EVALUATION OF LANDFILL DISPOSAL OF ROYERSFORD SEWAGE SLUDGE

5/24/05

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1.0 Purpose:

The purpose of this evaluation is to determine the total effective dose equivalent (TEDE) due to disposal of dewatered sewage sludge containing byproduct radioactivity disposed in a municipal waste landfill.

This calculation applies to the dewatered sludge that alarmed the radiation monitoring equipment at GROWS landfill on April 20, 2004. The source of the dewatered sludge originated from the Royersford Wastewater Treatment Facility (RWTF). The source sludge of the RWTF was combined with other off-site sludge at the Pottstown Wastewater Treatment Plant (PWTP) and then dewatered. This calculation also applies to the source sludge of the secondary digester tanks at the RWTF and roll-off containers at the PWTP. Sludge in the reed beds of the RWTF is outside of the scope of this evaluation and therefore is not included.

Note: The initial evaluation for this material was performed prior to landfill disposal of this material. This evaluation revised the landfill design the minimum Pennsylvania specifications (Ref. Attachment 1, Landfill Design). The TEDE results in the revised evaluation are consistent with the results of the initial evaluation, TEDE less than 1millirem.

2.0 Results:

Using the conservative assumption that a resident farmer moves onto the site immediately after placement of the waste in the landfill, the committed exposure from all pathways is within the limits for general public exposure. The exposure to the hypothetical resident farmer is less than 1 mrem/yr, assuming the waste is deposited in any landfill lift. Measured average dose rates of less than 100 uR/hr measured at contact of any roll-off containing dewatered sludge from the sampled volume may be acceptable for landfill disposal.

3.0 Methodology:

This calculation was performed using the RESRAD computer code to evaluate the TEDE due to disposal of dewatered sewage sludge contaminated with byproduct material in a landfill constructed in accordance with Pennsylvania regulations. The "Resident Farmer" scenario is used, this scenario assumes that the sludge is disposed in the landfill and then the landfill is closed and a farmer builds a house, raises crops and keeps livestock on the affected area for family consumption.

Most of the source sludge is not in its final form. The source sludge is still in various storage tanks and not dewatered or in the roll-off containers. The known dose rates of roll-of containers and known sample results are also correlated to obtain a dose rate limit for future roll-off containers from the sampled tanks.

Radium and associated radioactivity measured in sludge samples was not included in this evaluation because this radioactivity is considered Naturally Occurring Radioactive Material (NORM) and not from a licensed operation.

The RESRAD and MicroShield reports are contained in Attachment 1

4.0 References:

4.1 Data Collection Handbook to Support Modeling the Impacts of Radiological Material in Soil, ANL/EAIS-8, Argonne National Laboratory, 4/1993

4.2 Pennsylvania Regulations as shown in Table 2.

4.3 Telephone conversation between Rick Croll, SERO RHP-2 and Tonda Lewis BRP Environmental Surveillance Section Chief on 4/29/04.

4.4 Discussion with DEP Waste Management personnel on typical dimensions of a lift at the GROWS Landfill.

4.5 Discussion with management personnel at the Royersford and Pottstown WTFs.

4.6 Radiation surveys performed by Rick Croll at the Pottstown WTF on 4/23/04.

4.7 NRC sample results provided on May 5, 2004 of the associated tanks, attached.

4.8 RESRAD, Ver 6.2, Environmental Assessment Division of Argonne National Laboratoy, 2/6/2004

4.9 MicroShield, Ver. 6.02, Grove Engineering, 1995-2003

5.0 Assumptions:

5.1 The dewatered sludge is homogeneously mixed with other waste in the landfill lift. The volume of a "lift" is used for the mixing volume, 200' x 200' x 8' (Reference 4.4). This is done because the inputs are all dumped together. There is also expected to be considerable mixing in a landfill caused by decomposition and gas movement. A two-foot thick cover is assumed. This implies that a standard two-foot thick final cover is used.

5.2 The landfill is constructed per Pennsylvania regulations; inputs for the landfill sub-base are used. Synthetic membranes are not considered due to the potential for failure of these membranes during the 1000-year evaluation period.

