the peak dose

We have already encountered the peak dose and the time at which it occurs in Section 3.1.1 (i.e., "Maximum TDOSE(t)"), when doing the initial test run. We will now offer a more detailed examination of this information. Figure 1 below shows a screen capture of the "Contaminated Zone and Total Dose Summary" section from the sample summary report included in Appendix D. In the event that the peak dose occurs at one of the nine specified calculation times (see Section 2.2), then there is no detailed "Contaminated Zone and Total Dose Summary" section and the peak dose summary is included in the "Total Dose Components" section for the specified time of peak dose. In either case the format of the information is the same so we will continue to focus on the first case which is more common.[83]



```
ResRad_Example - WordPad
File  Edit  View  Insert  Format  Help

RESRAD, Version 6.4      T½ Limit = 1 day          06/01/2008  14:34  Page  15
 Summary : RESRAD Default Parameters
 File    : C:\RESRAD_FAMILY\RESRAD\USERFILES\RESRAD_MANUAL_EXAMPLE.RAD

      Contaminated Zone Dimensions          Initial Soil Concentrations, pCi/g

        Area:  20000.00 square meters              Pu-239     1.030E+00
   Thickness:       4.00 meters                    Th-232     1.420E+00
 Cover Depth:       1.00 meters                    U-234      2.300E+00
                                                   U-238      1.300E+01

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

   t (years):  0.000E+00  1.000E+02  5.000E+02  1.000E+03  5.000E+03  1.000E+04  5.000E+04  1.000E+05
    TDOSE(t):  5.345E-06  6.241E-03  8.958E+00  4.463E+01  1.519E+00  1.595E+00  1.974E+00  1.471E+00
        M(t):  2.138E-07  2.496E-04  3.583E-01  1.785E+00  6.077E-02  6.379E-02  7.897E-02  5.883E-02
Maximum TDOSE(t):  4.884E+01 mrem/yr   at t =    1221 ± 2 years

              Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                          As mrem/yr and Fraction of Total Dose At t = 1.221E+03 years
                           Water Independent Pathways (Inhalation excludes radon)
           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.
 Nuclide

 Pu-239  1.610E-04 0.0000 2.785E-02 0.0006 0.000E+00 0.0000 2.914E-01 0.0060 1.198E-02 0.0002 1.709E-04 0.0000 9.158E-02 0.0019
 Th-232  1.293E+01 0.2648 1.935E-01 0.0040 0.000E+00 0.0000 7.751E+00 0.1587 4.262E-01 0.0087 5.263E-01 0.0108 1.924E-01 0.0039
 U-234   1.255E-02 0.0003 2.981E-03 0.0001 0.000E+00 0.0000 3.814E-02 0.0008 3.281E-03 0.0001 4.036E-03 0.0001 2.941E-03 0.0001
 U-238   1.483E-01 0.0030 1.393E-02 0.0003 0.000E+00 0.0000 9.846E-02 0.0020 6.505E-03 0.0001 1.546E-02 0.0003 1.264E-02 0.0003

 Total   1.309E+01 0.2681 2.382E-01 0.0049 0.000E+00 0.0000 8.179E+00 0.1675 4.479E-01 0.0092 5.460E-01 0.0112 2.996E-01 0.0061

              Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
                          As mrem/yr and Fraction of Total Dose At t = 1.221E+03 years
                                          Water Dependent Pathways
           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

 Pu-239  3.217E-06 0.0000 4.023E-08 0.0000 0.000E+00 0.0000 2.476E-07 0.0000 6.617E-08 0.0000 2.397E-08 0.0000 4.232E-01 0.0087
 Th-232  0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 0.000E+00 0.0000 2.202E+01 0.4509
 U-234   3.976E+00 0.0814 5.449E-02 0.0011 0.000E+00 0.0000 3.126E-01 0.0064 5.212E-02 0.0011 1.103E-01 0.0023 4.569E+00 0.0936
 U-238   1.930E+01 0.3951 4.163E-02 0.0009 0.000E+00 0.0000 1.503E+00 0.0308 1.444E-01 0.0030 5.426E-01 0.0111 2.182E+01 0.4469

 Total   2.327E+01 0.4765 9.612E-02 0.0020 0.000E+00 0.0000 1.816E+00 0.0372 1.965E-01 0.0040 6.529E-01 0.0134 4.884E+01 1.0000
*Sum of all water independent and dependent pathways.
```

Figure 1: A screen capture reproducing the "Contaminated Zone and Total Dose Summary" section from the sample summary report included as an example in Appendix D.

The total peak dose from all pathways and the time at which it occurs are both reported roughly one-third of the way down the page as "Maximum TDOSE(t): *peak dose*" and "t = *time* ±

[83] It is somewhat unusual for the peak dose to occur at one of the specified times, unless it is the longest time included in the list of "Calculation Times" (see Section 2.2). In such a case, the true peak dose may not adequately be represented by the RESRAD calculation since its cutoff time is not long enough. If a time less than 100,000 years is used for the longest calculation time you should explore the impacts of lengthening this cutoff. If the peak dose occurs at 100,000 years you cannot increase the cutoff time since RESRAD cannot go out beyond 100,000 years. However, in such a case you should explore the assumptions made about the distribution coefficients, water infiltration rate, and erosion rates to ensure they are realistic and adequately representative of your site (see Sections 2.4 through 2.6).

uncertainty." In the example of Figure 1, the peak dose is 48.84 millirem per year and occurs at 1,221 ± 2 years. It is the peak dose that should first be compared against the regulatory dose limits summarized in Appendix A.[84] For example, the peak dose in our example would be nearly twice the Nuclear Regulatory Commission's limit of 25 millirem per year for the free release of contaminated sites.[85]

To help you practice making the needed changes to calculate doses to children, we have included as Appendix E a modified version of the Reference Man example from Appendix D that calculates the dose for a 10 year old child. In making this new example, we started with the template from Appendix D and first changed the dose conversion factor library to "ICRP 72 (Age 10)." Second, we changed the dietary exposure factors to those summarized in Table 3 leaving the amount of "other seafood" at its default value. Third, we changed the inhalation rate to the EPA's recommendation from FGR 13 (see Table 7). Finally, we changed the amount of soil consumption to the more conservative EPA estimate of 73 grams per year for routine, incidental ingestion (see Section 2.7.3). If you are following along in this manual for the first time, you should be able to repeat these changes without having to refer to the summary file in Appendix E.

When all of these changes have been made, we find that the timing of the peak dose doesn't meaningfully change. The peak dose for Reference Man occurred at 1,221 ± 2 years while the peak dose for the 10 year old occurs at 1,222 ± 2 years. On the other hand, the value of the peak dose increased significantly. Before we can make a final comparison, however, we first need to adjust the dose from external irradiation as mentioned in Section 1.3. Increasing the external dose by 30 percent in agreement with the recommendations of the National Council on Radiological Protection, would add 3.93 millirem per year to the total peak dose of 95.96 millirem per year from this example.[86] With this increase in the external dose to account for the smaller stature of the child, the total peak dose for a 10 year old would be 99.9 millirem per year as compared to 48.8 millirem per year for the default Reference Man. This is an increase of more than 100 percent.

If you find, as we did in our example, that the peak dose estimated for children is significantly larger than that predicted for "Reference Man," this will be important information to use in seeking revisions to the site operator's model. Cleanup standards and licenses for waste disposal units should consider doses to the most vulnerable member of the population, and therefore if you can show the possibility of a significant increase in the projected dose for children at your site, this can be a powerful tool in seeking more protective standards.[87]

---

[84] Most commonly this dose limit will be 25 millirem per year, which is the NRC dose limit for the annual dose from a single nuclear facility.
[85] 10 CFR 20.1402
[86] From the summary report Appendix E we find that the external dose for the 10 year old child is 13.09 millirem per year according to RESRAD (see page 13 of the summary report). Increasing this by 30 percent (per NCRP) would make the new estimate for the external dose equal to 17.02 millirem per year. Section 3.3.2 will discuss in more detail how to interpret the breakdown of the peak dose into the water dependent and independent pathways including the dose from external radiation.
[87] See Makhijani, Smith, and Thorne 2006 for more details on the need to consider the most vulnerable member of society when implementing radiation protection standards.

Section 3.3.2 - Breaking down the peak dose

At sites where contamination will reach the water table, the dose from drinking water should be separately compared to the 4 millirem per year drinking water standard used for most radionuclides by the EPA (see Appendix A). It is important that all cleanup standards include a separate sub-limit of 4 millirem per year to the maximally exposed organ from the drinking water pathway to help ensure that the most restrictive regulatory limit will be used at each site. While RESRAD, even with the updated dose conversion factor libraries in version 6.4, will only give the effective whole body dose, it is still important to compare its projections to the 4 millirem per year organ dose limit

The drinking water dose at the time of peak total dose is reported by RESRAD on the same page of the summary report as the peak dose in the lower left hand portion of the page. It is under the main heading "Water Dependent Pathways" and under the column subheading "Water." The drinking water dose from each radionuclide present is listed individually, and the total dose from the drinking water pathway for all contaminants combined is reported at the bottom of the column. RESRAD also gives you the fraction of the total dose accounted for by drinking water as the second number under that heading. In the example of Figure 1, the dose from the drinking water pathway for Reference Man at the time of peak total dose is 23.27 millirem per year and it accounts for nearly 48 percent of the total peak dose. This dose is significantly higher than 4 millirem, and thus would likely be a cause for further investigation of the drinking water pathway.[88]

In addition to the drinking water pathway, RESRAD breaks down the peak dose into a total of thirteen separate subcategories as can be seen in Figure 1. These include seven water independent categories listed on top and six water dependent categories listed underneath. The water independent categories include such things as the dose received by external irradiation (called "Ground" in this table) and the dose received via ingestion of plants contaminated by radionuclides taken up directly through their roots. The water dependent pathways include such things as drinking contaminated water from a well or eating food crops contaminated by radionuclides in water used for irrigation. In either case, it is important to note that the doses reported for each radionuclide listed in the summary report include all doses from its respective daughter products even if its daughter products are listed separately as a contaminant.

For each of the thirteen water dependent and independent dose pathways listed in the summary report, the fraction of the total dose it represents is given at the bottom of the column allowing you to quickly identify which of these pathways make a contribution to the peak dose and which do not. This information can be very useful when exploring the significance of site specific parameters like the distribution coefficients or erosion rates (see Sections 2.4 through 2.6). Changing these kinds of site parameters may increase the importance of an already important

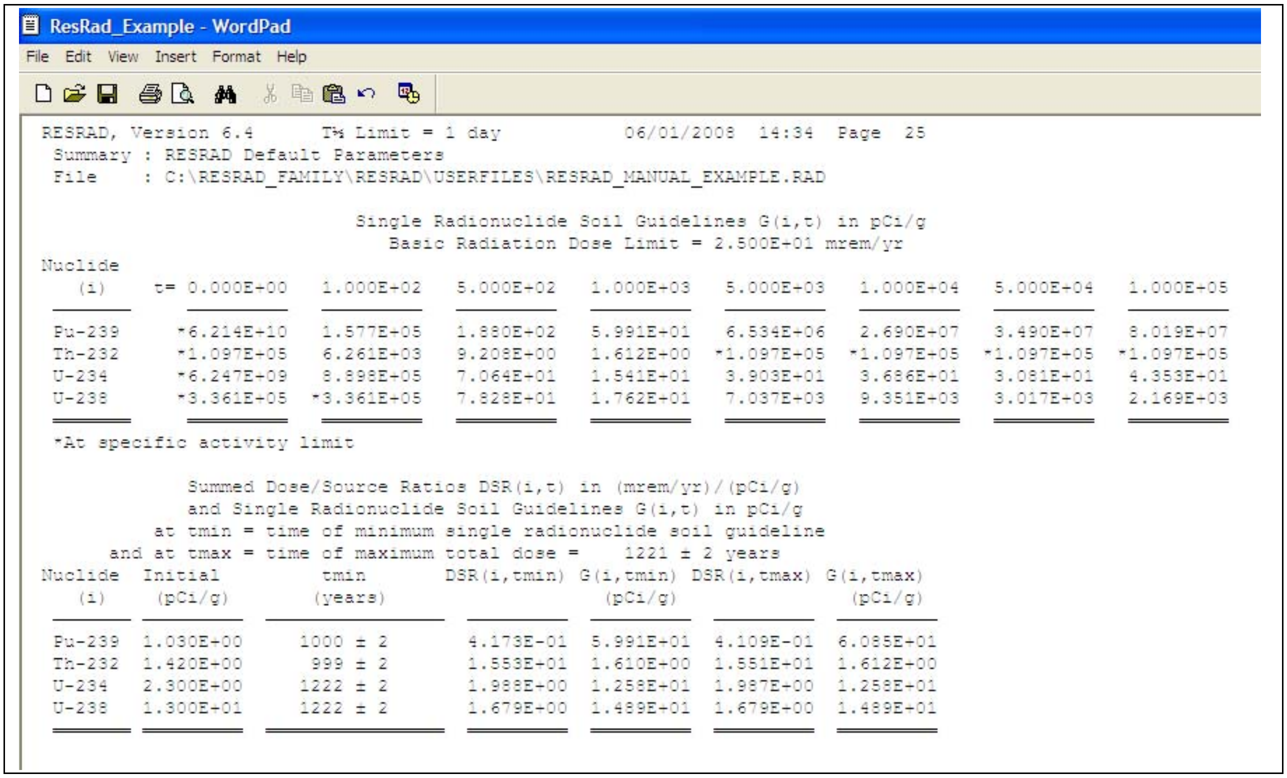
[88] It is important to note that, in our example, the majority of the drinking water dose is attributable to uranium isotopes which are not subject to the 4 millirem drinking water standard. They are covered by a separate EPA regulation that limits the mass of uranium allowable per liter of water rather than limiting the dose that such a quantity of uranium would deliver. (40 CFR 141.66)

pathway (such as drinking water), or it may cause a previously unimportant pathway (such as external irradiation) to suddenly begin making a major contribution to the projected peak dose. In either case, as with showing an increase in the peak dose for children compared to Reference Man, showing an increased dose or a significant change in the pathways contributing to the peak dose can be powerful tools in seeking more protective regulatory limits or cleanup standards at your site.

For the example of a 10 year old child included as Appendix E to this manual, we find that the relative importance of several pathways changed when we moved away from the Reference Man defaults. For example, the dose received from the water independent milk and plant pathways increased by more than a factor of seven (64.31 millirem per year for the 10 year old versus 8.725 millirem per year for the Reference Man). Smaller increases also occurred in the water independent meat and soil pathways and the water dependent milk pathway. On the other hand, the dose from drinking water was more than cut in half for the 10 year old compared to the Reference Man (11.59 millirem per year versus 23.27 millirem per year), although it remains well above 4 millirem. These changes to the dose and its breakdown resulted from the differences in dose conversion and exposure factors for the child compared to the adult. Changing site parameters like the distribution coefficients or erosion rates would result in still further changes to the peak dose and how it is distributed among the various pathways.

Section 3.3.3 - Interpreting the Single Radionuclide Soil Guidelines

Finally, we must discuss how to locate and interpret the Single Radionuclide Soil Guidelines in cases where RESRAD is not being used to predict the peak dose, but is instead being used to set soil cleanup guidelines (see Section 2.3). In these cases, you will not need to examine the summary of peak doses discussed in the previous section. Instead you will want to focus on the second page of the "Single Radionuclide Soil Guidelines" section which appears later in the summary report. For the example included in Appendix D, the section of interest occurs on page 25. A screen capture of this page is reproduced below as Figure 2.



ResRad_Example - WordPad

File Edit View Insert Format Help

RESRAD, Version 6.4   T½ Limit = 1 day   06/01/2008 14:34 Page 25
Summary : RESRAD Default Parameters
File   : C:\RESRAD_FAMILY\RESRAD\USERFILES\RESRAD_MANUAL_EXAMPLE.RAD

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

Nuclide (i)	t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	*6.214E+10	1.577E+05	1.880E+02	5.991E+01	6.534E+06	2.690E+07	3.490E+07	8.019E+07
Th-232	*1.097E+05	6.261E+03	9.208E+00	1.612E+00	*1.097E+05	*1.097E+05	*1.097E+05	*1.097E+05
U-234	*6.247E+09	8.898E+05	7.064E+01	1.541E+01	3.903E+01	3.686E+01	3.081E+01	4.353E+01
U-238	*3.361E+05	*3.361E+05	7.828E+01	1.762E+01	7.037E+03	9.351E+03	3.017E+03	2.169E+03

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose =   1221 ± 2 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pu-239	1.030E+00	1000 ± 2	4.173E-01	5.991E+01	4.109E-01	6.085E+01
Th-232	1.420E+00	999 ± 2	1.553E+01	1.610E+00	1.551E+01	1.612E+00
U-234	2.300E+00	1222 ± 2	1.988E+00	1.258E+01	1.987E+00	1.258E+01
U-238	1.300E+01	1222 ± 2	1.679E+00	1.489E+01	1.679E+00	1.489E+01

Figure 2: A screen capture reproducing the "Single Radionuclide Soil Guidelines" section from the sample summary report included as an example in Appendix D.

