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AIR PATHWAY DOSE MODELING FOR THE F-AREA TANK FARM

Eduardo B. Farfan

AUGUST 6, 2007

Savannah River National Laboratory
Washington Savannah River Company
Savannah River Site
Aiken, SC 29808

Prepared for the U.S. Department of Energy Under
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SRNL

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REVIEWS AND APPROVALS

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Eduardo B. Farfan, Environmental Sciences and Biotechnology — Date

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Patricia L. Lee, Peer Reviewer, Environmental Sciences and Biotechnology — Date

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William E. Stevens, Environmental & Chemical Process Technology — Date

Marcia B. Birk — 8/14/07

Marcia B. Birk, Site Regulatory Integration and Planning — Date

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LIST OF ACRONYMS

CIG	Components in Grout
DF	Dose Conversion Factor
DRF	Dose-Release Factors
EDE	effective dose equivalent
FGR	Federal Guidance Report
FTF	F-Area Tank Farm
ICRP	International Commission on Radiological Protection
IL	Intermediate Level
LAW	Low Activity Waste
LLWF	Low Level Waste Facility
MEI	Maximally Exposed Individual
NCRP	National Council on Radiation Protection and Measurements
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NRCDA	Naval Reactor Component Disposal Areas
PA	Performance Assessment
SRS	Savannah River Site
USEPA	United States Environmental Protection Agency
USDOE	United States Department of Energy

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1.0 ABSTRACT

Dose-release factors (DRFs) were calculated for potential atmospheric releases of C-14, Cl-36, H-3, I-129, Sb-125, Se-79, Sn-126, and Tc-99 from the F-Area Tank Farm (FTF). DRFs represent the dose to the receptor exposed to 1 Ci of the specified radionuclide being released to the atmosphere. Receptors at the SRS boundary, 100, 400, 800, 1,200 and 1,600 meters from the source were evaluated assuming a point or area source where appropriate. These DRFs can be used to estimate flux rates for this facility to estimate the potential dose to an individual.

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2.0 INTRODUCTION

Site Regulatory Integration and Planning identified C-14, Cl-36, H-3, I-129, Sb-125, Se-79, Sn-126, and Tc-99 as potential radionuclides for atmospheric release from the F-Area Tank Farm (FTF) (Figure 1). The potential dose to an individual located at the SRS boundary (10,230 m), 100, 400, 800, 1,200, and 1,600 (seepline) meters due to exposure to these radionuclides if released from the FTF can be estimated by application of radionuclide-specific dose-release factors (DRFs) (mrem/Ci) to estimated flux rates (Ci/yr) at a particular time period. The methodology for estimating these DRFs for the FTF are described in this report.

