APPENDIX C

MODIFIED RAGS HHEM EQUATIONS

EQUATIONS FOR CALCULATING EXTERNAL EXPOSURE RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{external} = [RS \times SF_e \times \frac{EF_r}{365} \times ED_r] \times [ET_{ro} + (ET_{ri} \times GSF)] \quad (1a)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

$$Risk_{external} = [RS \times SF_e \times \frac{EF_c}{365} \times ED_c] \times [ET_{co} + (ET_{ci} \times GSF)] \quad (1b)$$

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_e	External exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
GSF	Gamma shielding factor - indoor (unitless)	0.8 (20% shielding)
ET_{ro}	Exposure time fraction - residential, outdoor (unitless)	0.02 (0.439 hr/24 hr)
ET_{co}	Exposure time fraction - commercial/industrial, outdoor (unitless)	0.02 (0.5 hr/24 hr)
ET_{ri}	Exposure time fraction - residential, indoor (unitless)	0.62 (14.93 hr/24 hr)
ET_{ci}	Exposure time fraction - commercial/industrial, indoor (unitless)	0.31 (7.5 hr/24 hr)
EF_r	Exposure frequency - residential (d/yr)	350
EF_c	Exposure frequency - commercial/industrial (d/yr)	250
ED_r	Exposure duration - residential (yr)	30
ED_c	Exposure duration - commercial/industrial (yr)	25

EQUATIONS FOR CALCULATING FUGITIVE DUST INHALATION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$sk_{dust} = [RS \times SF_i \times IR_i \times PEF \times CF_{PEF} \times EF_r \times ED_r] \times [ET_{ro} + (ET_{ri} \times DF_i \quad (2a)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

$$sk_{dust} = [RS \times SF_i \times IR_i \times PEF \times CF_{PEF} \times EF_c \times ED_c] \times [ET_{co} + (ET_{ci} \times DF_i \quad (2b)$$

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_i	Inhalation slope factor (risk/pCi)	radionuclide-specific
IR_i	Inhalation rate (m^3/d)	20
CF_i	Conversion factor - inhalation (liter/m^3)	1,000
PEF	Particulate emission factor (µg/m^3)	200
CF_{PEF}	Conversion factor - PEF (g/µg)	1E-06
DF_i	Dilution factor for indoor inhalation (unitless)	0.4
ET_{ro}	Exposure time fraction - residential, outdoors (unitless)	0.02 (0.439 hr/24 hr)
ET_{co}	Exposure time fraction - commercial/industrial, outdoors (unitless)	0.02 (0.5 hr/24 hr)
ET_{ri}	Exposure time fraction - residential, indoors (unitless)	0.62 (14.93 hr/24 hr)
ET_{ci}	Exposure time fraction - commercial/industrial, indoors (unitless)	0.31 (7.5 hr/24 hr)
EF_r	Exposure frequency - residential (d/yr)	350
EF_c	Exposure frequency - commercial/industrial (d/yr)	250
ED_r	Exposure duration - residential (yr)	30
ED_c	Exposure duration - commercial/industrial (yr)	25

EQUATIONS FOR CALCULATING RADON INHALATION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

Equation (3a) for Ra-226 and Rn-222 (Radon):

$$Risk_{Rn-222} = [RS_{Ra-226} \times SFi_{Rn-222} \times IR_i \times EF_r \times ED_r] \times [(ET_{ro} \times VFo_{Rn-222}) + ((ET_{ri} \times VFi_{Rn-222})]$$

Equation (3b) for Ra-224 and Rn-220 (Thoron):

$$Risk_{Rn-220} = [RS_{Ra-224} \times SFi_{Rn-220} \times IR_i \times EF_r \times ED_r] \times [(ET_{ro} \times VFo_{Rn-220}) + ((ET_{ri} \times VFi_{Rn-220})]$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

Equation (3c) for Ra-226 and Rn-222 (Radon):

$$Risk_{Rn-222} = [RS_{Ra-226} \times SFi_{Rn-222} \times IR_i \times EF_c \times ED_c] \times [(ET_{co} \times VFo_{Rn-222}) + ((ET_{ci} \times VFi_{Rn-222})]$$

