This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

WSRC-TR-2005-00390
Revision 0

KEY WORDS:
Performance Assessment
Inadvertent Intruder

Inadvertent Intruder Calculations for F Tank Farm

Larry D. Koffman

September 12, 2005

UNCLASSIFIED
DOES NOT CONTAIN
CLASSIFIED CONTROLLED
NUCLEAR INFORMATION

ADC & Reviewing Official: W. E. Stevens - SRNL Manager
(Name and Title)

Date: 9/12/05

Westinghouse Savannah River Company LLC
Savannah River Site
Aiken, SC 29808

Prepared for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500

DISCLAIMER

Printed in the United States of America

Prepared For
U.S. Department of Energy

WSRC-TR-2005-00390
Revision 0

KEY WORDS:
Performance Assessment
Inadvertent Intruder

Inadvertent Intruder Calculations for F Tank Farm

Larry D. Koffman

September 12, 2005

UNCLASSIFIED
DOES NOT CONTAIN
CLASSIFIED CONTROLLED
NUCLEAR INFORMATION

ADC & Reviewing Official: W. E. Stevens - SRNL Manager
(Name and Title)
Date: 9/12/05

Westinghouse Savannah River Company LLC
Savannah River Site
Aiken, SC 29808

Prepared for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500

APPROVALS

Larry D. Koffman, Author — 9-12-05 Date
Engineering Modeling and Simulation, SRNL

Glenn A. Taylor, Technical Reviewer — 9/12/05 Date
Waste Disposal and Environmental Development, SRNL

Jason M. Buice, Technical Reviewer — 9/12/05 Date
Tank Closure Planning, WSMS

Jeffry L. Newman, Technical Reviewer — 9/12/05 Date
Tank Closure Planning, Closure Business Unit

B. T. Butcher, Level 4 — 9/12/05 Date
Waste Disposal and Environmental Development, SRNL

W. E. Stevens, Level 3 — 9/12/05 Date
Waste Processing Technology, SRNL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYMS

DOE	U.S. Department of Energy
SRNL	Savannah River National Laboratory
SRS	Savannah River Site

ABBREVIATIONS

Ci	Curie
cm	centimeter
ft	feet
kg	kilogram
L	liter
m	meter
mrem	millirem
pCi	picoCurie
PD	used to denote Post-Drilling scenario
yr	year

1. Introduction

Savannah River National Laboratory (SRNL) has been providing radiological performance assessment analysis for Savannah River Site (SRS) solid waste disposal facilities (McDowell-Boyer 2000). The performance assessment considers numerous potential exposure pathways that could occur in the future. One set of exposure scenarios, known as inadvertent intruder analysis, considers the impact on hypothetical individuals who are assumed to inadvertently intrude onto the waste disposal site. An Automated Intruder Analysis application was developed by SRNL (Koffman 2004) that simplifies the inadvertent intruder analysis into a routine, automated calculation.

Based on SRNL's experience, personnel from Planning Integration & Technology of Closure Business Unit asked SRNL to assist with inadvertent intruder calculations for F Tank Farm to support the development of the Tank Closure Waste Determination Document. Meetings were held to discuss the scenarios to be calculated and the assumptions to be used in the calculations. As a result of the meetings, SRNL was asked to perform four scenario calculations. Two of the scenarios are the same as those calculated by the Automated Intruder Analysis application and these can be calculated directly by providing appropriate inputs. The other two scenarios involve use of groundwater by the intruder and the Automated Intruder Analysis application was adapted to perform these calculations.

The four calculations to be performed are

1. A post-drilling scenario in which the drilling penetrates a transfer line.
2. A calculation of internal exposure due to drinking water from a well located near a waste tank.
3. A post-drilling calculation in which waste is introduced by irrigation of the garden with water from a well located near a waste tank.
4. A resident scenario where a house is built above transfer lines.

Note that calculations 1 and 4 use sources from the waste inventory in the transfer line (given in Table 1) whereas calculations 2 and 3 use sources from groundwater beneath the waste tank (given in Appendix B). It is important to recognize that there are two different sources in the calculations.

In these calculations, assumptions are made for parameter values. Three key parameters are the size of the garden, the amount of vegetables eaten, and the distance of the well from the waste tank. For these three parameters, different values are considered in the calculations to determine the impact of the change in these parameters.

Another key parameter is the length of time of institutional control, which determines when an inadvertent intruder could first be exposed. The standard length of time for institutional control is 100 years from the time of closure. In this analysis, waste inventory values are used from year 2005 but tanks will not be closed until year 2020. Thus, the effective length of time of institutional control used in the calculations is 115 years from year 2005, which is taken to be time zero for radiological decay calculations. All calculations are carried out for a period of 10,000 years.

In the following, each of the four calculations will be described and the resulting maximum dose for each set of parameters will be presented along with discussion of the results.

2. Calculation 1: Post-Drilling Scenario for Drilling through Transfer Line

The post-drilling scenario calculated by the Automated Intruder Analysis application occurs when a well is drilled into waste. It is assumed that the soil removed from drilling is mixed with soil in a garden used to grow vegetables. With this assumption there are four exposure pathways.

- Internal exposure from ingestion of vegetables that take up radionuclides from the soil in the garden
- Internal exposure from ingestion of soil from the garden, primarily from soil on the surface of vegetables
- External exposure from the soil while working in the garden
- Internal exposure from inhalation of particulates while working in the garden

For F Tank Farm, drilling into a tank is not deemed credible. However, drilling through a transfer line is deemed credible. The radionuclide inventory from drilling through an 8" length of transfer line has been calculated (Caldwell 2005) and the results are given in Table 1. This is the waste inventory input to the Automated Intruder Analysis application. Note that this inventory is calculated for the year 2005, which is taken to be time zero in the intruder analysis.

Nuclide	Inventory (Ci)	Nuclide	Inventory (Ci)	Nuclide	Inventory (Ci)
H-3	2.80E-03	Cs-135	2.12E-08	U-238	2.56E-08
C-14	3.69E-08	Cs-137	3.18E-01	Np-237	7.13E-08
Al-26	3.37E-07	Ba-137m	3.01E-01	Pu-238	9.95E-03
Co-60	1.32E-03	Ce-144	4.77E-06	Pu-239	8.86E-05
Ni-59	2.55E-06	Pr-144	4.77E-06	Pu-240	6.20E-05
Ni-63	2.55E-04	Pm-147	2.23E-02	Pu-241	7.21E-03
Se-79	1.83E-06	Sm-151	6.63E-03	Pu-242	2.51E-07
Sr-90	2.54E-01	Eu-152	5.17E-05	Pu-244	4.15E-10
Y-90	2.54E-01	Eu-154	2.79E-93	Am-241	2.18E-04
Nb-94	1.37E-09	Eu-155	2.54E-03	Am-242m	2.89E-07
Tc-99	3.58E-05	Ra-226	2.76E-09	Am-243	8.73E-08
Rh-106	3.39E-05	Ac-227	8.33E-11	Cm-242	2.76E-07
Ru-106	3.39E-05	Th-229	2.38E-04	Cm-243	5.89E-08
Te-125m	3.17E-04	Th-230	3.53E-09	Cm-244	6.37E-06
Sb-125	1.30E-03	Pa-231	8.35E-11	Cm-245	2.93E-09
Sb-126	4.76E-07	U-232	2.35E-08	Cm-247	9.91E-18
Sb-126m	3.40E-06	U-233	3.81E-04	Cm-248	4.74E-14
Sn-126	3.40E-06	U-234	3.38E-08	Bk-249	7.13E-20
I-129	3.40E-08	U-235	5.54E-10	Cf-249	5.89E-17
Cs-134	9.34E-04	U-236	1.01E-08		

Table 1. Inventory for Drilling through Transfer Line at F Tank Farm (Caldwell 2005)

We note that the inadvertent intruder input (Lee 2004) does not include Rh-106, Ru-106, Ce-144, Pr-144, and Pm-147, which occur in the inventory in Table 1. This is because these radionuclides had been screened out as insignificant for inadvertent intruder analysis. However, we added the inputs for these as a matter of completeness. The calculations confirmed that these radionuclides are insignificant for the inadvertent intruder analysis.