On this page of the summary report you will find the Single Radionuclide Soil Guidelines for each of the radionuclides included in the contaminated zone under the heading "Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g) and Single Radionuclide Soil Guidelines." The last four columns under this heading give the largest and smallest Single Radionuclide Soil Guidelines for each contaminant present under the "G(i,tmax) (pCi/g)" and "G(i,tmin) (pCi/g)" headings respectively. Of these, the most important piece of information on this page is the last column on the right which gives the most restrictive soil guidelines for each radionuclide in the units of picocuries per gram (i.e. "G(i,tmax) (pCi/g)"). For example, from Figure 2 we can see that if uranium-238 had been the only contaminant in the soil, a maximum concentration of 14.89 pCi/g could have been in the soil while still keeping the peak dose within regulatory limits. If multiple contaminants are present, as they are in the example from Figure 2, their concentrations must be such that they obey the sum of fractions rule introduced in Section 2.3.

For example, from Figure 2, the concentrations of the four contaminants at this site are

Pu-239	1.03 pCi/g
Th-232	1.42 pCi/g
U-234	2.30 pCi/g
U-238	13.0 pCi/g

while the Single Radionuclide Soil Guidelines calculated by RESRAD are

Pu-239	60.85 pCi/g

Th-232	1.612 pCi/g
U-234	12.58 pCi/g
U-238	14.89 pCi/g

From these results the sum of fractions rule would give us

$$1.03/60.85 + 1.42/1.612 + 2.30/12.58 + 13.0/14.89 = 1.95$$

While no individual radionuclide is present in this example at a concentration above its single radionuclide guideline, the sum of fractions is greater than one.[89] Thus, further cleanup at this site would be necessary in order to maintain the peak dose within regulatory limits. For example, if the concentration of each radionuclide were reduced by a factor of two due to excavation of some of the contaminated soil, then the sum of fractions in our example would be

$$0.515/60.85 + 0.710/1.612 + 1.15/12.58 + 6.50/14.89 = 0.977$$

Thus, the site would now be just within the regulatory limits for this example. Since this example would result in a fraction very close to one, it would be very important to ensure that the sampling of the site accurately characterized the contamination present to ensure that the true fraction is, indeed, less than one.

As a final note, one very useful feature of RESRAD is that it will not report physically unreasonable soil guidelines. If the value for the soil guideline given in the summary report is preceded by an asterisk (*), this denotes that there is no limit to the contaminant's concentration other than that imposed by the density of the material itself. In other words, if you see an asterisk preceding any of the Single Radionuclide Soil Guidelines on this page, then this means that, given the parameters chosen for the site, RESRAD predicts that the contaminated zone could be made up of a solid, undiluted mass of the specified radionuclide, and no violation of the regulatory dose limit would occur over the length of time being considered. In such cases, it is particularly important to explore what time limits have been imposed on the RESRAD run as described in Section 2.2 to ensure that the actual peak dose has been captured by the run and that the high soil guidelines reported in such cases are not the consequence of an artificially short time being used for the calculation or unrealistic default or generic parameters for site characteristics like the distribution coefficients or erosion rates.

[89] What does this mean? The basic idea is that the ratios between the concentration and the soil guideline tell you what fraction of the allowed dose you would get from that one contaminant. In other words, if 60.85 pCi/g of Pu-239 would give you 25 millirem then 1.03 would give you 1.03/60.85*25 = 0.423 millirem. Thus when you add the fractions together if they are over 1.00 then you would get more than 25 millirem in total dose, if they sum to less than 1.00 you would get less than 25 millirem of dose.

Chapter Four - Summary and Conclusions.

Section 4.1 - How to use these results in your work.

This manual is designed to help give you the ability to take an existing RESRAD calculation and to modify it so that doses to children can be calculated. In addition, the importance of site specific parameters like the distribution coefficients and soil erosion rates have also been discussed to allow to you to more deeply understand the assumptions that have gone into the RESRAD calculations and to explore where these may or may not be good assumptions for your site. How you make use of your RESRAD results is entirely up to you. However, it is important to consider that while the program does give reasonable results overall (provided the input data represent the environmental conditions specific to the site being modeled), we would recommend that you avoid putting too much significance on the precise values you derive. In large part, this is due to the fact that you will likely have to retain many default values or make use of the generic recommendations for exposure factors we have given in Chapter Two which were derived from national averages and may not necessarily be the most appropriate values to use at your site or for your exposure scenarios

Given the complexity of the task and the uncertainties inherent in projecting doses hundreds to thousands of years in the future, the choice of any single parameter to use in RESRAD can often be questioned. RESRAD does offer a partial solution to this problem by allowing distributions to be specified for each of the parameters in the model. Calculations in which many different possible values of the parameters are sampled are called probabilistic calculations since each parameter may now take on a variety of different values and the model uses these values to predict the probability that a given peak dose would result. While such calculations allow for more accurate and realistic representations of a site than simple deterministic calculations in which only a single value for each parameter is chosen, they are also much more complicated and time consuming to carry out and are outside the scope of the present work.

Overall, what is likely to be most important for you, and what you should consider stressing in any use of your own RESRAD calculations, is where you can show significant differences between your results for the peak dose in either magnitude or timing and those presented by the site operator.[90] These differences may arise directly from taking children into account without making any other changes or they may arise from using different assumptions about calculation times, contaminant K_d values, or water infiltration or erosion rates. In any case, your RESRAD calculations can be used to argue that those of the site operator are not adequately protective and that the site operator needs to address the concerns you have raised in order to provide a better basis for making regulatory decisions regarding contamination at your site. As such, being able to meet the regulators or site operators on their own ground, with their own model, can be a very powerful tool.

---

[90] As a general rule of thumb, anything more than a factor of two increase in the peak dose would be considered significant and should raise serious questions regarding the need for the site operator to do a more detailed analysis in response to your concerns. For the example included in Appendix E, we saw that changing the dose conversion and exposure factors to those appropriate to a 10 year old child raised the peak dose by a factor of more than two. Thus, this would be a case where a more detailed treatment of children would likely be in order.

Section 4.2 - Next steps in learning the tool

As you continue to explore RESRAD you will find that it has many additional functions not mentioned in this manual. Detailed descriptions of how to use each of them can be found in the RESRAD user's manual provided by Argonne National Laboratory. However, we will briefly mention one other function here which is of great value to more advanced users. This is the standard graphics function which can be accessed either by clicking on the "Results" tab of the "Navigator" window on the right hand side of the main window and then clicking on the "Standard Graphics" button or by selecting "Graphic Output" under the "View" menu. We will give a short introduction to its features below, but the best way to learn this tool is simply to play with its various features and explore what each will do for your RESRAD runs.

By launching the standard graphics function, a window will open allowing you to explore your RESRAD results in graphical form rather than in the text based format of the summary report. Under the "Type" option you will most often want to select "Dose," however, "Concentration" allows you to explore the movement of radionuclides out of the contaminated zone, down through the unsaturated zones, and into the water table and, as such, can also provide helpful insights.

After selecting "Dose" as the type of graph to work with, you will then be able to choose the contaminants you wish to examine. If you select "Summed" you will see the total dose for all radionuclides present, along with their daughters. If you select "Individual" you will be able to explore the dose contributions from any of the principle radionuclides you added to the contaminated zone by choosing from a drop down menu. In this case, the dose displayed on the graph will show the total dose, not only from the specified radionuclide, but also from all of its daughter products as well. Finally, if you select "Individual and Progeny" you will be able to see a breakdown of the dose resulting from the parent and each of its daughters individually.

Finally, you may also select different "Pathways" to explore. By choosing "Summed" you will be shown the dose from all active exposure pathways rolled into one. On the other hand, by selecting "Components" you will be shown a breakdown of the dose resulting from each of the thirteen water dependent and independent pathways specified in the summary report. If this is too much detail, you can select "Water Indep./Dependent" which will show the total dose due to all water independent pathways like inhalation and soil ingestion and all water dependent pathways like drinking water and eating foods grown with contaminated irrigation water summed into two separate pieces. Finally, by selecting "Individual" you can explore the dose from any one of the individual pathways by choosing from a drop down menu. As mention above, the best way to learn what is possible with these graphs is to explore them for you various RESRAD runs.

Section 4.3 - Where to turn for additional help

As new updates to this manual are made you will be able to find them on our website at http://www.ieer.org. If additional help is required and the information you seek is not available in the RESRAD Manual[91] or *Data Collection Handbook*,[92] you can email the developers of the RESRAD program at Argonne National Laboratory at resrad@anl.gov. Additional contact information for the Argonne group can be found at http://web.ead.anl.gov/resrad/contact/.[93] While the staff at Argonne is usually very good about answering questions from users it would be best to seek answers for site specific inquires from your site operator or local regulator before attempting to contact Argonne. If, after contacting these groups, you still have questions you may contact IEER at info@ieer.org.

---

[91] Yu et al. 2001

[92] Yu et al. 1993

[93] In addition, Argonne National Laboratory offers specialized workshops for users of RESRAD. The cost of these workshops, however, runs on the order of several hundred dollars. For additional information about the Argonne workshop trainings see http://web.ead.anl.gov/resrad/training/.

Appendix A - Summary of Current Common Radiation Standards[94]

	Standard	Dose Limit
Nuclear Regulatory Commission	Standards for Protection Against Radiation: Dose limits for individual members of the public. (10 CFR 20.1301)	"(a) Each licensee shall conduct operations so that— (1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv [millisievert]) in a year, exclusive of the dose contributions from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under § 35.75, from voluntary participation in medical research programs, and from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.2003…"[(a)]
	Standards for Protection Against Radiation: Radiological criteria for unrestricted use. (10 CFR 20.1402)	"A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE [total effective dose equivalent] to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA)."
	Licensing Requirements for Land Disposal of Radioactive Waste: Protection of the general population from releases of radioactivity. (10 CFR 61.41)	"Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."

[94] 10 CFR 20 Sections 1301 and 1402, 10 CFR 61 Section 41, 40 CFR 141 Section 66, and DOE 1993 p. II-1

	Standard	Dose Limit
Environmental Protection Agency	National Primary Drinking Water Regulations: Maximum contaminant levels for radionuclides. (40 CFR 141.66)	"(b) *MCL [Maximum contaminant level] for combined radium-226 and -228*. The maximum contaminant level for combined radium-226 and radium-228 is 5 pCi/L. The combined radium-226 and radium-228 value is determined by the addition of the results of the analysis for radium-226 and the analysis for radium-228. (c) *MCL for gross alpha particle activity (excluding radon and uranium)*. The maximum contaminant level for gross alpha particle activity (including radium-226 but excluding radon and uranium) is 15 pCi/L. (d) *MCL for beta particle and photon radioactivity*. (1) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water must not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year (mrem/year). … (e) *MCL for uranium*. The maximum contaminant level for uranium is 30 µg/L."[(b)]
Department of Energy	U.S. Department of Energy Order 5400.5, Radiation Protection of the Public and the Environment, Change 2	"Except as provided by 11.1a(4), the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem (1 mSv). Dose evaluations should reflect realistic exposure conditions…"[(c)]

(a) The peak dose reported by RESRAD in the summary report is the total effective dose equivalent.
(b) The maximum contaminant level (MCL) for plutonium and other alpha-emitting transuranic elements is based on outdated science and should be lowered by roughly 100 times to 0.15 picocuries per liter.[95]
(c) The exception to the DOE public dose limit in paragraph 11.1a(4) notes that "[u]nusual circumstances could affect a DOE activity in such a manner that the potential public dose could exceed an effective dose equivalent of 100 mrem (1 mSv) in a year." It goes on to state that "[i]f avoidance of the higher exposures is impracticable, the Manager of the DOE Field Office, in coordination with their Program Office, may request from EH-1 [the Assistant Secretary for Environment, Safety and Health] specific authorization for a temporary public dose limit higher than 100 mrem (1 mSv), but not to exceed 500 mrem (5 mSv), for the year."[96]

[95] For more details see *Bad to the Bone: Analysis of the Federal Maximum Contaminant Levels for Plutonium-239 and Other Alpha-Emitting Transuranic Radionuclides in Drinking Water* by Arjun Makhijani (Makhijani 2005).
[96] DOE 1993 p. II-3

Appendix B - Summary of Important RESRAD Variables[97]

In order to access the data entry popup windows for any of these variables you will first have to click on the "Modify Data" button on the far left of the screen. This will open a new menu with 12 buttons from which these parameters may be accessed.

Variable Name	Menu Button	Comments / Description
Nuclide Concentration (pCi/g)	Soil Concentrations	Select the desired radionuclide from the list on the right (Nuclide List) then enter its concentration in the box at the center of the window and click "Add Nuclide." You may change the units from pCi/g by using the dropdown menus under "Activity" in the top left of the window. To remove a radionuclide, select it in the window on the left (Nuclide Concentration) and click "Delete Nuclide."
Distribution Coefficients (cm^3/g)	Soil Concentrations → Transport	After opening the Soil Concentrations window, select the radionuclide of interest and click the "Transport" button. You can then update the K_d values for the contaminated, unsaturated zone(s), and saturated zone. Be sure to check that all isotopes of the same chemical have the same values for K_d in all zones as RESRAD will not check for you.
Times for Calculations (yr)	Calculation Times	Up to nine different times can be selected. RESRAD will not report doses for times beyond the largest time specified here.
Area of contaminated zone (m^2)	Contaminated Zone	RESRAD will internally makes a number of corrections to dose pathways (such as external gamma exposure) to account for the size of the contaminated zone.
Thickness of contaminated zone (m)	Contaminated Zone	The depth of contaminated soil. RESRAD can only handle a single contaminated zone of uniform thickness.
Cover depth (m)	Cover/Hydrol.	The amount of clean soil that is on top of the contaminated soil. RESRAD can only handle a single layer for the cover.
Cover erosion rate (m/yr)	Cover/Hydrol.	The rate at which the cover is eroded away by all processes.

[97] For more information see Yu et al. 2001 Sections 4.3 and 4.4 (p. 4-5 to 4-43).

Variable Name	Menu Button	Comments / Description
Contaminated zone erosion rate (m/yr)	Cover/Hydrol.	The rate at which the contaminated soil is eroded away once the cover is gone. In RESRAD, the contaminated soil is no longer considered once it has been eroded. Where the contaminated soil may go must be dealt with outside RESRAD.
Average annual wind speed (m/sec)	Cover/Hydrol.	Used in calculating tritium and C-14 inhalation dose.
Precipitation (m/yr)	Cover/Hydrol.	The annual amount of precipitation that falls in any form (snow, rain, etc.).
Irrigation (m/yr)	Cover/Hydrol.	The amount of additional water pumped up from the aquifer to be added to crops. This will only be used for farming scenarios.
Evapotranspiration coefficient (dimensionless)	Cover/Hydrol.	The percentage of the water (both precipitation and irrigation) that evaporates before entering the soil. For example, a value of 0.5 would mean that 50 percent of the water that fell would evaporate and thus not penetrate into the soil.
Runoff coefficient (dimensionless)	Cover/Hydrol.	The percentage of the water (both precipitation and irrigation) that runs off before entering the soil. For example, a value of 0.2 would mean that 20 percent of the water that fell would run off and thus not penetrate into the soil.
Unsaturated zone thickness (m)	Unsaturated	The thickness of the unsaturated zone(s) lying between the contamination and the water table. Up to five different unsaturated zones with different soil properties can be specified.
Inhalation rate (m^3/yr)	Occupancy	The annual amount of air taken into the lungs. This is the average respiratory rate for all types of activities to be conducted onsite.
Fraction of time spent indoors (dimensionless)	Occupancy	Percentage of the day spent indoors onsite. This is only used for residential scenarios.
Fraction of time spent outdoors on site (dimensionless)	Occupancy	Percentage of the day spent outdoors onsite. Time spent offsite is not considered in RESRAD.
Fruit, vegetable, and grain consumption (kg/yr)	Ingestion: Dietary	The annual amount of all fruits, non-leafy vegetables, and grains consumed. This is only used in farming scenarios.
Leafy vegetable consumption (kg/yr)	Ingestion: Dietary	The annual amount of all leafy vegetables consumed. This is only used in farming scenarios.