Equation (3d) for Ra-224 and Rn-220 (Thoron):

$$Risk_{Rn-220} = [RS_{Ra-224} \times SFi_{Rn-220} \times IR_i \times EF_c \times ED_c] \times [(ET_{co} \times VFo_{Rn-220}) + ((ET_{ci} \times VFi_{Rn-220})]$$

where:

Parameter	Definition (units)	Default Value
RS_{Ra-226}	Ra-226 soil concentration (pCi/g)	1
RS_{Ra-224}	Ra-224 soil concentration (pCi/g)	1
SFi_{Rn-222}	Inhalation slope factor for Rn-222+D (risk/pCi)	7.7E-12
SFi_{Rn-220}	Inhalation slope factor for Rn-220+D (risk/pCi)	1.2E-13
IR_i	Inhalation rate (m^3/d)	20
VFo_{Rn-222}	Volatilization factor for Rn-222 - outdoor (pCi/m^3/pCi/g)	120
VFo_{Rn-220}	Volatilization factor for Rn-220 - outdoor (pCi/m^3/pCi/g)	5
VFi_{Rn-222}	Volatilization factor for Rn-222 - indoor (pCi/m^3/pCi/g)	1,250
VFi_{Rn-220}	Volatilization factor for Rn-220 - outdoor (pCi/m^3/pCi/g)	5
ET_{ro}	Exposure time fraction - residential, outdoors (unitless)	0.02 (0.439 hr/24 hr)
ET_{co}	Exposure time fraction - commercial/industrial, outdoors (unitless)	0.02 (0.5 hr/24 hr)
ET_{ri}	Exposure time fraction - residential, indoors (unitless)	0.62 (14.93 hr/24 hr)
ET_{ci}	Exposure time fraction - commercial/industrial, indoors (unitless)	0.31 (7.5 hr/24 hr)
EF_r	Exposure frequency - residential (d/yr)	350
EF_c	Exposure frequency - commercial/industrial (d/yr)	250
ED_r	Exposure duration - residential (yr)	30
ED_c	Exposure duration - commercial/industrial (yr)	25

EQUATIONS FOR CALCULATING PLANT UPTAKE/INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{plant} = RS \times SF_{ing} \times (IR_{vf} + IR_{lv}) \times CF_p \times TF_p \times ED_r \quad (4)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

***** Not Applicable Exposure Pathway *****

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_{ing}	Ingestion slope factor (risk/pCi)	radionuclide-specific
IR_{vf}	Ingestion rate - vegetables and fruit (kg/yr)	42.7
IR_{lv}	Ingestion rate - leafy vegetables (kg/yr)	14
CF_p	Conversion factor - plant (g/kg)	1,000
TF_p	Soil-to-plant transfer factor (pCi/g plant per pCi/g soil)	radionuclide-specific
ED_r	Exposure duration - residential (yr)	30

EQUATIONS FOR CALCULATING MEAT UPTAKE/INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$sk_{meat} = [RS \times SF_{ing} \times IR_m \times CF_m \times ED_r] \times [(PTF_m \times FI_m \times TF_p) + (PTF_m \times FI_s) + (PTF_m \times FI_{wm} \times \frac{1}{(Kd + \sigma \times (\frac{S}{\rho}))} \times (\frac{1}{DF_v} \quad (5)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

***** Not Applicable Exposure Pathway *****

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_{ing}	Ingestion slope factor (risk/pCi)	radionuclide-specific
IR_m	Ingestion rate - meat & poultry (kg/yr)	63
CF_m	Conversion factor - meat (g/kg)	1,000
PTF_m	Plant-to-meat transfer factor (pCi/kg per pCi/d)	radionuclide-specific
TF_p	Soil-to-plant transfer factor (pCi/g plant per pCi/g soil)	radionuclide-specific
FI_m	Fodder intake rate for meat (kg/d)	68
FI_s	Livestock soil intake rate (kg/d)	0.5
FI_{wm}	Beef cattle water intake rate (L/d)	50
Kd	Distribution coefficient (ml/g)	radionuclide-specific (Ch. 3)
S	Fraction water content (l water/l pore space)	0.3
σ	Total soil porosity (l pore space/l soil)	0.5
ρ	Soil bulk density (kg/l soil)	1.5
DF_w	Dilution factor for drinking water (unitless)	10
ED_r	Exposure duration - residential (yr)	30

