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Disclaimer:

Radiological Impact of 2016 Operations at the Savannah River Site

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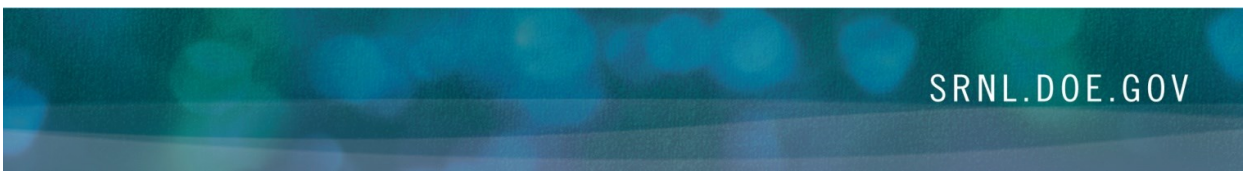

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Savannah River National Laboratory™
OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

EXECUTIVE SUMMARY

This report presents the environmental dose assessment methods and the estimated potential doses to the offsite public from 2016 Savannah River Site (SRS) air and liquid radioactive releases. Also documented are potential doses from special-case exposure scenarios, such as the consumption of wildlife or goat milk.

Dose to the Offsite Representative Person

The 2016 dose to the offsite representative person from SRS liquid releases was 0.15 mrem and from SRS air releases was 0.038 mrem. To show compliance with the U. S. Department of Energy (DOE) all-pathway dose standard of 100 mrem/yr, SRS conservatively adds these two doses for a total representative person dose of 0.19 mrem which is 0.19% of the DOE standard.

Sportsman Doses

Onsite Hunter: SRS conducts annual hunts to control onsite deer and feral hog populations. The estimated dose from consuming harvested deer or hog meat is determined for every onsite hunter. During 2016, the maximum potential dose an onsite hunter received was 13.5 mrem, or 13.5% of DOE's 100 mrem/yr all-pathway dose standard.

Creek Mouth Fisherman: SRS estimated the maximum potential dose from fish consumption at 0.22 mrem from bass collected at the mouth of Fourmile Branch. This dose is 0.22% of the DOE standard. SRS bases this hypothetical dose on the low probability scenario that, during 2016, a fisherman consumed 24 kg (53 lb) of bass caught exclusively from the mouth of Fourmile Branch.

Release of Material Containing Residual Radioactivity

SRS did not release any real property (land or buildings) in 2016. SRS unconditionally released a total of 11,516 items of personal property (such as tools) from radiological areas in 2016. Most of these items did not leave the Site. However, all of these items required no additional radiological controls post-survey as they met DOE Order 458.1 release criteria.

Radiation Dose to Aquatic and Terrestrial Biota

SRS conducts screening evaluations of plant and animal doses for aquatic and terrestrial ecosystems. For 2016, all but one SRS aquatic system locations passed the initial screening and no further assessments were required at those locations. The Z-Area Basin sampling location failed the Level 1 screening with a sum of the fractions of 1.05. This location did pass an additional Level 2 screening using average concentrations, and thus no further assessments were needed.

For the land based systems evaluation, SRS performed initial screenings using concentration data from the five onsite radiological soil sampling locations. Typically, SRS collects and analyzes only one soil sample per year from each location. For 2016, all land based locations passed their initial pathway screenings.

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LIST OF ACRONYMS AND ABBREVIATIONS

ALARA	As Low as Reasonably Achievable
BCG	Biota Concentration Guide
BJWSA	Beaufort-Jasper Water and Sewer Authority
BLLDF	Barnwell Low-Level Disposal Facility
DOE	U. S. Department of Energy
EPA	U. S. Environmental Protection Agency
GDNR	Georgia Department of Natural Resources
ICRP	International Commission on Radiological Protection
MCL	Maximum Contaminant Levels
MEI	Maximally Exposed Individual
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NRC	Nuclear Regulatory Commission
RM	River Mile
SCDHEC	South Carolina Department of Health and Environmental Control
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
USGS	U. S. Geological Survey
VEGP	Georgia Power Company's Vogtle Electric Generating Plant

Introduction

This report presents environmental dose assessment methods and the estimated potential doses to the offsite public from 2016 Savannah River Site (SRS) atmospheric and liquid radioactive releases. It also documents potential doses from special-case exposure scenarios, such as the consumption of wildlife and/or goat milk. Unless noted, the generic term "dose," as used in this report, includes both the committed effective dose (50-year committed dose) from internal deposition of radionuclides and the effective dose attributable to sources external to the body. Using the effective dose allows doses from different types of radiation and to different parts of the body to be expressed on the same basis.

Humans, plants, and animals potentially receive radiation doses from natural and man-made occurrences. The average annual "background" dose for all people living in the United States is 625 mrem. This includes an average background dose of 311 mrem from naturally occurring radionuclides (found in our bodies and in the earth) and from cosmic radiation. Man-made sources include medical procedures (300 mrem), consumer products (13 mrem), and industrial and occupational exposures (less than 1 mrem).

The U.S. Department of Energy (DOE) has established dose limits to the public, so that DOE operations will not contribute significantly to this average annual exposure. DOE Order 458.1 (DOE 2013) establishes 100 mrem/yr (1 mSv/yr) as the annual dose limit to a member of the public. As shown in Figure 1-1, radiation exposure primarily occurs through the following pathways:

- Inhalation,
- Ingestion,
- Skin absorption, and
- Direct (external) exposure to radionuclides in soil, air, and water.

1.0 Dose Assessment Methods

DOE Order 458.1 (2013) states that compliance with the DOE annual dose limit of 100 mrem (1 mSv), for a member of the public, may be demonstrated by calculating dose to the maximally exposed individual (MEI) or to a representative person. Prior to 2012, SRS used the MEI concept for dose compliance using adult dose coefficients and adult male usage parameters. Beginning in 2012, SRS now uses the representative person concept for dose compliance.

1.1 Representative Person

DOE Order 458.1 (2013) defines the representative person as an individual receiving a dose that is representative of the more highly exposed individuals in the population. This term is equivalent of and replaces the "average member of the critical group." However, in the *International Commission on Radiological Protection* (ICRP) *Report 101* (ICRP 2006), the definition is extended to include the average value for the more highly exposed group or the 95th percentile of appropriate national or regional data. At SRS, the reference person who is at the 95th percentile of national usage data is now used as a replacement for the MEI.

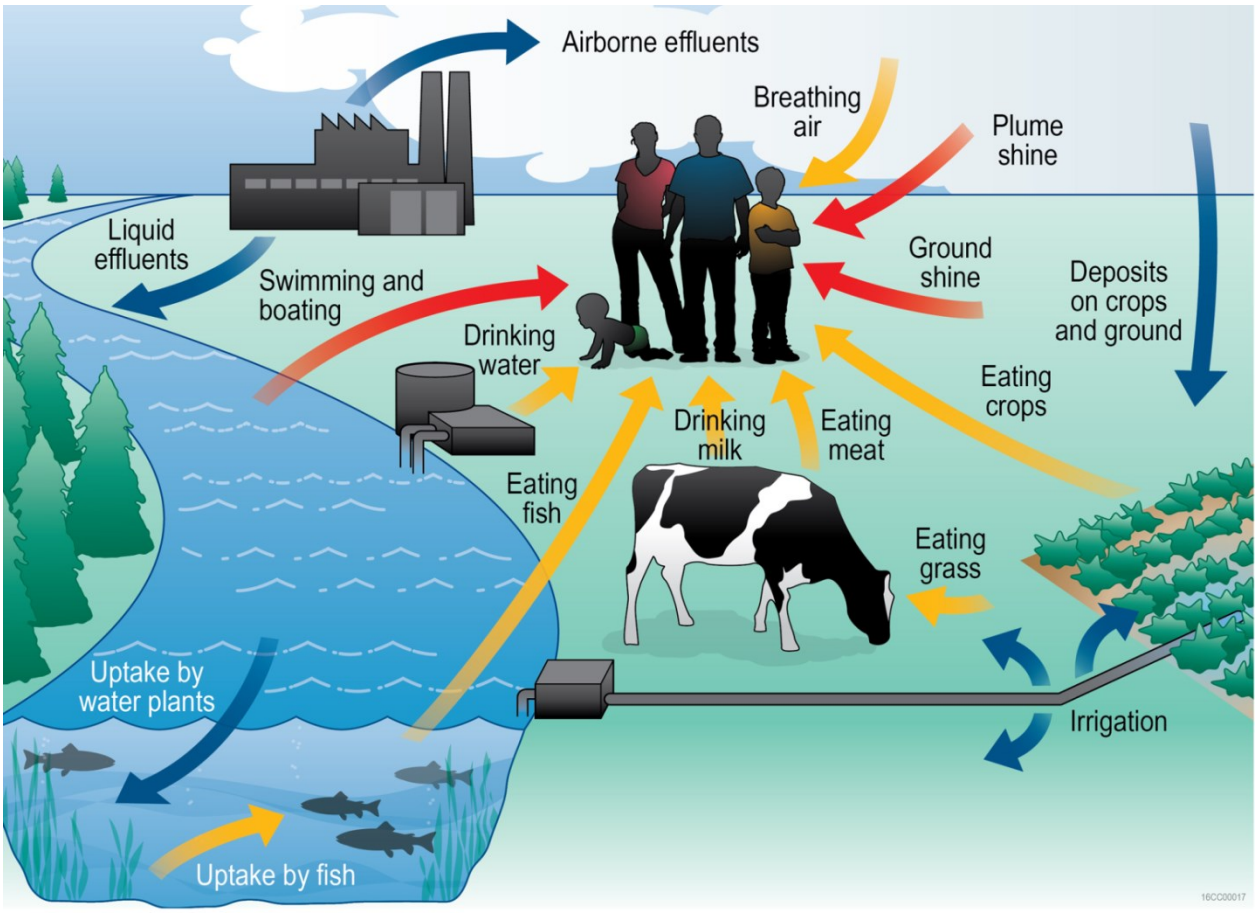


Figure 1-1. Exposure Pathways to Humans from Atmospheric and Liquid Effluents

The representative person dose is based on reference person usage parameters (at the 95th percentile of national and regional data) developed specifically for SRS. The applicable national and regional data used are from the EPA *Exposure Factors Handbook (Final Report)* (EPA 2011). SRS also developed reference usage parameters at the 50th percentile to calculate dose to a "typical" person for determining collective (population) doses.

The reference person is weighted, based on sex and age, and this weighting is based on the six age groups documented in Report 89 (ICRP 2002): infant (0 years), 1 year, 5 years, 10 years, 15 years, and adult. The EPA (2011) proportioned the various age- and gender-specific intake rates to correspond with these respective age groupings. The SRS-specific reference person usage parameters were developed by Stone and Jannik (2013) and are provided in Table 1-1.

The *Land and Water Use Characteristics and Human Health Input Parameters for use in Environmental Dosimetry and Risk Assessments at the Savannah River Site* (Jannik et al. 2017) documents all other applicable land- and water- use parameters used in the dose calculations. These parameters include local characteristics of food production, river recreational activities, and other human usage parameters required in the SRS dosimetry models. In addition, SRS documents the preferred elemental bioaccumulation and transfer factors to be used in human health exposure calculations in this land and water report. Data Table A-1 and Data Table A-2 provide a summary of the site-specific input parameters that are the most important to the dose calculations for the liquid and airborne pathways, respectively.

Table 1-1. SRS Reference and Typical Person Usage Parameters

	Unit	Reference Person	Typical Person
Air	m^3/y	6,400	5,000[a]
Water	L/y	800	300[b]
Meat	kg/y	81	32[c]
Leafy Vegetables	kg/y	31	11
Other Produce	kg/y	289	89
Milk/Dairy	L/y	260	69
Freshwater Fish	kg/y	24	3.7
Saltwater Invertebrate	kg/y	9.0	1.5

a. 1 cubic meter = 1.3 cubic yards
b. 1 liter = 1.06 quarts
c. ***1 kilogram = 2.2 pounds***

1.2 Dose Models

SRS calculates the potential offsite doses from SRS effluent releases of radioactive materials (air and liquid) for the following scenarios for DOE public dose compliance:

- Representative person living at the SRS boundary
- Population living within a 50-mile (80-kilometer [km]) radius of SRS

To demonstrate compliance with the DOE Order 458.1 all-pathway dose standard of 100 mrem per year, SRS conservatively combines the air pathway and liquid pathway dose estimates, even though the two doses are calculated for hypothetical individuals residing at different geographic locations.

For SRS dose calculations, unspecified alpha releases were treated as plutonium-239, and unspecified beta releases as strontium-90. These radionuclides have the highest dose factors of the alpha- and beta-emitters, respectively, commonly measured in SRS waste streams.

SRS has assessed the potential effects of routine radioactive releases annually since operations began and, since 1972, has published annual offsite dose estimates in Site environmental reports made available to the public. For all routine environmental dose calculations performed since 1978, SRS has used environmental transport models based on the Nuclear Regulatory Commission (NRC) developed codes (NRC 1977). The NRC-based transport models use DOE accepted methods, consider all significant exposure pathways, and permit detailed analysis of the effects of routine operations. For showing compliance with DOE Order 458.1 at SRS, the MAXDOSE-SR and POPDOSE-SR codes are used for air releases (representative person and population, respectively) and LADTAP XL© is used for liquid releases. The *SRS Environmental Dose Assessment Manual* (SRNL 2017) describes these models.

To demonstrate compliance with EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations (EPA 2006), SRS calculated the MEI and collective doses using 1) the CAP88 PC version 4.0.1.17 computer code, 2) the 2016 airborne-release source term (Data Table A-23), and 3) site-specific input parameters (Data Table A-24). The EPA requires the use of the MEI concept and does not allow use of the reference person concept at this time. The EPA hard-codes most of the input parameters in the CAP88 PC program, and they cannot be changed without EPA approval.

1.3 Dose Coefficients

From 1988 through 2009, SRS used the internal and external dose conversion factors provided in DOE (1988). In 2010, the internal dose conversion factors were updated to use the dose factors from ICRP Publication 72 (ICRP 1996) and the external dose conversion factors were updated to the dose factors provided in *Federal Guidance Report 12* (EPA 1993). From 2012 to the present, the dose to a representative person is based on: 1) the SRS-specific reference person usage parameters at the 95th percentile of appropriate national or regional data documented in Stone and Jannik (2013), 2) the reference person (gender- and age-averaged) ingestion and inhalation dose coefficients documented in *DOE Derived Concentration Technical Standard*, DOE-STD-1196-2011 (DOE 2011), and 3) the external dose coefficients provided in the DC_PAK3 toolbox. The DC_PAK3 toolbox can be accessed at http://www.epa.gov/rpdweb00/federal/ techdocs.html. Currently, there are no age-specific external dose factors available.

1.4 Meteorological Database

SRS calculated the potential offsite doses from radiological releases to the air with quality-assured meteorological data for A-Area, K-Area (for combined releases from C-Area, K-Area, and L-Area), and H-Area (for combined releases from all other areas) for DOE compliance. To show compliance with NESHAP regulations (EPA 2006), only the H-Area meteorological database was used in the calculations, because the EPA-required dosimetry code (CAP88 PC version 4.0.1.17) is limited to a single release location.

The current five-year meteorological datasets used in dose calculations cover the period 2007 through 2011 (Viner 2013). These datasets differ from previous five-year datasets in that they now 1) estimate atmospheric stability using the standard deviation of the vertical wind velocity and 2) use an updated surface roughness factor for SRS. Data Table A-3 shows the 2007-2011 meteorological database for H-Area. Figure 1-2 is the H-Area wind rose for 2007-2011, with the directions shown being those toward which the wind blows. As shown, the wind blows towards the East-Northeast the highest percentage of time (about 9%).

1.5 Population Database and Distribution

SRS calculates the collective (population) doses from air releases for the population within a 50-mile radius of the Site. Based on the U.S. Census Bureau's 2010 data, the population within a 50-mile radius of the center of SRS is 781,060. This translates to an average population density of about 104 people per square mile outside the SRS boundary, with the largest concentration in the Augusta metropolitan area. Data Table A-4 shows the population distribution around SRS.

SRS also calculates the collective doses resulting from SRS liquid releases for the populations served by the City of Savannah Industrial and Domestic Water Supply Plant (City of Savannah I&D), near Port Wentworth, Georgia, and for the Beaufort-Jasper Water and Sewer Authority's (BJWSA) Chelsea and Purrysburg Water Treatment Plants, both near Beaufort, South Carolina. According to the treatment plant operators, the population served by the City of Savannah I&D facility during 2016 was 35,000 people while the BJWSA Chelsea facility served 83,700 people and the BJWSA Purrysburg facility served 64,800 people. The total population dose resulting from routine SRS liquid releases is the sum of five contributing categories: 1) BJWSA water consumers, 2) City of Savannah I&D water consumers, 3) consumption of fish and invertebrates of Savannah River origin, 4) recreational activities on the Savannah River, and 5) irrigation of foodstuffs using river water near River Mile (RM) 118.8 (U.S. Highway 301 bridge).

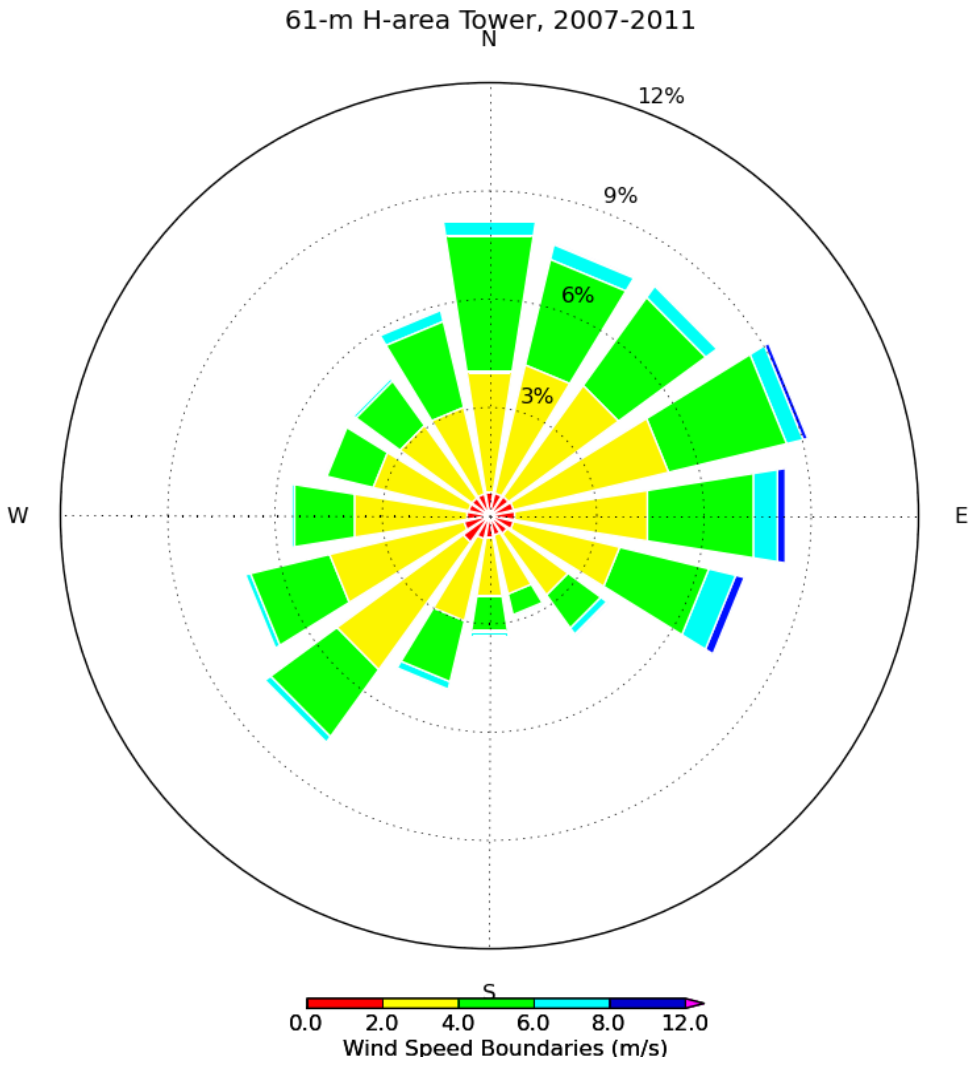


Figure 1-2. 2007-2011 Wind Rose for H-Area (Direction is toward which the wind blows)

1.6 Savannah River Flow Rate Data

SRS determines the Savannah River annual average flow rates using the recorded water elevation at a U.S. Geological Survey (USGS) gauging station #02197500, near RM 118.8. Data Table A-5 provides river flow rates measured at this location from 1954 through 2016. Figure 1-3 shows that the average river flow rate for these years is about 10,000 cubic feet per second (cfs). However, recently, there has been a downward trend in these data, with an average measured flow rate of just 7,567 cfs during the past 10 years.