Variable Name	Menu Button	Comments / Description
Milk consumption (L/yr)	Ingestion: Dietary	The effective annual amount of milk consumed as a liquid and through dairy products. RESRAD assumes the milk is cow's milk by default. This is only used in farming scenarios.
Meat and poultry consumption (kg/yr)	Ingestion: Dietary	The annual amount of all meat and poultry consumed. RESRAD meat parameters are primarily set for beef by default. This is only used in farming scenarios.
Fish consumption (kg/yr)	Ingestion: Dietary	The annual amount of fish consumed. This is only used in scenarios where an onsite pond is available for fishing.
Other seafood consumption (kg/yr)	Ingestion: Dietary	The annual amount of all non-fish seafood such as crustaceans consumed. This is only used in scenarios where an onsite water source provides the seafood.
Soil ingestion rate (g/yr)	Ingestion: Dietary	The average amount of soil ingested per year. This average would include both routine, incidental ingestion of soil and dust as well as periods of short term intentional ingestion (i.e., soil pica).
Drinking water intake (L/yr)	Ingestion: Dietary	The annual amount of water consumed. This is only used in scenarios where there is an onsite well for providing drinking water. RESRAD does not have an option for drinking surface water.

Appendix C - Unit Conversions

All parameters in RESRAD use the metric unit system. Below are some of the common conversions for weight, length, area, and volume as used by RESRAD into the more familiar unit system used in the United States.

Metric Unit	English/Imperial Unit
1 gram (g)	0.00220 pounds = 0.0353 ounces
1 kilogram (kg)	2.20 pounds = 35.3 ounces
1 meter (m)	1.09 yards = 3.28 feet = 39.4 inches
1 square meter (m^2)	1.20 square yards = 10.8 square feet = 1,555 square inches
1 cubic meter (m^3)	1.31 cubic yards = 35.3 cubic feet = 61,023 cubic inches
1 liter (L)	0.264 gallons = 33.8 fluid ounces

In addition, RESRAD often uses annual or daily averages for parameters you might be more familiar with on a different time scale. For example, a drinking water intake of two liter per day as used by the EPA would be equivalent to 730 liters per year (365 days per year x 2 liters per day). To facilitate the comparison of such parameters we have included below the conversion factors for years, days, and hours.

1 year	365 days
	8,760 hours
	525,600 minutes
	31,536,000 seconds
1 day	24 hours
	1,440 minutes
	86,400 seconds
1 hour	60 minutes
	3,600 seconds

Appendix D - Sample Summary Report Output File from RESRAD (Reference Man)

Summary : RESRAD Default Parameters

File   : C:\RESRAD_FAMILY\RESRAD\USERFILES\RESRAD_MANUAL_EXAMPLE.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 7
Summary of Pathway Selections 14
Contaminated Zone and Total Dose Summary 15
Total Dose Components
Time = 0.000E+00 16
Time = 1.000E+02 17
Time = 5.000E+02 18
Time = 1.000E+03 19
Time = 5.000E+03 20
Time = 1.000E+04 21
Time = 5.000E+04 22
Time = 1.000E+05 23
Dose/Source Ratios Summed Over All Pathways 24
Single Radionuclide Soil Guidelines 25
Dose Per Nuclide Summed Over All Pathways 26
Soil Concentration Per Nuclide 28

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

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	Ac-228 (Source: FGR 12)	5.978E+00	5.978E+00	DCF1(2)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(3)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(4)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(5)
A-1	Bi-212 (Source: FGR 12)	1.171E+00	1.171E+00	DCF1(6)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(7)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(8)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(9)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(10)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(11)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(12)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(13)
A-1	Pb-212 (Source: FGR 12)	7.043E-01	7.043E-01	DCF1(14)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(15)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(16)
A-1	Po-211 (Source: FGR 12)	4.764E-02	4.764E-02	DCF1(17)
A-1	Po-212 (Source: FGR 12)	0.000E+00	0.000E+00	DCF1(18)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(19)
A-1	Po-215 (Source: FGR 12)	1.016E-03	1.016E-03	DCF1(20)
A-1	Po-216 (Source: FGR 12)	1.042E-04	1.042E-04	DCF1(21)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(22)
A-1	Pu-239 (Source: FGR 12)	2.952E-04	2.952E-04	DCF1(23)
A-1	Ra-223 (Source: FGR 12)	6.034E-01	6.034E-01	DCF1(24)
A-1	Ra-224 (Source: FGR 12)	5.119E-02	5.119E-02	DCF1(25)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(26)
A-1	Ra-228 (Source: FGR 12)	0.000E+00	0.000E+00	DCF1(27)
A-1	Rn-219 (Source: FGR 12)	3.083E-01	3.083E-01	DCF1(28)
A-1	Rn-220 (Source: FGR 12)	2.298E-03	2.298E-03	DCF1(29)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(30)
A-1	Th-227 (Source: FGR 12)	5.212E-01	5.212E-01	DCF1(31)
A-1	Th-228 (Source: FGR 12)	7.940E-03	7.940E-03	DCF1(32)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(33)
A-1	Th-231 (Source: FGR 12)	3.643E-02	3.643E-02	DCF1(34)
A-1	Th-232 (Source: FGR 12)	5.212E-04	5.212E-04	DCF1(35)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(36)
A-1	Tl-207 (Source: FGR 12)	1.980E-02	1.980E-02	DCF1(37)
A-1	Tl-208 (Source: FGR 12)	2.298E+01	2.298E+01	DCF1(38)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(39)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(40)
A-1	U-235 (Source: FGR 12)	7.211E-01	7.211E-01	DCF1(41)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(42)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227	6.700E+00	6.700E+00	DCF2(1)
B-1	Ac-227+D	6.700E+00	6.700E+00	DCF2(2)
B-1	Bi-210	1.960E-04	1.960E-04	DCF2(3)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(4)
B-1	Pb-210	1.360E-02	1.360E-02	DCF2(6)

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
B-1	Po-210	9.400E-03	9.400E-03	DCF2(7)
B-1	Pu-239	4.290E-01	4.290E-01	DCF2(8)
B-1	Ra-223+D	7.849E-03	7.840E-03	DCF2(10)
B-1	Ra-224+D	3.351E-03	3.160E-03	DCF2(11)
B-1	Ra-226	8.580E-03	8.580E-03	DCF2(12)
B-1	Ra-228+D	5.078E-03	4.770E-03	DCF2(13)
B-1	Rn-222+D	1.440E-05	0.000E+00	DCF2(14)
B-1	Th-227	1.620E-02	1.620E-02	DCF2(15)
B-1	Th-228	3.420E-01	3.420E-01	DCF2(16)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(17)
B-1	Th-231	8.770E-07	8.770E-07	DCF2(18)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(20)
B-1	Th-234+D	3.500E-05	3.500E-05	DCF2(21)
B-1	U-234	1.320E-01	1.320E-01	DCF2(22)
B-1	U-235	1.230E-01	1.230E-01	DCF2(23)
B-1	U-238	1.180E-01	1.180E-01	DCF2(25)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227	1.410E-02	1.410E-02	DCF3(1)
D-1	Ac-227+D	1.411E-02	1.410E-02	DCF3(2)
D-1	Bi-210	6.400E-06	6.400E-06	DCF3(3)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(4)
D-1	Pb-210	5.370E-03	5.370E-03	DCF3(6)
D-1	Po-210	1.900E-03	1.900E-03	DCF3(7)
D-1	Pu-239	3.540E-03	3.540E-03	DCF3(8)
D-1	Ra-223+D	6.595E-04	6.590E-04	DCF3(10)
D-1	Ra-224+D	4.126E-04	3.660E-04	DCF3(11)
D-1	Ra-226	1.320E-03	1.320E-03	DCF3(12)
D-1	Ra-228+D	1.442E-03	1.440E-03	DCF3(13)
D-1	Rn-222+D	9.079E-07	0.000E+00	DCF3(14)
D-1	Th-227	3.810E-05	3.810E-05	DCF3(15)
D-1	Th-228	3.960E-04	3.960E-04	DCF3(16)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(17)
D-1	Th-231	1.350E-06	1.350E-06	DCF3(18)
D-1	Th-232	2.730E-03	2.730E-03	DCF3(20)
D-1	Th-234+D	1.371E-05	1.370E-05	DCF3(21)
D-1	U-234	2.830E-04	2.830E-04	DCF3(22)
D-1	U-235	2.660E-04	2.660E-04	DCF3(23)
D-1	U-238	2.550E-04	2.550E-04	DCF3(25)
D-34	Food transfer factors:			
D-34	Ac-227 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(2,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(2,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(2,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-34	Bi-210 , plant/soil concentration ratio, dimensionless	1.000E-01	1.000E-01	RTF(3,1)
D-34	Bi-210 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-03	2.000E-03	RTF(3,2)
D-34	Bi-210 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-04	5.000E-04	RTF(3,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(4,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(4,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(4,3)
D-34				
D-34	Pb-210 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(6,1)
D-34	Pb-210 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(6,2)
D-34	Pb-210 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(6,3)
D-34				
D-34	Po-210 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(7,1)
D-34	Po-210 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(7,2)
D-34	Po-210 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,3)
D-34				
D-34	Pu-239 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Pu-239 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Pu-239 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-06	1.000E-06	RTF(8,3)
D-34				
D-34	Ra-223+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(10,1)
D-34	Ra-223+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,2)
D-34	Ra-223+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,3)
D-34				
D-34	Ra-224+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(11,1)
D-34	Ra-224+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(11,2)
D-34	Ra-224+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(11,3)
D-34				
D-34	Ra-226 , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(12,1)
D-34	Ra-226 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(12,2)
D-34	Ra-226 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(12,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(13,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(13,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(13,3)
D-34				
D-34	Rn-222+D , plant/soil concentration ratio, dimensionless	0.000E+00	0.000E+00	RTF(14,1)
D-34	Rn-222+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	0.000E+00	0.000E+00	RTF(14,2)
D-34	Rn-222+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	0.000E+00	0.000E+00	RTF(14,3)
D-34				
D-34	Th-227 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(15,1)
D-34	Th-227 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(15,2)
D-34	Th-227 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(15,3)
D-34				
D-34	Th-228 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(16,1)
D-34	Th-228 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(16,2)
D-34	Th-228 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(16,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(17,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(17,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(17,3)
D-34				
D-34	Th-231 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(18,1)
D-34	Th-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(18,2)
D-34	Th-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(18,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(20,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(20,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(20,3)
D-34				
D-34	Th-234+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(21,1)
D-34	Th-234+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(21,2)
D-34	Th-234+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(21,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(22,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(22,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(22,3)
D-34				
D-34	U-235 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(23,1)
D-34	U-235 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(23,2)
D-34	U-235 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(23,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(25,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(25,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(25,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227 , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227 , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(2,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(2,2)
D-5				
D-5	Bi-210 , fish	1.500E+01	1.500E+01	BIOFAC(3,1)
D-5	Bi-210 , crustacea and mollusks	1.000E+01	1.000E+01	BIOFAC(3,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(4,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(4,2)
D-5				
D-5	Pb-210 , fish	3.000E+02	3.000E+02	BIOFAC(6,1)
D-5	Pb-210 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(6,2)
D-5				
D-5	Po-210 , fish	1.000E+02	1.000E+02	BIOFAC(7,1)
D-5	Po-210 , crustacea and mollusks	2.000E+04	2.000E+04	BIOFAC(7,2)
D-5				
D-5	Pu-239 , fish	3.000E+01	3.000E+01	BIOFAC(8,1)
D-5	Pu-239 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(8,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: FGR 11

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Ra-223+D , fish	5.000E+01	5.000E+01	BIOFAC(10,1)
D-5	Ra-223+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(10,2)
D-5				
D-5	Ra-224+D , fish	5.000E+01	5.000E+01	BIOFAC(11,1)
D-5	Ra-224+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(11,2)
D-5				
D-5	Ra-226 , fish	5.000E+01	5.000E+01	BIOFAC(12,1)
D-5	Ra-226 , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(12,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(13,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(13,2)
D-5				
D-5	Rn-222+D , fish	0.000E+00	0.000E+00	BIOFAC(14,1)
D-5	Rn-222+D , crustacea and mollusks	0.000E+00	0.000E+00	BIOFAC(14,2)
D-5				
D-5	Th-227 , fish	1.000E+02	1.000E+02	BIOFAC(15,1)
D-5	Th-227 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(15,2)
D-5				
D-5	Th-228 , fish	1.000E+02	1.000E+02	BIOFAC(16,1)
D-5	Th-228 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(16,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(17,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(17,2)
D-5				
D-5	Th-231 , fish	1.000E+02	1.000E+02	BIOFAC(18,1)
D-5	Th-231 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(18,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(20,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(20,2)
D-5				
D-5	Th-234+D , fish	1.000E+02	1.000E+02	BIOFAC(21,1)
D-5	Th-234+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(21,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(22,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(22,2)
D-5				
D-5	U-235 , fish	1.000E+01	1.000E+01	BIOFAC(23,1)
D-5	U-235 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(23,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(25,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(25,2)

#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	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	4.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.410E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	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+02	1.000E+00	---	T(2)
R011	Times for calculations (yr)	5.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+03	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+04	1.000E+02	---	T(6)
R011	Times for calculations (yr)	5.000E+04	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+05	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): Pu-239	1.030E+00	0.000E+00	---	S1(8)
R012	Initial principal radionuclide (pCi/g): Th-232	1.420E+00	0.000E+00	---	S1(20)
R012	Initial principal radionuclide (pCi/g): U-234	2.300E+00	0.000E+00	---	S1(22)
R012	Initial principal radionuclide (pCi/g): U-238	1.300E+01	0.000E+00	---	S1(25)
R012	Concentration in groundwater (pCi/L): Pu-239	not used	0.000E+00	---	W1(8)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(20)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(22)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(25)
R013	Cover depth (m)	1.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	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)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	2	1	---	NS
R015	Unsat. zone 1, thickness (m)	1.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R015	Unsat. zone 2, thickness (m)	3.000E+00	0.000E+00	---	H(2)
R015	Unsat. zone 2, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(2)
R015	Unsat. zone 2, total porosity	6.000E-01	4.000E-01	---	TPUZ(2)
R015	Unsat. zone 2, effective porosity	4.000E-01	2.000E-01	---	EPUZ(2)
R015	Unsat. zone 2, field capacity	2.000E-01	2.000E-01	---	FCUZ(2)
R015	Unsat. zone 2, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(2)
R015	Unsat. zone 2, hydraulic conductivity (m/yr)	1.000E+02	1.000E+01	---	HCUZ(2)
R016	Distribution coefficients for Pu-239				
R016	Contaminated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCU(8,1)
R016	Unsaturated zone 2 (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCU(8,2)
R016	Saturated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.166E-05	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(20)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(20,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(20,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(20)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(20)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(20)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(22)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(22,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(22,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(22)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(22)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(22)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(25)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(25,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(25,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(25)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(25)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(25)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Unsaturated zone 2 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,2)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.123E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Bi-210				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(3,1)
R016	Unsaturated zone 2 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(3,2)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.895E-01	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(4,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(4,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(6,1)
R016	Unsaturated zone 2 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(6,2)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.316E-04	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for daughter Po-210				
R016	Contaminated zone (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCU(7,1)
R016	Unsaturated zone 2 (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCU(7,2)
R016	Saturated zone (cm**3/g)	1.000E+01	1.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.159E-03	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Ra-223				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(10,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(10,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)
R016	Distribution coefficients for daughter Ra-224				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(11,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(11,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(12)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(12,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(12,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(12)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(12)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(12)
R016	Distribution coefficients for daughter Ra-228				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(13)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(13,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(13,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(13)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(13)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(13)
R016	Distribution coefficients for daughter Rn-222				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(14)
R016	Unsaturated zone 1 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(14,1)
R016	Unsaturated zone 2 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(14,2)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(14)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.895E-01	ALEACH(14)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(14)
R016	Distribution coefficients for daughter Th-227				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(15)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(15,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(15,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(15)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(15)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(15)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Th-228				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(16)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(16,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(16,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(16)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(16)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(16)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(17)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(17,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(17,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(17)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(17)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(17)
R016	Distribution coefficients for daughter Th-231				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(18)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(18,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(18,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(18)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(18)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(18)
R016	Distribution coefficients for daughter Th-234				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(21)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(21,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(21,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(21)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(21)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(21)
R016	Distribution coefficients for daughter U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(23)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(23,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(23,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(23)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(23)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(23)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	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	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.100E+01	FMEAT
R018	Contamination fraction of milk	-1	-1	0.100E+01	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	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)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
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)	9.000E-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)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	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	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	1	---	---	KYMAX