EQUATIONS FOR CALCULATING MILK UPTAKE/INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{milk} = [RS \times SF_{ing} \times IR_{mk} \times ED_r] \times [(PTF_{mk} \times FI_{mk} \times TF_p) + (PTF_{mk} \times FI_s) + (PTF_{mk} \times FI_{wmk} \times \frac{1}{(Kd + \sigma \times (\frac{S}{\rho}))} \times (\frac{1}{DF_w} \quad (6)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

***** Not Applicable Exposure Pathway *****

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_{ing}	Ingestion slope factor (risk/pCi)	radionuclide-specific
IR_{mk}	Ingestion rate - milk (l/yr)	92
PTF_{mk}	Plant-to-milk transfer factor (pCi/L per pCi/d)	radionuclide-specific
TF_p	Soil-to-plant transfer factor (pCi/g plant per pCi/g soil)	radionuclide-specific
FI_{mk}	Fodder intake rate for milk (kg/d)	55
FI_s	Livestock soil intake rate (kg/d)	0.5
FI_{wmk}	Milk cattle water intake rate (L/day)	160
Kd	Distribution coefficient (ml/g)	radionuclide-specific (Ch. 3)
S	Fraction water content (l water/l pore space)	0.3
σ	Total soil porosity (l water/l pore space)	0.5
ρ	Soil bulk density (kg/l soil)	1.5
DF_w	Dilution factor for drinking water (unitless)	10
ED_r	Exposure duration - residential (yr)	30

EQUATIONS FOR CALCULATING SOIL INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{soil} = RS \times SF_i \times IR_{sr} \times CF_s \times EF_r \times ED_r \quad (7a)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

$$Risk_{soil} = RS \times SF_i \times IR_{sc} \times CF_s \times EF_c \times ED_c \quad (7b)$$

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_i	Ingestion slope factor (Risk/pCi)	radionuclide-specific
IR_{sr}	Soil ingestion rate - residential (mg/d)	120 (age-averaged)
IR_{sc}	Soil ingestion rate - commercial/industrial (mg/d)	50
CF_s	Conversion factor - soil (g/mg)	0.001
EF_r	Exposure frequency - residential (d/yr)	350
EF_c	Exposure frequency - commercial/industrial (d/yr)	250
ED_r	Exposure duration - residential (yr)	30
ED_c	Exposure duration - commercial/industrial (yr)	25

EQUATIONS FOR CALCULATING DRINKING WATER INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{soil} = RS \times SF_i \times \frac{1}{(Kd + \sigma \times (\frac{S}{\rho}))} \times (\frac{1}{DF_w}) \times IR_{wr} \times CF_w \times EF_r \times ED_r \quad (8a)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

$$Risk_{soil} = RS \times SF_i \times \frac{1}{(Kd + \sigma \times (\frac{S}{\rho}))} \times (\frac{1}{DF_w}) \times IR_{wc} \times CF_w \times EF_c \times ED_c \quad (8b)$$

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_i	Ingestion slope factor (risk/pCi)	radionuclide-specific
IR_{wr}	Water ingestion rate - residential (l/d)	2
IR_{wc}	Water ingestion rate - commercial/industrial (l/d)	1
CF_s	Conversion factor - water (ml/l)	1,000
Kd	Distribution coefficient (ml/g)	radionuclide-specific (Ch. 3)
EF_r	Exposure frequency - residential (d/yr)	350
EF_c	Exposure frequency - commercial/industrial (d/yr)	250
DF_w	Dilution factor for drinking water (unitless)	10
ED_r	Exposure duration - residential (yr)	30
ED_c	Exposure duration - commercial/industrial (yr)	25
S	Fraction water content (l water/l pore space)	0.3
σ	Total soil porosity (l pore space/l soil)	0.5
ρ	Soil bulk density (kg/l soil)	1.5

EQUATIONS FOR CALCULATING FISH UPTAKE/INGESTION RISK

(a) RURAL RESIDENTIAL EXPOSURE:

$$Risk_{fish} = RS \times SF_i \times \frac{1}{(Kd + \sigma \times (\frac{S}{\rho}))} \times IR_f \times CF_f \times TF_f \times \frac{A_s}{A_w} \times ED \quad (9)$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE:

*****Not Applicable Exposure Pathway*****

where:

