APPENDIX C

RADON EMANATION

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHMENTS

C.1 INTRODUCTION

This appendix presents the calculations of radon-222 emanation and gamma radiation exposure from the cover over the proposed Sequoyah Fuels Corporation (SFC) disposal cell. These calculations comprise an update of analyses presented in the Preliminary Design Report (Reclamation Plan Appendix C), reflecting the multilayered cover system design and phased construction of the disposal cell. In addition, gamma radiation exposure calculations are summarized in Section C.6 of this appendix.

C.1.1 Background

The performance objective for the maximum rate of radon-222 emanation from the surface of reclaimed facilities is 20 pCi/m^2-sec, as outlined in Criterion 6 (1), Appendix A of NRC regulations (10 CFR 40). This maximum rate of emanation is an average over "the entire surface of each disposal area." This average accounts for minor variations in cover material and byproduct material properties as well as natural variations in cover material moisture content, vegetation cover, and other effects over the long-term design life of the reclaimed facility.

Due to the short half-life of radon-222 (3.8 days), the key factor in control of radon emanation through a soil cover is the travel time through the pore spaces in the cover. This attenuation of radon can be achieved with a layer of low-permeability material (such as clay) or a thicker layer of more permeable material (such as sand). This evaluation was conducted to calculate that the average rate of radon-222 emanation from the soil cover surface for comparison with the NRC performance standard of 20 pCi/m^2-sec.

C.1.2 RADON Model

The modeling was conducted with the RADON model (NRC, 1989), the standard model used to estimate emanation of radon-222 from materials containing radium-226. This model is accepted and approved by the US Nuclear Regulatory Commission (NRC), and documented in NRC publications NUREG/CR-3533 and Regulatory Guide 3.64 (NRC, 1984, 1989).

The RADON model has been shown to provide a conservative estimate of radon emanation from reclaimed uranium tailings impoundments, because actual measured radon emanation rates from reclaimed facilities are typically an order of magnitude lower than values calculated during reclamation plan design with the RADON model.

The modeling was also conducted utilizing previous information from evaluation of a multi-layered cover system for the disposal cell documented in ESCI (1996 and 1998), as well as soil property and radiological data collected by SFC.

C.2 ANALYZED PROFILES

The disposal cell profiles analyzed with the RADON model are based on the phases of cell construction and the materials planned for disposal in each cell phase. This phasing is outlined in Appendix A of this report. The cell phases are shown in Figure C.1. The profiles for the phases of the cell are shown in Figures C.2 through C.5. These profiles do not include the cover synthetic liner in the RADON modeling, to be consistent with NRC guidance.

These profiles include four specific types of contaminated material below the reclamation cover (material Types A through D). The general disposal scenario is based on placing the materials with the highest radium-226 and thorium-230 activity concentrations lowest in the profile. As shown in Figures C.2 through C.5, the materials to be placed in the disposal cell are primarily on-site soils (generally sandy, silty clays). Exceptions are material Type A, which consist of sludges and sediments, and material Type C, which consist of structural materials, miscellaneous buried materials and calcium fluoride solids.

The physical properties of the disposed materials and cover materials are based on drill logs and testing described in Appendix A of MFG (2002b). For the RADON modeling, the critical physical properties of these materials are porosity and long-term moisture content. The radiological properties are activity concentrations of radium-226 and thorium-230 (which decays to radium-226). These radiological properties are presented in Attachment C.1 and are summarized in the sections below.

C.3 MATERIAL PHYSICAL PROPERTIES

The physical properties of disposed materials and cover materials are summarized in Table C.1. The material density values are based on testing of site materials by SFC. Long-term moisture content values are either 6 percent for primarily sandy material (the conservative default value in NRC Regulatory Guide 3.64), 15 percent for on-site silty clays (that have Standard Proctor optimum values of 18 percent), or other values measured by SFC.

Table C.1 Physical Properties of Materials Used in the Model

Material	Description	Porosity	Dry Unit Weight (pcf)	Water Content (%)	Degree of Saturation (%)
COVER					
Topsoil	Sandy loam	0.49	84.4	6	17
Subsoil	Sandy silt	0.45	91.0	6, 15	19, 49
Liner cover	Sand	0.40	99.3	6	24
Clay liner	Silty clay	0.39	100.9	15	62
TYPE D					
Contaminated soils	Sandy silt and sed. rock	0.40	99.3	6	24
TYPE C					
Structural materials	Soil and debris	0.20, 0.40	132, 99.3	6	64, 24
Calcium fluoride sludge	Chemical precipitate	0.70	49.6	15	17
Buried materials	Sandy silt and debris	0.70	49.6	15	17
TYPE B					
Soil liner and subsoils	Sandy and clayey silt	0.70	49.6	15	17
TYPE A					
Raffinated sludge	Chemical precipitate	0.80	33.1	100, 50	66, 33
Pond 2 residual materials	Chemical precipitate	0.70	49.6	15	17
Pond sediments	Chemical precipitate	0.70	49.6	15	17

C.4 MATERIAL RADIOLOGICAL PROPERTIES

The radiological properties used in the RADON model for the contaminated soils are based on information presented in Attachment C.1. The radon emanation fraction from materials with a radium-226 activity concentration was 0.35 (the conservative default value used in the RADON model). The radon diffusion coefficient for cover and disposed materials was calculated by the RADON model (from void ratio and moisture content).

C.4.1 Radium-226 Values

Radium-226 activity concentrations of the materials in the disposal cell were estimated for each layer as a weighted average value from the individual material values to be placed in each phase of cell construction. The volumes, weights and radionuclide activity concentration values are listed in Attachment C.1.

Initial radiological properties of the disposal cell materials were derived from the SRC (SFC, 1998). Due to the relatively high activity concentration values of material Type A (the raffinate sludge, Pond 2 residual materials, and basin sediments), the Type A materials are the key source term parameters for the RADON modeling. As a result, the radium-226 and thorium-230 activity concentration values of these materials were evaluated in more detail for the RADON modeling. From review of sample analysis data

by SFC, statistical summaries of natural uranium, radium-226 and thorium-230 activity concentrations were developed. The summary values for these materials are summarized in Attachment C.1. The mean values and 95 percent upper confidence interval values were selected to conservatively represent the range of source-term conditions for the RADON modeling.

Due to the amount of thorium-230 in these materials, the amount of radium-226 ingrowth due to thorium-230 decay was considered for the material Type A source-term conditions. Natural uranium was not considered due to its significantly longer half-life. Ingrowth due to thorium-230 decay was evaluated with time for the Type A materials, with the maximum radium-226 values calculated at approximately 1,000 and 10,000 years from the present. For the RADON modeling, two source-term scenarios were evaluated: (1) 95 percent upper confidence-interval (UCI) values at 1,000 years, and (2) 95 percent UCI values in 10,000 years accounting for thorium-230 decay. The 95 percent upper confidence-interval values represent conservative source term values. The 10,000 year from present radium-226 values are beyond the required design life for the facility, but were evaluated as a sensitivity analysis of calculated radon emanation. In addition, radionuclide activity concentrations were conservatively based on the dry weights of these materials.

C.4.2 Values by Disposal Cell Phases

The radiological parameters used in the RADON modeling are presented in terms of the phases of cell construction. The radium-226 activity concentrations incorporate decay of thorium-230 to radium-226, and are calculated values at 1,000 and 10,000 years. The radiological parameters and layer thicknesses for the Phase I area of the disposal cell (Figure C.1) are summarized in Table C.2. The modeled profile is shown in Figure C.2.

Table C.2 Radiological Properties for Phase I Area Disposed Materials

Material	Volume (cu ft)	Fraction of Total (%)	Layer Thick-ness (ft)	Radium–226 Activity at 1,000 yrs (pCi/g)	Radium-226 Activity at 10,000 yrs (pCi/g)
TYPE A MATERIALS					
Emergency basin sediment	14,600	32	---	10,519	
North ditch sediment	20,770	45	---	184	
Sanitary lagoon sediment	10,365	23	---	405	
TOTAL/WEIGHTED AVERAGE	-----	100	2.0	3,542	9,013
TYPE B–D MATERIALS					
Emergency basin soils	162,500	50		90.1	
North ditch soils	87,500	27		90.1	
Sanitary lagoon soils	56,356	17		21.3	
Solid waste burials (No. 1)	20,000	6		21.3	
TOTAL/WEIGHTED AVERAGE	-----	100	14.0	74.3	81.5

The radiological parameters and layer thicknesses for the Phase IIA area of the disposal cell (Figure C.1) are summarized in Table C.3. The modeled profile is shown in Figure C.3.

Table C.3 Radiological Properties for Phase IIA Area Disposed Materials

Material	Volume (cu ft)	Fraction of Total (%)	Layer Thick-ness (ft)	Radium–226 Activity at 1,000 yrs (pCi/g)	Radium–226 Activity at 10,000 yrs (pCi/g)
TYPE A MATERIALS					
Raffinate sludge (28,600 sq ft area)	355,000	32	12.4	7,183	18, 587
Pond 2 residual material	762,000	68	4.2	1,038	2,568
TOTAL/WEIGHTED AVERAGE	-----	100	16.6	-----	-----
TYPE B–D MATERIALS					
Structural material	568,600	100	8.4	30.9	75.3
TOTAL/WEIGHTED AVERAGE	-----	100	8.4	-----	-----

The radiological parameters and layer thicknesses for the Phase IIB area of the disposal cell (Figure C.1) are summarized in Table C.4. The modeled profile is shown in Figure C.4.