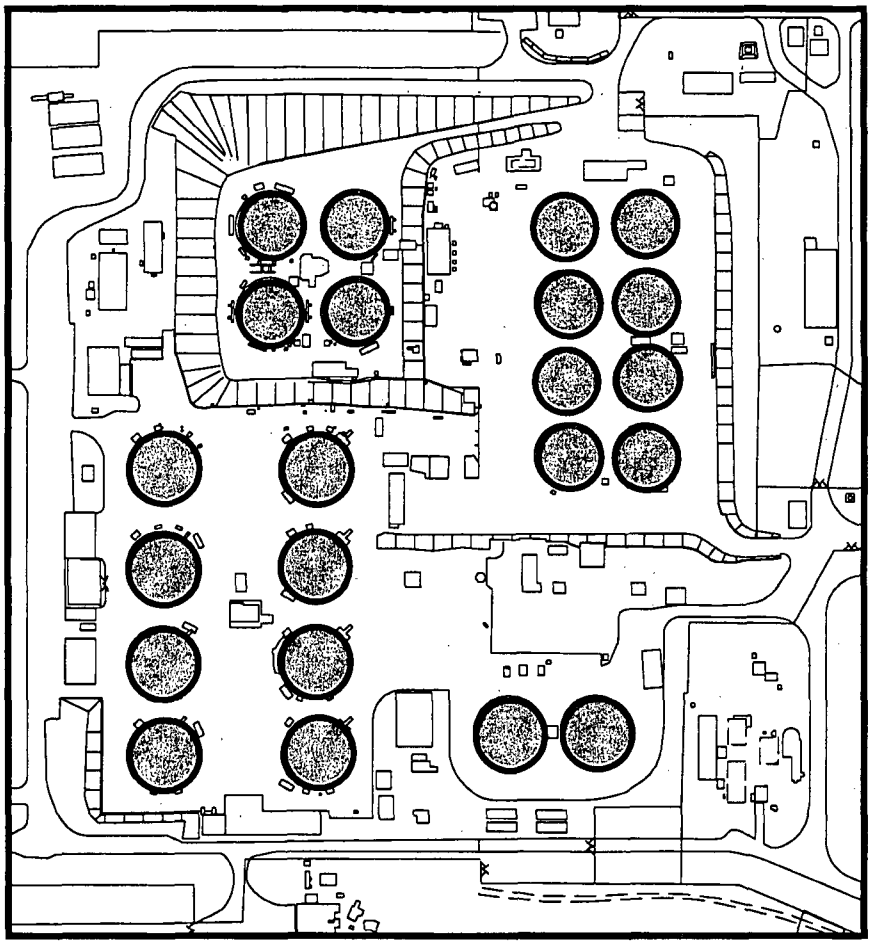

Figure 1. F-Area Tank Farm Conceptual Layout

2.1 F-AREA TANK FARM OVERVIEW

Figure 1 illustrates the layout of the F-Area Tank Farm. The dimensions of the FTF are 955.5 ft by 934.0 ft. Therefore, the area of this facility is 892,437 ft^2 (82,910 m^2) (Site Regulatory Integration and Planning). For the purposes of this evaluation, the FTF was assumed be of a uniform shape. The determination of area vs. point source is shown in Table 1.

Table 1. F-Area Tank Farm Area/Point Source Determination

Receptor Locations (m)	Receptor Location (m) /Eff. Length (m)*	Area Source (yes or no)
100	0.35	yes
400	1.39	yes
800	2.78	no
1200	4.17	no
1600	5.56	no
SRS Boundary**	35.53	no

*Effective Length is 287.94 m

**SRS Boundary = 10,230 m

2.2 DOSE-RELEASE FACTORS

Dose-release factors (DRFs) in mrem/Ci are estimated by modeling the effective dose equivalent (EDE) (mrem/yr) assuming an annual atmospheric release source term (Ci/yr) of the associated radionuclides. EDEs are modeled using the EPA computer code, CAP88 (Beres 1990) for demonstration of compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) (EPA 2002) where appropriate. The DRFs are simply the ratio of the EDE to the release activity.

For F-Area, the EDEs, and therefore the DRFs, were estimated for the maximally exposed individual (MEI) located at the site boundary (Lee 2003) and at distances of 100, 400, 800, 1,200, and 1,600 (seepline) meters from the release point. Point source DRFs were estimated for the MEI at the site boundary and 100-, 400-, 800-, 1,200-, and 1,600-meter locations. For radionuclides not contained within the CAP88 library, surrogates were assigned based on similar radiological properties and the dose was estimated by applying the appropriate dosimetric properties to the surrogate's relative air concentrations estimated by the model. Because of their size and close proximity to the source, area source DRFs were estimated for the receptor at 100 and 400 meters (See Table 1).

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3.0 DOSE METHODS

3.1 CAP88 MODELING

CAP88 (Beres 1990) models the EDE to a receptor at a specified location by first estimating the relative average air concentration (χ/Q) of the released radionuclides and then applying the appropriate exposure parameters and dosimetric values to estimate pathway-specific doses. To estimate the χ/Qs, CAP88 accesses a site-specific five-year meteorological database that includes wind speed, wind direction, temperature, dew point, and horizontal and vertical turbulence intensities. The resultant relative air concentrations are used to estimate EDE for ingestion, inhalation, plume shine (air immersion), and ground shine exposure pathways for the MEI. In accordance with 40CFR61 (EPA 2002), the MEI is assumed to be located at the nearest home, farm, business, or school and is assumed to eat vegetables, meat, and milk produced at that location.

For the FTF, 1 Ci of the radionuclides listed in Section 2.0 were assumed to be released from ground level and over a one year period. The 1997-2001 meteorological database for the F-Area (Weber and Kurzeja 2002) was used to disperse the releases to the MEI at the site boundary and an additional receptor locations are assumed to be 100, 400, 800, 1,200, and 1,600 meters from the potential release location. For F-Area, the MEI at the site boundary is located at a distance of approximately 10,230 meters in the west-southwest (WSW) cardinal direction (247.25° from the north) (Lee 2003). Site- and pathway- specific parameters used in the CAP88 model to estimate the resultant EDEs are taken from Lee (2001).

CAP88 model results assuming a 1 Ci release of the radionuclides listed in Section 2.0 from the FTF are listed in Table 2. Radionuclides not contained within the CAP88 database (Cl-36 and Se-79) are not listed in Table 2 but are discussed in subsequent sections (Section 3.2).