Parameter	Definition (units)	Default Value
RS	Radionuclide soil concentration (pCi/g)	1
SF_i	Ingestion slope factor (risk/pCi)	radionuclide-specific
IR_f	Ingestion rate - fish (g/yr)	2,300
CF_f	Conversion factor - water (ml/l)	1,000
Kd	Distribution coefficient (ml/g)	radionuclide-specific (Ch. 3)
TF_f	Water-to-fish transfer factor (pCi/kg per pCi/L)	radionuclide-specific
A_s	Surface area of contaminated site	10,000 m^2
A_w	Surface area of watershed	100,000 m^2
ED_r	Exposure duration - residential (yr)	30
S	Fraction water content (l water/l pore space)	0.3
σ	Total soil porosity (l pore space/l soil)	0.5
ρ	Soil bulk density (kg/l soil)	1.5

(a) RURAL RESIDENTIAL EXPOSURE (Eq. 10a):

$$Tot.\ Risk_{resid.} = \frac{TR}{Risk_{external} + Risk_{dust} + Risk_{radon} + Risk_{plant} + Risk_{meat} + Risk_{milk} + Risk_{soil} + Risk_{water}}$$

(b) COMMERCIAL/INDUSTRIAL EXPOSURE (Eq. 10b):

$$Tot.\ Risk_{comm./indust.} = \frac{TR}{Risk_{external} + Risk_{dust} + Risk_{radon} + Risk_{soil} + Risk_{water}}$$

where:

Parameter	Definition (units)	Default Value
TR	Target risk level	1E-04

Table C-1. EPA RAGS/HHEM Part B Risk Modeling Exposure Assumptions

Parameter	Definition	Value	Units
TR	Target risk level	1.00E-04	lifetime risk
RS	Radionuclide soil concentration	1	pCi/g
IRi	Inhalation rate	20	m^3/day
IRs	Soil ingestion rate - residential	120	mg/day
IRsc	Soil ingestion rate - commercial/industrial	50	mg/day
IRw	Water ingestion rate - residential	2	L/day
IRwc	Water ingestion rate - commercial/industrial	1	L/day
IRv	Veg./fruit/grain ingestion rate	61,250	g/yr
IRv2	Leafy vegetables intake rate	6,650	g/yr
IRm	Meat & poultry intake rate	63,000	g/yr
IRmk	Milk ingestion rate	92,000	mL/yr
IRf	Fish ingestion rate	2,300	g/yr
FIm	Fodder intake rate for meat	68	kg/d
FImk	Fodder intake rate for milk	55	kg/d
FIwm	Livestock water intake for meat	50	L/d (or kg/d)
FIwmilk	Livestock water intake for milk	160	L/d (or kg/d)
FIs	Livestock soil intake rate	0.5	kg/d
QSRs	Fodder/soil ratio for soil intake	1.0	(unitless)
ETo	Outdoor exposure time - residential	0.02	(0.439 hrs/24 hrs)
ETi	Indoor exposure time - residential	0.62	(14.93 hrs/24 hrs)
ETOc	Outdoor exposure time - commercial/industrial	0.02	(0.5 hrs/24 hrs)
ETic	Indoor exposure time - commercial/industrial	0.31	(7.5 hrs/24 hrs)
EFr	Exposure frequency - residential	350	days/yr
EFc	Exposure frequency - commercial/industrial	250	days/yr
EDr	Exposure duration - residential	30	yrs
EDc	Exposure duration - commercial/industrial	25	yrs
VFo	Volitalization factor - outdoor radon	120	(120 pCi/m^3/1 pCi/g)
VFi	Volitalization factor - indoor radon	1250	(1250 pCi/m^3/1 pCi/g)
PEF	Particulate emission factor	2.00E-04	(g/m^3)
Gsf	Gamma shielding factor	0.8	(20% shielding)
DFi	Dilution factor for inhalation indoors	0.4	(unitless)
DFw	Dilution factor for drinking water	10	(unitless)
Theta	Total soil porosity	0.5	(Lpore/Lsoil)
S	Fraction water content	0.3	(Lwater/Lpore)
BD	Soil bulk density	1.5	kg/Lsoil
Aw	Surface Area of Water Shed	1.00E+06	m^2
As	Surface Area of Site	1.00E+04	m^2
SFr	Inhalation Slope Factor - Rn-222+D	1.00E-11	Risk/pCi
DCFr	Inhalation Dose Conversion Factor - Rn-222+D	2.50E+02	mrem/yr per pCi/L Rn (50% Eq.)
SFt	Inhalation Slope Factor - Rn-220	1.20E-13	Risk/pCi
QWRs	Fodder/water ratio for water intake	1	(unitless)