The Automated Intruder Analysis application determines dose for each radionuclide based upon its initial concentration in the garden. In order to determine concentration, we need to know the volume of the garden. The depth for mixing of soil is taken to be 15 cm, which is consistent with past SRS performance assessments. The area of the garden depends on how many people are fed from the garden. Wilhite (2005) suggests that an area of about 250 square meters is appropriate for a single person. However, he argues that the intruder analysis applies to a family and he suggests that a family of four is appropriate, so that garden area should be 1000 square meters. Other DOE sites have used garden area of 2000-2500 square meters. Since there is some variation in choice for the garden area, we will calculate with this parameter equal to 1000, 2200, and 500 square meters.

Another parameter of importance is the quantity of vegetables consumed in a year. Lee (2004) gives the amount of vegetables eaten from the garden as 90 kg/yr, which assumes that about 50% of all vegetables consumed come from the garden. The actual number from Hamby (1992) for total vegetable consumption is 184 kg/yr, so 50% should be 92 kg/yr. Calculations will be performed with values of 92 and 184 kg/yr, representing 50% and 100% of vegetable consumption coming from the garden.

All other parameters for the post-drilling scenario are held constant at the values specified by Lee (2004) for inadvertent intruder calculations.

Density of soil: 1400 kg/m^3
Consumption of contaminated soil: 0.037 kg/yr
Exposure time while working in garden as fraction of year: 0.01
Air intake (breathing rate): 8000 m^3/yr
Atmospheric mass loading of soil particulates while working in garden: 1.0E-07 kg/m^3

The input for the Automated Intruder Analysis application must be changed to account for the above parameter variations. In the IntruderInput.xls input file, there is a direct input for "Consumption of contaminated vegetables" in kg/yr on the "Parameter Values" worksheet, so the appropriate value of 92 or 184 should be input. In order to get the correct concentration in the garden, the input "Dilution factor for mixing of waste with soil in vegetable garden for post drilling scenario" on the "Parameter Values" worksheet should be set to one. Then, the garden volume should be input in the DisposalUnitInput.xls input file for the entry "Waste Volume (ft3)". Note that the volume should be input in cubic feet. Thus, for the case of a 1000 square meter garden with depth 15 cm, the correct input for "Waste Volume (ft3)" is 5297.2 cubic feet.

With a garden size of 1000 square meters and vegetable consumption from the garden of 92 kg/yr, the resulting maximum total dose calculated is 120.0 mrem/yr and occurs at 115 years (end of institutional control). The total dose rapidly falls off in time being 47.4 mrem/yr at 155 years, 10.3 mrem/yr at 225 years, and below 1 mrem/yr by 515 years.

The Automated Intruder Analysis application provides detailed output for dose over time for each radionuclide as well as detailed pathway contributions for each radionuclide and its decay chain. Looking at the detailed results, we find that the maximum dose is due almost entirely to vegetable consumption of Sr-90, accounting for 89.3% of the total. Another 7.8% is due to Cs-137, 2% is due to Pu-238, and everything else has insignificant contribution. Table 2 shows the detailed pathway contributions for Sr-90, Cs-137, and Pu-238.

Nuclide	Inventory (Ci)	PD Veg Ingest (mrem/yr)	PD Soil Ingest (mrem/yr)	PD Garden Exposure (mrem/yr)	PD Garden Inhale (mrem/yr)	PD Dose Total (mrem/yr)
Sr-90	2.54E-01	1.07E+02	4.29E-01	1.53E-02	7.94E-04	1.07E+02
Cs-137	3.18E-01	6.34E+00	1.98E-01	2.83E+00	2.73E-05	9.37E+00
Pu-238	9.95E-03	1.09E-01	2.26E+00	2.52E-05	5.99E-02	2.43E+00

Table 2. Detailed Pathway Contributions to Maximum Dose for Post-Drilling Scenario with Vegetable Consumption of 92 kg/yr and Garden Area of 1000 m^2

The maximum dose results for Calculation 1 with parameter variations are given in Table 3. Changing garden area changes the concentration of each radionuclide. The dose for each pathway is directly proportional to concentration, so we expect that changing the area will linearly change the maximum dose. We see that this is the case in Table 3 where reducing the garden area by half to 500 m^2 doubles the concentration and doubles the maximum dose. Likewise, increasing area by a factor of 2.2 reduces maximum dose by the inverse of 2.2.

The impact of changing vegetable consumption can be understood using the detailed pathway results in Table 2. We see that 94.3% of the maximum dose is due to vegetable ingestion of the three radionuclides in Table 2. Thus, if we double the consumption of vegetables from the garden, we expect that the dose will increase by the factor 1.943, which would give 120.0*1.943 = 233.2 mrem/yr. The result of 233.7 mrem/yr in Table 3 confirms this impact of changing vegetable consumption from the garden.

Calc 1	Garden Area (m^2)	Vegetable Consumption (kg/yr)	Max Dose (mrem/yr)	Time of Max (yr)
(a)	1000	92	120.0	115
(b)	1000	184	233.7	115
(c)	2200	92	54.6	115
(d)	500	92	240.1	115

Table 3. Maximum Dose Results for Calculation 1 with Parameter Variation

Detailed transient results are provided in an Excel file as a deliverable with these calculations. The detailed results for cases 1(a)-1(d) are in file Calc1-Results.xls. The structure of this file is described in Appendix A.

3. Calculation 2: Drinking Water from a Well Located Near a Waste Tank

Another source for dose to an intruder is assumed to be drinking water from a well near a waste tank that has contamination coming from the waste tank over time. The groundwater calculations have been performed elsewhere and the transient concentration results were supplied by Newman (2005) in Excel files. Two files were supplied with one for a 1-meter well and another for a 100-meter well. The expectation is that the 1-meter well concentrations will result in higher dose but the 100-meter well concentrations are used in a separate calculation to confirm this expectation. The radionuclides for the 1-meter well and their concentration time history are listed in Appendix B.

The Automated Intruder Analysis application does not handle groundwater as an intruder pathway. However, the application already has the dose conversion factors for ingestion that are needed to calculate this pathway. The only other parameter that is needed is the quantity of water ingested in a year. Past performance assessments (McDowell-Boyer 2000) have used a value of 730 liter/year for consumption of drinking water and Lee (2004) confirms this as the appropriate input.

The Automated Intruder Analysis application was modified to read the Excel file of groundwater radionuclide concentration as a function of time, multiply by the dose conversion factor and the consumption volume at each instant of time, and sum the contributions for all radionuclides at each instant of time to get total dose as a function of time. [Note that these simple calculations could be performed in the spreadsheet of transient groundwater concentrations. However, reading the input into the Automated Intruder Analysis application was needed for Calculation 3 that is described in the next section.]

For transient concentrations from the 1-meter well, the maximum dose is 0.38 mrem/yr and occurs at 665 years. The detailed results show that 90% of this maximum dose is due to Tc-99 with 10% due to I-129. For transient concentrations from the 100-meter well, the maximum dose is 0.10 mrem/yr and occurs at 735 years. The detailed results show that 65% of this maximum dose is due to Tc-99 with 35% due to I-129.

