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NQA 06-021

May 30, 2006

U.S. Nuclear Regulatory Commission
Attn.: Document Control Desk
Washington, DC 20555

Docket No. 50-312
Rancho Seco Nuclear Generating Station
License No. DPR-54
BURIED PIPING DCGL DETERMINATION AND DETECTOR SENSITIVITY

Attention: John Hickman

Attached are copies of two Decommissioning Technical Basis Documents (DTBDs) that support the Rancho Seco License Termination Plan:

- DTBD-05-012 "Eberline SPA-3 and Ludlum 44-10 Detector Sensitivity (MDC)." This DTBD examines the response of the Ludlum 44-10 and Eberline SPA-3 NaI detectors to Co-60 and Cs-137.

- DTBD-05-013 "Buried Piping Scenario and DCGL Determination Basis." This DTBD establishes the buried piping scenario and the DCGLs that are appropriate for evaluating the internal surfaces of buried piping.

Members of your staff with questions requiring additional information or clarification may contact Bob Jones at (916) 732-4843.

Sincerely,

Bob Jones
Supervising Quality Engineer

Cc w/ attachment: B.S. Mallett, NRC, Region IV

NMSS9

Rancho Seco Nuclear Generating Station Decommissioning Technical Basis Document	DTBD–05-012 Revision No. 0 DPT 05-069 RIC 2A.900

EBERLINE SPA-3 AND LUDLUM 44-10

DETECTOR SENSITIVITY (MDC)

PREPARED BY:	R. F. Decker Author	11/7/05 Date
REVIEWED BY:	Reviewer	11-9-2005 Date
REVIEWED BY:	Michael L. Brown QA Reviewer	11/30/05 Date
APPROVED BY:	M W Snyder Principal Radiological Engineer	12/5/05 Date

1.0 PURPOSE

The purpose of this Decommissioning Technical Basis Document examines the response of the Ludlum 44-10 and Eberline SPA-3 (2" x 2") 5.08 by 5.08 cm NaI detectors to Co-60 and Cs-137 radionuclides.

2.0 DISCUSSION

This DTBD applies to the Eberline SPA-3 and Ludlum Model 44-10 NaI detectors. The calculations exemplify the MARSSIM based determination for Minimum Detectable Concentration (MDC) for land areas. There are two principle objectives. The first objective is to qualify the response of each manufacturers NaI detector to Cs-137 and Co-60 sources. The second is to identify detectable residual soil concentrations for Co-60 and Cs-137 radionuclides in the Tank Farm area and other site locations where the soil nuclide fractions are consistent with the data provided in this document.

3.0 DEFINITIONS

None

4.0 TECHNICAL POSITION

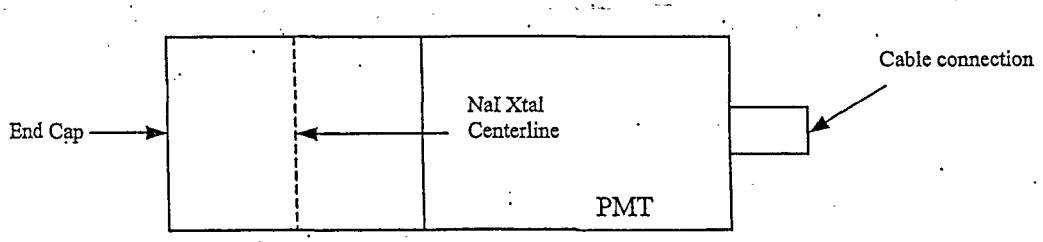
Published sensitivity for the Eberline SPA-3 and the Ludlum 44-10 are listed in the manufacturer's literature as 1200 CPM/mR/hr and 900 CPM/μR/hr respectively for Cs-137. This study was undertaken to verify the sensitivity to Cs-137 and to establish the sensitivity to Co-60.

5.0 LIMITATIONS

The conclusions of this DTBD are limited to (2" x 2") 5.08 by 5.08 cm NaI detectors.

6.0 TECHNICAL BASES

For determination of detector response factors for the SPA-3 and 44-10 detectors two NIST traceable sources were used, Co-60 and Cs-137. For both sealed sources the active area is very small in relationship to detector size and the distance from the source face to the detector centerline (located at 2.54 cm beyond the detector end cap).



The evaluation process to determine detector response factors for Cs-137 and Co-60 are provided in Attachment 1.0. The results of the evaluation are presented in Table 1 below.

Table 1
NaI Response Factors For SPA-3 and 44-10 Detectors

Source to Detector Distance (cm)	Microshield™ Derived μR/h		SPA-3 (5.08 x 5.08 cm) CPM/μR/h		44-10 (5.08 x 5.08 cm) CPM/μR/h	
	Co-60	Cs-137	Co-60	Cs-137	Co-60	Cs-137
7.62	24.12	--	385.5	--	410.1	--
15.24	6.032	128.1	454.9	975.3	387.3	868.4
30.48	1.508	32.01	454.4	1003.4	502.5	933.1
60.96	--	8.001	--	1032.6	--	1021.7
Average			432.0	1003.8	433.3	941.1

The average Cs-137 values for the SPA-3 and 44-10 NaI detectors are 1004.0 and 941.0 cpm/μR/h, respectively. These values are consistent with the results found in NUREG-1575. Table 6.7. The average Co-60 values for the SPA-3 and 44-10 NaI detectors are 432 and 433 cpm/μR/h, respectively. These results are also consistent with the values reported in Table 6.7. It is important to note that the principle gamma energy response for Cs-137 and Co-60 are in air and from a point source. The NaI detectors response will be greater for the lower energy gammas resulting from the scattering processes associated with the nuclides being distributed in soil media. Studies conducted at Maine Yankee resulted in a SPA-3 response factor for Cs-137 in soil (NIST traceable source) of 1568.0 cpm/μR/h. The Cs-137 response in air at Maine Yankee was determined to be 1050 cpm/μR/h and is consistent with the SPA-3 values in Table 1.

MODEL FOR DETERMINATION OF NAI DETECTOR MDA FOR SOIL

The MARSSIM suggested scan speed of 0.5 m/s is used with the elevated (soil) area of interest being 0.196 m^2 that relates to contaminants in a 50 cm diameter region that is 15 cm deep. The depth is consistent with the EPA and NRC definition of surface soils. The soil density is assumed at 1.6 g/cm^3 and the composition used for the MicroShield™ custom material soil model is composed of silicon oxide (sand). Recent acquisition of surface and subsurface soil samples in the Tank Farm area and the Spent Fuel Cooler pad areas indicate construction grade soils consisting primarily of sand and gravels that are of similar density values. The NaI detector height from the surface is varied and assumes surface to detector center distances of 2.0 (5.08 cm) and 3.0 (7.62 cm) inches. These distances provide reasonable estimates of the variation of detector height above the surface during scanning operations. The 50-centimeter diameter area is selected to provide a detector residence time of one second using a scan rate of 0.5 meters per second. It should be noted that soil and asphalt scan surveys can result in detector residence times greater than one second. To this end, scan measurements are expected to result in conservative MDA values. The SPA-3 and Model 44-10 NaI count rate to exposure rate from Table 1 are used for each of the principle gamma emitting

radionuclides. The NRC default values for surveyor efficiency and d' (detectability value) are included in the MDC determination. Inclusion of the surveyor efficiency and training of the surveyors to both listen for the instrument click rate and perform specific investigations following instrument alarms add conservatism to the MDC determination.

The soil data in Attachment 2.0 was derived from three sources:

- Previous Tank Farm area soil sampling results from remediation activities that were performed in 1990. The data is decay corrected to March 1, 2004 and represents the current observable residual contaminants and nuclide fraction that could be present.

- Spent Fuel Pool Cooler area soil samples acquired in October 2003 and represents the current observable residual nuclide fractions that could be present (on site gamma spectroscopy analysis).

- Effluent Pathway soil analysis results provided in Decomm 92-008 that represent samples collected in 1992. This data has been decay corrected to March 1, 2004 and presents the current observable residual nuclide fractions that could be present.

- Off -site laboratory analysis of the Spent Fuel Pool Cooler soil collected in October of 2003 indicates the weighted nuclide fraction for Cs-137 and Co-60 is closer to 0.99 and 0.01 respectively. The on site gamma spectroscopy results from eight soil locations were used to develop a nuclide fraction of 0.98 and 0.02 for Cs-137 and Co-60.

Specific MicroShield™ code runs (See Attachment 3.0) were conducted to determine the exposure rate for the individual or combined nuclides. The code runs are based on the above dimensions, soil composition and density for a 1.0 pCi/g concentration. These values are consistent with guidance provided in NUREG-1575 and 1757 Volume 2.

The data in Attachment 3.0 presents the exposure rate results for various Cs-137 and Co-60 soil nuclide mixtures. The nuclide mix is used in the Microshield™ code runs to derive exposure rate values based on the source to detector geometry. The spreadsheets in Attachments 4.0-10.0 utilized the MARSSIM guidance and formula, the detector response to the gamma emitting nuclides and the conversion basis for detector cpm to soil pCi/g concentration. Graphical presentation of the results is included. Table 2 compares the derived MDA results for the varied nuclide fractions and includes the individual detector models for an ambient background of 12,000 cpm. The derived MDA for the Cs-137 and Co-60 nuclide fractions (*nf*) do not significantly vary. The Ludlum 44-10 detector response is about 6 percent lower than the Eberline SPA-3. The overall variation for the nuclide fractions and detectors is 15.4 percent. Detector response for Co-60 (100% *nf*) results in a higher response (sensitivity) than Cs-137 and illustrates that if the Co-60 *nf* increases the MDA will decrease (as will the DCGL).

Table 2
SPA-3 and 44-10 Detectors MDA Results (pCi/g)*
For Varied Cs-137 and Co-60 Nuclide Fractions

Detector	nf, Cs-137 95%, Co-60 5%	nf, Cs-137 95%, Co-60 5%	nf, Cs-137 100%	nf, Co-60 100%
SPA-3	4.97	4.75	5.13	2.94
44-10	5.29	5.03	5.48	2.94

*Detector Background assumed at 12,000 cpm

Whereas the residual Cs-137 and Co-60 composition in the RSNGS site soil may vary, the results of Attachment 2.0 shows that the major radionuclide constituent is Cs-137. Spent Fuel Pool Cooler soil samples were submitted for vendor laboratory analysis. Cs-137 and Co-60 were identified as the principle gamma emitting nuclides. In addition to these nuclides, C-14, Ni-63, Sr-90 and Cs-134 were also present in the mixture. These latter nuclides and the remaining nuclide suite of 28 nuclides (which were reported as MDA levels) contribute about 2.0 percent of the dose to the annual 25.0 mrem limit. Additional information regarding the contribution and the Site Specific DCGL will be discussed latter in the document. The final survey soil samples will be analyzed using the on-site gamma spectroscopy system. This analysis methodology will insure the nuclide fractions are correctly addressed and assist in confirming the principle gamma constituents associated with each survey unit. The *final* soil nuclide constituents will be based on initial and continued site characterization sample results identified in the associated Decommissioning Technical Basis Documents (DTBD's) and the License Termination Plan (LTP).

Nuclide Fraction for Principle Gamma Nuclides in Soil

Soil nuclide fractions for Co-60 and Cs-137 were initially examined using the Lawrence Livermore National Laboratory (LLL) Rancho Seco environmental studies conducted from 1983 through 1986. The first examination was based on the results of the retention basin samples decayed-corrected to the year 2003. The 2003 decay-corrected Co-60 and Cs-137 nuclide fractions were 0.225 and 0.775, respectively. The second examination of LLL data was based on soil samples collected in 1985 and 1986. At the time of examination the samples were conservatively decay-corrected to 2003. The nuclide fraction for Co-60 and Cs-137 for these samples averaged 0.04 and 0.96 respectively. As presented in Table 3, soil sample results from past remediation activities associated with the BWST, the effluent stream soil and recent soil analysis results from the Spent Fuel Pool Cooler area were examined. The averaged gamma spectroscopy soil analysis results for each area are provided in Table 3.0. For these areas the nuclide fraction for Co-60 and Cs-137 averaged 0.02 and 0.98 respectively. By the time that final surveys (2008) are conducted the shorter-lived Co-60 fraction in the soil mixture will have undergone additional radioactive decay increasing the Cs-137 fraction.

Table 3.0

2004 Soil Nuclide Fractions (nf)

Nuclide	BWST	Effluent Stream	Spent Fuel Cooler Pad	Vendor Spent Fuel Cooler Pad	Average nf for Co-60 & Cs-137
Mn-54	1.19E-08	--	--	--	--
Co-60	9.95E-02	1.47E-02	2.34E-02	1.02E-02	1.61E-02
Ag-110m	2.23E-08	--	--	--	--
Sb-125	6.48E-03	--	--	--	--
Cs-134	6.09E-04	9.34E-04	--	7.23E-04	--
Cs-137	8.93E-01	9.84E-01	9.77E-01	9.891E-01	.9837E-01
	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.996E-01

DATA RESULTS

The data provided in this document illustrates the Minimum Detectable Concentration (MDC) response of the SPA-3 and 44-10 detectors for Co-60 and Cs-137 over a varied background range. Site-specific background values are anticipated to range from 8.0E+03 to 1.6+04 cpm. The graphs in Attachments 4.0-10.0 illustrate the detectable concentration of the principal nuclides and nuclide fractions in the soil for the given background count rate of the detector. Attachment 4.0 and 5.0 results show that for the soil nuclide fraction of 0.02 Co-60 and 0.98 Cs-137, the scan minimum detection capability of the detector ranges from 4.1 to 7.4 pCi/g. Soils containing 100% Co-60 (See Attachment 10.0) result in an estimated detection capability range of ~2.4 to 4.1 pCi/g (where the background cpm ranges from 8.0E+03 to 1.6E+04 cpm and the detector end cap is 1.0 to 2.0 inches from the soil surface). Soils containing 100% Cs-137 (See Attachment 9.0) result in an estimated detection capability range of ~4.2 to 7.6 pCi/g (where the background cpm ranges from 8.0E+03 to 1.6E+04 cpm and the detector end cap is 1.0 to 2.0 inches from the soil surface).

Conclusion

The data presents general sensitivity (MDC) for the principal gamma emitting nuclides associated with the RSNGS site. The results show that soil containing the respective nuclide fractions of 0.02 and 0.98 for Co-60 and Cs-137 have conservative SPA-3 and 44-10 detector MDC's of ~5.0 and 6.4 pCi/g (when the background is 1.20E+04 cpm). The lower value (5.0 pCi/g is ~10 percent of the limits assigned using the site specific DCGL of ~49.7 pCi/g (~24.5 mrem/y). Attachment 11.0 Provides the nuclide suite and the DCGL adjusted for nuclides removed from the suite. The adjusted value (~24.5 versus 25.0 mrem/y) accounts for all the nuclides in the suite as well as potential HTDN. The results do show that based on the mixtures presented, residual soil concentrations

significantly below the site-specific DCGL are readily detectable with the Eberline SPA-3 and Ludlum Model 44-10 detectors.

7.0 References

7.1 NUREG-1575, EPA 402-R-97-016, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)". Rev. 1 August 2000

7.2 Ludlum Measurements, Inc., Ludlum Model 44-10 Gamma Scintillator Instruction Manual

7.3 NUREG-1757 V2, Consolidated NMSS Decommissioning Guidance

8.0 ATTACHMENTS

8.1 Co-60 and Cs-137 Response Factor Determination Instructions and Results

- Evaluation of SPA-3 and Ludlum 44-10 cpm per μR/h Response Factors for Co-60
- Microshield™ runs for 7.62, 15.24 and 30.48 cm for Co-60
- Source Certificate for Co-60 Serial Number 214-17-195 (SCN 335)
- Evaluation of SPA-3 and Ludlum 44-10 cpm per μR/h Response Factors for Cs-137
- Microshield™ runs for 15.24, 30.48 and 60.96 cm for Cs-137
- Source Certificate for Cs-137 Serial Number LY 376 (SCN 618)
- NaI Response Factors for SPA-3 and 44-10 Detectors for Co-60
- ~~NaI Response Factors for SPA-3 and 44-10 Detectors for Cs-137~~

8.2 Soil Nuclide Fractions On Site Gamma Spectroscopy

8.3 Microshield™ Code Runs

8.4 Scan MDC (pCi/g) for Principal Soil Nuclides (Co-60 and Cs-137) 4 through 10

8.5 Draft Industrial Scenario DCGL for Soil

9.0 RESPONSIBLE INDIVIDUAL

R. F. Decker

Attachment 8.1

Evaluation of Eberline SPA-3 and Ludlum 44-10 cpm per μR/h Response Factors
August 19, 2004
RFD

The NaI detectors provided by Eberline and Ludlum include cpm per μR/h response factors for specific nuclides. The instructions below are used to evaluate the response of both detectors to Cs-137. The results of the evaluation are to confirm manufacturer results or modify the response factors accordingly.

Equipment:

- Calibrated Eberline E-600 and Ludlum 2350-1
- Eberline SPA-3 and Ludlum 44-10 detectors
- IPL Co-60 Source 214-17-195 8/1/1988 0.891 μCi
- Tape measure
- Materials to position the source and detector approximately 3 feet above the floor
- Materials to record the results of testing (utilize data logging features) and boxes provided in the table below.

Co-60 source 0.891 μCi on 8-1-88. Decay corrected activity is 3.995 kBq (0.108 μCi) on 8-19-04.

Microshield™ runs attached for point source at 7.62, 15.24 and 30.48 cm (3, 6 & 12 inches to centerline of detector active area)

NaI Response Factors for SPA-3 and 44-10 Detectors

Distance (cm)	Derived μ/h	SPA-3 Estimate	SPA-3 Observed	44-10 Estimated	44-10 Observed
7.62	24.12	1.447E+04 cpm	9.3217E+03 cpm	1.0372E+04 cpm	9.8920E+03 cpm
15.24	6.032	3.619E+03 cpm	2.7440E+03 cpm	2.5938E+03 cpm	2.3361E+03 cpm
30.48	1.508	9.048E+02 cpm	6.8530E+01 cpm	6.4844E+02 cpm	7.5780E+02 cpm
Estimates based on vendor values of 600 and 430 cpm/μR/h for SPA-3 and 44-10 respectively					

Determination is conducted in an open area with the detector and source elevated 1.0 meter above the surface. Walls and other solid obstructions should be at least 2 meters from the source and detector. The objective is to minimize scattering effects.

Each Measurement is conducted in the scaler mode for the instrument and the measurement (count) time is 10 minutes.

Background is evaluated by performing a 10-minute count prior to the tests and with the source removed from the area.

Background cpm value: SPA-3 – 8525, 44-10 - 8661

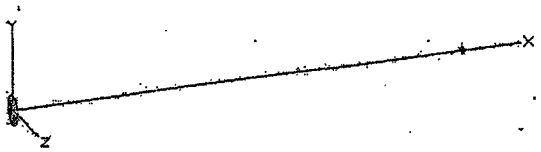
To determine the response to Co-60 the net counts per minute are divided by the μR/h provided for the specific distance.

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: August 24, 2004
Run Time: 7:45:23 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Co-60
Description: NaI Response Check @ 7.62 cm
Geometry: 3 - Disk



Source Dimensions

Radius	0.238 cm	0.1 in

Dose Points

	X	Y	Z
#1	7.62 cm	0 cm	0 cm
	3.0 in	0.0 in	0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm²	Bq/cm²
Co-60	1.0797e-007	3.9950e+003	6.0931e-001	2.2544e+004

Buildup
The material reference is : Air Gap

Integration Parameters

Radial	20
Circumferential	20

Results

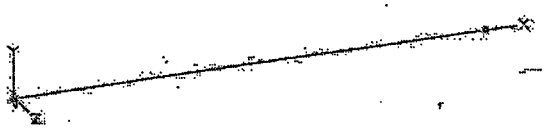
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.517e-01	6.189e-04	6.193e-04	1.195e-06	1.196e-06
1.1732	3.995e+03	6.417e+00	6.419e+00	1.147e-02	1.147e-02
1.3325	3.995e+03	7.288e+00	7.291e+00	1.264e-02	1.265e-02
TOTALS:	7.991e+03	1.371e+01	1.371e+01	2.411e-02	2.412e-02

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: August 24, 2004
Run Time: 7:47:04 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Co-60
Description: NaI Response Check @ 15.24 cm
Geometry: 3 - Disk



Source Dimensions

Radius	0.238 cm	0.1 in

Dose Points

	X	Y	Z
#1	15.24 cm 6.0 in	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	1.0797e-007	3.9950e+003	6.0931e-001	2.2544e+004

Buildup
The material reference is : Air Gap

Integration Parameters

Radial	20
Circumferential	20

Results

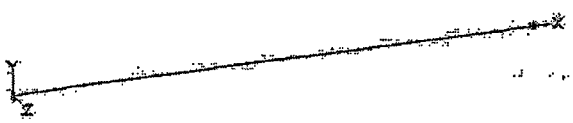
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	5.517e-01	1.547e-04	1.549e-04	2.986e-07	2.990e-07
1.1732	3.995e+03	1.604e+00	1.605e+00	2.866e-03	2.869e-03
1.3325	3.995e+03	1.822e+00	1.823e+00	3.161e-03	3.163e-03
TOTALS:	7.991e+03	3.426e+00	3.429e+00	6.027e-03	6.032e-03

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: August 24, 2004
Run Time: 7:48:15 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Co-60
Description: NaI Response Check @ 30.48 cm
Geometry: 3 - Disk



Source Dimensions

Radius	0.238 cm	0.1 in

Dose Points

	X	Y	Z
#1	30.48 cm 1 ft	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	1.0797e-007	3.9950e+003	6.0931e-001	2.2544e+004

Buildup
The material reference is : Air Gap

Integration Parameters

Radial	20
Circumferential	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.517e-01	3.862e-05	3.871e-05	7.456e-08	7.474e-08
1.1732	3.995e+03	4.006e-01	4.012e-01	7.158e-04	7.170e-04
1.3325	3.995e+03	4.550e-01	4.557e-01	7.895e-04	7.906e-04
TOTALS:	7.991e+03	8.557e-01	8.570e-01	1.505e-03	1.508e-03

8/12/88

CERTIFICATE OF GAMMA STANDARD SOURCE

Radionuclide: Co-60 Half-life: 5.2714 ± 0.0005 y

Customer: SACRAMENTO MUNICIPAL UTILITIES DISTRICT P.O. No.: EN 880525589

Catalog No.: CF-060 Source No.: 214-17-195 Reference Date: AUG. 1, 1988

Contained Radioactivity: 0.891 uCi

Description of Source

a. Capsule type: D

b. Nature of active deposit: EVAPORATED METALLIC SALTS

c. Active diameter: 0.187"

d. Backing: N/A

e. Cover: N/A

Radioimpurities

NONE DETECTED

Method of Calibration

(X) The source was assayed by gamma spectrometry, integrating under the 1.173 & 1.332 Mev peak(s). The branching ratio(s) used was/were 1.0 & 1.0 gamma rays per decay.