5.3 The volume of sludge to be disposed is 3145 yd3. This is based on a 20 yd3 volume in 1 roll-off container at GROWS Landfill, 60 yd3 contained in three roll-offs at Pottstown WTF, the estimated volume of 1430 yd3 (Reference 4.5) contained in the secondary digester at Royersford WTF and the estimated volume of 1634 yd3 contained in the digester at Pottstown WTF (Reference 4.5).

6.0 Inputs:

6.1 The RESRAD, version 6.2 program is used to calculate personnel dose due to occupancy by a hypothetical resident.

6.2 Dose rates on roll-off containers at Pottstown WTF are as follows: roll-off A; 50 uR/hr, B; 40 uR/hr and C; 50 uR/hr (Reference 4.6).

7.0 Calculation:

7.1 Table 1 shows available distribution coefficients for various sections of a landfill.

a. Distribution Coefficients were chosen based on the type material in the zone.

- The cover represents 24" of soil cover
- The cover liner is not considered.
- Defaults were used for the Contaminated zone due to various types of materials contained. Default values are representative of soil.
- The primary liner is not considered.
- Unsaturated Zone 1 represents the 12" leachate detection zone. This zone is engineered to draw leaked leachate into a collection pond. Coefficients specific to sand were chosen to represent this area.
- Unsaturated Zone 2 represents the sub-base, a 6"clay layer. Coefficients specific to clay were used for this region.
- The secondary liner is not considered.
- Unsaturated Zone 3 represents 96"of soil. This zone uses clean soil; default values were used for this zone.

- Default values were use for the Saturated Zone. This is the region that contains the water table below the landfill.

7.2 Table 2 shows non-radiological inputs used for the evaluation.

a. Zone thickness' was determined as described above.
b. Attributes for Unsaturated Zone 1 are based on sand values.
c. Attributes for Unsaturated Zone 2 are based on clay values.
d. Attributes for Unsaturated Zone 3 are based on soil default values.
e. The landfill cap thickness (2 ft) based on the minimum thickness of the final cap put on the landfill, 2 ft. It is 0.61 meters.
f. The landfill area is assumed to be 200 ft x 200 ft. This is the typical area of a lift.
g. Contaminated Zone thickness is assumed to be 8 feet. This is the typical thickness of one lift.

7.3 Table 3 shows the sample concentrations used. The concentrations determined in Reference 4.7 are modified to account for the different density and mixing in the lift.

7.4 Calculated dose rates from all pathways are shown on the graphs in Attachment 1, the RESRAD summary output is attached.

7.5 Table 3 shows average dose rates measurements taken on the identified roll-off containers and sample analysis results. Average roll-off container dose rates of 50 uR/hr will provide similar RESRAD results. MicroShield calculations using the Pottstown Roll-off A concentrations result in dose rates up to 128 uR/hr. Since the MicroShield calculations were performed using the highest concentration Roll-off data available, average roll-off dose rates of less than 100 uR/hr for sludge produced from the sampled tanks are acceptable without further analysis.

7.6 The MicroShield waste density input is conservatively defined at 1.0 g/cc.

7.6 Attachment 1 contains the following documents:

a. RESRAD Calculation Report "Royersford Sewage Sludge Disposal in PA Landfill"
b. Landfill Design matrix
c. MicroShield Calculation Report "Check LF Disposal Exposure Rate Estimation"
d. NRC sample results

TABLE 1
RESRAD DISTRIBUTION COEFFICIENTS

Distribution Coefficients (Kds):	SAND (used for unsat. zone 1)	CLAY (used for unsat. zone 2)	DEFAULT (used for unsat. zones 3 and sat. zone)
Cobalt	60	550	1000
Cesium	280	1900	1000
Manganese	50	180	200
Antimony	45	250	0
Zinc	200	2400	0
Silver	90	180	0
Cadmium	80	560	0
Lead	270	550	100
Radium	500	9100	70
Thorium	3200	5800	60000
Uranium	35	1600	50