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	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

Contaminated Zone Dimensions	
Area:	20000.00 square meters
Thickness:	4.00 meters
Cover Depth:	1.00 meters

Initial Soil Concentrations, pCi/g	
Pu-239	1.030E+00
Th-232	1.420E+00
U-234	2.300E+00
U-238	1.300E+01

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

t (years):	0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
TDOSE(t):	5.345E-06	6.241E-03	8.958E+00	4.463E+01	1.519E+00	1.595E+00	1.974E+00	1.471E+00
M(t):	2.138E-07	2.496E-04	3.583E-01	1.785E+00	6.077E-02	6.379E-02	7.897E-02	5.883E-02

Maximum TDOSE(t): 4.884E+01 mrem/yr at t = 1221 ± 2 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.221E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.610E-04	0.0000	2.785E-02	0.0006	0.000E+00	0.0000	2.914E-01	0.0060	1.198E-02	0.0002	1.709E-04	0.0000	9.158E-02	0.0019
Th-232	1.293E+01	0.2648	1.935E-01	0.0040	0.000E+00	0.0000	7.751E+00	0.1587	4.262E-01	0.0087	5.263E-01	0.0108	1.924E-01	0.0039
U-234	1.255E-02	0.0003	2.981E-03	0.0001	0.000E+00	0.0000	3.814E-02	0.0008	3.281E-03	0.0001	4.036E-03	0.0001	2.941E-03	0.0001
U-238	1.483E-01	0.0030	1.393E-02	0.0003	0.000E+00	0.0000	9.846E-02	0.0020	6.505E-03	0.0001	1.546E-02	0.0003	1.264E-02	0.0003
Total	1.309E+01	0.2681	2.382E-01	0.0049	0.000E+00	0.0000	8.179E+00	0.1675	4.479E-01	0.0092	5.460E-01	0.0112	2.996E-01	0.0061

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.221E+03 years

Water Dependent Pathways

Radio-Nuclide Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	3.217E-06	0.0000	4.023E-08	0.0000	0.000E+00	0.0000	2.476E-07	0.0000	6.617E-08	0.0000	2.397E-08	0.0000	4.232E-01	0.0087
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.202E+01	0.4509
U-234	3.976E+00	0.0814	5.449E-02	0.0011	0.000E+00	0.0000	3.126E-01	0.0064	5.212E-02	0.0011	1.103E-01	0.0023	4.569E+00	0.0936
U-238	1.930E+01	0.3951	4.163E-02	0.0009	0.000E+00	0.0000	1.503E+00	0.0308	1.444E-01	0.0030	5.426E-01	0.0111	2.182E+01	0.4469
Total	2.327E+01	0.4765	9.612E-02	0.0020	0.000E+00	0.0000	1.816E+00	0.0372	1.965E-01	0.0040	6.529E-01	0.0134	4.884E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	2.367E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	4.200E-06	0.7858	0.000E+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
U-234	1.002E-13	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
U-238	1.145E-06	0.2142	0.000E+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	5.345E-06	1.0000	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 Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+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	2.367E-13	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.200E-06	0.7858
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.002E-13	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.145E-06	0.2142
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	5.345E-06	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.781E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.627E-04	0.0261	5.817E-07	0.0001	7.776E-09	0.0000	0.000E+00	0.0000
Th-232	1.352E-03	0.2166	0.000E+00	0.0000	0.000E+00	0.0000	4.014E-03	0.6432	1.300E-04	0.0208	1.743E-04	0.0279	0.000E+00	0.0000
U-234	8.744E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.207E-05	0.0099	7.591E-07	0.0001	1.780E-06	0.0003	0.000E+00	0.0000
U-238	4.122E-06	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	3.252E-04	0.0521	3.951E-06	0.0006	9.057E-06	0.0015	0.000E+00	0.0000
Total	1.356E-03	0.2173	0.000E+00	0.0000	0.000E+00	0.0000	4.564E-03	0.7313	1.353E-04	0.0217	1.852E-04	0.0297	0.000E+00	0.0000

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+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	1.633E-04	0.0262
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.670E-03	0.9086
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.462E-05	0.0104
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.423E-04	0.0548
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	6.241E-03	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	5.707E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.363E-01	0.0152	6.707E-04	0.0001	7.924E-06	0.0000	0.000E+00	0.0000
Th-232	6.671E-02	0.0074	0.000E+00	0.0000	0.000E+00	0.0000	3.452E+00	0.3853	1.541E-01	0.0172	1.826E-01	0.0204	0.000E+00	0.0000
U-234	1.293E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.030E-02	0.0034	6.292E-04	0.0001	1.061E-03	0.0001	0.000E+00	0.0000
U-238	4.670E-04	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	1.444E-01	0.0161	2.417E-03	0.0003	4.896E-03	0.0005	0.000E+00	0.0000
Total	6.719E-02	0.0075	0.000E+00	0.0000	0.000E+00	0.0000	3.763E+00	0.4201	1.578E-01	0.0176	1.886E-01	0.0211	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	5.712E-08	0.0000	7.523E-10	0.0000	0.000E+00	0.0000	4.303E-09	0.0000	6.600E-10	0.0000	5.154E-10	0.0000	1.369E-01	0.0153
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.855E+00	0.4304
U-234	7.015E-01	0.0783	1.641E-03	0.0002	0.000E+00	0.0000	5.397E-02	0.0060	5.177E-03	0.0006	1.971E-02	0.0022	8.140E-01	0.0909
U-238	3.585E+00	0.4002	7.657E-03	0.0009	0.000E+00	0.0000	2.792E-01	0.0312	2.676E-02	0.0030	1.008E-01	0.0112	4.152E+00	0.4635
Total	4.287E+00	0.4785	9.297E-03	0.0010	0.000E+00	0.0000	3.331E-01	0.0372	3.193E-02	0.0036	1.205E-01	0.0134	8.958E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.635E-04	0.0000	2.828E-02	0.0006	0.000E+00	0.0000	2.960E-01	0.0066	1.217E-02	0.0003	1.736E-04	0.0000	9.302E-02	0.0021
Th-232	1.294E+01	0.2898	1.935E-01	0.0043	0.000E+00	0.0000	7.753E+00	0.1737	4.263E-01	0.0096	5.265E-01	0.0118	1.925E-01	0.0043
U-234	1.036E-02	0.0002	4.180E-03	0.0001	0.000E+00	0.0000	4.289E-02	0.0010	3.449E-03	0.0001	5.185E-03	0.0001	3.887E-03	0.0001
U-238	2.140E-01	0.0048	2.010E-02	0.0005	0.000E+00	0.0000	1.419E-01	0.0032	9.374E-03	0.0002	2.230E-02	0.0005	1.823E-02	0.0004
Total	1.316E+01	0.2949	2.461E-01	0.0055	0.000E+00	0.0000	8.234E+00	0.1845	4.513E-01	0.0101	5.542E-01	0.0124	3.076E-01	0.0069

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.710E-06	0.0000	2.100E-08	0.0000	0.000E+00	0.0000	1.315E-07	0.0000	3.334E-08	0.0000	1.387E-08	0.0000	4.298E-01	0.0096
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.203E+01	0.4936
U-234	3.252E+00	0.0729	2.893E-02	0.0006	0.000E+00	0.0000	2.534E-01	0.0057	3.470E-02	0.0008	9.074E-02	0.0020	3.730E+00	0.0836
U-238	1.615E+01	0.3619	3.466E-02	0.0008	0.000E+00	0.0000	1.258E+00	0.0282	1.208E-01	0.0027	4.541E-01	0.0102	1.844E+01	0.4132
Total	1.940E+01	0.4347	6.359E-02	0.0014	0.000E+00	0.0000	1.511E+00	0.0339	1.555E-01	0.0035	5.449E-01	0.0122	4.463E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.031E-07	0.0000	7.586E-08	0.0000	1.289E-10	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.491E-06	0.0000	6.470E-06	0.0000	3.603E-06	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.469E-08	0.0000	4.365E-08	0.0000	1.032E-08	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.278E-10	0.0000	5.392E-10	0.0000	1.582E-10	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.609E-06	0.0000	6.590E-06	0.0000	3.614E-06	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	3.361E-06	0.0000	4.414E-08	0.0000	0.000E+00	0.0000	2.590E-07	0.0000	7.871E-08	0.0000	1.895E-08	0.0000	3.941E-06	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.356E-05	0.0000
U-234	1.014E+00	0.6671	2.117E-01	0.1393	0.000E+00	0.0000	1.104E-01	0.0727	1.155E-01	0.0760	2.200E-02	0.0145	1.473E+00	0.9696
U-238	3.593E-02	0.0236	3.805E-03	0.0025	0.000E+00	0.0000	3.362E-03	0.0022	2.194E-03	0.0014	8.953E-04	0.0006	4.619E-02	0.0304
Total	1.050E+00	0.6908	2.155E-01	0.1418	0.000E+00	0.0000	1.138E-01	0.0749	1.177E-01	0.0774	2.289E-02	0.0151	1.519E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

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+04 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	8.554E-07	0.0000	1.104E-08	0.0000	0.000E+00	0.0000	6.601E-08	0.0000	1.972E-08	0.0000	5.200E-09	0.0000	9.574E-07	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	1.071E+00	0.6717	2.219E-01	0.1392	0.000E+00	0.0000	1.186E-01	0.0743	1.249E-01	0.0783	2.346E-02	0.0147	1.560E+00	0.9782
U-238	2.388E-02	0.0150	4.933E-03	0.0031	0.000E+00	0.0000	2.642E-03	0.0017	2.779E-03	0.0017	5.243E-04	0.0003	3.476E-02	0.0218
Total	1.095E+00	0.6866	2.269E-01	0.1423	0.000E+00	0.0000	1.212E-01	0.0760	1.277E-01	0.0801	2.399E-02	0.0150	1.595E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+04 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+04 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	6.594E-07	0.0000	9.427E-09	0.0000	0.000E+00	0.0000	5.074E-08	0.0000	1.593E-08	0.0000	2.333E-09	0.0000	7.378E-07	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	1.277E+00	0.6468	2.575E-01	0.1304	0.000E+00	0.0000	1.468E-01	0.0743	1.568E-01	0.0794	2.863E-02	0.0145	1.867E+00	0.9454
U-238	7.374E-02	0.0373	1.483E-02	0.0075	0.000E+00	0.0000	8.471E-03	0.0043	9.037E-03	0.0046	1.657E-03	0.0008	1.077E-01	0.0546
Total	1.351E+00	0.6841	2.723E-01	0.1379	0.000E+00	0.0000	1.553E-01	0.0786	1.658E-01	0.0840	3.029E-02	0.0153	1.974E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+05 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

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+05 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	2.872E-07	0.0000	4.183E-09	0.0000	0.000E+00	0.0000	2.190E-08	0.0000	6.907E-09	0.0000	9.375E-10	0.0000	3.211E-07	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	9.027E-01	0.6137	1.804E-01	0.1226	0.000E+00	0.0000	1.050E-01	0.0714	1.126E-01	0.0765	2.039E-02	0.0139	1.321E+00	0.8981
U-238	1.024E-01	0.0696	2.043E-02	0.0139	0.000E+00	0.0000	1.191E-02	0.0081	1.276E-02	0.0087	2.317E-03	0.0016	1.498E-01	0.1019
Total	1.005E+00	0.6834	2.008E-01	0.1365	0.000E+00	0.0000	1.169E-01	0.0795	1.253E-01	0.0852	2.271E-02	0.0154	1.471E+00	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways

Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	9.862E-01	2.266E-13	1.564E-04	1.311E-01	4.115E-01	1.714E-07	0.000E+00	0.000E+00	0.000E+00
Pu-239	U-235	9.862E-01	2.033E-19	2.791E-12	2.275E-08	6.762E-07	5.748E-07	1.641E-07	5.502E-08	1.404E-08
Pu-239	Th-231	9.862E-01	1.849E-24	1.359E-14	7.914E-11	1.092E-08	1.500E-09	4.283E-10	1.436E-10	3.663E-11
Pu-239	Pa-231	9.862E-01	1.011E-23	5.217E-13	1.329E-08	3.626E-07	7.780E-07	1.936E-07	1.617E-07	7.065E-08
Pu-239	Ac-227	9.862E-01	2.776E-31	7.988E-14	3.911E-08	1.056E-06	2.224E-06	5.555E-07	4.822E-07	2.129E-07
Pu-239	Th-227	9.862E-01	7.716E-26	1.351E-16	9.005E-12	1.111E-09	3.653E-10	9.099E-11	7.931E-11	3.547E-11
Pu-239	Ra-223+D	9.862E-01	2.006E-24	2.930E-14	4.137E-09	2.656E-08	2.277E-08	2.849E-09	7.307E-09	9.860E-09
Pu-239	∑DSR(j)		2.266E-13	1.564E-04	1.311E-01	4.115E-01	3.773E-06	9.165E-07	7.064E-07	3.075E-07
Pu-239	Pu-239	1.380E-02	3.171E-15	2.188E-06	1.835E-03	5.759E-03	2.399E-09	0.000E+00	0.000E+00	0.000E+00
Pu-239	U-235	1.380E-02	2.845E-21	3.906E-14	3.184E-10	9.462E-09	8.043E-09	2.296E-09	7.699E-10	1.964E-10
Pu-239	Th-231	1.380E-02	2.588E-26	1.902E-16	1.107E-12	1.528E-10	2.099E-11	5.993E-12	2.009E-12	5.126E-13
Pu-239	Pa-231	1.380E-02	1.414E-25	7.300E-15	1.859E-10	5.074E-09	1.089E-08	2.709E-09	2.263E-09	9.887E-10
Pu-239	Ac-227+D	1.380E-02	8.373E-29	1.107E-15	5.474E-10	1.479E-08	3.114E-08	7.776E-09	6.750E-09	2.981E-09
Pu-239	Ra-223+D	1.380E-02	3.730E-26	4.236E-16	1.812E-11	3.482E-10	5.521E-10	1.378E-10	1.195E-10	5.277E-11
Pu-239	∑DSR(j)		3.171E-15	2.188E-06	1.835E-03	5.759E-03	5.304E-08	1.293E-08	9.904E-09	4.219E-09
Th-232	Th-232	1.000E+00	7.297E-18	1.231E-04	1.062E-01	4.354E-01	1.899E-07	0.000E+00	0.000E+00	0.000E+00
Th-232	Ra-228+D	1.000E+00	7.465E-07	2.811E-03	2.440E+00	8.982E+00	9.152E-06	0.000E+00	0.000E+00	0.000E+00
Th-232	Th-228	1.000E+00	1.966E-15	2.702E-05	2.352E-02	9.291E-02	6.475E-08	0.000E+00	0.000E+00	0.000E+00
Th-232	Ra-224+D	1.000E+00	2.211E-06	1.032E-03	1.451E-01	6.003E+00	1.459E-07	0.000E+00	0.000E+00	0.000E+00
Th-232	∑DSR(j)		2.958E-06	3.993E-03	2.715E+00	1.551E+01	9.552E-06	0.000E+00	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	4.066E-17	2.800E-05	3.521E-01	1.543E+00	1.650E-03	0.000E+00	0.000E+00	0.000E+00
U-234	Th-230	1.000E+00	1.887E-21	2.063E-08	6.528E-05	3.904E-04	2.607E-05	2.500E-05	1.776E-05	1.158E-05
U-234	Ra-226	1.000E+00	1.880E-20	4.550E-08	6.704E-04	6.858E-03	3.078E-02	3.229E-02	3.620E-02	2.517E-02
U-234	Rn-222+D	1.000E+00	4.354E-14	3.802E-09	1.020E-05	4.908E-03	4.396E-03	4.853E-03	6.414E-03	4.680E-03
U-234	Pb-210	1.000E+00	0.000E+00	2.484E-08	6.229E-04	1.268E-02	8.730E-02	9.155E-02	1.062E-01	7.445E-02
U-234	Bi-210	1.000E+00	1.784E-23	8.198E-11	2.442E-05	3.243E-03	3.244E-02	3.603E-02	4.803E-02	3.508E-02
U-234	Po-210	1.000E+00	4.718E-23	4.196E-09	4.548E-04	5.118E-02	4.839E-01	5.135E-01	6.147E-01	4.350E-01
U-234	∑DSR(j)		4.358E-14	2.810E-05	3.539E-01	1.622E+00	6.405E-01	6.783E-01	8.116E-01	5.743E-01
U-238	U-238	5.400E-05	1.331E-37	1.363E-09	1.715E-05	7.527E-05	8.143E-08	0.000E+00	0.000E+00	0.000E+00
U-238	U-238	9.999E-01	2.465E-33	2.523E-05	3.177E-01	1.394E+00	1.508E-03	0.000E+00	0.000E+00	0.000E+00
U-238	Th-234+D	9.999E-01	8.808E-08	1.088E-06	1.186E-03	2.050E-02	3.967E-06	0.000E+00	0.000E+00	0.000E+00
U-238	U-234	9.999E-01	4.797E-23	7.984E-09	4.926E-04	4.358E-03	2.334E-05	0.000E+00	0.000E+00	0.000E+00
U-238	Th-230	9.999E-01	1.365E-27	2.859E-12	4.019E-08	4.168E-07	1.249E-07	1.464E-07	2.555E-07	2.914E-07
U-238	Ra-226	9.999E-01	9.460E-27	4.254E-12	3.130E-07	7.446E-06	9.996E-05	1.317E-04	3.821E-04	5.161E-04
U-238	Rn-222+D	9.999E-01	2.149E-20	3.549E-13	6.371E-09	4.186E-06	1.404E-05	1.929E-05	6.575E-05	9.412E-05
U-238	Pb-210	9.999E-01	0.000E+00	1.952E-12	3.095E-07	1.529E-05	2.760E-04	3.612E-04	1.084E-03	1.494E-03
U-238	Bi-210	9.999E-01	6.423E-30	6.437E-15	2.777E-08	4.401E-06	1.026E-04	1.418E-04	4.897E-04	7.032E-04
U-238	Po-210	9.999E-01	1.393E-29	3.290E-13	4.678E-07	6.901E-05	1.525E-03	2.019E-03	6.265E-03	8.717E-03
U-238	∑DSR(j)		8.808E-08	2.633E-05	3.193E-01	1.419E+00	3.553E-03	2.674E-03	8.287E-03	1.152E-02

The DSR includes contributions from associated (half-life ≤ 1 day) daughters.