The SRS liquid dose calculations typically do not use these data. Instead, SRS uses an "effective" flow rates based on 1) the measured annual release of tritium and 2) the annual average tritium concentrations measured from RM 118.8 and from the downriver water treatment plants. Data Table A-6 provides the effective river flow rate calculations.

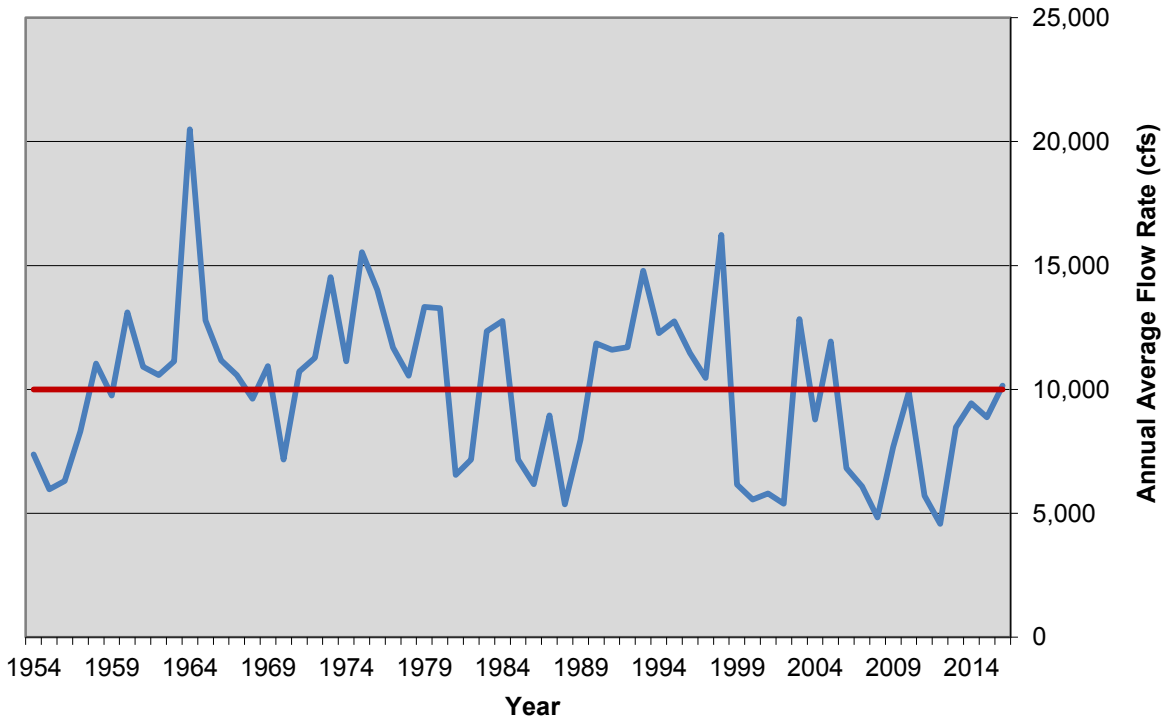


Figure 1-3. Savannah River Annual Average Flow Rates at River Mile 118.8

The effective flow rates used in the dose calculations are usually more conservative (that is, lead to higher dose estimates) than the measured flow rates because it accounts for less dilution. However, if SRS calculates an effective flow that is more than the measured value at RM 118.8, then the measured value is used.

For 2016, SRS used an effective Savannah River flow rate of 6,426 cfs in the dose calculations. The 2016 effective flow rate is 8% more than the 2015 effective flow rate of 5,972 cfs. This estimated flow rate (based on actual measured tritium concentrations in the river) is more conservative than the 2016 USGS measured flow rate (at RM 118.8) of 10,150 cfs.

2.0 Dose Calculation Results

2.1 Liquid Pathway Doses

No known large-scale uses of Savannah River water downstream of SRS exist for agricultural irrigation purposes. However, the potential for agricultural irrigation does exist, especially for individual garden use. Therefore, the totals for the SRS representative person and collective dose include doses from the irrigation pathway.

2.1.1 Liquid Release Source Terms

Table 2-1 shows, by radionuclide, the 2016 radioactive liquid release quantities used as the source term in SRS dose calculations and Data Table A-7 shows these liquid releases by Site stream. Data Table A-8 provides a five-year history of SRS liquid radioactive releases.

Tritium accounts for more than 99% of the total amount of radioactivity the Site released to the Savannah River. In 2016, SRS released a total of 731 curies of tritium to the river, a 7% decrease from the 2015 amount of 786 curies.

In 2016, the Georgia Power Company's Vogtle Electric Generating Plant (VEGP) released 992 curies of tritium to the Savannah River and 56 curies migrated from the Barnwell Low-Level Disposal Facility (BLLDF) for an overall total of 1,779 curies of tritium (SRS plus VEGP plus BLLDF). This is a 31% decrease from the combined total of 2,565 curies in 2015.

2.1.2 Radionuclide Concentrations in Savannah River Water, Drinking Water, and Fish

At several locations along the Savannah River, SRS measures the tritium concentrations in the river water and cesium-137 in fish. SRS uses these measurements to make dose determinations. The amounts of all other radionuclides released from SRS are so small that their concentration in the Savannah River usually cannot be detected using conventional analytical techniques. SRS calculates concentrations in the river based on the annual release amounts and river flow rates (using the LADTAP XL code).

2.1.2.1 Radionuclide Concentrations in River Water and Treated Drinking Water

Table 2-1 shows the measured tritium concentrations in the Savannah River near RM 118.8 and at the BJWSA Purrysburg Water Treatment Facility, which is representative of the BJWSA Chelsea and the City of Savannah I&D water treatment plants. These downriver tritium concentrations include tritium releases from SRS, VEGP, and BLLDF. Table 2-1 also provides the calculated concentrations for the other released radionuclides and a comparison of these concentrations to the Safe Drinking Water Act, 40 CFR 141 (EPA 2000) maximum contaminant level (MCL) for each radionuclide.

In 2016, the 12-month average tritium concentration measured in Savannah River water near RM 118.8 was 310 picocuries per liter (pCi/L). This reflects a 36% decrease from the 481 pCi/L measured in 2015. SRS attributes this decrease to the 30% decrease in the combined (SRS plus VEGP plus BLLDF) total of tritium released to the Savannah River in 2016 and to the 8% increase in the effective river flow rate from 2015 to 2016, which caused more dilution.

Table 2-1 indicates that all individual radionuclide concentrations at the three downriver community drinking water systems, as well as at RM 118.8, were below the EPA MCLs. Because SRS releases more than one radionuclide, the sum-of-the-fractions of the reported concentration of each radionuclide divided by its corresponding MCL must not exceed 1.0. As Data Table A-9 shows, the sum-of-the-fractions for the water treatment plants (determined at the BJWSA Chelsea plant) was 0.017, which is below the 1.0 sum-of-the-fractions requirement.

2.1.2.2 Radionuclide Concentrations in Fish

At SRS, an important dose pathway for the representative person is from the consumption of fish. Fish exhibit a high degree of bioaccumulation for certain elements. For cesium (including radioactive isotopes of cesium, such as cesium-137), the bioaccumulation factor for Savannah River fish is 3,000, meaning that the concentration of cesium in fish flesh is about 3,000 times the concentration of cesium found in the water in which the fish live (Carlton et al. 1994).

Because of this high bioaccumulation factor, SRS can detect cesium-137 more easily in fish flesh than in river water. Therefore, when conservative to do so, SRS will base the fish pathway dose from cesium-137 directly on the analysis of the fish collected near RM 118.8, the assumed location of the hypothetical representative person. As shown in Data Table A-10, the 2016 cesium-137 release value of 0.0479 Ci is based on analysis of fish in the river.

Table 2-1. 2016 Radioactive Liquid Releases and 12-Month Average Downriver Radionuclide Concentrations Compared to the EPA's Drinking Water Maximum Contaminant Levels (MCL)

Nuclide	Curies Released	12-Month Average Concentration (pCi/L)		
		Below SRS[a]	at BJWSA Purrysburg Plant[b]	EPA MCL[c]
H-3[d]	7.31E+02	3.10E+02	2.14E+02	2.00E+04
C-14	5.82E-04	1.01E-04	7.00E-05	2.00E+03
Sr-90	1.95E-02	3.40E-03	2.34E-03	8.00E+00
Tc-99	1.88E-02	3.27E-03	2.26E-03	9.00E+02
I-129	1.82E-02	3.17E-03	2.19E-03	1.00E+00
Cs-137	4.79E-02	8.34E-03	5.76E-03	2.00E+02
U-234	3.30E-02	5.75E-03	3.97E-03	1.03E+01
U-235	1.04E-03	1.81E-04	1.26E-04	4.67E-01
U-238	3.68E-02	6.41E-03	4.42E-03	1.00E+01
Np-237	2.78E-06	4.84E-07	3.34E-07	1.50E+01
Pu-238	2.60E-04	4.53E-05	3.13E-05	1.50E+01
Pu-239	1.37E-05	2.39E-06	1.65E-06	1.50E+01
Am-241	1.80E-03	3.13E-04	2.16E-04	1.50E+01
Cm-244	1.54E-04	2.68E-05	1.85E-05	1.50E+01
Alpha	1.98E-02	3.45E-03	2.38E-03	1.50E+01
Beta	1.36E-01	2.37E-02	1.63E-02	8.00E+00

a. Near Savannah River Mile 118.8, downriver of SRS at the U. S. Highway 301 bridge

b. Beaufort-Jasper Water and Sewer Authority, drinking water at the Purrysburg Plant

c. MCLs for uranium based on radioisotope specific activity X 30 µg/L X isotopic abundance

d. The tritium concentrations and source term are based on actual measurements of the Savannah River water at the various locations. They include contributions from VEGP and Barnwell Low-Level Disposal Facility. All other radionuclide concentrations are calculated based on the effective or measured river flow rate.

2.1.2.3 Dose to the Representative Person

Data Table A-11 shows the 2016 dose to the representative person from all liquid pathways, including irrigation, was estimated at 0.15 mrem (0.0015 mSv), which was the same as the comparable dose in 2015. Table 2-2 shows that this total dose is 0.15% of the all-pathway public dose standard of 100 mrem/yr (1 mSv/yr).

Table 2-2. Potential Dose to the Representative Person from SRS Liquid Releases in 2016

	Committed Dose (mrem)	Applicable Standard (mrem)	Percent of Standard (%)
Near Site Boundary (All Liquid Pathways)			
All Liquid Pathways Except Irrigation	0.053		
Irrigation Pathways	0.093		
Total Liquid Pathways	0.15	100[(a)]	0.15

a. All-pathway dose standard: 100 mrem/yr (DOE Order 458.1)

About 66% of the 2016 total dose to the representative person resulted from consuming meat, milk, and vegetables. The fish consumption pathway accounted for 23% and the drinking water pathway accounted for 11%. Figure 2-1 shows, cesium-137 (21%) and unidentified beta emitters (23%) were the major contributors to the total dose. Data Table A-12 provides a five-year history of SRS liquid pathway doses.

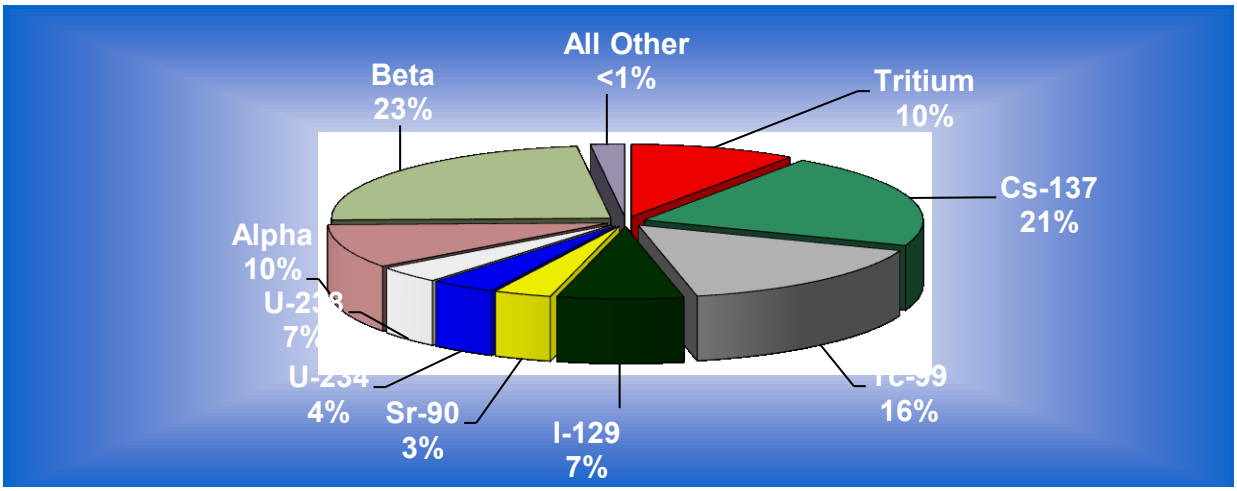


Figure 2-1. Radionuclide Contributions to the 2016 SRS Representative Person Total Liquid Pathway Dose of 0.15 mrem (0.0015 mSv)

2.1.2.4 Drinking Water Pathway Dose

People living downriver of SRS may receive some dose by consuming drinking water that contains radioactive releases from the Site. Tritium in downriver drinking water represented the highest percentage of the dose (about 46%) to customers of the three downriver water treatment plants.

Data Table A-13 shows the 2016 SRS-only releases were responsible for a maximum potential drinking water dose of 0.012 mrem (0.00012 mSv). This dose is 25% less than the 2015 dose of 0.016 mrem (0.00016 mSv). SRS attributes this decrease to the decrease in tritium releases and to the increase in the estimated Savannah River flow rate during 2016. There is not a separate drinking water dose standard, but the EPA MCLs, defined in 40 CFR 141 (EPA 2000), assume a potential dose of 4 mrem/yr for beta and gamma emitters.

2.1.2.5 Collective (Population) Dose

SRS calculates the collective drinking water consumption dose for the separate population groups the BJWSA and City of Savannah I&D water treatment plants serve (Data Table A-14). Calculations of collective doses from agricultural irrigation assume that 1,000 acres of land are used for each of the major food types grown in the SRS area (vegetables, milk, and meat) with the population within 50 miles of SRS consuming all the food produced on these 1,000-acre parcels. Historically, SRS limited the food consumption pathway dose to the smaller of 1) the total food-stuff actually produced in the SRS 50-mile radius or 2) the total food-stuffs produced on the 1,000-acre parcels (based on regional productivity rates (Jannik et al. 2017). The total amount of food-stuff produced in the SRS area (which is difficult to determine because of under reporting by small farms and individual gardens) has typically been less than the amount produced on 1,000-acre parcels. Beginning in 2016, SRS now conservatively uses only the amount produced on the 1,000-acre irrigated parcels for collective dose estimates.

In 2016, the collective dose from all liquid pathways was 3.5 person-rem (0.035 person-Sv) (Data Table A-15). Person-rem is calculated as the dose to a "typical" person multiplied by the number of people exposed. This is 35% more than the comparable 2015 collective dose of 2.6 person-rem (0.026 person-Sv). SRS attributes most of this increase to the change in using the amount of food-stuff produced on the 1,000-acre irrigated parcels. DOE Order 458.1 requires that a collective dose be calculated and reported, but there is not a separate collective dose standards for comparison.

2.2 Air Pathway Doses

2.2.1 Atmospheric Source Terms

Data Table A-16 documents the 2016 SRS radiological air releases by Site area. Data Table A-17 provides a five-year history of SRS atmospheric releases, and it shows that tritium oxide releases, which account for a majority of the offsite doses, decreased by 20% from 2015 to 2016. Estimates of unmonitored diffuse and fugitive sources were included in the atmospheric source term, as required for demonstrating compliance with EPA regulations.

2.2.2 Atmospheric Concentrations

For dose determinations, SRS uses calculated radionuclide concentrations from standard modeling of measured effluent releases instead of measured concentrations in the air surveillance samples. This is because most radionuclides SRS released in 2016 were not detected (using conventional analytical methods) in the air samples collected at the Site perimeter and offsite locations. The exception to this is tritium oxide, which can be measured at the site perimeter location. Therefore, to confirm the dose models, SRS compares the measured concentrations of tritium oxide with the calculated concentrations from CAP88 PC and MAXDOSE. In Data Table A-18, this comparison showed that in 2016 the dose models used at SRS were about 1.75 to 3.75 times more conservative than the actual measured tritium oxide concentrations.

2.2.3 Dose to the Representative Person

As shown in Data Table A-19, the 2016 estimated dose from air releases to the representative person was 0.038 mrem (0.00038 mSv), 0.38% of the DOE Order 458.1 air pathway standard of 10 mrem per year. Table 2-3 compares the representative person dose with the DOE standard. The 2016 dose was about 19% more than the 2015 dose of 0.032 mrem (0.00032 mSv). SRS attributes this increase to the 20% increase in tritium oxide releases during 2016.

Table 2-3. Potential Doses to the Representative Person and to the MEI from SRS Atmospheric Releases in 2016 and Comparison to the Applicable Dose Standard

	MAXDOSE-SR	CAP88-PC (EPA NESHAP)
Calculated dose (mrem)	0.038	0.024
Applicable Standard (mrem)	10[(a)]	10[(b)]
Percent of Standard (%)	0.38	0.24

a. DOE: DOE Order 458.1
b. EPA: (NESHAP) 40 CFR 61, Subpart H

As shown in Figure 2-2, tritium oxide releases accounted for nearly 94% of the dose to the representative person. Iodine-129 and cesium-137 accounted for about 2% each. No other individual radionuclide accounted for more than 1% of the representative person dose. Data Table A-19 also shows that the major pathways through which a representative person received radioactivity from atmospheric releases were inhalation (37%), vegetable consumption (36%), and cow milk consumption (24%). As shown in Data Table A-20 and in Figure 2-3, the due north sector of the Site was the location of the highest dose to the representative person.

Because of the potential in the SRS vicinity for the consumption of goat milk, additional calculations of the dose to the representative person were performed substituting goat milk for the customary cow milk pathway. As shown in Data Table A-21, SRS estimated that the potential dose to the representative person using the goat milk pathway is 0.044 mrem (0.00044 mSv). SRS provides this dose for reference only.