( ) The source was prepared from a weight aliquot of solution whose activity in uCi/gram was determined by the method above.

Uncertainty of Measurement

a. Systematic uncertainty in instrument calibration: ± 1.3 %

b. Random uncertainty

1. In assay: ± 1.1 %

2. In weighing(s): ± %

c. Total Uncertainty: ± 2.4 % at the 99% confidence level.

NBS Traceability

This calibration is implicitly traceable to the National Bureau of Standards.

Notes

1. Nuclear data were taken from "Table of Isotopes", Seventh Edition, edited by C. Michael Lederer et al.

2. IPL participates in an NBS measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NBS certification) of Standard Reference Materials. (As in NRC Regulatory Guide 4.15)

Michael Davies
Quality Control

ISOTOPE PRODUCTS LABORATORIES
1800 No. Keystone St., Burbank, California 91504
(818) 843-7000

Evaluation of Eberline SPA-3 and Ludlum 44-10 cpm per μR/h Response Factors
August 19, 2004
RED

The NaI detectors provided by Eberline and Ludlum include cpm per μR/h response factors for specific nuclides. The instructions below are used to evaluate the response of both detectors to Cs-137. The results of the evaluation are to confirm manufacturer results or modify the response factors accordingly.

Equipment:

- Calibrated Eberline E-600 and Ludlum 2350-1
- Eberline SPA-3 and Ludlum 44-10 detectors
- AEA Cs-137 Source 68970 – LY 376
- Tape measure.
- Materials to position the source and detector approximately 3 feet above the floor
- Materials to record the results of testing (utilize data logging features) and boxes provided in the table below.

Cs-137 source 344 kBq (9.297 μCi) on 10-1-03. Decay corrected activity is 337.1 kBq (9.111 μCi) on 8-18-04.

Microshield™ runs attached for point source at 15.24, 30.48 and 60.96 cm (6, 12 & 24 inches to centerline of detector active area)

NaI Response Factors for SPA-3 and 44-10 Detectors

Distance (cm)	Derived μR/h	SPA-3 Estimate	SPA-3 Observed	44-10 Estimated	44-10 Observed
15.24	128.1	1.537E+05 cpm	1.3642E+05 cpm	1.153E+05 cpm	1.2280E+05 cpm
30.48	32.01	3.841E+04 cpm	4.3608E+04 cpm	2.881E+04 cpm	4.1430E+04 cpm
60.96	8.001	9.601E+03 cpm	1.9749E+04 cpm	7.201E+03 cpm	1.9737E+04 cpm
Estimates based on vendor values of 600 and 430 μR/h for SPA-3 and 44-10 respectively					

Determination is conducted in an open area with the detector and source elevated 1.0 meter above the surface. Walls and other solid obstructions should be at least 2 meters from the source and detector. The objective is to minimize scattering effects.

Each Measurement is conducted in the scaler mode for the instrument and the measurement (count) time is 10 minutes.

Background is evaluated by performing a 10-minute count prior to the tests and with the source removed from the area.

Background cpm value: SPA-3 – 11488, 44-10 - 11562

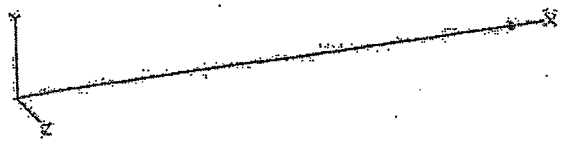
To determine the response to Cs-137 the net counts per minute are divided by the μR/h provided for the specific distance.

MicroShield v5.05 (5.05.00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: August 17, 2004
Run Time: 11:31:58 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: 9.11 uCi Cs-137
Description: Point Source at 15.24 cm
Geometry: 1 - Point



Dose Points

	X	Y	Z
#1	15.24 cm 6.0 in	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels
Ba-137m	8.6188e-006	3.1890e+005
Cs-137	9.1108e-006	3.3710e+005

Buildup
The material reference is : Air Gap

Results

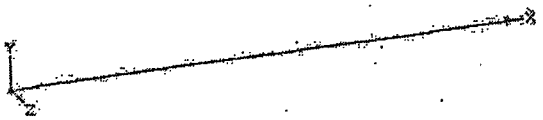
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	6.602e+03	7.157e-02	7.206e-02	5.962e-04	6.003e-04
0.0322	1.218e+04	1.336e-01	1.345e-01	1.075e-03	1.083e-03
0.0364	4.433e+03	5.502e-02	5.540e-02	3.126e-04	3.147e-04
0.6616	2.869e+05	6.496e+01	6.504e+01	1.259e-01	1.261e-01
TOTALS:	3.102e+05	6.522e+01	6.530e+01	1.279e-01	1.281e-01

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date : August 17, 2004
Run Time: 11:29:10 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: 9.11 uCi Cs-137
Description: Point Source at 30.48 cm
Geometry: 1 - Point



Dose Points

	X	Y	Z
# 1	30.48 cm 1 ft	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels
Ba-137m	8.6188e-006	3.1890e+005
Cs-137	9.1108e-006	3.3710e+005

Buildup
The material reference is : Air Gap

Results

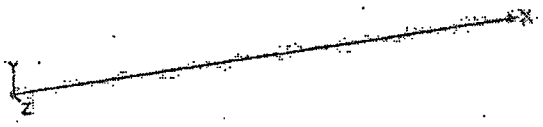
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	6.602e+03	1.779e-02	1.804e-02	1.482e-04	1.503e-04
0.0322	1.218e+04	3.323e-02	3.368e-02	2.674e-04	2.711e-04
0.0364	4.433e+03	1.369e-02	1.388e-02	7.779e-05	7.885e-05
0.6616	2.869e+05	1.622e+01	1.626e+01	3.144e-02	3.151e-02
TOTALS:	3.102e+05	1.628e+01	1.632e+01	3.193e-02	3.201e-02

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: August 17, 2004
Run Time: 11:30:55 AM
Duration : 00:00:00

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: 9.11 uCi Cs-137
Description: Point Source at 60.96 cm
Geometry: 1 - Point



Dose Points

	X	Y	Z
# 1	60.96 cm 2 ft	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Material	Density
Air Gap	Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels
Ba-137m	8.8188e-006	3.1890e+005
Cs-137	9.1108e-006	3.3710e+005

Buildup
The material reference is : Air Gap

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	6.602e+03	4.399e-03	4.521e-03	3.665e-05	3.766e-05
0.0322	1.218e+04	8.216e-03	8.444e-03	6.612e-05	6.795e-05
0.0364	4.433e+03	3.391e-03	3.484e-03	1.926e-05	1.980e-05
0.6616	2.869e+05	4.042e+00	4.062e+00	7.837e-03	7.875e-03
TOTALS:	3.102e+05	4.058e+00	4.079e+00	7.959e-03	8.001e-03

Receipt # 03-027

461, Issue 4, 03-01-03

AEA Technology QSA GmbH

Gieselweg 1
38110 Braunschweig
Postfach 11 37
38001 Braunschweig
Germany
Tel. +49 (0) 5307 932-0
Fax +49 (0) 5307 932-194

17 September 2003

CERTIFICATE

No. 68970 - LY 376

for a Sealed Radioactive Source

Source Type: Reference Source

Product code	CDRX1476
Drawing	VZ-477/2
Source no.	LY 376
Nuclide	Caesium-137

Measurement Data

Activity	344 kBq
Uncertainty*	3%
Reference date	1 October 2003
Traceability*	Defined on page 2
Radioactive Impurities	Related to Cs-137 (equal 100 %) the following radioactive impurities were detected: Cs-134 < 0.1 %

Leakage and Contamination Test/s

Test method/s*	II and I
Test/s passed on	16 September 2003

Additional Information

ISO classification*	C34313

* see page 2 for explanation

AEA Technology QSA GmbH

i.A. [signature]
(Production Manager)

SCN 018

Receipt # 03-027

Explanations for Certificates (Page 2 of Certificates)

Uncertainty

The reported uncertainty is based on standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95 %. (ISO Guide, 1995).

Traceability

This certificate documents the traceability of measurement results to national standards, standard measuring equipment and methods for the realisation of physical units of measurement according to the International System of Units (SI).
Traceability is defined as the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

AEA Technology QSA GmbH has been accredited as DKD (Deutscher Kalibrierdienst) calibration laboratory by the Physikalisch-Technische Bundesanstalt (PTB) and is authorized to issue reference sources which are traceable to national standards held at the PTB in Germany.
Because of the European co-operation for Accreditation (EA) mutual recognition agreement the certificates are also accepted by all EA-members (e. g. NAMAS, UK).

This product complies with the requirements for traceability to NIST specified in the American National Standard "Traceability of Radioactive Sources to the NIST and Associated Instrument Quality Control (ANSI N42.22-1995)".
As a requirement for the ANSI N42.22-1995 AEA Technology QSA participates in the NEI/NIST Measurements Assurance Program of the Nuclear Power Industry.

Leakage and contamination tests

Stringent tests for leakage are an essential feature of radioactive sources production. They are based on ISO 9978. Some standard methods used for testing radiation sources are listed below.

Wipe test I

The source is wiped with a swab or tissue, moistened with ethanol or water, the activity removed is measured.
Limit: 200 Bq
(Limit USA: 5 nCi)

Immersion test II

The source is immersed in a suitable liquid at 50 °C for at least 4 hours and the activity removed is measured.
Limit: 185 Bq

Bubble test III

The source is immersed in water or a suitable liquid and the pressure in the vessel reduced to 13 kPa (100 mm Hg). No bubbles must be observed.

ISO classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on safety requirements for typical uses (see ISO 2919). This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products. It also assists a user of such sealed sources to select types which suit the application he has in mind. The tests to which specimen sources are subjected are listed in the following table.

Classification of sealed source performance standard according to ISO 2919

	Class 1	2	3	4	5	6	X
Temperature	No test	-40 °C (20 min) + 80 °C (1 h)	-40 °C (20 min) + 180 °C (1 h)	-40 °C (20 min) + 400 °C (1 h) and thermal shock 400 °C to 20 °C	-40 °C (20 min) + 600 °C (1 h) and thermal shock 600 °C to 20 °C	-40 °C (20 min) + 800 °C (1 h) and thermal shock 800 °C to 20 °C	Special test
External Pressure	No test	25 kPa absolute	25 kPa absolute to 2 MPa absolute	25 kPa absolute to 7 MPa absolute	25 kPa absolute to 70 MPa absolute	25 kPa absolute to 170 MPa absolute	
Impact	No test	50 g from 1 m	200 g from 1 m	2 kg from 1 m	5 kg from 1 m	20 kg from 1 m	
Vibration	No test	3 x 10 min 25 - 500 Hz at 5 g peak amplitude	3 x 10 min 25 - 50 Hz at 5 g peak amplitude and 50 - 90 Hz at 0.635 mm amplitude peak to peak and 90 - 500 Hz at 10 g peak amplitude	3 x 30 min 25 - 80 Hz at 1.5 mm amplitude peak to peak and 80 - 2000 Hz at 20 g peak amplitude			
Puncture	No test	1 g from 1 m	10 g from 1 m	50 g from 1 m	300 g from 1 m	1 kg from 1 m	

Special applications

No test programme can cover all possible combinations of environments to which a source may be exposed.
Users should therefore consult our experts before using sources in potentially adverse environments.

IAEA Special Form

'Special Form' is a test specification for sealed sources given in the IAEA transport regulations (IAEA Safety Series No. 6, 1985, revised edition).
It is used in determining the maximum acceptable activities for various types of transport containers.

Quality assurance System

The quality assurance system of AEA Technology QSA GmbH was certified by Lloyd's Register Quality Assurance (LRQA) according to ISO 9001, Issue 1994. Isotrak products meet the requirements of 10CFR50 Appendix B.

REL, Issue 3, 2003-03-27

Co-60
NaI Response Factors for SPA-3 and 44-10 Detectors

Gross Data

Instrument	Serial Number	Background*	7.62 cm*	15.24 cm*	30.48 cm*
SPA-3	406074	85249	178466	112669	92102
44-10	211672	86613	185533	109974	94191

*Ten-minute count results

Net Counts

Distance (cm)	Derived µ/h	SPA-3 Estimated	SPA-3 Observed	44-10 Estimated	44-10 Observed
7.62	24.12	1.4472E+04	9.3217E+03	1.0372E+04	9.8920E+03
15.24	6.032	3.6192E+03	2.7449E+03	2.5938E+03	2.3361E+03
30.48	1.508	9.0480E+02	6.8539E+02	6.4844E+02	7.5788E+02
Estimates based on vendor values of 600 and 430 cpm/µR/h for SPA-3 and 44-10 respectively					

CPM/µR/h

Instrument	7.62 cm	15.24 cm	30.48 cm	Average
SPA-3	386	455	454	432
44-10	410	387	503	433

Cs-137
NaI Response Factors for SPA-3 and 44-10 Detectors

Gross Data

Instrument	Serial Number	Background	15.24 cm*	30.48 cm	60.96 cm
SPA-3	406074	114876	682101	436075	197493
44-10	211672	115620	613988	414299	197366

*3-minute count used for the 6" (15.24 cm) measurement due to high count rate instrument maxed out with approximately 1.5 minutes to go in a 10 minute count.

Net Counts

Distance (cm)	Derived µ/h	SPA-3 Estimated	SPA-3 Observed	44-10 Estimated	44-10 Observed
15.24	128.1	1.5370E+05	1.2493E+05	1.1530E+05	1.1124E+05
30.48	32.01	3.8410E+04	3.2120E+04	2.8810E+04	2.9868E+04
60.96	8.001	9.6010E+03	8.2617E+03	7.2010E+03	8.1748E+03

Estimates based on vendor values of 600 and 430 cpm/µR/h for SPA-3 and 44-10 respectively

CPM/µR/h

Instrument	7.62 cm	15.24 cm	30.48 cm	Average
SPA-3	975	1003	1033	1004
44-10	868	933	1022	941

Attachment 8.2

Soil Nuclide Fractions From On Site Gamma Spectroscopy

Attachment 2.0
Soil Nuclide Fractions

1.0 BWST Tank Farm Area (Decay results to 3/1/04)

	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	Average
Mn-54	1.07E-07	0.00E+00	0.00E+00	0.00E+00	3.00E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-08
Co-60	1.37E-01	1.454E-02	0.00E+00	0.00E+00	9.59E-02	5.21E-02	2.64E-02	3.69E-02	1.08E-02	5.17E-02	5.91E-02	9.81E-01	9.95E-02
Ag-110m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-07	2.23E-08
Sb-125	2.48E-03	7.843E-03	0.00E+00	0.00E+00	6.04E-04	1.96E-02	0.00E+00	1.72E-03	0.00E+00	1.50E-03	1.92E-03	4.23E-02	6.48E-03
Cs-134	7.28E-04	7.331E-04	0.00E+00	0.00E+00	1.87E-03	6.94E-04	5.20E-04	7.39E-04	9.53E-04	9.37E-04	5.42E-04	0.00E+00	6.09E-04
Cs-137	8.60E-01	9.271E-01	1.00E+00	1.00E+00	9.92E-01	9.05E-01	9.73E-01	9.56E-01	9.88E-01	9.46E-01	9.41E-01	2.77E-01	8.93E-01
	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

2.0 Effluent Pathway Soil Decayed to 3/1/04, * Indicates Higher Activity sample from DECOM 92-006

	nf	nf	nf	nf	nf	nf	nf	nf	nf	Average nf
Co-60	1.30E-02	1.10E-02	1.43E-02	2.37E-02	2.48E-02	1.49E-02	1.29E-02	9.21E-03	9.21E-03	1.41E-02
Cs-134	9.69E-04	9.41E-04	9.99E-04	9.05E-04	9.69E-04	9.40E-04	9.68E-04	9.00E-04	8.54E-04	9.38E-04
Cs-137	9.88E-01	9.885-01	9.85E-01	9.76E-01	9.73E-01	9.84E-01	9.86E-01	9.90E-01	9.90E-01	9.84E-01
	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

	Location Averages Co-60 nf	Cs-137 nf
1.0	9.95E-02	8.93E-01
2.0	1.47E-02	9.84E-01
3.0	2.34E-02	9.77E-01
	4.59E-02	9.61E-01

3.0 Spent Fuel Pool Cooler Soil 10/15/03

	nf	nf	nf	nf	nf	nf	nf	nf	Average
Co-60	5.40E-02	5.76E-02	5.28E-02	1.60E-02	1.24E-02	1.06E-02	1.61E-02	1.31E-02	2.34E-02
Cs-137	9.45E-01	9.42E-01	9.85E-01	9.84E-01	9.88E-01	9.89E-01	9.86E-01	9.85E-01	9.77E-01
	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00

Note: Spent Fuel Cooler Pad soil analysis from the vendor lab resulted in a weighted nuclide fraction of 0.99 for CS-137 and 0.01 for Co-60 (See Attachment 11.0).