Table C-2. EPA RAGS/HHEM Part B Risk Modeling
Cancer Slope Factors, Kd Values and Transfer Factors

	EPA 30-yr Slope Factors (Revised 1994)			DOE Dose Factors (RESRAD 1994)			Transfer Factors (RESRAD 5.01)			
Radionuclide	External	Inhalation	Ingestion	External	Inhalation	Ingestion	Plant	Fish (L/kg)	Beef (d/kg)	Milk (d/L)
Ac-227+D	1.64E-06	1.08E-07	8.44E-10	1.99E+00	6.70E+00	1.50E-02	2.50E-03	1.50E+01	2.00E-05	2.00E-05
Ag-108m+D	9.89E-06	1.08E-10	1.17E-11	8.01E+00	2.00E-04	7.50E-06	1.50E-01	5.00E+00	3.00E-03	2.50E-02
Ag-110m+D	1.86E-05	5.40E-11	1.64E-11	1.39E+01	5.30E-05	1.10E-05	1.50E-01	5.00E+00	3.00E-03	2.50E-02
Am-241	8.29E-09	2.92E-08	2.70E-10	3.41E-02	5.20E-01	4.50E-03	1.00E-03	3.00E+01	5.00E-05	2.00E-06
Am-243+D	4.73E-07	2.85E-08	2.76E-10	7.77E-01	5.20E-01	4.50E-03	1.00E-03	3.00E+01	5.00E-05	2.00E-06
Bi-207	9.69E-06	1.65E-11	1.05E-11	7.02E+00	1.40E-05	4.90E-06	1.00E-01	1.50E+01	2.00E-03	5.00E-04
C-14	0.00E+00	1.18E-14	1.77E-12	0.00E+00	2.10E-06	2.10E-06	5.50E+00	5.00E+04	3.10E-02	1.20E-02
Cd-109	1.07E-09	2.89E-11	1.37E-11	8.44E-03	1.00E-04	1.20E-05	3.00E-01	2.00E+02	4.00E-04	1.00E-03
Ce-144+D	2.76E-07	1.74E-10	6.34E-11	2.26E-01	3.50E-04	2.00E-05	2.00E-03	3.00E+01	2.00E-05	3.00E-05
Cl-36	0.00E+00	2.22E-12	3.96E-12	7.38E-04	2.00E-05	3.00E-06	2.00E+01	1.00E+03	6.00E-02	2.00E-02
Cm-243	3.03E-07	2.60E-08	2.50E-10	3.42E-01	3.07E-01	2.51E-03	1.00E-03	3.00E+01	2.00E-05	2.00E-06
Cm-244	4.03E-11	2.36E-08	2.24E-10	9.83E-04	2.70E-01	2.30E-03	1.00E-03	3.00E+01	2.00E-05	2.00E-06
Cm-248	2.86E-11	1.10E-07	1.15E-09	4.41E-06	1.90E+00	1.60E-02	1.00E-03	3.00E+01	2.00E-05	2.00E-06
Co-57	3.69E-07	4.74E-12	1.83E-12	3.64E-01	7.50E-06	1.10E-06	8.00E-02	3.00E+02	2.00E-02	2.00E-03
Co-60	1.72E-05	1.12E-10	3.34E-11	1.63E+01	1.50E-04	2.60E-05	8.00E-02	3.00E+02	2.00E-02	2.00E-03
Cs-134	1.04E-05	5.03E-11	8.18E-11	7.79E+00	4.70E-05	7.40E-05	4.00E-02	2.00E+03	3.00E-02	8.00E-03
Cs-135	0.00E+00	4.63E-12	7.66E-12	0.00E+00	4.50E-06	7.10E-06	4.00E-02	2.00E+03	3.00E-02	8.00E-03
Cs-137+D	3.68E-06	3.31E-11	5.40E-11	3.62E+00	3.20E-05	5.00E-05	4.00E-02	2.00E+03	3.00E-02	8.00E-03
Eu-152	7.18E-06	1.08E-10	1.15E-11	7.14E+00	2.20E-04	6.00E-06	2.50E-03	5.00E+01	2.00E-03	2.00E-05
Eu-154	8.21E-06	1.25E-10	1.92E-11	7.91E+00	2.60E-04	9.10E-06	2.50E-03	5.00E+01	2.00E-03	2.00E-05