Table C.4 Radiological Properties for Phase IIB Area Disposed Materials

Material	Volume (cu ft)	Fraction of Total (%)	Layer Thick-ness (ft)	Radium–226 Activity at 1,000 yrs (pCi/g)	Radium–226 Activityat 10,000 yrs (pCi/g)
TYPE A MATERIALS					
Pond 2 residual material	762,000	100	14.3	1,038	2,568
TOTAL/WEIGHTED AVERAGE	-----	100	14.3	-----	-----
TYPE B–D MATERIALS					
Structural material	568,600	100	10.7	30.9	75.3
TOTAL/WEIGHTED AVERAGE	-----	100	10.7	-----	-----

The radiological parameters and layer thicknesses for the Phase III area of the disposal cell (Figure C.1) are summarized in Table C.5. The modeled profile is shown in Figure C.5.

Table C.5 Radiological Properties for Phase III Area Disposed Materials

Material	Volume (cu ft)	Fraction of Total (%)	Layer Thick-ness (ft)	Radium–226 Activityat 1,000 yrs (pCi/g)	Radium–226 Activity at 10,000 yrs (pCi/g)
TYPE B-D MATERIALS					
Fluoride holding basin 1	171,400	18	---	3.4	
Fluoride holding basin 2	186,000	19	---	3.4	
Fluoride settling basin and clarifier	114,000	12	---	3.4	
Buried calcium fluoride	96,000	10	---	3.4	
Buried fluoride holding basin 1	57,000	6	---	3.4	
UF6 cylinders	15,500	2	---	3.4	
Clarifier liners	332,400	34	---	90.1	
TOTAL/WEIGHTED AVERAGE	-----	100	15.0	32.9	38.4

C.5 RADON MODEL RESULTS

The RADON model output for the four scenarios outlined above is provided in Attachment C.2. The calculated radon-222 flux values through the top of the cover (in pCi/m^2-sec) are presented in the Table C.6 below.

Table C.6 RADON Model Results

Cell Phase Area	Radium-226 Value	Water Content Variations	Radon–222 Flux (pCi/m^2-sec)
Phase I	1,000 years	Subsoil at 15%	2.0
	10,000 years	Subsoil at 15%	2.9
	10,000 years	Subsoil at 6%	7.7
Phase IIA	1,000 years	Subsoil at 15%	1.0
	1,000 years	Raffinate at 50%	1.0
	1,000 years	Lower debris density	3.0
	10,000 years	Subsoil at 15%	2.4
	10,000 years	Subsoil at 6%	6.3
Phase IIB	1,000 years	Subsoil at 15%	1.0
	10,000 years	Subsoil at 15%	2.4
	10,000 years	Subsoil at 6%	12.5
Phase III	1,000 years	Subsoil at 15%	0.2
	10,000 years	Subsoil at 15%	0.2
	10,000 years	Subsoil at 6%	0.6

C.5.1 General Conclusions

The proposed cover system was evaluated for acceptable performance in reduction of radon-222 emanation from the disposal materials using modeling recommended by NRC, with the results compared with NRC criteria for maximum rate of radon emanation. Conservative assumptions in cover and disposal material porosity and moisture content were made, and conservatively high radium-226 activity concentrations were used.

The radiological parameters used in the model were based on a limited number of samples, with analysis results showing significant variability. The existing data was evaluated statistically, with mean and 95 percent upper confidence interval values used in the modeling to represent a conservative range of source term parameters.

With these conservative assumptions and values, the modeling results show that the proposed cover (and planned order of material disposal) maintains radon-222 emanation rates from the top of the cover within NRC performance standards for conditions over the design life (up to 1,000 years). Analyses

representing conditions of maximum thorium-230 ingrowth (although beyond the design life at 10,000 years) show acceptable radon-222 emanation rates.

C.5.2 Variability Due to Root Penetration

The effect of root penetration into the cover on radon emanation was evaluated based on a percentage of the cover having root holes (of relatively large diameter) extending to the bottom of the cover (through the synthetic liner and two-foot thick clay layer). One percent of the cover surface area was evaluated with a higher radon emanation rate, equivalent to two one-inch diameter root holes for each square foot of cover surface area.

This higher rate of radon emanation was calculated with the RADON model with no cover over the disposed materials. For maximum ingrowth conditions, this rate is approximately 46 pCi/m^2-sec in the Phase I area and 38 pCi/m^2-sec in the Phase IIA and IIB areas. If one percent of the cover surface area had this higher rate of radon emanation, the average radon emanation rate from the top of the cover increases from approximately 7.7 to 8.1 pCi/m^2-sec in the Phase I area and approximately 12.5 to 12.8 pCi/m^2-sec in the Phase IIB area, or an increase of up to 5 percent.

Actual root holes from vegetation on the cover would not be continuous from the top to the bottom of the cover, and the travel time of radon-222 migrating through pore spaces and root holes through the 10-foot thick cover would reduce the radon emanation rate at the cover surface, so this calculation is extremely conservative.

These calculations show that the effects of root penetration into the SFC disposal cell cover do not have a significant impact on the rate of radon emanation from the cover surface. Root penetration deep into the cover with subsequent decay of plant material may increase the average rate of radon emanation from the cover surface by a few percent, but would not significantly affect the rate of radon emanation relative to the performance standard of 20 pCi/m^2-sec.

C.6 GAMMA RADIATION EXPOSURE

The gamma radiation exposure from covered areas of the site was estimated from exposure relationships presented in Schiager (1974) and Shleien (1992). The effect of a soil cover in reducing exposure from a gamma radiation source is calculated as the ratio of the shielded exposure rate (due to the soil) to the unshielded exposure rate. Using coefficients for soil, the shielded exposure rate is approximately 1/10 of

the unshielded rate at a soil cover thickness of one foot. This ratio is 1/100 at a soil cover thickness of over two feet, and is 1/1000 at a soil cover thickness of over three feet. For a soil cover thickness of 10 feet, the ratio is approximately $1/10^9$. These calculations show that gamma radiation exposure is significantly reduced by a small thickness of soil cover.

C.7 REFERENCES

Earth Science Consultants, Inc. (ESCI), 1998. "Calculation Brief, RADON Analysis, Case I and Case II Scenarios, Sequoyah Fuels Corporation, Gore, Oklahoma, Project No. 4881-04." Prepared for SFC, December 9.

Earth Science Consultants, Inc. (ESCI), 1996. "Conceptual Design Report, Decommissioning, Excavation, and Stabilization/Solidification Program." Prepared for SFC, December.

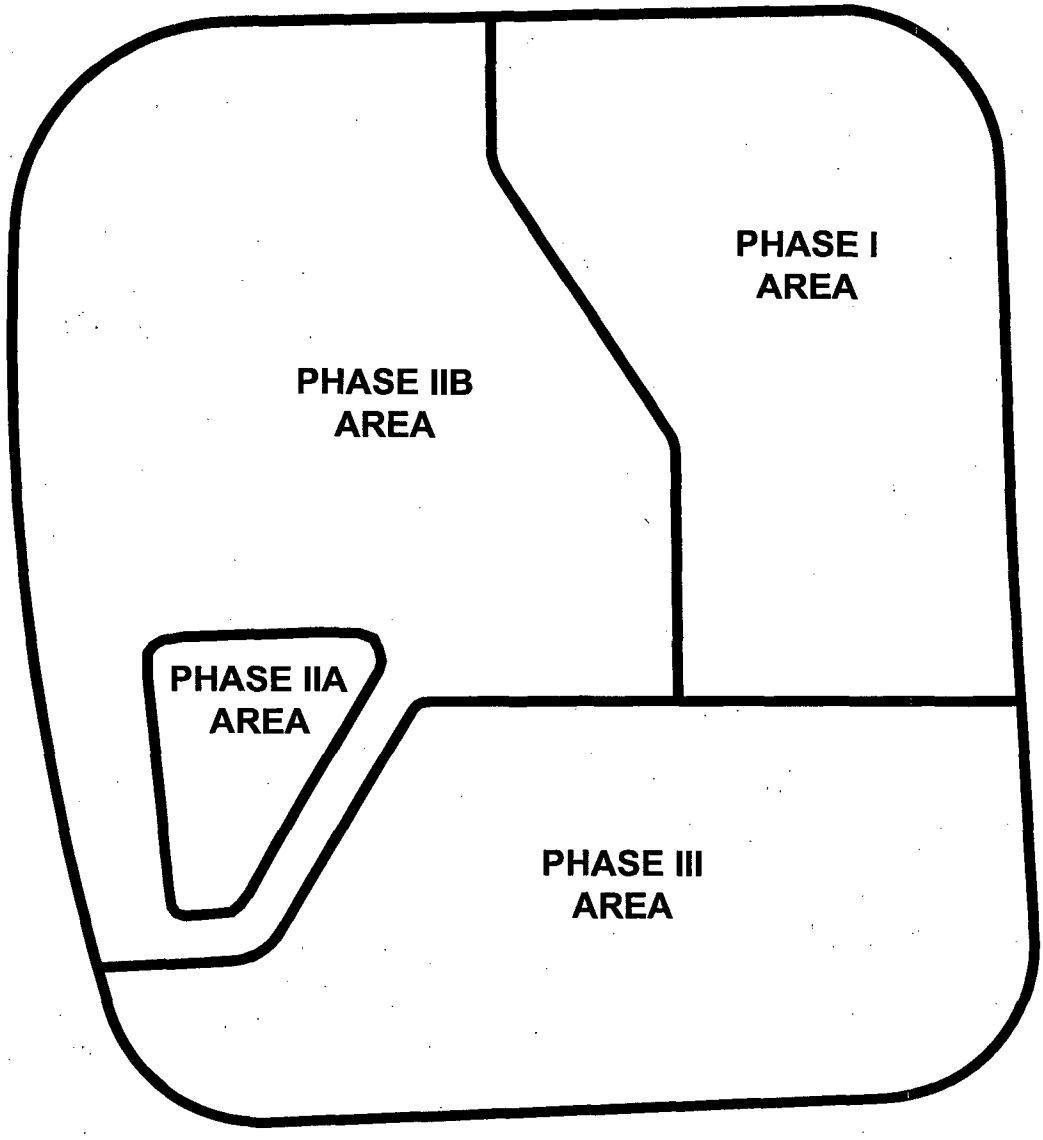
Schiager, K.J., 1974. "Analysis of Radiation Exposures on or Near Uranium Mill Tailings Piles." *Radiation Data and Reports*, Vol. 15, No. 7, July, pp. 411-425. Reprinted by U.S. EPA Office of Radiation Programs.