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

Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	*6.214E+10	1.577E+05	1.880E+02	5.991E+01	6.534E+06	2.690E+07	3.490E+07	8.019E+07
Th-232	*1.097E+05	6.261E+03	9.208E+00	1.612E+00	*1.097E+05	*1.097E+05	*1.097E+05	*1.097E+05
U-234	*6.247E+09	8.898E+05	7.064E+01	1.541E+01	3.903E+01	3.686E+01	3.081E+01	4.353E+01
U-238	*3.361E+05	*3.361E+05	7.828E+01	1.762E+01	7.037E+03	9.351E+03	3.017E+03	2.169E+03

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose =   1221 ± 2 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pu-239	1.030E+00	1000 ± 2	4.173E-01	5.991E+01	4.109E-01	6.085E+01
Th-232	1.420E+00	999 ± 2	1.553E+01	1.610E+00	1.551E+01	1.612E+00
U-234	2.300E+00	1222 ± 2	1.988E+00	1.258E+01	1.987E+00	1.258E+01
U-238	1.300E+01	1222 ± 2	1.679E+00	1.489E+01	1.679E+00	1.489E+01

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

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	9.862E-01	2.334E-13	1.611E-04	1.350E-01	4.239E-01	1.766E-07	0.000E+00	0.000E+00	0.000E+00
Pu-239	Pu-239	1.380E-02	3.266E-15	2.254E-06	1.890E-03	5.931E-03	2.471E-09	0.000E+00	0.000E+00	0.000E+00
Pu-239	∑DOSE(j)		2.367E-13	1.633E-04	1.369E-01	4.298E-01	1.790E-07	0.000E+00	0.000E+00	0.000E+00
U-235	Pu-239	9.862E-01	2.094E-19	2.875E-12	2.343E-08	6.965E-07	5.920E-07	1.690E-07	5.667E-08	1.446E-08
U-235	Pu-239	1.380E-02	2.931E-21	4.023E-14	3.279E-10	9.746E-09	8.284E-09	2.365E-09	7.930E-10	2.023E-10
U-235	∑DOSE(j)		2.124E-19	2.915E-12	2.376E-08	7.063E-07	6.003E-07	1.714E-07	5.746E-08	1.466E-08
Th-231	Pu-239	9.862E-01	1.905E-24	1.400E-14	8.151E-11	1.125E-08	1.545E-09	4.411E-10	1.479E-10	3.773E-11
Th-231	Pu-239	1.380E-02	2.665E-26	1.959E-16	1.141E-12	1.574E-10	2.162E-11	6.173E-12	2.069E-12	5.280E-13
Th-231	∑DOSE(j)		1.931E-24	1.420E-14	8.265E-11	1.140E-08	1.567E-09	4.473E-10	1.500E-10	3.826E-11
Pa-231	Pu-239	9.862E-01	1.041E-23	5.374E-13	1.368E-08	3.735E-07	8.014E-07	1.994E-07	1.665E-07	7.277E-08
Pa-231	Pu-239	1.380E-02	1.456E-25	7.519E-15	1.915E-10	5.226E-09	1.121E-08	2.790E-09	2.331E-09	1.018E-09
Pa-231	∑DOSE(j)		1.055E-23	5.449E-13	1.388E-08	3.787E-07	8.126E-07	2.022E-07	1.689E-07	7.379E-08
Ac-227	Pu-239	9.862E-01	0.000E+00	8.228E-14	4.028E-08	1.088E-06	2.291E-06	5.721E-07	4.966E-07	2.193E-07
Th-227	Pu-239	9.862E-01	7.947E-26	1.392E-16	9.275E-12	1.144E-09	3.763E-10	9.372E-11	8.169E-11	3.654E-11
Ra-223	Pu-239	9.862E-01	2.067E-24	3.018E-14	4.261E-09	2.735E-08	2.345E-08	2.935E-09	7.526E-09	1.016E-08
Ra-223	Pu-239	1.380E-02	3.841E-26	4.363E-16	1.866E-11	3.586E-10	5.687E-10	1.419E-10	1.231E-10	5.435E-11
Ra-223	∑DOSE(j)		2.105E-24	3.062E-14	4.280E-09	2.771E-08	2.402E-08	3.077E-09	7.649E-09	1.021E-08
Ac-227	Pu-239	1.380E-02	8.624E-29	1.140E-15	5.638E-10	1.523E-08	3.207E-08	8.010E-09	6.953E-09	3.070E-09
Th-232	Th-232	1.000E+00	1.036E-17	1.749E-04	1.507E-01	6.182E-01	2.697E-07	0.000E+00	0.000E+00	0.000E+00
Ra-228	Th-232	1.000E+00	1.060E-06	3.992E-03	3.465E+00	1.275E+01	1.300E-05	0.000E+00	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	2.791E-15	3.837E-05	3.340E-02	1.319E-01	9.195E-08	0.000E+00	0.000E+00	0.000E+00
Ra-224	Th-232	1.000E+00	3.140E-06	1.465E-03	2.060E-01	8.524E+00	2.072E-07	0.000E+00	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	9.352E-17	6.439E-05	8.098E-01	3.548E+00	3.795E-03	0.000E+00	0.000E+00	0.000E+00
U-234	U-238	9.999E-01	6.236E-22	1.038E-07	6.404E-03	5.665E-02	3.035E-04	0.000E+00	0.000E+00	0.000E+00
U-234	∑DOSE(j)		9.352E-17	6.450E-05	8.162E-01	3.605E+00	4.099E-03	0.000E+00	0.000E+00	0.000E+00
Th-230	U-234	1.000E+00	4.341E-21	4.745E-08	1.501E-04	8.980E-04	5.996E-05	5.751E-05	4.084E-05	2.664E-05
Th-230	U-238	9.999E-01	1.775E-26	3.717E-11	5.225E-07	5.418E-06	1.624E-06	1.904E-06	3.321E-06	3.788E-06
Th-230	∑DOSE(j)		4.341E-21	4.749E-08	1.507E-04	9.034E-04	6.159E-05	5.941E-05	4.416E-05	3.043E-05
Ra-226	U-234	1.000E+00	4.324E-20	1.047E-07	1.542E-03	1.577E-02	7.080E-02	7.426E-02	8.325E-02	5.788E-02
Ra-226	U-238	9.999E-01	1.230E-25	5.530E-11	4.069E-06	9.680E-05	1.300E-03	1.712E-03	4.967E-03	6.709E-03
Ra-226	∑DOSE(j)		4.324E-20	1.047E-07	1.546E-03	1.587E-02	7.210E-02	7.598E-02	8.822E-02	6.459E-02
Rn-222	U-234	1.000E+00	1.002E-13	8.744E-09	2.346E-05	1.129E-02	1.011E-02	1.116E-02	1.475E-02	1.076E-02
Rn-222	U-238	9.999E-01	2.794E-19	4.614E-12	8.282E-08	5.441E-05	1.826E-04	2.508E-04	8.548E-04	1.224E-03
Rn-222	∑DOSE(j)		1.002E-13	8.749E-09	2.355E-05	1.134E-02	1.029E-02	1.141E-02	1.561E-02	1.199E-02

Summary : RESRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\RESRAD_MANUAL_EXAMPLE.RAD

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

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pb-210	U-234	1.000E+00	0.000E+00	5.713E-08	1.433E-03	2.917E-02	2.008E-01	2.106E-01	2.442E-01	1.712E-01
Pb-210	U-238	9.999E-01	0.000E+00	2.538E-11	4.024E-06	1.987E-04	3.588E-03	4.696E-03	1.410E-02	1.942E-02
Pb-210	∑DOSE(j)		0.000E+00	5.716E-08	1.437E-03	2.937E-02	2.044E-01	2.153E-01	2.583E-01	1.906E-01
Bi-210	U-234	1.000E+00	4.103E-23	1.885E-10	5.617E-05	7.459E-03	7.460E-02	8.287E-02	1.105E-01	8.068E-02
Bi-210	U-238	9.999E-01	8.349E-29	8.368E-14	3.611E-07	5.722E-05	1.334E-03	1.844E-03	6.367E-03	9.142E-03
Bi-210	∑DOSE(j)		4.103E-23	1.886E-10	5.653E-05	7.516E-03	7.593E-02	8.471E-02	1.168E-01	8.982E-02
Po-210	U-234	1.000E+00	1.085E-22	9.650E-09	1.046E-03	1.177E-01	1.113E+00	1.181E+00	1.414E+00	1.000E+00
Po-210	U-238	9.999E-01	1.810E-28	4.276E-12	6.081E-06	8.971E-04	1.982E-02	2.625E-02	8.145E-02	1.133E-01
Po-210	∑DOSE(j)		1.085E-22	9.654E-09	1.052E-03	1.186E-01	1.133E+00	1.207E+00	1.495E+00	1.114E+00
U-238	U-238	5.400E-05	0.000E+00	1.771E-08	2.230E-04	9.785E-04	1.059E-06	0.000E+00	0.000E+00	0.000E+00
U-238	U-238	9.999E-01	0.000E+00	3.280E-04	4.130E+00	1.812E+01	1.960E-02	0.000E+00	0.000E+00	0.000E+00
U-238	∑DOSE(j)		0.000E+00	3.280E-04	4.130E+00	1.812E+01	1.960E-02	0.000E+00	0.000E+00	0.000E+00
Th-234	U-238	9.999E-01	1.145E-06	1.414E-05	1.542E-02	2.665E-01	5.157E-05	0.000E+00	0.000E+00	0.000E+00

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

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	9.862E-01	1.016E+00	1.009E+00	9.806E-01	9.467E-01	7.141E-01	5.021E-01	2.997E-02	8.842E-04
Pu-239	Pu-239	1.380E-02	1.421E-02	1.411E-02	1.372E-02	1.325E-02	9.993E-03	7.026E-03	4.194E-04	1.237E-05
Pu-239	∑S(j):		1.030E+00	1.023E+00	9.943E-01	9.599E-01	7.241E-01	5.091E-01	3.039E-02	8.965E-04
U-235	Pu-239	9.862E-01	0.000E+00	9.185E-08	3.332E-07	4.670E-07	4.424E-07	3.112E-07	1.857E-08	5.480E-10
U-235	Pu-239	1.380E-02	0.000E+00	1.285E-09	4.662E-09	6.534E-09	6.191E-09	4.354E-09	2.599E-10	7.668E-12
U-235	∑S(j):		0.000E+00	9.313E-08	3.378E-07	4.735E-07	4.486E-07	3.155E-07	1.883E-08	5.556E-10
Th-231	Pu-239	9.862E-01	0.000E+00	9.184E-08	3.332E-07	4.670E-07	4.424E-07	3.112E-07	1.857E-08	5.480E-10
Th-231	Pu-239	1.380E-02	0.000E+00	1.285E-09	4.662E-09	6.534E-09	6.191E-09	4.354E-09	2.599E-10	7.668E-12
Th-231	∑S(j):		0.000E+00	9.313E-08	3.378E-07	4.735E-07	4.486E-07	3.155E-07	1.883E-08	5.556E-10
Pa-231	Pu-239	9.862E-01	0.000E+00	9.452E-11	1.526E-09	3.661E-09	5.798E-09	4.089E-09	2.440E-10	7.200E-12
Pa-231	Pu-239	1.380E-02	0.000E+00	1.323E-12	2.136E-11	5.124E-11	8.113E-11	5.721E-11	3.415E-12	1.008E-13
Pa-231	∑S(j):		0.000E+00	9.584E-11	1.548E-09	3.713E-09	5.879E-09	4.146E-09	2.475E-10	7.301E-12
Ac-227	Pu-239	9.862E-01	0.000E+00	5.059E-11	1.242E-09	3.148E-09	5.143E-09	3.627E-09	2.165E-10	6.387E-12
Th-227	Pu-239	9.862E-01	0.000E+00	5.050E-11	1.242E-09	3.148E-09	5.143E-09	3.627E-09	2.165E-10	6.387E-12
Ra-223	Pu-239	9.862E-01	0.000E+00	5.044E-11	1.242E-09	3.147E-09	5.143E-09	3.627E-09	2.165E-10	6.387E-12
Ra-223	Pu-239	1.380E-02	0.000E+00	7.071E-13	1.738E-11	4.405E-11	7.196E-11	5.075E-11	3.029E-12	8.937E-14
Ra-223	∑S(j):		0.000E+00	5.115E-11	1.259E-09	3.191E-09	5.214E-09	3.678E-09	2.195E-10	6.476E-12
Ac-227	Pu-239	1.380E-02	0.000E+00	7.079E-13	1.738E-11	4.405E-11	7.196E-11	5.075E-11	3.029E-12	8.938E-14
Th-232	Th-232	1.000E+00	1.420E+00	1.420E+00	1.419E+00	1.418E+00	1.410E+00	1.400E+00	1.325E+00	1.236E+00
Ra-228	Th-232	1.000E+00	0.000E+00	1.406E+00	1.405E+00	1.404E+00	1.396E+00	1.387E+00	1.312E+00	1.224E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.406E+00	1.405E+00	1.404E+00	1.396E+00	1.387E+00	1.312E+00	1.224E+00
Ra-224	Th-232	1.000E+00	0.000E+00	1.406E+00	1.405E+00	1.404E+00	1.396E+00	1.387E+00	1.312E+00	1.224E+00
U-234	U-234	1.000E+00	2.300E+00	1.948E+00	1.002E+00	4.363E-01	5.648E-04	1.387E-07	1.833E-36	0.000E+00
U-234	U-238	9.999E-01	0.000E+00	3.119E-03	8.031E-03	7.001E-03	4.557E-05	2.254E-08	1.578E-36	0.000E+00
U-234	∑S(j):		2.300E+00	1.951E+00	1.010E+00	4.433E-01	6.103E-04	1.612E-07	3.411E-36	0.000E+00
Th-230	U-234	1.000E+00	0.000E+00	1.906E-03	7.010E-03	1.003E-02	1.190E-02	1.130E-02	7.454E-03	4.434E-03
Th-230	U-238	9.999E-01	0.000E+00	1.483E-06	2.426E-05	5.919E-05	1.153E-04	1.097E-04	7.243E-05	4.308E-05
Th-230	∑S(j):		0.000E+00	1.908E-03	7.034E-03	1.009E-02	1.201E-02	1.141E-02	7.527E-03	4.477E-03
Ra-226	U-234	1.000E+00	0.000E+00	4.022E-05	6.601E-04	1.619E-03	3.194E-03	3.040E-03	2.006E-03	1.193E-03
Ra-226	U-238	9.999E-01	0.000E+00	2.112E-08	1.633E-06	7.335E-06	3.074E-05	2.954E-05	1.949E-05	1.159E-05
Ra-226	∑S(j):		0.000E+00	4.024E-05	6.618E-04	1.626E-03	3.225E-03	3.070E-03	2.026E-03	1.205E-03
Rn-222	U-234	1.000E+00	0.000E+00	3.997E-05	6.562E-04	1.609E-03	3.175E-03	3.022E-03	1.995E-03	1.186E-03
Rn-222	U-238	9.999E-01	0.000E+00	2.098E-08	1.623E-06	7.291E-06	3.056E-05	2.936E-05	1.938E-05	1.153E-05
Rn-222	∑S(j):		0.000E+00	3.999E-05	6.579E-04	1.616E-03	3.206E-03	3.052E-03	2.014E-03	1.198E-03