TABLE 2
LANDFILL RESRAD INPUTS

PARAMETER	DEFAULT	VALUE USED	BASIS
Unsaturated Zone Thickness	4 m total	2.897 m Total	
Unsaturated Zone Thickness (1)	Included in above	0.305 m	Reference 25 PaCODE 273.255.b.1 & 288.435.b.4, leachate detection zone thickness
Unsaturated Zone Thickness (2)	Included in above	0.152 m	Reference 25 PaCODE 273.253.b.1 & 288.433.b.1, clay sub-base layer
Unsaturated Zone Thickness (3)	Included in above	2.44 m	Reference 25 PaCODE 273.252.b & 288.432.b minimum distance from sub-base to water table
Unsaturated Zone (1) Attributes			
total porosity	0.4	0.39	Based on ref. 4.1, table 3.2 value for coarse sand
Eff. porosity	0.2	0.3	Based on ref. 4.1, table 3.2 value for coarse sand
Hydraulic conductivity	10	5550	Based on ref. 4.1, table 5.2 value for sand
b parameter	5.3	4.05	Based on ref. 4.1, table 13.1 value for sand
Density	1.5	1.52	Based on ref. 4.1, table 2.1 value for sand
Unsaturated Zone (2) Attributes			
Total porosity	0.4	0.42	Based on reference 4.1, table 3.2 value for clay
Eff. Porosity	0.2	0.06	Based on reference 4.1, table 3.2 value for clay
Hydraulic conductivity	10	40.5	Based on reference 4.1, table 5.2 value for clay
b parameter	5.3	11.4	Based on reference 4.1, table 13.1 value for clay
Density	1.5	1.2	Based on reference 4.1, table 3.2 value for clay
Cap Thickness	0 m	0.61 m	Reference 25 PaCODE 273.233.c.1.1, 234.a.3 & 288.233.d.1, 234.f.4 requires a 2 foot thick cap.
Contaminated Zone Attributes			
Area	10000m2	3716.1 m2	Assume 200 ft x 200 ft lift area
Length parallel to aquifer flow	100 m	60.96 m	Assume the lift area is square, this is the length of one side
Thickness	2 m	2.44 m	Assume 8 foot thickness
Density	1.5 g/cm3	1.5 g/cm3	
Building Depth Below Ground Surface	-1 m	2 m	Assume building has basement