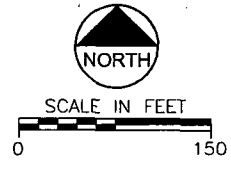
Sequoyah Fuels Corporation (SFC), 1998. "Site Characterization Report," (SCR).

Shleien, B., 1992. *The Health Physics and Radiological Health Handbook*, Revised Edition, Scinta, Inc.

U.S. Nuclear Regulatory Commission (NRC), 1989. "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," Regulatory Guide 3.64.

U.S. Nuclear Regulatory Commission (NRC), 1984. "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," NUREG/CR-3533.

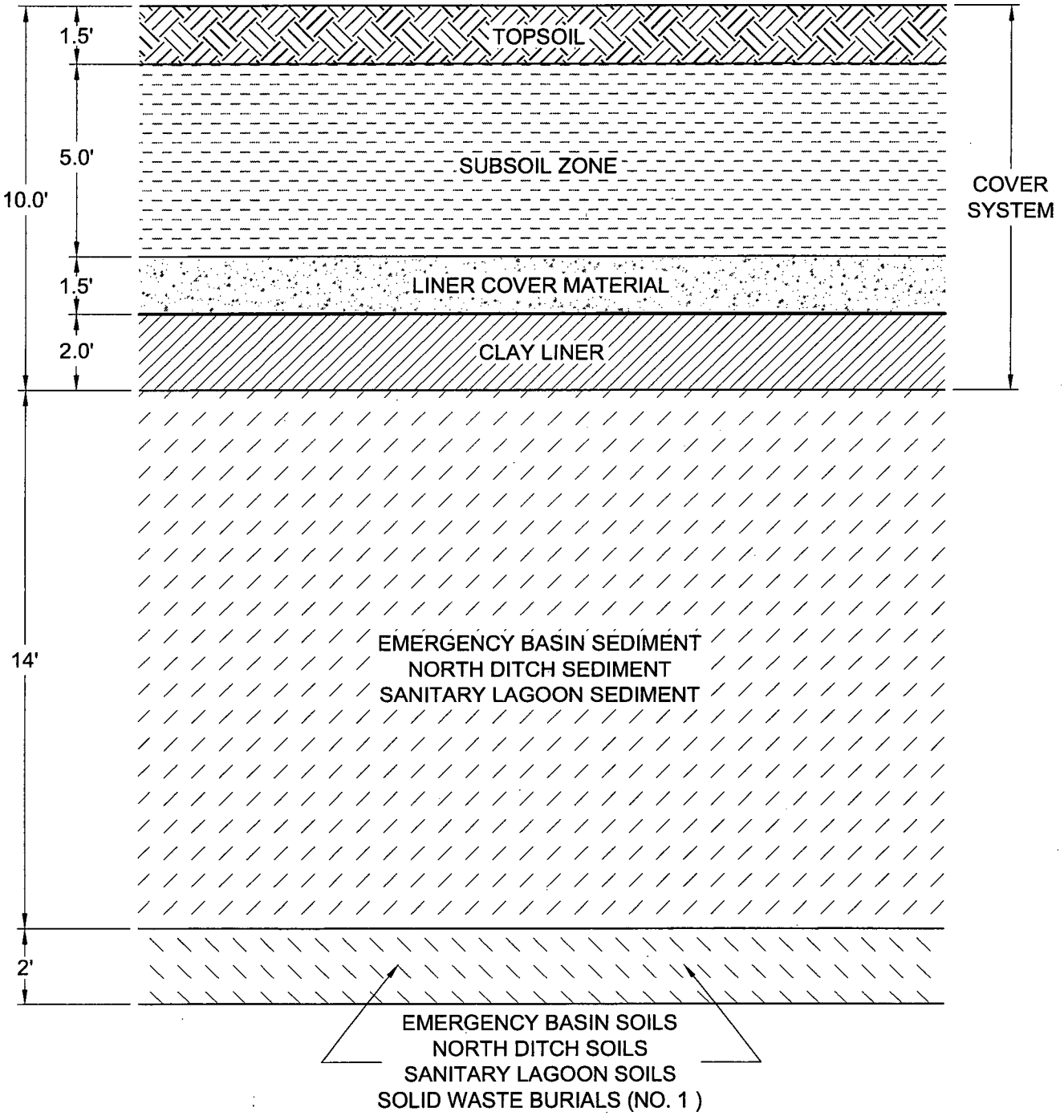




MFG, Inc.
consulting scientists and engineers

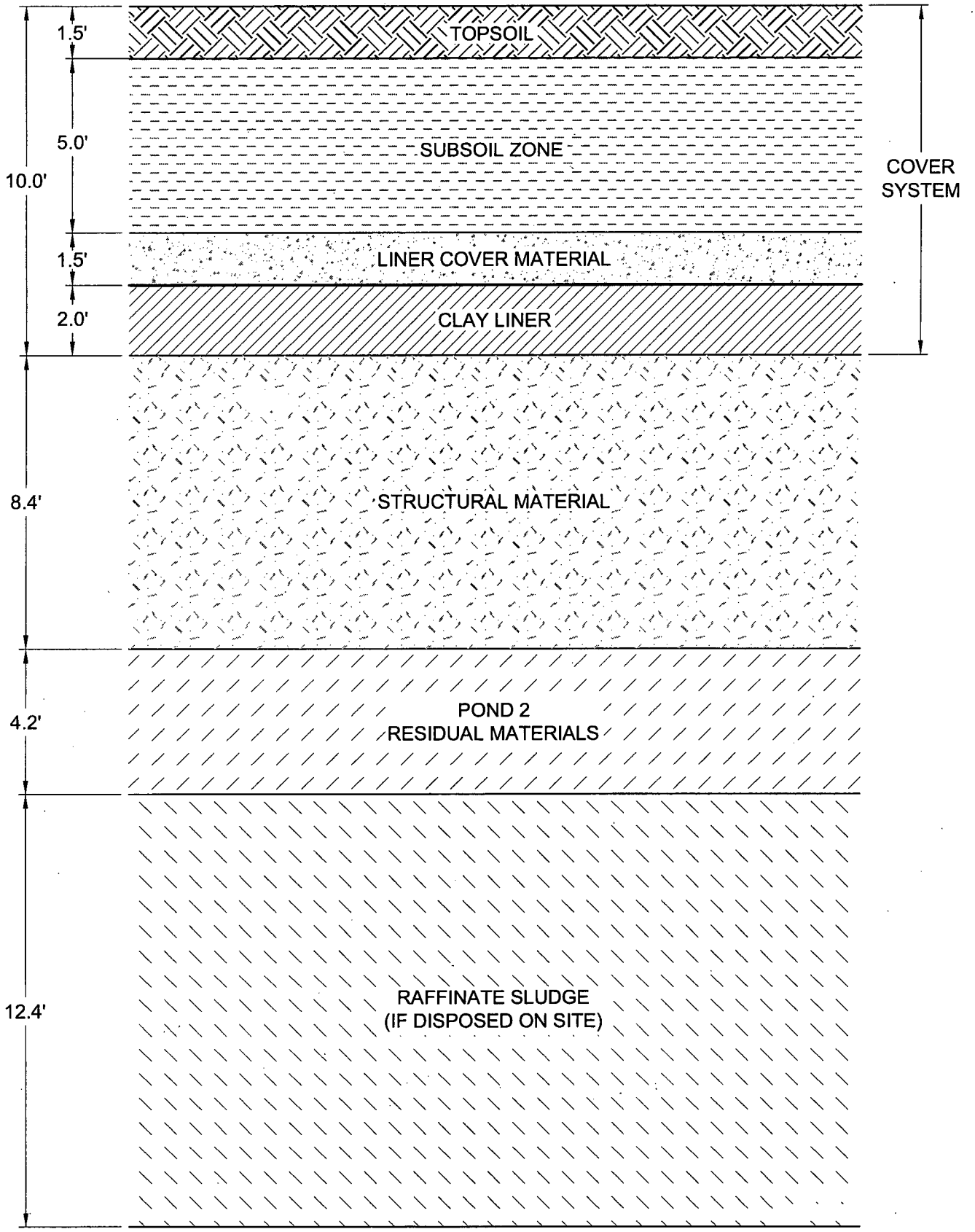
FIGURE C.1
PLAN OF CELL SHOWING PHASE AREAS

Date:	DECEMBER 2007
Project:	180734
File:	CELL-FIG-PLAN



MFG, Inc. *consulting scientists and engineers*	FIGURE C.2 PHASE I AREA TYPICAL INTERIOR CELL PROFILE

