QA:NA

Calculation Report

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Title: ICRP-60 and ICRP-72 RADTRAN 5 and RISKIND Dose Conversion Factors

Summary:

Dose calculations were completed using the computer codes RADTRAN 5 (Neuhauser and Kanipe 2000) and RISKIND (Yuan et al. 1995). Both codes required input files of a specific format which included dose conversion factors for each radionuclide. The dose conversion factors required were of different units for each computer code.

The dosimetric data for the internal pathways (inhalation and ingestion) came from the *ICRP Database of Dose Coefficients: Workers and Members of the Public* (ICRP 2001). The dosimetric data for the external pathways (ground shine and immersion) came from the *Federal Guidance Report 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides: CD Supplement* (EPA 2002). These dosimetric data are based on the recommendations by the International Commission on Radiological Protection in ICRP Publication 60 (ICRP 1991) and incorporate the dose coefficients from ICRP Publication 72 (ICRP 1996).

Calculations were completed to convert the original dosimetric data to the format required by each computer code. Included in this report are five tables. Table 1 shows the lung absorption type selections. Table 2 shows the ingrowth fractions for significant nuclides and progeny. Table 3 lists the original dosimetric data. Table 4 contains the RISKIND input file data and Table 5 contains the RADTRAN 5 input file data.

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DOSE CONVERSION FACTOR CALCULATION

Estimates for radiation doses through the inhalation, ingestion, immersion, and ground surface pathways were calculated using the RADTRAN 5 (Neuhauser and Kanipe 2000) and RISKIND (Yuan et al. 1995) computer codes, which require dose conversion factors (also known as dose coefficients) as input. Consistent dosimetric data for external and internal doses were provided through separate sources. External dosimetric data was obtained from the *Federal Guidance Report 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides: CD Supplement* (EPA 2002). For immersion and ground exposure dose conversion factors, dosimetric data were selected according to radionuclide (e.g. Pu-238).

The internal dosimetric data was taken from the *ICRP Database of Dose Coefficients: Workers and Members of the Public* (ICRP 2001). For each radionuclide, the inhalation and ingestion dose conversion factors were selected according to the lung absorption types outlined in *ICRP-72 Dose Conversion Factor Input File for MACCS2* (BSC 2005, Table 8) (see Table 1). For elements with multiple lung absorption types, the lung type was selected based on the following prioritization:

1. Type recommended from fuel fission or activation product release data.
2. Type is recommended for the oxide form of the element.
3. Default type recommended by ICRP-72 (ICRP 1996).
4. Type with the highest effective dose conversion factor.

The ingrowth of radionuclide progeny was included in the dose calculations for significant nuclides where the progeny were in equilibrium with parent nuclides. The ingrowth fractions were determined through decay data provided in Federal Guidance Report No. 12, *External Exposure to Radionuclides in Air, Water, and Soil* (Eckerman and Ryman 1993). The ingrowth fractions are contained in Table 2.

The dosimetric data used in the calculations are contained in Table 3, where columns 2 and 3 contain the original external dosimetric data, and columns 4 through 7 contain the original internal dosimetric data.

The RISKIND code input file requires the dose conversion factors in the same units as provided by the sources. The ingestion and inhalation dose conversion factors have units of Sv/Bq, the immersion dose conversion factors have units of Sv-m^3/Bq-s, and the ground exposure dose conversion factors have units of Sv-m^2/Bq-s. For the RISKIND input file, only the effective dose [E(50)] values were used. For this reason, all other values are zero in the input file data for RISKIND (see Table 4).

Table 1. Lung Absorption Type Selection.

Atomic No.	Element	Symbol	Lung Absorption Type [a]F	[b]M	[c]S	Selection Basis from Reference
1	Hydrogen	H	F	M	S	HTO use SR-2
4	Beryllium	Be		M	[d]S	Y(S) for oxides
6	Carbon	C	F	M	S	CO_2 use SR-2
9	Fluorine	F	F	M	[d]S	Use maximum
11	Sodium	Na	[d]F	–	–	[e]See NOTES
12	Magnesium	Mg	F	[d]M	–	W(M) for oxides
13	Aluminum	Al	F	[d]M	–	W(M) for oxides
14	Silicon	Si	F	[d]M	S	W(M) for oxides
15	Phosphorus	P	[d]F	M	–	D(F) for all except W(M) for phosphates
16	Sulfur	S	[d]F	M	S	SO_2 use SR-1 and F
17	Chlorine	Cl	F	[d]M	–	Use maximum
19	Potassium	K	[d]F	–	–	[e]See NOTES
20	Calcium	Ca	F	[d]M	S	M for all compounds
21	Scandium	Sc	–	–	[d]S	[e]See NOTES
22	Titanium	Ti	F	[d]M	S	W(M) for oxides
23	Vanadium	V	F	[d]M	–	W(M) for oxides
24	Chromium	Cr	F	M	[d]S	Y(S) for oxides
25	Manganese	Mn	F	[d]M	–	W(M) for oxides
26	Iron	Fe	F	[d]M	S	M for oxides
27	Cobalt	Co	F	M	[d]S	S for oxides
28	Nickel	Ni	F	[d]M	S	M for oxides
29	Copper	Cu	F	M	[d]S	Y(S) for oxides
30	Zinc	Zn	F	M	[d]S	S for oxides
31	Gallium	Ga	F	[d]M	–	W(M) for oxides
32	Germanium	Ge	F	[d]M	–	W(M) for oxides
33	Arsenic	As	–	[d]M	–	[e]See NOTES
34	Selenium	Se	[d]F	M	S	F for all compounds
35	Bromine	Br	F	[d]M	–	Use maximum
37	Rubidium	Rb	[d]F	–	–	[e]See NOTES
38	Strontium	Sr	F	[d]M	S	M for reactor fuel activities
39	Yttrium	Y	–	M	[d]S	Y(S) for oxides
40	Zirconium	Zr	F	[d]M	S	M for fuel release
41	Niobium	Nb	F	[d]M	S	M for fuel release
42	Molybdenum	Mo	F	[d]M	S	M for oxides
43	Technetium	Tc	F	[d]M	S	M for oxides
44	Ruthenium	Ru	F	[d]M	S	M for fuel release
45	Rhodium	Rh	F	M	[d]S	Y(S) for oxides
46	Palladium	Pd	F	M	[d]S	Y(S) for oxides
47	Silver	Ag	F	[d]M	S	M for activated corrosion products
48	Cadmium	Cd	F	M	[d]S	Y(S) for oxides
49	Indium	In	F	[d]M	–	W(M) for oxides
50	Tin	Sn	F	[d]M	–	W(M) for oxides
51	Antimony	Sb	F	[d]M	S	M for oxides

Table 1. Lung Absorption Type Selection.