Attachment 8.3

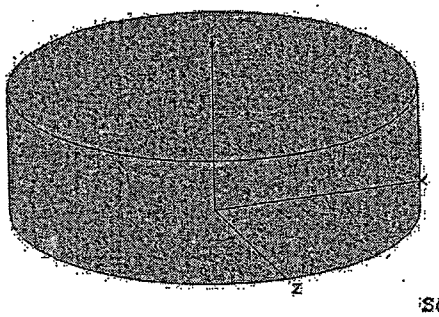
Microshield Code Runs

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: September 8, 2004
Run Time: 2:31:58 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Soil 1.0 pCi/g
Description: Cs-137 (95%) Co-60 (5%) 1.0 & 2.0" From Detector End Cap
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	15.0 cm	5.9 in
Radius	25.0 cm	9.8 in

Dose Points

	X	Y	Z
#1	0 cm	20.08 cm	0 cm
	0.0 in	7.9 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	2.95e+04 cm³	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.2350e-008	1.5670e+003	1.4379e-006	5.3203e-002
Co-60	2.3562e-009	8.7179e+001	8.0000e-008	2.9600e-003
Cs-137	1.4768e-008	1.6364e+003	1.5200e-006	5.6240e-002

Buildup
The material reference is : Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.244e+01	1.239e-05	1.754e-05	1.032e-07	1.461e-07
0.0322	5.985e+01	2.377e-05	3.394e-05	1.913e-07	2.731e-07
0.0364	2.178e+01	1.285e-05	2.029e-05	7.300e-08	1.153e-07
0.6616	1.410e+03	8.474e-02	1.571e-01	1.643e-04	3.047e-04
0.6938	1.422e-02	9.095e-07	1.660e-06	1.756e-09	3.204e-09
1.1732	8.718e+01	1.108e-02	1.726e-02	1.980e-05	3.084e-05
1.3325	8.718e+01	1.307e-02	1.967e-02	2.267e-05	3.413e-05
TOTALS:	1.698e+03	1.089e-01	1.942e-01	2.071e-04	3.702e-04

	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(20.08 cm)
0.0318	3.244e+01	1.239e-05	1.754e-05	1.032e-07	1.461e-07
0.0322	5.985e+01	2.377e-05	3.394e-05	1.913e-07	2.731e-07
0.0364	2.178e+01	1.285e-05	2.029e-05	7.300e-08	1.153e-07
0.6616	1.410e+03	8.474e-02	1.571e-01	1.643e-04	3.047e-04
0.6938	1.422e-02	9.095e-07	1.660e-06	1.756e-09	3.204e-09
1.1732	8.718e+01	1.108e-02	1.726e-02	1.980e-05	3.084e-05
1.3325	8.718e+01	1.307e-02	1.967e-02	2.267e-05	3.413e-05

Page : 2
DOS File : Case1
Run Date: September 8, 2004
Run Time: 2:31:58 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.698e+03	1.089e-01	1.942e-01	2.071e-04	3.702e-04
	Sensitivity	Variable:	Y Dose Point 1	(2 of 2)	(22.62 cm)
0.0318	3.244e+01	1.038e-05	1.539e-05	9.063e-08	1.281e-07
0.0322	5.985e+01	2.088e-05	2.976e-05	1.680e-07	2.395e-07
0.0364	2.178e+01	1.127e-05	1.776e-05	6.401e-08	1.009e-07
0.6616	1.410e+03	7.190e-02	1.303e-01	1.394e-04	2.525e-04
0.6938	1.422e+02	7.718e-07	1.376e-06	1.489e-09	2.655e-09
1.1732	8.718e+01	9.331e-03	1.426e-02	1.667e-05	2.549e-05
1.3325	6.718e+01	1.099e-02	1.525e-02	1.900e-05	2.636e-05
TOTALS:	1.698e+03	8.226e-02	1.608e-01	1.754e-04	3.087e-04

MicroShield v5.05 (5.05-00488) 09/08/04

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District
Conversion of calculated exposure in air to dose
FILE: Case1
Case Title: Soil 1.0 pCi/g
This case was run on Wednesday, September 8, 2004 at 2:31:58 PM
Dose Point # 1 - (0,20.08,0) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Reference Case for Y Dose Point 1			
Photon Fluence Rate (flux)	Photons/cm²/sec	1.468e-001	2.691e-001
Photon Energy Fluence Rate	MeV/cm²/sec	1.089e-001	1.942e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.071e-004	3.702e-004
Absorbed Dose Rate in Air	mGy/hr	1.809e-006	3.231e-006
"	mrad/hr	1.809e-004	3.231e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.123e-006	3.799e-006
o Opposed	"	1.724e-006	3.078e-006
o Rotational	"	1.723e-006	3.078e-006
o Isotropic	"	1.527e-006	2.727e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.257e-006	4.039e-006
o Opposed	"	2.148e-006	3.843e-006
o Rotational	"	2.148e-006	3.843e-006
o Isotropic	"	1.630e-006	2.911e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.882e-006	3.367e-006
o Posterior/Anterior	"	1.675e-006	2.993e-006
o Lateral	"	1.261e-006	2.247e-006
o Rotational	"	1.499e-006	2.678e-006
o Isotropic	"	1.287e-006	2.296e-006
Sensitivity Case Number 1 of 2:	Variable:	Y Dose Point 1	(20.08 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	1.468e-001	2.691e-001
Photon Energy Fluence Rate	MeV/cm²/sec	1.089e-001	1.942e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	2.071e-004	3.702e-004
Absorbed Dose Rate in Air	mGy/hr	1.809e-006	3.231e-006
"	mrad/hr	1.809e-004	3.231e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.123e-006	3.799e-006
o Opposed	"	1.724e-006	3.078e-006
o Rotational	"	1.723e-006	3.078e-006
o Isotropic	"	1.527e-006	2.727e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.257e-006	4.039e-006
o Opposed	"	2.148e-006	3.843e-006
o Rotational	"	2.148e-006	3.843e-006
o Isotropic	"	1.630e-006	2.911e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		

Page 1

MicroShield v5.05 (5.05-00488) 09/08/04

Results (Summed over energies)	Units	Without Buildup	With Buildup
o Anterior/Posterior Geometry	mSv/hr	1.882e-006	3.367e-006
o Posterior/Anterior	"	1.675e-006	2.993e-006
o Lateral	"	1.261e-006	2.247e-006
o Rotational	"	1.499e-006	2.678e-006
o Isotropic	"	1.287e-006	2.296e-006

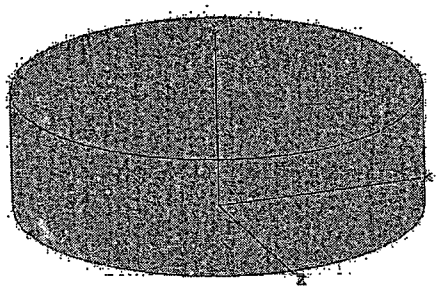
Sensitivity Case Number 2 of 2	Variable:	Y Dose Point 1	(22.62 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	1.262e-001	2.231e-001
Photon Energy Fluence Rate	MeV/cm²/sec	8.228e-002	1.608e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.754e-004	3.067e-004
Absorbed Dose Rate in Air	mGy/hr	1.532e-006	2.677e-006
"	mrad/hr	1.532e-004	2.677e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.798e-006	3.147e-006
o Opposed	"	1.460e-006	2.550e-006
o Rotational	"	1.460e-006	2.550e-006
o Isotropic	"	1.294e-006	2.259e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.912e-006	3.346e-006
o Opposed	"	1.820e-006	3.184e-006
o Rotational	"	1.820e-006	3.184e-006
o Isotropic	"	1.381e-006	2.411e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.594e-006	2.789e-006
o Posterior/Anterior	"	1.419e-006	2.479e-006
o Lateral	"	1.068e-006	1.882e-006
o Rotational	"	1.270e-006	2.219e-006
o Isotropic	"	1.090e-006	1.902e-006

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date : September 22, 2004
Run Time : 12:04:30 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Soil 1.0 pCi/g
Description: Cs-137 (98%), Co-60 (2%) 1.0 & 2.0" From Detector End Cap
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	15.0 cm	5.9 in
Radius	25.0 cm	9.8 in

Dose Points

	X	Y	Z
#1	0 cm 0.0 in	20.08 cm 7.9 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	2.95e+04 cm³	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	pCi/cm³	Bq/cm³
Ba-137m	4.3688e-008	1.6164e+003	1.4833e-005	5.4883e-002
Co-60	9.4248e-010	3.4872e+001	3.2000e-006	1.1840e-003
Cs-137	4.6181e-008	1.7087e+003	1.5680e-006	5.8016e-002

Buildup
The material reference is : Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.347e+01	1.278e-05	1.809e-05	1.064e-07	1.507e-07
0.0322	6.174e+01	2.452e-05	3.501e-05	1.974e-07	2.818e-07
0.0364	2.247e+01	1.325e-05	2.093e-05	7.531e-08	1.189e-07
0.6616	1.454e+03	8.741e-02	1.621e-01	1.395e-04	3.143e-04
0.6938	5.688e-03	3.538e-07	6.839e-07	7.024e-10	1.282e-09
1.1732	3.487e+01	4.432e-03	6.903e-03	7.920e-06	1.234e-05
1.3325	3.487e+01	5.227e-03	7.868e-03	9.068e-06	1.365e-05
TOTALS	1.642e+03	9.712e-02	1.770e-01	1.268e-04	3.409e-04

	Sensitivity	Variable	Y Dose Point 1	(1 of 3)	(20.08 cm)
0.0318	3.347e+01	1.278e-05	1.809e-05	1.064e-07	1.507e-07
0.0322	6.174e+01	2.452e-05	3.501e-05	1.974e-07	2.818e-07
0.0364	2.247e+01	1.325e-05	2.093e-05	7.531e-08	1.189e-07
0.6616	1.454e+03	8.741e-02	1.621e-01	1.395e-04	3.143e-04
0.6938	5.688e-03	3.538e-07	6.839e-07	7.024e-10	1.282e-09
1.1732	3.487e+01	4.432e-03	6.903e-03	7.920e-06	1.234e-05
1.3325	3.487e+01	5.227e-03	7.868e-03	9.068e-06	1.365e-05

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DOS File: Case1
Run Date: September 22, 2004
Run Time: 12:04:30 PM
Duration : 00:00:01

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	1.642e+03	9.712e-02	1.770e-01	1.068e-04	3.408e-04
	Sensitivity	Variable	Y Dose Point 1	(2 of 3)	(22.62 cm)
0.0318	3.247e+01	1.122e-05	1.587e-05	9.350e-08	1.322e-07
0.0322	6.174e+01	2.154e-05	3.670e-05	1.733e-07	2.471e-07
0.0364	2.247e+01	1.152e-05	1.932e-05	8.603e-08	1.041e-07
0.6616	1.454e+03	7.417e-02	1.344e-01	1.438e-04	2.605e-04
0.6938	5.688e-03	3.085e-07	5.501e-07	5.986e-10	1.062e-09
1.1732	3.487e+01	3.732e-03	5.705e-03	6.670e-06	1.020e-05
1.3325	3.487e+01	4.391e-03	6.496e-03	7.624e-06	1.127e-05
TOTALS:	1.642e+03	8.234e-02	1.469e-01	1.584e-04	2.824e-04
	Sensitivity	Variable	N Dose Point 1	(3 of 3)	(25.16 cm)
0.0318	3.247e+01	9.816e-06	1.387e-05	8.177e-08	1.155e-07
0.0322	6.174e+01	1.883e-05	2.683e-05	1.518e-07	2.159e-07
0.0364	2.247e+01	1.015e-05	1.598e-05	5.758e-08	9.082e-08
0.6616	1.454e+03	6.321e-02	1.127e-01	1.225e-04	2.184e-04
0.6938	5.688e-03	2.628e-07	4.612e-07	5.074e-10	8.904e-10
1.1732	3.487e+01	3.164e-03	4.775e-03	5.555e-06	6.533e-06
1.3325	3.487e+01	3.721e-03	5.436e-03	6.456e-06	9.431e-06
TOTALS:	1.642e+03	7.013e-02	1.229e-01	1.349e-04	2.368e-04

MicroShield v5.05 (5.05-00488) 09/22/04

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District
Conversion of calculated exposure in air to dose
FILE: Case1
Case Title: Soil 1.0 pCi/g
This case was run on Wednesday, September 22, 2004 at 12:04:30 PM
Dose Point # 1 - (0,20.08,0) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Reference Case for Y Dose Point 1			
Photon Fluence Rate (flux)	Photons/cm²/sec	1.413e-001	2.590e-001
Photon Energy Fluence Rate	MeV/cm²/sec	9.712e-002	1.770e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.698e-004	3.408e-004
Absorbed Dose Rate in Air	mGy/hr	1.631e-006	2.975e-006
"	mrad/hr	1.631e-004	2.975e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.924e-006	3.512e-006
o Opposed	"	1.549e-006	2.825e-006
o Rotational	"	1.549e-006	2.825e-006
o Isotropic	"	1.371e-006	2.500e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.045e-006	3.733e-006
o Opposed	"	1.944e-006	3.547e-006
o Rotational	"	1.944e-006	3.547e-006
o Isotropic	"	1.465e-006	2.671e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.702e-006	3.107e-006
o Posterior/Anterior	"	1.538e-006	2.760e-006
o Lateral	"	1.125e-006	2.050e-006
o Rotational	"	1.348e-006	2.459e-006
o Isotropic	"	1.152e-006	2.100e-006

Sensitivity Case Number 1 of 3	Variable	Y Dose Point 1	(20.08 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	1.413e-001	2.590e-001
Photon Energy Fluence Rate	MeV/cm²/sec	9.712e-002	1.770e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.698e-004	3.408e-004
Absorbed Dose Rate in Air	mGy/hr	1.631e-006	2.975e-006
"	mrad/hr	1.631e-004	2.975e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.924e-006	3.512e-006
o Opposed	"	1.549e-006	2.825e-006
o Rotational	"	1.549e-006	2.825e-006
o Isotropic	"	1.371e-006	2.500e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	2.045e-006	3.733e-006
o Opposed	"	1.944e-006	3.547e-006
o Rotational	"	1.944e-006	3.547e-006
o Isotropic	"	1.465e-006	2.671e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		

Page 1

MicroShield v6.05 (6.05-00488) 09/22/04

Results (Summed over energies)	Units	Without Buildup	With Buildup
o Anterior/Posterior Geometry	mSv/hr	1.702e-006	3.107e-006
o Posterior/Anterior	"	1.508e-006	2.750e-006
o Lateral	"	1.125e-006	2.060e-006
o Rotational	"	1.348e-006	2.459e-006
o Isotropic	"	1.152e-006	2.100e-006

Sensitivity Case Number 2 of 3	Variable:	Y Dose Point 1	(22.62 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	1.199e-001	2.148e-001
Photon Energy Fluence Rate	MeV/cm²/sec	8.234e-002	1.466e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.584e-004	2.824e-004
Absorbed Dose Rate in Air	mGy/hr	1.383e-006	2.465e-006
"	mrad/hr	1.383e-004	2.466e-004
Deep Dose Equivalent Rate	[ICRP 51 - 1987]		
o Parallel Geometry	mSv/hr	1.631e-006	2.910e-006
o Opposed	"	1.314e-006	2.341e-006
o Rotational	"	1.313e-006	2.341e-006
o Isotropic	"	1.153e-006	2.072e-006
Shallow Dose Equivalent Rate	[ICRP 51 - 1987]		
o Parallel Geometry	mSv/hr	1.734e-006	3.004e-006
o Opposed	"	1.646e-006	2.940e-006
o Rotational	"	1.648e-006	2.940e-006
o Isotropic	"	1.242e-006	2.214e-006
Effective Dose Equivalent Rate	[ICRP 51 - 1987]		
o Anterior/Posterior Geometry	mSv/hr	1.443e-006	2.575e-006
o Posterior/Anterior	"	1.278e-006	2.279e-006
o Lateral	"	9.539e-007	1.699e-006
o Rotational	"	1.143e-006	2.038e-006
o Isotropic	"	9.767e-007	1.740e-006

Sensitivity Case Number 3 of 3	Variable:	Y Dose Point 1	(25.16 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	1.022e-001	1.801e-001
Photon Energy Fluence Rate	MeV/cm²/sec	7.013e-002	1.229e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.349e-004	2.368e-004
Absorbed Dose Rate in Air	mGy/hr	1.178e-006	2.067e-006
"	mrad/hr	1.178e-004	2.067e-004
Deep Dose Equivalent Rate	[ICRP 51 - 1987]		
o Parallel Geometry	mSv/hr	1.390e-006	2.440e-006
o Opposed	"	1.119e-006	1.963e-006
o Rotational	"	1.119e-006	1.963e-006
o Isotropic	"	9.802e-007	1.737e-006
Shallow Dose Equivalent Rate	[ICRP 51 - 1987]		
o Parallel Geometry	mSv/hr	1.477e-006	2.594e-006
o Opposed	"	1.404e-006	2.465e-006
o Rotational	"	1.404e-006	2.465e-006
o Isotropic	"	1.058e-006	1.856e-006
Effective Dose Equivalent Rate	[ICRP 51 - 1987]		

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MicroShield v5.05 (5.05-00488) 09/22/04

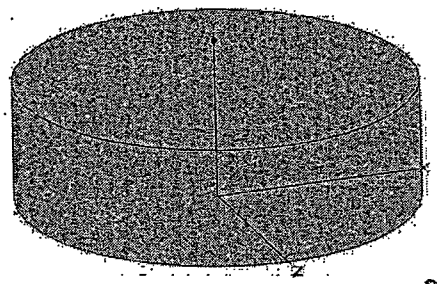
Results (Summed over energies)	Units	Without Buildup	With Buildup
o Anterior/Posterior Geometry	mSv/hr	1.229e-006	2.159e-006
o Posterior/Anterior	"	1.089e-006	1.911e-006
o Lateral	"	8.125e-007	1.424e-006
o Rotational	"	9.737e-007	1.709e-006
o Isotropic	"	8.319e-007	1.459e-006

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date : September 7, 2004
Run Time: 4:54:58 PM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Soil 1.0 pCi/g
Description: Cs-137 (100%) 2.54 & 5.08 cm from detector end cap
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	15.0 cm	5.91 in
Radius	25.0 cm	9.8 in

Dose Points

	X	Y	Z
#1	0 cm 0.0 in	20.08 cm 7.9 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	2.95e+04 cm³	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.4679e-008	1.6494e+003	1.5136e-006	5.6003e-002
Cs-137	4.7124e-008	1.7436e+003	1.6000e-006	5.9200e-002

Buildup
The material reference is : Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.415e+01	1.304e-05	1.846e-05	1.086e-07	1.538e-07
0.0322	6.300e+01	2.502e-05	3.572e-05	2.014e-07	2.875e-07
0.0364	2.293e+01	1.352e-05	2.136e-05	7.684e-08	1.214e-07
0.6616	1.484e+03	8.920e-02	1.654e-01	1.723e-04	3.207e-04
TOTALS:	1.604e+03	8.925e-02	1.655e-01	1.733e-04	3.213e-04

	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(20.08 cm)
0.0318	3.415e+01	1.304e-05	1.846e-05	1.086e-07	1.538e-07
0.0322	6.300e+01	2.502e-05	3.572e-05	2.014e-07	2.875e-07
0.0364	2.293e+01	1.352e-05	2.136e-05	7.684e-08	1.214e-07
0.6616	1.484e+03	8.920e-02	1.654e-01	1.723e-04	3.207e-04
TOTALS:	1.604e+03	8.925e-02	1.655e-01	1.733e-04	3.213e-04

	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(22.62 cm)
0.0318	3.415e+01	1.145e-05	1.619e-05	9.540e-08	1.349e-07
0.0322	6.300e+01	2.198e-05	3.133e-05	1.769e-07	2.521e-07
0.0364	2.293e+01	1.186e-05	1.869e-05	6.738e-08	1.062e-07

MicroShield v5.05 (5.05-00488) 09/07/04

Results (Summed over energies)	Units	Without Buildup	With Buildup
o Anterior/Posterior Geometry	mSv/hr	1.562e-006	2.934e-006
o Posterior/Anterior	"	1.395e-006	2.589e-006
o Lateral	"	1.035e-006	1.919e-006
o Rotational	"	1.248e-006	2.313e-006
o Isotropic	"	1.062e-006	1.969e-006

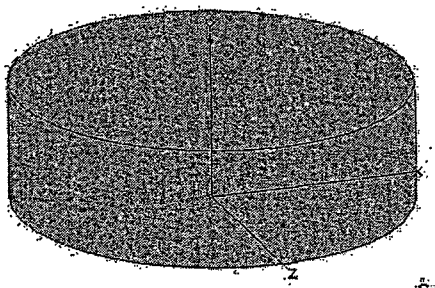
Sensitivity Case Number 2 of 2	Variable	Y Dose Point 1	(22.62 cm)
Photon Fluence Rate (flux)	Photons/cm^2/sec	1.158e-001	2.092e-001
Photon Energy Fluence Rate	MeV/cm^2/sec	7.573e-002	1.372e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	1.471e-004	2.663e-004
Absorbed Dose Rate in Air	mGy/hr	1.284e-006	2.325e-006
	mrad/hr	1.284e-004	2.325e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.520e-006	2.753e-006
o Opposed	"	1.216e-006	2.202e-006
o Rotational	"	1.218e-006	2.202e-006
o Isotropic	"	1.075e-006	1.947e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	1.616e-006	2.925e-006
o Opposed	"	1.533e-006	2.777e-006
o Rotational	"	1.533e-006	2.777e-006
o Isotropic	"	1.150e-006	2.082e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	1.343e-006	2.432e-006
o Posterior/Anterior	"	1.184e-006	2.146e-006
o Lateral	"	8.782e-007	1.591e-006
o Rotational	"	1.059e-006	1.917e-006
o Isotropic	"	9.012e-007	1.632e-006

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : Case1
Run Date: September 10, 2004
Run Time: 11:47:41 AM
Duration : 00:00:01

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Soil 1.0pCi/g
Description: Co-60 (100%) 1.0 & 2.0" from Detector End Cap
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	15.0 cm	5.9 in
Radius	25.0 cm	9.8 in

Dose Points

	X	Y	Z
# 1	0 cm 0.0 in	20.03 cm 7.9 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	2.95e+04 cm³	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method 1 Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	4.7124e-008	1.7436e+003	1.6000e-006	5.9200e-002

Buildup
The material reference is : Source

Integration Parameters

Radial	20
Circumferential	10
Y Direction (axial)	10

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6338	2.844e-01	1.819e-05	3.319e-05	3.512e-08	6.409e-08
1.1732	1.744e+03	2.216e-01	3.452e-01	3.960e-04	6.168e-04
1.3325	1.744e+03	2.613e-01	3.934e-01	4.534e-04	6.825e-04
TOTALS:	3.487e+03	4.829e-01	7.386e-01	8.494e-04	1.299e-03
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(20.03 cm)
0.6338	2.844e-01	1.819e-05	3.319e-05	3.512e-08	6.409e-08
1.1732	1.744e+03	2.216e-01	3.452e-01	3.960e-04	6.168e-04
1.3325	1.744e+03	2.613e-01	3.934e-01	4.534e-04	6.825e-04
TOTALS:	3.487e+03	4.829e-01	7.386e-01	8.494e-04	1.299e-03
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(22.82 cm)
0.6338	2.844e-01	1.543e-05	2.761e-05	2.978e-08	5.310e-08
1.1732	1.744e+03	1.866e-01	2.853e-01	3.335e-04	5.098e-04
1.3325	1.744e+03	2.197e-01	3.249e-01	3.812e-04	5.637e-04
TOTALS:	3.487e+03	4.063e-01	6.102e-01	7.147e-04	1.074e-03

MicroShield v5.05 (5.05-00488) 09/10/04

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District
Conversion of calculated exposure in air to dose
FILE: Case1
Case Title: Soil 1.0pCi/g
This case was run on Friday, September 10, 2004 at 11:47:41 AM
Dose Point # 1 - (0,20.08,0) cm