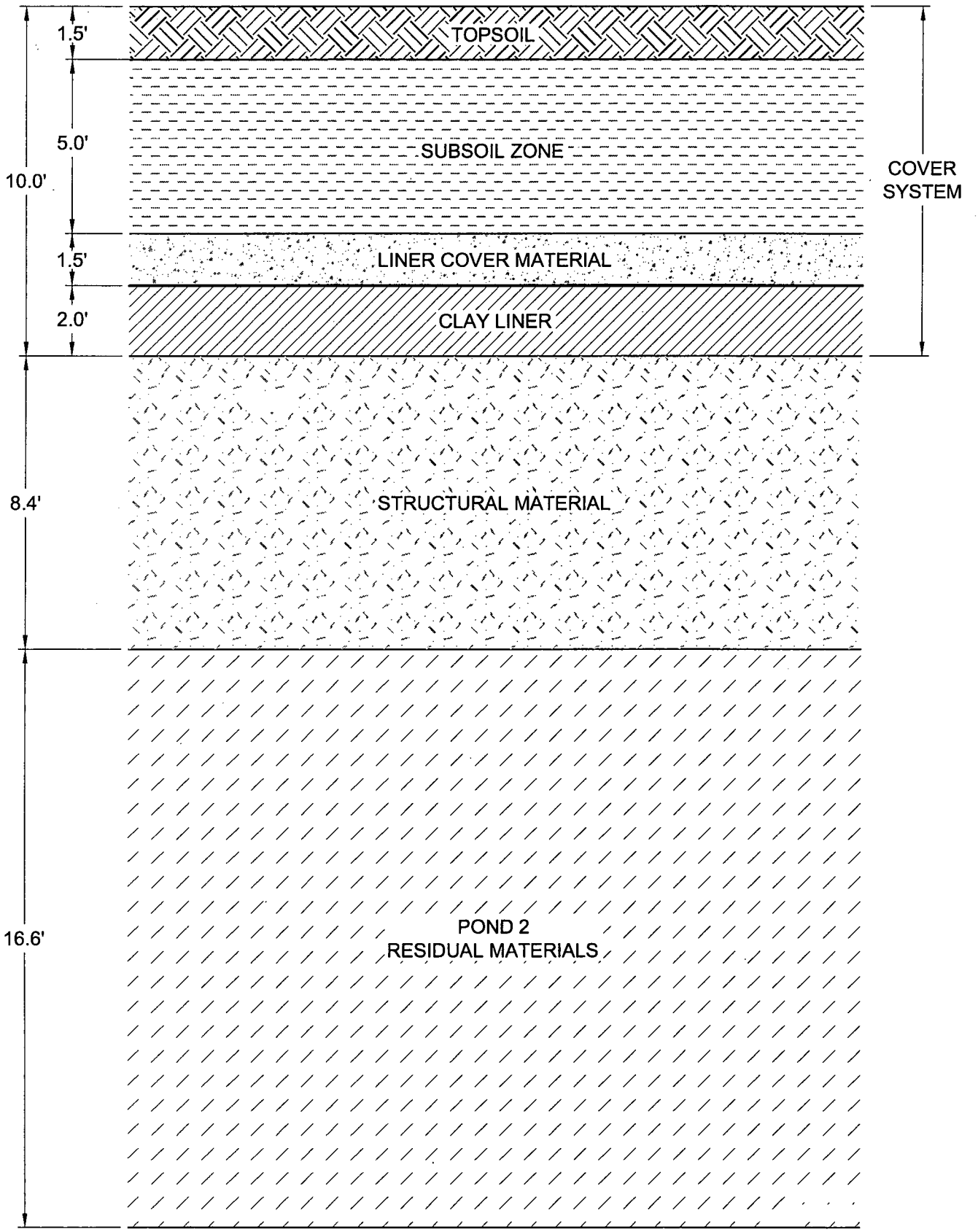
Date:	DECEMBER 2007
Project:	180734
File:	CELL-FIG-XS.DWG



MFG, Inc.
consulting scientists and engineers

FIGURE C.3
PHASE IIA AREA
TYPICAL INTERIOR CELL PROFILE

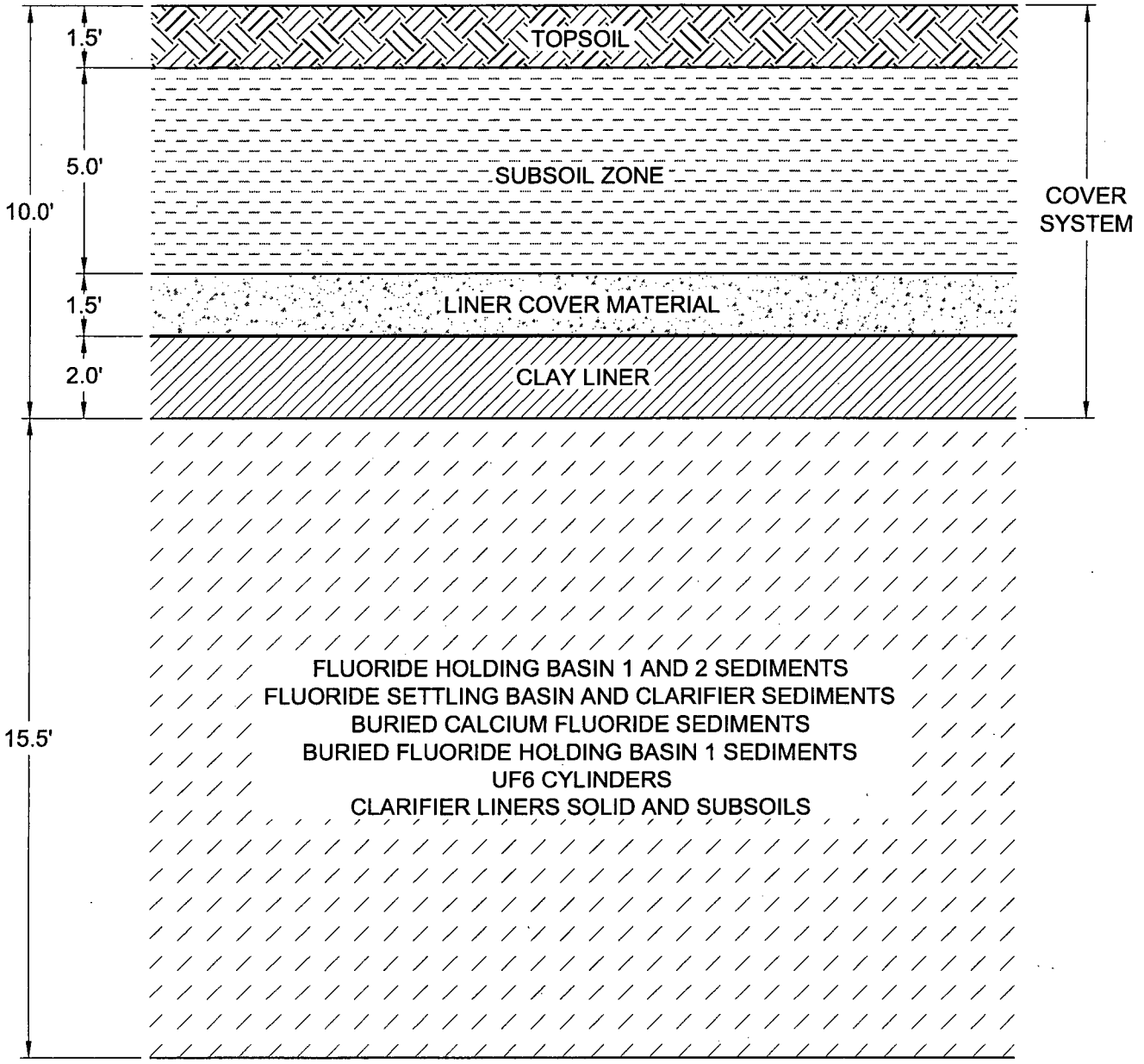
Date:	DECEMBER 2007
Project:	180734
File:	CELL-FIG-XS.DWG



MFG, Inc.
consulting scientists and engineers

FIGURE C.4
PHASE IIB AREA
TYPICAL INTERIOR CELL PROFILE

Date:	DECEMBER 2007
Project:	180734
File:	CELL-FIG-XS.DWG



MFG, Inc. *consulting scientists and engineers*	FIGURE C.5 PHASE III AREA TYPICAL INTERIOR CELL PROFILE