Atomic No.	Element	Symbol	Lung Absorption Type [a]F	[b]M	[c]S	Selection Basis from Reference
52	Tellurium	Te	F	[d]M	S	M for oxides
53	Iodine	I	[d]F	M	S	F no data to support M or S
55	Cesium	Cs	[d]F	M	S	F for fuel release
56	Barium	Ba	F	[d]M	S	M for default
57	Lanthanum	La	F	[d]M	–	W(M) for oxides
58	Cerium	Ce	F	[d]M	S	M for fuel release
59	Praseodymium	Pr	–	M	[d]S	Y(S) for oxides
60	Neodymium	Nd	–	M	[d]S	Y(S) for oxides
61	Promethium	Pm	–	M	[d]S	Y(S) for oxides
62	Samarium	Sm	–	[d]M	–	[e]See NOTES
63	Europium	Eu	–	[d]M	–	[e]See NOTES
64	Gadolinium	Gd	F	[d]M	–	W(M) for oxides
65	Terbium	Tb	–	[d]M	–	[e]See NOTES
66	Dysprosium	Dy	–	[d]M	–	[e]See NOTES
67	Holmium	Ho	–	[d]M	–	[e]See NOTES
68	Erbium	Er	–	[d]M	–	[e]See NOTES
69	Thulium	Tm	–	[d]M	–	[e]See NOTES
70	Ytterbium	Yb	–	M	[d]S	Y(S) for oxides
71	Lutetium	Lu	–	M	[d]S	Y(S) for oxides
72	Hafnium	Hf	F	[d]M	–	W(M) for oxides
73	Tantalum	Ta	–	M	[d]S	Y(S) for oxides
74	Tungsten	W	[d]F	–	–	[e]See NOTES
75	Rhenium	Re	F	[d]M	–	W(M) for oxides
76	Osmium	Os	F	M	[d]S	Y(S) for oxides
77	Iridium	Ir	F	M	[d]S	Y(S) for oxides
78	Platinum	Pt	[d]F	–	–	[e]See NOTES
79	Gold	Au	F	M	[d]S	Y(S) for oxides
80	Mercury	Hg	F	[d]M	–	W(M) for oxides
81	Thallium	Tl	[d]F	–	–	[e]See NOTES
82	Lead	Pb	F	[d]M	S	M for default
83	Bismuth	Bi	F	[d]M	–	W(M) for all except nitrates
84	Polonium	Po	F	[d]M	S	M for default
85	Astatine	At	F	[d]M	–	Use maximum
87	Francium	Fr	[d]F	–	–	[e]See NOTES
88	Radium	Ra	F	[d]M	S	M for all compounds
89	Actinium	Ac	F	M	[d]S	Y(S) for oxides
90	Thorium	Th	F	M	[d]S	Y for oxides
91	Protactinium	Pa	–	M	[d]S	Y(S) for oxides
92	Uranium	U	F	M	[d]S	[f]Y(S) for oxide f1 per ICRP-68
93	Neptunium	Np	F	[d]M	S	M for all compounds
94	Plutonium	Pu	F	M	[d]S	[f]Y(S) for oxide f1 per ICRP-68
95	Americium	Am	F	[d]M	S	M for all compounds
96	Curium	Cm	F	[d]M	S	M for oxides

Table 1. Lung Absorption Type Selection.

Atomic No.	Element	Symbol	Lung Absorption Type [a]F	[b]M	[c]S	Selection Basis from Reference
97	Berkelium	Bk	–	[d]M	–	[e]See NOTES
98	Californium	Cf	–	[d]M	–	[e]See NOTES
99	Einsteinium	Es	–	[d]M	–	[e]See NOTES
100	Fermium	Fm	–	[d]M	–	[e]See NOTES
101	Mendelevium	Md	–	[d]M	–	[e]See NOTES

NOTES:

a. F is the lung absorption type for deposited materials that are readily absorbed into body fluids from the respiratory tract (Fast absorption). Broadly similar to Type D lung retention class.

b. M is the lung absorption type for deposited materials that have intermediate rates of absorption into body fluids from the respiratory tract (Moderate absorption). Broadly similar to Type W lung retention class.

c. S is the lung absorption type for deposited materials that are relatively insoluble in the respiratory tract (Slow absorption). Broadly similar to Type Y lung retention class.

d. Selected lung absorption types for elements are shown in the shaded boxes.

e. Only one single lung absorption class

f. ICRP Publication 68 (ICRP 1995).

HTO is tritiated water.

Table 2. Decay Ingrowth Fractions

Parent Nuclide	Progeny	Ingrowth Fraction		Parent Nuclide	Progeny	Ingrowth Fraction
Sr-90	Y-90	1.0000		**Actinium Decay Series (4n+3)**		
				U-235	Th-231	1.0000
Ru-106	Rh-106	1.0000				
				Ac-227	Th-227	0.9862
Sn-126	Sb-126m	1.0000			Fr-223	0.0138
	Sb-126	0.1400			Ra-223	1.0000
					Rn-219	1.0000
Sb-125	Te-125m	0.2280			Po-215	1.0000
					Pb-211	1.0000
Cs-137	Ba-137m	0.9460			Bi-211	1.0000
					Po-211	0.0028
Ce-144	Pr-144	1.0000			Tl-207	0.9972
	Pr-144m	0.0178				
				Neptunium Decay Series (4n+1)		
Misc.				Np-237	Pa-233	1.0000
Am-242m	Am-242	0.9952				
	Np-238	0.0048		Th-229	Ra-225	1.0000
					Ac-225	1.0000
Am-243	Np-239	1.0000			Fr-221	1.0000
					At-217	1.0000

Table 2. Decay Ingrowth Fractions

Parent Nuclide	Progeny	Ingrowth Fraction		Parent Nuclide	Progeny	Ingrowth Fraction
Cm-247	Pu-243	1.0000			Bi-213	1.0000
					Po-213	0.9784
Uranium Decay Series (4n+2)					Tl-209	0.0216
U-238	Th-234	1.0000			Pb-209	1.0000
	Pa-234m	0.9980				
	Pa-234	0.0033				
				Thorium Decay Series (4n)		
Ra-226	Rn-222	1.0000		Ra-228	Ac-228	1.0000
	Po-218	1.0000				
	Pb-214	0.9998		Th-228	Ra-224	1.0000
	At-218	0.0002			Rn-220	1.0000
	Bi-214	1.0000			Po-216	1.0000
	Po-214	1.0000			Pb-212	1.0000
					Bi-212	1.0000
Pb-210	Bi-210	1.0000			Po-212	0.6407
	Po-210	1.0000			Tl-208	0.3593

The RADTRAN 5 computer code uses different units for the input files. Units of rem/Ci are used for ingestion and inhalation dose conversion factors, rem-m^3/Ci-s is used for immersion dose conversion factors, and MeV and rem-m^2/μCi-day are used for ground exposure. The conversion of the units to the units used by RADTRAN 5 is a simple unit conversion for the ingestion, inhalation, and immersion dose conversion factors (e.g., Sv/Bq to rem/Ci). For example, the calculation below shows the conversion from Sv/Bq to rem/Ci.

$$\frac{\text{rem}}{\text{Ci}} = \frac{\text{Sv}}{\text{Bq}} \times \frac{3.7\times10^{10}\,\text{Bq}}{\text{Ci}} \times \frac{100\ \text{rem}}{\text{Sv}}$$

RADTRAN 5 requires MeV for ground exposure and uses the following expression to estimate the dose rate from groundshine:

$$\text{Dose Rate (rem/day)} = \text{Contamination Level } (\mu\text{Ci/m}^2) \times \text{Photon Energy (MeV)} \times 3.04\times10^{-4}\,\frac{\text{rem-m}^2}{\text{day}-\mu\text{Ci}-\text{MeV}}$$

As explained in *Environmental Baseline File for National Transportation* (CRWMS 1999), the constant 3.04×10^{-4} relates dose rate to deposited activity, based on dry air, an average photon energy of 0.33 MeV, and a 1 meter exposure distance above the ground. The value for MeV for each radionuclide was calculated from the Federal Guidance Report No. 13 ground surface dose conversion factors, converted from units of Sv-m^2/Bq-s to units of rem-m^2/μCi-day, as follows:

$$\text{Dose Conversion Factor}\ \frac{\text{rem-m}^2}{\mu\text{Ci}-\text{day}} = 3.04\times10^{-4}\ \frac{\text{rem-m}^2}{\mu\text{Ci}-\text{day}-\text{MeV}} \times \text{Photon Energy (MeV)}$$

$$\text{Photon Energy (MeV)} = \text{Dose Conversion Factor}\ \frac{\text{rem-m}^2}{\mu\text{Ci}-\text{day}} \div 3.04\times10^{-4}\ \frac{\text{rem-m}^2}{\mu\text{Ci}-\text{day}-\text{MeV}}$$

Input data for the RADTRAN 5 input files is provided in Table 5.