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pb-210	U-234	1.000E+00	0.000E+00	2.224E-05	5.804E-04	1.514E-03	3.093E-03	2.945E-03	1.943E-03	1.156E-03
Pb-210	U-238	9.999E-01	0.000E+00	9.804E-09	1.360E-06	6.689E-06	2.976E-05	2.861E-05	1.888E-05	1.123E-05
Pb-210	∑S(j):		0.000E+00	2.225E-05	5.817E-04	1.521E-03	3.123E-03	2.973E-03	1.962E-03	1.167E-03
Bi-210	U-234	1.000E+00	0.000E+00	2.206E-05	5.759E-04	1.502E-03	3.069E-03	2.922E-03	1.928E-03	1.147E-03
Bi-210	U-238	9.999E-01	0.000E+00	9.723E-09	1.350E-06	6.638E-06	2.953E-05	2.839E-05	1.873E-05	1.114E-05
Bi-210	∑S(j):		0.000E+00	2.207E-05	5.772E-04	1.509E-03	3.099E-03	2.950E-03	1.947E-03	1.158E-03
Po-210	U-234	1.000E+00	0.000E+00	2.168E-05	5.723E-04	1.495E-03	3.056E-03	2.909E-03	1.920E-03	1.142E-03
Po-210	U-238	9.999E-01	0.000E+00	9.499E-09	1.340E-06	6.601E-06	2.940E-05	2.826E-05	1.865E-05	1.109E-05
Po-210	∑S(j):		0.000E+00	2.169E-05	5.737E-04	1.501E-03	3.085E-03	2.937E-03	1.938E-03	1.153E-03
U-238	U-238	5.400E-05	7.020E-04	5.947E-04	3.062E-04	1.335E-04	1.748E-07	4.354E-11	6.447E-40	0.000E+00
U-238	U-238	9.999E-01	1.300E+01	1.101E+01	5.670E+00	2.473E+00	3.238E-03	8.063E-07	1.194E-35	0.000E+00
U-238	∑S(j):		1.300E+01	1.101E+01	5.670E+00	2.473E+00	3.238E-03	8.064E-07	1.194E-35	0.000E+00
Th-234	U-238	9.999E-01	0.000E+00	1.101E+01	5.670E+00	2.473E+00	3.238E-03	8.065E-07	1.194E-35	0.000E+00

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

RESCALC.EXE execution time = 19.26 seconds

Appendix E - Sample Summary Report Output File from RESRAD (10 year old)

Summary : RESRAD Default Parameters

File : C:\RESRAD_FAMILY\RESRAD\USERFILES\RESRAD MANUAL 10 YEAR OLD.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary ... 2
Site-Specific Parameter Summary 6
Summary of Pathway Selections 12
Contaminated Zone and Total Dose Summary 13
Total Dose Components
Time = 0.000E+00 14
Time = 1.000E+02 15
Time = 5.000E+02 16
Time = 1.000E+03 17
Time = 5.000E+03 18
Time = 1.000E+04 19
Time = 5.000E+04 20
Time = 1.000E+05 21
Dose/Source Ratios Summed Over All Pathways 22
Single Radionuclide Soil Guidelines 22
Dose Per Nuclide Summed Over All Pathways 24
Soil Concentration Per Nuclide 25

Dose Conversion Factor (and Related) Parameter Summary

Dose Library: ICRP 72 (Age 10)

Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	Ac-228 (Source: FGR 12)	5.978E+00	5.978E+00	DCF1(2)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(3)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(4)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(5)
A-1	Bi-212 (Source: FGR 12)	1.171E+00	1.171E+00	DCF1(6)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(7)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(8)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(9)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(10)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(11)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(12)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(13)
A-1	Pb-212 (Source: FGR 12)	7.043E-01	7.043E-01	DCF1(14)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(15)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(16)
A-1	Po-211 (Source: FGR 12)	4.764E-02	4.764E-02	DCF1(17)
A-1	Po-212 (Source: FGR 12)	0.000E+00	0.000E+00	DCF1(18)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(19)
A-1	Po-215 (Source: FGR 12)	1.016E-03	1.016E-03	DCF1(20)
A-1	Po-216 (Source: FGR 12)	1.042E-04	1.042E-04	DCF1(21)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(22)
A-1	Pu-239 (Source: FGR 12)	2.952E-04	2.952E-04	DCF1(23)
A-1	Ra-223 (Source: FGR 12)	6.034E-01	6.034E-01	DCF1(24)
A-1	Ra-224 (Source: FGR 12)	5.119E-02	5.119E-02	DCF1(25)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(26)
A-1	Ra-228 (Source: FGR 12)	0.000E+00	0.000E+00	DCF1(27)
A-1	Rn-219 (Source: FGR 12)	3.083E-01	3.083E-01	DCF1(28)
A-1	Rn-220 (Source: FGR 12)	2.298E-03	2.298E-03	DCF1(29)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(30)
A-1	Th-227 (Source: FGR 12)	5.212E-01	5.212E-01	DCF1(31)
A-1	Th-228 (Source: FGR 12)	7.940E-03	7.940E-03	DCF1(32)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(33)
A-1	Th-231 (Source: FGR 12)	3.643E-02	3.643E-02	DCF1(34)
A-1	Th-232 (Source: FGR 12)	5.212E-04	5.212E-04	DCF1(35)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(36)
A-1	Tl-207 (Source: FGR 12)	1.980E-02	1.980E-02	DCF1(37)
A-1	Tl-208 (Source: FGR 12)	2.298E+01	2.298E+01	DCF1(38)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(39)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(40)
A-1	U-235 (Source: FGR 12)	7.211E-01	7.211E-01	DCF1(41)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(42)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	2.756E+00	2.664E+00	DCF2(1)
B-1	Pa-231	5.550E-01	5.550E-01	DCF2(2)
B-1	Pb-210+D	4.895E-02	2.664E-02	DCF2(3)
B-1	Pu-239	4.440E-01	4.440E-01	DCF2(4)
B-1	Ra-226+D	4.456E-02	4.440E-02	DCF2(5)

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: ICRP 72 (Age 10)

Menu	Parameter	Current Value#	Base Case*	Parameter Name
B-1	Ra-228+D	7.421E-02	7.400E-02	DCF2(6)
B-1	Th-228+D	2.209E-01	2.035E-01	DCF2(7)
B-1	Th-230	4.070E-01	4.070E-01	DCF2(8)
B-1	Th-232	4.810E-01	4.810E-01	DCF2(9)
B-1	U-234	4.440E-02	4.440E-02	DCF2(10)
B-1	U-235+D	4.070E-02	4.070E-02	DCF2(11)
B-1	U-238	3.700E-02	3.700E-02	DCF2(12)
B-1	U-238+D	3.704E-02	3.700E-02	DCF2(13)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	7.301E-03	5.550E-03	DCF3(1)
D-1	Pa-231	3.404E-03	3.404E-03	DCF3(2)
D-1	Pb-210+D	1.666E-02	7.030E-03	DCF3(3)
D-1	Pu-239	9.990E-04	9.990E-04	DCF3(4)
D-1	Ra-226+D	2.962E-03	2.960E-03	DCF3(5)
D-1	Ra-228+D	1.443E-02	1.443E-02	DCF3(6)
D-1	Th-228+D	1.556E-03	5.180E-04	DCF3(7)
D-1	Th-230	8.880E-04	8.880E-04	DCF3(8)
D-1	Th-232	1.073E-03	1.073E-03	DCF3(9)
D-1	U-234	2.738E-04	2.738E-04	DCF3(10)
D-1	U-235+D	2.654E-04	2.627E-04	DCF3(11)
D-1	U-238	2.516E-04	2.516E-04	DCF3(12)
D-1	U-238+D	2.790E-04	2.516E-04	DCF3(13)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Pu-239 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(4,1)
D-34	Pu-239 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(4,2)
D-34	Pu-239 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-06	1.000E-06	RTF(4,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(5,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(5,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(6,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(6,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(6,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: ICRP 72 (Age 10)

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(7,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(7,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(7,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(8,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(8,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(8,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(9,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(9,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(9,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(10,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(10,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(10,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(11,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(11,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(11,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(12,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(12,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(12,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(13,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(13,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(13,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Pu-239 , fish	3.000E+01	3.000E+01	BIOFAC(4,1)
D-5	Pu-239 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(4,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(5,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(5,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(6,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(6,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(7,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(7,2)
D-5				

Dose Conversion Factor (and Related) Parameter Summary (continued)

Dose Library: ICRP 72 (Age 10)

Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(8,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(8,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(9,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(9,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(10,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(10,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(11,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(11,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(12,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(12,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(13,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(13,2)

#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	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	2.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	4.000E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.410E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	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+02	1.000E+00	---	T(2)
R011	Times for calculations (yr)	5.000E+02	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+03	1.000E+01	---	T(4)
R011	Times for calculations (yr)	5.000E+03	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+04	1.000E+02	---	T(6)
R011	Times for calculations (yr)	5.000E+04	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+05	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): Pu-239	1.030E+00	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Th-232	1.420E+00	0.000E+00	---	S1(9)
R012	Initial principal radionuclide (pCi/g): U-234	2.300E+00	0.000E+00	---	S1(10)
R012	Initial principal radionuclide (pCi/g): U-238	1.300E+01	0.000E+00	---	S1(12)
R012	Concentration in groundwater (pCi/L): Pu-239	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(9)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(10)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(12)
R013	Cover depth (m)	1.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	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)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	2	1	---	NS
R015	Unsat. zone 1, thickness (m)	1.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R015	Unsat. zone 2, thickness (m)	3.000E+00	0.000E+00	---	H(2)
R015	Unsat. zone 2, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(2)
R015	Unsat. zone 2, total porosity	6.000E-01	4.000E-01	---	TPUZ(2)
R015	Unsat. zone 2, effective porosity	4.000E-01	2.000E-01	---	EPUZ(2)
R015	Unsat. zone 2, field capacity	2.000E-01	2.000E-01	---	FCUZ(2)
R015	Unsat. zone 2, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(2)
R015	Unsat. zone 2, hydraulic conductivity (m/yr)	1.000E+02	1.000E+01	---	HCUZ(2)
R016	Distribution coefficients for Pu-239				
R016	Contaminated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCU(4,1)
R016	Unsaturated zone 2 (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCU(4,2)
R016	Saturated zone (cm**3/g)	2.000E+03	2.000E+03	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.166E-05	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(9)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(9,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(9,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(9)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(9)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(9)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(10)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(10,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(10,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(10)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(10)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(10)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(12)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(12,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(12,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(12)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(12)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(12)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Unsaturated zone 2 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,2)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.123E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Unsaturated zone 2 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,2)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.316E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(5,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(5,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for daughter Ra-228				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(6,1)
R016	Unsaturated zone 2 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(6,2)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.187E-03	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Th-228				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(7,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(7,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(8,1)
R016	Unsaturated zone 2 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(8,2)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.389E-06	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(11,1)
R016	Unsaturated zone 2 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(11,2)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.660E-03	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R017	Inhalation rate (m**3/yr)	5.580E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	7.000E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.300E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	4.400E+00	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	1.700E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	3.600E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	3.900E+01	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	7.300E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	2.500E+02	5.100E+02	---	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	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	-1	-1	0.500E+00	FPLANT
R018	Contamination fraction of meat	-1	-1	0.100E+01	FMEAT
R018	Contamination fraction of milk	-1	-1	0.100E+01	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	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)	1.600E+02	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)	9.000E-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)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	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	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

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

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	20000.00 square meters	Pu-239	1.030E+00
Thickness:	4.00 meters	Th-232	1.420E+00
Cover Depth:	1.00 meters	U-234	2.300E+00
		U-238	1.300E+01

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

t (years):	0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
TDOSE(t):	5.597E-06	3.376E-02	3.153E+01	9.362E+01	5.497E-01	5.677E-01	6.624E-01	4.852E-01
M(t):	2.239E-07	1.350E-03	1.261E+00	3.745E+00	2.199E-02	2.271E-02	2.650E-02	1.941E-02

Maximum TDOSE(t): 9.596E+01 mrem/yr at t = 1222 ± 2 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.222E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio- Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.610E-04	0.0000	1.914E-02	0.0002	0.000E+00	0.0000	6.351E-02	0.0007	1.932E-03	0.0000	8.913E-05	0.0000	5.169E-02	0.0005
Th-232	1.293E+01	0.1348	5.001E-02	0.0005	0.000E+00	0.0000	5.455E+01	0.5685	2.319E+00	0.0242	9.192E+00	0.0958	1.312E+00	0.0137
U-234	1.263E-02	0.0001	8.183E-04	0.0000	0.000E+00	0.0000	5.129E-02	0.0005	2.448E-03	0.0000	9.741E-03	0.0001	7.072E-03	0.0001
U-238	1.481E-01	0.0015	2.904E-03	0.0000	0.000E+00	0.0000	8.066E-02	0.0008	3.938E-03	0.0000	3.117E-02	0.0003	2.622E-02	0.0003
Total	1.309E+01	0.1364	7.288E-02	0.0008	0.000E+00	0.0000	5.475E+01	0.5705	2.327E+00	0.0242	9.233E+00	0.0962	1.397E+00	0.0146

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.222E+03 years

Water Dependent Pathways

Radio- Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	9.272E-07	0.0000	3.684E-08	0.0000	0.000E+00	0.0000	9.679E-08	0.0000	1.439E-08	0.0000	3.914E-08	0.0000	1.365E-01	0.0014
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.036E+01	0.8374
U-234	1.851E+00	0.0193	5.868E-02	0.0006	0.000E+00	0.0000	1.933E-01	0.0020	1.658E-02	0.0002	1.943E-01	0.0020	2.398E+00	0.0250
U-238	1.033E+01	0.1077	1.837E-01	0.0019	0.000E+00	0.0000	1.079E+00	0.0112	8.770E-02	0.0009	1.095E+00	0.0114	1.307E+01	0.1362
Total	1.218E+01	0.1270	2.424E-01	0.0025	0.000E+00	0.0000	1.272E+00	0.0133	1.043E-01	0.0011	1.289E+00	0.0134	9.596E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	2.367E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	4.333E-06	0.7740	0.000E+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
U-234	1.054E-13	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
U-238	1.265E-06	0.2260	0.000E+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	5.597E-06	1.0000	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 Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+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	2.367E-13	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.333E-06	0.7740
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.054E-13	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.265E-06	0.2260
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	5.597E-06	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.781E-12	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.534E-05	0.0010	9.380E-08	0.0000	4.055E-09	0.0000	0.000E+00	0.0000
Th-232	1.352E-03	0.0401	0.000E+00	0.0000	0.000E+00	0.0000	2.812E-02	0.8331	7.319E-04	0.0217	3.174E-03	0.0940	0.000E+00	0.0000
U-234	8.798E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.643E-05	0.0014	4.233E-07	0.0000	3.195E-06	0.0001	0.000E+00	0.0000
U-238	4.122E-06	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	2.655E-04	0.0079	2.396E-06	0.0001	1.828E-05	0.0005	0.000E+00	0.0000
Total	1.356E-03	0.0402	0.000E+00	0.0000	0.000E+00	0.0000	2.847E-02	0.8434	7.348E-04	0.0218	3.196E-03	0.0947	0.000E+00	0.0000