Date:	DECEMBER 2007
Project:	180734
File:	CELL-FIG-XS.DWG

ATTACHMENT C.1

DISPOSAL MATERIAL CHARACTERIZATION SUMMARY

Updated Disposal Material Radiological Characterization Summary

Type A Material

Location	Vol. (ft^3)	Number Of Samples	Th-230, pCi/g			Ra-226, pCi/g			Ra-226 @ 1000 yrs, pCi/g		
			Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%
Raffinate Sludge	355,000	11	11100	13400	20200	128	62.2	170	3970	4732	7183
Pond 2 Residual Materials	762,000	52	2100	2460	2790	71.5	79.6	93.7	782	913	1038
Emergency Basin Sediment	14,600	Estimate	16300	10300	29100	332	142	508	5923	3699	10519
North Ditch Sediment	20,770	Estimate	211	232	499	7.18	5.41	13.9	78.5	84.7	184
Sanitary Lagoon Sediment	10,365	Estimate	276	338	1120	5.77	5.61	19.7	100	122	405

Type B Material

Location	Vol. (ft^3)	Number Of Samples	Th-230, pCi/g			Ra-226, pCi/g			Ra-226 @ 1000 yrs, pCi/g		
			Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%
Clarifier & Pond 4 Liners	332,400	28	149	238	241	5.42	8.62	8.77	55.7	88.9	90.1
Calcium Fluoride Basin Liner	95,285	Estimate	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Emergency Basin Soils	162,500	Estimate	149	238	241	5.42	8.62	8.77	55.7	88.9	90.1
North Ditch Soils	87,500	Estimate	149	238	241	5.42	8.62	8.77	55.7	88.9	90.1
Sanitary Lagoon Liner	56,356	Estimate	47.1	36.1	56.6	2.11	0.882	2.34	17.9	13.2	21.3
Pond 1 Spoils Pile	437,400	59	47.1	36.1	56.6	2.11	0.882	2.34	17.9	13.2	21.3
Chipped Pallets	3,000										

Type C Material

Location	Vol. (ft^3)	Number Of Samples	Th-230, pCi/g			Ra-226, pCi/g			Ra-226 @ 1000 yrs, pCi/g		
			Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%
Fluoride Holding Basin #1	171,400	Estimate	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Fluoride Holding Basin #2	186,000	Estimate	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Fluoride Settling Basins & Clar.	114,300	Estimate	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Buried Calcium Fluoride	96,380	6	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Buried Fluoride Holding Basin 1	57,200	Estimate	4.91	2.87	7.91	0.703	0.236	0.95	2.2	1.2	3.4
Interim Storage Cell	154,887	Estimate	47.1	36.1	56.6	2.11	0.882	2.34	17.9	13.2	21.3
Solid Waste Burials (No. 1)	43,000	Estimate	47.1	36.1	56.6	2.11	0.882	2.34	17.9	13.2	21.3
Solid Waste Burials (No. 2)	8,100	Estimate	47.1	36.1	56.6	2.11	0.882	2.34	17.9	13.2	21.3
UF6 Cyliners	15,500										
DUF4 Drummed Contam. Trash	2,200										
Other Drummed Contam. Trash	4,050										
Empty Contam. Drums	2,000										
Main Process Building	436,600										
Solvent Extraction Building	36,000										
DUF4 Building	56,200										
ADU/Misc. Digestion Bldg	15,000										
Laundry Building	2,500										
Centrifuge Building	3,000										
Bechtel Building	5,400										
Solid Waste Building	3,600										
Cooling Tower	6,000										
RCC Evaporator	3,700										
Incinerator	1,500										
Concrete and Asphalt	511,795										
Scrap Metal	50,000										

Type D Material

Location	Vol. (ft^3)	Number Samples	Th-230, pCi/g			Ra-226, pCi/g			Ra-226 @ 1000 yrs, pCi/g		
			Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%	Mean	Std Dev	UCL, 95%
Site Soils	600,000	8	36.5	54.1	81.8	2.48	1.26	3.54	14.4	19.8	30.9

Initial Disposal Material Characterization Summary*

Material	SCU No.[a]	Item No.[b]	Layer No.[c]	Volume (cu ft)[d]	Weight (10^9 g)	Nat. Uranium		Thorium-230		Radium -226	
						pCi/g	Ci	pCi/g	Ci	pCi/g	Ci
SLUDGES & SEDIMENTS											
Raffinate sludge	17	5	A	1,064,000	6.76	5914	37.14	9611.1	60.4	118.1	0.7
Pond 2 residual materials	18	8	A	635,000	17.8	288	10.77	1284	48.03	43.0	1.61
Emergency basin sediment	6	11	A	14,600	0.139	3864	0.54	33,900	4.71	885	0.123
North ditch sediment	9	11	A	20,770	0.198	3865	0.77	698	0.137	170	0.033
Sanitary lagoon sediment	7	10	A	10,365	0.099	12,884	1.28	276	0.50	5.8	0.008
Fluoride holding basin #1	13	7	C	171,400	2.62	311	0.82	4.8	0.013	0.8	0.002
Fluoride holding basin #2	12	7	C	186,000	2.85	356	1.02	4.8	0.014	0.8	0.002
Fluoride settling basins & clarifier	14	7	C	114,300	1.79	520	0.92	4.8	0.008	0.8	0.001
Buried calcium fluoride	15	7	C	96,380	--	--	1.52	--	--	--	--
Buried fluoride holding basin #1	15	7	C	57,200	0.875	313	0.27	4.8	0.004	0.8	0.001
LINER SOILS & SUBSOILS											
Clarifier liners	17	8	B	332,400	16.6	28	0.47	70	1.16	0.5	0.008
Calcium fluoride basin liner	12, 13, 14	8	B	95,285	4.76	13.3	0.064	--	--	--	--
Pond 3E clay liner	24	8	B	88,232	4.41	4.9	0.02	--	--	--	--
Emergency basin soils	6	11	B	162,500	8.12	95	0.78	--	--	--	--
North ditch soils	9	11	B	87,500	4.37	68	0.30	--	--	--	--
Sanitary lagoon liner	7	10	B	56,356	2.81	28	0.08	70	0.20	0.5	0.001
BURIED MATERIALS & DRUMS											
Pond 1 spoils pile	8	8	B	437,400	21.8	4.8	0.11	47	1.02	2.1	0.046
Interim storage cell	9	35	C	154,887	7.74	373	2.89	2.1	0.016	0.21	0.0016
Solid waste burials	5	12	C	51,100	--	--	0.681	--	--	--	--
DUF_4 drummed contaminated trash	--	2	C	2,200	--	--	0.37[e]	--	--	--	--
Other drummed contaminated trash	--	6	C	4,050	--	--	0.015	--	--	--	--
Empty contam. Drums	--	3	C	2,000	--	--	0.015	--	--	--	--

* From SCR (SFC, 1998).

Initial Disposal Material Characterization Summary (continued)*

Material	SCU No.[a]	Item No.[b]	Layer No.[c]	Volume (cu ft)[d]	Weight (10^9 g)	Nat. Uranium		Thorium-230		Radium -226	
						pCi/g	Ci	pCi/g	Ci	pCi/g	Ci
STRUCTURAL MATERIALS	(see below)	(see below)		568,550	51.6	168	8.67	--	--	--	--
Main plant building	1	13	C	[2,178,000]							
Solvent Extraction Building	2	13	C	[180,000]							
DUF_4 Building	29	13	C	[281,000]							
ADU/Misc. digestion building	21	13	C	[75,000]							
Laundry building	17	13	C	[12,500]							
Centrifuge building	17	13	C	[15,000]							
Bechtel building	30	13	C	[27,000]							
Solid waste building	10	13	C	[18,000]							
Cooling tower	2	13	C	[30,000]							
RCC evaporator	2	13	C	[18,750]							
Incinerator	10	13	C	[7,500]							
Concrete and asphalt	Various	13	C	511,795	46.5	168	7.81				
Scrap metal	--	4	C	100,000	--	--	0.15	--	--	--	--
Chipped pallets	--	--	B	3,000	--	--	--	--	--	--	--
SUBSOILS & BEDROCK											
Contaminated materials[f]	Various	14	D	3,574,000	178.5	250	44.8	--	--	--	--

* From SCR (SFC, 1998).

a Site characterization unit number from Section 4 of SCR (SFC, 1998).

b Calculation item number in Attachment III of SCR.

c Layer number in disposal cell sequence.

d Values are from Attachment III of SCR; values in brackets are calculated building volumes from floor area and building height; disposal volume is 20 percent of building volume.

e Depleted uranium value

f Materials above 27 pCi/g natural uranium.