References

BSC (Bechtel SAIC Company) 2005. *ICRP-72 Dose Conversion Factor Input File for MACCS2.* 000-00C-MGR0-02200-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

CRWMS M&O 1999. *Environmental Baseline File for National Transportation.* B00000000-01717-5705-00116 REV 01. Las Vegas, Nevada: CRWMS M&O.

Eckerman, K.F. and Ryman, J.C. 1993. *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. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air.

EPA (U.S. Environmental Protection Agency) 2002. *Federal Guidance Report 13, Cancer Risk Coefficients for Environmental Exposure to Radionuclides: CD Supplement.* EPA-402-C-99-001, Rev. 1. [Washington, D.C.]: U.S. Environmental Protection Agency.

ICRP (International Commission on Radiological Protection) 1991. *1990 Recommendations of the International Commission on Radiological Protection.* Volume 21, No. 1-3 of Annals of the ICRP. ICRP Publication 60. New York, New York: Pergamon Press.

ICRP (International Commission on Radiological Protection) 1995. *Dose Coefficients for Intakes of Radionuclides by Workers, Replacement of ICRP Publication 61.* Volume 24, No. 4 of Annals of the ICRP. ICRP Publication 68. Tarrytown, New York: Pergamon.

ICRP (International Commission on Radiological Protection) 1996. *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients.* Volume 26, No. 1 of Annals of the ICRP. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press.

ICRP (International Commission on Radiological Protection) 2001. *The ICRP Database of Dose Coefficients: Workers and Members of the Public.* ICRP Publications 72. [New York, New York]: Elsevier.

Neuhauser, K.S. and Kanipe, F.L. 2000. *RADTRAN 5, User Guide.* SAND2000-1257. Albuquerque, New Mexico: Sandia National Laboratories.

Yuan, Y.C.; Chen, S.Y.; Biwer, B.M.; and LePoire, D.J. 1995. *RISKIND - A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel.* ANL/EAD-1. Argonne, Illinois: Argonne National Laboratory.

Table 3. Original Dose Conversion Factor Data.

Nuclide	Plane (Sv-m2/Bq-s)	Submersion (Sv-m3/Bq-s)	Inhalation (Sv/Bq)	Inhalation f1	Ingestion (Sv/Bq)	Ingestion f1
H-3	0.00E+00	0.00E+00	2.700E-11[a]	1.0	1.80E-11	1.0
Be-10	3.41E-18	1.38E-16	3.500E-08	0.0050	1.10E-09	0.0
C-14	1.28E-20	2.60E-18	6.200E-12	1.0	5.80E-10	1.0
Cl-36	1.12E-17	1.66E-16	7.300E-09	1.0	9.30E-10	1.0
Mn-54	7.89E-16	3.83E-14	1.500E-09	0.10	7.10E-10	0.1
Fe-55	0.00E+00	0.00E+00	3.800E-10	0.10	3.30E-10	0.1
Fe-59	1.10E-15	5.62E-14	3.700E-09	0.10	1.80E-09	0.1
Co-58	9.23E-16	4.45E-14	2.100E-09	0.010	7.40E-10	0.1
Co-60	2.30E-15	1.19E-13	3.100E-08	0.010	3.40E-09	0.1
Ni-59	0.00E+00	0.00E+00	1.300E-10	0.050	6.30E-11	0.1
Ni-63	0.00E+00	0.00E+00	4.800E-10	0.050	1.50E-10	0.1
Se-79	1.65E-20	3.94E-18	1.100E-09	0.80	2.90E-09	0.8
Kr-85	1.05E-17	2.40E-16	0.00E+00		0.00E+00	
Sr-90	1.64E-18	9.83E-17	3.600E-08	0.10	2.80E-08	0.30
Y-90	1.10E-16	7.93E-16	1.500E-09	0.00010	2.70E-09	0.00010
Sr-90+P	1.12E-16	8.91E-16	3.75E-08		3.07E-08	0.30
Zr-93	0.00E+00	0.00E+00	1.000E-08	0.0020	1.10E-09	0.010
Nb-93m	6.82E-19	3.05E-18	5.100E-10	0.010	1.20E-10	0.010
Nb-94	1.49E-15	7.20E-14	1.100E-08	0.010	1.70E-09	0.010
Nb-95	7.27E-16	3.49E-14	1.500E-09	0.010	5.80E-10	0.010
Tc-99	6.49E-20	2.87E-17	4.000E-09	0.10	6.40E-10	0.50
Ru-106	0.00E+00	0.00E+00	2.800E-08	0.050	7.00E-09	0.050
Rh-106	3.45E-16	1.06E-14	0.00E+00		0.00E+00	
Ru-106+P	3.45E-16	1.06E-14	2.80E-08		7.00E-09	0.050
Rh-102	2.02E-15	9.69E-14	1.700E-08	0.050	2.60E-09	0.050
Pd-107	0.00E+00	0.00E+00	5.900E-10	0.0050	3.70E-11	0.0050
Cd-113m	1.77E-18	9.06E-17	3.100E-08	0.050	2.30E-08	0.050
Sn-126	4.83E-17	1.85E-15	2.800E-08	0.020	4.70E-09	0.020
Sb-126m	1.54E-15	7.02E-14	1.900E-11	0.010	3.60E-11	0.100
Sb-126	2.71E-15	1.28E-13	2.800E-09	0.010	2.40E-09	0.100
Sn-126+P	1.97E-15	9.00E-14	2.84E-08		5.07E-09	0.020
Sb-125	4.08E-16	1.87E-14	4.800E-09	0.010	1.10E-09	0.10
Te-125m	2.68E-17	3.37E-16	3.400E-09	0.10	8.70E-10	0.30
Sb-125+P	4.14E-16	1.88E-14	5.58E-09		1.30E-09	0.10
I-129	1.96E-17	2.83E-16	3.600E-08	1.0	1.10E-07	1.0
Cs-134	1.48E-15	7.07E-14	6.600E-09	1.0	1.90E-08	1.0
Cs-135	2.69E-20	9.50E-18	6.900E-10	1.0	2.00E-09	1.0
Cs-137	2.99E-18	9.28E-17	4.600E-09	1.0	1.30E-08	1.0

Table 3. Original Dose Conversion Factor Data.