Results (Summed over energies)	Units	Without Buildup	With Buildup
Reference Case for Y Dose Point 1			
Photon Fluence Rate (flux)	Photons/cm²/sec	3.850e-001	5.895e-001
Photon Energy Fluence Rate	MeV/cm²/sec	4.829e-001	7.386e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.494e-004	1.269e-003
Absorbed Dose Rate in Air	mGy/hr	7.416e-006	1.134e-005
	mrad/hr	7.416e-004	1.134e-003
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.422e-006	1.288e-005
o Opposed	"	7.247e-006	1.108e-005
o Rotational	"	7.247e-006	1.108e-005
o Isotropic	"	6.471e-006	9.898e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.968e-006	1.372e-005
o Opposed	"	8.631e-006	1.320e-005
o Rotational	"	8.631e-006	1.320e-005
o Isotropic	"	8.859e-006	1.049e-005
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	7.583e-006	1.160e-005
o Posterior/Anterior	"	6.981e-006	1.068e-005
o Lateral	"	5.546e-006	8.483e-006
o Rotational	"	6.286e-006	9.614e-006
o Isotropic	"	5.580e-006	8.504e-006
Sensitivity Case Number 1 of 2	Variable	Y Dose Point 1	(20,08 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	3.850e-001	5.895e-001
Photon Energy Fluence Rate	MeV/cm²/sec	4.829e-001	7.386e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	8.494e-004	1.269e-003
Absorbed Dose Rate in Air	mGy/hr	7.416e-006	1.134e-005
	mrad/hr	7.416e-004	1.134e-003
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.422e-006	1.288e-005
o Opposed	"	7.247e-006	1.108e-005
o Rotational	"	7.247e-006	1.108e-005
o Isotropic	"	6.471e-006	9.898e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	8.968e-006	1.372e-005
o Opposed	"	8.631e-006	1.320e-005
o Rotational	"	8.631e-006	1.320e-005
o Isotropic	"	8.859e-006	1.049e-005
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		

Page 1

MicroShield v5.05 (5.05-00488) 09/10/04

Results (Summed over energies)	Units	Without Buildup	With Buildup
o Anterior/Posterior Geometry	mSv/hr	7.583e-006	1.160e-005
o Posterior/Anterior	"	6.981e-006	1.068e-005
o Lateral	"	5.546e-006	8.483e-006
o Rotational	"	6.285e-006	9.514e-006
o Isotropic	"	5.560e-006	8.504e-006

Sensitivity Case Number 2 of 2	Variable:	Y Dose Point 1	(22.52 cm)
Photon Fluence Rate (flux)	Photons/cm²/sec	3.248e-001	4.870e-001
Photon Energy Fluence Rate	MeV/cm²/sec	4.063e-001	6.102e-001
Exposure and Dose Rates:			
Exposure Rate in Air	mR/hr	7.147e-004	1.074e-003
Absorbed Dose Rate in Air	mGy/hr	6.239e-006	9.372e-006
	mrad/hr	6.239e-004	9.372e-004
Deep Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.086e-006	1.064e-005
o Opposed	"	6.097e-006	9.158e-006
o Rotational	"	6.097e-006	9.158e-006
o Isotropic	"	5.445e-006	8.177e-006
Shallow Dose Equivalent Rate	(ICRP 51 - 1987)		
o Parallel Geometry	mSv/hr	7.545e-006	1.133e-005
o Opposed	"	7.262e-006	1.091e-005
o Rotational	"	7.262e-006	1.091e-005
o Isotropic	"	5.771e-006	8.668e-006
Effective Dose Equivalent Rate	(ICRP 51 - 1987)		
o Anterior/Posterior Geometry	mSv/hr	6.380e-006	9.583e-006
o Posterior/Anterior	"	5.874e-006	8.823e-006
o Lateral	"	4.667e-006	7.008e-006
o Rotational	"	5.268e-006	7.943e-006
o Isotropic	"	4.678e-006	7.025e-006

Attachments 8.4 - 8.10

Scan MDC (pCi/g) For Principal Soil Nuclides

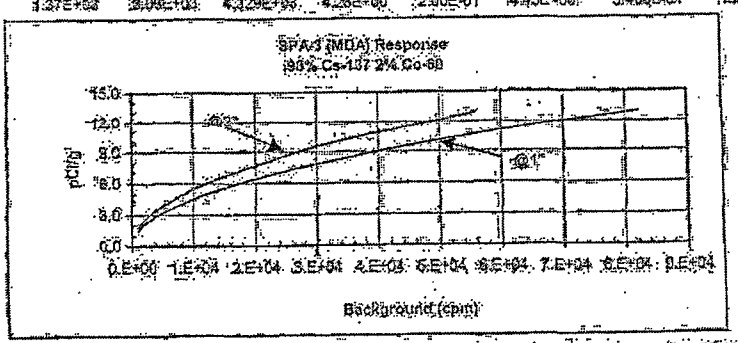
(Co-60 and Cs-137)

Attachment 4
SPA-3 Detector MDA 98% Cs-137, 2% Co-60

SPA-3 98.0% Cs-137 2.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l = 5.08 cm)
Area = 0.196 m²

9/7/2004
SPA3_Cs-137090904.xls

SPA-3 Bkgd. cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.33E+02	4.750E+02	4.67E-01	2.21E-02	4.89E-01	3.403E-01	1.434E+00
2.00E+03	3.33E+01	4.73E+02	6.761E+02	6.60E-01	3.12E-02	6.91E-01	3.408E-01	2.026E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.33E-01	4.42E-02	9.77E-01	3.409E-01	2.860E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.32E+00	6.25E-02	1.38E+00	3.408E-01	4.056E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.40E+00	6.62E-02	1.47E+00	3.409E-01	4.302E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.48E+00	6.99E-02	1.55E+00	3.408E-01	4.535E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.62E+00	7.65E-02	1.69E+00	3.409E-01	4.967E+00
1.60E+04	2.67E+02	1.36E+03	1.912E+03	1.87E+00	8.83E-02	1.95E+00	3.408E-01	5.736E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.09E+00	9.87E-02	2.18E+00	3.408E-01	6.413E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.64E+00	1.25E-01	2.76E+00	3.408E-01	8.112E+00
5.20E+04	8.33E+02	2.55E+03	3.764E+03	3.67E+00	1.74E-01	3.85E+00	3.408E-01	1.129E+01
8.20E+04	1.37E+03	3.09E+03	4.329E+03	4.28E+00	2.00E-01	4.48E+00	3.408E-01	1.299E+01



using: c = 1.38, surveyor efficiency 50%, 0.5 m/s scan speed, 0.1963 m^2 (29 cm radius) elevated area, at 2.54 % (5.08 cm)
SPA-3 Cs-137 response = 1,004 cpm per uR/h; SPA-3 Co-60 response = 433 cpm per uR/h

SPA-3 98.0% Cs-137 2.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l = 7.62 cm)
Area = 0.196 m²

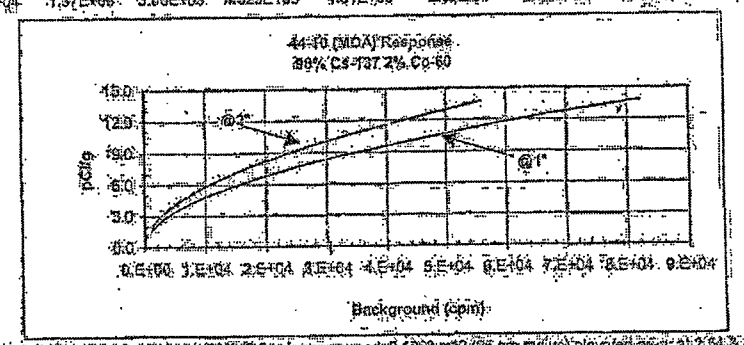
SPA3_Cs-137090904.xls

SPA-3 Bkgd. cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.33E+02	4.750E+02	4.67E-01	2.21E-02	4.89E-01	2.824E-01	1.731E+00
2.00E+03	3.33E+01	4.73E+02	6.761E+02	6.60E-01	3.12E-02	6.91E-01	2.824E-01	2.447E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.33E-01	4.42E-02	9.77E-01	2.824E-01	3.461E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.32E+00	6.25E-02	1.38E+00	2.824E-01	4.895E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.40E+00	6.62E-02	1.47E+00	2.824E-01	5.192E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.48E+00	6.99E-02	1.55E+00	2.824E-01	5.472E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.62E+00	7.65E-02	1.69E+00	2.824E-01	5.968E+00
1.60E+04	2.67E+02	1.36E+03	1.912E+03	1.87E+00	8.83E-02	1.95E+00	2.824E-01	6.922E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.09E+00	9.87E-02	2.18E+00	2.824E-01	7.739E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.64E+00	1.25E-01	2.76E+00	2.824E-01	9.789E+00
5.20E+04	8.33E+02	2.55E+03	3.608E+03	3.49E+00	1.65E-01	3.66E+00	2.824E-01	1.295E+01

Attachment 6
44-10 Detector MDA 98% Cs-137, 2% Co-60

44-10 98.0% Cs-137 2.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l=5.08 cm)
Area = 0.196 m²

9/7/2004 SPA3_Cs-137090804.xls 44-10 Bkgd cpm	Counts net 1.0 second	MDCR	$MDCR_{surveys}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	4.98E-01	2.21E-02	5.20E-01	3.408E-01	1.526E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	7.04E-01	3.12E-02	7.35E-01	3.408E-01	2.158E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.96E-01	4.42E-02	1.04E+00	3.408E-01	3.051E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.41E+00	6.25E-02	1.47E+00	3.408E-01	4.315E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.49E+00	6.62E-02	1.56E+00	3.408E-01	4.577E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.57E+00	6.98E-02	1.64E+00	3.408E-01	4.825E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.72E+00	7.65E-02	1.80E+00	3.408E-01	5.285E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.99E+00	8.84E-02	2.08E+00	3.408E-01	6.103E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.23E+00	9.87E-02	2.33E+00	3.408E-01	6.823E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.82E+00	1.25E-01	2.94E+00	3.408E-01	8.630E+00
6.20E+04	1.03E+03	2.55E+03	3.764E+03	3.92E+00	1.74E-01	4.09E+00	3.408E-01	1.201E+01
8.20E+04	1.37E+03	3.06E+03	4.329E+03	4.51E+00	2.00E-01	4.71E+00	3.408E-01	1.382E+01



using k=1.38, surveyor efficiency 50%, 0.6 m/s scan speed, 0.1963 m^2 (25 cm radius) elevated area, at 2.54 & 5.08 cm
44-10 Cs-137 response = 941 cpm per uR/h, 44-10 Co-60 response = 433 cpm per uR/h

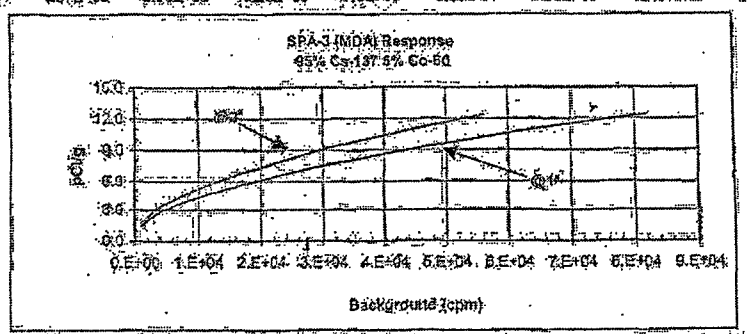
44-10 98.0% Cs-137 2.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l=7.62 cm)
Area = 0.196 m²

SPA3_Cs-137090804.xls 44-10 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{surveys}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	4.98E-01	2.21E-02	5.20E-01	2.824E-01	1.841E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	7.04E-01	3.12E-02	7.35E-01	2.824E-01	2.604E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.96E-01	4.42E-02	1.04E+00	2.824E-01	3.682E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.41E+00	6.25E-02	1.47E+00	2.824E-01	5.209E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.49E+00	6.62E-02	1.56E+00	2.824E-01	5.523E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.57E+00	6.98E-02	1.64E+00	2.824E-01	5.822E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.72E+00	7.65E-02	1.80E+00	2.824E-01	6.378E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.99E+00	8.83E-02	2.08E+00	2.824E-01	7.365E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.23E+00	9.87E-02	2.33E+00	2.824E-01	8.233E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.82E+00	1.25E-01	2.94E+00	2.824E-01	1.042E+01
6.20E+04	1.03E+03	2.55E+03	3.56E+03	3.73E+00	1.65E-01	3.89E+00	2.824E-01	1.378E+01

Attachment 6
SPA-3 Detector MDA 95% Cs-137, 5% Co-60

SPA-3 95.0% Cs-137 5.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l = 5.08 cm)
Area = 0.196 m²

8/8/2004 SPA-3 Cs-137 SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	4.52E-01	5.52E-02	5.08E-01	3.702E-01	1.371E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	6.40E-01	7.81E-02	7.18E-01	3.702E-01	1.939E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.05E-01	1.10E-01	1.02E+00	3.702E-01	2.742E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.28E+00	1.56E-01	1.44E+00	3.702E-01	3.878E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.36E+00	1.66E-01	1.52E+00	3.702E-01	4.113E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.43E+00	1.75E-01	1.60E+00	3.702E-01	4.336E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.57E+00	1.91E-01	1.76E+00	3.702E-01	4.749E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.81E+00	2.21E-01	2.03E+00	3.702E-01	5.484E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.02E+00	2.47E-01	2.27E+00	3.702E-01	6.131E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.56E+00	3.12E-01	2.87E+00	3.702E-01	7.755E+00
6.40E+04	1.03E+03	2.69E+03	3.764E+03	3.56E+00	4.35E-01	3.99E+00	3.702E-01	1.080E+01
8.20E+04	1.37E+03	3.04E+03	4.329E+03	4.10E+00	5.00E-01	4.60E+00	3.702E-01	1.241E+01



using: d'=1.38; surveyor efficiency 50%; 0.5 m/s scan speed; 0.1963 m² (25 cm radius) elevated area; at 2.54 & 5.08 cm
SPA-3 Cs-137 response = 1024 cpm per uR/h; SPA-3 Co-60 response = 438 cpm per uR/h

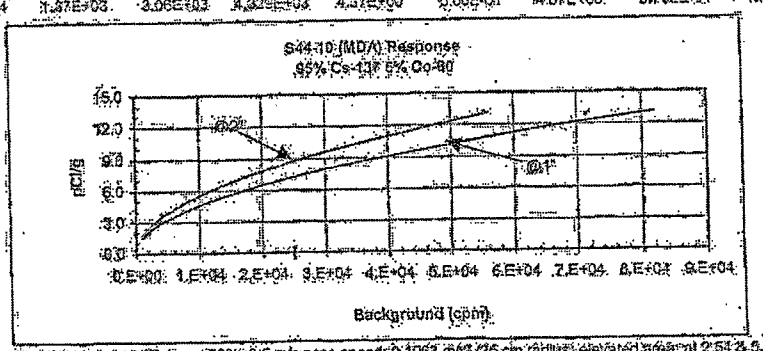
SPA-3 95.0% Cs-137 5.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l = 7.62 cm)
Area = 0.196 m²

SPA-3 Cs-137 20050304.xls SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	4.52E-01	5.52E-02	5.08E-01	3.067E-01	1.658E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	6.40E-01	7.81E-02	7.18E-01	3.067E-01	2.348E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.05E-01	1.10E-01	1.02E+00	3.067E-01	3.310E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.28E+00	1.56E-01	1.44E+00	3.067E-01	4.681E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.36E+00	1.66E-01	1.52E+00	3.067E-01	4.964E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.43E+00	1.75E-01	1.60E+00	3.067E-01	5.233E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.57E+00	1.91E-01	1.76E+00	3.067E-01	5.732E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.81E+00	2.21E-01	2.03E+00	3.067E-01	6.619E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.02E+00	2.47E-01	2.27E+00	3.067E-01	7.401E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.56E+00	3.12E-01	2.87E+00	3.067E-01	9.361E+00
5.50E+04	8.33E+02	2.53E+03	3.58E+03	3.38E+00	4.13E-01	3.80E+00	3.067E-01	1.238E+01

Attachment 7
44-10 Detector 95% Cs-137, 5% Co-60

44-10 95.0% Cs-137 5.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l = 5.08 cm)
Area = 0.196 m²

9/8/2004 SPA3_Cs-137050804.xls 44-10 Bkgd cpm	Counts per 1.0 second	MDCR	MDCR$_{survey}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.760E+02	4.83E-01	5.52E-02	5.36E-01	3.702E-01	1.453E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	6.83E-01	7.81E-02	7.61E-01	3.702E-01	2.055E+00
4.00E+03	6.67E+01	6.78E+02	9.561E+02	9.65E-01	1.10E-01	1.08E+00	3.702E-01	2.906E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.37E+00	1.56E-01	1.52E+00	3.702E-01	4.109E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.45E+00	1.66E-01	1.61E+00	3.702E-01	4.368E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.53E+00	1.75E-01	1.70E+00	3.702E-01	4.604E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.67E+00	1.91E-01	1.86E+00	3.702E-01	5.033E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.93E+00	2.21E-01	2.15E+00	3.702E-01	5.811E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.16E+00	2.47E-01	2.41E+00	3.702E-01	6.497E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.73E+00	3.12E-01	3.04E+00	3.702E-01	8.218E+00
4.20E+04	1.03E+03	2.68E+03	3.794E+03	3.80E+00	4.35E-01	4.23E+00	3.702E-01	1.144E+01
6.20E+04	1.37E+03	3.06E+03	4.329E+03	4.37E+00	5.00E-01	4.87E+00	3.702E-01	1.319E+01



Using: d = 1.38, surveyor efficiency 50%, 0.5 m/s scan speed, 0.1963 m^2 (25 cm radius), elevated area at 2.54 & 5.08 cm
44-10 Cs-137 response = 941 cpm per uR/h; 44-10 Co-60 response = 453 cpm per uR/h

44-10 95.0% Cs-137 5.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l = 7.62 cm)
Area = 0.196 m²

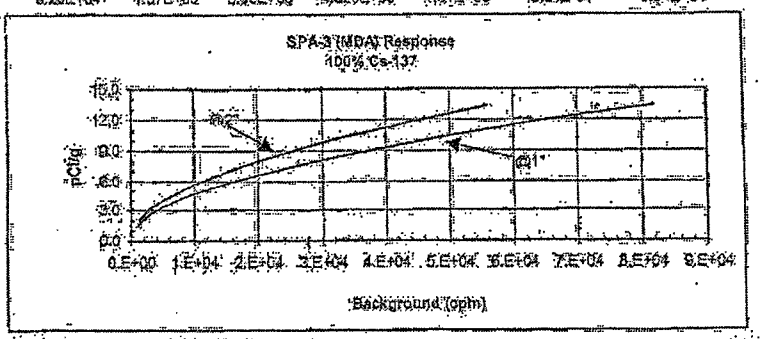
SPA-3_Cs-137050804.xls 44-10 Bkgd cpm	Counts per 1.0 second	MDCR	MDCR$_{survey}$	Detectable Exp. Rate Cs-137 uR/h	Detectable Exp. Rate Co-60 uR/h	Detectable Exp. Rate Total uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.760E+02	4.83E-01	5.52E-02	5.36E-01	3.067E-01	1.754E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	6.83E-01	7.81E-02	7.61E-01	3.067E-01	2.480E+00
4.00E+03	6.67E+01	6.78E+02	9.561E+02	9.65E-01	1.10E-01	1.08E+00	3.067E-01	3.507E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.37E+00	1.56E-01	1.52E+00	3.067E-01	4.960E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.45E+00	1.66E-01	1.61E+00	3.067E-01	5.231E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.53E+00	1.75E-01	1.70E+00	3.067E-01	5.545E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.67E+00	1.91E-01	1.86E+00	3.067E-01	6.075E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.93E+00	2.21E-01	2.15E+00	3.067E-01	7.014E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.16E+00	2.47E-01	2.41E+00	3.067E-01	7.842E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.73E+00	3.12E-01	3.04E+00	3.067E-01	9.920E+00
5.60E+04	9.33E+02	2.53E+03	3.58E+03	3.61E+00	4.13E-01	4.02E+00	3.067E-01	1.312E+01

Attachment 8
SPA-3 Detector MDA 100% Cs-137

SPA-3 100.0% Cs-137 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l =5.08 cm)
Area =0.196 m²

SPA3_Cs-137090804.xls
9/7/2004

SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{survey}$	Detectable Exp. Rate Cs-137 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.760E+02	4.76E-01	3.21E-01	1.48E+00
2.00E+03	3.33E+01	4.78E+02	6.731E+02	6.73E-01	3.21E-01	2.10E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.52E-01	3.21E-01	2.98E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.35E+00	3.21E-01	4.19E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.43E+00	3.21E-01	4.45E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.51E+00	3.21E-01	4.69E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.65E+00	3.21E-01	5.13E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.90E+00	3.21E-01	5.93E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.13E+00	3.21E-01	6.63E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.69E+00	3.21E-01	8.38E+00
6.20E+04	1.03E+03	2.66E+03	3.764E+03	3.75E+00	3.21E-01	1.17E+01
8.20E+04	1.37E+03	3.38E+03	4.329E+03	4.31E+00	3.21E-01	1.34E+01



using: d=1.33, survey efficiency 50%, 0.5 m/s scan speed, 0.1963 m^2 (25 cm radius) detected area, at 2.54 & 5.08 cm
SPA-3 Cs-137 response = 1,004 cpm per uR/h