Eu-155	1.09E-07	1.26E-11	3.45E-12	1.19E-01	3.90E-05	1.30E-06	2.50E-03	5.00E+01	2.00E-03	2.00E-05
Fe-55	0.00E+00	9.29E-13	6.14E-13	3.21E-06	2.60E-06	5.80E-07	1.00E-03	2.00E+02	2.00E-02	3.00E-04
Gd-153	1.29E-07	5.07E-12	2.78E-12	1.53E-01	2.10E-05	1.10E-06	2.50E-03	2.50E+01	2.00E-03	2.00E-05
H-3	0.00E+00	1.69E-13	1.29E-13	0.00E+00	6.30E-08	6.30E-08	4.80E+00	1.00E+00	1.20E-02	1.00E-02
I-129	4.92E-09	2.30E-10	3.46E-10	2.31E-02	1.80E-04	2.80E-04	2.00E-02	4.00E+01	7.00E-03	1.00E-02
K-40	1.08E-06	1.28E-11	2.16E-11	8.46E-01	1.20E-05	1.90E-05	3.00E-01	1.00E+03	2.00E-02	7.00E-03
Mn-54	5.74E-06	6.40E-12	3.74E-12	4.25E+00	6.40E-06	2.70E-06	3.00E-01	4.00E+02	5.00E-04	3.00E-04
Na-22	1.44E-05	8.25E-12	1.37E-11	1.11E+01	8.00E-06	1.20E-05	5.00E-02	2.00E+01	8.00E-02	4.00E-02
Nb-94	1.07E-05	1.25E-10	1.42E-11	1.02E+01	3.30E-04	5.10E-06	1.00E-02	3.00E+02	3.00E-07	2.00E-06
Ni-59	0.00E+00	6.66E-13	3.52E-13	3.89E-06	2.70E-06	2.00E-07	5.00E-02	1.00E+02	5.00E-03	2.00E-02
Ni-63	0.00E+00	1.70E-12	1.08E-12	0.00E+00	6.30E-06	5.40E-07	5.00E-02	1.00E+02	5.00E-03	2.00E-02
Np-237+D	8.17E-07	2.58E-08	2.50E-10	1.16E+00	4.90E-01	3.90E-03	2.00E-02	3.00E+01	1.00E-03	5.00E-06
Pa-231	4.81E-08	2.81E-08	1.10E-10	1.59E-01	1.30E+00	1.10E-02	1.00E-02	1.00E+01	5.00E-03	5.00E-06
Pb-210+D	2.65E-10	5.27E-09	1.29E-09	3.27E-03	2.10E-02	6.70E-03	1.00E-02	3.00E+02	8.00E-04	3.00E-04
Pm-147	1.13E-11	1.15E-11	3.02E-12	1.06E-05	3.40E-05	9.50E-07	2.50E-03	3.00E+01	2.00E-03	2.00E-05
Pu-238	3.77E-11	3.13E-08	2.57E-10	1.00E-03	4.60E-01	3.80E-03	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Pu-239	2.41E-11	3.02E-08	2.55E-10	5.40E-04	5.10E-01	4.30E-03	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Pu-240	3.62E-11	3.02E-08	2.55E-10	9.52E-04	5.10E-01	4.30E-03	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Pu-241	0.00E+00	1.43E-10	2.59E-12	3.46E-06	8.25E-03	6.85E-05	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Pu-242	3.01E-11	2.87E-08	2.42E-10	7.96E-04	4.80E-01	4.10E-03	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Pu-244+D	6.44E-06	2.91E-08	2.82E-10	1.61E+00	4.80E-01	4.00E-03	1.00E-03	3.00E+01	1.00E-04	1.00E-06
Ra-226 (+Rn)	1.19E-05	4.30E-09	4.78E-10	1.12E+01	7.90E-03	1.10E-03	4.00E-02	5.00E+01	1.00E-03	1.00E-03