ATTACHMENT C.2

RADON MODEL OUTPUT

----------*****! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: phase I 95% ucl

AREA I

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS		2.65

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 layer A

THICKNESS	61	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	3542	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.957D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 layer b-d

THICKNESS	426	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	74.3	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.171D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 3 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 6 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	6.100D+01	4.942D-02	7.000D-01	2.957D-03	1.704D-01	0.795
2	4.260D+02	3.131D-02	4.000D-01	2.171D-04	2.385D-01	1.590
3	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
4	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
5	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
6	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 1.021D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	6.100D+01	4.935D+02	6.192D+05
2	4.260D+02	3.175D+01	1.018D+05
3	6.100D+01	1.412D+01	1.151D+04
4	4.600D+01	8.192D+00	1.351D+04
5	1.520D+02	2.139D+00	3.347D+02
6	4.600D+01	2.031D+00	0.000D+00

-----******! RADON !******-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: raff storage 95% UCL for Ra

AREA II A

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	7	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 raff sludge

THICKNESS	377	cm
POROSITY	.8	
CALCULATED MASS DENSITY	.5299999999999999	g cm^-3
MEASURED RADIUM ACTIVITY	7183	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	3.498D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	100	%
MOISTURE SATURATION FRACTION	.662	
CALCULATED DIFFUSION COEFFICIENT	1.618D-02	cm^2 s^-1

LAYER 2 pond 2

THICKNESS	128	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	1038	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	8.665D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 3 struct debris

THICKNESS	256	cm
POROSITY	.2	
CALCULATED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	30.9	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.407D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 4 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 5 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 6 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 7 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
7	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	3.770D+02	1.618D-02	8.000D-01	3.498D-03	6.625D-01	0.530
2	1.280D+02	4.942D-02	7.000D-01	8.665D-04	1.704D-01	0.795
3	2.560D+02	4.015D-03	2.000D-01	2.407D-04	6.360D-01	2.120
4	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
5	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
6	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
7	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.422D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	3.770D+02	1.350D+03	7.273D+05
2	1.280D+02	8.971D+01	9.950D+05
3	2.560D+02	1.565D+01	3.224D+04
4	6.100D+01	6.960D+00	5.673D+03
5	4.600D+01	4.037D+00	6.657D+03
6	1.520D+02	1.054D+00	1.649D+02
7	4.600D+01	1.001D+00	0.000D+00

----------******! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: phase 2 wo raff

AREA IIB

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 pond 2

THICKNESS	505	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	1038	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	8.665D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 struct debris

THICKNESS	256	cm
POROSITY	.2	
CALCULATED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	30.9	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.407D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 3 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 6 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	5.050D+02	4.942D-02	7.000D-01	8.665D-04	1.704D-01	0.795
2	2.560D+02	4.015D-03	2.000D-01	2.407D-04	6.360D-01	2.120
3	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
4	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
5	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
6	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 8.948D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.050D+02	2.220D+01	3.880D+05
2	2.560D+02	1.537D+01	3.166D+04
3	6.100D+01	6.835D+00	5.571D+03
4	4.600D+01	3.964D+00	6.537D+03
5	1.520D+02	1.035D+00	1.620D+02
6	4.600D+01	9.829D-01	0.000D+00

----------! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: phase 3

AREA III

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS		2.65

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 layer b-d

THICKNESS	457	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	32.9	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.746D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 3 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 4 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 5 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	FO1	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	4.570D+02	4.942D-02	7.000D-01	2.746D-05	1.704D-01	0.795
2	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
3	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
4	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
5	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.793D+01 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	4.570D+02	3.236D+00	1.101D+04
2	6.100D+01	1.439D+00	1.173D+03
3	4.600D+01	8.349D-01	1.377D+03
4	1.520D+02	2.180D-01	3.411D+01
5	4.600D+01	2.070D-01	0.000D+00

----------! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: raff sludge - lower debris density

DESCRIPTION: no AREA II A - Low Debris Density

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	7	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 raff sludge

THICKNESS	377	cm
POROSITY	.8	
CALCULATED MASS DENSITY	.5299999999999999	g cm^-3
MEASURED RADIUM ACTIVITY	7183	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	3.498D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	100	%
MOISTURE SATURATION FRACTION	.662	
CALCULATED DIFFUSION COEFFICIENT	1.618D-02	cm^2 s^-1

LAYER 2 pond 2

THICKNESS	128	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	1038	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	8.665D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 3 struc debris

THICKNESS	256	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	30.9	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	9.028D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 4 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 5 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 6 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 7 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE 'RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
7	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	3.770D+02	1.618D-02	8.000D-01	3.498D-03	6.625D-01	0.530
2	1.280D+02	4.942D-02	7.000D-01	8.665D-04	1.704D-01	0.795
3	2.560D+02	3.131D-02	4.000D-01	9.028D-05	2.385D-01	1.590
4	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
5	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
6	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
7	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.422D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	3.770D+02	1.493D+03	6.307D+05
2	1.280D+02	6.337D+02	7.093D+05
3	2.560D+02	4.683D+01	1.501D+05
4	6.100D+01	2.083D+01	1.698D+04
5	4.600D+01	1.208D+01	1.992D+04
6	1.520D+02	3.154D+00	4.937D+02
7	4.600D+01	2.996D+00	0.000D+00

----------! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: raff sludge - lower water content

DESCRIPTION: no AREA II A - Low Sludge w

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	7	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 raff sludge

THICKNESS	377	cm
POROSITY	.8	
CALCULATED MASS DENSITY	.5299999999999999	g cm^-3
MEASURED RADIUM ACTIVITY	7183	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	3.498D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	50	%
MOISTURE SATURATION FRACTION	.331	
CALCULATED DIFFUSION COEFFICIENT	4.276D-02	cm^2 s^-1

LAYER 2 pond 2

THICKNESS	128	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	1038	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	8.665D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 3 struct debris

THICKNESS	256	cm
POROSITY	.2	
CALCULATED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	30.9	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.407D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 4 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 5 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 6 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 7 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
7	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	3.770D+02	4.276D-02	8.000D-01	3.498D-03	3.312D-01	0.530
2	1.280D+02	4.942D-02	7.000D-01	8.665D-04	1.704D-01	0.795
3	2.560D+02	4.015D-03	2.000D-01	2.407D-04	6.360D-01	2.120
4	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
5	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
6	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
7	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 3.693D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	3.770D+02	1.257D+03	1.027D+06
2	1.280D+02	8.513D+01	9.538D+05
3	2.560D+02	1.563D+01	3.220D+04
4	6.100D+01	6.952D+00	5.666D+03
5	4.600D+01	4.032D+00	6.649D+03
6	1.520D+02	1.053D+00	1.647D+02
7	4.600D+01	9.997D-01	0.000D+00

----------*****! RADON !*****------

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: 10000 I AREA I, 10,000 YRS

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 layer A

THICKNESS	61	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	9013	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	7.524D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 layer b-d

THICKNESS	426	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	81.5	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.381D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 3 clay layer

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 6 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	FO1	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	6.100D+01	4.942D-02	7.000D-01	7.524D-03	1.704D-01	0.795
2	4.260D+02	3.131D-02	4.000D-01	2.381D-04	2.385D-01	1.590
3	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
4	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
5	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
6	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.599D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	6.100D+01	1.327D+03	1.493D+06
2	4.260D+02	4.602D+01	1.475D+05
3	6.100D+01	2.047D+01	1.669D+04
4	4.600D+01	1.187D+01	1.958D+04
5	1.520D+02	3.100D+00	4.852D+02
6	4.600D+01	2.944D+00	0.000D+00

----------! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: 10000 IIA

AREA II A. — 10,000 YRS

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	7	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 raff sludge

THICKNESS	377	cm
POROSITY	.8	
CALCULATED MASS DENSITY	.5299999999999999	g cm^-3
MEASURED RADIUM ACTIVITY	18587	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	9.051D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	100	%
MOISTURE SATURATION FRACTION	.662	
CALCULATED DIFFUSION COEFFICIENT	1.618D-02	cm^2 s^-1

LAYER 2 pond 2

THICKNESS	128	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	2568	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.144D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 3 struc debris

THICKNESS	256	cm
POROSITY	.2	
CALCULATED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	75.3	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	5.867D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 4 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 5 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 6 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 7 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE 'RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
7	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	3.770D+02	1.618D-02	8.000D-01	9.051D-03	6.625D-01	0.530
2	1.280D+02	4.942D-02	7.000D-01	2.144D-03	1.704D-01	0.795
3	2.560D+02	4.015D-03	2.000D-01	5.867D-04	6.360D-01	2.120
4	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
5	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
6	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
7	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 6.268D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	3.770D+02	3.520D+03	1.865D+06
2	1.280D+02	2.315D+02	2.540D+06
3	2.560D+02	3.818D+01	7.867D+04
4	6.100D+01	1.698D+01	1.384D+04
5	4.600D+01	9.851D+00	1.624D+04
6	1.520D+02	2.572D+00	4.025D+02
7	4.600D+01	2.442D+00	0.000D+00

----------! RADON !**********

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: 10000 IIB AREA IIB - 10,000 YRS

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 pond 2

THICKNESS	505	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	2568	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.144D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 struc debris

THICKNESS	256	cm
POROSITY	.2	
CALCULATED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	75.3	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	5.867D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 3 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 6 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	5.050D+02	4.942D-02	7.000D-01	2.144D-03	1.704D-01	0.795
2	2.560D+02	4.015D-03	2.000D-01	5.867D-04	6.360D-01	2.120
3	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
4	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
5	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
6	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.214D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.050D+02	5.565D+01	9.596D+05
2	2.560D+02	3.745D+01	7.717D+04
3	6.100D+01	1.666D+01	1.358D+04
4	4.600D+01	9.662D+00	1.593D+04
5	1.520D+02	2.523D+00	3.948D+02
6	4.600D+01	2.396D+00	0.000D+00

-----*****! RADON !*****------

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: 10000 III

AREA III - 10,000 YRS

DESCRIPTION: no

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
NO LIMIT ON RADON FLUX		
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.1	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 layer b-d