Note that this drinking water dose should be added to the post-drilling scenario dose from Calculation 1. We have seen that Calculation 1 has a maximum dose that occurs at 115 years and falls off rapidly, being below 1 mrem/yr by 515 years. The drinking water maximum dose occurs at 665 years and is insignificant until after 455 years. Thus, these two different sources of dose are essentially independent in time and there is no significant addition from one to the other.

Detailed transient results are provided in an Excel file as a deliverable with these calculations. The detailed results for case 2(a) for the 1-meter well and for 2(b) for the 100-meter well are in file Calc2-Results.xls. The structure of this file is described in Appendix A.

4. Calculation 3: Irrigate Garden with Well Water

Another use of well water that can contribute to dose is irrigation of the garden in Calculation 1 with contaminated water from a well near a waste tank. Over time the addition of contaminants increases the radionuclide inventory in the garden and this increased inventory is used to evaluate the post-drilling pathways described in Calculation 1.

In order to assess the impact, we need to know the total volume of water added, which is the product of the irrigation rate times the buildup time. For the irrigation rate and the buildup time in the soil, we used the inputs used in LADTAP XL (Jannik 2005), which evaluates a similar pathway. The irrigation rate is 3.4 liter/m^2/day and the buildup time in the soil is 9125 days.

As noted in Calculation 2, the Automated Intruder Analysis application was modified to read the Excel file of groundwater radionuclide concentration as a function of time. At each instant of time the concentration for a radionuclide is multiplied by the irrigation rate of 3.4 liter/m^2/day and multiplied by the buildup time of 9125 days to give the added inventory for that radionuclide. With the parameters set for garden area and vegetable consumption, the post-drilling pathway calculations are evaluated and added together to give the dose for each radionuclide, which are in turn added together to give the total dose.

Table 4 gives the results for the parametric calculations. The garden area and vegetable consumption are varied as in Calculation 1 and these four variations are repeated for the 1-meter well and for the 100-meter well, to give a total of eight calculations. For the 1-meter well with a garden area of 1000 m^2 and a vegetable consumption of 92 kg/yr, the maximum dose is 4.11 mrem/yr and occurs at 665 years. The detailed results show that 99% of this maximum dose is due to Tc-99 and the detailed pathway results show that the vegetable ingestion pathway accounts for 99.9% of the dose. Thus, we expect doubling the vegetable consumption to double the maximum dose and we see that this is the case for both the 1-meter well and the 100-meter well. As before, we find that changing the garden area changes the dose by an inverse proportion due to the change in concentration.

Since the dose here is due almost entirely to Tc-99, we find that the transient for the maximum dose follows the Tc-99 concentration transient just as Calculation 2 did. That is, there is insignificant dose until after 455 years. Calculation 3 overlaps with Calculation 2 but Calculation 2 only had a maximum dose of 0.38 mrem/yr, so the sum is not significantly different than Calculation 3. Calculation 1 is essentially independent in time just as it is for Calculation 2.

Calc 3	Well Location	Garden Area (m^2)	Vegetable Consumption (kg/yr)	Max Dose (mrem/yr)	Time of Max (yr)
(a)	1 m	1000	92	4.11	665
(b)	1 m	1000	184	8.23	665
(c)	1 m	2200	92	1.87	665
(d)	1 m	500	92	8.23	665
(e)	100 m	1000	92	0.85	665
(f)	100 m	1000	184	1.71	665
(g)	100 m	2200	92	0.39	665
(h)	100 m	500	92	1.71	665

Table 4. Maximum Dose Results for Calculation 3 with Parameter Variation

5. Calculation 4: Resident Scenario for House Built Above Transfer Lines

Another exposure scenario included in the Automated Intruder Analysis application is known as the resident scenario. There is only one pathway in this scenario, which is external exposure to a resident in a house built above the waste with shielding from the intervening soil. The thickness of the intervening soil is of importance here and one limitation in the Automated Intruder Analysis application is that the maximum soil thickness for shielding is one meter. It is assumed that the house is built with a basement that requires that 3 meters of soil be excavated. Even with this excavation, the thickness of soil above the transfer lines would be greater than one meter, so there is a built-in conservatism is this calculation in that we only take credit for one meter of soil shielding.

For the exposure calculation in the resident scenario, the waste is distributed over a waste volume to give a concentration that is used as a semi-infinite source concentration for the shielding calculation. From Dixon (2005a), the well drilling cuts through an 8” section of nominal 4” transfer line that has 4.5” outside diameter. For the shielding calculation, we assume that the waste in this section of transfer line is distributed over the total volume occupied by this section:

$$\text{volume} = (\ 8") \ \pi \ (4.5")(4.5") \ / \ 4 = 127.23 \ \text{in}^3 = 0.073631 \ \text{ft}^3$$

Note that the choice of volume is not obvious here because the application is different than the large solid waste volumes for which the Automated Intruder Analysis application was designed. Our reasoning is that if a man is standing on a meter of soil covering the transfer line then the source of radiation would appear to be nearly the same as if the curies were distributed over the entire volume of the pipe section.

To account for the fact that the transfer lines are not actually a continuous layer, the calculation uses a “geometry factor” that represents the fraction of tank farm footprint area that is covered by the projected area of the transfer lines. From Dixon (2005b), the ratio of transfer line area to tank farm area is 0.011, which is input as the geometry factor for the resident scenario.

Other parameters for the resident scenario specified by Lee (2004) for inadvertent intruder calculations are:

Exposure time while residing in home as fraction of year: 0.50
Shielding factor of home for external exposure during indoor residence: 0.7

With the resident scenario geometry factor set to 0.011, the waste volume input set to 0.073631 ft^3, and the radionuclide inventory given in Table 1, the Automated Intruder Analysis application is run for 10,000 years with an institutional control time set to 115 years. The resulting maximum dose is 2.7 mrem/yr at 115 years and the dose falls off quickly in time being below 1 mrem/yr by 165 years. The detailed results show that Cs-137 is responsible for 98% of the maximum dose.

Detailed transient results are provided in an Excel file as a deliverable with these calculations. The detailed results for Calculation 4 are in file Calc4-Results.xls. The structure of this file is described in Appendix A.

6. Summary

Calculations were performed for four inadvertent intruder scenarios for F Tank Farm:

1. A post-drilling scenario in which the drilling penetrates a transfer line.
2. A calculation of internal exposure due to drinking water from a well located near a waste tank.
3. A post-drilling calculation in which waste is introduced by irrigation of the garden with water from a well located near a waste tank.
4. A resident scenario where a house is built above transfer lines.

Parameters that were varied in the calculations are garden area and vegetable consumption for post-drilling calculations and well location for calculations that use groundwater from a well.

A summary of results for maximum dose for the calculations is given in Table 5. Detailed analysis of these results leads to the following observations.

- Maximum dose is inversely proportional to choice of garden area for Calculations 1 and 3 since the waste is distributed over the garden to give the waste concentration.
- Maximum dose for Calculations 1 and 3 is dominated by vegetable ingestion. Hence, change in vegetable consumption results in almost linear change in maximum dose.
- Maximum dose for Calculations 2 and 3 is dominated by ingestion of Tc-99, so the results follow the transient concentration for Tc-99 with maximum at 665 years.
- The doses for the transfer line calculations 1 and 4 are essentially independent in time of the doses for the groundwater calculations 2 and 3 since significant doses occur over different time ranges, i.e. little overlap in time of significant dose.