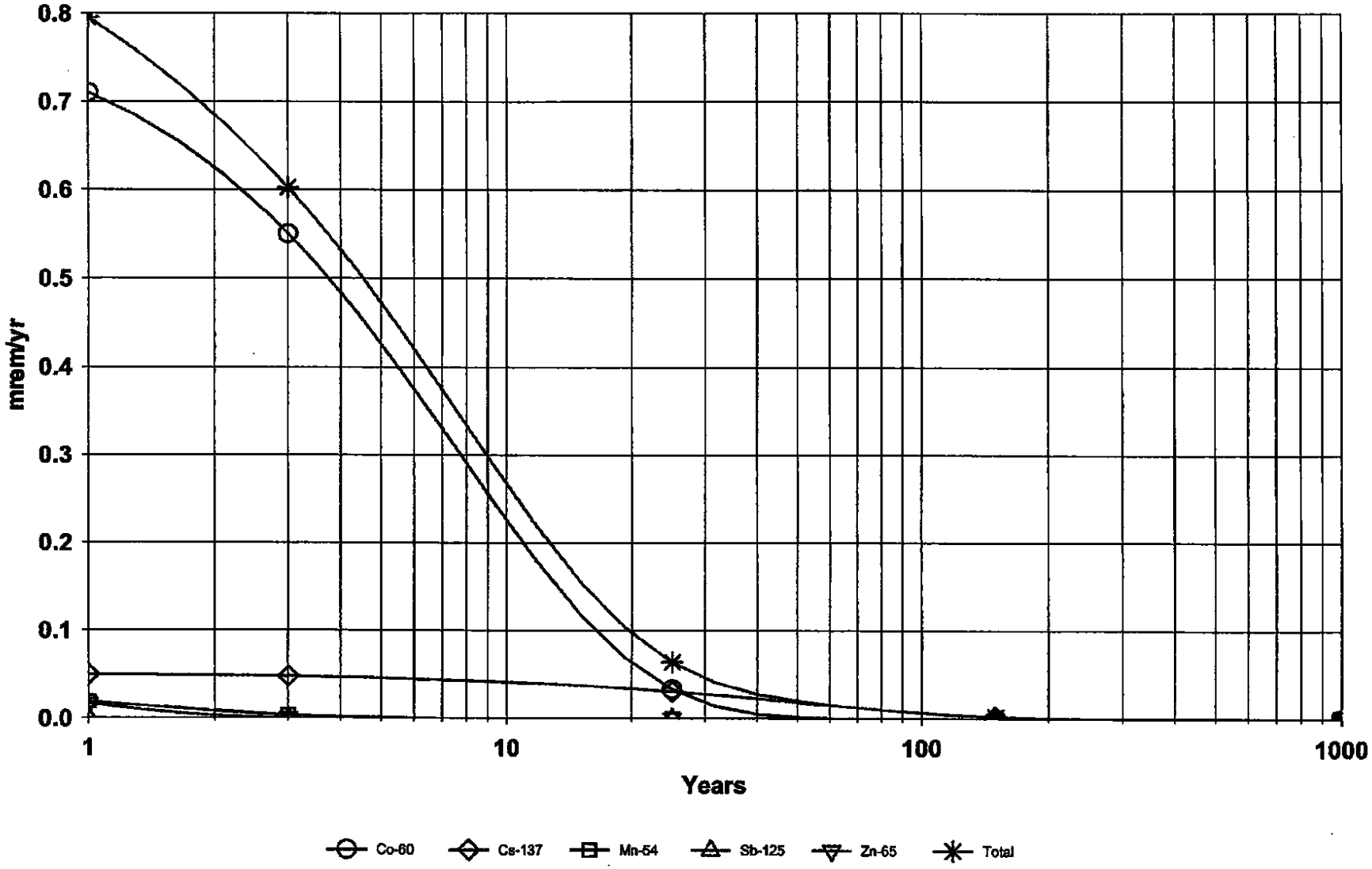
TABLE 3
ISOTOPIC MIX AND CONCENTRATIONS USED

ISOTOPE	Royersford Sec Digester (pCi/wet gm)	Pottstown Roll-off A (pCi/wet gm)	Pottstown Roll-off B (pCi/wet gm)	Pottstown Roll-off C (pCi/wet gm)	Pottstown Digester (pCi/wet gm)	GROWS Roll-off (pCi/wet gm)	Total pCi	Landfill Lift (pCi/gm)
Mn-54	1.86E+01	1.76E+01	9.21E+00	9.24E+00	1.25E+00	1.11E+01	2.28E+10	2.52E+00
Co-58 (2)	3.29E+00	2.18E+00	1.09E+00	1.13E+00	1.67E-01	1.39E+00	3.93E+09	4.33E-01
Co-60	8.21E+01	6.25E+01	3.11E+01	3.20E+01	4.21E+00	3.65E+01	9.82E+10	1.08E+01
Zn-65	3.89E+00	3.41E+00	1.59E+00	1.50E+00	2.57E-01	1.95E+00	4.74E+09	5.23E-01
Sb-125	1.05E+00	7.55E-01	5.35E-01	3.30E-01	5.67E-02	4.85E-01	1.26E+09	1.39E-01
I-131 (2)	-2.00E-02	4.40E-01	1.96E+00	1.42E+00	2.23E-01	4.05E-01	3.54E+08	3.90E-02
Cs-137	5.00E+00	3.72E+00	1.98E+00	1.80E+00	2.97E-01	2.36E+00	6.04E+09	6.66E-01
Tank Volume	1.1e9 cc	1.5e7 cc	1.5e7 cc	1.5e7 cc	1.3e9 cc	1.5e7 cc		
Measured Dose Rate		50 uR/hr	40 uR/hr	50 uR/hr				