THICKNESS	457	cm
POROSITY	.7	
CALCULATED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	38.4	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	3.205D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 clay liner

THICKNESS	61	cm
POROSITY	.39	
CALCULATED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 3 liner cover

THICKNESS	46	cm
POROSITY	.4	
CALCULATED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 4 subsoil

THICKNESS	152	cm
POROSITY	.45	
CALCULATED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.486	
CALCULATED DIFFUSION COEFFICIENT	1.334D-02	cm^2 s^-1

LAYER 5 topsoil

THICKNESS	46	cm
POROSITY	.49	
CALCULATED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
5	-1.000D+00	0.000D+00	0	0.000D+00	1.000D-01

LAYER	DX	D	P	Q	XMS	RHO
1	4.570D+02	4.942D-02	7.000D-01	3.205D-05	1.704D-01	0.795
2	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
3	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
4	1.520D+02	1.334D-02	4.500D-01	0.000D+00	4.858D-01	1.458
5	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 3.260D+01 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	4.570D+02	3.777D+00	1.285D+04
2	6.100D+01	1.680D+00	1.369D+03
3	4.600D+01	9.744D-01	1.607D+03
4	1.520D+02	2.544D-01	3.982D+01
5	4.600D+01	2.416D-01	0.000D+00

Parameters	Area I, 10,000 Years	
Layer A		
Specific Gravity	0.80	0.80
Porosity	0.7	0.7
Density (g/cc)	0.795	0.795
Density (pcf)	49.6	49.6
Moisture Content (%)	15	16
Degree of Saturation (%)	0.17	0.17
Radium Activity (pCi/g)	9013	9013
Diffusion Coef (cm^2/sec)	0.04942	0.04942
Thickness (cm)	61	61
Thickness (ft)	2.0	2.0
Radon Flux (pCi/m^2-sec)	1327	1327
Layer b-d		
Specific Gravity	1.59	1.59
Porosity	0.4	0.4
Density (g/cc)	1.59	1.59
Density (pcf)	99.3	99.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.238	0.238
Radium Activity (pCi/g)	81.5	81.5
Diffusion Coef (cm^2/sec)	0.03131	0.03131
Thickness (cm)	426	426
Thickness (ft)	14.0	14.0
Radon Flux (pCi/m^2-sec)	46.02	42.04
Clay Liner		
Specific Gravity	1.62	1.62
Porosity	0.39	0.39
Density (g/cc)	1.6165	1.6165
Density (pcf)	100.9	100.9
Moisture Content (%)	15	15
Degree of Saturation (%)	0.662	0.662
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.005861	0.005861
Thickness (cm)	61	61
Thickness (ft)	2.0	2.0
Radon Flux (pCi/m^2-sec)	20.47	22.65
Liner Cover		
Specific Gravity	1.59	1.59
Porosity	0.4	0.4
Density (g/cc)	1.59	1.59
Density (pcf)	99.3	99.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.238	0.238
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.03131	0.03131
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	11.87	16.92
Subsoil		
Specific Gravity	1.46	1.46
Porosity	0.45	0.45
Density (g/cc)	1.4575	1.4575
Density (pcf)	91.0	91.0
Moisture Content (%)	15	6
Degree of Saturation (%)	0.486	0.194
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.01334	0.0376
Thickness (cm)	152	152
Thickness (ft)	5.0	5.0
Radon Flux (pCi/m^2-sec)	3.1	8.109
Topsoil		
Specific Gravity	1.35	1.35
Porosity	0.49	0.49
Density (g/cc)	1.3515	1.3515
Density (pcf)	84.4	84.4
Moisture Content (%)	6	6
Degree of Saturation (%)	0.165	0.165
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.04231	0.04231
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	2.944	7.701

Parameters	Area IIA, 10,000 Years	
Raff Sludge		
Specific Gravity	0.53	0.53
Porosity	0.8	0.8
Density (g/cc)	0.53	0.53
Density (pcf)	33.1	33.1
Moisture Content (%)	100	100
Degree of Saturation (%)	0.662	0.662
Radium Activity (pCi/g)	18587	18587
Diffusion Coef (cm^2/sec)	0.01618	0.01618
Thickness (cm)	377	377
Thickness (ft)	12.4	12.4
Radon Flux (pCi/m^2-sec)	3520	3520
Pond 2		
Specific Gravity	0.80	0.80
Porosity	0.7	0.7
Density (g/cc)	0.795	0.795
Density (pcf)	49.6	49.6
Moisture Content (%)	15	15
Degree of Saturation (%)	0.17	0.17
Radium Activity (pCi/g)	2568	2568
Diffusion Coef (cm^2/sec)	0.0494	0.0494
Thickness (cm)	128	128
Thickness (ft)	4.2	4.2
Radon Flux (pCi/m^2-sec)	231.5	231.5
Struc Debris		
Specific Gravity	2.12	2.12
Porosity	0.2	0.2
Density (g/cc)	2.12	2.12
Density (pcf)	132.3	132.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.636	0.636
Radium Activity (pCi/g)	75.3	75.3
Diffusion Coef (cm^2/sec)	0.004015	0.004015
Thickness (cm)	256	256
Thickness (ft)	8.4	8.4
Radon Flux (pCi/m^2-sec)	38.18	38.48
Clay Liner		
Specific Gravity	1.62	1.62
Porosity	0.39	0.39
Density (g/cc)	1.6165	1.6165
Density (pcf)	100.9	100.9
Moisture Content (%)	15	15
Degree of Saturation (%)	0.622	0.622
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.00586	0.00586
Thickness (cm)	61	61
Thickness (ft)	2.0	2.0
Radon Flux (pCi/m^2-sec)	16.98	18.53
Liner Cover		
Specific Gravity	1.59	1.59
Porosity	0.4	0.4
Density (g/cc)	1.59	1.59
Density (pcf)	99.3	99.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.238	0.238
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.03131	0.03131
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	9.851	13.84
Subsoil		
Specific Gravity	1.46	1.46
Porosity	0.45	0.45
Density (g/cc)	1.4575	1.4575
Density (pcf)	91.0	91.0
Moisture Content (%)	15	6
Degree of Saturation (%)	0.486	0.194
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.01334	0.0376
Thickness (cm)	152	152
Thickness (ft)	5.0	5.0
Radon Flux (pCi/m^2-sec)	2.572	6.633
Topsoil		
Specific Gravity	1.35	1.35
Porosity	0.49	0.49
Density (g/cc)	1.3515	1.3515
Density (pcf)	84.4	84.4
Moisture Content (%)	6	6
Degree of Saturation (%)	0.165	0.165
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.04231	0.04231
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	2.442	6.3

Parameters	Area IIB, 10,000 Years	
Pond 2		
Specific Gravity	0.80	0.80
Porosity	0.7	0.7
Density (g/cc)	0.795	0.795
Density (pcf)	49.6	49.6
Moisture Content (%)	15	15
Degree of Saturation (%)	0.17	0.17
Radium Activity (pCi/g)	2568	2568
Diffusion Coef (cm^2/sec)	0.04942	0.04942
Thickness (cm)	505	505
Thickness (ft)	16.6	16.6
Radon Flux (pCi/m^2-sec)	55.65	55.65
Struc Debris		
Specific Gravity	2.12	2.12
Porosity	0.2	0.2
Density (g/cc)	2.12	2.12
Density (pcf)	132.3	132.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.636	0.636
Radium Activity (pCi/g)	75.3	75.3
Diffusion Coef (cm^2/sec)	0.0040	0.0040
Thickness (cm)	256	256
Thickness (ft)	8.4	8.4
Radon Flux (pCi/m^2-sec)	37.45	37.87
Clay Liner		
Specific Gravity	1.62	1.62
Porosity	0.39	0.39
Density (g/cc)	1.6165	1.6165
Density (pcf)	100.9	100.9
Moisture Content (%)	15	15
Degree of Saturation (%)	0.622	0.622
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.005861	0.005861
Thickness (cm)	61	61
Thickness (ft)	2.0	2.0
Radon Flux (pCi/m^2-sec)	16.66	18.8
Liner Cover		
Specific Gravity	1.59	1.59
Porosity	0.4	0.4
Density (g/cc)	1.59	1.59
Density (pcf)	99.3	99.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.238	0.238
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.03131	0.03131
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	9.662	15.21
Subsoil		
Specific Gravity	1.46	1.46
Porosity	0.45	0.45
Density (g/cc)	1.4575	1.4575
Density (pcf)	91.0	91.0
Moisture Content (%)	15	6
Degree of Saturation (%)	0.486	0.194
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.01334	0.0376
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	2.523	3.523
Topsoil		
Specific Gravity	1.35	1.35
Porosity	0.49	0.49
Density (g/cc)	1.3515	1.3515
Density (pcf)	84.4	84.4
Moisture Content (%)	6	6
Degree of Saturation (%)	0.165	0.165
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.04231	0.04231
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	2.396	12.53