Calculation	Well Location	Garden Area (m^2)	Vegetable Consumption (kg/yr)	Max Dose (mrem/yr)	Time of Max (yr)
Calc 1(a)	---	1000	92	120.0	115
Calc 1(b)	---	1000	184	233.7	115
Calc 1(c)	---	2200	92	54.6	115
Calc 1(d)	---	500	92	240.1	115
Calc 2(a)	1 m	---	---	0.38	665
Calc 2(b)	100 m	---	---	0.10	735
Calc 3(a)	1 m	1000	92	4.11	665
Calc 3(b)	1 m	1000	184	8.23	665
Calc 3(c)	1 m	2200	92	1.87	665
Calc 3(d)	1 m	500	92	8.23	665
Calc 3(e)	100 m	1000	92	0.85	665
Calc 3(f)	100 m	1000	184	1.71	665
Calc 3(g)	100 m	2200	92	0.39	665
Calc 3(h)	100 m	500	92	1.71	665
Calc 4	---	---	---	2.7	115

Table 5. Summary of Maximum Dose Results for All Calculations

7. References

Caldwell, T. B. 2005. *Radioactivity from Drilling a Domestic Water Well Into a 4-Inch F-Tank Farm Transfer Line*. CBU-PIT-2005-00160. Westinghouse Savannah River Company, Aiken, South Carolina.

Dixon, E. N. 2005a. *Effected Volume of F Tank Farm Transfer Line by Drilling a Domestic Water Well*. CBU-PIT-2005-00161. Westinghouse Savannah River Company, Aiken, South Carolina.

Dixon, E. N. 2005b. *Ratio of FTF Transfer Line Projected Area to FTF Surface Area*. CBU-PIT-2005-00163. Westinghouse Savannah River Company, Aiken, South Carolina.

Hamby, D. M. 1992. *Site-Specific Parameter Values for the Nuclear Regulatory Commission's Food Pathway Dose Model*. Health Physics, 62:136.

Jannik, G. T. 2005. *Potential Radiological Doses from Groundwater Contaminated by the Saltstone Disposal Facility*. WSRC-TR-2005-00084. Westinghouse Savannah River Company, Aiken, South Carolina.

Koffman, L. D. 2004. *An Automated Inadvertent Intruder Analysis Application*. WSRC-TR-2004-00293. Westinghouse Savannah River Company, Aiken, South Carolina.

Lee, P. L. 2004. *Inadvertent Intruder Analysis Input for Radiological Performance Assessments*. WSRC-TR-2004-00295. Westinghouse Savannah River Company, Aiken, South Carolina.

McDowell-Boyer, L., Yu, A. D., Cook, J. R., Kocher, D. C., Wilhite, E. L., Holmes-Burns, H., and Young, K. E. 2000. *Radiological Performance Assessment for the E-Area Low-Level Waste Facility*. WSRC-RP-94-218, Revision 1. Westinghouse Savannah River Company, Aiken, SC.

Newman, J. L. 2005. Personal communication, sent Excel files of transient groundwater concentrations provided by Tetra Tech. The source of these results is described in Section 4.1 of CBU-PIT-2005-00106, *Demonstration of Tank 19 and Tank 18 Conformance to 10 CFR 61, Subpart C, Performance Objectives*.

Wilhite, E. L. 2005. Email communication, “Garden Size for Post-Drilling Intruder Scenario”, July 12, 2005.

Appendix A. Description of Detailed Results in Excel Files

For each of the four calculations in this report there is an Excel file with detailed results for each case of parameters. The Excel files are named by the calculation number, e.g. Calc1-Results.xls. Following is a description of the file structure and content for each Excel file.

Calc1-Results.xls
There are five worksheets in this Excel file. The "Inventory" worksheet has a listing of the radionuclides with curies used in calculation (Caldwell 2005). There is also a summary of maximum dose and time for each of the four cases Calc1(a)-Calc1(d) listed in Table 5. These maximum values computed from the detailed results worksheets are in mrem/yr and were used to populate the results in Table 5.

For each case there is a detailed worksheet named with the case names used in Table 5. At the top of the case worksheet is a header that shows the choice of parameters that generate the results in that worksheet. The worksheet has time from 115 to 10,005 years in 10 year increments. The first column has total dose in rem/yr. The succeeding columns have the dose for each radionuclide that appears in the inventory. Note that all doses here are in rem/yr (not mrem/yr).

Calc2-Results.xls
There are two worksheets in this Excel file labeled by the case names in Table 5. At the top of each worksheet is a header that shows which well is used for concentration transient. There is a summary result for the maximum dose in mrem/yr, which was used to populate the results in Table 5. Following are the detailed transient dose results with time from 35 to 9975 years with 70 year increments. These are the time steps in the concentration transients from the Excel file provided by Newman (2005). The first column has total dose and succeeding columns have the dose for individual radionuclides. Note that all doses here are in rem/yr (not mrem/yr).

Calc3-Results.xls
There are eight worksheets in this Excel file that correspond to the eight cases for Calculation 3 given in Table 5. The format of these worksheets is the same as the worksheets in Calc2-Results.xls. The header gives the parameter choices that correspond to Table 5. The resulting doses follow in rem/yr (not mrem/yr).

Calc4-Results.xls
There are two worksheets in the Excel file, which has the same structure as Calc1-Results.xls. The "Inventory" worksheet shows the transfer line inventory and a summary of the maximum dose in mrem/yr. The "Calc4" worksheet has the detailed dose results in rem/yr (not mrem/yr).

Appendix B. F-Area Tank Farm 1-meter Well Radionuclide Concentrations

Following are the radionuclide concentrations as a function of time provided by Newman (2005) for the 1-meter well.
The footnotes in the table heading are as follows:

a. This table includes all radionuclides that have a non-zero value in the output of the modeling.
b. Daughter product of Sn-126.
c. Daughter product of Np-237.