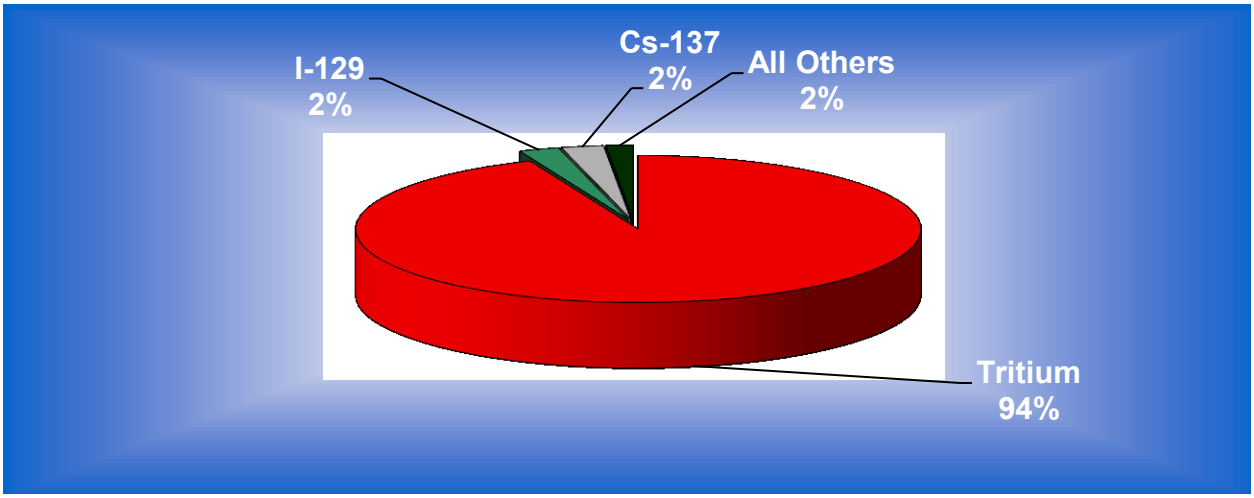
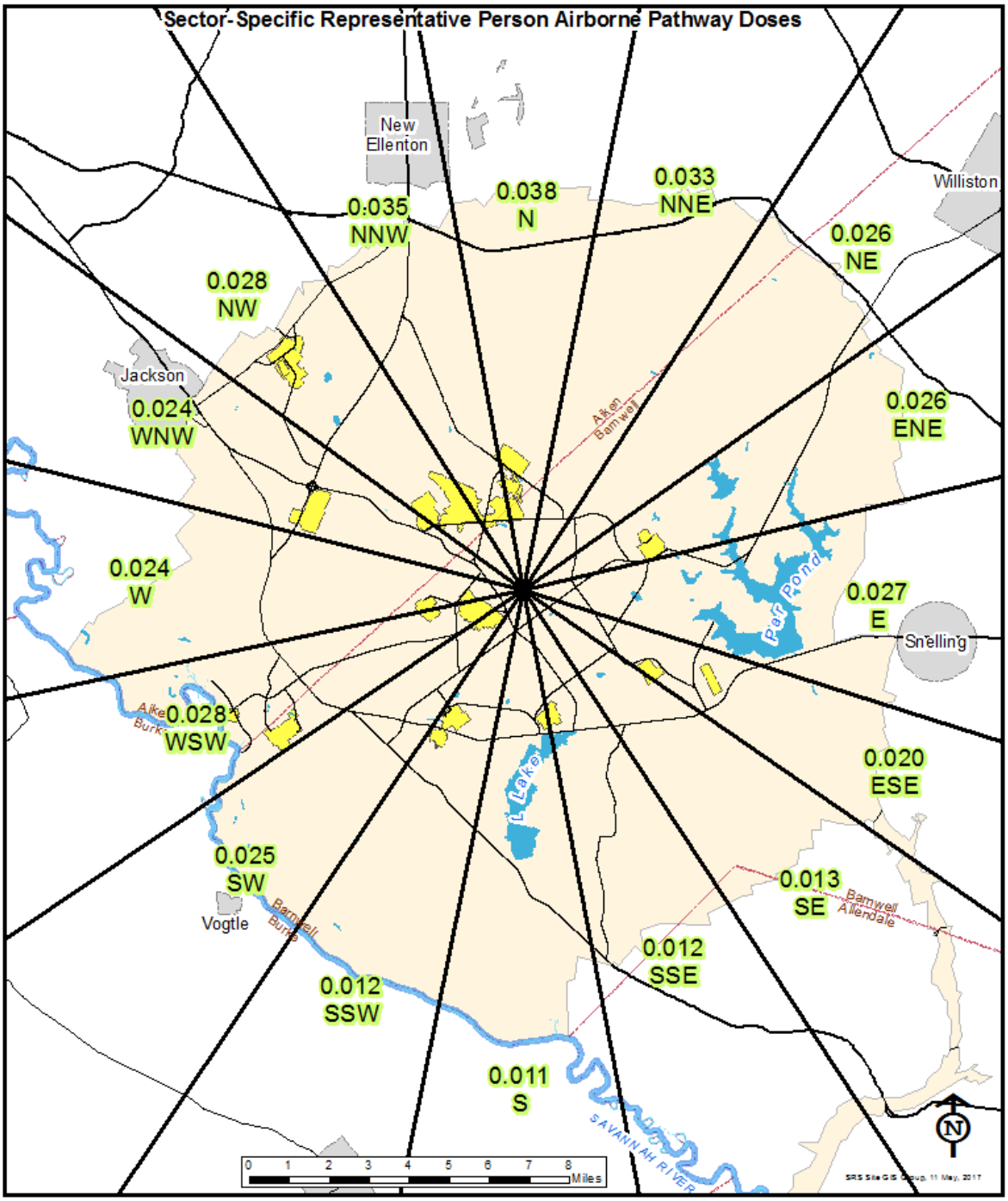


Figure 2-2. Radionuclide Contributions to the 2016 SRS Air Pathway Dose of 0.038 mrem (0.00038 mSv)



Doses are shown for each of the 16 major compass point directions surrounding SRS.
In 2016, the N sector was the highest at 0.038 mrem

Figure 2-3. Sector-specific Representative Person Site Boundary Doses

2.2.4 Collective (Population) Dose

SRS calculates the air-pathway collective dose for the entire 781,060 population living within 50 miles of the center of the Site. Data Table A-4 shows the population distribution around SRS.

In 2016, SRS estimated the air-pathway collective dose at 1.4 person-rem (0.014 person-Sv), which is less than 0.01% of the annual collective dose from natural sources of radiation (about 234,000 person-rem). Data Table A-22 shows the 2016 air-pathway collective doses by radionuclide and pathway. Tritium oxide releases accounted for 92% of the collective dose.

2.2.5 National Emission Standards for Hazardous Air Pollutants (NESHAP) Compliance

2.2.5.1 Maximally Exposed Individual Dose

To demonstrate compliance with NESHAP regulations (EPA 2006), SRS calculated MEI and collective doses using 1) CAP88 PC version 4.0.1.17 computer code, 2) the 2016 air-release source term shown in Data Table A-23, and 3) Site-specific input parameters shown in Data Table A-24. The EPA requires the use of the MEI concept and does not allow use of the reference person concept at this time. The EPA specifies most of the input parameters in the CAP88 PC program; they cannot be changed without specific EPA approval.

For 2016, SRS used CAP88 PC (version 4.0.1.17, dated September 2014) to demonstrate compliance with the EPA's 10 mrem/yr (0.1 mSv/yr) public dose standard for airborne emissions from DOE sites. For 2016, the MEI dose was estimated at 0.024 mrem (0.00024 mSv), or 0.24% of the 10-mrem/yr EPA standard, as shown in Table 2-3.

Data Table A-25 shows tritium oxide releases accounted for about 88% of the MEI dose and elemental tritium accounted for 6.5%. The CAP88 PC model very conservatively treats elemental tritium the same as tritium oxide. The 2016 NESHAP compliance dose (MEI dose) was about 10% more than the 2015 dose of 0.022 mrem (0.00022 mSv). SRS attributes this increase to the 20% increase in tritium oxide releases during 2016.

2.2.5.2 Dose from Diffuse and Fugitive Releases

NESHAP regulations require separate dose reporting from diffuse and fugitive releases. Data Table A-26 shows the MEI dose from diffuse and fugitive releases was about 0.0038 mrem (0.000038 mSv). The diffuse and fugitive releases account for about 16% of the total 2016 MEI dose.

2.2.5.3 Collective Dose

The CAP88 PC-determined collective (population) dose for 2016 was estimated at 3.5 person-rem (0.035 person-Sv), which is 9% more than the 2015 collective dose of 3.2 person-rem (0.032 person-Sv). Tritium releases accounted for nearly 94% of the NESHAP collective dose.

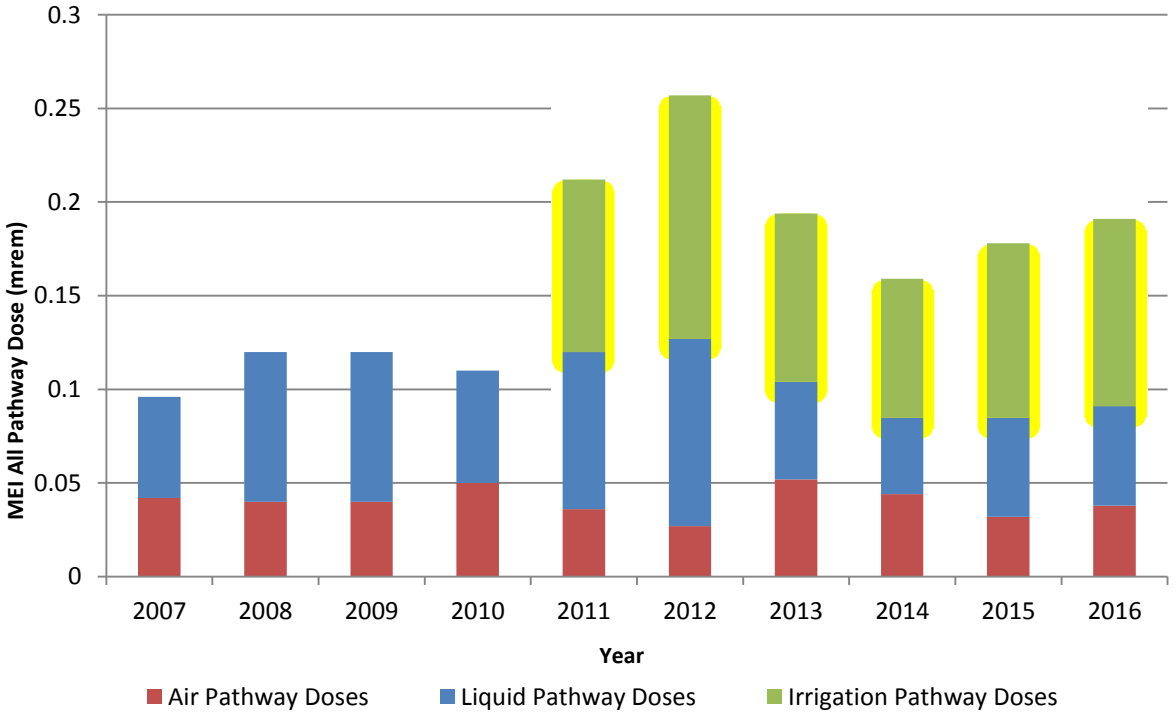
Comparisons (by pathway and major radionuclides) of the CAP88 PC-determined MEI and collective doses with the MAXDOSE-SR and POPDOSE-SR representative person doses are provided in Data Table A-27 and Data Table A-28, respectively. As shown in Data Table A-27, the CAP88 PC version 4.0.1.17 code estimates a lower dose for the MEI mainly because of the lower human usage parameters used in the EPA code.

However, for the population dose (Data Table A-28), the CAP88 PC version 4.0.1.17 estimates a higher dose, because 1) it assumes the general population has the same inhalation and consumption rates as the maximally exposed individual, and 2) it assumes a one-to-one ratio between tritium oxide in air and tritium oxide in plant leaves (whereas POPDOSE-SR assumes a 50% ratio).

2.3 All-Pathway Dose

As stated in DOE Order 458.1, the all-pathway dose standard is 100 mrem/yr. SRS ensures a conservative estimate by combining the representative person airborne pathway and liquid pathway dose estimates, even though the two estimated doses are for hypothetical individuals residing at different geographic locations.

For 2016, the potential representative person all-pathway dose was 0.19 mrem (0.0019 mSv), calculated as 0.038 mrem from air pathways plus 0.15 mrem from liquid pathways. The all-pathway dose is 0.19% of the 100 mrem/yr (1 mSv/yr) DOE dose standard. The 2016 all-pathway dose is about 6% more than the 2015 total dose of 0.18 mrem (0.0016 mSv). SRS attributes this increase to the 20% increase in airborne tritium oxide releases during 2016. Data Table A-12 provides a five-year history of the SRS all-pathway doses. Figure 2-4 shows a 10-year history of SRS's all-pathway (airborne, liquid, and irrigation pathways) doses to the MEI/representative person.



1. Beginning in 2011, the irrigation pathway dose is included in the liquid pathway dose. Previous years do not include the irrigation pathway dose.
2. Beginning in 2012, SRS began using the representative person dose instead of the MEI dose.

Figure 2-4. Ten-Year History of SRS Maximum Potential All-Pathway Doses

2.4 Sportsman Dose

DOE Order 458.1 specifies radiation dose standards for individual members of the public. The dose standard of 100 mrem/yr includes the dose a person receives from routine DOE operations through all exposure pathways. Additionally, SRS considers and quantifies unique exposure pathways that are not included in the standard calculations of the doses to the representative person. This is because they apply to unlikely scenarios, such as eating fish caught only from the mouths of SRS streams ("creek-mouth fish"), or to special scenarios, such as onsite volunteer hunters.

In addition to deer, hog, fish, and turkey consumption, SRS considered the following exposure pathways for an offsite hunter and an offsite fisherman on Creek Plantation, a privately-owned portion of the Savannah River Swamp.

- External exposure to contaminated soil,
- Incidental ingestion of contaminated soil, and
- Incidental inhalation of renewed suspension of contaminated soil.

2.4.1 Onsite Hunter Dose

2.4.1.1 Deer and Hog Consumption Pathway

SRS holds annual hunts for the public to control the Site's deer and wild pig populations and to reduce animal-vehicle accidents. The estimated dose from consuming harvested deer or hog meat is determined for every onsite hunter. During 2016, the maximum potential dose an onsite hunter received was 13.5 mrem (0.135 mSv), or 13.5% of DOE's 100 mrem/yr dose standard (Table 2-4). This dose is for an actual hunter who harvested two deer during the hunts. For the hunter-dose calculation, SRS conservatively assumes that this hunter individually consumed the entire edible portion, about 40 kilogram (kg) (89 lbs).

2.4.1.2 Turkey Consumption Pathway

SRS hosts a special turkey hunt during April for hunters with mobility impairments. Hunters harvested 25 turkeys in 2016. SRS measured all of the turkeys for cesium-137. Since none of them measured above background, SRS did not assign a dose to these hunters.

2.4.2 Hypothetical Offsite Hunter Doses

2.4.2.1 Deer and Hog Consumption Pathway

The deer and hog consumption pathways considered were for hypothetical offsite individuals whose entire intake of meat (81 kg) during the year was either deer or hog meat. SRS assumes these individuals harvested deer or hogs that had resided on SRS during the year and then moved offsite prior to hunting season.

Based on these unlikely assumptions and on the measured average concentration of cesium-137 in all deer (2.06 pCi/g) and hogs (1.05 pCi/g) harvested from SRS during 2016, the potential maximum doses from this pathway were estimated at 6.4 mrem (0.064 mSv) for the offsite deer hunter and 2.2 mrem (0.022 mSv) for the offsite hog hunter. Data Table A-29 documents these dose calculations.

Beginning in 2013, a background cesium-137 concentration of 0.5 pCi/g is now subtracted from the onsite average concentrations, before calculating the offsite hunter doses. Prior to 2013, the background value was 1.0 pCi/g. The 0.5 pCi/g background concentration is based on the median value determined by South Carolina Department of Health and Environmental Control (SCDHEC) for South Carolina deer, from 2008 through 2012 (SCDHEC 2013).

2.4.2.2 Savannah River Swamp Hunter Soil Exposure Pathway

SRS estimated the potential dose to a recreational hunter exposed to SRS legacy contamination on the privately-owned Creek Plantation. SRS assumes that this recreational sportsman hunted for 120 hours during the year (8 hours per day for 15 days) at the location of maximum radionuclide contamination. Table 2-4 shows the offsite deer consumption pathway and the Savannah River swamp hunter soil exposure pathway were conservatively added together to obtain a total offsite hunter dose of 9.3 mrem (0.093 mSv). This potential dose is 9.3% of the DOE 100 mrem/yr all-pathway dose standard.

2.4.3 Hypothetical Offsite Fisherman Dose and Risk

2.4.3.1 Creek-Mouth Fish Consumption Pathway

For 2016, SRS analyzed three species of fish (panfish, catfish, and bass) taken from the mouths of four SRS streams. Using these concentrations, SRS estimated the maximum potential dose from fish consumption at 0.22 mrem (0.0022 mSv) from bass collected at the mouth of Fourmile Branch. SRS bases this hypothetical dose on the low-probability scenario that, during 2016, a fisherman consumed 24 kg (53 lb) of bass caught exclusively from the mouth of Fourmile Branch. About 86% of this potential dose was from cesium-137. Data Table A-30a and Data Table A-30b, respectively, show the measured concentrations and resulting doses for each location and species combination.

2.4.3.2 Savannah River Swamp Fisherman Soil Exposure Pathway

Using the RESRAD code (Yu et al. 2001), SRS calculated the potential dose to a recreational fisherman exposed to SRS legacy contamination in Savannah River Swamp soil on the privately-owned Creek Plantation. SRS assumes that this recreational sportsman fished on the South Carolina bank of the Savannah River, near the mouth of Steel Creek, for 250 hours during the year.

Using the radionuclide concentrations measured in soil at this location, SRS estimated the potential dose to a fisherman to be 0.67 mrem (0.0067 mSv) from a combination of 1) external exposure to the contaminated soil, 2) incidental ingestion of the soil, and 3) incidental inhalation of renewed suspension soil to be 0.67 mrem (0.0067 mSv).

Table 2-4 shows how SRS conservatively combined the maximum Steel Creek fish consumption dose (0.14 mrem) and the Savannah River Swamp fisherman soil exposure pathway (0.67 mrem) to obtain a total offsite fisherman dose of 0.81 mrem (0.0081 mSv). This potential dose is 0.81% of the DOE 100 mrem/yr all-pathway dose standard.

2.4.3.3 Potential Risk from Consumption of SRS Creek-Mouth Fish

During 1991 and 1992, in response to a U.S. House of Representatives Appropriations Committee request for a plan to evaluate risk to the public from fish collected from the Savannah River, SRS developed a fish monitoring plan in conjunction with the EPA, the Georgia Department of Natural Resources (GDNR), and SCDHEC. This plan ensures SRS assesses the radiological risk from the consumption of Savannah River fish, and requires that SRS present a summary of the results in the SRS Annual Site Environmental Report.

Table 2-4. 2016 Representative Person All-Pathways and Sportsman Doses Compared to the DOE All-Pathways Dose Standard

	Committed Dose (mrem)	Applicable Standard (mrem)[a]	Percent of Standard (%)
Representative Person Dose			
All-Pathways (Liquid Plus Airborne Pathways)	0.19	100	0.19
Sportsman Dose			
Onsite Hunter	13.5	100	13.5
Creek-Mouth Fisherman[b]	0.22	100	0.22
Savannah River Swamp Hunter			
Offsite Hog Consumption	2.24		
Offsite Deer Consumption	6.36		
Soil Exposure[c]	2.90		
Total Offsite Deer Hunter Dose (Deer + Soil Exposure)	9.26	100	9.26
Savannah River Swamp Fisherman			
Steel Creek Fish Consumption	0.14		
Soil Exposure[d]	0.67		
Total Offsite Fisherman Dose (Fish + Soil Exposure)	0.81	100	0.81

a. All-pathway dose standard; 100 mrem/yr (DOE Order 458.1)
b. In 2016, the maximum dose to a hypothetical fisherman resulted from the consumption of bass from the mouth of Fourmile Branch
c. Includes the dose from a combination of external exposure to and incidental ingestion and inhalation of the worst-case Savannah River swamp soil
d. Includes the dose from a combination of external exposure and incidental ingestion and inhalation of Savannah River swamp soil near the mouth of Steel Creek

2.4.3.4 Risk Comparisons

For 2016, SRS compared the maximum potential radiation doses and lifetime fatal and nonfatal cancer risks (from the consumption of SRS creek-mouth fish for 1-year, 30-year, and 50-year exposure durations) to the radiation risks associated with the DOE Order 458.1 all-pathway dose standard of 100 mrem/yr (1.0 mSv/yr) in Table 2-5. SRS estimated the potential risks using the cancer morbidity risk coefficients from Federal Guidance Report No. 13 (EPA, 1999). The assumed maximum fish consumption rate is 24 kg per year (Table 1-1).

In 2016, the maximum dose and risk to a hypothetical fisherman resulted from the consumption of bass from the mouth of Fourmile Branch (Data Table A-30b and Data Table A-30c). Figure 2-5 shows the history (1992-2016) of the annual potential radiation doses from consumption of Savannah River fish. Over the past ten years, there are no apparent trends in these data. This is because of the relatively large variability in the radionuclide concentrations measured in fish from the same location, due to differences in the following:

- Size of the fish collected each year,
- Mobility and location within the stream mouth from which they are collected,
- Time of year they are collected,
- Amount of radionuclides in the stream water and sediments in which they live that are chemically and physically available to the fish,
- Water quality at each SRS stream mouth, caused by annual changes in stream flow rates (turbulence) and water chemistry.

Table 2-5. Potential Lifetime Risks from the Consumption of Savannah River Fish Compared to Dose Standards

	Committed Dose (mrem)	Potential Risk[(a)]
2016 Savannah River Fish		
1-Year Exposure	0.22	1.5E-07
30-Year Exposure	6.6	4.4E-06
50-Year Exposure	11.0	7.3E-06
Dose Standard		
100 mrem/yr All Pathway		
1-Year Exposure	100	7.3E-05
30-Year Exposure	3,000	2.2E-03
50-Year Exposure	5,000	3.7E-03

a. All radiological risk factors are based on observed and documented health effects to actual people who have received high doses (more than 10,000 mrem) of radiation, such as the Japanese atomic bomb survivors. Radiological risks at low doses (less than 10,000 mrem) are theoretical and are estimated by extrapolating the observed health effects at high doses to the low-dose region by using a linear, no-threshold model. However, cancer and other health effects have not been observed consistently at low radiation doses because the health risks either do not exist or are so low that they are undetectable by current scientific methods.

As indicated in Table 2-5, the 50-year maximum potential lifetime risk from consumption of SRS creek-mouth fish was 7.3E-06, well below the 50-year risk (3.7E-03) associated with the 100 mrem/yr dose standard.