(1) Volume of the lift in the landfill is 9.06E9 cm3

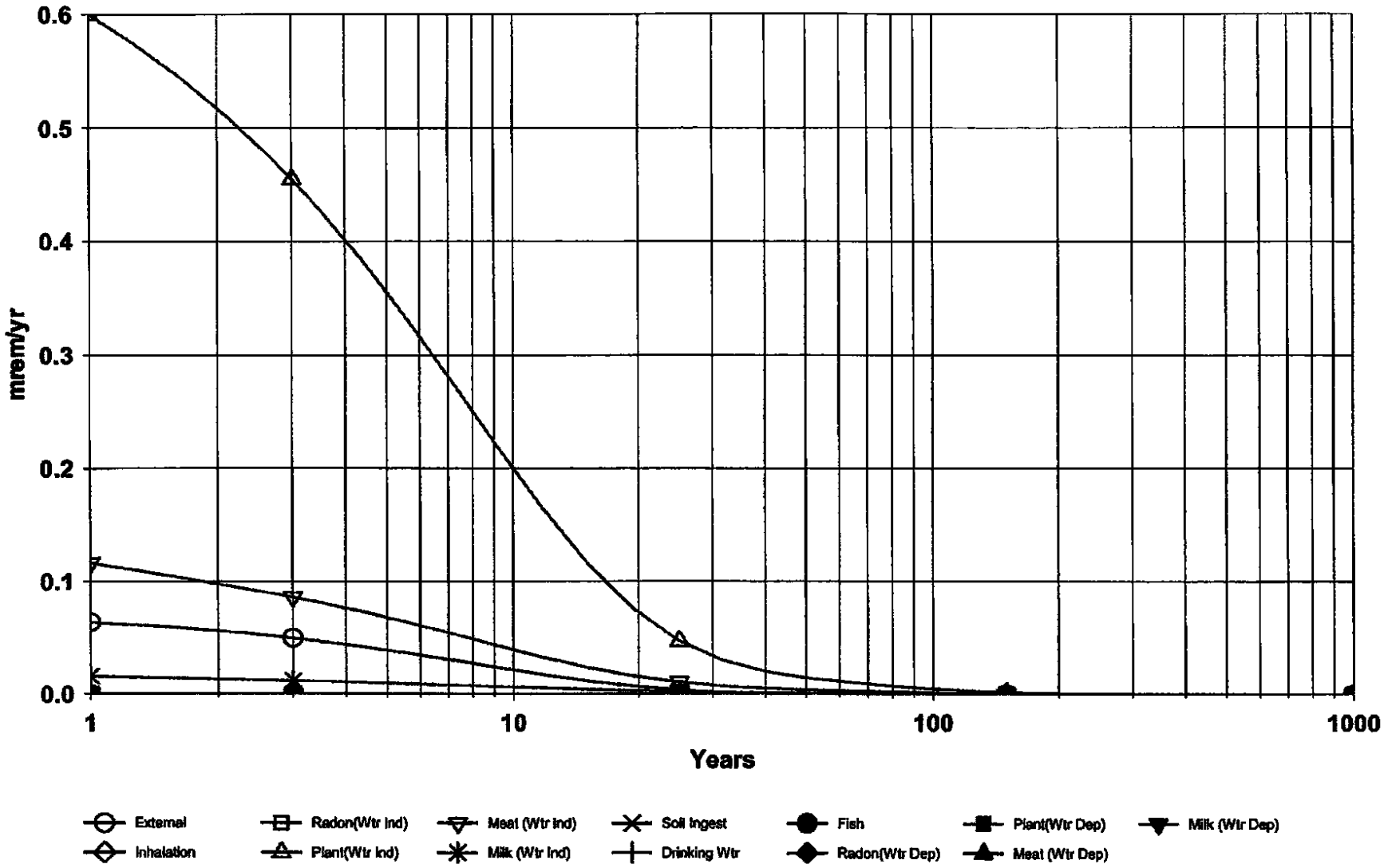
(2) Sample results not used, not in RESRAD library