	Beta Gamma emitter concentrations[a]						Alpha emitter and daughter concentrations[a]					
Year	Tc-99 (pCi/L)	C-14 (pCi/L)	I-129 (pCi/L)	H-3 (pCi/L)	Sn-126 (pCi/L)	Sb-126[b] (pCi/L)	Np-237 (pCi/L)	Pa-233[c] (pCi/L)	U-233[c] (pCi/L)	Th-229[c] (pCi/L)	Ra-225[c] (pCi/L)	Ac-225[c] (pCi/L)
35	3.20E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
105	2.30E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
175	5.70E-13	0.00E+00	0.00E+00	4.70E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
245	2.40E-10	0.00E+00	0.00E+00	1.50E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
315	5.80E-07	0.00E+00	0.00E+00	2.80E-30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
385	9.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
455	7.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
525	5.40E+01	0.00E+00	6.80E-07	8.20E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
595	1.80E+02	6.40E-17	7.40E-03	1.30E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
665	3.20E+02	9.00E-10	1.90E-01	1.10E-14	0.00E+00	0.00E+00	2.90E-10	2.90E-10	5.10E-13	9.80E-15	9.80E-15	9.80E-15
735	2.90E+02	5.10E-05	3.30E-01	8.90E-17	0.00E+00	0.00E+00	1.90E-06	1.90E-06	3.80E-09	8.40E-11	8.40E-11	8.40E-11
805	2.30E+02	2.00E-03	3.20E-01	0.00E+00	0.00E+00	0.00E+00	7.30E-06	7.30E-06	1.50E-08	3.30E-10	3.30E-10	3.30E-10
875	1.80E+02	9.40E-02	2.60E-01	0.00E+00	0.00E+00	0.00E+00	1.30E-05	1.30E-05	2.60E-08	5.70E-10	5.70E-10	5.70E-10
945	1.50E+02	3.30E-01	2.10E-01	0.00E+00	0.00E+00	0.00E+00	1.80E-05	1.80E-05	3.80E-08	8.50E-10	8.50E-10	8.50E-10
1015	1.30E+02	5.80E-01	1.70E-01	0.00E+00	0.00E+00	0.00E+00	2.60E-05	2.60E-05	6.40E-08	1.80E-09	1.80E-09	1.80E-09
1085	1.10E+02	6.10E-01	1.40E-01	0.00E+00	0.00E+00	0.00E+00	3.40E-05	3.40E-05	9.50E-08	2.90E-09	2.90E-09	2.90E-09
1155	9.70E+01	5.20E-01	1.20E-01	0.00E+00	0.00E+00	0.00E+00	4.20E-05	4.20E-05	1.30E-07	4.10E-09	4.10E-09	4.10E-09
1225	8.60E+01	4.10E-01	1.10E-01	0.00E+00	0.00E+00	0.00E+00	5.00E-05	5.00E-05	1.60E-07	5.60E-09	5.60E-09	5.60E-09
1295	7.80E+01	3.30E-01	9.40E-02	0.00E+00	0.00E+00	0.00E+00	5.80E-05	5.80E-05	2.10E-07	8.20E-09	8.20E-09	8.20E-09
1365	7.00E+01	2.80E-01	8.40E-02	0.00E+00	0.00E+00	0.00E+00	6.60E-05	6.60E-05	2.60E-07	1.10E-08	1.10E-08	1.10E-08
1435	6.40E+01	2.40E-01	7.60E-02	0.00E+00	0.00E+00	0.00E+00	7.40E-05	7.40E-05	3.10E-07	1.40E-08	1.40E-08	1.40E-08
1505	5.90E+01	2.00E-01	6.90E-02	0.00E+00	0.00E+00	0.00E+00	8.20E-05	8.20E-05	3.70E-07	1.70E-08	1.70E-08	1.70E-08
1575	5.50E+01	1.80E-01	6.40E-02	0.00E+00	0.00E+00	0.00E+00	9.00E-05	9.00E-05	4.30E-07	2.20E-08	2.20E-08	2.20E-08
1645	5.10E+01	1.60E-01	5.90E-02	0.00E+00	0.00E+00	0.00E+00	9.80E-05	9.80E-05	5.00E-07	2.70E-08	2.70E-08	2.70E-08

Year	Beta Gamma emitter concentrations[a]						Alpha emitter and daughter concentrations[a]					
	Tc-99 (pCi/L)	C-14 (pCi/L)	I-129 (pCi/L)	H-3 (pCi/L)	Sn-126 (pCi/L)	Sb-126[b] (pCi/L)	Np-237 (pCi/L)	Pa-233[c] (pCi/L)	U-233[c] (pCi/L)	Th-229[c] (pCi/L)	Ra-225[c] (pCi/L)	Ac-225[c] (pCi/L)
1715	4.80E+01	1.40E-01	5.50E-02	0.00E+00	0.00E+00	0.00E+00	1.10E-04	1.10E-04	5.70E-07	3.20E-08	3.20E-08	3.20E-08
1785	4.50E+01	1.30E-01	5.10E-02	0.00E+00	0.00E+00	0.00E+00	1.10E-04	1.10E-04	6.50E-07	3.90E-08	3.90E-08	3.90E-08
1855	4.30E+01	1.20E-01	4.80E-02	0.00E+00	0.00E+00	0.00E+00	1.20E-04	1.20E-04	7.30E-07	4.60E-08	4.60E-08	4.60E-08
1925	4.00E+01	1.10E-01	4.60E-02	0.00E+00	0.00E+00	0.00E+00	1.30E-04	1.30E-04	8.20E-07	5.30E-08	5.30E-08	5.30E-08
1995	3.80E+01	9.90E-02	4.30E-02	0.00E+00	0.00E+00	0.00E+00	1.40E-04	1.40E-04	9.10E-07	6.20E-08	6.20E-08	6.20E-08
2065	3.70E+01	9.20E-02	4.10E-02	0.00E+00	0.00E+00	0.00E+00	1.50E-04	1.50E-04	1.00E-06	7.30E-08	7.30E-08	7.30E-08
2135	3.50E+01	8.60E-02	3.90E-02	0.00E+00	0.00E+00	0.00E+00	1.50E-04	1.50E-04	1.10E-06	8.30E-08	8.30E-08	8.30E-08
2205	3.30E+01	8.00E-02	3.70E-02	0.00E+00	0.00E+00	0.00E+00	1.60E-04	1.60E-04	1.20E-06	9.40E-08	9.40E-08	9.40E-08
2275	3.20E+01	7.50E-02	3.50E-02	0.00E+00	0.00E+00	0.00E+00	1.70E-04	1.70E-04	1.30E-06	1.10E-07	1.10E-07	1.10E-07
2345	3.10E+01	7.10E-02	3.40E-02	0.00E+00	0.00E+00	0.00E+00	1.80E-04	1.80E-04	1.40E-06	1.20E-07	1.20E-07	1.20E-07
2415	3.00E+01	6.70E-02	3.30E-02	0.00E+00	0.00E+00	0.00E+00	1.90E-04	1.90E-04	1.60E-06	1.30E-07	1.30E-07	1.30E-07
2485	2.80E+01	6.30E-02	3.10E-02	0.00E+00	0.00E+00	0.00E+00	1.90E-04	1.90E-04	1.70E-06	1.50E-07	1.50E-07	1.50E-07
2555	2.70E+01	6.00E-02	3.00E-02	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.00E-04	1.80E-06	1.70E-07	1.70E-07	1.70E-07
2625	2.70E+01	5.70E-02	2.90E-02	0.00E+00	0.00E+00	0.00E+00	2.10E-04	2.10E-04	2.00E-06	1.90E-07	1.90E-07	1.90E-07
2695	2.60E+01	5.50E-02	2.80E-02	0.00E+00	0.00E+00	0.00E+00	2.20E-04	2.20E-04	2.10E-06	2.00E-07	2.00E-07	2.00E-07
2765	2.50E+01	5.20E-02	2.70E-02	0.00E+00	0.00E+00	0.00E+00	2.30E-04	2.30E-04	2.30E-06	2.30E-07	2.30E-07	2.30E-07
2835	2.40E+01	5.00E-02	2.60E-02	0.00E+00	0.00E+00	0.00E+00	2.40E-04	2.40E-04	2.40E-06	2.50E-07	2.50E-07	2.50E-07
2905	2.30E+01	4.80E-02	2.60E-02	0.00E+00	0.00E+00	0.00E+00	2.50E-04	2.50E-04	2.60E-06	2.80E-07	2.80E-07	2.80E-07
2975	2.30E+01	4.60E-02	2.50E-02	0.00E+00	0.00E+00	0.00E+00	2.60E-04	2.60E-04	2.90E-06	3.10E-07	3.10E-07	3.10E-07
3045	2.20E+01	4.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	2.90E-04	2.90E-04	3.20E-06	3.70E-07	3.70E-07	3.70E-07
3115	2.20E+01	4.20E-02	2.30E-02	0.00E+00	0.00E+00	0.00E+00	3.20E-04	3.20E-04	3.60E-06	4.20E-07	4.20E-07	4.20E-07
3185	2.10E+01	4.10E-02	2.30E-02	0.00E+00	0.00E+00	0.00E+00	3.50E-04	3.50E-04	4.10E-06	4.80E-07	4.80E-07	4.80E-07
3255	2.00E+01	4.00E-02	2.20E-02	0.00E+00	0.00E+00	0.00E+00	3.90E-04	3.90E-04	4.70E-06	5.60E-07	5.60E-07	5.60E-07
3325	2.00E+01	3.80E-02	2.20E-02	0.00E+00	0.00E+00	0.00E+00	4.20E-04	4.20E-04	5.20E-06	6.50E-07	6.50E-07	6.50E-07
3395	1.90E+01	3.70E-02	2.10E-02	0.00E+00	0.00E+00	0.00E+00	4.60E-04	4.60E-04	5.80E-06	7.40E-07	7.40E-07	7.40E-07
3465	1.90E+01	3.60E-02	2.10E-02	0.00E+00	0.00E+00	0.00E+00	5.00E-04	5.00E-04	6.40E-06	8.30E-07	8.30E-07	8.30E-07
3535	1.90E+01	3.50E-02	2.00E-02	0.00E+00	0.00E+00	0.00E+00	5.40E-04	5.40E-04	7.10E-06	9.40E-07	9.40E-07	9.40E-07
3605	1.80E+01	3.40E-02	2.00E-02	0.00E+00	0.00E+00	0.00E+00	5.70E-04	5.70E-04	7.80E-06	1.00E-06	1.00E-06	1.00E-06
3675	1.80E+01	3.30E-02	1.90E-02	0.00E+00	0.00E+00	0.00E+00	6.10E-04	6.10E-04	8.40E-06	1.20E-06	1.20E-06	1.20E-06
3745	1.70E+01	3.20E-02	1.90E-02	0.00E+00	0.00E+00	0.00E+00	6.50E-04	6.50E-04	9.10E-06	1.30E-06	1.30E-06	1.30E-06
3815	1.70E+01	3.10E-02	1.80E-02	0.00E+00	0.00E+00	0.00E+00	6.80E-04	6.80E-04	9.90E-06	1.40E-06	1.40E-06	1.40E-06