SPA-3 100% Cs-137 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l =7.62 cm)
Area =0.196 m²

SPA3_Cs-137090804.xls

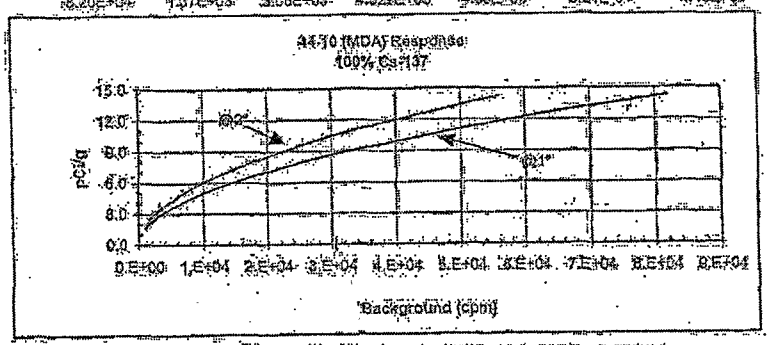
SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{survey}$	Detectable Exp. Rate Cs-137 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	9.780E+02	4.76E-01	2.68E-01	1.789E+00
2.00E+03	3.33E+01	4.78E+02	6.751E+02	6.72E-01	2.68E-01	2.529E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	9.52E-01	2.68E-01	3.575E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	1.35E+00	2.68E-01	5.057E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	1.43E+00	2.68E-01	5.364E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.51E+00	2.68E-01	5.654E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.65E+00	2.68E-01	6.194E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	1.90E+00	2.68E-01	7.152E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.13E+00	2.68E-01	7.988E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.69E+00	2.68E-01	1.011E+01
5.60E+04	9.33E+02	2.53E+03	3.58E+03	3.56E+00	2.68E-01	1.338E+01

Attachment 9
44-10 Detector MDA Cs-137 100%

44-10 100.0% Cs-137 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l = 5.08 cm)
Area = 0.196 m²

SPA3_Cs-137090804.xls
9/7/2005

44-10 Bkgd cpm	Counts per 4.0 second	MDCR	$MDCR_{survey}$	Detectable Exp. Rate Cs-137 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.36E+02	4.750E+02	5.08E-01	3.21E-01	1.58E+00
2.00E+03	3.33E+01	4.76E+02	6.761E+02	7.18E-01	3.21E-01	2.24E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	1.02E+00	3.21E-01	3.18E+00
6.00E+03	1.33E+02	9.56E+02	1.352E+03	1.44E+00	3.21E-01	4.47E+00
8.00E+03	1.50E+02	1.01E+03	1.434E+03	1.52E+00	3.21E-01	4.74E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.61E+00	3.21E-01	5.00E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.76E+00	3.21E-01	5.48E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	2.03E+00	3.21E-01	6.32E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.27E+00	3.21E-01	7.07E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.87E+00	3.21E-01	8.94E+00
6.20E+04	1.03E+03	2.68E+03	3.794E+03	4.00E+00	3.21E-01	1.24E+01
8.20E+04	1.37E+03	3.36E+03	4.758E+03	4.90E+00	3.21E-01	1.43E+01



rating: d=1.36; surveyor efficiency 50%; 0.5 m/s scan speed; 0.1963 m^2 (25 cm radius)
elevated area; at 2.53 & 5.08 cm, 44-10 Cs-137 response = 941 cpm per uR/h

44-10 100% Cs-137 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l = 7.62 cm)
Area = 0.196 m²

SPA3_Cs-137090804.xls

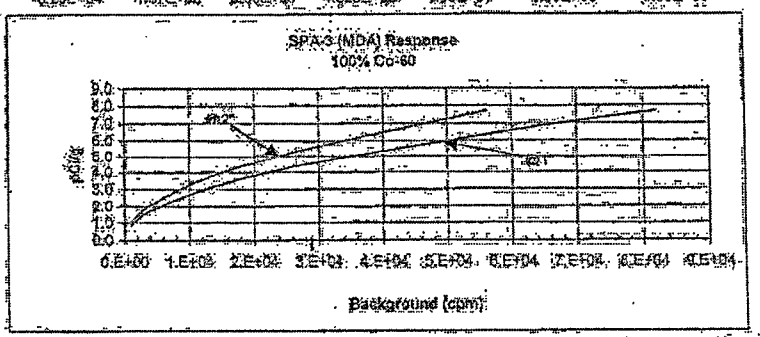
SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{survey}$	Detectable Exp. Rate Cs-137 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.36E+02	4.750E+02	5.08E-01	2.86E-01	1.908E+00
2.00E+03	3.33E+01	4.76E+02	6.761E+02	7.18E-01	2.86E-01	2.698E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	1.02E+00	2.86E-01	3.816E+00
6.00E+03	1.33E+02	9.56E+02	1.352E+03	1.44E+00	2.86E-01	5.398E+00
8.00E+03	1.50E+02	1.01E+03	1.434E+03	1.52E+00	2.86E-01	5.723E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	1.61E+00	2.86E-01	6.033E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	1.76E+00	2.86E-01	6.605E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	2.03E+00	2.86E-01	7.631E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	2.27E+00	2.86E-01	8.531E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	2.87E+00	2.86E-01	1.079E+01
6.60E+04	9.32E+02	2.53E+03	3.58E+03	3.80E+00	2.86E-01	1.428E+01

Attachment 10
SPA-3 and 44-10 Detectors MDA, 100% Co-60

SPA-3 100.0% Co-60 Scan MDC (pCi/g)
Detector End Cap 1" above Soil Surface at Detector Centerline (l =5.08 cm)
Area ~0.196 m²

SPA3_Co-137090904.xls
9/7/2004

SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Co-60 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	1.10E+00	1.30E+00	3.50E+01
2.00E+03	3.33E+01	4.78E+02	6.761E+02	1.56E+00	1.30E+00	1.20E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	2.21E+00	1.30E+00	1.70E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	3.12E+00	1.30E+00	2.40E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	3.31E+00	1.30E+00	2.55E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	3.49E+00	1.30E+00	2.69E+00
1.20E+04	2.00E+02	1.17E+03	1.656E+03	3.82E+00	1.30E+00	2.94E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	4.42E+00	1.30E+00	3.40E+00
2.00E+04	3.33E+02	1.51E+03	2.138E+03	4.94E+00	1.30E+00	3.80E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	6.25E+00	1.30E+00	4.81E+00
6.20E+04	1.03E+03	2.66E+03	3.764E+03	8.69E+00	1.30E+00	6.69E+00
8.20E+04	1.37E+03	3.06E+03	4.329E+03	1.00E+01	1.30E+00	7.70E+00



using: R=1.35, surveyor efficiency 50%, 0.5 m/s scan speed, 0.1963 m² (25 cm) radius elevated area, at 2.54 & 5.08 cm
SPA-3 Co-60 response = 423 cpm per uR/h

SPA-3 100% Co-60 Scan MDC (pCi/g)
Detector End Cap 2" above Soil Surface at Detector Centerline (l =7.62 cm)
Area ~0.196 m²

SPA3_Co-137090904.xls

SPA-3 Bkgd cpm	Counts per 1.0 second	MDCR	$MDCR_{surveyor}$	Detectable Exp. Rate Co-60 uR/h	1.0 pCi/g (cc) uShield result @5.08 cm	Scan MDC pCi/g
1.00E+03	1.67E+01	3.38E+02	4.780E+02	1.10E+00	1.07E+00	1.028E+00
2.00E+03	3.33E+01	4.78E+02	6.761E+02	1.56E+00	1.07E+00	1.454E+00
4.00E+03	6.67E+01	6.76E+02	9.561E+02	2.21E+00	1.07E+00	2.055E+00
8.00E+03	1.33E+02	9.56E+02	1.352E+03	3.12E+00	1.07E+00	2.908E+00
9.00E+03	1.50E+02	1.01E+03	1.434E+03	3.31E+00	1.07E+00	3.084E+00
1.00E+04	1.67E+02	1.07E+03	1.512E+03	3.49E+00	1.07E+00	3.251E+00
1.20E+03	2.00E+02	1.17E+03	1.656E+03	3.82E+00	1.07E+00	3.561E+00
1.60E+04	2.67E+02	1.35E+03	1.912E+03	4.42E+00	1.07E+00	4.112E+00
2.00E+03	3.33E+02	1.51E+03	2.138E+03	4.94E+00	1.07E+00	4.597E+00
3.20E+04	5.33E+02	1.91E+03	2.704E+03	6.25E+00	1.07E+00	5.815E+00
6.00E+04	9.33E+02	2.56E+03	3.58E+03	8.36E+00	1.07E+00	7.693E+00

Attachment 8.11

Draft Industrial Scenario DCGL for Soil

Attachment 11.0
DRAFT Industrial Scenario DCGL for Soil

[02]04
GEL results for Spent Fuel Pool Cooler Soil 8/11/04

Nuclides		SFPC Soil 03/08/04 pCi/g	S/C4100010 DS06A1 Original nf*	D-K(yrs)==> Half-Life yrs	8/5/2004 0.5103 e^-λt	7/8/2004 Estimated pCi/g	8/8/2004 nf	RESRAD Industrial DCGL pCi/g	nf/DCGL	% Dose	% Dose Removed	Assumed nf	Normalized nf
H-3	A	8.600E+00	8.685E-03	1.228E+01	8.731E-01	1.777E+00	5.719E-03	1.000E+06	5.554E-09	5.575E-05	5.575E-05		
C-14	A	1.740E+00	3.115E-03	5.730E+03	9.999E-01	4.740E+00	3.520E-03	1.000E+06	1.181E-09	1.186E-04	1.186E-04		
Na-22	A	2.280E-01	1.013E-04	2.602E+00	8.751E-01	1.926E-01	1.430E-04	1.490E+01	9.596E-06	6.177E-02	6.177E-02		
K-40	A	1.300E+01	9.630E-03	1.277E+09	1.000E+00	1.300E+01	9.656E-03	1.850E+02	5.219E-05	3.360E-01	3.360E-01		
Fe-55	A	9.720E+00	7.129E-03	2.700E+00	8.783E-01	8.547E-01	6.348E-03	6.060E+00	7.003E-10	4.508E-06	4.508E-06		
Ni-59	A	7.030E+00	5.176E-03	7.500E+04	1.000E+00	7.030E+00	5.244E-03	2.220E+07	2.362E-10	1.520E-06	1.520E-06		
Co-60		1.190E+01	8.284E-03	5.271E+00	8.262E-01	1.058E+01	7.838E-03	1.290E+01	6.141E-01	4.140E-00		7.958E-03	1.019E-02
Ni-63		1.750E+02	1.268E-01	1.001E+02	9.966E-01	1.744E+02	1.296E-01	8.160E+06	1.587E-08	1.022E-04	1.022E-04		
Sr-90		1.410E+00	1.034E-03	2.860E+01	9.879E-01	1.393E+00	1.035E-03	5.560E+03	1.922E-07	1.173E-03	1.173E-03		
Nb-94		2.940E-01	1.862E-04	2.030E+04	1.000E+00	2.940E-01	1.887E-04	1.340E+01	1.026E-05	6.600E-02	6.600E-02		
Tc-99		2.740E+00	2.009E-03	2.130E+05	1.000E+00	2.740E+00	2.035E-03	2.800E+03	7.269E-07	4.679E-03	4.679E-03		
Ag-108m		1.224E+00	9.973E-04	1.270E+02	9.973E-01	1.221E+00	9.068E-04	1.330E+01	4.034E-05	2.189E-01	2.189E-01		
Sb-125		4.530E+00	3.958E-03	2.770E+00	8.622E-01	4.049E+00	3.001E-03	8.090E+01	3.737E-05	2.406E-01	2.406E-01		
Cs-134		8.900E-01	9.526E-01	2.062E+00	9.450E-01	7.920E-01	6.686E-04	2.760E+01	2.064E-05	1.329E-01	1.329E-01		
Cs-137		1.040E+03	7.624E-01	3.017E+01	9.886E-01	1.028E+03	7.636E-01	5.240E+01	1.457E-02	9.380E+01		7.038E-01	9.868E-01
Pm-147		9.240E+00	2.376E-03	2.623E+00	8.700E-01	8.038E+00	2.138E-03	2.120E+06	9.946E-10	6.401E-06	6.401E-06		
Eu-152		3.380E+00	2.478E-03	1.360E+01	9.748E-01	3.295E+00	2.447E-03	2.600E+01	9.200E-05	5.922E-01	5.922E-01		
Eu-154		7.560E-01	5.542E-04	8.800E+00	9.018E-01	7.267E-01	5.398E-04	2.470E+01	2.185E-05	1.407E-01	1.407E-01		
Eu-155		1.220E+00	1.627E-03	4.960E+00	9.924E-01	2.070E+00	1.537E-03	8.640E+02	1.595E-06	1.027E-02	1.027E-02		
U-233		2.800E-01	2.053E-04	1.592E+05	1.000E+00	2.800E-01	2.080E-04	1.449E+02	1.435E-06	9.239E-03	9.239E-03		
U-234		2.800E-01	2.053E-04	2.445E+05	1.000E+00	2.800E-01	2.080E-04	2.100E+02	9.903E-07	6.375E-03	6.375E-03		
U-235		1.550E-01	1.136E-04	7.038E+08	1.000E+00	1.550E-01	1.151E-04	2.180E+02	5.281E-07	3.398E-03	3.398E-03		
U-238		1.550E-01	1.136E-04	2.342E+07	1.000E+00	1.550E-01	1.151E-04	2.210E+02	5.209E-07	3.353E-03	3.353E-03		
Np-237		3.080E-01	2.258E-04	2.140E+06	1.000E+00	3.080E-01	2.288E-04	1.670E+01	1.223E-05	7.870E-02	7.870E-02		
U-238		4.170E-01	3.057E-04	4.468E+09	1.000E+00	4.170E-01	3.097E-04	1.130E+03	2.741E-07	1.764E-03	1.764E-03		
Pu-238		2.460E-01	6.002E-01	8.775E+01	9.961E-01	2.427E-01	6.259E-01	1.730E+03	3.617E-07	2.329E-03	2.329E-03		
Pu-239		2.180E-01	1.598E-04	2.413E+04	1.000E+00	2.180E-01	1.619E-04	1.210E+03	1.338E-07	8.614E-04	8.614E-04		
Pu-240		2.180E-01	1.598E-04	6.569E+03	9.999E-01	2.180E-01	1.619E-04	1.230E+03	1.316E-07	8.476E-04	8.476E-04		
Pu-241		6.540E+01	5.088E-02	1.440E+01	9.762E-01	6.770E+01	5.032E-02	8.600E+04	5.851E-07	3.524E-03	3.524E-03		
Am-241		6.600E-01	4.838E-04	4.322E+02	9.992E-01	6.595E-01	4.898E-04	9.050E+02	5.412E-07	3.484E-03	3.484E-03		
Pu-242		1.768E-01	1.306E-04	3.758E+05	1.000E+00	1.764E-01	1.325E-04	1.300E+03	1.019E-07	6.561E-04	6.561E-04		
Am-243		5.860E-01	4.298E-04	7.380E+03	1.000E+00	5.860E-01	4.392E-04	1.500E+02	2.928E-06	1.751E-02	1.751E-02		
Cm-243		3.130E-01	2.909E-04	2.850E+01	9.879E-01	3.113E-01	2.311E-04	2.450E+02	9.292E-07	5.979E-03	5.979E-03		
Cm-244		3.160E-01	2.302E-04	1.811E+01	9.810E-01	3.000E-01	2.295E-04	2.190E+03	1.048E-07	6.746E-04	6.746E-04		
		1.364E+03	1.000E+00			1.346E+03	1.000E+00						
								Gross DCGL	6.437E+01	Total	2.049E+00	7.716E-01	1.000E+00
										removed Dose (mrem/y)	0.612		

Note: Assumes MDA at 2 times TRU

Nuclide	Normalized nf	RESRAD Industrial DCGL pCi/g	nf/DCGL	% Dose
Co-60	1.019E-02	1.220E+01	8.348E-04	4.233E-00
Cs-137	9.868E-01	5.340E+01	1.848E-02	9.377E+01
			1.972E-02	1.000E+02
		DCGL Total	5.070E+01	based on 25 mrem/y
		Cs-137 Surrogate DCGL	5.020E+01	

Nuclide	Normalized nf	Adj DCGL pCi/g	nf/DCGL	% Dose
Co-60	1.019E-02	1.165E+01	8.590E-04	4.233E-00
Cs-137	9.868E-01	5.153E+01	1.916E-02	9.377E+01
			2.014E-02	1.000E+02
		DCGL Total	4.966E+01	Adjusted for 24.48 mR/y
		Cs-137 Surrogate DCGL	4.917E+01	Adjusted to 24.48 mR/y

Adjusted DCGL: 24.48 mrem/y (where 25 mrem/y minus removed dose = 24.48 mrem/y)

	pCi/g/mRAY (25 mrem/y)	adj DCGL ~24.6 mrem/y
Co-60	0.480	1.195E+01
Cs-137	2.096	5.133E+01

Rancho Seco Nuclear Generating Station **Decommissioning Technical Basis Document**	**DTBD–05-013** **Revision No. 0** **DPT 05-070** **RIC 2A.900**

Buried Piping Scenario and DCGL Determination Basis

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1.0 PURPOSE

The purpose of this Decommissioning Technical Basis Document (DTBD) is to establish the buried piping scenario and the derived concentration guideline levels (DCGLs) that are appropriate for evaluating the internal surfaces of buried piping associated with the Rancho Seco Nuclear Generating station (RSNGS).

2.0 DISCUSSION

The methodology established is this DTBD is to be used as the basis for determining the disposition of buried piping systems associated with the RSNGS. Because buried piping is located below the first 15 centimeters of soil (6 inches) the piping is associated with subsurface soils. DTBD 05-004 for subsurface soil states that the subsurface soil concentration will be limited to the surface soil DCGL.

3.0 DEFINITIONS

None

4.0 TECHNICAL POSITION

This document establishes the buried piping DCGL value at 100,000 dpm/100 cm^2. The DCGL assumes an averaged nuclide mixture of 0.17 for Co-60 and 0.83 for Cs-137 (95% C. L.). If conditions are encountered where a buried piping system's Co-60 nuclide fraction exceeds the 95% confidence level of the mean (>60% of the nuclide fraction is Co-60) the system will be addressed on an independent basis and as required, the DCGL adjusted accordingly.

The action level for grouting buried piping is the same as that established for embedded piping (20,000 dpm/100 cm^2). The grouting action level is based on the NRC Screening Level for the applicable gamma emitting nuclides (see Table 5.19 of NUREG-5512 V3). The grouting level determination is found in DTBD 05-009, "Embedded Piping Scenario and DCGL Basis".

5.0 LIMITATIONS

None

6.0 TECHNICAL BASES

6.1 Surface Soil

DTBD 04-005, "DCGLs for RSNGS Industrial Area Surface Soils" provides the basis for the surface soil single nuclide DCGLs. On May 28, 2004 RSNGS submitted to General Engineering Laboratories (GEL) a spent fuel pool cooler pad soil sample collected on March 8, 2004 for analysis of the entire potential suite of 26 radionuclides. This sample

was known by onsite gamma spectroscopy to have the highest level of contamination of any soil samples collected during the site characterization process. Of the suite of 26 potential radionuclides, GEL positively identified only six radionuclides. These were C-14, Co-60, Ni-63, Sr-90, Cs-134, and Cs-137. The nuclide fractions for the spent fuel pool cooler pad remaining six nuclides were determined from the entire nuclide suite by normalizing the remaining nuclide fractions to the mixture. This is illustrated in Attachment 8.1. The derived nuclide fractions are used to determine the Industrial Area Surface Soil DCGL from the Spent Fuel Pool Cooler Pad soil. This DCGL is presented in Table 6.1.