Nuclide	Plane (Sv-m2/Bq-s)	Submersion (Sv-m3/Bq-s)	Inhalation (Sv/Bq)	Inhalation f1	Ingestion (Sv/Bq)	Ingestion f1
Ba-137m	5.78E-16	2.69E-14	0.00E+00		0.00E+00	
Cs-137+P	5.50E-16	2.55E-14	4.60E-09		1.30E-08	1.0
Ce-144	1.84E-17	7.65E-16	3.600E-08	0.00050	5.20E-09	0.00050
Pr-144	1.63E-16	2.65E-15	1.800E-11	0.00050	5.00E-11	0.00050
Pr-144m	1.05E-17	2.21E-16	0.00E+00		0.00E+00	
Ce-144+P	1.82E-16	3.42E-15	3.60E-08		5.25E-09	0.00050
Pm-147	2.81E-20	8.67E-18	4.900E-09	0.00050	2.60E-10	0.00050
Sm-151	3.55E-21	2.47E-20	4.000E-09	0.00050	9.80E-11	0.00050
Eu-154	1.17E-15	5.76E-14	5.300E-08	0.00050	2.00E-09	0.00050
Eu-155	5.35E-17	2.15E-15	6.900E-09	0.00050	3.20E-10	0.00050
Uranium Decay Series (4n+2)						
Cm-246	5.76E-19	3.10E-18	4.200E-05	0.00050	2.10E-07	0.00050
Pu-242	4.98E-19	2.91E-18	0.00E+00		0.00E+00	
U-238	4.24E-19	2.51E-18	8.000E-06	0.0020	4.50E-08	0.020
Th-234	7.50E-18	2.95E-16	7.700E-09	0.00050	3.40E-09	0.00050
Pa-234m	1.08E-16	1.21E-15	0.00E+00		0.00E+00	
Pa-234	1.80E-15	8.73E-14	4.000E-10	0.00050	5.10E-10	0.00050
U-238+P	1.22E-16	1.79E-15	8.01E-06		4.84E-08	0.020
U-234	5.86E-19	6.13E-18	9.400E-06	0.0020	4.90E-08	0.020
Th-230	6.37E-19	1.49E-17	1.400E-05	0.00050	2.10E-07	0.00050
Ra-226	6.11E-18	2.84E-16	3.500E-06	0.10	2.80E-07	0.20
Rn-222	3.82E-19	1.78E-17	0.00E+00		0.00E+00	
Po-218	8.64E-21	4.21E-19	0.00E+00		0.00E+00	
Pb-214	2.40E-16	1.10E-14	1.400E-08	0.10	1.40E-10	0.20
At-218	3.65E-18	9.76E-17	0.00E+00		0.00E+00	
Bi-214	1.44E-15	7.25E-14	1.400E-08	0.050	1.10E-10	0.050
Po-214	7.91E-20	3.81E-18	0.00E+00		0.00E+00	
Ra-226+P	1.69E-15	8.38E-14	3.53E-06		2.80E-07	0.20
Pb-210	2.13E-18	4.51E-17	1.100E-06	0.10	6.90E-07	0.20
Bi-210	3.51E-17	2.58E-16	9.300E-08	0.050	1.30E-09	0.050
Po-210	8.07E-21	3.89E-19	3.300E-06	0.10	1.20E-06	0.50
Pb-210+P	3.72E-17	3.03E-16	4.49E-06		1.89E-06	0.20
Actinium Decay Series (4n+3)						
Cm-243	1.18E-16	5.31E-15	3.100E-05	0.00050	1.50E-07	0.00050

Table 3. Original Dose Conversion Factor Data.

Nuclide	Plane (Sv-m2/Bq-s)	Submersion (Sv-m3/Bq-s)	Inhalation (Sv/Bq)	Inhalation f1	Ingestion (Sv/Bq)	Ingestion f1
Pu-239	2.84E-19	3.49E-18	1.600E-05	0.000010	2.50E-07	0.00050
U-235	1.40E-16	6.48E-15	8.500E-06	0.0020	4.70E-08	0.020
Th-231	1.56E-17	4.59E-16	3.300E-10	0.00050	3.40E-10	0.00050
U-235+P	1.56E-16	6.94E-15	8.50E-06		4.73E-08	0.020
Pa-231	3.78E-17	1.57E-15	3.400E-05	0.00050	7.10E-07	0.00050
Ac-227	1.41E-19	5.13E-18	7.200E-05	0.00050	1.10E-06	0.00050
Th-227	9.81E-17	4.44E-15	1.000E-05	0.00050	8.80E-09	0.00050
Fr-223	7.76E-17	2.21E-15	8.900E-10	1.0	2.40E-09	1.0
Ra-223	1.21E-16	5.48E-15	7.400E-06	0.10	1.00E-07	0.20
Rn-219	5.28E-17	2.46E-15	0.00E+00		0.00E+00	
Po-215	1.68E-19	7.80E-18	0.00E+00		0.00E+00	
Pb-211	9.49E-17	2.59E-15	1.100E-08	0.10	1.80E-10	0.20
Bi-211	4.40E-17	2.04E-15	0.00E+00		0.00E+00	
Po-211	7.41E-18	3.56E-16	0.00E+00		0.00E+00	
Tl-207	5.56E-17	4.53E-16	0.00E+00		0.00E+00	
Ac-227+P	4.66E-16	1.74E-14	8.93E-05		1.21E-06	0.00050
Neptunium Decay Series (4n+1)						
Cm-245	8.05E-17	3.50E-15	4.200E-05	0.00050	2.10E-07	0.00050
Pu-241	1.72E-21	6.35E-20	1.700E-07	0.000010	4.80E-09	0.00050
Am-241	2.33E-17	6.77E-16	4.200E-05	0.00050	2.00E-07	0.00050
Np-237	2.52E-17	8.90E-16	2.300E-05	0.00050	1.10E-07	0.00050
Pa-233	1.86E-16	8.57E-15	3.900E-09	0.00050	8.70E-10	0.00050
Np-237+P	2.11E-16	9.46E-15	2.30E-05		1.11E-07	0.00050
U-233	6.00E-19	1.42E-17	9.600E-06	0.0020	5.10E-08	0.020
Th-229	7.90E-17	3.37E-15	7.100E-05	0.00050	4.90E-07	0.00050
Ra-225	1.07E-17	2.41E-16	6.300E-06	0.10	9.90E-08	0.20
Ac-225	1.47E-17	6.38E-16	8.500E-06	0.00050	2.40E-08	0.00050
Fr-221	2.84E-17	1.33E-15	0.00E+00		0.00E+00	
At-217	2.92E-19	1.37E-17	0.00E+00		0.00E+00	
Bi-213	1.68E-16	6.17E-15	3.000E-08	0.050	2.00E-10	0.050
Po-213	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
Tl-209	1.92E-15	9.66E-14	0.00E+00		0.00E+00	
Pb-209	3.19E-18	1.00E-16	5.600E-11	0.10	5.70E-11	0.20
Th-229+P	3.46E-16	1.39E-14	8.58E-05		6.13E-07	0.00050

Table 3. Original Dose Conversion Factor Data.

Nuclide	Plane (Sv-m2/Bq-s)	Submersion (Sv-m3/Bq-s)	Inhalation (Sv/Bq)	Inhalation f1	Ingestion (Sv/Bq)	Ingestion f1
Thorium Decay Series (4n)						
Cm-244	6.44E-19	3.41E-18	2.700E-05	0.00050	1.20E-07	0.00050
Pu-240	6.01E-19	3.43E-18	1.600E-05	0.000010	2.50E-07	0.00050
U-236	5.03E-19	3.87E-18	8.700E-06	0.0020	4.70E-08	0.020
Th-232	4.55E-19	7.27E-18	2.500E-05	0.00050	2.30E-07	0.00050
Ra-228	0.00E+00	0.00E+00	2.600E-06	0.10	6.90E-07	0.20
Ac-228	9.38E-16	4.49E-14	1.600E-08	0.00050	4.30E-10	0.00050
Ra-228+P	9.38E-16	4.49E-14	2.62E-06		6.90E-07	0.20
Th-228	2.13E-18	8.13E-17	4.000E-05	0.00050	7.20E-08	0.00050
Ra-224	9.15E-18	4.30E-16	3.000E-06	0.10	6.50E-08	0.20
Rn-220	3.69E-19	1.72E-17	0.00E+00		0.00E+00	
Po-216	1.61E-20	7.75E-19	0.00E+00		0.00E+00	
Pb-212	1.35E-16	6.26E-15	1.700E-07	0.10	6.00E-09	0.20
Bi-212	2.25E-16	8.96E-15	3.100E-08	0.050	2.60E-10	0.050
Po-212	0.00E+00	0.00E+00	0.00E+00		0.00E+00	
Tl-208	2.97E-15	1.69E-13	0.00E+00		0.00E+00	
Th-228+P	1.44E-15	7.65E-14	4.32E-05		1.43E-07	0.00050
Miscellaneous						
U-232	8.08E-19	1.18E-17	3.700E-05	0.0020	3.30E-07	0.020
Pu-238	6.26E-19	3.51E-18	1.600E-05	0.000010	2.30E-07	0.00050
Am-242m	2.26E-18	2.49E-17	3.700E-05	0.00050	1.90E-07	0.00050
Am-242	1.61E-17	6.11E-16	1.700E-08	0.00050	3.00E-10	0.00050
Np-238	5.32E-16	2.56E-14	2.100E-09	0.00050	9.10E-10	0.00050
Am-242m+P	2.08E-17	7.56E-16	3.70E-05		1.90E-07	5.00E-04
Am-243	4.80E-17	1.86E-15	4.100E-05	0.00050	2.00E-07	0.00050
Np-239	1.54E-16	6.96E-15	9.300E-10	0.00050	8.00E-10	0.00050
Am-243+P	2.02E-16	8.82E-15	4.10E-05		2.01E-07	0.00050
Cm-242	7.03E-19	4.02E-18	5.200E-06	0.00050	1.20E-08	0.00050
Cm-247	2.99E-16	1.39E-14	3.900E-05	0.00050	1.90E-07	0.00050
Pu-243	2.27E-17	9.63E-16	8.600E-11	0.000010	8.50E-11	0.00050
Cm-247+P	3.22E-16	1.49E-14	3.90E-05		1.90E-07	0.00050
Cm-248	4.40E-19	2.36E-18	1.500E-04	0.00050	7.70E-07	0.00050
Cf-252	5.25E-19	3.64E-18	2.000E-05	0.00050	9.00E-08	0.00050