If a potential lifetime risk is less than 1.0E-06 (i.e., one additional case of cancer over that expected in a group of 1,000,000 people), the risk is considered minimal and the corresponding contaminant concentrations are considered negligible. If a calculated risk is more than 1.0E-04 (one additional case of cancer in a population of 10,000), some form of corrective action or remediation may be required. However, if a calculated risk falls between 1.0E-04 and 1.0E-06 (the case with the maximum potential lifetime risks from the consumption of Savannah River fish), then the risk may be deemed acceptable, if it is kept ‘as low as reasonably achievable’ (ALARA). At SRS, an environmental ALARA program (3Q 18.5) is in place, to ensure that the potential doses and risks from Site radioactive liquid effluents (and, therefore, from consumption of Savannah River fish) is kept ALARA (SRS 2015).

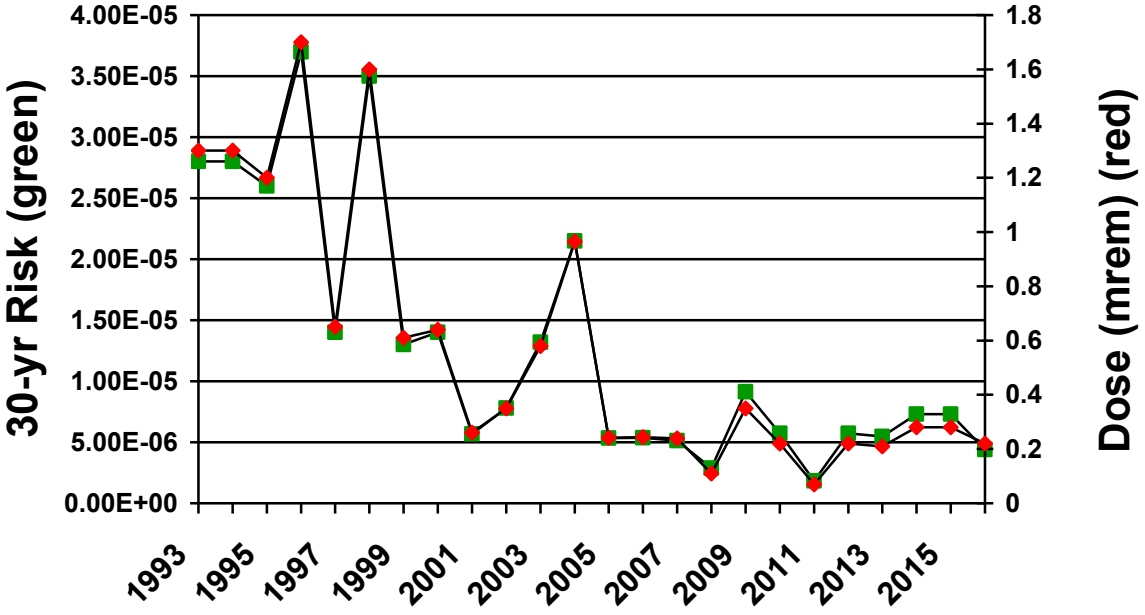


Figure 2-5. History of SRS Maximum Potential Fisherman Doses and 30-y Projected Risks

3.0 Release of Material Containing Residual Radioactivity

DOE Order 458.1 establishes authorized surface contamination limits, which, in turn, allow SRS to release personal and real property unconditionally. This order defines personal property as, "*property of any kind, except for real property" and defines real property as "land and anything permanently affixed to the land such as buildings, fences and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures, or other such items, that would be personal property if not attached.*" SRS handles unconditional release of real property on a case-by-case basis, which requires specific approval from DOE. SRS did not release any real property in 2016, so the following discussion is associated with release of personal property from SRS. DOE Order 458.1 specifies that SRS must prepare and submit an annual summary of cleared property to the Field Element Manager (i.e. DOE-SR Manager).

3.1 Property Release Methodology

Through the use of procedures, SRS governs the unconditional release of equipment and material. Following a radiological survey, SRS can unconditionally release an item if it meets specific documented limits. For items meeting unconditional release criteria, SRS generates a form and electronically attaches it to the applicable radiological survey, via the Visual Survey Data System. To determine the amount of material and equipment released from SRS facilities in 2016, SRS subsequently compiled these electronic forms and coordinated a site-wide review. These measures ensure that radiological releases of material from SRS are consistent with the requirements of DOE Order 458.1.

In 2015, SRS unconditionally released a total of 11,516 items of personal property from radiological areas. Most of these items did not leave the Site. However, all of these items required no additional radiological controls, post-survey, as they met DOE Order 458.1 release criteria. The recently

implemented DOE Order 458.1 allows using DOE Order 5400.5 derived supplemental limits for unconditional release of equipment and materials.

In 2003, DOE approved an SRS request to use supplemental limits for releasing material from the Site, with no further DOE controls. These supplemental release limits, provided in Data Table A-31, are dose-based. These limits are such, that if any member of the public received any exposure, it would be less than 1 mrem/yr. The supplemental limits include both surface and volume concentration criteria. The surface criteria are very similar to those used in previous years. The volume criteria allow SRS the option to dispose of potentially volume-contaminated material in Three Rivers Landfill, an onsite sanitary waste facility. In 2016, SRS did not release any material from the Site using the supplemental release limits volume concentration criteria.

4.0 Radiation Dose to Aquatic and Terrestrial Biota

DOE Order 458.1 requires that SRS conduct Site operations in a manner that protects the local biota from adverse effects due to radiation and radioactive material releases. To demonstrate compliance with this requirement, SRS uses the approved DOE Standard, DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002).

The biota dose rate limits specified in this standard are:

- Aquatic animals 1.0 rad/day (0.01 gray/day),
- Riparian animals 0.1 rad/day (0.001 gray/day),
- Terrestrial plants 1.0 rad/day (0.01 gray/day), and
- Terrestrial animals 0.1 rad/day (0.001 gray/day).

4.1 DOE Biota Concentration Guides

SRS evaluates biota doses for aquatic and terrestrial systems using the RESRAD Biota model (version 1.8) (DOE 2004), which directly implements the DOE (2002) guidance.

For aquatic systems (aquatic and riparian animals), the RESRAD Biota model performs a combined water-plus-sediment evaluation. SRS performed initial (Level 1) screenings in 2016 using maximum radionuclide concentration data from the 14 SRS environmental monitoring stream and sediment sampling locations that are co-located. These screenings determine the biota concentration guide (BCG) sum-of-the-fractions for each of the 14 assessed aquatic systems. A sum-of-the-fractions less than 1.0 indicates the sampling site has passed its initial pathway screening. This means that the biota dose rate limits were not exceeded, and that no further assessments are needed.

Data Table A-32 presents the results of the 2016 biota dose assessment. For 2016, all but one SRS aquatic system locations passed the initial screening and no further assessments were required at those locations. The Z-Area Basin sampling location failed the Level 1 screening with a sum-of-the-fractions of 1.05. A Level 2 screening was performed at this location using average concentrations and it passed. Therefore, SRS did not need to assess this location further.

To evaluate the terrestrial systems (terrestrial plants and animals), SRS performed initial screenings using concentration data from the five onsite radiological soil sampling locations. Typically, SRS collects and analyzes only one soil sample per year from each location. For 2016, all terrestrial locations passed their initial pathway screenings (Data Table A-32).

5.0 References

Carlton, W.H., C.E. Murphy, Jr., and A.G. Evans. "Radiocesium in the Savannah River Site Environment," *Health Physics*, Volume 67, Number 3, Williams & Wilkins, Baltimore, MD; 1994.

International Commission on Radiological Protection. Age dependent dosses to members of the public from intake of radionuclides: part 5 compilation of ingestion and inhalation dose coefficients. Oxford: ICRP; Publication 72, Ann. 26(1); 1996.

International Commission on Radiological Protection. Basic anatomical and physiological data for use in radiological protection reference values. Oxford: ICRP; Publication 89, Ann. ICRP 32 (3-4); 2002.

International Commission on Radiological Protection. Assessing dose of the representative person for the purpose of radiation protection of the public. Oxford: ICRP; Publication 101, Ann. ICRP 36 (No. 3); 2006.

Jannik, G.T., B. Stagich, L. Hartman. "Land and Water Use Characteristics and Human Health Input Parameters for Use in Environmental Dosimetry and Risk Assessments at the Savannah River Site - 2017 Update," SRNL-STI-2016-00456, Revision 1, Savannah River National Laboratory, Savannah River Site, Aiken, SC; 2017.

Savannah River National Laboratory. "Environmental Dose Assessment Manual," SRNL-TR-2010-00274, Revision 2, Savannah River National Laboratory, Aiken, SC; 2017.

Savannah River Site, "Savannah River Site Environmental Monitoring Program Management Plan," SRS Manual 3Q1-101, Revision 7, Savannah River Site, Aiken, SC; 2015.

South Carolina Department of Health and Environmental Control. "Environmental Surveillance and Oversight Program, 2012 Data Report," CR-004111, 2013, Columbia, SC; 2013.

Stone, D. K., Jannik, G. T. Site Specific Reference Person Parameters and Derived Concentration Standards for the Savannah River Site. SRNL-STI-2013-00115. Savannah River National Laboratory. Aiken, SC: 2013.

U.S. Department of Energy. "External and Internal Dose Conversion Factors for Calculation of Dose to the Public", DOE/EH-0070 & 71, Washington, D.C., 1988

U.S. Department of Energy. "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," DOE Standard, DOE-STD-1153-2002, July 2002, Washington, DC; 2002.

U.S. Department of Energy. "RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation" DOE/EH-0676, January 2004, Washington, DC; 2002.

U.S. Department of Energy. "DOE Derived Concentration Technical Standard," DOE-STD-1196-2011, Washington, DC; 2011.

U.S. Department Of Energy. Radiation protection of the public and the environment, Change #3, Washington, DC: U.S. DOE Order 458.1; 2013.

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

U.S. Environmental Protection Agency. "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," Federal Guidance Report No.13, USEPA 402-R-99-001, September 1999, Washington, DC; 1999.

U.S. Environmental Protection Agency. "National Primary Drinking Water Regulations," Title 40 Code of Federal Regulations, Part 141, December 2000, Washington, DC; 2000.

U.S. Environmental Protection Agency. Exposure factors handbook 2011 edition (final report). Washington, DC: U.S. Environmental Protection Agency; EPA/600/R-09/052F; 2011.

U.S. Environmental Protection Agency (EPA). "National Emissions Standards for Hazardous Air Pollutants; Radionuclides," Title 40 Code of the Federal Regulations, Part 61, Washington, D.C. 2006.

U.S. Nuclear Regulatory Commission. "Regulatory Guide 1.109 - Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," Revision 1, Washington, DC; 1977.

Viner, B.J., "Summary of Data and Steps for Processing the 2007-2011 SRS Meteorological Database," SRNL-STI-2013-00268, Savannah River National Laboratory, Aiken, SC, 2013.

Yu, C., A.J. Zielen, J.J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, Amish, A. Wallo III, W.A. Williams, and H. Peterson, "User's Manual for RESRAD," Version 6, Environmental Assessment Division, Argonne National Laboratory, July 2001, Argonne, IL; 2001.

Appendix A

Data Table A-1. Parameters Used for Liquid Pathway Dose Calculations

Data Table A-1, Parameters Used for Liquid Pathway Dose Calculations **2 Pages**

Reference and Typical Person Consumption and Usage Rates

(Note: Values developed by Savannah River National Laboratory for SRS in Stone and Jannik, 2013)

Pathway	Reference Person 95th percentile	Typical Person 50th percentile	Units
Fish consumption	24	3.7	kg/y
Marine invertebrates	Not applicable	1.5	kg/y
Boating	44	3,110,000	h/y (person-h/y)
Swimming	14	295,000	h/y (person-h/y)
Shoreline recreation	20	822,000	h/y (person-h/y)
Water consumption	800	300	L/y
Population Served by Downriver Water Treatment Plants			
Beaufort-Jasper Purrysburg Plant		64,800	persons
Beaufort-Jasper Chelsea Plant		83,700	persons
City of Savannah Industrial & Domestic Water Supply		35,000	persons
50-mile Population			
2010 US Census		781,060	persons
Site-Specific Parameters Used in Liquid Dose Calculations		**Value**	**Units**
Savannah River *effective* flow rate at Hwy 301 for 2015 [(a)]		6,426	ft^3/s
River dilution in estuary		3	
Transport Time			
Recreation		1	d
Drinking Water		1.5	d
Fish		2	d
Treatment Plant Drinking Water		4	d
Sport Fish		10	d
Commercial Fish		13	d
Salt Water Invertebrate		13	d
Edible aquatic food harvest			
Fish - sport		8,220	person-kg/y
Fish - commercial		57,000	person-kg/y
Invertebrates - salt water		380,000	person-kg/y
Shoreline width factor		0.2	
Fish bioaccumulation factor for cesium		3,000	

a) The effective river flow rate was based on tritium concentration measurements. The 2016 measured river flow rate was 10,150 cfs. See Data Table A-6 for details.

Data Table A-1. Parameters Used for Liquid Pathway Dose Calculations **2 Pages**

Irrigation Parameter Values:

Parameter	Value	Units	Comments
50Mile Total Vegetable Production:	7122412	kg/yr	5.30E+06*
50Mile Total Leafy Veg Production:	1780603	kg/yr	1.40E+06*
Irrigated land area:	1000	acres	
Pop dose determined by:	area		POP or AREA
River transit time:	2	d	
Irrigation rate:	3.6	L/sum/d	102 L/sqm/mo
Weathering removal constant:	0.0495	1/d	14 d half-life
Crop exposure time:	70	d	
Grass exposure time:	30	d	
Vegetable crop yield:	2.2	kg/sqm	
Pasture grass yield:	0.7	kg/sqm	
Milk production yield:	0.34	L/sqm	
Meat production yield:	0.01	kg/sqm	
Surface density of soil:	240	kg/sqm	
Pasture grass hold-up time:	0	d	
Veg transport time (individual):	1	d	d
Veg transport time (population):	6	d	d
Milk transport time:	3	d	d
Meat transport time:	6	d	d
Fraction of fodder from irrigated field:	1.00		
Cattle consumption rate of fodder:	36	kg/d	beef
	52	kg/d	milk
Fraction of water from Savannah River:	1.00		
Cattle consumption rate of water:	28	L/d	beef
	50	L/d	milk
Individual consumption rates:	289	kg/yr	veg
	31	kg/yr	leafy
	81	kg/yr	meat
	260	L/yr	milk
Population consumption rates:	89	kg/yr	veg
	11	kg/yr	leafy
	32	kg/yr	meat
	69	L/yr	milk
Fractional retention on leaves:	0.25		all nuclides

Data Table A-2. Site-Specific Parameters Used for Airborne Pathway Doses

Data Table A-2, Site-Specific Parameters Used for Airborne Pathway Doses

Pathway	Reference Person 95th Percentile (Individual)	SRS MEI Pre-2012 Adult Individual	Percent Difference	Typical Person 50th Percentile (Population)	SRS Population Pre-2012 Average Adult	Percent Difference
Fruits, vegetables, and grains (kg/yr)	289	276	↑4.7%	89	163	↓45.4%
Leafy vegetables (kg/yr)	31	43	↓27.9%	11	21	↓47.6%
Milk (L/yr)	260	230	↑13%	69	120	↓42.3%
Meat (beef) (kg/yr)	81	81	0.00%	32	43	↓26.3%
Inhalation (m^3/yr)	6,400	8,000	↓20.0%	5,000	5,548	↓9.9%

50-mile Population	
2010 US Census (persons)	781,060

Release Locations for Representative Person Dose				
	Reactors	F & H	SRNL	Diffuse and Fugitive
Release height, m	40	61	31	0
Release location (site coordinates)				
East	40740	63380	51860	58000
North	54130	71900	106670	62000

Data Table A-3. Meteorological Data (2007-2011)

Data Table A-3, Meteorological Data (2007-2011) 1 of 7

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class A
Extremely Unstable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.170	0.160	0.140	0.144	0.147	0.140	0.151	0.138
4.00	0.199	0.252	0.296	0.403	0.447	0.342	0.261	0.241
6.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.370	0.410	0.440	0.550	0.590	0.480	0.410	0.380

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class A
Extremely Unstable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.131	0.135	0.158	0.202	0.202	0.220	0.147	0.158	2.542
4.00	0.335	0.337	0.433	0.660	0.729	0.392	0.252	0.227	5.806
6.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.470	0.470	0.590	0.860	0.930	0.610	0.400	0.390	8.350

Data Table A-3. Meteorological Data (2007-2011) (continued) **2 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class B
Moderately Unstable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.025	0.034	0.041	0.025	0.046	0.037	0.032	0.032
4.00	0.151	0.163	0.282	0.488	0.424	0.316	0.218	0.105
6.00	0.011	0.011	0.062	0.080	0.066	0.046	0.011	0.002
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.190	0.210	0.390	0.590	0.540	0.400	0.260	0.140

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class B
Moderately Unstable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.005	0.028	0.034	0.046	0.032	0.062	0.037	0.032	0.548
4.00	0.197	0.261	0.376	0.695	0.582	0.397	0.135	0.138	4.928
6.00	0.030	0.037	0.053	0.105	0.133	0.064	0.028	0.009	0.750
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.230	0.330	0.460	0.850	0.750	0.520	0.200	0.180	6.230

Data Table A-3. Meteorological Data (2007-2011) (continued) **3 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class C
Slightly Unstable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.064	0.064	0.108	0.087	0.089	0.064	0.055	0.048
4.00	0.202	0.323	0.722	0.745	0.566	0.406	0.300	0.179
6.00	0.138	0.229	0.791	0.697	0.369	0.183	0.172	0.117
8.00	0.048	0.057	0.117	0.073	0.011	0.005	0.018	0.048
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.450	0.670	1.740	1.600	1.040	0.660	0.550	0.390

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class C
Slightly Unstable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.062	0.034	0.060	0.096	0.078	0.062	0.062	0.055	1.089
4.00	0.403	0.463	0.575	0.882	0.555	0.509	0.238	0.181	7.250
6.00	0.328	0.436	0.623	1.029	0.933	0.752	0.266	0.110	7.172
8.00	0.050	0.057	0.115	0.206	0.277	0.238	0.048	0.014	1.384
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.840	0.990	1.370	2.210	1.840	1.560	0.610	0.360	16.900

Data Table A-3. Meteorological Data (2007-2011) (continued) **4 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class D
Neutral Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.108	0.142	0.215	0.204	0.121	0.119	0.131	0.131
4.00	0.431	0.731	1.563	1.295	0.995	0.798	0.653	0.665
6.00	0.367	0.591	1.057	0.614	0.532	0.419	0.656	1.364
8.00	0.101	0.115	0.048	0.028	0.018	0.025	0.025	0.215
12.00	0.018	0.016	0.000	0.002	0.000	0.000	0.005	0.023
14.10	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
TOTAL	1.020	1.600	2.880	2.140	1.670	1.360	1.470	2.400

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class D
Neutral Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.160	0.167	0.144	0.117	0.165	0.131	0.133	0.138	2.774
4.00	1.300	1.169	1.389	1.389	1.213	1.015	0.692	0.488	17.725
6.00	1.937	1.116	1.187	1.249	1.217	1.238	0.486	0.273	15.445
8.00	0.293	0.355	0.257	0.289	0.433	0.546	0.121	0.037	3.044
12.00	0.053	0.032	0.032	0.121	0.183	0.241	0.032	0.005	0.791
14.10	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.005
TOTAL	3.740	2.840	3.010	3.170	3.210	3.170	1.460	0.940	39.780

Data Table A-3. Meteorological Data (2007-2011) (continued) **5 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class E
Slightly Stable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.048	0.041	0.066	0.055	0.085	0.057	0.080	0.050
4.00	0.193	0.270	0.706	0.653	0.546	0.626	0.635	0.672
6.00	0.248	0.342	0.257	0.442	0.523	0.415	0.470	0.740
8.00	0.002	0.000	0.000	0.000	0.000	0.002	0.000	0.005
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.490	0.650	1.030	1.150	1.150	1.100	1.190	1.470

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class E
Slightly Stable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.066	0.055	0.057	0.073	0.062	0.066	0.053	0.048	0.965
4.00	0.795	0.853	0.678	0.587	0.630	0.486	0.403	0.332	9.065
6.00	1.277	0.983	0.972	0.814	0.628	0.436	0.215	0.083	8.843
8.00	0.011	0.011	0.007	0.000	0.000	0.000	0.000	0.000	0.039
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	2.150	1.900	1.710	1.470	1.320	0.990	0.670	0.460	18.910

Data Table A-3. Meteorological Data (2007-2011) (continued) **6 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class F
Moderately Stable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.064	0.048	0.092	0.066	0.046	0.066	0.055	0.089
4.00	0.309	0.346	0.465	0.213	0.176	0.254	0.332	0.497
6.00	0.163	0.319	0.094	0.030	0.025	0.080	0.135	0.167
8.00	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.540	0.720	0.650	0.310	0.250	0.400	0.520	0.750