Table 2. Cap88 Model Results - EDE (mrem/yr)

	Receptor Location (m)					
Radionuclide	**100**	**400**	**800**	**1200**	**1600**	**SRS Boundary**
C-14	3.9E-01	2.9E-02	8.0E-03	3.9E-03	2.4E-03	1.4E-04
H-3	8.1E-03	6.0E-04	1.7E-04	8.0E-05	4.9E-05	2.8E-06
I-129	5.9E+02	3.6E+01	8.8E+00	4.0E+00	2.3E+00	7.4E-02
Sb-125	1.1E+01	9.3E-01	2.8E-01	1.5E-01	9.7E-02	8.4E-03
Sn-126*	5.1E+02	4.2E+01	1.3E+01	6.8E+00	4.4E+00	3.8E-01
Tc-99	3.1E+00	2.5E-01	7.7E-02	4.1E-02	2.6E-02	2.3E-03

*Includes progeny

3.2 RADIONUCLIDES NOT CONTAINED IN CAP88

Two of the radionuclides listed in Section 2.0 are not contained within the CAP88 library (Cl-36 and Se-79). Therefore atmospheric transport was assumed to be equivalent to that of surrogate radionuclides with similar radiological properties (Table 3).

Table 3. Surrogates for Radionuclides not in CAP88 Database

Radionuclide	Half-Life (yr)	Surrogate	Surrogate Half-Life (yr)
Cl-36	3.01E+05	Sn-126	2.30E+05
Se-79	2.95E+05	Sn-126	2.30E+05

EDEs for these radionuclides were estimated by applying their pathway-specific dosimetric properties to the surrogate's χ/Q estimated by the model. For ease, this was accomplished by applying a ratio of the dose coefficients to the surrogate EDEs estimated by the model. For example, the EDEs for Se-79 are estimated as follows:

$$EDE_{Se-79} = EDE^{Ing}_{Sn-126} * \frac{DF^{Ing}_{Se-79}}{DF^{Ing}_{Sn-126}} + EDE^{Inh}_{Sn-126} * \frac{DF^{Inh}_{Se-79}}{DF^{Inh}_{Sn-126}} + EDE^{plume}_{Sn-126} * \frac{DF^{plume}_{Se-79}}{DF^{plume}_{Sn-126}} + EDE^{ground}_{Sn-126} * \frac{DF^{ground}_{Se-79}}{DF^{ground}_{Sn-126}}$$

where,

DF^{ing} = ingestion dose conversion factors from EPA (1988)[1] (mrem/pCi)
DF^{inh} = inhalation dose conversion factors from EPA (1988)[1] (mrem/pCi)
DF^{plume} = air immersion dose conversion factors from EPA (1993)[1] (rem/hr per $\mu Ci/cm^3$)
DF^{ground} = ground surface dose conversion factors from EPA (1993)[1] (rem/hr per $\mu Ci/cm^2$)

EDEs for the radionuclides in Table 3 based on this methodology are listed in Table 4.

Table 4. Point Source EDE (mrem/yr) for radionuclides not in CAP88

	Receptor Location (m)					
Radionuclide	**100**	**400**	**800**	**1200**	**1600**	**SRS Boundary**
Cl-36*	8.3E-01	6.5E-02	1.9E-02	9.7E-03	6.2E-03	4.6E-04
Se-79*	1.1E+00	9.0E-02	2.7E-02	1.4E-02	9.4E-03	7.6E-04

*Based on Sn-126 surrogate relative air concentration

[1] EPA (1988 and 1993) used only for radionuclides not in the CAP88 database. DFs for radionuclides contained in the CAP88 database are those supplied by CAP88.

3.3 AREA SOURCE ESTIMATES

CAP88 models area sources for releases where the receptor distance/source effective length ratio is less that 2.5 (EPA 2006). Based on the source dimensions in Table 1, the F-Area Farm Tank must be treated as an area source when considering receptor distances of 100 and 400 meters. However, CAP88 Version 1.0 is deemed inappropriate close to the source (distance/diameter ratio is less than 1.3) as stated in Moore et al. (1979) and it does not handle area sources (Beres 1990). Therefore, point source and area source sector-average relative air concentration were estimated as described in Simpkins and Lee (2006).

The estimated point source area concentration (χ/Q) of 8.1E-4 s/m^3 calculated in Simpkins and Lee (2006) was compared to the area source sector-average relative air concentrations for the FTF to estimate the point/area source ratio for a receptor location of 100 meters. Similar calculations were performed for 400 meters, which resulted in an estimated point source area concentration (χ/Q) of 5.9E-5 s/m^3. The area source average air concentrations and point/area source ratios are listed in Table 5. The point/area sources are conservatively rounded down to the nearest integer to roughly represent the overestimate of the average air concentration that would result from assuming a point source. These factors are applied to the CAP88 modeled 100- and 400-meter point source estimate to determine estimate area source EDEs for the FTF. Area source estimates for the FTF are listed in Table 6.

