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AIR PATHWAY DOSE MODELING FOR THE SALTSTONE DISPOSAL FACILITY

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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 Saltstone Disposal Facility (SDF). DRFs represent the dose to the receptor exposed to 1 Ci of the specified radionuclide being released to the atmosphere. Receptors at the SRS site boundary were evaluated assuming a point source. Receptors at 100 meters were evaluated assuming an area source due to the receptor proximity to the SDF relative to the size of the source. These DRFs can be applied to estimate flux rates for this facility to estimate the potential dose to an individual.

2.0 INTRODUCTION

The SDF is 650,000 m^2 (Jones and Phifer 2008) yielding an effective length of 806 m. For the purposes of this evaluation, the SDF is assumed to be of a uniform shape. C-14, Cl-36, H-3, I-129, Sb-125, Se-79, Sb-126, Sn-126, and Tc-99 were identified by the Section 3116 support group as potential radionuclides for atmospheric release from the SDF. Sb-126 is not evaluated separately because it is included as progeny in the Sn-126 evaluation.

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). The DRFs are simply the ratio of the EDE to the release activity. The potential dose to an individual located at the SRS boundary and 100 meters due to exposure to these radionuclides if released from the SDF can be estimated by application of radionuclide-specific DRFs (mrem/Ci) to estimated flux rates (Ci/yr) at a particular time period.

The methodology for estimating these DRFs for the SDF are described in this report.

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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. For the SDF, the EDEs, and therefore the DRFs, were estimated for the maximally exposed individual (MEI) located at the site boundary (Farfan 2008) and at distances of 100 meters from the release point. 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 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 the large SDF size an evaluation was performed to determine if the release required modeling as an area or point source for all receptors. CAP88 models area sources for releases where the receptor distance/source effective length ratio is less that 2.5 (EPA 2006). Employing this evaluation, the 100 m receptor was modeled as an area source due to its close proximity to the source (see Table 1). The receptor at the site boundary is modeled as a point source.

Table 1. SDF Area/Point Source Determination

Receptor Locations	Distance/Length	Area Source (yes or no)
100 m	0.1	yes
SRS Boundary (11,800 m)	14.6	no

For the SDF, 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 2002-2006 meteorological database for H Area (Kabela and Weber 2007) was used to disperse the releases to the MEI at the site boundary and 100 meters from the potential release location. The MEI at the site boundary is located at a distance of approximately 11,800 meters from the SDF in the north cardinal direction (Farfan 2008). 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 SDF 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 (Point Source) - EDE (mrem/yr)

Radionuclide	Receptor Location	
	100 m	11,800 m(SRS Boundary)
C-14	3.7E-01	1.1E-04
H-3	7.7E-03	2.3E-06
I-129	5.5E+02	4.8E-02
Sb-125	1.1E+01	6.6E-03
Sn-126*	4.9E+02	3.0E-01
Tc-99	2.9E+00	1.8E-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 $\mu Ci/cm^2$)

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

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

Radionuclide	Receptor Location (m) 100	11,800 (SRS Boundary)
Cl-36	7.9E-01	3.6E-04
Se-79	1.1E+00	6.0E-04

3.3 AREA SOURCE EVALUATION

Based on the source dimensions in Table 1, the SDF must be treated as an area source when considering receptor distances of 100 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).

Simpkins and Lee (2006) estimated a point source sector-average concentration 8.1E-4 s/m^3 using average weather conditions. The estimated point source area concentration (χ/Q) of 6.2E-6 s/m^3 calculated based on the methodology in Simpkins and Lee (2006) using the 2002-2006 meteorological database was compared to the area source sector-average relative air concentrations for the SDF to estimate the point/area source ratio for a receptor location of 100 meters. The area source average air concentrations and point/area source ratio of 130 is conservatively rounded down to 100 to represent the overestimate of the average air concentration that would result from assuming a point source. This factor is applied to the CAP88 modeled 100 meter point source estimate to determine estimate area source EDEs for the SDF. Area source estimates for the SDF are listed in Table 5.

Table 5. Area Source Atmospheric EDE (mrem/yr)

Radionuclide	Receptor Location (m) 100
C-14	3.7E-03
Cl-36*	7.9E-03
H-3	7.7E-05
I-129	5.5E+00
Sb-125	1.1E-01
Se-79*	1.1E-02
Sn-126**	4.9E+00
Tc-99	2.9E-02

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

**Includes progeny

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4.0 RESULTS AND CONCLUSIONS

As described in Section 2.0 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 (11,800 m) and 100 meters is listed in Table 6. 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 6. SDF Atmospheric DRFs (mrem/Ci)

Radionuclide	Receptor Location (m)	
	100	11,800 (SRS Boundary)
C-14	3.7E-03	1.1E-04
Cl-36*	7.9E-03	3.6E-04
H-3	7.7E-05	2.3E-06
I-129	5.5E+00	4.8E-02
Sb-125	1.1E-01	6.6E-03
Se-79*	1.1E-02	6.0E-04
Sn-126**	4.9E+00	3.0E-01
Tc-99	2.9E-02	1.8E-03

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

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