a. The inhalation dose coefficient for H-3 (1.80E-11 Sv/Bq) was multiplied by 1.5 to account for absorption of HTO through the skin.

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.70E-11	0.00E+00	0.00E+00	0.00E+00	Inh	HTO
	0.00E+00	0.00E+00	0.00E+00	1.80E-11	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Be-10	0.00E+00	0.00E+00	0.00E+00	1.38E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.41E-18	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.50E-08	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	1.10E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.0050
C-14	0.00E+00	0.00E+00	0.00E+00	2.60E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.28E-20	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	6.20E-12	0.00E+00	0.00E+00	0.00E+00	Inh	CO2
	0.00E+00	0.00E+00	0.00E+00	5.80E-10	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Cl-36	0.00E+00	0.00E+00	0.00E+00	1.66E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.12E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	7.30E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	9.30E-10	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Mn-54	0.00E+00	0.00E+00	0.00E+00	3.83E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	7.89E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.50E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	7.10E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.80E-10	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	3.30E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
Fe-59	0.00E+00	0.00E+00	0.00E+00	5.62E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.10E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.70E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.80E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
Co-58	0.00E+00	0.00E+00	0.00E+00	4.45E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	9.23E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.10E-09	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	7.40E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
Co-60	0.00E+00	0.00E+00	0.00E+00	1.19E-13	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.30E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.10E-08	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	3.40E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
Ni-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.30E-10	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	6.30E-11	0.00E+00	0.00E+00	0.00E+00	Ing	0.050
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.80E-10	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.50E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.050
Se-79	0.00E+00	0.00E+00	0.00E+00	3.94E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.65E-20	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.10E-09	0.00E+00	0.00E+00	0.00E+00	Inh	F
	0.00E+00	0.00E+00	0.00E+00	2.90E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.80
Kr-85	0.00E+00	0.00E+00	0.00E+00	2.40E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.05E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Inh	NA
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Ing	
Sr-90+P	0.00E+00	0.00E+00	0.00E+00	8.91E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.12E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.75E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	3.07E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.30
Zr-93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.00E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.10E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.010
Nb-93m	0.00E+00	0.00E+00	0.00E+00	3.05E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.82E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	5.10E-10	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.20E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.010
Nb-94	0.00E+00	0.00E+00	0.00E+00	7.20E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.49E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.10E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.70E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.010
Tc-99	0.00E+00	0.00E+00	0.00E+00	2.87E-17	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.49E-20	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.00E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	6.40E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.50
Ru-106+P	0.00E+00	0.00E+00	0.00E+00	1.06E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.45E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.80E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
	0.00E+00	0.00E+00	0.00E+00	7.00E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.050
Rh-102	0.00E+00	0.00E+00	0.00E+00	9.69E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.02E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.70E-08	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.60E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.050
Pd-107	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	5.90E-10	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	3.70E-11	0.00E+00	0.00E+00	0.00E+00	Ing	0.0050
Cd-113m	0.00E+00	0.00E+00	0.00E+00	9.06E-17	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.77E-18	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.10E-08	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.30E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.050
Sn-126+P	0.00E+00	0.00E+00	0.00E+00	9.00E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.97E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.84E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	5.07E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
Sb-125+P	0.00E+00	0.00E+00	0.00E+00	1.88E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	4.14E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	5.58E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.30E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.10
I-129	0.00E+00	0.00E+00	0.00E+00	2.83E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.96E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.60E-08	0.00E+00	0.00E+00	0.00E+00	Inh	F
	0.00E+00	0.00E+00	0.00E+00	1.10E-07	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Cs-134	0.00E+00	0.00E+00	0.00E+00	7.07E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.48E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	6.60E-09	0.00E+00	0.00E+00	0.00E+00	Inh	F
	0.00E+00	0.00E+00	0.00E+00	1.90E-08	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Cs-135	0.00E+00	0.00E+00	0.00E+00	9.50E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.69E-20	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	6.90E-10	0.00E+00	0.00E+00	0.00E+00	Inh	F
	0.00E+00	0.00E+00	0.00E+00	2.00E-09	0.00E+00	0.00E+00	0.00E+00	Ing	1.0
Cs-137+P	0.00E+00	0.00E+00	0.00E+00	2.55E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.50E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.60E-09	0.00E+00	0.00E+00	0.00E+00	Inh	F
	0.00E+00	0.00E+00	0.00E+00	1.30E-08	0.00E+00	0.00E+00	0.00E+00	Ing	1.0

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
Ce-144+P	0.00E+00	0.00E+00	0.00E+00	3.42E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.82E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.60E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	5.25E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Pm-147	0.00E+00	0.00E+00	0.00E+00	8.67E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.81E-20	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.90E-09	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.60E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Sm-151	0.00E+00	0.00E+00	0.00E+00	2.47E-20	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.55E-21	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.00E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	9.80E-11	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Eu-154	0.00E+00	0.00E+00	0.00E+00	5.76E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.17E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	5.30E-08	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	2.00E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Eu-155	0.00E+00	0.00E+00	0.00E+00	2.15E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.35E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	6.90E-09	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	3.20E-10	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
U-238+P	0.00E+00	0.00E+00	0.00E+00	1.79E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.22E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	8.01E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	4.84E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
U-234	0.00E+00	0.00E+00	0.00E+00	6.13E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.86E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	9.40E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	4.90E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
Th-230	0.00E+00	0.00E+00	0.00E+00	1.49E-17	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.37E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.40E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.10E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Ra-226+P	0.00E+00	0.00E+00	0.00E+00	8.38E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.69E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.53E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.80E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.20
Pb-210+P	0.00E+00	0.00E+00	0.00E+00	3.03E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.72E-17	0.00E+00	0.00E+00	0.00E+00	Grd	