Year	Beta Gamma emitter concentrations[a]						Alpha emitter and daughter concentrations[a]					
	Tc-99 (pCi/L)	C-14 (pCi/L)	I-129 (pCi/L)	H-3 (pCi/L)	Sn-126 (pCi/L)	Sb-126[b] (pCi/L)	Np-237 (pCi/L)	Pa-233[c] (pCi/L)	U-233[c] (pCi/L)	Th-229[c] (pCi/L)	Ra-225[c] (pCi/L)	Ac-225[c] (pCi/L)
3885	1.70E+01	3.00E-02	1.80E-02	0.00E+00	0.00E+00	0.00E+00	7.20E-04	7.20E-04	1.10E-05	1.50E-06	1.50E-06	1.50E-06
3955	1.60E+01	2.90E-02	1.80E-02	0.00E+00	0.00E+00	0.00E+00	7.60E-04	7.60E-04	1.10E-05	1.70E-06	1.70E-06	1.70E-06
4025	1.00E+01	2.70E-02	1.70E-02	0.00E+00	0.00E+00	0.00E+00	8.00E-04	8.00E-04	1.20E-05	1.80E-06	1.80E-06	1.80E-06
4095	1.90E+00	2.00E-02	1.00E-02	0.00E+00	0.00E+00	0.00E+00	8.30E-04	8.30E-04	1.30E-05	2.00E-06	2.00E-06	2.00E-06
4165	2.60E-11	8.80E-03	1.70E-03	0.00E+00	0.00E+00	0.00E+00	8.70E-04	8.70E-04	1.40E-05	2.20E-06	2.20E-06	2.20E-06
4235	2.80E-11	2.30E-03	1.90E-18	0.00E+00	0.00E+00	0.00E+00	9.10E-04	9.10E-04	1.50E-05	2.30E-06	2.30E-06	2.30E-06
4305	2.90E-11	2.10E-03	1.80E-18	0.00E+00	0.00E+00	0.00E+00	9.40E-04	9.40E-04	1.60E-05	2.50E-06	2.50E-06	2.50E-06
4375	3.00E-11	2.10E-03	7.50E-19	0.00E+00	0.00E+00	0.00E+00	9.80E-04	9.80E-04	1.70E-05	2.70E-06	2.70E-06	2.70E-06
4445	3.10E-11	2.20E-03	7.50E-20	0.00E+00	0.00E+00	0.00E+00	1.00E-03	1.00E-03	1.70E-05	2.90E-06	2.90E-06	2.90E-06
4515	3.30E-11	2.20E-03	3.50E-29	0.00E+00	0.00E+00	0.00E+00	1.10E-03	1.10E-03	1.80E-05	3.10E-06	3.10E-06	3.10E-06
4585	3.40E-11	2.20E-03	4.50E-29	0.00E+00	2.30E-24	2.30E-24	1.10E-03	1.10E-03	1.90E-05	3.30E-06	3.30E-06	3.30E-06
4655	3.50E-11	2.20E-03	5.30E-29	0.00E+00	5.90E-23	5.90E-23	1.10E-03	1.10E-03	2.00E-05	3.50E-06	3.50E-06	3.50E-06
4725	3.60E-11	2.20E-03	6.00E-29	0.00E+00	1.20E-22	1.20E-22	1.20E-03	1.20E-03	2.10E-05	3.80E-06	3.80E-06	3.80E-06
4795	3.80E-11	2.20E-03	7.00E-29	0.00E+00	1.70E-22	1.70E-22	1.20E-03	1.20E-03	2.20E-05	4.00E-06	4.00E-06	4.00E-06
4865	3.90E-11	2.10E-03	8.00E-29	0.00E+00	2.70E-15	2.70E-15	1.20E-03	1.20E-03	2.40E-05	4.30E-06	4.30E-06	4.30E-06
4935	4.00E-11	2.10E-03	9.10E-29	0.00E+00	8.40E-15	8.40E-15	1.30E-03	1.30E-03	2.50E-05	4.50E-06	4.50E-06	4.50E-06
5005	4.10E-11	2.10E-03	1.00E-28	0.00E+00	1.40E-14	1.40E-14	1.30E-03	1.30E-03	2.60E-05	4.80E-06	4.80E-06	4.80E-06
5075	4.20E-11	2.10E-03	1.20E-28	0.00E+00	2.60E-13	2.60E-13	1.30E-03	1.30E-03	2.60E-05	5.00E-06	5.00E-06	5.00E-06
5145	4.30E-11	2.00E-03	1.40E-28	0.00E+00	2.80E-12	2.80E-12	1.40E-03	1.40E-03	2.70E-05	5.20E-06	5.20E-06	5.20E-06
5215	4.40E-11	2.00E-03	1.60E-28	0.00E+00	5.90E-12	5.90E-12	1.40E-03	1.40E-03	2.80E-05	5.50E-06	5.50E-06	5.50E-06
5285	4.40E-11	1.90E-03	1.80E-28	0.00E+00	9.00E-12	9.00E-12	1.40E-03	1.40E-03	2.90E-05	5.70E-06	5.70E-06	5.70E-06
5355	4.50E-11	1.90E-03	2.00E-28	0.00E+00	3.20E-11	3.20E-11	1.40E-03	1.40E-03	2.90E-05	5.90E-06	5.90E-06	5.90E-06
5425	4.60E-11	1.90E-03	2.30E-28	0.00E+00	9.20E-11	9.20E-11	1.40E-03	1.40E-03	3.00E-05	6.10E-06	6.10E-06	6.10E-06
5495	4.70E-11	1.80E-03	2.50E-28	0.00E+00	1.50E-10	1.50E-10	1.50E-03	1.50E-03	3.20E-05	6.50E-06	6.50E-06	6.50E-06
5565	4.70E-11	1.80E-03	2.80E-28	0.00E+00	2.20E-10	2.20E-10	1.50E-03	1.50E-03	3.30E-05	6.90E-06	6.90E-06	6.90E-06
5635	4.80E-11	1.70E-03	3.20E-28	0.00E+00	4.50E-10	4.50E-10	1.60E-03	1.60E-03	3.50E-05	7.30E-06	7.30E-06	7.30E-06
5705	4.80E-11	1.70E-03	3.60E-28	0.00E+00	7.40E-10	7.40E-10	1.60E-03	1.60E-03	3.70E-05	7.80E-06	7.80E-06	7.80E-06
5775	4.90E-11	1.60E-03	4.00E-28	0.00E+00	1.00E-09	1.00E-09	1.70E-03	1.70E-03	3.90E-05	8.30E-06	8.30E-06	8.30E-06
5845	4.90E-11	1.60E-03	4.50E-28	0.00E+00	1.40E-09	1.40E-09	1.80E-03	1.80E-03	4.10E-05	8.80E-06	8.80E-06	8.80E-06
5915	4.90E-11	1.50E-03	4.90E-28	0.00E+00	2.40E-09	2.40E-09	1.80E-03	1.80E-03	4.30E-05	9.30E-06	9.30E-06	9.30E-06
5985	5.00E-11	1.50E-03	5.50E-28	0.00E+00	4.90E-09	4.90E-09	1.90E-03	1.90E-03	4.50E-05	9.80E-06	9.80E-06	9.80E-06