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class F
Moderately Stable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.105	0.103	0.092	0.069	0.071	0.083	0.069	0.092	1.210
4.00	0.536	0.607	0.474	0.433	0.328	0.303	0.339	0.328	5.944
6.00	0.309	0.438	0.232	0.257	0.140	0.138	0.066	0.083	2.675
8.00	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.007
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.950	1.150	0.800	0.760	0.540	0.520	0.470	0.500	9.840

Data Table A-3. Meteorological Data (2007-2011) (continued) **7 of 7**

Direction is from which the wind blows

43824 WIND STATS H_AREA 60MIN 62M 07-11 STABILITY FROM SIGMA E

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class G
Extremely Stable Conditions

UMAX(M/S)	N	NNE	NE	ENE	E	ESE	SE	SSE
2.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Joint Frequency Distribution of Wind Speed and Direction: Atmospheric Stability Class G
Extremely Stable Conditions

UMAX(M/S)	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
2.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14.10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Data Table A-4. Population Distribution Around SRS (2010 Census)

Data Table A-4, Population Distribution Around SRS (2010 Census)

Dir(Miles)	0-10	10-20	20-30	30-40	40-50	TOTAL
N	29	9561	13784	4919	12842	41135
NNE	0	3572	2756	7035	32199	45562
NE	0	4791	2835	6128	18663	32417
ENE	16	1919	4524	5598	47214	59271
E	57	8029	7260	7301	4361	27008
ESE	26	2366	1371	1723	3048	8534
SE	10	536	6513	6300	9595	22954
SSE	5	122	242	431	5251	6051
S	0	306	1206	7932	3871	13315
SSW	0	1119	2149	5416	3472	12156
SW	4	1052	1634	1026	1871	5587
WSW	53	1310	10111	1226	5732	18432
W	1	3245	9710	4818	7206	24980
WNW	360	2598	115475	87020	17035	222488
NW	222	8478	93847	56513	3194	162254
NNW	449	28925	30971	10834	7737	78916
Total	1232	77929	304388	214220	183291	781060

Data Table A-5. Savannah River Mile 118.8 Flow Rates, 1954-2016

Data Table A-5, Savannah River Mile 118.8 Flow Rates, 1954-2016

Year	Mean Annual Flow (cfs)	Year	Mean Annual Flow (cfs)
1954	7,382	1990	11,858
1955	5,974	1991	11,598
1956	6,309	1992	11,697
1957	8,312	1993	14,788
1958	11,038	1994	12,271
1959	9,748	1995	12,750
1960	13,112	1996	11,467
1961	10,909	1997	10,464
1962	10,580	1998	16,239
1963	11,138	1999	6,160
1964	20,497	2000	5,550
1965	12,785	2001	5,804
1966	11,175	2002	5,386
1967	10,573	2003	12,842
1968	9,624	2004	8,778
1969	10,945	2005	11,935
1970	7,169	2006	6,818
1971	10,715	2007	6,088
1972	11,275	2008	4,833
1973	14,536	2009	7,666
1974	11,138	2010	9,893
1975	15,533	2011	5,714
1976	14,008	2012	4,570
1977	11,695	2013	8,479
1978	10,547	2014	9,440
1979	13,333	2015	8,833
1980	13,282	2016	10,150
1981	6,544	**Mean =**	**9,998**
1982	7,169	Harmonic Mean =	8,950
1983	12,348	Geometric Mean =	9,477
1984	12,759		
1985	7,167		
1986	6,175		
1987	8,955		
1988	5,364		
1989	7,966		

(USGS #02197500)
Near River Mile 118.8 (Hwy 301 Bridge)

Data Table A-6. Calculated Effective River Flow Rates

Data Table A-6, Calculated Effective River Flow Rates

Savannah River Monthly Flow Rate
Based on USGS Daily Flow Rate
Average is Monthly Average

	Flow, cfs
Month	River Mile 118.8 (Hwy 301)
January	34,735
February	18,495
March	11,684
April	9,669
May	7,864
June	6,262
July	6,364
August	5,329
September	5,862
October	5,388
November	4,647
December	5,271
Average	**10,131**

Savannah River Annual Flow Rate
Annual Average Based on
USGS Daily Flow Rate

Year	River Mile 118.8
	cfs
2007	6,088
2008	4,833
2009	7,666
2010	9,893
2011	5,714
2012	4,570
2013	8,479
2014	9,440
2015	8,833
2016	**10,150**
10-y Average	**7,567**

NOTE:
The annual measured river flow rate shown in the tables above is not used in the dose calculations unless the calculated "effective" river flow rate is higher.

River Flow Rate Adjustment Based on Tritium Measurements

Total Tritium Released to the Savannah River: **1,779** Curies
(731 Ci from SRS, 56 Ci from the Barnwell Low-Level Disposal Facility, and 992 Ci from Plant Vogtle)

Location	Finished Water Meas. Conc. pCi/ml	Calculated Total Flow ml	Effective Flow Rate cfs
River Mile 118.8 - calc [a,b]	0.310	5.74E+15	6,426
Beaufort-Jasper/Purrysburg - calc [a,b]	0.214	8.31E+15	9,309
Beaufort-Jasper/Chelsea - calc [a,b]	N/A	N/A	9,309
Savannah I&D - calc [a,b]	N/A	N/A	9,309
Estuary (1.1 x River Mile 118.8 Effective Flow Rate)[c]			7,069

a) Total flow calculated on basis of releases of tritium and measured tritium concentrations in the river using the following equation: Total flow, ml=(Q,Ci)(1.0E+12 pCi/Ci)/(Conc,pCi/ml).

b) Effective Flow rate, in cfs, is calculated using the following equation:

$$\text{Flow Rate, cfs} = (\text{Total Flow, ml/yr})/(8.93\text{E+11 ml-sec/ft}^3\text{-yr})$$

c) Estuary effective flow rate is used for the collective dose calculation

Data Table A-7. Radioactive Liquid Releases by Source (Curies)

Data Table A-7, Radioactive Liquid Releases by Source (Curies)

Nuclide	Upper Three Runs (A,M,F,H)	Fourmile Branch (F,H,Tritium)	Steel Creek + Pen Branch (K,L)	Lower Three Runs (P,R)	Totals
H-3[a]	1.12E+02	3.16E+02	2.35E+02	5.31E+00	**6.68E+02**
C-14	2.54E-04	3.28E-04			**5.82E-04**
Sr-90	8.02E-06	1.95E-02	0.00E+00		**1.95E-02**
Tc-99	0.00E+00	1.88E-02			**1.88E-02**
I-129	0.00E+00	1.82E-02			**1.82E-02**
Cs-137[b]	8.19E-03	9.62E-03	0.00E+00	0.00E+00	**1.78E-02**
U-234	3.16E-02	1.38E-03			**3.30E-02**
U-235	8.84E-04	1.55E-04			**1.04E-03**
U-238	3.45E-02	2.29E-03			**3.68E-02**
Np-237	0.00E+00	2.78E-06			**2.78E-06**
Pu-238	3.55E-06	2.56E-04			**2.60E-04**
Pu-239	8.50E-07	1.28E-05			**1.37E-05**
Am-241	1.71E-03	9.17E-05			**1.80E-03**
Cm-244	3.21E-08	1.54E-04			**1.54E-04**
Alpha[c]	5.99E-04	1.12E-03	1.25E-02	5.57E-03	**1.98E-02**
Beta-Gamma[d]	2.01E-03	3.41E-03	7.15E-02	5.90E-02	**1.36E-01**

a) Depending which one is higher, the tritium release total includes direct + migration releases or tritium transport in streams totals. The higher one is used in the dose calculations for determining SRS-only impacts.

It does not include releases to the Savannah River from the Vogtle Electric Generating Plant or migration releases into Lower Three Runs from the Barnwell Low-Level Radioactive Waste Disposal Facility.

b) Depending on which value is higher, the Cs-137 release total is based on concentrations measured in RM 118.8 fish or on the actual measured effluent release total from the site. Refer to chapter 6 (Dose) for more information.

c,d) For dose calculations, unspecified alpha and beta/gamma releases are assumed to be Pu-239 and Sr-90, respectively.

Data Table A-8. Radioactive Liquid Releases, 2012-2016 (Curies)

Data Table A-8, Radioactive Liquid Releases, 2012-2016 (curies)

Radionuclide	2012	2013	2014	2015	2016	2015 to 2016 Percent Change
H-3	7.46E+02	1.08E+03	6.99E+02	7.86E+02	**6.68E+02**	-15%
C-14	4.33E-03	6.13E-03	6.40E-03	5.33E-03	**5.82E-04**	-89%
Sr-89,90	1.81E-02	2.39E-02	5.36E-02	2.43E-02	**1.95E-02**	-20%
Tc-99	1.09E-02	1.85E-02	2.64E-02	1.30E-02	**1.88E-02**	45%
I-129	1.33E-02	2.70E-02	2.45E-02	1.44E-02	**1.82E-02**	26%
Cs-137	5.09E-02	3.34E-02	5.09E-02	1.08E-02	**1.78E-02**	65%
U-234	7.48E-02	4.54E-02	7.22E-02	6.77E-02	**3.30E-02**	-51%
U-235	3.84E-03	2.63E-03	3.65E-03	2.50E-03	**1.04E-03**	-58%
U-238	7.73E-02	5.50E-02	8.45E-02	7.55E-02	**3.68E-02**	-51%
Np-237	5.14E-06	5.05E-07	5.97E-06	3.21E-07	**2.78E-06**	768%
Pu-238	6.79E-04	6.27E-04	3.65E-04	5.13E-04	**2.60E-04**	-49%
Pu-239	5.69E-05	4.81E-05	1.56E-04	1.10E-04	**1.37E-05**	-88%
Am-241	3.93E-03	4.27E-03	3.36E-03	1.79E-04	**1.80E-03**	907%
Cm-244	6.82E-04	2.23E-05	4.83E-04	1.21E-04	**1.54E-04**	28%
Alpha	1.40E-02	5.18E-03	3.56E-03	8.60E-03	**1.98E-02**	130%
Beta-Gamma	4.88E-02	4.12E-02	2.87E-02	9.53E-02	**1.36E-01**	43%

Data Table A-9. Radionuclide Concentrations at Downriver Drinking Water Plants Compared to EPA MCLs

Data Table A-9,
Radionuclide Concentrations at the Downriver Drinking Water Plants Compared to EPA MCLs

		12-Month Average Concentrations			
Nuclide	EPA MCL (pCi/L)	Below SRS [a] (pCi/L)	Fraction of EPA MCL (unitless)	BJWSA Purrysburg [b] (pCi/L)	Fraction of EPA MCL (unitless)
H-3[c]	2.00E+04	3.10E+02	1.55E-02	2.14E+02	1.07E-02
C-14	2.00E+03	1.01E-04	5.05E-08	7.00E-05	3.50E-08
Sr-90	8.00E+00	3.40E-03	4.25E-04	2.34E-03	2.93E-04
Tc-99	9.00E+02	3.27E-03	3.63E-06	2.26E-03	2.51E-06
I-129	1.00E+00	3.17E-03	3.17E-03	2.19E-03	2.19E-03
Cs-137	2.00E+02	8.34E-03	4.17E-05	5.76E-03	2.88E-05
U-234[d]	1.03E+01	5.75E-03	5.58E-04	3.97E-03	3.86E-04
U-235[d]	4.67E-01	1.81E-04	3.88E-04	1.26E-04	2.69E-04
U-238[d]	1.00E+01	6.41E-03	6.41E-04	4.42E-03	4.42E-04
Np-237	1.50E+01	4.84E-07	3.23E-08	3.34E-07	2.23E-08
Pu-238	1.50E+01	4.53E-05	3.02E-06	3.13E-05	2.09E-06
Pu-239	1.50E+01	2.39E-06	1.59E-07	1.65E-06	1.10E-07
Am-241	1.50E+01	3.13E-04	2.09E-05	2.16E-04	1.44E-05
Cm-244	1.50E+01	2.68E-05	1.79E-06	1.85E-05	1.23E-06
Alpha	1.50E+01	3.45E-03	2.30E-04	2.38E-03	1.59E-04
Nonvolatile Beta	8.00E+00	2.37E-02	2.96E-03	1.63E-02	2.04E-03
Sum of the Fractions =			**2.39E-02**		**1.65E-02**

a. Near Savannah River Mile 118.8, downriver of SRS at the U.S. Highway 301 bridge

b. Beaufort-Jasper Water and Sewer Authority, drinking water at the Purrysburg Plant

c. The tritium concentrations and source term are based on actual measurements of the Savannah River water at the various locations. They include contributions from VEGP and the Barnwell Low-Level Disposal Facility. All other radionuclide concentrations are calculated based on the effective or measured river flow rate.

d. MCLs for Uranium based on radioisotope specific activity X 30 µg/L X isotopic abundance

Data Table A-9 – *Support*. 2016 Radioactive Liquid Release Source Term and 12-Month Average Downriver Radionuclide Concentrations Compared to the US EPA's Drinking Water Maximum Contaminant Levels (MCL)

2016 Radioactive Liquid Release Source Term and 12-Month Average Downriver Radionuclide Concentrations Compared to the US EPA's Drinking Water Maximum Contaminant Levels (MCL)

	12-Month Average Concentration (pCi/L)				Output from LADTAP XL (uCi/mL)	
Nuclide	Curies Released	Below SRS [a]	at BJWSA Purrysburg [b]	EPA MCL[d]	Below SRS [a]	at BJWSA Purrysburg [b]
H-3[c]	1.78E+03	3.10E+02	2.14E+02	2.00E+04	3.10E-07	2.14E-07
C-14	5.82E-04	1.01E-04	7.00E-05	2.00E+03	1.01E-13	7.00E-14
Sr-90	1.95E-02	3.40E-03	2.34E-03	8.00E+00	3.40E-12	2.34E-12
Tc-99	1.88E-02	3.27E-03	2.26E-03	9.00E+02	3.27E-12	2.26E-12
I-129	1.82E-02	3.17E-03	2.19E-03	1.00E+00	3.17E-12	2.19E-12
Cs-137	4.79E-02	8.34E-03	5.76E-03	2.00E+02	8.34E-12	5.76E-12
U-234	3.30E-02	5.75E-03	3.97E-03	1.03E+01	5.75E-12	3.97E-12
U-235	1.04E-03	1.81E-04	1.26E-04	4.67E-01	1.81E-13	1.26E-13
U-238	3.68E-02	6.41E-03	4.42E-03	1.00E+01	6.41E-12	4.42E-12
Np-237	2.78E-06	4.84E-07	3.34E-07	1.50E+01	4.84E-16	3.34E-16
Pu-238	2.60E-04	4.53E-05	3.13E-05	1.50E+01	4.53E-14	3.13E-14
Pu-239	1.37E-05	2.39E-06	1.65E-06	1.50E+01	2.39E-15	1.65E-15
Am-241	1.80E-03	3.13E-04	2.16E-04	1.50E+01	3.13E-13	2.16E-13
Cm-244	1.54E-04	2.68E-05	1.85E-05	1.50E+01	2.68E-14	1.85E-14
Alpha	1.98E-02	3.45E-03	2.38E-03	1.50E+01	3.45E-12	2.38E-12
Beta	1.36E-01	2.37E-02	1.63E-02	8.00E+00	2.37E-11	1.63E-11

a. Near Savannah River Mile 118.8, downriver of SRS at the U.S. Highway 301 bridge

b. Beaufort-Jasper Water and Sewer Authority, drinking water at the Purrysburg Plant

c. The tritium concentrations and source term are based on actual measurements of the Savannah River water at the various locations.

They include contributions from VEGP and the Barnwell Low-Level Disposal Facility.

All other radionuclide concentrations are calculated based on the effective or measured river flow rate.

d. MCLs for Uranium based on radioisotope specific activity X 30 µg/L X isotopic abundance

Data Table A-10. Adjustment of Cs-137 Release Based on Fish Concentrations

Data Table A-10, Adjustment of Cs-137 Release Based on Fish Concentrations

Activity in Fish	**Cs-137 Conc,pCi/g**
River Mile 118.8 wtd avg conc	2.50E-02

Cs-137	Measured Ci Released	LADTAP BAF	RM 118.8 Flow, cfs	Calc Fish Conc,pCi/g	Meas Fish Conc,pCi/g	Ratio meas/calc
RM118.8-Max Ind	1.78E-02	3000	6,426	9.31E-03	2.50E-02	2.69

Ratios (right column) are multipliers for measured releases in order for LADTAP to calculate the appropriate dose using the built in BAF factors. Calculated release values used in LADTAP calculations are shown below:

Cs-137	Multiplier (ratio)	Measured Ci Release	Calc Ci Release	
RM118.8-Max Ind	2.69	1.78E-02	4.79E-02	(see note below)

Cs-137 direct releases:	1.78E-02	Ci
2015 total effective flow RM 118.8:	5.74E+15	ml
Calc Cs-137 conc =	3.10E-06	pCi/ml

Ratios of Measured/Calculated Conc. of Cs-137 in fish

Year	Ratio	Year	Ratio
1985	5.2	2001	0.8
1986	8.4	2002	2.1
1987	3.0	2003	0.54
1988	1.4	2004	0.27
1989	1.2	2005	0.42
1990	6.8	2006	0.39
1991	25.3	2007	0.6
1992	1.2	2008	0.56
1993	1.1	2009	0.45
1994	1.4	2010	1.3
1995	3.1	2011	0.34
1996	1.3	2012	0.5
1997	2.6	2013	2.36
1998	1.2	2014	0.77
1999	2.3	2015	4.33
2000	1.1	2016	2.69

NOTE: FOR 2016, THE CALCULATED CS-137 EFFLUENT RELEASE VALUE OF 0.0479 CURIE WAS USED IN THE DOSE CALCULATIONS INSTEAD OF THE MEASURED EFFLUENT RELEASE VALUE OF 0.0178 CURIE.

Data Table A-10 – *Support.* Adjustment of Cs-137 Liquid Release Based on Fish Concentrations

Adjustment of Cs-137 Liquid Release Based on Fish Concentrations

Cesium-137 Measured Mean Concentrations in River Mile 118.8 Fish

Location	Species	Number of Composites	Cs-137, pCi/g Average	# comp X avg. conc. pCi/g
River Mile 118.8	bass	3	3.77E-02	1.13E-01
	catfish	3	2.48E-02	7.44E-02
	panfish	3	1.26E-02	3.78E-02
	Total Composites	9	Sum =	2.25E-01
		Overall weighted average----->		2.50E-02

Data Table A-11. Representative Person Dose - All Liquid Pathways Including Irrigation

Data Table A-11, Representative Person Dose - All Liquid Pathways Including Irrigation

By Pathway

Pathway	Representative Person Dose, mrem [(a)]	Percent of Total Dose
Vegetable	8.4E-02	55%
Milk	1.2E-02	8%
Meat	4.0E-03	3%
Fish Consumption	3.5E-02	23%
Water Consumption	1.7E-02	11%
Shoreline	3.6E-04	0%
Swimming and Boating	5.1E-06	0%
Total	**1.5E-01**	

By Radionuclide

Radionuclide	Representative Person Dose, mrem [(a)]	Percent of Total Dose
H-3 (oxide)	1.5E-02	10%
C-14	8.3E-06	0%
Sr-90	5.1E-03	3%
Tc-99	2.4E-02	16%
I-129	1.1E-02	7%
Cs-137	3.2E-02	21%
U-234	5.8E-03	4%
U-235	1.7E-04	0%
U-238	5.8E-03	4%
Np-237	9.7E-07	0%
Pu-238	1.8E-04	0%
Pu-239	1.0E-05	0%
Am-241	2.5E-03	2%
Cm-244	6.2E-05	0%
Alpha	1.5E-02	10%
Nonvolatile Beta	3.6E-02	23%
Total	**1.5E-01**	

a) Committed effective dose

Data Table A-11 – *Support*. Irrigation Pathway Doses from IRRIDOSE

Irrigation Pathway Doses from IRRIDOSE

Irrigation Pathway Doses	
Food Type	**Representative Person, mrem**
Vegetable	8.4E-02
Milk	1.2E-02
Meat	4.0E-03
Total	**1.0E-01**

Irrigation Radionuclide Doses	
Radionuclide	**Representative Person Dose, mrem**
H-3 (oxide)	6.5E-03
C-14	8.1E-06
Sr-90	4.7E-03
Tc-99	2.4E-02
I-129	9.0E-03
Cs-137	2.4E-03
U-234	4.8E-03
U-235	1.4E-04
U-238	4.8E-03
Np-237	6.8E-07
Pu-238	1.1E-04
Pu-239	6.5E-06
Am-241	7.2E-04
Cm-244	3.9E-05
Alpha	9.4E-03
Nonvolatile Beta	3.3E-02
Total	**1.0E-01**

Data Table A-12. Comparison of 2012-2016 Offsite Doses

Data Table A-12, Comparison of 2012-2016 Offsite Doses

	2012	2013	2014	2015	2016
Atmospheric Releases					
MEI or Representative Person, mrem [a]					
All Pathways	2.7E-02	5.2E-02	4.4E-02	3.2E-02	3.8E-02
Population, person-rem					
50-mile (80-km) Population	7.6E-01	2.2E+00	1.7E+00	1.1E+00	1.4E+00
Liquid Releases					
MEI or Representative Person, mrem [a]					
All Pathways Except Irrigation	1.0E-01	5.2E-02	4.1E-02	5.3E-02	5.3E-02
Irrigation Pathway	1.3E-01	9.0E-02	7.4E-02	9.3E-02	1.0E-01
Population, person-rem					
Down River Population	1.9E+00	1.2E+00	9.1E-01	1.3E+00	1.1E+00
Irrigation Pathway at RM 118.8	1.9E+00	1.3E+00	1.1E+00	1.3E+00	2.4E+00
Total MEI or Representative Person [b] (Air + Liquid + Irrigation) (mrem)	**0.26**	**0.19**	**0.16**	**0.18**	**0.19**
Total Population [b] (Air + Liquid + Irrigation) (person-rem)	**4.6**	**4.7**	**3.7**	**3.7**	**4.9**

a. In 2012, SRS changed from the MEI to the Representative Person concept for dose compliance.