Table 6.1
Surface Soil DCGL

Nuclides	Normalized Nuclide Fraction (nf)	DCGL* pCi/g	nf/DCGL	% DCGL*
C-14	4.214E-03	8.330E+06	5.059E-10	3.099E-06
Co-60	5.697E-03	1.260E+01	4.521E-04	2.769E+00
Ni-63	1.511E-01	1.520E+07	9.939E-09	6.088E-05
Sr-90	1.130E-03	6.490E+03	1.740E-07	1.066E-03
Cs-134	1.854E-04	2.240E+01	8.278E-06	5.071E-02
Cs-137	8.377E-01	5.28E+01	1.587E-02	9.718E+01
		Sum	1.633E-02	1.00E+02
* based on 25 mrem/y		DCGL Total	6.125E+01	pCi/g
	Cs-137 Surrogate DCGL		5.155E+01	pCi/g

A separate DTBD for surface soils examines the surface soil radionuclides from other areas of the RSNGS site (DTBD-05-014 RSGS Surface Soil Nuclide Fraction and DCGL). These areas include the Spent Fuel Pool Cooler Area, Turbine-Spent Fuel and Diesel Generator Room gap, the Effluent Stream (Corridor) and two regions associated with the Tank Farm. These samples were selected for vendor (GEL Laboratory) analysis based on RSNGS gamma spectroscopic analysis results and site regions where the radionuclide profile could vary significantly. The samples selected represented the maximum radionuclide soil concentrations from the regions of the most significant activity. From the Effluent Stream four samples were compiled and represent regions where the highest concentrations were found. For the Tank Farm two samples each were compiled from two different regions of the Tank Farm. The first Tank Farm sample set represented the highest surface soil concentrations where the on site gamma spectroscopic results indicated Cs-137 concentrations at 90% or more of the mixture. The second Tank Farm sample set represented soil concentrations where the observed (on site gamma spectroscopy results) Co-60 and Cs-137 ratios were nearly 1:1. It should be noted that for this latter Tank Farm region the original soil concentrations for Co-60 and Cs-137 were well below the DCGL presented in Table 6.1. The DTBD for surface soils compares the results of the soil samples on a dose basis. The results of the comparison show that the surface soil samples noted above are in good agreement with each other. The sampling locations noted above are the only RSNGS locations where soil contamination has been found in significant quantities. The averaged DCGL total ($DCGL_{gross}$) for the five soil samples (Spent Fuel Pool Cooler

Pad included) is 78 pCi/g and the Cs-137 Surrogate DCGL is 50.6 pCi/g. The $DCGL_{gross}$ for these five locations ranged from 61.3 to 377.5 pCi/g while the Cs-137 Surrogate DCGL ranged from 48.8 to 52.7 pCi/g. The range spread for the $DCGL_{gross}$ is due to the high Ni-63 nuclide fraction (87.4 percent) in one Tank Farm sample composite. When this sample is removed from the sample set the $DCGL_{gross}$ range is 61.3 to 70.2 pCi/g. Because there is little dose significance for Ni-63 the Cs-137 surrogate range is not impacted and the results are conservative. Table 6.2 presents the range and average values for soil locations and the change to the soil DCGL for the conditions stated.

Table 6.2
RSNGS Individual and Averaged Soil DCGL's

Nuclides	SFPCP 7/1/2008 nf	SFP Gap 7/1/2008 nf	Effluent Stream 7/1/2008 nf	Tank Farm 7/1/2008 nf	Tank Farm 7/1/2008 nf	average nf	RESRAD Industrial DCGL pCi/g	nf/DCGL	%dose
C-14	4.214E-03	1.183E-02	6.802E-02	3.019E-02	4.658E-02	3.217E-02	8.330E+06	3.861E-09	3.011E-05
Co-60	5.698E-03	3.495E-04	1.072E-02	9.442E-03	2.126E-02	9.496E-03	1.260E+01	7.536E-04	5.876E+00
Ni-63	1.511E-01	1.945E-01	9.303E-02	2.408E-01	**8.742E-01**	3.107E-01	1.520E+07	2.044E-08	1.594E-04
Sr-90	1.130E-03	7.881E-04	4.441E-02	8.437E-03	7.831E-03	1.252E-02	6.490E+03	1.929E-06	1.504E-02
Cs-134	1.855E-04	1.614E-04	6.381E-03	7.389E-04	4.049E-04	1.574E-03	2.240E+01	7.029E-05	5.481E-01
Cs-137	8.377E-01	7.923E-01	7.774E-01	7.104E-01	4.974E-02	6.335E-01	5.280E+01	1.200E-02	9.356E+01
(in pCi/g)	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00		1.282E-02	1.000E+02
$DCGL_{gross}$	6.125E+01	6.648E+01	6.302E+01	7.023E+01	3.775E+02		average $DCGL_{gross}$	7.798E+01	
$Cs\text{-}137_{surrogate}$	5.155E+01	5.270E+01	4.980E+01	5.070E+01	4.843E+01		average $Cs\text{-}137_{surrogate}$	5.059E+01	

Removal of sample with high Ni-63

Nuclides	SFPCP 7/1/2008 nf	SFP Gap 7/1/2008 nf	Effluent Stream 7/1/2008 nf	Tank Farm 7/1/2008 nf	average nf	RESRAD Industrial DCGL pCi/g	nf/DCGL	%dose
C-14	4.214E-03	1.183E-02	6.802E-02	3.019E-02	2.856E-02	8.330E+06	3.429E-09	2.231E-05
Co-60	5.698E-03	3.495E-04	1.072E-02	9.442E-03	6.553E-03	1.260E+01	5.201E-04	3.384E+00
Ni-63	1.511E-01	1.945E-01	9.303E-02	2.408E-01	1.699E-01	1.520E+07	1.117E-08	7.271E-05
Sr-90	1.130E-03	7.881E-04	4.441E-02	8.437E-03	1.369E-02	6.490E+03	2.110E-06	1.373E-02
Cs-134	1.855E-04	1.614E-04	6.381E-03	7.389E-04	1.867E-03	2.240E+01	8.334E-05	5.423E-01
Cs-137	8.377E-01	7.923E-01	7.774E-01	7.104E-01	7.795E-01	5.280E+01	1.476E-02	9.606E+01
(in pCi/g)	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00		1.537E-02	1.000E+02
$DCGL_{gross}$	6.125E+01	6.648E+01	6.302E+01	7.023E+01		average $DCGL_{gross}$	6.507E+01	
$Cs\text{-}137_{surrogate}$	5.155E+01	5.270E+01	4.980E+01	5.070E+01		average $Cs\text{-}137_{surrogate}$	5.116E+01	

6.2 Buried Piping Radionuclides

The Buried Piping radionuclide mixture will use the same nuclide fraction for Co-60 (0.167) and Cs-137 (0.833) as Embedded Piping. The principle radionuclides (Cs-137 and Co-60) are readily determined by on site gamma spectroscopy. The hard-to-detect radionuclides for Buried Piping are accounted for by using the radionuclide mixture associated with the Turbine Polisher Sump (See Attachment 8.3) that is in communication with the Regenerative Holdup Tank (RHUT) piping and is a reasonable estimate of buried piping nuclide constituents (The Regenerative Holdup Tanks were effluent batch release tanks). If conditions are encountered where a buried piping system's Co-60 nuclide fraction exceeds the 95% confidence level of the mean (>60%

of the nuclide fraction is Co-60) the system will be addressed on an independent basis and as required, the DCGL adjusted accordingly. It should be noted however, that a 100 percent mixture of Co-60 at the buried pipe DCGL would not result in soil contamination exceeding the soil DCGL, nor would the dose rate from subsurface soil result in a significant dose to the receptor one meter from the surface of the soil.

6.3 Buried Piping Scenario

Of the buried piping that may remain after license termination, the piping associated with the RHUT and associated Storm Drains exhibits the greatest radiological potential. The RSNGS HSA notes several incidents of spillage, overflow and leaks with the RHUT system. The RHUT piping system is used to examine the subsurface buried piping contribution to the surface soil DCGL.

The buried piping scenario assumes the piping disintegrates instantaneously. The disintegrated media is assumed as soil and the media volume is assumed to be equal to the piping volume. Standard formulas for a cylinder are used to determine the surface area and volume of the piping. The soil volume is treated as subsurface soil (soil below a depth of 15 cm). Buried piping that will remain following decommissioning is located at a soil depth of three or more feet. This soil depth results in an insignificant direct exposure dose to the receptor at one meter above the surface. Attachments 8.3 through 8.5 present the calculations for this evaluation.

Attachment 8.2 is an inventory of the Buried Piping that is anticipated to remain following license termination. This inventory reflects the current condition and is subject to change due to dynamics of the decommissioning and remediation processes. Attachment 8.3 presents the adjusted vendor analysis results associated with the Turbine Building Polisher Sump and the application of the results to the determination of a piping interior surface concentration for the RHUT piping that is modified by the surface soil DCGL to derive the buried piping DCGL. Attachment 8.4 derives and compares the buried piping subsurface soil results to the surface soil DCGL. Attachment 8.5 presents the Microshield code runs and subsequent results that are used to determine the direct gamma dose rate from the subsurface soil to the receptor at one meter above the soil surface. Attachment 8.6 is the Vendor Laboratory (GEL) Analytical Results for the Turbine Polisher Sump.

A majority of the buried piping that is associated with systems that contained known contamination will be excavated and systems remaining have a low potential for significant internal contamination.

7.0 REFERENCES

7.1 DTBD 05-004 Rev 0, Applicability of Surface Soil DCGLs to Subsurface Soil Contamination

7.2 DTBD 05-009 Rev 0, Embedded Piping Scenario and DCGL Basis

7.3 NUREG-5512 V3, Residual Radioactive Contamination From Decommissioning Parameter Analysis

8.0 ATTACHMENTS

8.1 Derived Nuclide Fraction for Spent Fuel Pool Cooler Pad Soil

8.2 Buried Piping Inventory

8.3 Polisher Sump GEL Sample Analysis and RHUT Piping Concentration (3 pages)

8.4 Buried Piping Subsurface Soil Results and Comparison to the Surface Soil DCGL (2 pages)

8.5 Microshield Code Runs and Dose Results for Buried Piping (7 pages)

8.6 General Engineering Laboratories Analytical Results for Turbine Polisher Sump Sludge, SB899007 PM01, GEL #1355690005, July 11, 2005. (2 pages)

9.0 RESPONSIBLE INDIVIDUAL

Robert F. Decker

Attachment 8.1

Derived Nuclide Fraction for Spent Fuel Pool Cooler Pad Soil

GEL results for Spent Fuel Pool Cooler Soil 8/11/04 #3

Nuclides		SFPC Soil 03/08/04 pCi/g	SC8100010 DS08A1 original nf	D-K(yrs)==> Half-Life Yrs	7/1/2008 4.3176 $e^{-\lambda t}$	7/1/2008 Estimated pCi/g		7/1/2008 nf	Assumed nf	Normalized nf
H-3	<	6.820E+00	5.332E-03	1.228E+01	7.837E-01	5.345E+00	<	4.617E-03		
C-14		4.740E+00	3.706E-03	5.730E+03	9.995E-01	4.738E+00		4.093E-03	4.093E-03	**4.214E-03**
Na-22	<	2.460E-01	1.923E-04	2.602E+00	3.166E-01	7.788E-02	<	6.728E-05		
Fe-55	<	3.560E+00	2.784E-03	2.700E+00	3.301E-01	1.175E+00	<	1.015E-03		
Ni-59	<	3.580E+00	2.799E-03	7.500E+04	1.000E+00	3.580E+00	<	3.093E-03		
Co-60		1.130E+01	8.835E-03	5.271E+00	5.668E-01	6.405E+00		5.533E-03	5.533E-03	**5.697E-03**
Ni-63		1.750E+02	1.368E-01	1.001E+02	9.705E-01	1.698E+02		1.467E-01	1.467E-01	**1.511E-01**
Sr-90		1.410E+00	1.102E-03	2.860E+01	9.006E-01	1.270E+00	<	1.097E-03	1.097E-03	**1.130E-03**
Nb-94	<	2.230E-01	1.744E-04	2.030E+04	9.999E-01	2.230E-01	<	1.926E-04		
Tc-99	<	2.350E+00	1.837E-03	2.130E+05	1.000E+00	2.350E+00	<	2.030E-03		
Ag-108m	<	1.230E+00	9.617E-04	1.270E+02	9.767E-01	1.201E+00	<	1.038E-03		
Sb-125	<	3.530E+00	2.760E-03	2.770E+00	3.395E-01	1.198E+00	<	1.035E-03		
Cs-134		8.900E-01	6.959E-04	2.062E+00	2.342E-01	2.085E-01		1.801E-04	1.801E-04	**1.854E-04**
Cs-137		1.040E+03	8.132E-01	3.017E+01	9.056E-01	9.418E+02		8.136E-01	8.136E-01	**8.377E-01**
Pm-147	<	2.760E+00	2.158E-03	2.623E+00	3.196E-01	8.820E-01	<	7.619E-04		
Eu-152	<	2.610E+00	2.041E-03	1.360E+01	8.025E-01	2.094E+00	<	1.809E-03		
Eu-154	<	6.560E-01	5.129E-04	8.800E+00	7.117E-01	4.669E-01	<	4.033E-04		
Eu-155	<	1.610E+00	1.259E-03	4.960E+00	5.470E-01	8.806E-01	<	7.607E-04		
Np-237	<	4.410E-01	3.448E-04	2.140E+06	1.000E+00	4.410E-01	<	3.810E-04		
Pu-238	<	8.510E-01	6.654E-04	8.775E+01	9.665E-01	8.225E-01	<	7.105E-04		
Pu-239	<	2.070E-01	1.619E-04	2.413E+04	9.999E-01	2.070E-01	<	1.788E-04		
Pu-240	<	2.070E-01	1.619E-04	6.569E+03	9.995E-01	2.069E-01	<	1.787E-04		
Pu-241	<	1.320E+01	1.032E-02	1.440E+01	8.123E-01	1.072E+01	<	9.263E-03		
Am-241c	<	3.807E-01	2.976E-04	4.322E+02	9.931E-01	3.780E-01	<	3.266E-04		
Pu-242	<	5.940E-01	4.644E-04	3.758E+05	1.000E+00	5.940E-01	<	5.131E-04		
Cm-244	<	5.600E-01	4.379E-04	1.811E+01	8.477E-01	4.747E-01	<	4.101E-04		
		1.279E+03	1.000E+00			1.158E+03		1.000E+00		
								Total	9.712E-01	1.000E+00

The **bolded** values indicate the derived nuclide fraction for the Spent Fuel Cooler Pad soil.

Attachment 8.2
Buried Piping Inventory

Line Number	Diameter inches	Diameter m	Length Feet	Length Meters	Volume m^3	Surface Area m^2	System/Location
RHUT Piping							
95080	8	0.203	188	61.7	2.0	39.4	RHUT to Pumps
95084	8	0.203	80	26.2	0.9	16.8	B-RHUT Overflow Drain to 95086
95081	8	0.203	18	5.9	0.2	3.8	A-RHUT Overflow Drain to 95086
95086	8	0.203	135	44.3	1.4	28.3	Combined Overflow to SD
68303	6	0.152	28	9.2	0.2	4.4	Pump to 95086
68304	8	0.203	1200	393.7	12.8	251.3	RHUT Discharge to Retention Basin
96520	6	0.152	276	90.6	1.7	43.4	Polisher Sump to RHUTs
96527	2	0.051	155	50.9	0.1	8.1	LERTS to SRT's
96528	6	0.152	65	21.3	0.4	10.2	MU Sump to B RHUT
96603	6	0.152	250	82.0	1.5	39.3	MU Sump to C RHUT
CDS-Turbine Building Drains & Oily Water Separator							
94503-4-LE	4	0.102	470	154.2	1.3	49.2	Cask Storage Bldg to Transformer Line
	6	0.152	210	68.9	1.3	33.0	Aux Bldg Transformer Area to Turbine Bldg line
	6	0.152	70	23.0	0.4	11.0	Turbine Bldg to Distribution Box
	10	0.254	75	24.6	1.2	19.6	Turbine Bldg to Distribution Box
	10	0.254	70	23.0	1.2	18.3	Transformer Yard to 18" line
	18	0.457	75	24.6	4.0	35.3	Distribution Box to MH-D17
	18	0.457	45	14.8	2.4	21.2	MH-D17 to Oily Water Separator
	18	0.457	1120	367.5	60.3	527.8	Oily Water Separator to Retention Basin Mixing Box
Other Piping for Survey and Abandonment							
35823	12	0.305	360	118.1	8.6	113.1	MCM/Condensate Reject - Condenser Pit to CST
46047	3	0.076	340	111.5	0.5	26.7	CCW cooling for Circ Pumps
40226	3	0.076	280	91.9	0.4	22.0	CCW cooling for Circ Pumps
32820	8	0.203	4	1.3	0.0	0.8	Aux Steam BD TK to Storm Drain
31823	6	0.152	250	82.0	1.5	39.3	Aux FW to A OTSG
31920	6	0.152	227	74.5	1.4	35.7	Aux FW to B OTSG
31822	2.5	0.064	175	57.4	0.2	11.5	Aux FW to Condensate
31922	2.5	0.064	178	58.4	0.2	11.7	Aux FW to Condensate
40099	2	0.051	522	171.3	0.3	27.3	Waste Gas to Cooling Tower (sealed and never used)
26061	18	0.457	100	32.8	5.4	47.1	NSCW from DHS to Cooler
48223	18	0.457	100	32.8	5.4	47.1	NSCW to DHS from Cooler
33080	4	0.102	200	65.6	0.5	20.9	Polisher to CRUD TK Rm.
	1	0.025	315	103.3	0.1	8.2	NGS Tanks to Tank Farm
	2	0.051	315	103.3	0.2	16.5	NGS Tanks to Tank Farm
TBD							Service and Instrument Air Systems
CDS-Cooling Tower, BD, Storm Drains to Effluent							
	42	1.067	300	98.4	88.0	329.9	Mixing Box to Outfall
	36	0.914	1400	459.3	301.6	1319.5	Cooling Tower Overflow to Mixing Box
	24	0.610	330	108.3	31.6	207.3	Spray Pond
	18	0.457	1700	557.7	91.6	801.1	Spray Pond, CTB
	15	0.381	90	29.5	3.4	35.3	Tank Farm Storm Drain
	12	0.305	128	42.0	3.1	40.2	Tank Farm Storm Drain
CDS-Storm Drains Direct Off Site							
	60	1.524	580	190.3	347.1	911.1	Parking and Administration to Dike Area
	30	0.762	500	164.0	74.8	392.7	NW Corner of Switchyard to Clay Creek
	24	0.610	100	32.8	9.6	62.8	SE Corner of Site to Dike Area
	24	0.610	390	128.0	37.3	245.0	Warehouse Area to 30" line
	18	0.457	850	278.9	45.8	400.6	Various to 30 or 60" lines
	15	0.381	1050	344.5	39.3	412.3	Various to 30 or 60" lines
	12	0.305	450	147.6	10.8	141.4	Various to 30 or 60" lines
	8	0.203	140	45.9	1.5	29.3	Auxiliary Building Roof Drains to 60" Line
	6	0.152	50	16.4	0.3	7.9	Auxiliary Building Roof Drains to 12" Line

Attachment 8.2
Buried Piping Inventory (continued)

Line Number	Diameter inches	Diameter m	Length Feet	Length Meters	Volume m^3	Surface Area m^2	System/Location
CDS- Sewer (not anticipated to be impacted)							
	4	0.102	1500	492.1	4.0	157.1	Force Main from Plant to Pond
	6	0.152	2000	656.2	12.0	314.2	All Buildings to Sewer Plant
Remaining Underground Lines (not anticipated to be impacted)							
99820	4	0.102	90	29.5	0.2	9.4	COS - CO^2
99920	1	0.025	90	29.5	0.0	2.4	COS - CO^2
	2.5	0.064	1400	459.3	1.5	91.6	DFO Diesel Fuel Oil
	3	0.076	1400	459.3	2.1	110.0	DFO Diesel Fuel Oil
TBD ==>		0.000		0.0	0.0	0.0	FPW Fire Protection Water
	108	2.743	1550	508.5	3005.5	4382.5	MCW - Main Cooling Water
4854,55,62,63	24	0.610	4100	1345.1	392.6	2576.1	NRW to-from Spray Ponds
47350	10	0.254	95	31.2	1.6	24.9	NRW Cooling or SF Cooler
47360	10	0.254	95	31.2	1.6	24.9	NRW Cooling or SF Cooler
	33	0.838	660	216.5	119.5	570.2	PCW Plant Cooling Water
	30	0.762	70	23.0	10.5	55.0	PCW Plant Cooling Water
	24	0.610	160	52.5	15.3	100.5	PCW Plant Cooling Water
31802	8	0.203	185	60.7	2.0	38.7	SRS Folsom South Canal to CST
99600	14	0.356	170	55.8	5.5	62.3	SRS Folsom South Canal to 31802
	30	0.762	1200	393.7	179.5	942.5	SRS Folsom South Canal to Circulation Basin
TBD ==>		0.000		0.0	0.0	0.0	SWS Domestic Water
			Feet	Meters	m^3	m^2	
Total			30719.0	10078.4	4957.0	16386.9	Total

TBD = To be Determined

Attachment 8.3
Page 8.3.1 of 3 Pages (Continued)
Polisher Sump GEL Sample Analysis and RHUT Piping Concentration