Year	Beta Gamma emitter concentrations[a]						Alpha emitter and daughter concentrations[a]					
	Tc-99 (pCi/L)	C-14 (pCi/L)	I-129 (pCi/L)	H-3 (pCi/L)	Sn-126 (pCi/L)	Sb-126[b] (pCi/L)	Np-237 (pCi/L)	Pa-233[c] (pCi/L)	U-233[c] (pCi/L)	Th-229[c] (pCi/L)	Ra-225[c] (pCi/L)	Ac-225[c] (pCi/L)
6055	5.00E-11	1.40E-03	6.00E-28	0.00E+00	7.40E-09	7.40E-09	1.90E-03	1.90E-03	4.70E-05	1.00E-05	1.00E-05	1.00E-05
6125	5.00E-11	1.40E-03	6.60E-28	0.00E+00	1.00E-08	1.00E-08	2.00E-03	2.00E-03	4.90E-05	1.10E-05	1.10E-05	1.10E-05
6195	5.00E-11	1.30E-03	7.20E-28	0.00E+00	3.70E-08	3.70E-08	2.10E-03	2.10E-03	5.10E-05	1.20E-05	1.20E-05	1.20E-05
6265	5.00E-11	1.30E-03	7.90E-28	0.00E+00	8.10E-08	8.10E-08	2.10E-03	2.10E-03	5.30E-05	1.20E-05	1.20E-05	1.20E-05
6335	5.00E-11	1.30E-03	8.70E-28	0.00E+00	1.30E-07	1.30E-07	2.20E-03	2.20E-03	5.50E-05	1.30E-05	1.30E-05	1.30E-05
6405	5.00E-11	1.20E-03	9.60E-28	0.00E+00	1.80E-07	1.80E-07	2.20E-03	2.20E-03	5.70E-05	1.30E-05	1.30E-05	1.30E-05
6475	5.00E-11	1.20E-03	1.00E-27	0.00E+00	2.90E-07	2.90E-07	2.30E-03	2.30E-03	6.00E-05	1.40E-05	1.40E-05	1.40E-05
6545	5.00E-11	1.10E-03	1.10E-27	0.00E+00	4.10E-07	4.10E-07	2.40E-03	2.40E-03	6.20E-05	1.50E-05	1.50E-05	1.50E-05
6615	5.00E-11	1.10E-03	1.30E-27	0.00E+00	5.30E-07	5.30E-07	2.40E-03	2.40E-03	6.40E-05	1.60E-05	1.60E-05	1.60E-05
6685	5.00E-11	1.00E-03	1.40E-27	0.00E+00	6.70E-07	6.70E-07	2.50E-03	2.50E-03	6.70E-05	1.60E-05	1.60E-05	1.60E-05
6755	5.00E-11	9.90E-04	1.50E-27	0.00E+00	8.40E-07	8.40E-07	2.60E-03	2.60E-03	6.90E-05	1.70E-05	1.70E-05	1.70E-05
6825	4.90E-11	9.50E-04	1.60E-27	0.00E+00	1.00E-06	1.00E-06	2.60E-03	2.60E-03	7.10E-05	1.80E-05	1.80E-05	1.80E-05
6895	4.90E-11	9.00E-04	1.70E-27	0.00E+00	1.20E-06	1.20E-06	2.70E-03	2.70E-03	7.40E-05	1.90E-05	1.90E-05	1.90E-05
6965	4.90E-11	8.60E-04	1.90E-27	0.00E+00	1.40E-06	1.40E-06	2.70E-03	2.70E-03	7.60E-05	1.90E-05	1.90E-05	1.90E-05
7035	4.80E-11	8.20E-04	2.00E-27	0.00E+00	1.60E-06	1.60E-06	2.80E-03	2.80E-03	7.90E-05	2.00E-05	2.00E-05	2.00E-05
7105	4.80E-11	7.80E-04	2.20E-27	0.00E+00	1.80E-06	1.80E-06	2.90E-03	2.90E-03	8.10E-05	2.10E-05	2.10E-05	2.10E-05
7175	4.80E-11	7.50E-04	2.40E-27	0.00E+00	2.00E-06	2.00E-06	2.90E-03	2.90E-03	8.40E-05	2.20E-05	2.20E-05	2.20E-05
7245	4.70E-11	7.10E-04	2.50E-27	0.00E+00	2.30E-06	2.30E-06	3.00E-03	3.00E-03	8.70E-05	2.30E-05	2.30E-05	2.30E-05
7315	4.70E-11	6.80E-04	2.70E-27	0.00E+00	2.50E-06	2.50E-06	3.00E-03	3.00E-03	8.90E-05	2.40E-05	2.40E-05	2.40E-05
7385	4.60E-11	6.40E-04	3.00E-27	0.00E+00	2.70E-06	2.70E-06	3.10E-03	3.10E-03	9.20E-05	2.40E-05	2.40E-05	2.40E-05
7455	4.60E-11	6.10E-04	3.20E-27	0.00E+00	2.90E-06	2.90E-06	3.20E-03	3.20E-03	9.50E-05	2.50E-05	2.50E-05	2.50E-05
7525	4.50E-11	5.80E-04	3.40E-27	0.00E+00	3.20E-06	3.20E-06	3.20E-03	3.20E-03	9.70E-05	2.60E-05	2.60E-05	2.60E-05
7595	4.40E-11	5.50E-04	3.60E-27	0.00E+00	3.40E-06	3.40E-06	3.30E-03	3.30E-03	1.00E-04	2.70E-05	2.70E-05	2.70E-05
7665	4.40E-11	5.20E-04	3.80E-27	0.00E+00	3.70E-06	3.70E-06	3.30E-03	3.30E-03	1.00E-04	2.80E-05	2.80E-05	2.80E-05
7735	4.30E-11	4.90E-04	4.10E-27	0.00E+00	3.90E-06	3.90E-06	3.40E-03	3.40E-03	1.10E-04	2.90E-05	2.90E-05	2.90E-05
7805	4.30E-11	4.60E-04	4.40E-27	0.00E+00	4.20E-06	4.20E-06	3.40E-03	3.40E-03	1.10E-04	3.00E-05	3.00E-05	3.00E-05
7875	4.20E-11	4.40E-04	4.70E-27	0.00E+00	4.40E-06	4.40E-06	3.50E-03	3.50E-03	1.10E-04	3.10E-05	3.10E-05	3.10E-05
7945	4.10E-11	4.10E-04	5.00E-27	0.00E+00	4.70E-06	4.70E-06	3.50E-03	3.50E-03	1.10E-04	3.20E-05	3.20E-05	3.20E-05
8015	4.10E-11	3.90E-04	5.40E-27	0.00E+00	5.00E-06	5.00E-06	3.50E-03	3.50E-03	1.10E-04	3.20E-05	3.20E-05	3.20E-05
8085	4.00E-11	3.60E-04	5.70E-27	0.00E+00	5.20E-06	5.20E-06	3.50E-03	3.50E-03	1.20E-04	3.30E-05	3.30E-05	3.30E-05
8155	3.90E-11	3.40E-04	6.10E-27	0.00E+00	5.50E-06	5.50E-06	3.50E-03	3.50E-03	1.20E-04	3.40E-05	3.40E-05	3.40E-05