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
	0.00E+00	0.00E+00	0.00E+00	4.49E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	1.89E-06	0.00E+00	0.00E+00	0.00E+00	Ing	0.20
U-235+P	0.00E+00	0.00E+00	0.00E+00	6.94E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.56E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	8.50E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	4.73E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
Pa-231	0.00E+00	0.00E+00	0.00E+00	1.57E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.78E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.40E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	7.10E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Ac-227+P	0.00E+00	0.00E+00	0.00E+00	1.74E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	4.66E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	8.93E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	1.21E-06	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Pu-241	0.00E+00	0.00E+00	0.00E+00	6.35E-20	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.72E-21	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.70E-07	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	4.80E-09	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Am-241	0.00E+00	0.00E+00	0.00E+00	6.77E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.33E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.20E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	2.00E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Np-237+P	0.00E+00	0.00E+00	0.00E+00	9.46E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.11E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.30E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	1.11E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
U-233	0.00E+00	0.00E+00	0.00E+00	1.42E-17	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.00E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	9.60E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	5.10E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
Th-229+P	0.00E+00	0.00E+00	0.00E+00	1.39E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.46E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	8.58E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	6.13E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Th-232	0.00E+00	0.00E+00	0.00E+00	7.27E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	4.55E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.50E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.30E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
Ra-228+P	0.00E+00	0.00E+00	0.00E+00	4.49E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	9.38E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.62E-06	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	6.90E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.20
Th-228+P	0.00E+00	0.00E+00	0.00E+00	7.65E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.44E-15	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.32E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.43E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
U-232	0.00E+00	0.00E+00	0.00E+00	1.18E-17	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	8.08E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.70E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	3.30E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
U-236	0.00E+00	0.00E+00	0.00E+00	3.87E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.03E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	8.70E-06	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	4.70E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.020
Pu-238	0.00E+00	0.00E+00	0.00E+00	3.51E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.26E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.60E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.30E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Pu-239	0.00E+00	0.00E+00	0.00E+00	3.49E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.84E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.60E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.50E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Pu-240	0.00E+00	0.00E+00	0.00E+00	3.43E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.01E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.60E-05	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	2.50E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Pu-242	0.00E+00	0.00E+00	0.00E+00	2.91E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	4.98E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Inh	S
	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	Ing	
Am-242m+P	0.00E+00	0.00E+00	0.00E+00	7.56E-16	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	2.08E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.70E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.90E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Am-243+P	0.00E+00	0.00E+00	0.00E+00	8.82E-15	0.00E+00	0.00E+00	0.00E+00	Sub	

Table 4. Input Data for RISKIND

Nuclide	Red Marrow	Lung	Intestine	E(50)	Gonad	Thyroid	Bone Surface	Route	Type/f1
	0.00E+00	0.00E+00	0.00E+00	2.02E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.10E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	2.01E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-242	0.00E+00	0.00E+00	0.00E+00	4.02E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	7.03E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	5.20E-06	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.20E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-243	0.00E+00	0.00E+00	0.00E+00	5.31E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	1.18E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.10E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.50E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-244	0.00E+00	0.00E+00	0.00E+00	3.41E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	6.44E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.70E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.20E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-245	0.00E+00	0.00E+00	0.00E+00	3.50E-15	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	8.05E-17	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.20E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	2.10E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-246	0.00E+00	0.00E+00	0.00E+00	3.10E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.76E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	4.20E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	2.10E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-247+P	0.00E+00	0.00E+00	0.00E+00	1.49E-14	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	3.22E-16	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	3.90E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	1.90E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cm-248	0.00E+00	0.00E+00	0.00E+00	2.36E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	4.40E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	1.50E-04	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	7.70E-07	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050
Cf-252	0.00E+00	0.00E+00	0.00E+00	3.64E-18	0.00E+00	0.00E+00	0.00E+00	Sub	
	0.00E+00	0.00E+00	0.00E+00	5.25E-19	0.00E+00	0.00E+00	0.00E+00	Grd	
	0.00E+00	0.00E+00	0.00E+00	2.00E-05	0.00E+00	0.00E+00	0.00E+00	Inh	M
	0.00E+00	0.00E+00	0.00E+00	9.00E-08	0.00E+00	0.00E+00	0.00E+00	Ing	0.00050

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/µCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
H-3	1.0	HTO	4.51E+03	0.00E+00	0.00E+00	0.00E+00	9.99E+01	6.66E+01	3.15E+01
Be-10	0.0050	S	5.84E+08	3.59E-03	5.11E-04	1.09E-06	1.30E+05	4.07E+03	1.92E+03
C-14	1.0	CO2	2.09E+06	1.35E-05	9.62E-06	4.09E-09	2.29E+01	2.15E+03	1.01E+03
Cl-36	1.0	M	1.10E+08	1.18E-02	6.14E-04	3.58E-06	2.70E+04	3.44E+03	1.63E+03
Mn-54	0.10	M	3.13E+02	8.30E-01	1.42E-01	2.52E-04	5.55E+03	2.63E+03	1.24E+03
Fe-55	0.10	M	9.86E+02	0.00E+00	0.00E+00	0.00E+00	1.41E+03	1.22E+03	5.77E+02
Fe-59	0.10	M	4.45E+01	1.16E+00	2.08E-01	3.52E-04	1.37E+04	6.66E+03	3.15E+03
Co-58	0.010	S	7.08E+01	9.71E-01	1.65E-01	2.95E-04	7.77E+03	2.74E+03	1.29E+03
Co-60	0.010	S	1.92E+03	2.42E+00	4.40E-01	7.35E-04	1.15E+05	1.26E+04	5.95E+03
Ni-59	0.050	M	2.74E+07	0.00E+00	0.00E+00	0.00E+00	4.81E+02	2.33E+02	1.10E+02
Ni-63	0.050	M	3.50E+04	0.00E+00	0.00E+00	0.00E+00	1.78E+03	5.55E+02	2.62E+02
Se-79	0.80	F	2.37E+07	1.74E-05	1.46E-05	5.27E-09	4.07E+03	1.07E+04	5.07E+03
Kr-85			3.91E+03	1.10E-02	8.88E-04	3.36E-06	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.10	M	1.06E+04	1.72E-03	3.64E-04	5.24E-07	1.33E+05	1.04E+05	4.90E+04
Y-90	0.00010	S	2.67E+00	1.16E-01	2.93E-03	3.52E-05	5.55E+03	9.99E+03	4.72E+03
Sr-90+P			1.06E+04	1.17E-01	3.30E-03	3.57E-05	1.39E+05	1.14E+05	5.37E+04
Zr-93	0.0020	M	5.58E+08	0.00E+00	0.00E+00	0.00E+00	3.70E+04	4.07E+03	1.92E+03
Nb-93m	0.010	M	4.96E+03	7.17E-04	1.13E-05	2.18E-07	1.89E+03	4.44E+02	2.10E+02
Nb-94	0.010	M	7.41E+06	1.57E+00	2.66E-01	4.76E-04	4.07E+04	6.29E+03	2.97E+03
Nb-95	0.010	M	3.52E+01	7.64E-01	1.29E-01	2.32E-04	5.55E+03	2.15E+03	1.01E+03
Tc-99	0.10	M	7.77E+07	6.82E-05	1.06E-04	2.07E-08	1.48E+04	2.37E+03	1.12E+03
Ru-106	0.050	M	3.68E+02	0.00E+00	0.00E+00	0.00E+00	1.04E+05	2.59E+04	1.22E+04
Rh-106		S	3.46E-04	3.63E-01	3.92E-02	1.10E-04	0.00E+00	0.00E+00	0.00E+00
Ru-106+P			3.68E+02	3.63E-01	3.92E-02	1.10E-04	1.04E+05	2.59E+04	1.22E+04