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+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	3.544E-05	0.0010
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.338E-02	0.9889
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.005E-05	0.0015
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.903E-04	0.0086
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	3.376E-02	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	5.707E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.970E-02	0.0009	1.082E-04	0.0000	4.132E-06	0.0000	0.000E+00	0.0000
Th-232	6.671E-02	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	2.430E+01	0.7706	8.676E-01	0.0275	3.325E+00	0.1055	0.000E+00	0.0000
U-234	1.300E-05	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.594E-02	0.0008	4.263E-04	0.0000	2.159E-03	0.0001	0.000E+00	0.0000
U-238	4.670E-04	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.183E-01	0.0038	1.466E-03	0.0000	9.878E-03	0.0003	0.000E+00	0.0000
Total	6.719E-02	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	2.447E+01	0.7761	8.696E-01	0.0276	3.337E+00	0.1058	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+02 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.627E-08	0.0000	6.667E-10	0.0000	0.000E+00	0.0000	1.697E-09	0.0000	1.605E-10	0.0000	7.113E-10	0.0000	2.981E-02	0.0009
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.856E+01	0.9057
U-234	3.325E-01	0.0105	5.955E-03	0.0002	0.000E+00	0.0000	3.470E-02	0.0011	2.820E-03	0.0001	3.522E-02	0.0011	4.397E-01	0.0139
U-238	1.919E+00	0.0609	3.408E-02	0.0011	0.000E+00	0.0000	2.003E-01	0.0064	1.627E-02	0.0005	2.033E-01	0.0064	2.504E+00	0.0794
Total	2.252E+00	0.0714	4.004E-02	0.0013	0.000E+00	0.0000	2.350E-01	0.0075	1.909E-02	0.0006	2.385E-01	0.0076	3.153E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.635E-04	0.0000	1.945E-02	0.0002	0.000E+00	0.0000	6.451E-02	0.0007	1.962E-03	0.0000	9.053E-05	0.0000	5.250E-02	0.0006
Th-232	1.294E+01	0.1382	5.003E-02	0.0005	0.000E+00	0.0000	5.457E+01	0.5829	2.319E+00	0.0248	9.195E+00	0.0982	1.313E+00	0.0140
U-234	1.042E-02	0.0001	1.076E-03	0.0000	0.000E+00	0.0000	5.068E-02	0.0005	2.427E-03	0.0000	1.134E-02	0.0001	8.675E-03	0.0001
U-238	2.139E-01	0.0023	4.191E-03	0.0000	0.000E+00	0.0000	1.163E-01	0.0012	5.679E-03	0.0001	4.499E-02	0.0005	3.786E-02	0.0004
Total	1.316E+01	0.1406	7.474E-02	0.0008	0.000E+00	0.0000	5.480E+01	0.5854	2.329E+00	0.0249	9.251E+00	0.0988	1.412E+00	0.0151

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

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	5.021E-07	0.0000	1.949E-08	0.0000	0.000E+00	0.0000	5.241E-08	0.0000	7.416E-09	0.0000	2.273E-08	0.0000	1.387E-01	0.0015
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.038E+01	0.8586
U-234	1.525E+00	0.0163	3.902E-02	0.0004	0.000E+00	0.0000	1.592E-01	0.0017	1.335E-02	0.0001	1.608E-01	0.0017	1.982E+00	0.0212
U-238	8.645E+00	0.0923	1.536E-01	0.0016	0.000E+00	0.0000	9.026E-01	0.0096	7.337E-02	0.0008	9.162E-01	0.0098	1.111E+01	0.1187
Total	1.017E+01	0.1086	1.927E-01	0.0021	0.000E+00	0.0000	1.062E+00	0.0113	8.671E-02	0.0009	1.077E+00	0.0115	9.362E+01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

Radio-Nuclide	Ground mrem/yr	Ground fract.	Inhalation mrem/yr	Inhalation fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	Soil mrem/yr	Soil fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.359E-08	0.0000	1.223E-08	0.0000	6.721E-11	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.618E-05	0.0000	3.587E-05	0.0001	6.557E-05	0.0001	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.950E-08	0.0000	4.032E-08	0.0000	4.437E-08	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.582E-10	0.0000	4.601E-10	0.0000	5.457E-10	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.623E-05	0.0000	3.592E-05	0.0001	6.562E-05	0.0001	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+03 years

Water Dependent Pathways

Radio-Nuclide	Water mrem/yr	Water fract.	Fish mrem/yr	Fish fract.	Radon mrem/yr	Radon fract.	Plant mrem/yr	Plant fract.	Meat mrem/yr	Meat fract.	Milk mrem/yr	Milk fract.	All Pathways* mrem/yr	All Pathways* fract.
Pu-239	9.106E-07	0.0000	3.872E-08	0.0000	0.000E+00	0.0000	9.507E-08	0.0000	1.629E-08	0.0000	2.992E-08	0.0000	1.127E-06	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.276E-04	0.0002
U-234	3.311E-01	0.6023	1.294E-01	0.2354	0.000E+00	0.0000	3.472E-02	0.0632	6.944E-03	0.0126	2.598E-02	0.0473	5.281E-01	0.9608
U-238	1.558E-02	0.0284	2.532E-03	0.0046	0.000E+00	0.0000	1.630E-03	0.0030	2.079E-04	0.0004	1.486E-03	0.0027	2.144E-02	0.0390
Total	3.466E-01	0.6306	1.319E-01	0.2400	0.000E+00	0.0000	3.635E-02	0.0661	7.152E-03	0.0130	2.747E-02	0.0500	5.497E-01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+04 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

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+04 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	2.362E-07	0.0000	9.826E-09	0.0000	0.000E+00	0.0000	2.466E-08	0.0000	4.064E-09	0.0000	8.471E-09	0.0000	2.832E-07	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	3.475E-01	0.6120	1.366E-01	0.2406	0.000E+00	0.0000	3.644E-02	0.0642	7.308E-03	0.0129	2.717E-02	0.0479	5.550E-01	0.9776
U-238	7.967E-03	0.0140	3.129E-03	0.0055	0.000E+00	0.0000	8.354E-04	0.0015	1.676E-04	0.0003	6.241E-04	0.0011	1.272E-02	0.0224
Total	3.554E-01	0.6261	1.397E-01	0.2461	0.000E+00	0.0000	3.727E-02	0.0657	7.475E-03	0.0132	2.780E-02	0.0490	5.677E-01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+04 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 5.000E+04 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	1.641E-07	0.0000	7.800E-09	0.0000	0.000E+00	0.0000	1.713E-08	0.0000	3.077E-09	0.0000	3.104E-09	0.0000	1.952E-07	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	3.914E-01	0.5908	1.540E-01	0.2325	0.000E+00	0.0000	4.104E-02	0.0620	8.229E-03	0.0124	3.056E-02	0.0461	6.252E-01	0.9439
U-238	2.328E-02	0.0351	9.156E-03	0.0138	0.000E+00	0.0000	2.441E-03	0.0037	4.895E-04	0.0007	1.819E-03	0.0027	3.719E-02	0.0561
Total	4.147E-01	0.6260	1.632E-01	0.2463	0.000E+00	0.0000	4.348E-02	0.0656	8.718E-03	0.0132	3.238E-02	0.0489	6.624E-01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+05 years

Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	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

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+05 years

Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pu-239	6.764E-08	0.0000	3.359E-09	0.0000	0.000E+00	0.0000	7.061E-09	0.0000	1.306E-09	0.0000	8.721E-10	0.0000	8.024E-08	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	2.722E-01	0.5611	1.071E-01	0.2208	0.000E+00	0.0000	2.855E-02	0.0588	5.724E-03	0.0118	2.125E-02	0.0438	4.349E-01	0.8963
U-238	3.150E-02	0.0649	1.239E-02	0.0255	0.000E+00	0.0000	3.303E-03	0.0068	6.624E-04	0.0014	2.461E-03	0.0051	5.032E-02	0.1037
Total	3.037E-01	0.6260	1.195E-01	0.2464	0.000E+00	0.0000	3.185E-02	0.0656	6.386E-03	0.0132	2.371E-02	0.0489	4.852E-01	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways

Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	1.000E+00	2.298E-13	3.441E-05	2.895E-02	1.346E-01	3.484E-08	0.000E+00	0.000E+00	0.000E+00
Pu-239	U-235+D	1.000E+00	2.062E-19	2.251E-12	1.484E-08	4.845E-07	3.164E-07	9.032E-08	3.028E-08	7.726E-09
Pu-239	Pa-231	1.000E+00	1.038E-23	1.257E-13	2.800E-09	6.576E-08	1.335E-07	3.253E-08	2.717E-08	1.187E-08
Pu-239	Ac-227+D	1.000E+00	3.369E-24	3.234E-14	1.093E-08	2.949E-07	6.090E-07	1.521E-07	1.320E-07	5.830E-08
Pu-239	∑DSR(j)		2.298E-13	3.441E-05	2.895E-02	1.346E-01	1.094E-06	2.750E-07	1.895E-07	7.790E-08
Th-232	Th-232	1.000E+00	7.297E-18	3.723E-05	3.220E-02	1.557E-01	5.326E-08	0.000E+00	0.000E+00	0.000E+00
Th-232	Ra-228+D	1.000E+00	7.465E-07	2.248E-02	1.997E+01	5.045E+01	8.964E-05	0.000E+00	0.000E+00	0.000E+00
Th-232	Th-228+D	1.000E+00	2.305E-06	9.906E-04	1.126E-01	6.004E+00	1.726E-07	0.000E+00	0.000E+00	0.000E+00
Th-232	∑DSR(j)		3.051E-06	2.351E-02	2.011E+01	5.661E+01	8.987E-05	0.000E+00	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	4.066E-17	2.159E-05	1.884E-01	8.183E-01	8.684E-04	0.000E+00	0.000E+00	0.000E+00
U-234	Th-230	1.000E+00	1.887E-21	2.572E-08	8.156E-05	5.728E-04	2.416E-05	2.317E-05	1.645E-05	1.073E-05
U-234	Ra-226+D	1.000E+00	4.580E-14	8.659E-08	1.229E-03	1.560E-02	4.085E-02	4.285E-02	4.803E-02	3.340E-02
U-234	Pb-210+D	1.000E+00	2.230E-22	6.061E-08	1.438E-03	2.714E-02	1.879E-01	1.984E-01	2.238E-01	1.557E-01
U-234	∑DSR(j)		4.584E-14	2.176E-05	1.912E-01	8.617E-01	2.296E-01	2.413E-01	2.718E-01	1.891E-01
U-238	U-238	5.400E-05	1.331E-37	1.072E-09	9.364E-06	4.072E-05	4.371E-08	0.000E+00	0.000E+00	0.000E+00
U-238+D	U-238+D	9.999E-01	9.730E-08	2.232E-05	1.923E-01	8.525E-01	8.974E-04	0.000E+00	0.000E+00	0.000E+00
U-238+D	U-234	9.999E-01	5.790E-23	6.163E-09	2.675E-04	2.324E-03	1.240E-05	0.000E+00	0.000E+00	0.000E+00
U-238+D	Th-230	9.999E-01	1.787E-27	3.570E-12	5.017E-08	6.067E-07	1.157E-07	1.357E-07	2.368E-07	2.700E-07
U-238+D	Ra-226+D	9.999E-01	3.247E-20	8.116E-12	5.644E-07	1.510E-05	1.327E-04	1.748E-04	5.070E-04	6.849E-04
U-238+D	Pb-210+D	9.999E-01	1.266E-28	4.784E-12	7.015E-07	3.193E-05	6.066E-04	8.037E-04	2.353E-03	3.186E-03
U-238+D	∑DSR(j)		9.730E-08	2.233E-05	1.926E-01	8.549E-01	1.649E-03	9.787E-04	2.860E-03	3.871E-03

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

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

Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	*6.214E+10	7.266E+05	8.637E+02	1.857E+02	2.286E+07	9.092E+07	1.319E+08	3.209E+08
Th-232	*1.097E+05	1.063E+03	1.243E+00	4.416E-01	*1.097E+05	*1.097E+05	*1.097E+05	*1.097E+05
U-234	*6.247E+09	1.149E+06	1.308E+02	2.901E+01	1.089E+02	1.036E+02	9.197E+01	1.322E+02
U-238	*3.361E+05	*3.361E+05	1.298E+02	2.924E+01	1.516E+04	2.555E+04	8.740E+03	6.459E+03

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 1222 ± 2 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pu-239	1.030E+00	1000 ± 2	1.346E-01	1.857E+02	1.325E-01	1.886E+02
Th-232	1.420E+00	1002 ± 2	5.661E+01	4.416E-01	5.659E+01	4.418E-01
U-234	2.300E+00	1222 ± 2	1.043E+00	2.397E+01	1.043E+00	2.398E+01
U-238	1.300E+01	1222 ± 2	1.006E+00	2.486E+01	1.005E+00	2.486E+01

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

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	1.000E+00	2.367E-13	3.544E-05	2.981E-02	1.387E-01	3.589E-08	0.000E+00	0.000E+00	0.000E+00
U-235	Pu-239	1.000E+00	2.124E-19	2.318E-12	1.528E-08	4.990E-07	3.258E-07	9.303E-08	3.119E-08	7.957E-09
Pa-231	Pu-239	1.000E+00	1.069E-23	1.295E-13	2.884E-09	6.773E-08	1.375E-07	3.351E-08	2.798E-08	1.223E-08
Ac-227	Pu-239	1.000E+00	3.470E-24	3.331E-14	1.126E-08	3.038E-07	6.273E-07	1.567E-07	1.360E-07	6.005E-08
Th-232	Th-232	1.000E+00	1.036E-17	5.287E-05	4.573E-02	2.210E-01	7.563E-08	0.000E+00	0.000E+00	0.000E+00
Ra-228	Th-232	1.000E+00	1.060E-06	3.192E-02	2.835E+01	7.163E+01	1.273E-04	0.000E+00	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	3.272E-06	1.407E-03	1.599E-01	8.526E+00	2.451E-07	0.000E+00	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	9.352E-17	4.965E-05	4.334E-01	1.882E+00	1.997E-03	0.000E+00	0.000E+00	0.000E+00
U-234	U-238	9.999E-01	7.527E-22	8.011E-08	3.478E-03	3.022E-02	1.612E-04	0.000E+00	0.000E+00	0.000E+00
U-234	∑DOSE(j)		9.352E-17	4.973E-05	4.369E-01	1.912E+00	2.158E-03	0.000E+00	0.000E+00	0.000E+00
Th-230	U-234	1.000E+00	4.341E-21	5.915E-08	1.876E-04	1.317E-03	5.557E-05	5.329E-05	3.784E-05	2.468E-05
Th-230	U-238	9.999E-01	2.323E-26	4.642E-11	6.523E-07	7.888E-06	1.505E-06	1.764E-06	3.078E-06	3.510E-06
Th-230	∑DOSE(j)		4.341E-21	5.919E-08	1.882E-04	1.325E-03	5.707E-05	5.506E-05	4.092E-05	2.819E-05
Ra-226	U-234	1.000E+00	1.053E-13	1.992E-07	2.826E-03	3.588E-02	9.396E-02	9.855E-02	1.105E-01	7.681E-02
Ra-226	U-238	9.999E-01	4.221E-19	1.055E-10	7.337E-06	1.963E-04	1.724E-03	2.272E-03	6.591E-03	8.903E-03
Ra-226	∑DOSE(j)		1.053E-13	1.993E-07	2.834E-03	3.608E-02	9.568E-02	1.008E-01	1.171E-01	8.571E-02
Pb-210	U-234	1.000E+00	5.128E-22	1.394E-07	3.308E-03	6.243E-02	4.321E-01	4.564E-01	5.147E-01	3.581E-01
Pb-210	U-238	9.999E-01	1.646E-27	6.219E-11	9.120E-06	4.151E-04	7.886E-03	1.045E-02	3.059E-02	4.141E-02
Pb-210	∑DOSE(j)		5.128E-22	1.395E-07	3.317E-03	6.284E-02	4.400E-01	4.669E-01	5.453E-01	3.995E-01
U-238	U-238	5.400E-05	0.000E+00	1.393E-08	1.217E-04	5.294E-04	5.682E-07	0.000E+00	0.000E+00	0.000E+00
U-238	U-238	9.999E-01	1.265E-06	2.902E-04	2.500E+00	1.108E+01	1.167E-02	0.000E+00	0.000E+00	0.000E+00
U-238	∑DOSE(j)		1.265E-06	2.902E-04	2.500E+00	1.108E+01	1.167E-02	0.000E+00	0.000E+00	0.000E+00