Data Table A-13. Representative Person Drinking Water Dose

Data Table A-13, Representative Person Drinking Water Dose

(Based on Tritium Measurements from the BJSWA Purrysburg Treatment Plant)

Radionuclide	Representative Person Dose, mrem [a]	Percent of Total Dose
H-3 (oxide)	5.5E-03	46%
C-14	1.3E-07	0%
Sr-90	2.5E-04	2%
Tc-99	6.0E-06	0%
I-129	7.8E-04	6%
Cs-137	2.3E-04	2%
U-234	6.8E-04	6%
U-235	2.0E-05	0%
U-238	6.9E-04	6%
Np-237	1.2E-07	0%
Pu-238	2.4E-05	0%
Pu-239	1.4E-06	0%
Am-241	1.5E-04	1%
Cm-244	8.3E-06	0%
Alpha	2.0E-03	17%
Nonvolatile Beta	1.7E-03	14%
Total	**1.2E-02**	

a) Committed effective dose

Data Table A-14. Collective Drinking Water Doses (person-rems)

Data Table A-14, Collective Drinking Water Doses (person-rems)

For the Beaufort Jasper Water and Sewer Authority Chelsea and Purrysburg Water Treatment Plants and the Savannah Industrial and Domestic Water Treatment Plant

Radionuclide	BJWSA Chelsea[a]	BJWSA Purrysburg[b]	Savannah I&D[c]
H-3 (oxide)	1.7E-01	1.3E-01	7.2E-02
C-14	4.1E-06	3.2E-06	1.7E-06
Sr-90	7.8E-03	6.1E-03	3.3E-03
Tc-99	1.9E-04	1.5E-04	7.9E-05
I-129	2.5E-02	1.9E-02	1.0E-02
Cs-137	7.1E-03	5.5E-03	3.0E-03
U-234	2.1E-02	1.7E-02	9.0E-03
U-235	6.4E-04	4.9E-04	2.7E-04
U-238	2.2E-02	1.7E-02	9.0E-03
Np-237	3.9E-06	3.0E-06	1.6E-06
Pu-238	7.6E-04	5.9E-04	3.2E-04
Pu-239	4.4E-05	3.4E-05	1.8E-05
Am-241	4.8E-03	3.7E-03	2.0E-03
Cm-244	2.6E-04	2.0E-04	1.1E-04
Alpha	6.4E-02	4.9E-02	2.7E-02
Nonvolatile Beta	5.5E-02	4.2E-02	2.3E-02
Total	**3.8E-01**	**2.9E-01**	**1.6E-01**

a) 83,700 people served (3/24/17 email from Tricia Kilgore to Tim Jannik)

b) 64,800 people served (3/24/17 email from Tricia Kilgore to Tim Jannik)

c) 35,000 people served (4/3/17 email from Tony Tucker to Tim Jannik)

Data Table A-15. Collective Dose - All Liquid Pathways Including Irrigation

Data Table A-15, Collective Dose - All Liquid Pathways Including Irrigation

By Pathway

Pathway	Collective Dose (person-rem)[a]	Percent of Total Dose
Sport fish	1.2E-02	0%
Commercial fish	8.4E-02	2%
Saltwater invertebrates	1.6E-01	5%
Shoreline Exposure	1.5E-02	0%
Swimming	1.0E-04	0%
Boating	1.1E-05	0%
Beaufort-Jasper (Chelsea)	3.8E-01	11%
Beaufort-Jasper (Purrysburg)	2.9E-01	8%
Savannah I&D	1.6E-01	5%
Vegetable consumption	2.3E+00	67%
Milk consumption	6.1E-02	1%
Meat consumption	2.0E-03	0%
Total	**3.5E+00**	

By Radionuclide

Radionuclide	Collective Dose (person-rem)[a]	Percent of Total Dose
H-3	4.8E-01	14%
C-14	6.9E-04	0%
Sr-90	1.4E-01	4%
Tc-99	6.0E-01	17%
I-129	2.4E-01	7%
Cs-137	1.5E-01	4%
U-234	1.7E-01	5%
U-235	5.0E-03	0%
U-238	1.7E-01	5%
Np-237	2.8E-05	0%
Pu-238	6.4E-03	0%
Pu-239	3.7E-04	0%
Am-241	4.6E-02	1%
Cm-244	2.5E-03	0%
Alpha	5.3E-01	15%
Nonvolatile Beta	9.7E-01	28%
Total	**3.5E+00**	

a) Committed effective dose

Data Table A-16. 2016 Radioactive Atmospheric Releases by Site Area (Curies)[a]

Table A-16, 2016 Radioactive Atmospheric Releases by Site Area (Curies)[a] 2 Pages

Radionuclide	Half-Life[b]	Calculated[c]	Reactors	Separations[d]	SRNL	Total
Gases and Vapors						
H-3 (oxide)	12.3 y	2.24E+03	9.15E+02	1.67E+04		**1.99E+04**
H-3 (elemental)	12.3 y			1.88E+03		**1.88E+03**
H-3 Total	12.3 y	2.24E+03	9.15E+02	1.86E+04		**2.17E+04**
C-14	5700 y	1.57E-07		1.64E-02		**1.64E-02**
Hg-203	46.6 d	5.22E-10				**5.22E-10**
Kr-85	10.8 y			3.96E+03		**3.96E+03**
I-129	1.57E+07 y	2.01E-04		1.89E-03	9.06E-06	**2.09E-03**
I-131	8.02 d	6.75E-10				**6.75E-10**
Particles						
Ag-110m	250 d	1.48E-11				**1.48E-11**
Am-241	432 y	1.12E-05	0.00E+00	2.61E-05		**3.73E-05**
Am-243	7370 y	4.50E-09				**4.50E-09**
Ba-133	10.5 y	7.01E-10				**7.01E-10**
Cd-109	461 d	1.34E-08				**1.34E-08**
Ce-139	138 d	5.20E-10				**5.20E-10**
Ce-141	32.5 d	4.94E-11				**4.94E-11**
Ce-144	285 d	2.00E-08				**2.00E-08**
Cm-244	18.1 y	2.83E-07	0.00E+00	8.54E-07		**1.14E-06**
Co-57	272 d	4.96E-10				**4.96E-10**
Co-60	5.27 y	4.96E-07	0.00E+00	0.00E+00	0.00E+00	**4.96E-07**
Cs-134	2.06 y	4.31E-07				**4.31E-07**
Cs-137	30.2 y	1.25E-03	0.00E+00	7.80E-03	0.00E+00	**9.05E-03**
Eu-152	13.5 y	1.47E-09				**1.47E-09**
Eu-154	8.59 y	3.56E-07				**3.56E-07**
Eu-155	4.76 y	1.18E-07				**1.18E-07**
F-18	110 m	4.00E-02				**4.00E-02**
Fe-55	2.74 y	1.17E-08				**1.17E-08**
Mn-54	312 d	3.78E-10				**3.78E-10**
Nb-94	2.03E+04 y	2.42E-07				**2.42E-07**
Nb-95	35.0 d	3.63E-07				**3.63E-07**
Ni-59	1.01E+05 y	5.76E-11				**5.76E-11**
Ni-63	100 y	5.46E-09				**5.46E-09**
Np-237	2.14E+06 y	1.62E-06	0.00E+00	8.79E-08		**1.71E-06**
Pa-233	27.0 d	1.42E-06				**1.42E-06**
Pb-212	10.6 h	8.43E-07				**8.43E-07**
Pm-147	2.62 y	2.89E-06				**2.89E-06**
Pm-148m	41.3 d	1.90E-12				**1.90E-12**
Pr-144	17.3 m	2.00E-08				**2.00E-08**
Pu-236	2.86 y	5.55E-10				**5.55E-10**
Pu-238	87.7 y	3.14E-05	4.72E-10	8.01E-06		**3.94E-05**
Pu-239	2.41E+04 y	4.34E-05	0.00E+00	6.09E-05		**1.04E-04**
Pu-240	6560 y	7.73E-06				**7.73E-06**
Pu-241	14.4 y	2.07E-04				**2.07E-04**
Pu-242	3.75E+05 y	2.16E-06				**2.16E-06**

Table A-16, 2016 Radioactive Atmospheric Releases by Site Area (Curies)[a] **2 Pages**

Radionuclide	Half-Life[b]	Calculated[c]	Reactors	Separations[d]	SRNL	Total
Particles						
Ra-226	1600 y	2.48E-07				**2.48E-07**
Ra-228	5.75 y	2.29E-07				**2.29E-07**
Rh-106	29.8 s	1.19E-08				**1.19E-08**
Ru-103	39.3 d	5.11E-10				**5.11E-10**
Ru-106	374 d	3.04E-06				**3.04E-06**
Sb-125	2.76 y	1.18E-06				**1.18E-06**
Sb-126[e]	12.4 d	1.70E-07				**1.70E-07**
Se-75	120 d			1.94E-07		**1.94E-07**
Se-79	2.95E+05 y	4.90E-09				**4.90E-09**
Sm-151	90 y	2.89E-06				**2.89E-06**
Sn-113	115 d	6.27E-10				**6.27E-10**
Sn-123	129 d	6.66E-12				**6.66E-12**
Sn-126	2.30E+05 y	1.70E-07				**1.70E-07**
Sr-85	64.8 d	6.00E-10				**6.00E-10**
Sr-89	50.5 d	5.99E-10				**5.99E-10**
Sr-90	28.8 y	3.34E-05	2.30E-09	1.53E-04		**1.87E-04**
Tc-99	2.11E+05 y	1.06E-06				**1.06E-06**
Te-127	9.35 h	1.04E-11				**1.04E-11**
Te-129	69.6 m	1.05E-12				**1.05E-12**
Th-228	1.91 y	1.26E-10	8.29E-10			**9.55E-10**
Th-229	7340 y	1.60E-09				**1.60E-09**
Th-230	7.54E+04 y	1.43E-10	7.68E-09			**7.82E-09**
Th-231	25.5 h	2.12E-04				**2.12E-04**
Th-232	1.41E+10 y	4.79E-12	2.17E-09			**2.18E-09**
Tl-208	3.05 m	1.41E-06				**1.41E-06**
U-232	68.9 y	6.04E-09				**6.04E-09**
U-233	1.59E+05 y	4.21E-10				**4.21E-10**
U-234	2.46E+05 y	6.11E-07	2.41E-09	1.02E-04		**1.03E-04**
U-235	7.04E+08 y	8.41E-09	0.00E+00	6.33E-06		**6.34E-06**
U-236	2.34E+07 y	3.01E-08				**3.01E-08**
U-238	4.47E+09 y	2.08E-07	1.99E-09	1.48E-04		**1.48E-04**
Y-88	107 d	4.58E-10				**4.58E-10**
Y-90[e]	64.1 h	3.34E-05	2.30E-09	1.53E-04		**1.87E-04**
Y-91	58.5 d	7.98E-10				**7.98E-10**
Zn-65	244 d	9.56E-10				**9.56E-10**
Zr-95	64.0 d	1.22E-07				**1.22E-07**
Unidentified alpha	N/A	3.94E-05	0.00E+00	1.21E-05	0.00E+00	**5.15E-05**
Unidentified beta	N/A	2.17E-03	5.17E-05	9.05E-04	1.73E-06	**3.13E-03**

a. One curie equals 3.7E+10 Becquerel
b. ICRP 107, Nuclear Decay Data for Dosimetric Calculations (2008)
c. Estimated releases from unmonitored sources. Beginning in 2016, individual isotope annual releases below 1E-12 Ci (1 pCi) are no longer reported in this table and, therefore, not used in the dose calculations.
d. Includes separations, waste management, and tritium facilities
e. Daughter products (Sb-126 & Y-90) in secular equilibrium with source terms (Sn-126 & Sr-90, respectively). In MAXDOSE/POPDOSE, they are included in the source term and their ingrowth is included in their parents' source term.

Data Table A-17. 2012-2016 Atmospheric Releases (Curies)

Data Table A-17, 2012-2016 Atmospheric Releases (Curies) **3 Pages**

Radionuclide	2012	2013	2014	2015	2016[a]	2015-2016 %Change
Gases and Vapors						
H-3 (oxide)	1.39E+04	2.11E+04	2.38E+04	1.66E+04	1.99E+04	20%
H-3 (elemental)	2.77E+03	3.17E+03	3.49E+03	2.47E+03	1.88E+03	-24%
H-3 Total	1.67E+04	2.43E+04	2.73E+04	1.91E+04	2.17E+04	14%
C-14	5.34E-02	1.14E-01	2.08E-01	1.37E-02	1.64E-02	20%
Hg-203					5.22E-10	
Kr-85	8.91E+03	1.51E+04	6.46E+03	2.78E+03	3.96E+03	42%
I-129	1.65E-03	1.41E-03	2.21E-03	1.93E-03	2.09E-03	9%
I-131					6.75E-10	
Particles						
Ag-110m	1.57E-11	1.48E-11	1.48E-11	1.48E-11	1.48E-11	0%
Am-241	2.76E-05	1.60E-05	1.91E-05	1.33E-05	3.73E-05	181%
Am-242m			6.19E-10			
Am-243	2.14E-06		1.25E-08	5.26E-09	4.50E-09	-14%
Ba-133	1.37E-04				7.01E-10	
Bi-212	1.06E-04					
Bi-214	1.28E-03					
Cd-109					1.34E-08	
Ce-139					5.20E-10	
Ce-141	1.61E-04	4.94E-11	4.94E-11	4.94E-11	4.94E-11	0%
Ce-144	6.07E-04	2.00E-08	6.50E-06	2.00E-08	2.00E-08	0%
Cf-249	1.35E-04		3.74E-08			
Cf-251	3.74E-04		3.04E-08			
Cm-242	2.14E-09	1.89E-16	5.12E-10	1.89E-16		
Cm-243			3.45E-08			
Cm-244	1.86E-06	3.66E-07	4.31E-07	2.97E-07	1.14E-06	282%
Cm-245			2.97E-08			
Cm-246			4.90E-09			
Cm-247	1.17E-06		3.30E-08			
Co-57	7.79E-05				4.96E-10	
Co-58	1.33E-05					
Co-60	3.20E-04	8.49E-06	4.30E-06	4.37E-07	4.96E-07	13%
Cs-134	1.92E-05	4.31E-07	4.31E-07	4.31E-07	4.31E-07	0%
Cs-137	1.21E-02	7.70E-02	1.69E-02	1.18E-03	9.05E-03	670%
Eu-152	3.04E-04		5.43E-07	5.01E-08	1.47E-09	-97%
Eu-154	7.20E-04	3.55E-07	7.19E-07	3.55E-07	3.56E-07	0%

Data Table A-17, 2012-2016 Atmospheric Releases (Curies) **3 Pages**

Radionuclide	2012	2013	2014	2015	2016[a]	2015-2016 %Change
Eu-155	3.20E-04	1.18E-07	2.22E-06	1.18E-07	1.18E-07	0%
F-18	3.20E-02	3.60E-02	2.00E-02	4.00E-02	4.00E-02	0%
Fe-55					1.17E-08	
Mn-54	1.36E-05		4.84E-07		3.78E-10	
Na-22	1.17E-05					
Nb-94	1.38E-05	2.42E-07	2.42E-07	2.42E-07	2.42E-07	0%
Nb-95	2.70E-09	3.63E-07	3.63E-07	3.63E-07	3.63E-07	0%
Ni-59	6.70E-05	5.76E-11	2.91E-07	5.76E-11	5.76E-11	0%
Ni-63	3.70E-03	5.62E-09	2.00E-06	5.62E-09	5.46E-09	-3%
Np-237	4.08E-06	1.53E-06	7.09E-06	1.61E-06	1.71E-06	6%
Np-239	5.87E-04					
Pa-233	1.99E-04	1.42E-06	1.42E-06	1.42E-06	1.42E-06	0%
Pb-212	1.69E-04	8.43E-07	8.43E-07	8.43E-07	8.43E-07	0%
Pb-214	2.07E-06		8.84E-13			
Pm-144	1.44E-05					
Pm-146	1.77E-04					
Pm-147	3.29E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06	0%
Pm-148m	2.02E-12	1.90E-12	1.90E-12	1.90E-12	1.90E-12	0%
Particles						
Pr-144	2.12E-08	2.00E-08	2.00E-08	2.00E-08	2.00E-08	0%
Pu-236			1.83E-10	5.75E-10	5.55E-10	-3%
Pu-238	9.45E-05	1.48E-04	4.25E-05	3.55E-05	3.94E-05	11%
Pu-239	9.79E-04	8.58E-04	4.27E-05	4.72E-05	1.04E-04	121%
Pu-240	2.91E-05	7.68E-06	7.73E-06	7.73E-06	7.73E-06	0%
Pu-241	3.24E-04	2.07E-04	2.09E-04	2.07E-04	2.07E-04	0%
Pu-242	2.54E-06	1.38E-08	1.56E-08	1.78E-08	2.16E-06	12048%
Ra-226	1.17E-06	3.01E-07	2.73E-07	2.76E-07	2.48E-07	-10%
Ra-228	3.44E-07	3.01E-07	2.65E-07	2.62E-07	2.29E-07	-13%
Rh-106	1.40E-08	1.19E-08	1.19E-08	1.19E-08	1.19E-08	0%
Ru-103	1.16E-04	5.11E-10	5.11E-10	5.11E-10	5.11E-10	0%
Ru-106	6.43E-04	3.04E-06	3.04E-06	3.04E-06	3.04E-06	0%
Sb-125	1.59E-05	1.18E-06	1.28E-06	1.18E-06	1.18E-06	0%
Sb-126	1.93E-04	1.70E-07	1.70E-07	1.70E-07	1.70E-07	0%
Se-75					1.94E-07	
Se-79	3.59E-06	4.90E-09	4.90E-09	4.90E-09	4.90E-09	0%
Sm-151	3.07E-06	2.89E-06	2.89E-06	2.89E-06	2.89E-06	0%
Sn-113	1.46E-04				6.27E-10	
Sn-123	7.06E-12	6.66E-12	6.66E-12	6.66E-12	6.66E-12	0%

Data Table A-17, 2012-2016 Atmospheric Releases (Curies) **3 Pages**

Radionuclide	2012	2013	2014	2015	2016[a]	2015-2016 %Change
Sn-126	1.93E-04	1.70E-07	1.70E-07	1.70E-07	1.70E-07	0%
Sr-85					6.00E-10	
Sr-89	4.36E-10	4.12E-10	5.18E-10	6.02E-10	5.99E-10	0%
Sr-89,90	9.83E-02	4.88E-04	9.79E-05	4.44E-05	1.87E-04	320%
Tc-99	1.58E-03	4.09E-07	1.94E-06	3.87E-07	1.06E-06	173%
Te-127	1.10E-11	1.04E-11	1.04E-11	1.04E-11	1.04E-11	0%
Te-129	1.11E-12	1.05E-12	1.05E-12	1.05E-12	1.05E-12	0%
Th-228	2.48E-10	1.71E-10	2.17E-09	8.64E-10	9.55E-10	11%
Th-229			9.28E-10	1.56E-09	1.60E-09	2%
Th-230	6.32E-09	9.71E-08	6.80E-07	9.36E-09	7.82E-09	-16%
Th-231	2.25E-04	2.12E-04	2.12E-04	2.12E-04	2.12E-04	0%
Th-232	1.21E-09	1.04E-09	4.44E-09	2.43E-09	2.18E-09	-10%
Tl-208	7.88E-05	1.41E-06	1.41E-06	1.41E-06	1.41E-06	0%
U-232	3.39E-06	2.23E-10	3.19E-09	6.56E-09	6.04E-09	-8%
U-233	8.32E-05	3.47E-10	3.93E-07	5.78E-09	4.21E-10	-93%
U-234	5.94E-06	2.85E-05	9.38E-06	7.02E-06	1.03E-04	1366%
U-235	2.42E-05	1.00E-06	2.27E-07	8.26E-07	6.34E-06	667%
U-236	3.19E-08	3.01E-08	3.01E-08	3.01E-08	3.01E-08	0%
U-238	8.90E-06	3.00E-05	1.29E-05	8.69E-06	1.48E-04	1608%
Y-88	1.26E-05				4.58E-10	
Y-90	9.80E-02	4.78E-04	9.47E-05	4.44E-05	1.87E-04	320%
Y-91	8.46E-10	7.98E-10	7.98E-10	7.98E-10	7.98E-10	0%
Zn-65	3.15E-05		1.96E-06		9.56E-10	
Zr-95	2.59E-05	1.22E-07	1.22E-07	1.22E-07	1.22E-07	0%
Unidentified Alpha	1.52E-04	1.25E-03	1.04E-04	3.08E-05	5.15E-05	67%
Unidentified Beta	1.99E-02	4.17E-02	2.15E-03	2.09E-03	3.13E-03	49%

a. Beginning in 2016, individual isotope annual releases below 1E-12 Ci (1 pCi) will no longer be reported in this table.