Ra-226 (-Rn)	1.19E-05	4.30E-09	4.78E-10	1.12E+01	7.90E-03	1.10E-03	4.00E-02	5.00E+01	1.00E-03	1.00E-03
Ra-228+D	5.77E-06	1.56E-09	4.03E-10	5.89E+00	4.50E-03	1.20E-03	4.00E-02	5.00E+01	1.00E-03	1.00E-03
Ru-106+D	1.33E-06	1.87E-10	7.22E-11	9.77E-01	4.40E-04	2.16E-05	3.00E-02	1.00E+01	2.00E-03	3.30E-06
Sb-125+D	2.36E-06	1.02E-11	7.33E-12	2.03E+00	1.13E-05	3.40E-06	1.00E-02	1.00E+02	1.00E-03	1.00E-04
Sm-147	0.00E+00	6.96E-09	3.54E-11	0.00E+00	7.10E-02	1.80E-04	2.50E-03	2.50E+01	2.00E-03	2.00E-05
Sm-151	5.59E-13	4.55E-12	9.73E-13	3.94E-07	2.90E-05	3.40E-07	2.50E-03	2.50E+01	2.00E-03	2.00E-05
Sr-90+D	0.00E+00	7.56E-11	7.94E-11	0.00E+00	1.30E-03	1.40E-04	3.00E-01	6.00E+01	8.00E-03	2.00E-03
Tc-99	1.11E-12	4.92E-12	2.89E-12	1.21E-06	7.50E-06	1.30E-06	5.00E+00	2.00E+01	1.00E-04	1.00E-03
Th-228+D	1.09E-05	1.47E-07	4.52E-10	9.59E+00	3.10E-01	7.50E-04	1.00E-03	1.00E+02	1.00E-04	5.00E-06
Th-229+D	1.36E-06	1.19E-07	6.49E-10	1.58E+00	2.00E+00	4.30E-03	1.00E-03	1.00E+02	1.00E-04	5.00E-06
Th-230	8.21E-11	2.31E-08	5.92E-11	1.44E-03	3.20E-01	5.30E-04	1.00E-03	1.00E+02	1.00E-04	5.00E-06
Th-232+D	3.74E-11	2.56E-08	5.11E-11	8.84E-04	1.60E+00	2.80E-03	1.00E-03	1.00E+02	1.00E-04	5.00E-06
Th-Sep (+Rn)										
Th-Sep (-Rn)										
Th-Series (+Rn)										
Th-Series (-Rn)										
Tl-204	1.56E-09	1.94E-12	3.43E-12	1.59E-03	2.30E-06	3.20E-06	2.00E-01	1.00E+04	2.00E-03	3.00E-03
U-232	6.51E-11	7.77E-08	1.20E-10	1.45E-03	6.70E-01	1.30E-03	2.50E-03	1.00E+01	3.40E-04	6.00E-04
U-233	6.55E-11	2.12E-08	7.47E-11	9.70E-04	1.30E-01	2.50E-05	2.50E-03	1.00E+01	3.40E-04	6.00E-04
U-234	4.11E-11	2.09E-08	7.44E-11	1.03E-03	1.30E-01	2.60E-04	2.50E-03	1.00E+01	3.40E-04	6.00E-04
U-235+D	4.70E-07	1.95E-08	8.01E-11	6.42E-01	1.20E-01	2.50E-04	2.50E-03	1.00E+01	3.40E-04	6.00E-04
U-236	3.32E-11	1.98E-08	7.03E-11	8.69E-04	1.20E-01	2.50E-04	2.50E-03	1.00E+01	3.40E-04	6.00E-04
U-238+D	1.01E-07	1.87E-08	1.10E-10	9.12E-02	1.20E-01	2.50E-04	2.50E-03	1.00E+01	3.40E-04	6.00E-04
DU (+Rn)										
DU (-Rn)										
U-Sep (+Rn)										
U-Sep (-Rn)										
U-Series (+Rn)										
U-Series (-Rn)										
Zn-65	4.00E-06	1.70E-11	1.73E-11	2.68E+00	1.80E-05	1.40E-05	4.00E-01	1.00E+03	1.00E-01	1.00E-02