Year	Beta Gamma emitter concentrations[a]						Alpha emitter and daughter concentrations[a]					
	Tc-99 (pCi/L)	C-14 (pCi/L)	I-129 (pCi/L)	H-3 (pCi/L)	Sn-126 (pCi/L)	Sb-126[b] (pCi/L)	Np-237 (pCi/L)	Pa-233[c] (pCi/L)	U-233[c] (pCi/L)	Th-229[c] (pCi/L)	Ra-225[c] (pCi/L)	Ac-225[c] (pCi/L)
8225	3.90E-11	3.20E-04	6.50E-27	0.00E+00	5.80E-06	5.80E-06	3.60E-03	3.60E-03	1.20E-04	3.50E-05	3.50E-05	3.40E-05
8295	3.80E-11	3.00E-04	6.80E-27	0.00E+00	6.10E-06	6.10E-06	3.60E-03	3.60E-03	1.20E-04	3.50E-05	3.50E-05	3.50E-05
8365	3.70E-11	2.80E-04	7.20E-27	0.00E+00	6.40E-06	6.40E-06	3.60E-03	3.60E-03	1.20E-04	3.60E-05	3.60E-05	3.60E-05
8435	3.60E-11	2.60E-04	7.60E-27	0.00E+00	6.60E-06	6.60E-06	3.60E-03	3.60E-03	1.20E-04	3.70E-05	3.70E-05	3.70E-05
8505	3.60E-11	2.50E-04	8.00E-27	0.00E+00	6.90E-06	6.90E-06	3.60E-03	3.60E-03	1.20E-04	3.70E-05	3.70E-05	3.70E-05
8575	3.50E-11	2.30E-04	8.50E-27	0.00E+00	7.20E-06	7.20E-06	3.60E-03	3.60E-03	1.30E-04	3.80E-05	3.80E-05	3.80E-05
8645	3.40E-11	2.20E-04	9.10E-27	0.00E+00	7.50E-06	7.50E-06	3.70E-03	3.70E-03	1.30E-04	3.90E-05	3.90E-05	3.90E-05
8715	3.40E-11	2.00E-04	9.60E-27	0.00E+00	7.80E-06	7.80E-06	3.70E-03	3.70E-03	1.30E-04	4.00E-05	4.00E-05	4.00E-05
8785	3.30E-11	1.90E-04	1.00E-26	0.00E+00	8.10E-06	8.10E-06	3.70E-03	3.70E-03	1.30E-04	4.00E-05	4.00E-05	4.00E-05
8855	3.20E-11	1.80E-04	1.10E-26	0.00E+00	8.40E-06	8.40E-06	3.70E-03	3.70E-03	1.30E-04	4.10E-05	4.10E-05	4.10E-05
8925	3.10E-11	1.60E-04	1.10E-26	0.00E+00	8.60E-06	8.60E-06	3.70E-03	3.70E-03	1.30E-04	4.20E-05	4.20E-05	4.20E-05
8995	3.10E-11	1.50E-04	1.20E-26	0.00E+00	8.90E-06	8.90E-06	3.70E-03	3.70E-03	1.40E-04	4.30E-05	4.30E-05	4.30E-05
9065	3.00E-11	1.40E-04	1.20E-26	0.00E+00	9.20E-06	9.20E-06	3.70E-03	3.70E-03	1.40E-04	4.40E-05	4.40E-05	4.40E-05
9135	2.90E-11	1.30E-04	1.30E-26	0.00E+00	9.50E-06	9.50E-06	3.80E-03	3.80E-03	1.40E-04	4.40E-05	4.40E-05	4.40E-05
9205	2.90E-11	1.20E-04	1.40E-26	0.00E+00	9.80E-06	9.80E-06	3.80E-03	3.80E-03	1.40E-04	4.50E-05	4.50E-05	4.50E-05
9275	2.80E-11	1.20E-04	1.40E-26	0.00E+00	1.00E-05	1.00E-05	3.80E-03	3.80E-03	1.40E-04	4.60E-05	4.60E-05	4.60E-05
9345	2.70E-11	1.10E-04	1.50E-26	0.00E+00	1.00E-05	1.00E-05	3.80E-03	3.80E-03	1.40E-04	4.70E-05	4.70E-05	4.70E-05
9415	2.70E-11	1.00E-04	1.60E-26	0.00E+00	1.10E-05	1.10E-05	3.80E-03	3.80E-03	1.50E-04	4.80E-05	4.80E-05	4.80E-05
9485	2.60E-11	9.20E-05	1.70E-26	0.00E+00	1.10E-05	1.10E-05	3.80E-03	3.80E-03	1.50E-04	4.80E-05	4.80E-05	4.80E-05
9555	2.50E-11	8.50E-05	1.70E-26	0.00E+00	1.10E-05	1.10E-05	3.80E-03	3.80E-03	1.50E-04	4.90E-05	4.90E-05	4.90E-05
9625	2.50E-11	7.90E-05	1.80E-26	0.00E+00	1.20E-05	1.20E-05	3.90E-03	3.90E-03	1.50E-04	5.00E-05	5.00E-05	5.00E-05
9695	2.40E-11	7.40E-05	1.90E-26	0.00E+00	1.20E-05	1.20E-05	3.90E-03	3.90E-03	1.50E-04	5.10E-05	5.10E-05	5.10E-05
9765	2.30E-11	6.80E-05	2.00E-26	0.00E+00	1.20E-05	1.20E-05	3.90E-03	3.90E-03	1.50E-04	5.20E-05	5.20E-05	5.20E-05
9835	2.30E-11	6.30E-05	2.10E-26	0.00E+00	1.20E-05	1.20E-05	3.90E-03	3.90E-03	1.60E-04	5.30E-05	5.30E-05	5.30E-05
9905	2.20E-11	5.90E-05	2.20E-26	0.00E+00	1.30E-05	1.30E-05	3.90E-03	3.90E-03	1.60E-04	5.40E-05	5.40E-05	5.40E-05
9975	2.10E-11	5.40E-05	2.20E-26	0.00E+00	1.30E-05	1.30E-05	3.90E-03	3.90E-03	1.60E-04	5.50E-05	5.50E-05	5.50E-05

Distribution:

Robinson, T. C.	766-H, Rm 2016
Newman, J. L.	766-H, Rm 2500
Buice, J. M.	766-H, Rm 2256
Stevens, W. T.	773-A, Rm A-261
Butcher, B. T.	773-43A, Rm 216
Wilhite, E. L.	773-43A, Rm 214
Cook, J. R.	773-43A, Rm 209
Koffman, L. D.	773-42A, Rm 181
Holding-Smith, C. P.	773-42A, Rm 146
WPT Files (5)	773-43A, Rm 213