062905 using MDA

GEL results for Turbine Drain Sump #5

Nuclides		Turbine Drain 04/20/05 pCi/g	SB8990070 PM01 original Nf	D-K(yrs)==> Half-Life yrs	7/1/5008 3.1937 $e^{-\lambda\tau}$	7/1/5008 Estimated pCi/g		7/1/5008 nf	RESRAD Industrial DCGL (Surface) dpm/100cm²	nf/DCGL	% Dose	% Dose Removed	Assumed nf	Normalized nf
H-3		7.530E+00	5.355E-03	1.228E+01	8.350E-01	6.288E+00		4.732E-03	3.150E+08	1.502E-11	3.716E-04	3.716E-04		
C-14		4.420E+00	3.143E-03	5.730E+03	9.996E-01	4.418E+00		3.325E-03	8.560E+06	3.885E-10	9.609E-03		3.325E-03	3.465E-03
Na-22	<	3.030E-01	2.155E-04	2.602E+00	4.271E-01	1.294E-01	<	9.739E-05	1.700E+04	5.729E-09	1.417E-01	1.417E-01		
Fe-55	<	3.560E+01	2.532E-02	2.700E+00	4.405E-01	1.568E+01	<	1.180E-02	3.420E+07	3.451E-10	8.536E-03	8.536E-03		
Ni-59	<	9.270E+00	6.592E-03	7.500E+04	1.000E+00	9.270E+00	<	6.976E-03	7.990E+07	8.731E-11	2.160E-03	2.160E-03		
Co-60		3.540E+01	2.517E-02	5.271E+00	6.571E-01	2.326E+01		1.751E-02	1.520E+04	1.152E-06	2.849E+01		1.751E-02	1.824E-02
Ni-63		1.110E+03	7.893E-01	1.001E+02	9.781E-01	1.086E+03		8.171E-01	3.050E+07	2.679E-08	6.627E-01		8.171E-01	8.515E-01
Sr-90	<	1.400E+00	9.956E-04	2.860E+01	9.255E-01	1.296E+00	<	9.751E-04	1.210E+05	8.059E-09	1.994E-01	1.994E-01		
Nb-94	<	3.570E-01	2.539E-04	2.030E+04	9.999E-01	3.570E-01	<	2.686E-04	2.290E+04	1.173E-08	2.902E-01	2.902E-01		
Tc-99	<	3.640E+00	2.588E-03	2.130E+05	1.000E+00	3.640E+00	<	2.739E-03	1.170E+07	2.341E-10	5.792E-03	5.792E-03		
Ag-108m	<	6.450E-01	4.587E-04	1.270E+02	9.827E-01	6.339E-01	<	4.770E-04	2.210E+04	2.159E-08	5.340E-01	5.340E-01		
Sb-125	<	1.750E+00	1.244E-03	2.770E+00	4.497E-01	7.870E-01	<	5.923E-04	7.990E+04	7.413E-09	1.834E-01	1.834E-01		
Cs-134	<	4.790E-01	3.406E-04	2.062E+00	3.418E-01	1.637E-01	<	1.232E-04	2.190E+04	5.626E-09	1.392E-01	1.392E-01		
Cs-137		1.710E+02	1.216E-01	3.017E+01	9.293E-01	1.589E+02		1.196E-01	5.560E+04	2.151E-06	5.321E+01		1.196E-01	1.246E-01
Pm-147	<	6.470E+00	4.601E-03	2.623E+00	4.301E-01	2.782E+00	<	2.094E-03	1.670E+07	1.254E-10	3.102E-03	3.102E-03		
Eu-152	<	1.410E+00	1.003E-03	1.360E+01	8.498E-01	1.198E+00	<	9.017E-04	3.180E+04	2.836E-08	7.015E-01		9.017E-04	9.397E-04
Eu-154	<	8.450E-01	6.009E-04	8.800E+00	7.776E-01	6.571E-01	<	4.945E-04	1.150E+04	4.300E-08	1.064E+00	1.064E+00		
Eu-155	<	9.060E-01	6.443E-04	4.960E+00	6.400E-01	5.798E-01	<	4.364E-04	5.230E+05	8.344E-10	2.064E-02	2.064E-02		
Np-237	<	3.140E-01	2.233E-04	2.140E+06	1.000E+00	3.140E-01	<	2.363E-04	2.380E+03	9.929E-08	2.456E+00	2.456E+00		
Pu-238	<	6.190E-01	4.402E-04	8.775E+01	9.751E-01	6.036E-01	<	4.542E-04	3.420E+03	1.328E-07	3.286E+00		4.542E-04	4.734E-04
Pu-239	<	1.860E-01	1.323E-04	2.413E+04	9.999E-01	1.860E-01	<	1.400E-04	3.050E+03	4.589E-08	1.135E+00		1.400E-04	1.459E-04
Pu-240	<	1.860E-01	1.323E-04	6.569E+03	9.997E-01	1.859E-01	<	1.399E-04	3.050E+03	4.588E-08	1.135E+00		1.399E-04	1.458E-04
Pu-241	<	1.230E+01	8.747E-03	1.440E+01	8.575E-01	1.055E+01		7.938E-03	1.820E+05	4.361E-08	1.079E+00	1.079E+00		
Am-241c	<	2.690E-01	1.913E-04	4.322E+02	9.949E-01	2.676E-01	<	2.014E-04	2.990E+03	6.736E-08	1.666E+00		2.014E-04	2.099E-04
Pu-242	<	3.160E-01	2.247E-04	3.758E+05	1.000E+00	3.160E-01	<	2.378E-04	3.200E+03	7.432E-08	1.838E+00		2.378E-04	2.478E-04
Cm-243	<	3.115E-01	2.215E-04	2.850E+01	9.253E-01	2.882E-01	<	2.169E-04	6.020E+03	3.603E-08	8.913E-01	8.913E-01		
Cm-244	<	3.115E-01	2.215E-04	1.811E+01	8.849E-01	2.757E-01	<	2.075E-04	6.020E+03	3.446E-08	8.525E-01	8.525E-01		
		1.406E+03	1.000E+00			1.329E+03		1.000E+00		4.043E-06	1.000E+02			
									gross	2.474E+05		7.871E+00	9.596E-01	1.000E+00
										removed dose (mrem/y)		1.968		

Attachment 8.3
Page 8.3.2 of 3 (Continued)
Polisher Sump GEL Sample Analysis and RHUT Piping Concentration

Nuclide		Normalized *nf*	RESRAD Industrial DCGL (surface) dpm/100cm²	*nf*/DCGL	% Dose	Beta *f*
C-14		3.465E-03	8.560E+06	4.048E-10	1.043E-02	3.465E-03
Ni-63		8.515E-01	3.050E+07	2.792E-08	7.193E-01	
Co-60		1.824E-02	1.520E+04	1.200E-06	3.092E+01	1.824E-02
Cs-137		1.246E-01	5.560E+04	2.241E-06	5.775E+01	1.246E-01
Eu-152	<	9.397E-04	3.180E+04	2.955E-08	7.614E-01	9.397E-04
Pu-238	<	4.734E-04	3.420E+03	1.384E-07	3.566E+00	
Pu-239	<	1.459E-04	3.050E+03	4.782E-08	1.232E+00	
Pu-240	<	1.458E-04	3.050E+03	4.781E-08	1.232E+00	
Am-241c	<	2.099E-04	2.990E+03	7.020E-08	1.809E+00	
Pu-242	<	2.478E-04	3.200E+03	7.745E-08	1.995E+00	
		1.000E+00		3.881E-06	1.000E+02	1.473E-01
			DCGL Total	**2.577E+05**		
			Gross Beta dpm/100 cm²	**3.795E+04**		

Nuclide		Normalized *nf*	Adjusted DCGL dpm/100cm²	*nf*/DCGL	% Dose	Beta *f*
C-14		3.465E-03	7.886E+06	4.394E-10	1.043E-02	3.465E-03
Ni-63		8.515E-01	2.810E+07	3.030E-08	7.193E-01	
Co-60		1.824E-02	1.400E+04	1.303E-06	3.092E+01	1.824E-02
Cs-137		1.246E-01	5.122E+04	2.433E-06	5.775E+01	1.246E-01
Eu-152	<	9.397E-04	2.930E+04	3.208E-08	7.614E-01	9.397E-04
Pu-238	<	4.734E-04	3.151E+03	1.502E-07	3.566E+00	
Pu-239	<	1.459E-04	2.810E+03	5.191E-08	1.232E+00	
Pu-240	<	1.458E-04	2.810E+03	5.190E-08	1.232E+00	
Am-241c	<	2.099E-04	2.755E+03	7.620E-08	1.809E+00	
Pu-242	<	2.478E-04	2.948E+03	8.406E-08	1.995E+00	
		1.000E+00		4.213E-06	1.000E+02	1.473E-01
			DCGL Total	**2.374E+05**	<=======	Adjusted for 23.032 mrem/y
			Gross Beta dpm/100 cm²	**3.496E+04**	<=======	Adjusted for 23.032 mrem/y

Adjusted DCGL: **23.032**

Nuclide		dpm/100 cm² per mrem/y	Adjusted DCGL ~23.0 mrem/y
C-14		342400	7.886E+06
Ni-63		1220000	2.810E+07
Co-60		608	1.400E+04
Cs-137		2224	5.122E+04
Eu-152	<	1272	2.930E+04
Pu-238	<	136.8	3.151E+03
Pu-239	<	122	2.810E+03
Pu-240	<	122	2.810E+03
Am-241c	<	119.6	2.755E+03
Pu-242	<	128	2.948E+03

Attachment 8.3
Page 8.3.3 of 3
Polisher Sump GEL Sample Analysis and RHUT Piping Concentration

DCGL Adjusted For RHUT Piping Using Cs-137 Surrogate for Turbine Sump

Nuclide		Normalized nf	Adj. DCGL dpm/100cm²	nf/DCGL	% Dose	Beta f	Ratio to Cs-137	Ratio to Cs-137 ÷ Cs-137 DCGL	Ratio to Cs-137 ÷ Cs-137 DCGL w/o Co-60
C-14		3.465E-03	7.886E+06	4.394E-10	1.043E-02	3.465E-03	2.781E-02	3.526E-09	3.526E-09
Ni-63		8.515E-01	2.810E+07	3.030E-08	7.193E-01		6.833E+00	2.432E-07	2.432E-07
Co-60		1.824E-02	1.400E+04	1.303E-06	3.092E+01	1.824E-02	1.464E-01	1.045E-05	
Cs-137		1.246E-01	5.122E+04	2.433E-06	5.775E+01	1.246E-01	1.000E+00	1.952E-05	1.952E-05
Eu-152	<	9.397E-04	2.930E+04	3.208E-08	7.614E-01	9.397E-04	7.540E-03	2.574E-07	2.574E-07
Pu-238	<	4.734E-04	3.151E+03	1.502E-07	3.566E+00		3.798E-03	1.206E-06	1.206E-06
Pu-239	<	1.459E-04	2.810E+03	5.191E-08	1.232E+00		1.170E-03	4.165E-07	4.165E-07
Pu-240	<	1.458E-04	2.810E+03	5.190E-08	1.232E+00		1.170E-03	4.164E-07	4.164E-07
Am-241c	<	2.099E-04	2.755E+03	7.620E-08	1.809E+00		1.684E-03	6.114E-07	6.114E-07
Pu-242	<	2.478E-04	2.948E+03	8.406E-08	1.995E+00		1.989E-03	6.745E-07	6.745E-07
		1.000E+00		4.213E-06	1.000E+02	1.473E-01	8.024E+00	3.380E-05	2.335E-05
								2.958E+04	**4.283E+04**

RHUT Concentration Total	**2.374E+05**	<======= Adjusted for 23.032 mrem/y
Gross Beta dpm/100 cm²	**3.496E+04**	<======= Adjusted for 22.032 mrem/y
Cs-137 surrogate	2.958E+04	Using Turbine Sump Cs-137 Ratios (includes Co-60 mix from sump)
Cs-137 surrogate	**4.283E+04**	Without including Co-60 from Turbine Sump Cs-137 Ratios

Adjusting Co-60 and Cs-137 Using Turbine Sump Cs-137 Surrogate and derived nuclide fractions from Embedded Piping

Nuclide	nf*	Adj. DCGL dpm/100cm²	nf/DCGL	% Dose	Beta f
Co-60	0.167	1.400E+04	1.193E-05	3.802E+01	1.67E-01
Cs-137	0.833	4.283E+04**	1.945E-05	6.198E+01	8.33E-01
	1.000E+00		3.138E-05	1.000E+02	1.000E+00
		Gross Beta dpm/100 cm²	**3.187E+04**	**Adjusted for Cs-137 surrogate for all nuclides except Co-60	

* normalized

Then 3.187E+04 dpm/100 cm² is the piping internal surface concentration to be modified by the surface soil DCGL in Attachment 8.4.

ATTACHMENT 8.4
Page 8.4.1 of 2 pages (continued)
Buried Piping Subsurface Soil Results and Comparison to the Surface Soil DCGL

RHUT Piping

Under the scenario, the RHUT buried piping is assumed to disintegrate instantaneously. The disintegrated media is assumed as soil and the media volume is assumed to be equal to the piping volume. Standard formulas for a cylinder are used to determine the surface area and volume of the piping. The piping interior surface is contaminated at the surface DCGL presented in Attachment 8.3, Page 8.3.3 (3.187E+04 dpm/100 cm^2). As previously stated in Section 6.3, the RHUT piping is used to examine the dose contribution to the subsurface and surface soil DCGL. The piping size and length is presented in Table A-8.4-1 below. It should be noted most of this piping is being excavated.

Table A-8.4-1
RHUT Piping Dimensions Used for Bounding Condition

Line Designation	Size inches (cm)	Length ft. (m)	Volume (m^3)	Surface Area (m^2)
*RHUT Recirc	6 (15.24)	35 (10.7)	0.195	5.123
*RHUT Recirc	8 (20.32)	170 (51.8)	1.680	33.068
*RHUT Discharge	6 (15.24)	35 (10.7)	0.195	5.123
*RHUT Discharge	8 (20.32)	241 (73.5)	2.384	46.920
Sump to RHUT Tanks	6 (15.24)	126 (38.4)	0.701	18.385
	Total:	607 (185)	5.155	108.619

*Length based on measurements taken during the piping survey

- The total number of 100 cm^2 regions associated with the RHUT piping is:

$$\frac{108.619 m^2 * 10^4 \frac{cm^2}{m^2}}{100 cm^2} = 1.086E+04 \text{ 100 cm}^2 \text{ regions}$$

- The total activity (in pCi's) associated with the RHUT piping is the piping surface "DCGL" (3.187E+04 dpm/100 cm^2) times the number of 100 cm^2 regions times 0.4505 (pCi/dpm).

$$1.086E+04 * 3.187E+04 * 0.4505 = 1.559E+08 \text{ pCi}$$

- The mass of the soil is determined by multiplying the piping volume (converted to cm^3) by the assumed soil density of 1.6 g/cm^3.

$$5.155 m^3 * 10^6 \frac{cm^3}{m^3} * 1.6 \frac{g}{cm^3} = 8.248E+06 \text{ g}$$

- The resulting subsurface soil concentration in pCi/g is determined by dividing the total activity by the derived soil mass.

$$\frac{1.559E+08 pCi}{8.248E+06 g} = 18.90 \text{ pCi/g}$$

ATTACHMENT 8.4
Page 8.4.2 of 2 pages

- The derived subsurface soil concentration for the buried RHUT piping listed in Table A-8.4-1 is lower than the gross surface soil DCGL (78.0 pCi/g) by a factor of 4.13.

$$\frac{78.0}{18.9} = 4.13$$

- The most conservative of the gross surface soil DCGL values reported in Table 6.2 (61.25 pCi/g) is 61.25 pCi/g and the derived surface soil concentration for the buried RHUT piping is lower by a factor of 3.24.

- In order for the derived subsurface soil concentration (from the buried RHUT piping) to equal the surface soil DCGL the RHUT piping interior surface concentration is 1.32E+05 dpm/100 cm^2 (3.187E+04 dpm/100 cm^2 times 4.13). Using the most conservative gross surface DCGL observed (61.25 pCi/g) the RHUT piping interior surface concentration would be 1.03E+05 dpm/100 cm^2 (3.187E+04 dpm/100 cm^2 times 3.24). The same values may be back calculated by reversing the computational steps provided above (and beginning with the soil mass of the buried piping).

- A conservative value of 1.00E+05 dpm/100 cm^2 will be used as the buried piping interior surface DCGL.

Subsurface Soil Concentration Using All Buried Piping
The above condition using a portion of the RHUT piping is conservative. Using the entire buried piping inventory (Attachment 8.2, *Buried Piping Estimate*) and the piping interior surface DCGL of 1.00E+05 dpm/100 cm^2 result in the following subsurface soil concentration where:

- Buried Piping Estimated Total Surface Area: 1.639E+04 m^2

- Buried Piping Estimated Total Volume: 4.957E+03 m^3

Using the same conversion process as provided for the RHUT piping, the total activity from the Buried Piping Estimated Total Surface Area is 7.382E+10 pCi. The Buried Piping soil mass is 7.931E+09 g. The derived subsurface soil concentration using all the buried piping (with an interior surface concentration of 1.00E+05 dpm/100 cm^2) is 9.31 pCi/g and is a factor of 8.4 lower than the gross surface soil DCGL. Using the most conservative surface gross DCGL value (61.25 pCi/g) the concentration is 6.6 times lower.

$$\frac{78.0}{9.31} = 8.38$$

Attachment 8.5
Page 8.5.1 of 7 Pages
Microshield Dose Results Buried Piping

The potential dose from buried piping is based primarily on its subsurface soil concentration that is limited to the surface soil DCGL that meets the 25 mrem/y limit as presented in DTBD 05-004, *Applicability of Surface Soil DCGLs to Subsurface Soil Contamination.* The previous pages of this Attachment show that a gross concentration of 1.00E+05 dpm/100 cm^2 will result in a soil concentration below the gross surface soil DCGL. Two additional conditions are presented below. These are:

- The direct gamma dose from contamination on the interior surface of the buried piping to the receptor point located one meter above the soil surface.
- The direct gamma dose from disintegrated buried piping *soil* to the receptor point at one meter above the soil surface.

The first condition presents the gamma dose from a section of buried piping that is 6.1 meters long (20 feet) and 0.61 meters (24 inches) in diameter. The condition assumes the entire interior surface of the piping to be contaminated to a level of 1.00E+05 dpm/100 cm^2 with the nuclide fractions of the piping being 0.167 for Co-60 and 0.833 for Cs-137. The dose to the receptor at one meter above the surface soil assumes a soil cover of 0.305 and 1.0 meter. The latter depth is considered a nominal depth for buried piping that will remain on site after license termination.

The second condition presents the gamma dose for the same piping diameter and length. The condition assumes the piping has disintegrated and results in a lateral cylinder of soil that comprises the piping volume. The concentration and total activity presented for the first condition is also used for the second condition.

Direct Gamma Dose from Intact Buried Piping (First Condition)

- The piping surface area is:

$$2\pi * 30.48 * 609.6 = 1.168E + 05\, cm^2$$

- The surface area results in 1.168E+03 100 cm^2 regions maximally contaminated at 1.00E+05 dpm/100 cm^2 or a total activity of 1.168E+08 dpm (52.59 uCi's). Table A-8.5-1 below presents the activity breakdown for Microshield Version 5.05 Software code input.

Table A-8.5-1
Nuclide Activity For Microshield Input

Nuclide	Nuclide Fraction	Total Activity (Ci)	Nuclide Activity (Ci)
Co-60	0.167	5.259E-05	8.78E-06
Cs-137	0.833		4.381E-05

Attachment 8.5
Page 8.5.2 of 7 Pages
Microshield Dose Results Buried Piping

Microshield Model Dimensions and Parameter Input Values

For intact 24" diameter, 20 foot section of buried piping:

- Annular Cylinder, External Dose Point
- Height: 609.6 cm
- Internal Radius (cylinder core): 29.926 cm (Air)
- Source: 0.1 cm (iron)
- Shield 3: 0.454 cm (iron and remaining wall of piping)
- Transition: Air (no thickness or dimension)
- Shield 5: 30.48 & 100 cm SiO, (Sand at a density of 1.6 g/cc)
- Air Gap: 100 cm (Air, STP density)
- Dose Points: Z = 0, Y = 304.8 cm, X = 160.96 & 230.48 cm

The conditions result in the receptor being located at the midpoint of the pipe. The depth of sand is varied at 0.305 and 1.0 meters. The receptor point as stated is 1 meter above the ground surface.

The results of the Microshield Code runs were 3.118E-04 mR/hr with 30.48 centimeters of soil cover and 8.09E-07 mR/hr with 1.0 meter of soil cover. The occupancy time for a normal work year is 2000 hours and results in a dose of 0.623 and 1.61E-03 mrem/y for 0.305 and 1.0 meters soil depth, respectively. The current Industrial Scenario actually assumes that fifty percent of the dose receptor's time is spent indoor and fifty percent outside which would result in the one-half the above annual dose values.

Direct Gamma Dose From Disintegrated Buried Piping (Second Condition)

As previously stated the second condition for direct gamma dose is from buried piping that has disintegrated. For the calculation the source term is the same activity as for the intact buried piping (Table A-8.5-1). The condition assumes the contaminated region is the same dimension as the original pipe segment and the source term is distributed throughout a soil volume of the disintegrated pipe.

Microshield Model Dimensions and Parameter Input Values

For disintegrated 24" diameter, 20 foot section of buried piping:

- Cylinder Volume, External Dose Point
- Height: 609.6 cm
- Radius: 30.48 cm (Sand, 1.6 g/cc)
- Source: Sand cylinder (see radius above)
- Transition: Air (no thickness or dimension)

Attachment 8.5
Page 8.5.3 of 7 pages (continued)
Microshield Dose Results

- Buried Piping Shield 2: 30.48 & 100 cm (soil cover above source term, 1.6 g/cc)
- Air Gap: 100 cm (Air, STP density)
- Dose Points: Z = 0, Y = 304.8 cm, X = 160.96 & 230.48 cm

The conditions result in the receptor being located at the center of the pipe. The depth of sand is varied at 0.305 and 1.0 meters. The receptor point as stated is 1 meter above the ground surface.