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/μCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
Rh-102	0.050	S	1.06E+03	2.12E+00	3.59E-01	6.46E-04	6.29E+04	9.62E+03	4.55E+03
Pd-107	0.0050	S	2.37E+09	0.00E+00	0.00E+00	0.00E+00	2.18E+03	1.37E+02	6.47E+01
Cd-113m	0.050	S	4.96E+03	1.86E-03	3.35E-04	5.66E-07	1.15E+05	8.51E+04	4.02E+04
Sn-126	0.020	M	3.65E+07	5.08E-02	6.85E-03	1.54E-05	1.04E+05	1.74E+04	8.22E+03
Sb-126m	0.010	M	1.32E-02	1.62E+00	2.60E-01	4.92E-04	7.03E+01	1.33E+02	6.30E+01
Sb-126	0.010	M	1.24E+01	2.85E+00	4.74E-01	8.66E-04	1.04E+04	8.88E+03	4.20E+03
Sn-126+P			3.65E+07	2.07E+00	3.33E-01	6.29E-04	1.05E+05	1.88E+04	8.87E+03
Sb-125	0.010	M	1.01E+03	4.29E-01	6.92E-02	1.30E-04	1.78E+04	4.07E+03	1.92E+03
Te-125m	0.10	M	5.80E+01	2.82E-02	1.25E-03	8.57E-06	1.26E+04	3.22E+03	1.52E+03
Sb-125+P			1.01E+03	4.35E-01	6.95E-02	1.32E-04	2.06E+04	4.80E+03	2.27E+03
I-129	1.0	F	5.73E+09	2.06E-02	1.05E-03	6.27E-06	1.33E+05	4.07E+05	1.92E+05
Cs-134	1.0	F	7.53E+02	1.56E+00	2.62E-01	4.73E-04	2.44E+04	7.03E+04	3.32E+04
Cs-135	1.0	F	8.40E+08	2.83E-05	3.52E-05	8.60E-09	2.55E+03	7.40E+03	3.50E+03
Cs-137	1.0	F	1.10E+04	3.14E-03	3.43E-04	9.56E-07	1.70E+04	4.81E+04	2.27E+04
Ba-137m		M	1.77E-03	6.08E-01	9.95E-02	1.85E-04	0.00E+00	0.00E+00	0.00E+00
Cs-137+P			1.10E+04	5.78E-01	9.45E-02	1.76E-04	1.70E+04	4.81E+04	2.27E+04
Ce-144	0.00050	M	2.84E+02	1.93E-02	2.83E-03	5.88E-06	1.33E+05	1.92E+04	9.10E+03
Pr-144	0.00050	S	1.20E-02	1.71E-01	9.81E-03	5.21E-05	6.66E+01	1.85E+02	8.75E+01
Pr-144m		S	5.00E-03	1.10E-02	8.18E-04	3.36E-06	0.00E+00	0.00E+00	0.00E+00
Ce-144+P			2.84E+02	1.91E-01	1.27E-02	5.80E-05	1.33E+05	1.94E+04	9.19E+03
Pm-147	0.00050	S	9.58E+02	2.95E-05	3.21E-05	8.98E-09	1.81E+04	9.62E+02	4.55E+02

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/μCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
Sm-151	0.00050	M	3.29E+04	3.73E-06	9.14E-08	1.13E-09	1.48E+04	3.63E+02	1.71E+02
Eu-154	0.00050	M	3.21E+03	1.23E+00	2.13E-01	3.74E-04	1.96E+05	7.40E+03	3.50E+03
Eu-155	0.00050	M	1.81E+03	5.63E-02	7.96E-03	1.71E-05	2.55E+04	1.18E+03	5.60E+02
Uranium Decay Series (4n+2)									
Cm-246	0.00050	M	1.73E+06	6.06E-04	1.15E-05	1.84E-07	1.55E+08	7.77E+05	3.67E+05
Pu-242		S	1.37E+08	5.24E-04	1.08E-05	1.59E-07	0.00E+00	0.00E+00	0.00E+00
U-238	0.0020	S	1.63E+12	4.46E-04	9.29E-06	1.36E-07	2.96E+07	1.67E+05	7.87E+04
Th-234	0.00050	S	2.41E+01	7.89E-03	1.09E-03	2.40E-06	2.85E+04	1.26E+04	5.95E+03
Pa-234m		S	8.13E-04	1.14E-01	4.48E-03	3.45E-05	0.00E+00	0.00E+00	0.00E+00
Pa-234	0.00050	S	2.79E-01	1.89E+00	3.23E-01	5.75E-04	1.48E+03	1.89E+03	8.92E+02
U-238+P			1.63E+12	1.28E-01	6.63E-03	3.89E-05	2.96E+07	1.79E+05	8.47E+04
U-234	0.0020	S	8.92E+07	6.16E-04	2.27E-05	1.87E-07	3.48E+07	1.81E+05	8.57E+04
Th-230	0.00050	S	2.81E+07	6.70E-04	5.51E-05	2.04E-07	5.18E+07	7.77E+05	3.67E+05
Ra-226	0.10	M	5.84E+05	6.43E-03	1.05E-03	1.95E-06	1.30E+07	1.04E+06	4.90E+05
Rn-222			3.82E+00	4.02E-04	6.59E-05	1.22E-07	0.00E+00	0.00E+00	0.00E+00
Po-218		M	2.12E-03	9.09E-06	1.56E-06	2.76E-09	0.00E+00	0.00E+00	0.00E+00
Pb-214	0.10	M	1.86E-02	2.52E-01	4.07E-02	7.67E-05	5.18E+04	5.18E+02	2.45E+02
At-218		M	2.31E-05	3.84E-03	3.61E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00
Bi-214	0.050	M	1.38E-02	1.51E+00	2.68E-01	4.60E-04	5.18E+04	4.07E+02	1.92E+02
Po-214		M	1.90E-09	8.32E-05	1.41E-05	2.53E-08	0.00E+00	0.00E+00	0.00E+00
Ra-226+P			5.84E+05	1.77E+00	3.10E-01	5.39E-04	1.31E+07	1.04E+06	4.90E+05

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/μCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
Pb-210	0.10	M	8.14E+03	2.24E-03	1.67E-04	6.81E-07	4.07E+06	2.55E+06	1.21E+06
Bi-210	0.050	M	5.01E+00	3.69E-02	9.55E-04	1.12E-05	3.44E+05	4.81E+03	2.27E+03
Po-210	0.10	M	1.38E+02	8.49E-06	1.44E-06	2.58E-09	1.22E+07	4.44E+06	2.10E+06
Pb-210+P			8.14E+03	3.92E-02	1.12E-03	1.19E-05	1.66E+07	7.00E+06	3.31E+06
Actinium Decay Series (4n+3)									
Cm-243	0.00050	M	1.04E+04	1.24E-01	1.96E-02	3.77E-05	1.15E+08	5.55E+05	2.62E+05
Pu-239	0.000010	S	8.78E+06	2.99E-04	1.29E-05	9.08E-08	5.92E+07	9.25E+05	4.37E+05
U-235	0.0020	S	2.57E+11	1.47E-01	2.40E-02	4.48E-05	3.15E+07	1.74E+05	8.22E+04
Th-231	0.00050	S	1.06E+00	1.64E-02	1.70E-03	4.99E-06	1.22E+03	1.26E+03	5.95E+02
U-235+P			2.57E+11	1.64E-01	2.57E-02	4.97E-05	3.15E+07	1.75E+05	8.28E+04
Pa-231	0.00050	S	1.20E+07	3.97E-02	5.81E-03	1.21E-05	1.26E+08	2.63E+06	1.24E+06
Ac-227	0.00050	S	7.95E+03	1.48E-04	1.90E-05	4.51E-08	2.66E+08	4.07E+06	1.92E+06
Th-227	0.00050	S	1.87E+01	1.03E-01	1.64E-02	3.14E-05	3.70E+07	3.26E+04	1.54E+04
Fr-223	1.0	F	1.51E-02	8.16E-02	8.18E-03	2.48E-05	3.29E+03	8.88E+03	4.20E+03
Ra-223	0.10	M	1.14E+01	1.27E-01	2.03E-02	3.87E-05	2.74E+07	3.70E+05	1.75E+05
Rn-219			4.58E-05	5.55E-02	9.10E-03	1.69E-05	0.00E+00	0.00E+00	0.00E+00
Po-215		M	2.06E-08	1.77E-04	2.89E-05	5.37E-08	0.00E+00	0.00E+00	0.00E+00
Pb-211	0.10	M	2.51E-02	9.98E-02	9.58E-03	3.03E-05	4.07E+04	6.66E+02	3.15E+02
Bi-211		M	1.49E-03	4.63E-02	7.55E-03	1.41E-05	0.00E+00	0.00E+00	0.00E+00
Po-211		M	5.97E-06	7.79E-03	1.32E-03	2.37E-06	0.00E+00	0.00E+00	0.00E+00
Tl-207		F	3.31E-03	5.85E-02	1.68E-03	1.78E-05	0.00E+00	0.00E+00	0.00E+00
Ac-227+P			7.95E+03	4.90E-01	6.45E-02	1.49E-04	3.30E+08	4.47E+06	2.12E+06