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

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+02	5.000E+02	1.000E+03	5.000E+03	1.000E+04	5.000E+04	1.000E+05
Pu-239	Pu-239	1.000E+00	1.030E+00	1.023E+00	9.943E-01	9.599E-01	7.241E-01	5.091E-01	3.039E-02	8.965E-04
U-235	Pu-239	1.000E+00	0.000E+00	9.313E-08	3.378E-07	4.735E-07	4.486E-07	3.155E-07	1.883E-08	5.556E-10
Pa-231	Pu-239	1.000E+00	0.000E+00	9.585E-11	1.548E-09	3.713E-09	5.879E-09	4.146E-09	2.475E-10	7.301E-12
Ac-227	Pu-239	1.000E+00	0.000E+00	5.130E-11	1.260E-09	3.192E-09	5.215E-09	3.678E-09	2.195E-10	6.477E-12
Th-232	Th-232	1.000E+00	1.420E+00	1.420E+00	1.419E+00	1.418E+00	1.410E+00	1.400E+00	1.325E+00	1.236E+00
Ra-228	Th-232	1.000E+00	0.000E+00	1.406E+00	1.405E+00	1.404E+00	1.396E+00	1.387E+00	1.312E+00	1.224E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.406E+00	1.405E+00	1.404E+00	1.396E+00	1.387E+00	1.312E+00	1.224E+00
U-234	U-234	1.000E+00	2.300E+00	1.948E+00	1.002E+00	4.363E-01	5.648E-04	1.387E-07	1.833E-36	0.000E+00
U-234	U-238	9.999E-01	0.000E+00	3.121E-03	8.031E-03	7.000E-03	4.557E-05	2.254E-08	1.578E-36	0.000E+00
U-234	∑S(j):		2.300E+00	1.951E+00	1.010E+00	4.433E-01	6.103E-04	1.612E-07	3.411E-36	0.000E+00
Th-230	U-234	1.000E+00	0.000E+00	1.906E-03	7.010E-03	1.003E-02	1.190E-02	1.130E-02	7.454E-03	4.434E-03
Th-230	U-238	9.999E-01	0.000E+00	1.485E-06	2.427E-05	5.920E-05	1.153E-04	1.097E-04	7.243E-05	4.308E-05
Th-230	∑S(j):		0.000E+00	1.908E-03	7.034E-03	1.009E-02	1.201E-02	1.141E-02	7.527E-03	4.477E-03
Ra-226	U-234	1.000E+00	0.000E+00	4.022E-05	6.601E-04	1.619E-03	3.194E-03	3.040E-03	2.006E-03	1.193E-03
Ra-226	U-238	9.999E-01	0.000E+00	2.117E-08	1.634E-06	7.336E-06	3.074E-05	2.954E-05	1.949E-05	1.159E-05
Ra-226	∑S(j):		0.000E+00	4.024E-05	6.618E-04	1.626E-03	3.225E-03	3.070E-03	2.026E-03	1.205E-03
Pb-210	U-234	1.000E+00	0.000E+00	2.238E-05	5.838E-04	1.523E-03	3.111E-03	2.962E-03	1.955E-03	1.163E-03
Pb-210	U-238	9.999E-01	0.000E+00	9.899E-09	1.369E-06	6.730E-06	2.993E-05	2.878E-05	1.899E-05	1.130E-05
Pb-210	∑S(j):		0.000E+00	2.239E-05	5.852E-04	1.530E-03	3.141E-03	2.991E-03	1.974E-03	1.174E-03
U-238	U-238	5.400E-05	7.020E-04	5.947E-04	3.062E-04	1.335E-04	1.748E-07	4.354E-11	6.447E-40	0.000E+00
U-238	U-238	9.999E-01	1.300E+01	1.101E+01	5.670E+00	2.473E+00	3.238E-03	8.063E-07	1.194E-35	0.000E+00
U-238	∑S(j):		1.300E+01	1.101E+01	5.670E+00	2.473E+00	3.238E-03	8.064E-07	1.194E-35	0.000E+00

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

RESCALC.EXE execution time = 7.56 seconds

References

10 CFR 20 2008 — United States. Nuclear Regulatory Commission. *Code of Federal Regulations. Title 10 – Energy. Part 20 – Standards For Protection Against Radiation*. 1-1-08 Edition. Washington, DC: Office of the Federal Register, National Archives and Records Administration; U.S. Government Printing Office, 2008. On the Web at http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr20_08.html.

10 CFR 61 2008 — United States. Nuclear Regulatory Commission. *Code of Federal Regulations. Title 10 – Energy. Part 61 – Licensing Requirements for Land Disposal Of Radioactive Waste*. 1-1-08 Edition. Washington, DC: Office of the Federal Register, National Archives and Records Administration; U.S. Government Printing Office, 2008. On the Web at http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr61_08.html.

10 CFR 61 DEIS 1981 — United States. Nuclear Regulatory Commission. *Draft Environmental Impact Statement on 10 CFR 61 "Licensing Requirements for Land Disposal of Radioactive Waste." Appendices G-Q*. NUREG-0782, Vol. 4. Washington, DC: NRC, Office of Nuclear Material Safety and Safeguards, September 1981.

40 CFR 141 2007 — United States. Environmental Protection Agency. *Code of Federal Regulations. Title 40 – Protection of Environment. Part 141 – National Primary Drinking Water Regulations*. 7-1-07 Edition. Washington, DC: Office of the Federal Register, National Archives and Records Administration; U.S. Government Printing Office, 2007. On the Web at http://www.access.gpo.gov/nara/cfr/waisidx_07/40cfr141_07.html.

DOE 1993 — United States. Department of Energy. Office of Environment, Safety and Health. *Radiation Protection of the Public and the Environment*. Order. DOE 5400.5, Change 2: 1-7-93. Washington, DC: DOE, February 8, 1990; January 7, 1993. On the Web at http://www.directives.doe.gov/pdfs/doe/doetext/oldord/5400/o54005c2.pdf.

DOE 2007 — United States. Department of Energy. *Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas*. Prepared by Argonne National Laboratory, Environmental Science Division (John Peterson, Margaret MacDonell, Lynne Haroun, and Fred Monette). In collaboration with U.S. Department of Energy, Richland Operations Office (R. Douglas Hildebrand) and Chicago Operations Office (Anibal Taboas). [Argonne, IL: ANL], March 2007. On the Web at http://www.ead.anl.gov/pub/doc/ANL_ContaminantFactSheets_All_070418.pdf.

EPA 1997 — United States. Environmental Protection Agency. *Exposure Factors Handbook. Volume I: General Factors*. EPA/600/P-95/002Fa. Washington, DC: EPA Office of Research and Development, August 1997. On the Web at http://rais.ornl.gov/homepage/EFH_Final_1997_EPA600P95002Fa.pdf.

EPA 1999 — United States. Environmental Protection Agency. *Understanding Variation in Partition Coefficient, Kd, Values: Volume I: The Kd Model of Measurement, and Application of Chemical Reaction Codes*. EPA 402-R-99-004A. Washington, DC: Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, EPA; Office of Environmental Restoration, U.S. Department of Energy, August 1999. On the Web at http://www.epa.gov/radiation/docs/kdreport/vol1/402-r-99-004a.pdf.

EPA 1999b — United States. Environmental Protection Agency. *Understanding Variation in Partition Coefficient, Kd, Values: Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (3H) and Uranium*. EPA 402-R-99-004B. Washington, DC: Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, EPA; Office of Environmental Restoration, U.S. Department of Energy, August 1999. On the Web at http://www.epa.gov/radiation/docs/kdreport/vol2/402-r-99-004b.pdf.

EPA 2004 — United States. Environmental Protection Agency. *Understanding Variation in Partition Coefficient, Kd, Values. Volume III: Review of Geochemistry and Available Kd Values for Americium, Arsenic, Curium, Iodine, Neptunium, Radium, and Technetium*. EPA 402-R-04-002C. Washington, DC: EPA Office of Air and Radiation, July 2004. On the Web at http://www.epa.gov/radiation/docs/kdreport/vol3/402-r-04-002c.pdf.

EPA 2008 — United States. Environmental Protection Agency. *Child-Specific Exposure Factors Handbook*. EPA/600/R-06/096F. Washington, DC: EPA National Center for Environmental Assessment, Office of Research and Development, September 2008. On the Web at http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=478628.

FGR 11 — Keith F. Eckerman, Anthony B. Wolbarst, and Allan C.B. Richardson. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. Federal Guidance Report No. 11. EPA-520/1-88-020. Oak Ridge, TN: Oak Ridge National Laboratory; Washington, DC: Office of Radiation Programs, U.S. Environmental Protection Agency, September 1988. On the Web at http://www.epa.gov/radiation/docs/federal/520-1-88-020.pdf.

FGR 12 — Keith F. Eckerman and Jeffrey C. Ryman. *External Exposure to Radionuclides in Air, Water, and Soil: Exposure-to-Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance*. EPA 402-R-93-081. Federal Guidance Report No. 12. Oak Ridge, TN: Oak Ridge National Laboratory; Washington, DC: Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, September 1993. On the Web at http://www.epa.gov/radiation/docs/federal/402-r-93-081.pdf.

FGR 13 and Suppl. — Keith F. Eckerman, Richard W. Leggett, Christopher B. Nelson, Jerome S. Puskin, and Allan C.B. Richardson. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. EPA 402-R-99-001. Federal Guidance Report No. 13, CD Supplement. Rev. 1. Oak Ridge, TN: Oak Ridge National Laboratory; Washington, DC: Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, April 2002. Includes original 1999 FGR no. 13, which is also on the Web at http://www.epa.gov/radiation/docs/federal/402-r-99-001.pdf.

Fioravanti and Makhijani 1997 — Marc Fioravanti and Arjun Makhijani. *Containing the Cold War Mess: Restructuring the Environmental Management of the U.S. Nuclear Weapons Complex*. Takoma Park: MD: Institute for Energy and Environmental Research, October 1997. On the Web at http://www.ieer.org/reports/cleanup/ccwm.pdf.

ICRP 23 — International Commission on Radiological Protection. *Report of the Task Group on Reference Man*. [ICRP Publication] No. 23. Oxford: Pergamon Press, 1975. Adopted October 1974.

ICRP 56 — International Commission on Radiological Protection. *Age-dependent Doses to Members of the Public From Intake of Radionuclides: Part 1*. Annals of the ICRP, v. 20 no. 2. ICRP publication 56. Oxford: Pergamon, 1989.

ICRP 67 — International Commission on Radiological Protection. *Age-dependent Doses to Members of the Public From Intake of Radionuclides: Part 2 Ingestion Dose Coefficients*. Annals of the ICRP, v. 23 no. 3/4. ICRP publication 67. Oxford: Pergamon, 1993.

ICRP 69 — International Commission on Radiological Protection. *Age-dependent Doses to Members of the Public From Intake of Radionuclides: Part 3 Ingestion Dose Coefficients*. Annals of the ICRP, v. 25 no. 1. ICRP publication 69. Oxford: Pergamon, 1995.

ICRP 71 — International Commission on Radiological Protection. *Age-dependent Doses to Members of the Public From Intake of Radionuclides: Part 4 Inhalation Dose Coefficients*. Annals of the ICRP, v. 25 no. 3-4. ICRP publication 71. Oxford: Pergamon, 1995.

ICRP 72 — International Commission on Radiological Protection. *Age-dependent Doses to Members of the Public From Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients*. Annals of the ICRP, v. 26 no. 1. ICRP publication 72. Oxford: Pergamon, 1996.

ICRP 88 — International Commission on Radiological Protection. *Doses to the Embryo and Fetus From Intakes of Radionuclides by the Mother*. Annals of the ICRP, v. 31 no. 1-3. ICRP publication 88. Oxford: Pergamon, 2001 (Corrected Version, May 2002).

ICRP 95 — International Commission on Radiological Protection. *Doses to Infants From Ingestion of Radionuclides in Mother's Milk*. Annals of the ICRP, v. 34 no. 3-4. ICRP publication 95. Oxford: Pergamon, 2004. (Erratum in Annals of the ICRP, v. 36 no. 1-2. 2006.)

Makhijani 2005 — Arjun Makhijani. *Bad to the Bone: Analysis of the Federal Maximum Contaminant Levels for Plutonium-239 and Other Alpha-Emitting Transuranic Radionuclides in Drinking Water*. Takoma Park: MD: Institute for Energy and Environmental Research, June 2005. On the Web at http://www.ieer.org/reports/badtothebone/fullrpt.pdf.

Makhijani and Boyd 2001 — Arjun Makhijani and Michele Boyd. *Poison in the Vadose Zone: An Examination of the Threats to the Snake River Plain Aquifer from the Idaho National Engineering and Environmental Laboratory*. Takoma Park: MD: Institute for Energy and Environmental Research, October 2001. On the Web at http://www.ieer.org/reports/poison/pvz.pdf.

Makhijani and Boyd 2004 — Arjun Makhijani and Michele Boyd. *Nuclear Dumps by the Riverside: Threats to the Savannah River from Radioactive Contamination at the Savannah River Site (SRS)*. Takoma Park: MD: Institute for Energy and Environmental Research, March 2004. On the Web at http://www.ieer.org/reports/srs/fullrpt.pdf.

Makhijani and Gopal 2001 — Arjun Makhijani and Sriram Gopal. *Setting Cleanup Standards to Protect Future Generations: The Scientific Basis of the Subsistence Farmer Scenario and Its Application to the Estimation of Radionuclide Soil Action Levels (RSALs) for Rocky Flats*. Takoma Park: MD: Institute for Energy and Environmental Research, December 2001. On the Web at http://www.ieer.org/reports/rocky/fullrpt.pdf.

Makhijani and Smith 2005	Arjun Makhijani and Brice Smith. *Update to Costs and Risks of Management and Disposal of Depleted Uranium From the National Enrichment Facility Proposed to be Built in Lea County New Mexico by LES by Arjun Makhijani, PhD. and Brice Smith, Ph.D. based on information obtained since November 2004*. Takoma Park: MD: Institute for Energy and Environmental Research, July 5, 2005 (Version for public release redacted August 10, 2005 to remove information considered confidential by LES). On the Web at http://www.ieer.org/reports/du/LESrptupdate.pdf.
Makhijani and Smith 2005b	Arjun Makhijani and Brice Smith. *Comments on the U.S. Environmental Protection Agency's Proposed Rule for the Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada Submitted on Behalf of the Institute for Energy and Environmental Research*. Takoma Park: MD: Institute for Energy and Environmental Research, November 21, 2005. On the Web at http://www.ieer.org/yuccaepa.pdf.
Makhijani, Smith, and Thorne 2006	Arjun Makhijani, Brice Smith, and Michael C. Thorne. *Science for the Vulnerable: Setting Radiation and Multiple Exposure Environmental Health Standards to Protect Those Most at Risk*. Takoma Park: MD: Institute for Energy and Environmental Research, October 19, 2006, On the Web at http://www.ieer.org/campaign/report.pdf.
NCRP 129	National Council on Radiation Protection. *Recommended Screening Limits for Contaminated Surface Soil and Review of Factors Relevant to Site-Specific Studies*. Recommendations of the National Council on Radiation Protection and Measurements. NCRP Report No. 129. Bethesda, MD: NCRP, 1999.
NRC 1977	United States. Nuclear Regulatory Commission. *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*. Regulatory Guide 1.109, October 1977. On the Web at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/power-reactors/active/01-109/01-109.pdf.
RESRAD 6.4	Argonne National Laboratory. Environmental Science Division. *RESRAD for Windows*. Version 6.4. Argonne, IL, ANL, created December 19, 2007. On the Web at http://www.ead.anl.gov/resrad.
Saunders and Young 1983	Ian Saunders and Anthony Young. "Rates of Surface Processes on Slopes, Slope Retreat, and Denudation." *Earth Surface Processes and Landforms* v.8 (1983). pages 473-501.
Simon 1998	Steven L. Simon. "Soil Ingestion by Humans: a Review of History, Data, and Etiology with Application to Risk Assessment of Radioactively Contaminated Soil." *Health Physics* v.74, no.6 (June 1998). pages 647-672.
Smith 2005	Brice Smith. *Soil Cleanup at Los Alamos National Laboratory: Sediment Contamination in the South Fork of Acid Canyon*. Takoma Park: MD: Institute for Energy and Environmental Research, November 29, 2005. On the Web at http://www.ieer.org/reports/lanl/cleanup.pdf.
Smith and Amonette 2006	Brice Smith and Alexandra Amonette. *The Environmental Transport of Radium and Plutonium: A Review*. Takoma Park: MD: Institute for Energy and Environmental Research, June 23, 2006. On the Web at http://www.ieer.org/reports/envtransport/fullrpt.pdf.

Yu et al. 1993	C. Yu et al. *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil*. Argonne, IL: Environmental Assessment and Information Sciences Division, Argonne National Laboratory, April 1993. On the Web at http://web.ead.anl.gov/resrad/documents/data_collection.pdf.
Yu et al. 2001	C. Yu et al. *User's Manual for RESRAD Version 6*. ANL/EAD-4. Argonne, IL: Environmental Assessment Division, Argonne National Laboratory, July 2001. On the Web at http://web.ead.anl.gov/resrad/documents/resrad6.pdf.
Zerriffi and Makhijani 2000	Hisham Zerriffi and Annie Makhijani. *The Nuclear Alchemy Gamble: An Assessment of Transmutation as a Nuclear Waste Management Strategy*. Takoma Park: MD: Institute for Energy and Environmental Research, May 2000. On the Web at http://www.ieer.org/reports/transm/report.pdf.