Data Table A-18. Comparison of Measured vs. Calculated Tritium in Air Concentrations

Data Table A-18, Comparison of Measured vs. Calculated Tritium in Air Concentrations

	pCi/m^3	
Source of Data	**Avg. Conc. at Site Boundary**	**Avg. Conc. in the North Sector**
Measured	4.8	5.4[(a)]
Calculated:		
MAXDOSE-SR	10.6	20.3
CAP88PC	8.5	11.8[(a)]

CAP88 Chi/Q and HTO Concentration Calculated from Chi/Q based on Curies Released:

2.24E+03	0-m Ci/yr
1.95E+04	61-m Ci/yr

		2007-2011 Chi/Q		
Toward Sector	**Distance m**	**61-m sec/m^3**	**0-m sec/m^3**	**HTO Conc. pCi/m^3**
N	**15706**	**1.625E-08**	**2.428E-08**	**11.8**
NNW	15007	1.280E-08	1.972E-08	9.3
NW	14466	1.078E-08	1.599E-08	7.8
WNW	13684	1.105E-08	1.594E-08	8.0
W	13880	1.207E-08	1.602E-08	8.6
WSW	15341	1.276E-08	1.675E-08	9.1
SW	15941	1.436E-08	2.035E-08	10.3
SSW	16759	8.214E-09	1.269E-08	6.0
S	15034	6.886E-09	1.111E-08	5.0
SSE	15030	6.450E-09	1.084E-08	4.8
SE	15032	7.782E-09	1.210E-08	5.7
ESE	15273	1.136E-08	1.618E-08	8.2
E	12559	1.657E-08	2.333E-08	11.9
ENE	15985	1.377E-08	1.990E-08	9.9
NE	17217	1.268E-08	1.873E-08	9.2
NNE	16083	1.452E-08	2.288E-08	10.6
Maximum		1.657E-08	2.428E-08	12.0
Minimum		6.450E-09	1.084E-08	4.8
Mean		**1.177E-08**	**1.730E-08**	**8.5**

Measured Averages of HTO Concentration in Air at Site Perimeter:

Location	**pCi/m^3 of Air**
Allendale Gate	2.0
Barnwell Gate	10.6
D-Area	5.2
Darkhorse	5.1
East Talatha	**5.4**
Greenpond	4.5
Highways 21 & 167	3.7
Jackson	4.4
Patterson Mill Road	3.1
Talatha Gate	4.5
Maximum	10.6
Minimum	2.0
Mean	**4.8**

(a) Since the Site MEI and Reference Person are located in the North sector for air dose calculations, the East Talatha (located in the North sector) measured concentration and CAP88 North sector calculated concentration are used for comparison.

Data Table A-19. MAXDOSE-SR Representative Person Dose Using Cow Milk Pathway

Data Table A-19, MAXDOSE-SR Representative Person Dose Using Cow Milk Pathway

2016 MAXDOSE-SR Representative Person Dose Using Cow Milk Pathway (mrem)

Pathway	Representative Person Dose (mrem)[a]	Percent of Total Dose
Plume	7.4E-05	0.19%
Ground	8.4E-04	2.18%
Inhalation	1.4E-02	36.98%
Vegetation	1.4E-02	36.19%
Cow Milk	9.3E-03	24.09%
Meat	1.4E-04	0.37%
Total	**3.8E-02**	**100.0%**

Radionuclide	Representative Person Dose (mrem)[a]	Percent of Total Dose[b]
Gases and Vapors		
H-3	3.6E-02	93.61%
C-14	1.3E-05	0.03%
K-85	7.4E-05	0.19%
I-129	8.8E-04	2.29%
Particulates		
Am-241	4.0E-05	0.10%
Cs-137	9.3E-04	2.42%
Pu-238	5.4E-05	0.14%
Pu-239	1.4E-04	0.36%
Pu-240	1.2E-05	0.03%
Pu-241	5.7E-06	0.01%
Sr-90	1.3E-05	0.03%
U-234	1.1E-05	0.03%
U-238	1.4E-05	0.04%
Alpha	7.5E-05	0.20%
Non-Volatile Beta	1.9E-04	0.50%
Total	**3.8E-02**	**100.0%**

a. Committed effective dose

b. Radionuclides contributing 0.01% or more of the total dose

Data Table A-20. Sector-Specific Representative Person Airborne Pathway Doses (Using Cow Milk Pathway)

Data Table A-20, Sector-Specific Representative Person Airborne Pathway Doses (Using Cow Milk Pathway)

2016 Representative Person Airborne Pathway Doses (mrem)	
N[(a)]	0.038
NNE	0.033
NE	0.026
ENE	0.026
E	0.027
ESE	0.020
SE	0.013
SSE	0.012
S	0.011
SSW	0.014
SW	0.025
WSW	0.028
W	0.024
WNW	0.024
NW	0.028
NNW	0.035

a. Maximum Location

Data Table A-21. MAXDOSE-SR Representative Person Dose Using Goat Milk Pathway

Data Table A-21, MAXDOSE-SR Representative Person Dose Using Goat Milk Pathway

2016 Representative Person Dose Using Goat Milk Pathway (mrem)

Pathway	Maximally Exposed Individual Dose (mrem)[a]	Percent of Total Dose
Plume	7.4E-05	0.17%
Ground	8.4E-04	1.92%
Inhalation	1.4E-02	32.53%
Vegetation	1.4E-02	31.84%
Goat Milk	1.5E-02	33.22%
Meat	1.4E-04	0.33%
Total	**4.4E-02**	**100.0%**

Radionuclide	Maximally Exposed Individual Dose (mrem)[a]	Percent of Total Dose[b]
Gases and Vapors		
H-3	4.1E-02	93.67%
C-14	1.3E-05	0.03%
Kr-85	7.4E-05	0.17%
I-129	1.0E-03	2.36%
Particulates		
Am-241	4.0E-05	0.09%
Cs-137	1.1E-03	2.52%
Pu-238	5.4E-05	0.12%
Pu-239	1.4E-04	0.32%
Pu-240	1.2E-05	0.03%
Pu-241	5.7E-06	0.01%
Sr-90	1.3E-05	0.03%
U-234	1.1E-05	0.03%
U-238	1.3E-05	0.03%
Alpha	7.5E-05	0.17%
Non-Volatile Beta	1.8E-04	0.41%
Total	**4.4E-02**	**100.0%**

a. Committed effective dose

b. Radionuclides contributing 0.01% or more of the total dose

Data Table A-22. POPDOSE-SR Population Dose from Airborne Releases

Data Table A-22, POPDOSE-SR Population Dose from Airborne Releases

2016 Population Dose from Airborne Releases (person-rem)

Pathway	Population Dose (person-rem)[a]	Percent of Total Dose
Plume	5.4E-03	0.39%
Ground	7.5E-02	5.48%
Inhalation	1.0E+00	75.9%
Vegetation	4.0E-02	2.95%
Cow Milk	2.1E-01	15.11%
Meat	1.9E-03	0.14%
Total	**1.4E+00**	**100.0%**

Radionuclide	Population Dose (person-rem)[a]	Percent of Total Dose[b]
Gases and Vapors		
H-3	1.3E+00	91.8%
Kr-85	5.4E-03	0.39%
I-129	1.1E-02	0.79%
Particulates		
Am-241	2.3E-03	0.17%
Cs-137	7.5E-02	5.47%
Pu-238	2.7E-03	0.20%
Pu-239	7.7E-03	0.56%
Pu-240	5.7E-04	0.04%
Pu-241	2.7E-04	0.02%
Pu-242	1.5E-04	0.01%
Sr-90	3.5E-04	0.03%
U-234	6.0E-04	0.04%
U-238	7.1E-04	0.05%
Alpha	3.8E-03	0.28%
Non-Volatile Beta	1.2E-03	0.09%
Total	**1.4E+00**	**100.0%**

a. Committed effective dose
b. Radionuclides contributing 0.01% or more of the total dose

Data Table A-23. Airborne Releases by Source and Stack Height for NESHAP

Data Table A-23, Airborne Releases by Source and Stack Height for NESHAP **2 Pages**

2016 Airborne Releases by Source and Stack Height for NESHAP: Units are Curies

Radionuclide	200' Stack Reactors, Separations, and SRNL	Ground Diffuse/Fugitive[a]	Total
GASES AND VAPORS			
H-3 (oxide)	1.76E+04	2.24E+03	1.99E+04
H-3 (elemental)	1.88E+03		1.88E+03
H-3 Total	1.95E+04	2.24E+03	2.17E+04
C-14	1.64E-02	1.57E-07	1.64E-02
Hg-203		5.22E-10	5.22E-10
Kr-85	3.96E+03		3.96E+03
I-129	1.89E-03	2.01E-04	2.09E-03
I-131			
PARTICLES			
Ag-110m		1.48E-11	1.48E-11
Am-241	2.61E-05	1.12E-05	3.73E-05
Am-243		4.50E-09	4.50E-09
Ba-133		7.01E-10	7.01E-10
Cd-109		1.34E-08	1.34E-08
Ce-139		5.20E-10	5.20E-10
Ce-141		4.94E-11	4.94E-11
Ce-144		2.00E-08	2.00E-08
Cm-244	8.54E-07	2.83E-07	1.14E-06
Co-57		4.96E-10	4.96E-10
Co-60		4.96E-07	4.96E-07
Cs-134		4.31E-07	4.31E-07
Cs-137	7.80E-03	1.25E-03	9.05E-03
Eu-152		1.47E-09	1.47E-09
Eu-154		3.56E-07	3.56E-07
Eu-155		1.18E-07	1.18E-07
F-18		4.00E-02	4.00E-02
Fe-55		1.17E-08	1.17E-08
Mn-54		3.78E-10	3.78E-10
Nb-94		2.42E-07	2.42E-07
Nb-95		3.63E-07	3.63E-07
Ni-59		5.76E-11	5.76E-11
Ni-63		5.46E-09	5.46E-09
Np-237	8.79E-08	1.62E-06	1.71E-06
Pa-233		1.42E-06	1.42E-06
Pb-212		8.43E-07	8.43E-07
Pm-147		2.89E-06	2.89E-06
Pm-148m		1.90E-12	1.90E-12
Pr-144		2.00E-08	2.00E-08
Pu-236		5.55E-10	5.55E-10
Pu-238	8.01E-06	3.14E-05	3.94E-05
Pu-239	6.09E-05	4.34E-05	1.04E-04
Pu-240		7.73E-06	7.73E-06

Data Table A-23, Airborne Releases by Source and Stack Height for NESHAP **2 Pages**

2016 Airborne Releases by Source and Stack Height for NESHAP: Units are Curies

Radionuclide	200' Stack Reactors, Separations, and SRNL	Ground Diffuse/Fugitive[a]	Total
Pu-241		2.07E-04	2.07E-04
Pu-242		2.16E-06	2.16E-06
Ra-226		2.48E-07	2.48E-07
PARTICLES			
Ra-228		2.29E-07	2.29E-07
Rh-106		1.19E-08	1.19E-08
Ru-103		5.11E-10	5.11E-10
Ru-106			
Sb-125		1.18E-06	1.18E-06
Sb-126[b]		1.70E-07	1.70E-07
Se-75	1.94E-07		1.94E-07
Se-79		4.90E-09	4.90E-09
Sm-151		2.89E-06	2.89E-06
Sn-113		6.27E-10	6.27E-10
Sn-123		6.66E-12	6.66E-12
Sn-126		1.70E-07	1.70E-07
Sr-85		6.00E-10	6.00E-10
Sr-89		5.99E-10	5.99E-10
Sr-90	1.53E-04	3.34E-05	1.87E-04
Tc-99		1.06E-06	1.06E-06
Te-127		1.04E-11	1.04E-11
Te-129		1.05E-12	1.05E-12
Th-228	8.29E-10	1.26E-10	9.55E-10
Th-229		1.60E-09	1.60E-09
Th-230	7.68E-09	1.43E-10	7.82E-09
Th-231		2.12E-04	2.12E-04
Th-232	2.17E-09	4.79E-12	2.18E-09
Tl-208		1.41E-06	1.41E-06
U-232		6.04E-09	6.04E-09
U-233		4.21E-10	4.21E-10
U-234	1.02E-04	6.11E-07	1.03E-04
U-235	6.33E-06	8.41E-09	6.34E-06
U-236		3.01E-08	3.01E-08
U-238	1.48E-04	2.08E-07	1.48E-04
Y-88		4.58E-10	4.58E-10
Y-90[b]	1.53E-04	3.34E-05	1.87E-04
Y-91		7.98E-10	7.98E-10
Zn-65		9.56E-10	9.56E-10
Zr-95		1.22E-07	1.22E-07
Unidentified alpha	1.21E-05	3.94E-05	5.15E-05
Unidentified beta	9.59E-04	2.17E-03	3.13E-03

a. Beginning in 2016, calculated individual isotope annual releases below 1E-12 Ci (1 pCi) are no longer reported in this table and, therefore, not used in the dose calculations.

b. Daughter products (Sb-126 & Y-90) in secular equilibrium with source terms (Sn-126 & Sr-90, respectively). In CAP88, they are included in their parents' source term and are not run separately.

Data Table A-24. Site-Specific Parameters Used with CAP88 PC for NESHAP

Data Table A-24, Site-Specific Parameters Used with CAP88 PC for NESHAP

2016 Parameters Used with CAP88 PC for NESHAP

Particle size, AMAD	
Gases and Vapors	0
Particles	1
Meteorological data	2007-2011; H-Area
Plume rise	None
Number of stacks	2
Stack heights, m	0 and 61
Height of lid, m	1328
Rainfall rate, cm/yr	123.2
Average air temperature, C	18.1
Absolute humidity (g/cm^3)	12.9
Population size	781,060
Food supply fractions (fraction from local sources)	
Vegetable	0.7
Meat	0.44
Milk	0.4
EPA Food Source Scenario	Rural
State	South Carolina

Data Table A-25. Radioactive Atmospheric Releases and MEI Doses for NESHAP

Data Table A-25, Radioactive Atmospheric Releases and MEI Doses for NESHAP **2 Pages**

2015 CAP88 PC Dose Calculations for NESHAP Report to EPA

Radionuclide	Releases (Curies)		Maximally Exposed Individual Dose (mrem)	Fraction of Dose
	0 m	61 m		
H-3 (oxide)	2.24E+03	1.76E+04	2.12E-02	0.88
H-3 (elemental)	0.00E+00	1.88E+03	1.56E-03	0.065
Cs-137	1.25E-03	7.80E-03	8.60E-04	0.036
Unidentified beta	2.17E-03	9.59E-04	2.39E-04	0.010
U-234	6.11E-07	1.02E-04	5.99E-05	0.002
Kr-85	0.00E+00	3.96E+03	5.73E-05	0.002
Pu-239	4.34E-05	6.09E-05	5.60E-05	0.002
Unidentified alpha	3.94E-05	1.21E-05	3.04E-05	0.001
Pu-238	3.14E-05	8.01E-06	2.15E-05	0.001
Am-241	1.12E-05	2.61E-05	1.61E-05	0.001
Sr-90	3.34E-05	1.53E-04	1.36E-05	0.0006
U-238	2.08E-07	1.48E-04	7.07E-06	0.0003
Pu-240	7.73E-06		4.84E-06	0.0002
C-14	1.57E-07	1.64E-02	2.59E-06	0.0001
Pu-241	2.07E-04		2.39E-06	0.0001
I-129	2.01E-04	1.89E-03	2.11E-06	0.0001
Pu-242	2.16E-06		1.28E-06	0.00005
Np-237	1.62E-06	8.79E-08	5.60E-07	0.00002
U-235	8.41E-09	6.33E-06	3.56E-07	0.00001
Cm-244	2.83E-07	8.54E-07	3.00E-07	0.00001
F-18	4.00E-02		1.30E-07	0.00001
Ra-226	2.48E-07		1.10E-07	0.000005
Nb-94	2.42E-07		6.63E-08	0.000003
Sn-126	1.70E-07		6.42E-08	0.000003
Ra-228	2.29E-07		5.40E-08	0.000002
Co-60	4.96E-07	0.00E+00	3.46E-08	0.000001
Cs-134	4.31E-07		1.99E-08	0.000001
Eu-154	3.56E-07		1.83E-08	0.000001
Tc-99	1.06E-06		1.58E-08	0.000001
Ru-106	3.04E-06		1.06E-08	0.0000004
Sb-125	1.18E-06		8.27E-09	0.0000003
U-232	6.04E-09		4.63E-09	0.0000002
Th-230	1.43E-10	7.68E-09	4.30E-09	0.0000002
Am-243	4.50E-09		2.47E-09	0.0000001
Th-229	1.60E-09		1.74E-09	0.0000001
Th-232	4.79E-12	2.17E-09	1.65E-09	0.0000001
Pb-212	8.43E-07		1.40E-09	0.0000001
U-236	3.01E-08		1.14E-09	0.00000005
Se-75	0.00E+00	1.94E-07	7.80E-10	0.00000003
Th-231	2.12E-04		6.85E-10	0.00000003
U-233	4.21E-10		4.76E-10	0.00000002
Th-228	1.26E-10	8.29E-10	3.47E-10	0.00000001
Sm-151	2.89E-06		3.40E-10	0.00000001
Pm-147	2.89E-06		3.37E-10	0.00000001

Data Table A-25, Radioactive Atmospheric Releases and MEI Doses for NESHAP **2 Pages**

2015 CAP88 PC Dose Calculations for NESHAP Report to EPA

Radionuclide	Releases (Curies)		Maximally Exposed Individual Dose (mrem)	Fraction of Dose
	0 m	61 m		
Zr-95	1.22E-07		2.69E-10	0.00000001
Pa-233	1.42E-06		2.57E-10	0.00000001
Eu-155	1.18E-07		1.86E-10	0.00000001
Nb-95	3.63E-07		1.76E-10	0.00000001
Pu-236	5.55E-10		1.34E-10	0.00000001
Eu-152	1.47E-09		9.80E-11	0.000000004
Se-79	4.90E-09		8.61E-11	0.000000004
Ce-144	2.00E-08		3.66E-11	0.000000002
Ba-133	7.01E-10		1.32E-11	0.000000001
Zn-65	9.56E-10		9.47E-12	0.0000000004
Cd-109	1.34E-08		9.31E-12	0.0000000004
Fe-55	1.17E-08		2.88E-12	0.0000000001
Y-88	4.58E-10		2.08E-12	0.0000000001
Mn-54	3.78E-10		1.60E-12	0.0000000001
Ni-63	5.46E-09		1.29E-12	0.0000000001
Sn-113	6.27E-10		4.57E-13	0.00000000002
Sr-85	6.00E-10		3.77E-13	0.00000000002
Y-91	7.98E-10		3.23E-13	0.00000000001
Co-57	4.96E-10		3.20E-13	0.00000000001
Sr-89	5.99E-10		3.16E-13	0.00000000001
Ru-103	5.11E-10		2.03E-13	0.00000000001
I-131	6.75E-10		2.01E-13	0.00000000001
Ce-139	5.20E-10		1.94E-13	0.00000000001
Ag-110m	1.48E-11		1.69E-13	0.00000000001
Hg-203	5.22E-10		5.53E-14	0.000000000002
Ni-59	5.76E-11		6.68E-15	0.0000000000003
Ce-141	4.94E-11		5.72E-15	0.0000000000002
Sn-123	6.66E-12		5.43E-15	0.0000000000002
Pm-148m	1.90E-12		3.11E-15	0.0000000000001
Pr-144	2.00E-08		5.20E-16	0.00000000000002
Te-127	1.04E-11		1.21E-17	0.0000000000000005
Tl-208	1.41E-06		9.88E-18	0.0000000000000004
Rh-106	1.19E-08		2.81E-18	0.0000000000000001
Te-129	1.05E-12		3.39E-19	0.00000000000000001
TOTAL	**2.24E+03**	**2.35E+04**	**2.41E-02**	**1.00**