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/μCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
Neptunium Decay Series (4n+1)									
Cm-245	0.00050	M	3.10E+06	8.47E-02	1.30E-02	2.57E-05	1.55E+08	7.77E+05	3.67E+05
Pu-241	0.000010	S	5.26E+03	1.81E-06	2.35E-07	5.50E-10	6.29E+05	1.78E+04	8.40E+03
Am-241	0.00050	M	1.58E+05	2.45E-02	2.50E-03	7.45E-06	1.55E+08	7.40E+05	3.50E+05
Np-237	0.00050	M	7.81E+08	2.65E-02	3.29E-03	8.06E-06	8.51E+07	4.07E+05	1.92E+05
Pa-233	0.00050	S	2.70E+01	1.96E-01	3.17E-02	5.95E-05	1.44E+04	3.22E+03	1.52E+03
Np-237+P			7.81E+08	2.22E-01	3.50E-02	6.75E-05	8.51E+07	4.10E+05	1.94E+05
U-233	0.0020	S	5.79E+07	6.31E-04	5.25E-05	1.92E-07	3.55E+07	1.89E+05	8.92E+04
Th-229	0.00050	S	2.68E+06	8.31E-02	1.25E-02	2.53E-05	2.63E+08	1.81E+06	8.57E+05
Ra-225	0.10	M	1.48E+01	1.13E-02	8.92E-04	3.42E-06	2.33E+07	3.66E+05	1.73E+05
Ac-225	0.00050	S	1.00E+01	1.55E-02	2.36E-03	4.70E-06	3.15E+07	8.88E+04	4.20E+04
Fr-221		F	3.33E-03	2.99E-02	4.92E-03	9.08E-06	0.00E+00	0.00E+00	0.00E+00
At-217		M	3.74E-07	3.07E-04	5.07E-05	9.33E-08	0.00E+00	0.00E+00	0.00E+00
Bi-213	0.050	M	3.17E-02	1.77E-01	2.28E-02	5.37E-05	1.11E+05	7.40E+02	3.50E+02
Po-213		M	4.86E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-209		F	1.53E-03	2.02E+00	3.57E-01	6.14E-04	0.00E+00	0.00E+00	0.00E+00
Pb-209	0.10	M	1.36E-01	3.35E-03	3.70E-04	1.02E-06	2.07E+02	2.11E+02	9.97E+01
Th-229+P			2.68E+06	3.64E-01	5.16E-02	1.11E-04	3.18E+08	2.27E+06	1.07E+06
Thorium Decay Series (4n)									
Cm-244	0.00050	M	6.61E+03	6.77E-04	1.26E-05	2.06E-07	9.99E+07	4.44E+05	2.10E+05
Pu-240	0.000010	S	2.39E+06	6.32E-04	1.27E-05	1.92E-07	5.92E+07	9.25E+05	4.37E+05

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/µCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
U-236	0.0020	S	8.55E+09	5.29E-04	1.43E-05	1.61E-07	3.22E+07	1.74E+05	8.22E+04
Th-232	0.00050	S	5.13E+12	4.78E-04	2.69E-05	1.45E-07	9.25E+07	8.51E+05	4.02E+05
Ra-228	0.10	M	2.10E+03	0.00E+00	0.00E+00	0.00E+00	9.62E+06	2.55E+06	1.21E+06
Ac-228	0.00050	S	2.55E-01	9.86E-01	1.66E-01	3.00E-04	5.92E+04	1.59E+03	7.52E+02
Ra-228+P			2.10E+03	9.86E-01	1.66E-01	3.00E-04	9.68E+06	2.55E+06	1.21E+06
Th-228	0.00050	S	6.98E+02	2.24E-03	3.01E-04	6.81E-07	1.48E+08	2.66E+05	1.26E+05
Ra-224	0.10	M	3.66E+00	9.62E-03	1.59E-03	2.93E-06	1.11E+07	2.41E+05	1.14E+05
Rn-220		G	6.44E-04	3.88E-04	6.36E-05	1.18E-07	0.00E+00	0.00E+00	0.00E+00
Po-216		M	1.74E-06	1.69E-05	2.87E-06	5.15E-09	0.00E+00	0.00E+00	0.00E+00
Pb-212	0.10	M	4.43E-01	1.42E-01	2.32E-02	4.32E-05	6.29E+05	2.22E+04	1.05E+04
Bi-212	0.050	M	4.20E-02	2.37E-01	3.32E-02	7.19E-05	1.15E+05	9.62E+02	4.55E+02
Po-212		M	3.53E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-208		F	2.13E-03	3.12E+00	6.25E-01	9.49E-04	0.00E+00	0.00E+00	0.00E+00
Th-228+P			6.98E+02	1.51E+00	2.83E-01	4.60E-04	1.60E+08	5.30E+05	2.51E+05
Miscellaneous									
U-232	0.0020	S	2.63E+04	8.50E-04	4.37E-05	2.58E-07	1.37E+08	1.22E+06	5.77E+05
Pu-238	0.000010	S	3.20E+04	6.58E-04	1.30E-05	2.00E-07	5.92E+07	8.51E+05	4.02E+05
Am-242m	0.00050	M	5.55E+04	2.38E-03	9.21E-05	7.22E-07	1.37E+08	7.03E+05	3.32E+05
Am-242	0.00050	M	6.68E-01	1.69E-02	2.26E-03	5.15E-06	6.29E+04	1.11E+03	5.25E+02
Np-238	0.00050	M	2.12E+00	5.59E-01	9.47E-02	1.70E-04	7.77E+03	3.37E+03	1.59E+03
Am-242m+P			5.55E+04	2.19E-02	2.80E-03	6.66E-06	1.37E+08	7.04E+05	3.33E+05

Table 5. Input Data for RADTRAN 5.

Nuclide	f1	Type	Half Life (days)	Ground Surface E(50) (MeV)	Submersion E(50) (rem-m^2/Ci-s)	Ground Surface E(50) (rem-m^2/µCi-d)	Inhalation E(50) (rem/Ci)	Ingestion E(50) (rem/Ci)	Ingestion E(50) (rem/Ci × Ci deposited)
Am-243	0.00050	M	2.69E+06	5.05E-02	6.88E-03	1.53E-05	1.52E+08	7.40E+05	3.50E+05
Np-239	0.00050	M	2.36E+00	1.62E-01	2.58E-02	4.92E-05	3.44E+03	2.96E+03	1.40E+03
Am-243+P			2.69E+06	2.12E-01	3.26E-02	6.46E-05	1.52E+08	7.43E+05	3.51E+05
Cm-242	0.00050	M	1.63E+02	7.39E-04	1.49E-05	2.25E-07	1.92E+07	4.44E+04	2.10E+04
Cm-247	0.00050	M	5.69E+09	3.14E-01	5.14E-02	9.56E-05	1.44E+08	7.03E+05	3.32E+05
Pu-243	0.000010	S	2.07E-01	2.39E-02	3.56E-03	7.26E-06	3.18E+02	3.15E+02	1.49E+02
Cm-247+P			5.69E+09	3.38E-01	5.50E-02	1.03E-04	1.44E+08	7.03E+05	3.33E+05
Cm-248	0.00050	M	1.24E+08	4.63E-04	8.73E-06	1.41E-07	5.55E+08	2.85E+06	1.35E+06
Cf-252	0.00050	M	9.63E+02	5.52E-04	1.35E-05	1.68E-07	7.40E+07	3.33E+05	1.57E+05