Parameters	Area III 10,000 Years	
Layer b-d		
Specific Gravity	0.80	0.80
Porosity	0.7	0.7
Density (g/cc)	0.795	0.795
Density (pcf)	49.6	49.6
Moisture Content (%)	15	15
Degree of Saturation (%)	0.17	0.17
Radium Activity (pCi/g)	38.4	38.4
Diffusion Coef (cm^2/sec)	0.04942	0.04942
Thickness (cm)	457	457
Thickness (ft)	15.0	15.0
Radon Flux (pCi/m^2-sec)	3.777	3.777
Clay Liner		
Specific Gravity	1.62	1.62
Porosity	0.39	0.39
Density (g/cc)	1.6165	1.6165
Density (pcf)	100.9	100.9
Moisture Content (%)	15	15
Degree of Saturation (%)	0.622	0.622
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.0059	0.0059
Thickness (cm)	61	61
Thickness (ft)	2.0	2.0
Radon Flux (pCi/m^2-sec)	1.68	1.865
Layer 3		
Specific Gravity	1.59	1.59
Porosity	0.4	0.4
Density (g/cc)	1.59	1.59
Density (pcf)	99.3	99.3
Moisture Content (%)	6	6
Degree of Saturation (%)	0.238	0.238
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.03131	0.03131
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	0.9744	1.393
Subsoil		
Specific Gravity	1.46	1.46
Porosity	0.45	0.45
Density (g/cc)	1.4575	1.4575
Density (pcf)	91.0	91.0
Moisture Content (%)	15	6
Degree of Saturation (%)	0.486	0.194
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.01334	0.0376
Thickness (cm)	152	152
Thickness (ft)	5.0	5.0
Radon Flux (pCi/m^2-sec)	0.2544	0.6677
Topsoil		
Specific Gravity	1.35	1.35
Porosity	0.49	0.49
Density (g/cc)	1.3515	1.3515
Density (pcf)	84.4	84.4
Moisture Content (%)	6	6
Degree of Saturation (%)	0.165	0.165
Radium Activity (pCi/g)	0	0
Diffusion Coef (cm^2/sec)	0.04231	0.04231
Thickness (cm)	46	46
Thickness (ft)	1.5	1.5
Radon Flux (pCi/m^2-sec)	0.2416	0.6341

AREA I 1
-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: Area I 10000 Years 6%WC Subsoil

DESCRIPTION: Subsoil is 6% WC instead of 15%

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Layer A

THICKNESS	61	cm
POROSITY	.7	
MEASURED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	9013	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	7.524D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 Layer b-d

THICKNESS	426	cm
POROSITY	.4	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	81.5	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.381D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 3 Clay Liner

AREA I 1

THICKNESS	61	cm
POROSITY	.39	
MEASURED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 Liner Cover

THICKNESS	46	cm
POROSITY	.4	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 Subsoil

THICKNESS	152	cm
POROSITY	.45	
MEASURED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.194	
CALCULATED DIFFUSION COEFFICIENT	3.762D-02	cm^2 s^-1

LAYER 6 Topsoil

THICKNESS	46	cm
POROSITY	.49	
MEASURED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	2.000D+01	1.000D-03

LAYER	DX	D	P	Q	XMS	RHO

AREA I 1

1	6.100D+01	4.942D-02	7.000D-01	7.524D-03	1.704D-01	0.795
2	4.260D+02	3.131D-02	4.000D-01	2.381D-04	2.385D-01	1.590
3	6.100D+01	5.861D-03	3.900D-01	0.000D+00	6.217D-01	1.617
4	4.600D+01	3.131D-02	4.000D-01	0.000D+00	2.385D-01	1.590
5	1.520D+02	3.762D-02	4.500D-01	0.000D+00	1.943D-01	1.458
6	4.600D+01	4.231D-02	4.900D-01	0.000D+00	1.655D-01	1.352

BARE SOURCE FLUX FROM LAYER 1: 2.599D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	6.100D+01	1.327D+03	1.493D+06
2	4.260D+02	4.704D+01	1.465D+05
3	6.100D+01	2.265D+01	1.219D+04
4	4.600D+01	1.692D+01	1.141D+04
5	1.520D+02	8.109D+00	1.697D+03
6	4.600D+01	7.701D+00	0.000D+00

AREA 2A

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: Area 2A 10000 Years

DESCRIPTION: Subsoil with 6% wc instead of 15%

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	7	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Raff Sludge

THICKNESS	377	cm
POROSITY	.8	
MEASURED MASS DENSITY	.53	g cm^-3
MEASURED RADIUM ACTIVITY	18587	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	9.051D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	100	%
MOISTURE SATURATION FRACTION	.662	
CALCULATED DIFFUSION COEFFICIENT	1.618D-02	cm^2 s^-1

LAYER 2 Pond 2

THICKNESS	128	cm
POROSITY	.7	
MEASURED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	2568	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.144D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 3 Struc Debris

AREA 2A

THICKNESS	256	cm
POROSITY	.2	
MEASURED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	75.3	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	5.867D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 4 Clay Liner

THICKNESS	61	cm
POROSITY	.39	
MEASURED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 5 Liner Cover

THICKNESS	46	cm
POROSITY	.4	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 6 Subsoil

THICKNESS	152	cm
POROSITY	.45	
MEASURED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.194	
CALCULATED DIFFUSION COEFFICIENT	3.762D-02	cm^2 s^-1

LAYER 7 Topsoil

THICKNESS	46	cm
POROSITY	.49	
MEASURED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1

AREA 2A

WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: 6.268D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	3.770D+02	3.520D+03	1.865D+06
2	1.280D+02	2.315D+02	2.540D+06
3	2.560D+02	3.848D+01	7.705D+04
4	6.100D+01	1.853D+01	9.972D+03
5	4.600D+01	1.384D+01	9.335D+03
6	1.520D+02	6.633D+00	1.388D+03
7	4.600D+01	6.300D+00	0.000D+00

AREA 2B

-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: Area 2B 10000 Years

DESCRIPTION: Subsoil with 6%wc instead of 15%

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Pond 2

THICKNESS	505	cm
POROSITY	.7	
MEASURED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	2568	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	2.144D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 Struc Debris

THICKNESS	256	cm
POROSITY	.2	
MEASURED MASS DENSITY	2.12	g cm^-3
MEASURED RADIUM ACTIVITY	75.3	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	5.867D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.636	
CALCULATED DIFFUSION COEFFICIENT	4.015D-03	cm^2 s^-1

LAYER 3 Clay Liner

AREA 2B

THICKNESS	61	cm
POROSITY	.39	
MEASURED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 4 Liner Cover

THICKNESS	46	cm
POROSITY	.4	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 5 Subsoil

THICKNESS	46	cm
POROSITY	.45	
MEASURED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.194	
CALCULATED DIFFUSION COEFFICIENT	3.762D-02	cm^2 s^-1

LAYER 6 Topsoil

THICKNESS	46	cm
POROSITY	.49	
MEASURED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: 2.214D+03 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS	EXIT FLUX	EXIT CONC.

AREA 2B

	(cm)	(pCi m^-2 s^-1)	(pCi l^-1)
1	5.050D+02	5.565D+01	9.596D+05
2	2.560D+02	3.787D+01	7.491D+04
3	6.100D+01	1.880D+01	8.198D+03
4	4.600D+01	1.521D+01	6.331D+03
5	4.600D+01	1.320D+01	2.761D+03
6	4.600D+01	1.253D+01	0.000D+00

AREA 3 1
-----*****! RADON !*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

OUTPUT FILE: Area 3 10000 Years

DESCRIPTION: Subsoil with 6%wc instead of 15%

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
DEFAULT SPECIFIC GRAVITY OF COVER & TAILINGS		2.65

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	5	
DEFAULT RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.001	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 Layer b-d

THICKNESS	457	cm
POROSITY	.7	
MEASURED MASS DENSITY	.795	g cm^-3
MEASURED RADIUM ACTIVITY	38.4	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	3.205D-05	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.170	
CALCULATED DIFFUSION COEFFICIENT	4.942D-02	cm^2 s^-1

LAYER 2 Clay Liner

THICKNESS	61	cm
POROSITY	.39	
MEASURED MASS DENSITY	1.6165	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	15	%
MOISTURE SATURATION FRACTION	.622	
CALCULATED DIFFUSION COEFFICIENT	5.861D-03	cm^2 s^-1

LAYER 3 Layer 3

AREA 3 1

THICKNESS	46	cm
POROSITY	.4	
MEASURED MASS DENSITY	1.59	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.238	
CALCULATED DIFFUSION COEFFICIENT	3.131D-02	cm^2 s^-1

LAYER 4 Subsoil

THICKNESS	152	cm
POROSITY	.45	
MEASURED MASS DENSITY	1.4575	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.194	
CALCULATED DIFFUSION COEFFICIENT	3.762D-02	cm^2 s^-1

LAYER 5 Topsoil

THICKNESS	46	cm
POROSITY	.49	
MEASURED MASS DENSITY	1.3515	g cm^-3
MEASURED RADIUM ACTIVITY	0	pCi/g^-1
DEFAULT LAYER EMANATION COEFFICIENT	.35	
CALCULATED SOURCE TERM CONCENTRATION	0.000D+00	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.165	
CALCULATED DIFFUSION COEFFICIENT	4.231D-02	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: 3.260D+01 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	4.570D+02	3.873D+00	1.280D+04
2	6.100D+01	1.865D+00	1.004D+03
3	4.600D+01	1.393D+00	9.396D+02
4	1.520D+02	6.677D-01	1.397D+02
5	4.600D+01	6.341D-01	0.000D+00