Data Table A-26. Diffuse and Fugitive Releases and MEI Doses for NESHAP

Data Table A-26, Diffuse and Fugitive Releases and MEI Doses for NESHAP **2 Pages**

2016 Diffuse and Fugitive Releases and MEI Doses

Radionuclide	Releases (curies)	Maximally Exposed Individual Dose (mrem)	Fraction of Dose
H-3 (oxide)	2.24E+03	3.38E-03	0.90
Unidentified beta	2.17E-03	1.71E-04	0.045
Cs-137	1.25E-03	1.28E-04	0.034
Pu-239	4.34E-05	2.72E-05	0.007
Unidentified alpha	3.94E-05	2.47E-05	0.007
Pu-238	3.14E-05	1.80E-05	0.005
Am-241	1.12E-05	5.83E-06	0.002
Pu-240	7.73E-06	4.84E-06	0.001
Sr-90	3.34E-05	2.62E-06	0.001
Pu-241	2.07E-04	2.39E-06	0.0006
Pu-242	2.16E-06	1.28E-06	0.0003
Np-237	1.62E-06	5.38E-07	0.0001
U-234	6.11E-07	4.14E-07	0.0001
I-129	2.01E-04	2.89E-07	0.0001
F-18	4.00E-02	1.30E-07	0.00003
Ra-226	2.48E-07	1.10E-07	0.00003
Cm-244	2.83E-07	9.14E-08	0.00002
Nb-94	2.42E-07	6.63E-08	0.00002
Sn-126	1.70E-07	6.42E-08	0.00002
Ra-228	2.29E-07	5.40E-08	0.00001
Co-60	4.96E-07	3.46E-08	0.00001
Cs-134	4.31E-07	1.99E-08	0.00001
Eu-154	3.56E-07	1.83E-08	0.000005
Tc-99	1.06E-06	1.58E-08	0.000004
U-238	2.08E-07	1.19E-08	0.000003
Ru-106	3.04E-06	1.06E-08	0.000003
Sb-125	1.18E-06	8.27E-09	0.000002
U-232	6.04E-09	4.63E-09	0.000001
Am-243	4.50E-09	2.47E-09	0.000001
Th-229	1.60E-09	1.74E-09	0.0000005
Pb-212	8.43E-07	1.40E-09	0.0000004
U-236	3.01E-08	1.14E-09	0.0000003
Th-231	2.12E-04	6.85E-10	0.0000002
U-235	8.41E-09	5.64E-10	0.0000001
U-233	4.21E-10	4.76E-10	0.0000001
Sm-151	2.89E-06	3.40E-10	0.0000001
Pm-147	2.89E-06	3.37E-10	0.0000001
Zr-95	1.22E-07	2.69E-10	0.0000001
Pa-233	1.42E-06	2.57E-10	0.0000001
Eu-155	1.18E-07	1.86E-10	0.00000005
Nb-95	3.63E-07	1.76E-10	0.00000005
Pu-236	5.55E-10	1.34E-10	0.00000004
Eu-152	1.47E-09	9.80E-11	0.00000003
Th-230	1.43E-10	9.13E-11	0.00000002

Data Table A-26, Diffuse and Fugitive Releases and MEI Doses for NESHAP **2 Pages**

2016 Diffuse and Fugitive Releases and MEI Doses

Radionuclide	Releases (curies)	Maximally Exposed Individual Dose (mrem)	Fraction of Dose
Se-79	4.90E-09	8.61E-11	0.00000002
Th-228	1.26E-10	5.81E-11	0.00000002
C-14	1.57E-07	3.68E-11	0.00000001
Ce-144	2.00E-08	3.66E-11	0.00000001
Ba-133	7.01E-10	1.32E-11	0.000000004
Zn-65	9.56E-10	9.47E-12	0.000000003
Cd-109	1.34E-08	9.31E-12	0.000000002
Th-232	4.79E-12	4.27E-12	0.000000001
Fe-55	1.17E-08	2.88E-12	0.000000001
Y-88	4.58E-10	2.08E-12	0.000000001
Mn-54	3.78E-10	1.60E-12	0.0000000004
Ni-63	5.46E-09	1.29E-12	0.0000000003
Sn-113	6.27E-10	4.57E-13	0.0000000001
Sr-85	6.00E-10	3.77E-13	0.0000000001
Y-91	7.98E-10	3.23E-13	0.0000000001
Co-57	4.96E-10	3.20E-13	0.0000000001
Sr-89	5.99E-10	3.16E-13	0.0000000001
Ru-103	5.11E-10	2.03E-13	0.0000000001
I-131	6.75E-10	2.01E-13	0.0000000001
Ce-139	5.20E-10	1.94E-13	0.0000000001
Ag-110m	1.48E-11	1.69E-13	0.00000000004
Hg-203	5.22E-10	5.53E-14	0.00000000001
Ni-59	5.76E-11	6.68E-15	0.000000000002
Ce-141	4.94E-11	5.72E-15	0.000000000002
Sn-123	6.66E-12	5.43E-15	0.000000000001
Pm-148m	1.90E-12	3.11E-15	0.000000000001
Pr-144	2.00E-08	5.20E-16	0.0000000000001
Te-127	1.04E-11	1.21E-17	0.000000000000003
Tl-208	1.41E-06	9.88E-18	0.000000000000003
Rh-106	1.19E-08	2.81E-18	0.000000000000001
Te-129	1.05E-12	3.39E-19	0.0000000000000001
TOTAL	**2.24E+03**	**3.77E-03**	**1.00**

Data Table A-27. CAP88 MEI Dose Compared to MAXDOSE-SR

Data Table A-27, CAP88 MEI Dose Compared to MAXDOSE-SR

2016 Maximally Exposed Individual Dose Commitment at Site Boundary from Atmospheric Releases

Pathway	CAP88 PC Maximally Exposed Individual		MAXDOSE-SR Representative Person	
	(Millirem)[a]	(Percent of Dose)	(Millirem)[a]	(Percent of Dose)[d]
Plume	5.74E-05	0.24	7.35E-05	0.16
Ground	5.17E-04	2.14	8.36E-04	0.42
Inhalation	3.99E-03	16.54	1.42E-02	37.70
Food[b]	1.96E-02	81.08	2.33E-02	61.71
Total	**2.41E-02**		**3.84E-02**	

Radionuclide	CAP88 PC Maximally Exposed Individual		MAXDOSE-SR Representative Person	
	(Millirem)[a]	(Percent of Dose)	(Millirem)[a]	(Percent of Dose)[d]
Gases and Vapors				
H-3[c]	2.28E-02	94.31	3.60E-02	93.61
C-14	2.59E-06	0.01	1.25E-05	0.03
Kr-85	5.73E-05	0.24	7.35E-05	0.19
I-129	2.11E-06	0.01	8.80E-04	2.29
Particulates				
Am-241	1.61E-05	0.07	4.02E-05	0.10
Cs-137	8.60E-04	3.56	9.29E-04	2.42
Pu-238	2.15E-05	0.09	5.36E-05	0.14
Pu-239	5.60E-05	0.23	1.38E-04	0.36
Pu-240	4.84E-06	0.02	1.20E-05	0.03
Pu-241	2.39E-06	0.01	5.72E-06	0.01
Sr-90	1.36E-05	0.06	1.28E-05	0.03
U-234	5.99E-05	0.25	1.13E-05	0.03
U-238	7.07E-06	0.03	1.38E-05	0.04
Alpha	3.04E-05	0.13	7.52E-05	0.20
Non-Volatile Beta	2.39E-04	0.99	1.91E-04	0.50
Total	**2.41E-02**		**3.84E-02**	99.98

NOTE: (a) Committed effective dose.

NOTE: (b) Meat, milk, and vegetables.

NOTE: (c) Dose from tritium in foods calculated with absolute humidity of 12.9 g water/cubic meter of air.

NOTE: (d) Radionuclides contributing 0.01% or more from MAXDOSE-SR output.

Data Table A-28. CAP88 PC Population Dose Compared to POPDOSE-SR

Data Table A-28, CAP88 PC Population Dose Compared to POPDOSE-SR

2016 Collective Committed Dose from Atmospheric Releases

Pathway	CAP88 Code		POPDOSE-SR Code	
	Person-rem[(a)]	Percent of Dose	Person-rem[(a)]	Percent of Dose[(d)]
Plume	8.94E-03	0.26	5.35E-03	0.39
Ground	8.05E-02	2.33	7.50E-02	5.48
Inhalation	6.16E-01	17.82	1.04E+00	75.95
Food[(b)]	2.75E+00	79.59	2.49E-01	18.18
Total	**3.46E+00**		**1.37E+00**	

Radionuclide	CAP88 Code		POPDOSE-SR Code	
	Person-rem(a)	Percent of Dose	Person-rem(a)	Percent of Dose(d)
Gases and Vapors				
H-3[(c)]	3.26E+00	94.21	1.26E+00	91.87
Kr-85	8.94E-03	0.26	5.35E-03	0.39
I-129	3.27E-04	0.01	1.08E-02	0.79
Particulates				
Am-241	1.98E-03	0.06	2.33E-03	0.17
Cs-137	1.32E-01	3.81	7.50E-02	5.47
Pu-238	2.50E-03	0.07	2.70E-03	0.20
Pu-239	6.77E-03	0.20	7.69E-03	0.56
Pu-240	5.53E-04	0.02	5.72E-04	0.04
Pu-241	2.74E-04	0.01	2.72E-04	0.02
Sr-90	1.88E-03	0.05	3.51E-04	0.03
U-234	8.10E-03	0.23	5.96E-04	0.04
U-238	9.69E-04	0.03	7.07E-04	0.05
Alpha	3.55E-03	0.10	3.81E-03	0.28
Non-Volatile Beta	3.25E-02	0.94	1.17E-03	0.09
Total	**3.46E+00**		**1.37E+00**	

NOTE: (a) Committed effective dose equivalent

NOTE: (b) Meat, milk, and vegetables

NOTE: (c) Dose from tritium in foods calculated with absolute humidity of 12.9 g water/cubic meter of air

NOTE: (d) Radionuclides contributing 0.01% or more from POPDOSE-SR output.

Data Table A-29. Deer and Hog Hunter Doses

Data Table A-29, Deer and Hog Hunter Doses

2016 Deer and Hog Hunter Doses

Onsite Deer Hunter (Actual Hunter)				
Maximum Individual Dose determined by EMS lab analysis =			**13.50**	**mrem**
1 animal harvested (1-hog)				
Total gross (live) weight =	198	lbs	*90*	*kg*
Total edible weight =	89	lbs	*40*	*kg*
Offsite Deer Hunter Dose (Hypothetical Hunter)				
Mean of the gross cesium-137 concentration in onsite deer =			2.06	pCi/g
CSRA background concentration =			0.5	pCi/g
MEI meat consumption rate =			81	kg/y
Cesium-137 adult dose coefficient (from DOE-STD-1196-2011) =			5.03E-05	mrem/pCi
Dose =			**6.36**	**mrem**
Offsite Hog Hunter Dose (Hypothetical Hunter)				
Mean of the gross cesium-137 concentration in onsite hogs =			1.05	pCi/g
CSRA background concentration =			0.5	pCi/g
MEI meat consumption rate =			81	kg/y
Cesium-137 adult dose coefficient (from DOE-STD-1196-2011) =			5.03E-05	mrem/pCi
Dose =			**2.24**	**mrem**

Data Table A-30a. Average Concentration in Composites Used in the Dose Calculations (pCi/g)

Tables A-30 a, b, c -- Three Pages

Data Table A-30a, Average Concentration in Composites Used in the Dose Calculations (pCi/g) **Page 1 of 3**

Location	Species	H-3	Sr-89,90	Cs-137	I-129	Tc-99
Augusta	Bass			5.19E-02		4.52E-02
Lock + Dam	Catfish			2.51E-02		
	Panfish		6.51E-03	1.93E-02		
U3R	Bass		2.07E-03	1.20E-01		
Mouth	Catfish	7.14E-02		2.93E-02		5.86E-02
	Panfish	9.30E-02		1.73E-02		
Fourmile	Bass	2.44E-01	6.78E-03	1.57E-01		9.79E-02
Branch Mouth	Catfish		2.34E-03	5.20E-02		7.07E-02
	Panfish	1.31E-01	5.32E-03	1.08E-01		6.60E-02
Steel Creek	Bass	1.90E-01		1.15E-01		
Mouth	Catfish	1.12E-01	1.80E-03	7.25E-02		
	Panfish	4.94E-02		5.81E-02		
L3R	Bass	1.43E-01	2.57E-03	1.43E-01		
Mouth	Catfish	4.70E-02	2.10E-03	1.14E-01		
	Panfish	7.59E-02		1.78E-01		
Hwy-301	Bass	9.73E-02	1.83E-03	3.77E-02		
Bridge Area	Catfish			2.48E-02		
	Panfish			1.26E-02		

Note: Averages are based on three composites of up to five fish of each species from each location.
At least one of the three composite samples had to have a significant result for an average concentration to be reported.

Data Table A-30b. Total Dose from Consumption of 24 kg/y from Savannah River Fish (mrem)

Data Table A-30b, Total Dose from Consumption of 24 kg/y from Savannah River Fish (mrem) **Page 2 of 3**

Location	Species	H-3	Sr-90	Cs-137	I-129	Tc-99	Total
Augusta	Bass			6.13E-02		3.61E-03	6.49E-02
Lock + Dam	Catfish			2.96E-02			2.96E-02
	Panfish		2.08E-02	2.28E-02			4.36E-02
U3R	Bass		6.62E-03	1.42E-01			1.48E-01
Mouth	Catfish	1.33E-04		3.46E-02		4.68E-03	3.94E-02
	Panfish	1.73E-04		2.04E-02			2.06E-02
Fourmile	Bass	4.55E-04	2.17E-02	1.85E-01		7.82E-03	**2.15E-01**
Branch Mouth	Catfish		7.48E-03	6.14E-02		5.65E-03	7.45E-02
	Panfish	2.44E-04	1.70E-02	1.28E-01		5.27E-03	1.50E-01
Steel Creek	Bass	3.54E-04		1.36E-01			1.36E-01
Mouth	Catfish	2.09E-04	5.75E-03	8.56E-02			9.16E-02
	Panfish	9.21E-05		6.86E-02			6.87E-02
L3R	Bass	2.67E-04	8.22E-03	1.69E-01			1.77E-01
Mouth	Catfish	8.76E-05	6.71E-03	1.35E-01			1.41E-01
	Panfish	1.42E-04		2.10E-01			2.10E-01
Hwy-301	Bass	1.81E-04	5.85E-03	4.45E-02			5.06E-02
Bridge Area	Catfish			2.93E-02			2.93E-02
	Panfish			1.49E-02			1.49E-02

Data Table A-30c. Total Risk from Consumption of 24 kg/y from Savannah River Fish (risk/year)

Data Table A-30c, Total Risk from Consumption of 24 kg/y from Savannah River Fish (risk/year) **Page 3 of 3**

Location	Species	H-3	Sr-90	Cs-137	I-129	Tc-99	Total
Augusta	Bass			4.66E-08		4.34E-09	5.09E-08
Lock + Dam	Catfish			2.25E-08			2.25E-08
	Panfish		1.49E-08	1.73E-08			3.22E-08
U3R	Bass		4.73E-09	1.08E-07			1.12E-07
Mouth	Catfish	1.12E-10		2.63E-08		5.63E-09	3.20E-08
	Panfish	1.45E-10		1.55E-08			1.57E-08
Fourmile	Bass	3.81E-10	1.55E-08	1.41E-07		9.40E-09	**1.66E-07**
Branch Mouth	Catfish		5.35E-09	4.67E-08		6.79E-09	5.88E-08
	Panfish	2.05E-10	1.22E-08	9.69E-08		6.34E-09	1.16E-07
Steel Creek	Bass	2.97E-10		1.03E-07			1.04E-07
Mouth	Catfish	1.75E-10	4.12E-09	6.51E-08			6.94E-08
	Panfish	7.72E-11		5.22E-08			5.22E-08
L3R	Bass	2.23E-10	5.88E-09	1.28E-07			1.34E-07
Mouth	Catfish	7.34E-11	4.80E-09	1.02E-07			1.07E-07
	Panfish	1.19E-10		1.60E-07			1.60E-07
Hwy-301	Bass	1.52E-10	4.19E-09	3.38E-08			3.82E-08
Bridge Area	Catfish			2.23E-08			2.23E-08
	Panfish			1.13E-08			1.13E-08

Data Table A-31. SRS Supplemental Release Criteria

Data Table A-31, SRS Supplemental Release Criteria

Radionuclide Groups (a)	Removable (b) dpm/100 cm2	Total (Fixed+Removable)(c) dpm/100 cm2	Volumetric (d) pCi/g
Group 1 Radium, Thorium, and Transuranics: 210Po, 210Pb, 226Ra, 228Ra, 228Th, 230Th, 232Th, 237Np, 239Pu, 240Pu, 241Am, 244Cm, and associated decay chains(e), and others(a)	20	500	3
Group 2 U-nat, 234U, 235U, 238U, and associated decay products(f): 14C, 22Na, 24Na, 32P, 35S, 36Cl, 45Ca, 51Cr, 54Mn, 55Fe, 59Fe, 58Co, 60Co, 63Ni, 65Zn, 89Sr, 90Sr, 94Nb, 99Tc, 106Ru, 110mAg, 109Cd, 111In, 124Sb, 125I, 129I, 131I, 134Cs, 137Cs, 144Ce, 147Pm, 152Eu, 154Eu, 192Ir, 198Au, 241Pu, and others(a)	1000	5000	30
Tritium and tritiated compounds(g)	10,000/100,000(h)	N/A	2000

(a) To determine the specific group for radionuclides not shown, a comparison of the effective dose factors, by exposure pathway, listed in Table A.1 of NCRP Report No. 123
for the radionuclides in question and the radionuclides in the general groups above shall be performed and a determination of the proper group made, based on similarity of the factors.
(b) The amount of removable radioactive material per 100 cm2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note - The use of dry material may not be appropriate for tritium). When removable contamination on objects of surface area less than 100 cm2 is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
(c) The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm2 is less than three times the value specified. For purpose of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm2 area exceeds three times the applicable value.
(d) Volume criteria will only be applied for the purpose of release of materials for disposal in a state, DOE, permitted or approved on-site landfill.
(e) For decay chains, the screening levels represent the total activity (i.e., the activity of the parent plus the activity of all progeny) present.
(f) Alpha component of activity
(g) Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may
migrate to the surface in order to ensure the surface contamination value is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply.
(h) The criterion of 10,000 dpm/100 cm2 will be used for release of material for unrestricted use (reuse or recycle). The criterion of 100,000 dpm/100 cm2 will be used for the
controlled on-site landfill disposal of material. (Note - DOE Suspension (July 2000) for recycle of metals will apply until rescinded). However, WSRC will only implement this more relaxed tritium surface criterion if a future exemption to 10CFR835 is granted.

Data Table A-32. Biota Dose Assessment

Data Table A-32, Biota Dose Assessment

Initial Level 1 Aquatic Systems Screen using Maximum Radionuclide Concentrations in Water and Sediment[a,b]

Location	Sum-of-the-Fractions of BCGs
FM-2	0.2530
FM-2B	0.3130
FM-3A	0.1500
FM-A7	0.3110
L3R-1A	0.0886
L3R-2	0.0710
Z-Area Basin	1.0500
PB-3	0.0696
SC-2A	0.3840
SC-4	0.0789
TB-5	0.0978
U3R-1	0.0031
U3R-4	0.1200
100-R	0.0139

Initial Level 1 Terrestrial Systems Screen using Maximum Radionuclide Concentrations in Soil[a,b]

Location	Sum-of-the-Fractions of BCGs
F-Area	0.01110
H-Area	0.01530
Z-Area	0.01790
643-26E	0.00124
Burial Ground-North	0.00778

a. Soils and sediment are sampled on an annual basis. Stream water is generally sampled monthly.
b. Negative concentrations were assumed to be 0.

Level 2 Aquatic Systems Screen using Mean Radionuclide Concentrations

Location	Sum-of-the-Fractions of BCGs
Z-Area Basin	0.9530

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