Table 5. Area to Point Source Comparisons

Receptor Distance (m)	Point Source χ/Q (s/m^3)	Area Source (s/m^3)	Point/Area Ratio
100	8.1E-04	2.8E-05	29
400	5.9E-05	3.8E-06	15

Table 6. Area Source Atmospheric EDE (mrem/yr) for F-Area Tank Farm

Radionuclide	Receptor Location (m)	
	100	400
C-14	2.8E-04	4.0E-05
Cl-36*	2.9E-02	4.3E-03
H-3	1.3E-02	1.9E-03
I-129	2.0E+01	2.4E+00
Sb-125	3.9E-01	6.2E-02
Se-79*	3.8E-02	6.0E-03
Sn-126**	1.8E+01	2.8E+00
Tc-99	1.1E-01	1.7E-02

*Not in CAP88 database. Based on Sn-126 surrogate χ/Q

**Includes progeny

4.0 RESULTS AND CONCLUSIONS

As described in Section 2.2 DRFs are merely the ratio of the EDE to the annual release activity. Because the model was executed assuming 1 Ci release, these DRFs are equal to the appropriate estimated EDEs. DRFs for the receptor located at the site boundary (10,230 m). Additional receptor locations were also considered: 100, 400, 800, 1,200 and 1,600 meters from the FTF are listed in Table 7. These factors can be applied to expected release values from each disposal unit to estimate the potential dose to an individual located at each location.

Table 7. Atmospheric DRFs (mrem/Ci) for the F-Area Tank Farm

	Receptor Location (m)					
Radionuclide	**100**	**400**	**800**	**1200**	**1600**	**SRS Boundary**
C-14	2.8E-04	4.0E-05	8.0E-03	3.9E-03	2.4E-03	1.4E-04
Cl-36*	2.9E-02	4.3E-03	1.9E-02	9.7E-03	6.2E-03	4.6E-04
H-3	1.3E-02	1.9E-03	1.7E-04	8.0E-05	4.9E-05	2.8E-06
I-129	2.0E+01	2.4E+00	8.8E+00	4.0E+00	2.3E+00	7.4E-02
Sb-125	3.9E-01	6.2E-02	2.8E-01	1.5E-01	9.7E-02	8.4E-03
Se-79*	3.8E-02	6.0E-03	2.7E-02	1.4E-02	9.1E-03	7.6E-04
Sn-126**	1.8E+01	2.8E+00	1.3E+01	6.8E+00	4.4E+00	3.8E-01
Tc-99	1.1E-01	1.7E-02	7.7E-02	4.1E-02	2.6E-02	2.3E-03

*Not in CAP88 database. Based on Sn-126 surrogate x/Q

**Includes Progeny

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5.0 REFERENCES

Beres, D.A. 1990, The Clean Air Act Assessment Package-1988 (CAP-88) A Dose and Risk Assessment Methodology for Radionuclide Emissions to Air, U.S. Environmental Protection Agency Contract No. 68-D9-0170, Washington, D.C.

Lee, P.L. Environmental Dose Assessment Manual, WSRC-IM-91-1, Rev 3., Westinghouse Savannah River Company, Aiken, SC. July 2001.

Lee, P.L. Maximally Exposed Offsite Individual Worst Sector Determination for NESHAP Compliance Using 1997-2001 Meteorological Data. WSRC-RP-2003-000326. May 2003.

Moore, R.E., C.F. Baes III, L.M. McDowell-Boyer, A.P. Watson, F.O. Hoffman, J.C. Pleasant, C.W. Miller 1979, AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides, Oak Ridge National Laboratory Report: ORNL-5532, Oak Ridge, TN.

Simpkins, A.A. and Lee, P.L. "Modeling a Potential Atmospheric Release from a Waste Disposal Facility at the Savannah River Site as and Area Source" Operational Radiation Safety Supplement to the Health Physics Journal. Vol. 91, No. 2 August 2006.

United States Environmental Protection Agency. CAP88-PC Version 3.0 User Guide. Office of Radiation and Indoor Air. Washington DC 20460. March 2006.

U.S. Environmental Protection Agency, National Emission Standards for Hazardous Air Pollutants; Radionuclides, Title 40 Code of Federal Regulations, Part 61, Washington, D.C. 2002.

U.S. Environmental Protection Agency, Limiting Values of Radionuclides Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. Federal Guidance Report No. 11. EPA 520/1-88-020. Washington, DC. 1988.

U.S. Environmental Protection Agency, External Exposure to Radionuclides in Air, Water, and Soil, Federal Guidance Report No. 12. EPA 402-R-93-081. Washington, DC. 1993.

Weber, A.H and Kurzeja, R.J., Summary of Data and Steps for Processing the SRS 1997-2001 Meteorological Database (U). WSRC-TR-2002-00445, Westinghouse Savannah River Company, Aiken, SC, November 2002.