DOSE: All Nuclides Summed, All Pathways Summed



Royersford Sludge PA Landfill Min.RAD 05/12/2005 13:36 Includes All Pathways

DOSE: All Nuclides Summed, Component Pathways



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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ag-110m+D	8.030E-05	8.030E-05	DCF2(1)
B-1	Cd-109	1.140E-04	1.140E-04	DCF2(2)
B-1	Co-57	9.070E-06	9.070E-06	DCF2(3)
B-1	Co-60	2.190E-04	2.190E-04	DCF2(4)
B-1	Cs-134	4.630E-05	4.630E-05	DCF2(5)
B-1	Cs-137+D	3.190E-05	3.190E-05	DCF2(6)
B-1	Mn-54	6.700E-06	6.700E-06	DCF2(7)
B-1	Pb-210+D	2.320E-02	2.320E-02	DCF2(8)
B-1	Ra-226+D	8.600E-03	8.600E-03	DCF2(9)
B-1	Ra-228+D	5.080E-03	5.080E-03	DCF2(10)
B-1	Sb-125+D	1.386E-05	1.386E-05	DCF2(11)
B-1	Th-228+D	3.450E-01	3.450E-01	DCF2(12)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(13)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(14)
B-1	U-234	1.320E-01	1.320E-01	DCF2(15)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(16)
B-1	Zn-65	2.040E-05	2.040E-05	DCF2(17)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ag-110m+D	1.080E-05	1.080E-05	DCF3(1)
D-1	Cd-109	1.310E-05	1.310E-05	DCF3(2)
D-1	Co-57	1.180E-06	1.180E-06	DCF3(3)
D-1	Co-60	2.690E-05	2.690E-05	DCF3(4)
D-1	Cs-134	7.330E-05	7.330E-05	DCF3(5)
D-1	Cs-137+D	5.000E-05	5.000E-05	DCF3(6)
D-1	Mn-54	2.770E-06	2.770E-06	DCF3(7)
D-1	Pb-210+D	7.270E-03	7.270E-03	DCF3(8)
D-1	Ra-226+D	1.330E-03	1.330E-03	DCF3(9)
D-1	Ra-228+D	1.440E-03	1.440E-03	DCF3(10)
D-1	Sb-125+D	3.647E-06	3.647E-06	DCF3(11)
D-1	Th-228+D	8.080E-04	8.080E-04	DCF3(12)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(13)
D-1	Th-232	2.730E-03	2.730E-03	DCF3(14)
D-1	U-234	2.830E-04	2.830E-04	DCF3(15)
D-1	U-238+D	2.690E-04	2.690E-04	DCF3(16)
D-1	Zn-65	1.440E-05	1.440E-05	DCF3(17)
D-34	Food transfer factors:			
D-34	Ag-110m+D, plant/soil concentration ratio, dimensionless	1.500E-01	1.500E-01	RTF(1,1)
D-34	Ag-110m+D, beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-03	3.000E-03	RTF(1,2)
D-34	Ag-110m+D, milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.500E-02	2.500E-02	RTF(1,3)
D-34				
D-34	Cd-109 , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(2,1)
D-34	Cd-109 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	4.000E-04	4.000E-04	RTF(2,2)
D-34	Cd-109 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,3)
D-34				
D-34	Co-57 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF(3,1)
D-34	Co-57 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF(3,2)
D-34	Co-57 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(3,3)

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
D-34	Co-60 , plant/soil concentration ratio, dimensionless	8.000E-02	8.000E-02	RTF(4,1)
D-34	Co-60 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-02	2.000E-02	RTF(4,2)
D-34	Co-60 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-03	2.000E-03	RTF(4,3)
D-34				
D-34	Cs-134 , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(5,1)
D-34	Cs-134 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(5,2)
D-34	Cs-134 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(5,3)
D-34				
D-34	Cs-137+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(6,1)
D-34	Cs-137+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.000E-02	3.000E-02	RTF(6,2)
D-34	Cs-137+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	8.000E-03	8.000E-03	RTF(6,3)
D-34				
D-34	Mn-54 , plant/soil concentration ratio, dimensionless	3.000E-01	3.000E-01	RTF(7,1)
D-34	Mn-54 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-04	5.000E-04	RTF(7,2)
D-34	Mn-54 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(7,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(8,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(8,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(8,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(9,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(9,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(9,3)
D-34				
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(10,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(10,3)
D-34				
D-34	Sb-125+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(11,1)
D-34	Sb-125+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(11,2)
D-34	Sb-125+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-04	1.000E-04	RTF(11,3)
D-34				
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(12,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(12,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(12,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(13,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(13,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(13,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(14,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(14,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(14,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(15,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(15,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(15,3)
D-34				