The results of the Microshield Code runs were 1.194E-04 mR/hr with 30.48 centimeters of soil cover and 2.973E-07 mR/hr with 1.0 meter of soil cover. The occupancy time for a normal work year is 2000 hours and results in a dose of 0.239 and 5.95E-04 mrem/y for 0.305 and 1.0 meters soil depth, respectively. The current Industrial Scenario actually assumes that fifty percent of the dose receptor's time is spent indoor and fifty percent outside which would result in the one-half the above annual dose values.

The results of the dose calculations for the conditions noted show that for the worst condition (0.623 mrem/y) the dose contribution is about 2.5 percent of 25 mrem/y.

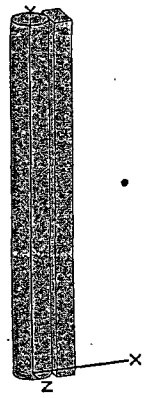
Attachment 8.5
Page 8.5.4 of 7 pages
Microshield Dose Results

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : BP1M1115.MS5
Run Date: November 15, 2005
Run Time: 1:16:53 PM
Duration : 00:00:19

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Buried Piping
Description: Receptor Dose with 0.3048 meter (1.0') of soil cover
Geometry: 12 - Annular Cylinder - External Dose Point



Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	29.926 cm	11.8 in

Dose Points

	X	Y	Z
# 1	160.96 cm	304.8 cm	0 cm
	5 ft 3.4 in	10 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	29.926 cm³	Air	0.00122
Source	.1 cm	Iron	7.86
Shield 3	.454 cm	Iron	7.86
Transition		Air	0.00122
Shield 5	30.48 cm	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.1440e-006	1.5333e+005	3.6093e-004	1.3355e+001
Co-60	8.7822e-006	3.2494e+005	7.6490e-004	2.8301e+001
Cs-137	4.3806e-006	1.6208e+005	3.8154e-004	1.4117e+001

Buildup
The material reference is : Shield 5

Integration Parameters

Radial	20
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.174e+03	2.104e-32	7.399e-30	1.753e-34	6.163e-32
0.0322	5.857e+03	2.380e-31	1.524e-29	1.915e-33	1.226e-31
0.0364	2.131e+03	5.590e-25	4.582e-24	3.176e-27	2.603e-26
0.6616	1.380e+05	9.947e-04	1.070e-02	1.928e-06	2.075e-05
0.6938	5.300e+01	4.426e-07	4.500e-06	8.546e-10	8.688e-09
1.1732	3.249e+05	1.291e-02	7.326e-02	2.307e-05	1.309e-04
1.3325	3.249e+05	1.844e-02	9.230e-02	3.200e-05	1.601e-04
TOTALS:	7.991e+05	3.235e-02	1.763e-01	5.699e-05	3.118e-04

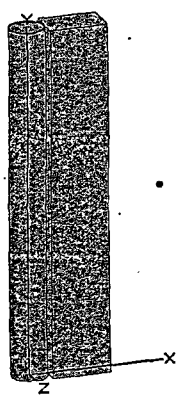
Attachment 8.5
Page 8.5.5 of 7 pages
Microshield Dose Results

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : BP1M1115.MS5
Run Date : November 16, 2005
Run Time : 3:37:29 PM
Duration : 00:00:19

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Buried Piping
Description: Receptor Dose with 1.0 meter of soil cover
Geometry: 12 - Annular Cylinder - External Dose Point



Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	29.926 cm	11.8 in

Dose Points

	X	Y	Z
# 1	230.48 cm	304.8 cm	0 cm
	7 ft 6.7 in	10 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Cyl. Core	29.926 cm³	Air	0.00122
Source	.1 cm	Iron	7.86
Shield 3	.454 cm	Iron	7.86
Transition		Air	0.00122
Shield 5	100.0 cm	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
~~Ba-137m~~	~~4.1440e-006~~	~~1.5333e+005~~	~~3.6093e-004~~	1.3355e+001
Co-60	8.7822e-006	3.2494e+005	7.6490e-004	2.8301e+001
Cs-137	4.3806e-006	1.6208e+005	3.8154e-004	1.4117e+001

Buildup
The material reference is : Shield 5

Integration Parameters

Radial	20
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.174e+03	1.183e-66	4.357e-30	9.857e-69	3.629e-32
0.0322	5.857e+03	1.147e-64	8.515e-30	9.234e-67	6.853e-32
0.0364	2.131e+03	2.471e-50	6.037e-30	1.404e-52	3.430e-32
0.6616	1.380e+05	8.014e-08	4.429e-06	1.554e-10	8.587e-09
0.6938	5.300e+01	4.281e-11	2.161e-09	8.266e-14	4.173e-12
1.1732	3.249e+05	8.247e-06	1.647e-04	1.474e-08	2.943e-07
1.3325	3.249e+05	1.786e-05	2.917e-04	3.098e-08	5.061e-07
TOTALS:	7.991e+05	2.619e-05	4.608e-04	4.588e-08	8.090e-07

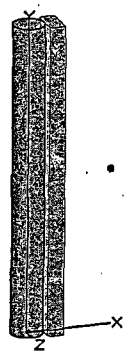
Attachment 8.5
Page 8.5.6 of 7 pages
Microshield Dose Results

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : BP1M1116.MS5
Run Date : November 16, 2005
Run Time : 3:46:49 PM
Duration : 00:00:13.

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Buried Pipe
Description: Disintegrated Pipe 0.3048 meter (1') of soil cover
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	30.48 cm	1 ft

Dose Points

	X	Y	Z
# 1	160.96 cm 5 ft 3.4 in	304.8 cm 10 ft 0.0 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.78e+06 cm³	Sand	1.6
Transition		Air	0.00122
Shield 2	30.48 cm	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.1440e-006	1.5333e+005	2.3292e-006	8.6179e-002
Co-60	8.7822e-006	3.2494e+005	4.9360e-006	1.8263e-001
Cs-137	4.3806e-006	1.6208e+005	2.4621e-006	9.1098e-002

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	20
Circumferential	30
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.174e+03	6.839e-22	3.140e-21	5.697e-24	2.615e-23
0.0322	5.857e+03	3.431e-21	1.625e-20	2.762e-23	1.308e-22
0.0364	2.131e+03	6.884e-18	4.556e-17	3.911e-20	2.588e-19
0.6616	1.380e+05	2.909e-04	3.565e-03	5.639e-07	6.912e-06
0.6938	5.300e+01	1.305e-07	1.513e-06	2.520e-10	2.922e-09
1.1732	3.249e+05	4.254e-03	2.781e-02	7.602e-06	4.970e-05
1.3325	3.249e+05	6.274e-03	3.619e-02	1.088e-05	6.279e-05
TOTALS:	7.991e+05	1.082e-02	6.757e-02	1.905e-05	1.194e-04

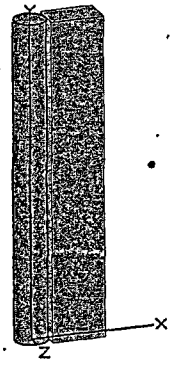
Attachment 8.5
Page 8.5.7 of 7 pages
Microshield Dose Results

MicroShield v5.05 (5.05-00488)
Sacramento Municipal Utility District

Page : 1
DOS File : BP1M1116.MS5
Run Date : November 16, 2005
Run Time: 8:52:11 AM
Duration : 00:00:13

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Buried Pipe
Description: Disintegrated Pipe 1.0 meter of soil cover
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	30.48 cm	1 ft

Dose Points

	X	Y	Z
# 1	230.48 cm 7 ft 6.7 in	304.8 cm 10 ft 0.0 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.78e+06 cm³	Sand	1.6
Transition		Air	0.00122
Shield 2	100.0 cm	Sand	1.6
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.1440e-006	1.5333e+005	2.3292e-006	8.6179e-002
Co-60	8.7822e-006	3.2494e+005	4.9360e-006	1.8263e-001
Cs-137	4.3806e-006	1.6208e+005	2.4621e-006	9.1098e-002

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	20
Circumferential	30
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0318	3.174e+03	3.000e-56	4.340e-30	2.499e-58	3.615e-32
0.0322	5.857e+03	1.295e-54	8.482e-30	1.042e-56	6.826e-32
0.0364	2.131e+03	2.455e-43	6.013e-30	1.395e-45	3.416e-32
0.6616	1.380e+05	2.389e-08	1.399e-06	4.631e-11	2.713e-09
0.6938	5.300e+01	1.288e-11	6.893e-10	2.486e-14	1.331e-12
1.1732	3.249e+05	2.783e-06	5.932e-05	4.974e-09	1.060e-07
1.3325	3.249e+05	6.226e-06	1.087e-04	1.080e-08	1.886e-07
TOTALS:	7.991e+05	9.033e-06	1.694e-04	1.582e-08	2.973e-07

Attachment 8.6
Page 8.6.1 of 2 pages
GEL Analytical Results for Turbine Polisher Sump SB899007 PM001, GEL # 1355690005, July 11, 2005

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

10 CFR Part 50/61 Certificate of Analysis

GEL Sample ID:	135569005	Client:	Rancho Seco Nuclear Generating Station
Client Sample ID:	#5 SB 899 0070 PM 01	Collect Date:	April 21, 2005
Matrix:	Sludge	Receive Date:	May 02, 2005
Amount of Sample Received:		Report Date:	July 11, 2005

Analyte	Run Date	Qualifier	Activity[2]	Uncertainty	MDA[1]	RL	TPU	Critical Level	Units
ALPHA	05/23/05	3	1.49E+01	7.07E+00	6.71E+00	4.00E+00	7.29E+00	2.57E+00	pCi/g
BETA	05/23/05	3	2.90E+02	1.68E+01	9.10E+00	1.00E+01	2.01E+01	4.22E+00	pCi/g
H-3	05/24/05	3	7.53E+00	2.84E+00	4.54E+00	6.00E+00	2.84E+00	2.22E+00	pCi/g
C-14	05/17/05	3	4.42E+00	1.13E+00	1.76E+00	2.00E+00	1.13E+00	8.64E-01	pCi/g
Fe-55	06/03/05	U	2.94E+01	2.61E+01	3.56E+01	5.00E+00	2.61E+01	1.76E+01	pCi/g
Ni-63	05/23/05	3	1.11E+03	2.38E+01	1.48E+01	4.00E+00	7.42E+01	7.24E+00	pCi/g
Tc-99	05/18/05	U	6.27E-01	2.11E+00	3.64E+00	5.00E+00	2.11E+00	1.74E+00	pCi/g
Pm-147	05/24/05	U	4.88E+00	3.88E+00	6.47E+00	1.00E+01	3.88E+00	3.19E+00	pCi/g
Pu-241	06/11/05	3	2.60E+01	1.47E+01	2.43E+01	1.50E+01	1.50E+01	1.20E+01	pCi/g
Total Strontium	05/12/05	U	4.16E-01	6.29E-01	1.40E+00	2.00E+00	6.29E-01	6.53E-01	pCi/g
Alpha Spec									
Np-237	05/12/05	U	6.05E-02	1.37E-01	3.14E-01	1.00E+00	1.37E-01	9.33E-02	pCi/g
Pu-238	05/27/05	U	4.18E-02	2.24E-01	6.19E-01	1.00E+00	2.24E-01	2.08E-01	pCi/g
Pu-239/240	05/27/05	U	2.06E-01	2.56E-01	3.72E-01	1.00E+00	2.57E-01	8.50E-02	pCi/g
Pu-242	05/27/05	U	1.06E-01	1.82E-01	3.16E-01	1.00E+00	1.82E-01	1.12E-01	pCi/g
Am-241	05/12/05	U	2.57E-01	2.38E-01	2.69E-01	1.00E+00	2.40E-01	6.14E-02	pCi/g
Cm-242	05/12/05	U	3.07E-02	1.22E-01	3.50E-01	1.00E+00	1.22E-01	9.52E-02	pCi/g
Cm-243/244	05/12/05	U	1.84E-01	2.97E-01	6.23E-01	1.00E+00	2.98E-01	2.38E-01	pCi/g
Cm-245/246	05/12/05	U	6.26E-02	1.23E-01	1.70E-01	1.00E+00	1.23E-01	0.00E+00	pCi/g
Gamma Spec									
Be-7	05/09/05	U	3.36E+00	4.38E+00	6.79E+00	7.00E-01	4.29E+00	3.32E+00	pCi/g
Na-22	05/09/05	U	-1.42E-01	1.88E-01	3.03E-01	8.00E-02	1.84E-01	1.36E-01	pCi/g
K-40	05/09/05	3	5.74E+00	3.13E+00	3.44E+00	1.00E+00	3.07E+00	1.56E+00	pCi/g
Cr-51	05/09/05	U	-1.34E+00	3.53E+00	5.36E+00	6.00E-01	3.46E+00	2.62E+00	pCi/g
Mn-54	05/09/05	U	-7.74E-03	3.02E-01	4.89E-01	1.00E-01	2.96E-01	2.34E-01	pCi/g
Fe-59	05/09/05	U	1.27E-01	8.08E-01	1.32E+00	3.00E-01	7.92E-01	6.28E-01	pCi/g
Co-56	05/09/05	U	2.08E-02	3.14E-01	5.13E-01	1.00E-01	3.08E-01	2.45E-01	pCi/g
Co-57	05/09/05	U	-7.58E-03	1.77E-01	2.25E-01	5.00E-02	1.73E-01	1.10E-01	pCi/g
Co-58	05/09/05	U	-1.86E-02	3.08E-01	5.00E-01	1.00E-01	3.02E-01	2.38E-01	pCi/g
Co-60	05/09/05	3	3.54E+01	2.44E+00	5.21E-01	1.00E-01	2.39E+00	2.45E-01	pCi/g
Ni-59	05/17/05	UUI	0.00E+00	7.45E+00	9.27E+00	2.00E+01	7.35E+00	4.45E+00	pCi/g
Zn-65	05/09/05	U	-4.18E-01	7.10E-01	1.10E+00	3.00E-01	6.95E-01	5.23E-01	pCi/g
Y-88	05/09/05	U	-1.13E-01	2.01E-01	3.28E-01	1.00E-01	1.97E-01	1.42E-01	pCi/g
Zr-95	05/09/05	U	-9.43E-02	5.03E-01	8.14E-01	2.00E-01	4.93E-01	3.87E-01	pCi/g
Nb-94	05/09/05	U	1.36E-01	2.10E-01	3.57E-01	1.00E+00	2.06E-01	1.70E-01	pCi/g
Nb-95	05/09/05	U	2.33E-01	3.30E-01	5.59E-01	5.00E-02	3.23E-01	2.67E-01	pCi/g
Ru-106	05/09/05	U	-4.60E-01	2.65E+00	4.27E+00	8.00E-01	2.60E+00	2.06E+00	pCi/g

Note(s): 1. Calculated MDAs are a-posteriori values.
2. Activity concentration net +/- 2 sigma overall on reference date.
3. Results are statistically positive at the 99.9% confidence level (activity is greater than three times the one sigma uncertainty)

U Target analyte was analyzed for but not detected above the MDL or LOD.
UI Uncertain identification for gamma spectroscopy.
X Lab-specific qualifier-please see case narrative, data summary package or contact your project manager for details.

Attachment 8.6
Page 8.6.2 of 2 pages
GEL Analytical Results for Turbine Polisher Sump SB899007 PM001, GEL # 1355690005, July 11, 2005

GENERAL ENGINEERING LABORATORIES, LLC

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

10 CFR Part 50/61 Certificate of Analysis

GEL Sample ID:	135569005	Client:	Rancho Seco Nuclear Generating Station
Client Sample ID:	#5 SB 899 0070 PM 01	Collect Date:	April 21, 2005
Matrix:	Sludge	Receive Date:	May 02, 2005
Amount of Sample Received:		Report Date:	July 11, 2005

Analyte	Run Date	Qualifier	Activity[2]	Uncertainty	MDA[1]	RL	TPU	Critical Level	Units
Ag-108m	05/09/05	U	1.33E-01	4.20E-01	6.45E-01	0.00E+00	4.12E-01	3.16E-01	pCi/g
Ag-110m	05/09/05	UUI	0.00E+00	5.18E-01	7.72E-01	8.00E-02	5.07E-01	3.77E-01	pCi/g
Sn-113	05/09/05	U	-4.10E-02	4.87E-01	7.43E-01	1.00E-01	4.78E-01	3.63E-01	pCi/g
Sb-124	05/09/05	U	1.86E-01	3.52E-01	5.13E-01	1.00E-01	3.45E-01	2.48E-01	pCi/g
Sb-125	05/09/05	U	3.97E-03	1.15E+00	1.75E+00	2.00E-01	1.13E+00	8.59E-01	pCi/g
Cs-134	05/09/05	U	2.24E-01	3.53E-01	4.79E-01	1.00E-01	3.46E-01	2.28E-01	pCi/g
Cs-136	05/09/05	U	-4.32E-02	1.09E+00	1.77E+00	3.00E-01	1.07E+00	8.42E-01	pCi/g
Cs-137	05/09/05	3	1.71E+02	1.85E+01	6.40E-01	1.00E-01	1.81E+01	3.11E-01	pCi/g
Ba-133	05/09/05	U	-4.55E-01	4.29E-01	6.32E-01	1.00E-01	4.21E-01	3.09E-01	pCi/g
Ba-140	05/09/05	U	-2.14E+00	2.96E+00	4.54E+00	5.00E-01	2.90E+00	2.20E+00	pCi/g
Ce-139	05/09/05	U	-9.16E-02	1.87E-01	2.64E-01	5.00E-02	1.84E-01	1.29E-01	pCi/g
Ce-141	05/09/05	U	-2.36E-02	4.42E-01	5.63E-01	1.00E-01	4.33E-01	2.75E-01	pCi/g
Ce-144	05/09/05	U	1.69E+00	1.82E+00	1.77E+00	5.00E-01	1.78E+00	8.66E-01	pCi/g
Nd-147	05/09/05	U	8.36E-01	6.73E+00	1.04E+01	1.00E+03	6.60E+00	5.03E+00	pCi/g
Pm-144	05/09/05	U	3.96E-02	2.13E-01	3.54E-01	8.00E-02	2.09E-01	1.68E-01	pCi/g
Pm-146	05/09/05	U	1.85E-02	5.87E-01	8.93E-01	1.00E+00	5.75E-01	4.38E-01	pCi/g
Eu-152	05/09/05	U	1.02E+00	1.09E+00	1.41E+00	2.00E-01	1.07E+00	6.91E-01	pCi/g
Eu-154	05/09/05	U	-3.95E-01	5.25E-01	8.45E-01	5.00E-01	5.14E-01	3.80E-01	pCi/g
Eu-155	05/09/05	U	3.89E-01	6.94E-01	9.06E-01	5.00E-01	6.80E-01	4.42E-01	pCi/g
Ir-192	05/09/05	U	2.78E-02	3.15E-01	4.85E-01	1.00E-01	3.09E-01	2.37E-01	pCi/g
Hg-203	05/09/05	U	-1.03E-01	3.42E-01	5.20E-01	1.00E-01	3.35E-01	2.54E-01	pCi/g
Tl-208	05/09/05	U	3.88E-03	3.02E-01	4.65E-01	8.00E-02	2.96E-01	2.24E-01	pCi/g
Pb-210	05/09/05	U	1.77E+01	2.86E+01	3.70E+01	4.00E+00	2.80E+01	1.80E+01	pCi/g
Pb-212	05/09/05	U	6.28E-01	4.32E-01	6.82E-01	1.00E-01	4.24E-01	3.34E-01	pCi/g
Pb-214	05/09/05	U	6.05E-01	6.74E-01	1.05E+00	1.00E-01	6.60E-01	5.15E-01	pCi/g
Bi-212	05/09/05	U	-1.99E+00	1.95E+00	2.97E+00	5.00E-01	1.91E+00	1.41E+00	pCi/g
Bi-214	05/09/05	U	4.27E-02	6.47E-01	9.17E-01	2.00E-01	6.34E-01	4.43E-01	pCi/g
Ra-228	05/09/05	U	3.50E-01	1.20E+00	1.96E+00	5.00E-01	1.17E+00	9.40E-01	pCi/g
Ac-228	05/09/05	U	3.50E-01	1.20E+00	1.96E+00	8.00E-01	1.17E+00	9.40E-01	pCi/g
Th-230	05/09/05	U	4.27E-02	6.47E-01	9.17E-01	1.00E+00	6.34E-01	4.43E-01	pCi/g
Th-234	05/09/05	U	6.28E+00	8.30E+00	1.08E+01	5.00E+00	8.14E+00	5.26E+00	pCi/g
U-235	05/09/05	UUI	0.00E+00	1.26E+00	1.83E+00	5.00E-01	1.23E+00	8.92E-01	pCi/g
U-238	05/09/05	U	6.28E+00	8.30E+00	1.08E+01	1.00E+00	8.14E+00	5.26E+00	pCi/g
Np-239	05/09/05	U	5.22E-01	1.27E+00	1.64E+00	2.00E+00	1.24E+00	8.01E-01	pCi/g
Am-241	05/09/05	U	-5.98E-01	1.04E+00	1.28E+00	2.00E-01	1.02E+00	6.26E-01	pCi/g

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