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 Morbidity

Menu	Parameter	Current Value	Default	Parameter Name
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(16,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(16,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(16,3)
D-34				
D-34	Zn-65 , plant/soil concentration ratio, dimensionless	4.000E-01	4.000E-01	RTF(17,1)
D-34	Zn-65 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-01	1.000E-01	RTF(17,2)
D-34	Zn-65 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-02	1.000E-02	RTF(17,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ag-110m+D, fish	5.000E+00	5.000E+00	BIOFAC(1,1)
D-5	Ag-110m+D, crustacea and mollusks	7.700E+02	7.700E+02	BIOFAC(1,2)
D-5				
D-5	Cd-109 , fish	2.000E+02	2.000E+02	BIOFAC(2,1)
D-5	Cd-109 , crustacea and mollusks	2.000E+03	2.000E+03	BIOFAC(2,2)
D-5				
D-5	Co-57 , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Co-57 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC(3,2)
D-5				
D-5	Co-60 , fish	3.000E+02	3.000E+02	BIOFAC(4,1)
D-5	Co-60 , crustacea and mollusks	2.000E+02	2.000E+02	BIOFAC(4,2)
D-5				
D-5	Cs-134 , fish	2.000E+03	2.000E+03	BIOFAC(5,1)
D-5	Cs-134 , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(5,2)
D-5				
D-5	Cs-137+D , fish	2.000E+03	2.000E+03	BIOFAC(6,1)
D-5	Cs-137+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(6,2)
D-5				
D-5	Mn-54 , fish	4.000E+02	4.000E+02	BIOFAC(7,1)
D-5	Mn-54 , crustacea and mollusks	9.000E+04	9.000E+04	BIOFAC(7,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(8,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(8,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(9,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(9,2)
D-5				
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(10,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(10,2)
D-5				
D-5	Sb-125+D , fish	1.000E+02	1.000E+02	BIOFAC(11,1)
D-5	Sb-125+D , crustacea and mollusks	1.000E+01	1.000E+01	BIOFAC(11,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(12,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(12,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(13,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(13,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(14,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(14,2)

Dose Conversion Factor (and Related) Parameter Summary (continued)
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Menu	Parameter	Current Value	Default	Parameter Name
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(15,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(15,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(16,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(16,2)
D-5				
D-5	Zn-65 , fish	1.000E+03	1.000E+03	BIOFAC(17,1)
D-5	Zn-65 , crustacea and mollusks	1.000E+04	1.000E+04	BIOFAC(17,2)

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	3.716E+03	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	2.440E+00	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	6.096E+01	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	2.500E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	2.500E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	1.500E+02	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+03	1.000E+02	---	T(6)
R011	Times for calculations (yr)	not used	3.000E+02	---	T(7)
R011	Times for calculations (yr)	not used	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Co-60	1.080E+01	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Cs-137	6.660E-01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): Mn-54	2.520E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): Sb-125	1.390E-01	0.000E+00	---	S1(11)
R012	Initial principal radionuclide (pCi/g): Zn-65	5.230E-01	0.000E+00	---	S1(17)
R012	Concentration in groundwater (pCi/L): Co-60	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Cs-137	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): Mn-54	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): Sb-125	not used	0.000E+00	---	W1(11)
R012	Concentration in groundwater (pCi/L): Zn-65	not used	0.000E+00	---	W1(17)
R013	Cover depth (m)	6.100E-01	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	1.500E+00	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	3	1	---	NS
R015	Unsat. zone 1, thickness (m)	3.050E-01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.520E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	3.900E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	3.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	4.050E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	5.550E+03	1.000E+01	---	HCUZ(1)
R015	Unsat. zone 2, thickness (m)	1.520E-01	0.000E+00	---	H(2)
R015	Unsat. zone 2, soil density (g/cm**3)	1.200E+00	1.500E+00	---	DENSUZ(2)
R015	Unsat. zone 2, total porosity	4.200E-01	4.000E-01	---	TPUZ(2)
R015	Unsat. zone 2, effective porosity	6.000E-02	2.000E-01	---	EPUZ(2)
R015	Unsat. zone 2, field capacity	2.000E-01	2.000E-01	---	FCUZ(2)
R015	Unsat. zone 2, soil-specific b parameter	1.140E+01	5.300E+00	---	BUZ(2)
R015	Unsat. zone 2, hydraulic conductivity (m/yr)	4.050E+01	1.000E+01	---	HCUZ(2)
R015	Unsat. zone 3, thickness (m)	2.438E+00	0.000E+00	---	H(3)
R015	Unsat. zone 3, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(3)
R015	Unsat. zone 3, total porosity	4.000E-01	4.000E-01	---	TPUZ(3)
R015	Unsat. zone 3, effective porosity	2.000E-01	2.000E-01	---	EPUZ(3)
R015	Unsat. zone 3, field capacity	2.000E-01	2.000E-01	---	FCUZ(3)
R015	Unsat. zone 3, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(3)
R015	Unsat. zone 3, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(3)
R016	Distribution coefficients for Co-60				
R016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+01	1.000E+03	---	DCNUCU(4,1)
R016	Unsaturated zone 2 (cm**3/g)	5.500E+02	1.000E+03	---	DCNUCU(4,2)
R016	Unsaturated zone 3 (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCU(4,3)
R016	Saturated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.366E-04	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for Cs-137				
R016	Contaminated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	2.800E+02	1.000E+03	---	DCNUCU(6,1)
R016	Unsaturated zone 2 (cm**3/g)	1.900E+03	1.000E+03	---	DCNUCU(6,2)
R016	Unsaturated zone 3 (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCU(6,3)
R016	Saturated zone (cm**3/g)	1.000E+03	1.000E+03	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.366E-04	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Mn-54				
R016	Contaminated zone (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	2.000E+02	---	DCNUCU(7,1)
R016	Unsaturated zone 2 (cm**3/g)	1.800E+02	2.000E+02	---	DCNUCU(7,2)
R016	Unsaturated zone 3 (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCU(7,3)
R016	Saturated zone (cm**3/g)	2.000E+02	2.000E+02	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.823E-04	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for Sb-125				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(11)
R016	Unsaturated zone 1 (cm**3/g)	4.500E+01	0.000E+00	---	DCNUCU(11,1)
R016	Unsaturated zone 2 (cm**3/g)	2.500E+02	0.000E+00	---	DCNUCU(11,2)
R016	Unsaturated zone 3 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(11,3)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(11)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.385E-01	ALEACH(11)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(11)
R016	Distribution coefficients for Zn-65				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(17)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+02	0.000E+00	---	DCNUCU(17,1)
R016	Unsaturated zone 2 (cm**3/g)	2.400E+03	0.000E+00	---	DCNUCU(17,2)
R016	Unsaturated zone 3 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(17,3)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(17)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.385E-01	ALEACH(17)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(17)
R016	Distribution coefficients for daughter Ag-110m				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	9.000E+01	0.000E+00	---	DCNUCU(1,1)
R016	Unsaturated zone 2 (cm**3/g)	1.800E+02	0.000E+00	---	DCNUCU(1,2)
R016	Unsaturated zone 3 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(1,3)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.385E-01	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Cd-109				
R016	Contaminated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	8.000E+01	0.000E+00	---	DCNUCU(2,1)
R016	Unsaturated zone 2 (cm**3/g)	5.600E+02	0.000E+00	---	DCNUCU(2,2)
R016	Unsaturated zone 3 (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCU(2,3)
R016	Saturated zone (cm**3/g)	0.000E+00	0.000E+00	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.385E-01	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)